Oct. 11, 1938. J. P. SMITH 2,132,655

SYSTEM FOR PRODUCING ELECTRICAL IMPULSES

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Fig. 1.

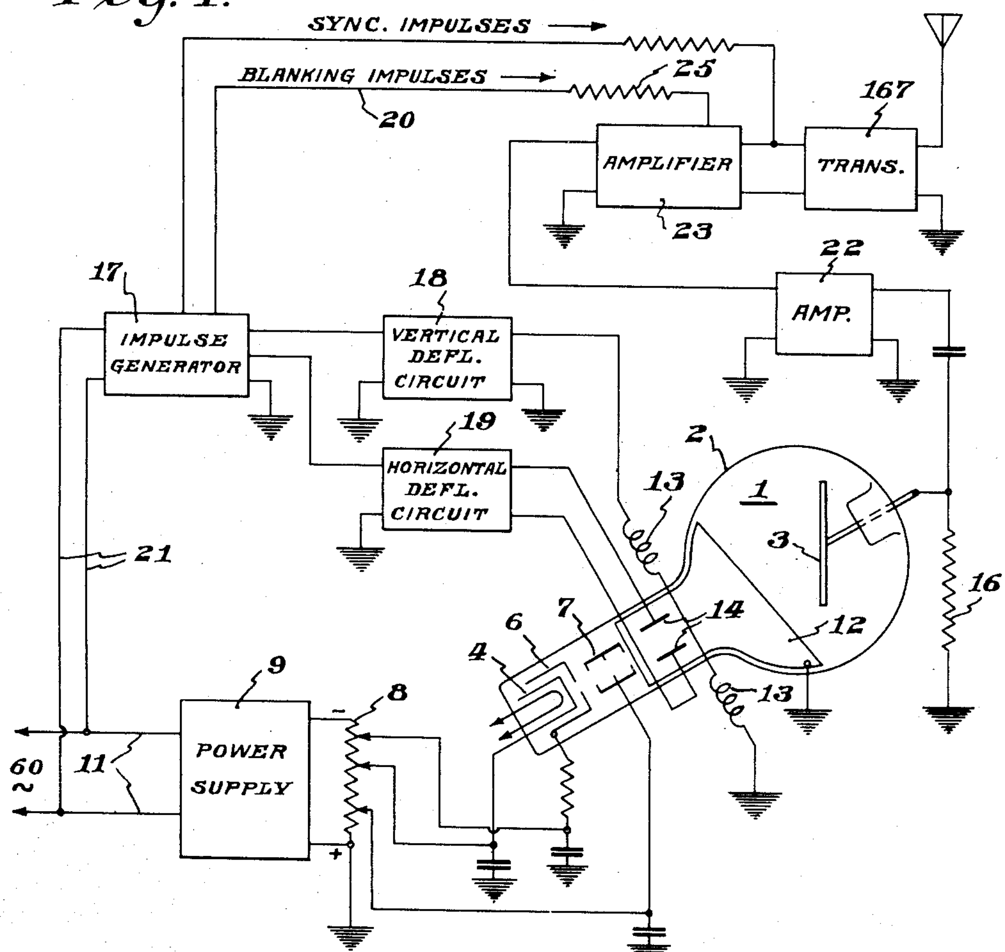
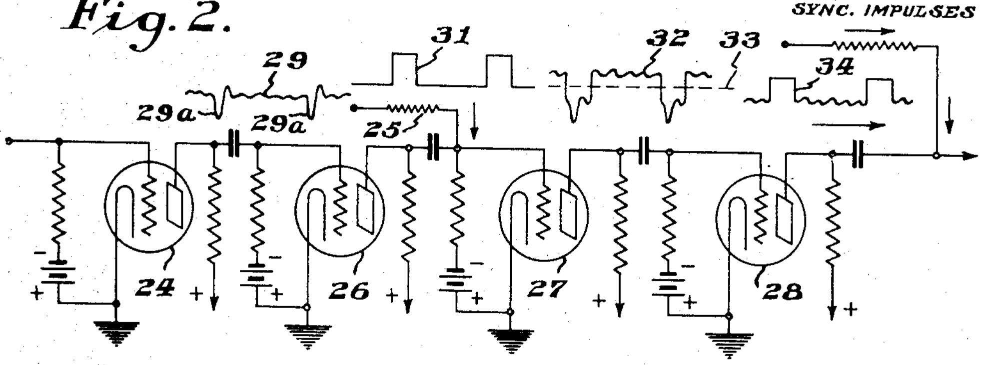


Fig. 2.



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SYSTEM FOR PRODUCING ELECTRICAL IMPULSES

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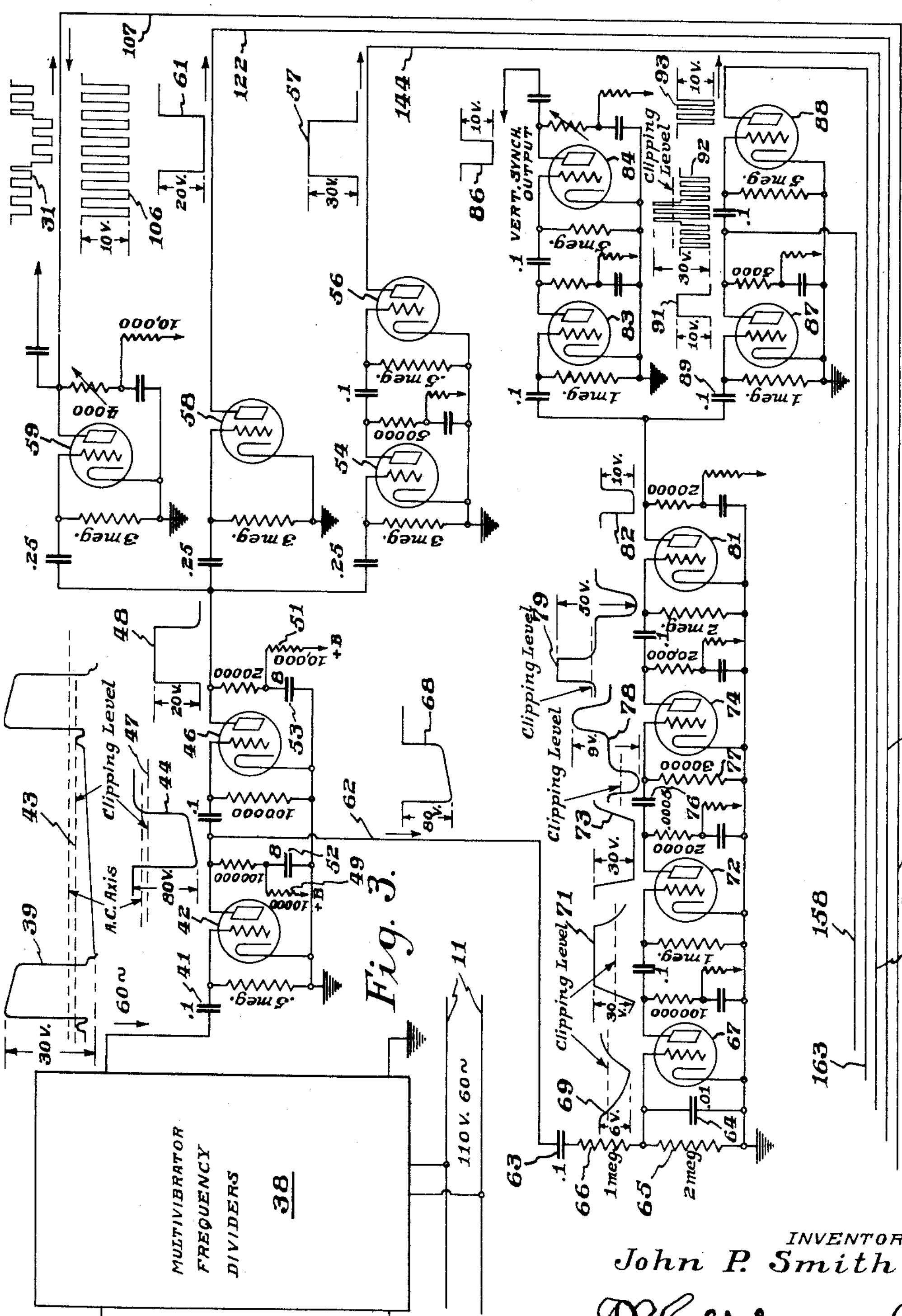

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SYSTEM FOR PRODUCING ELECTRICAL IMPULSES

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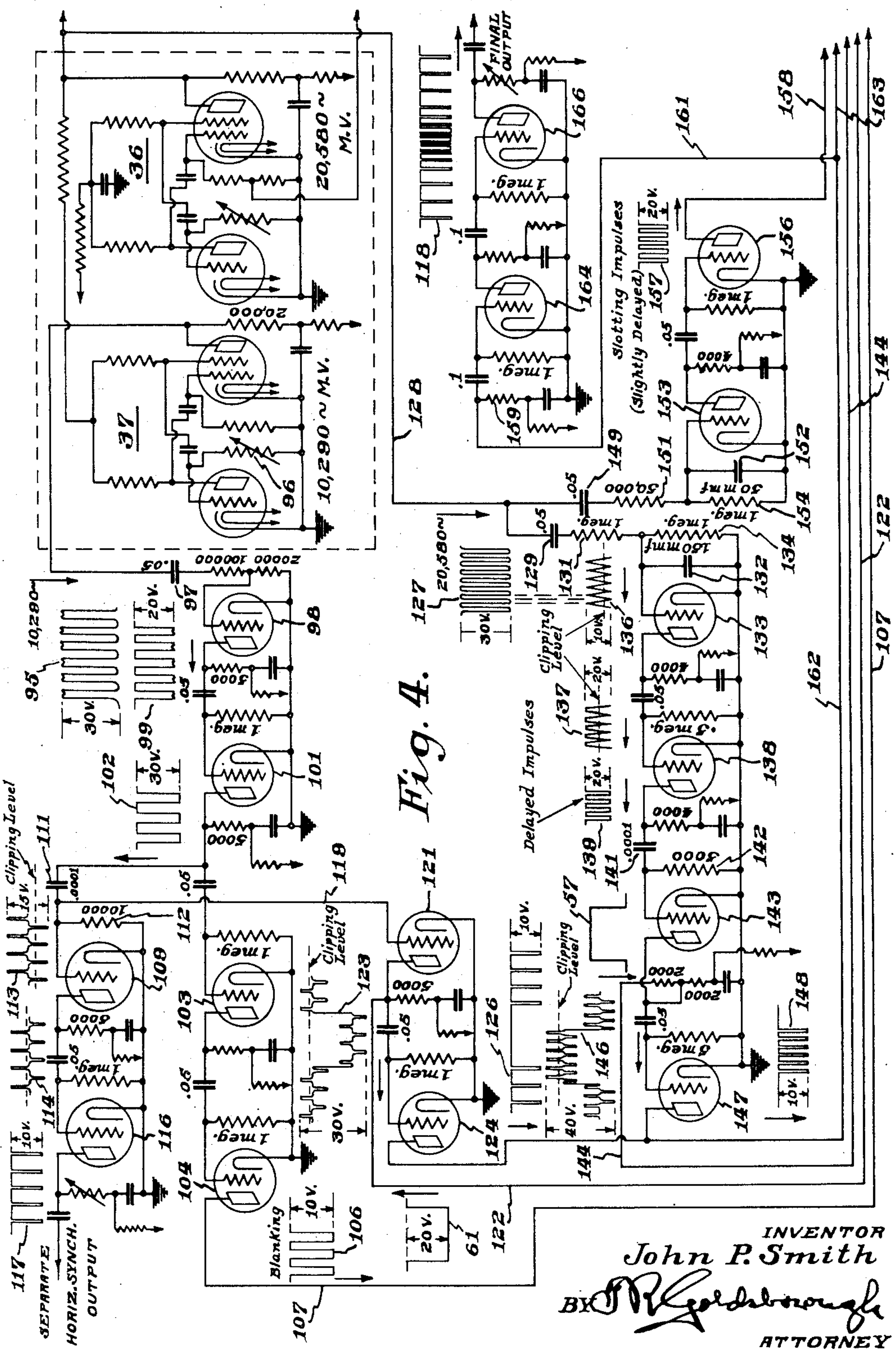

Fig. 4.

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SYSTEM FOR PRODUCING ELECTRICAL IMPULSES

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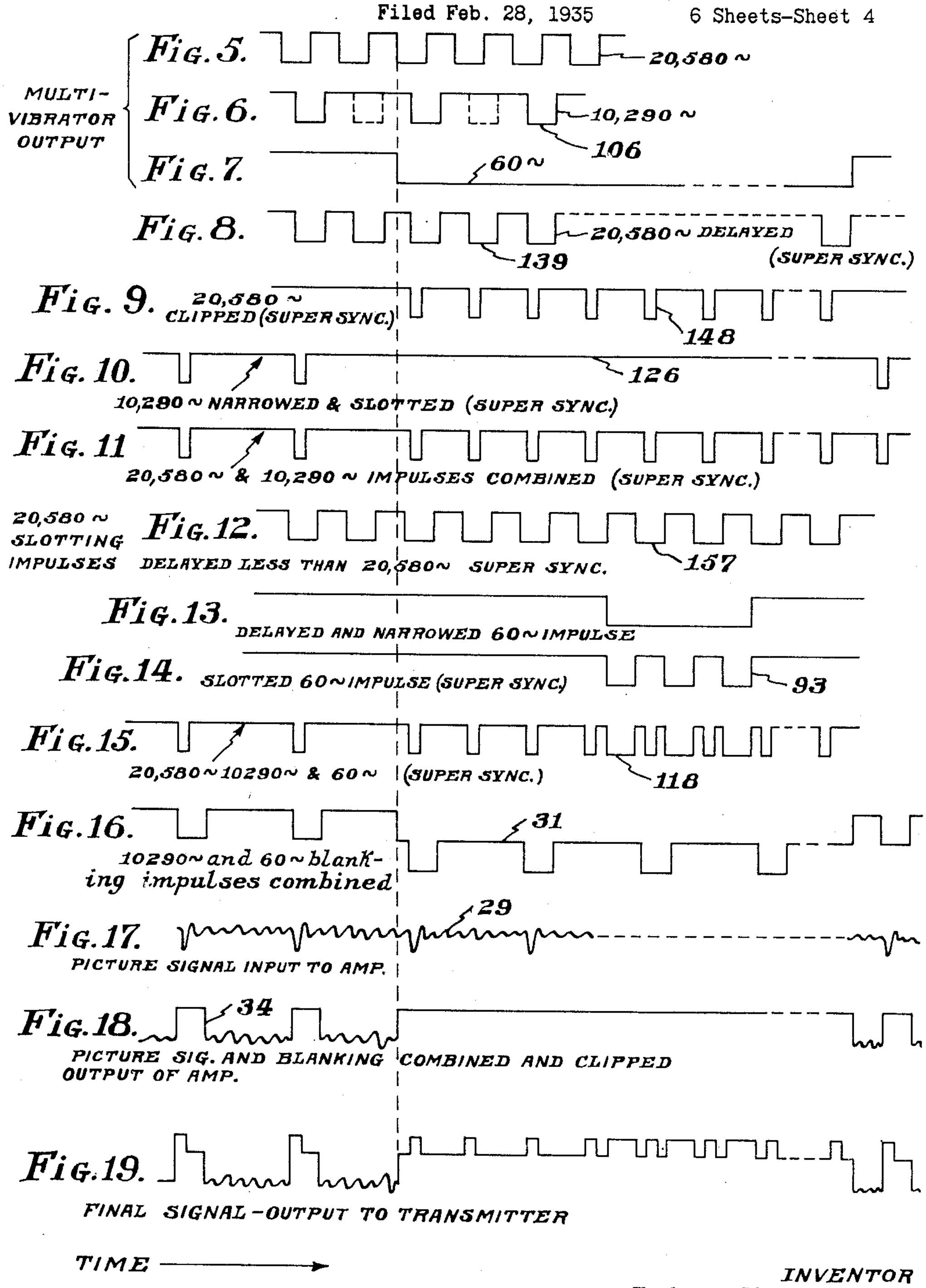

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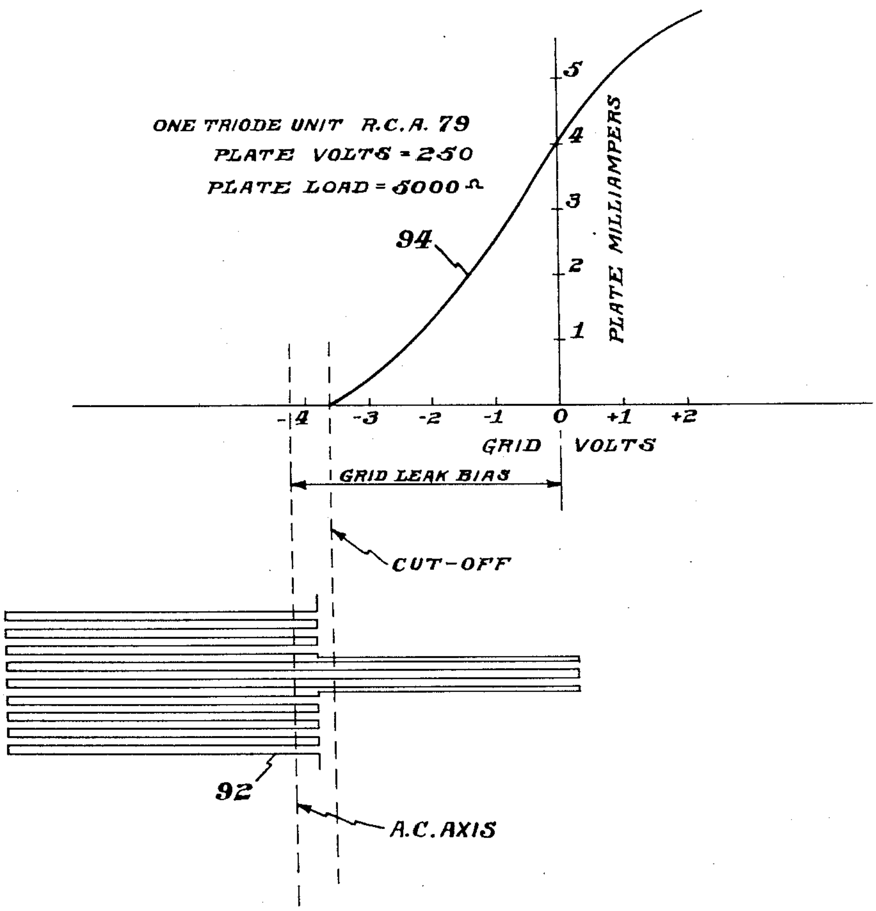
Fig. 20.



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SYSTEM FOR PRODUCING ELECTRICAL IMPULSES

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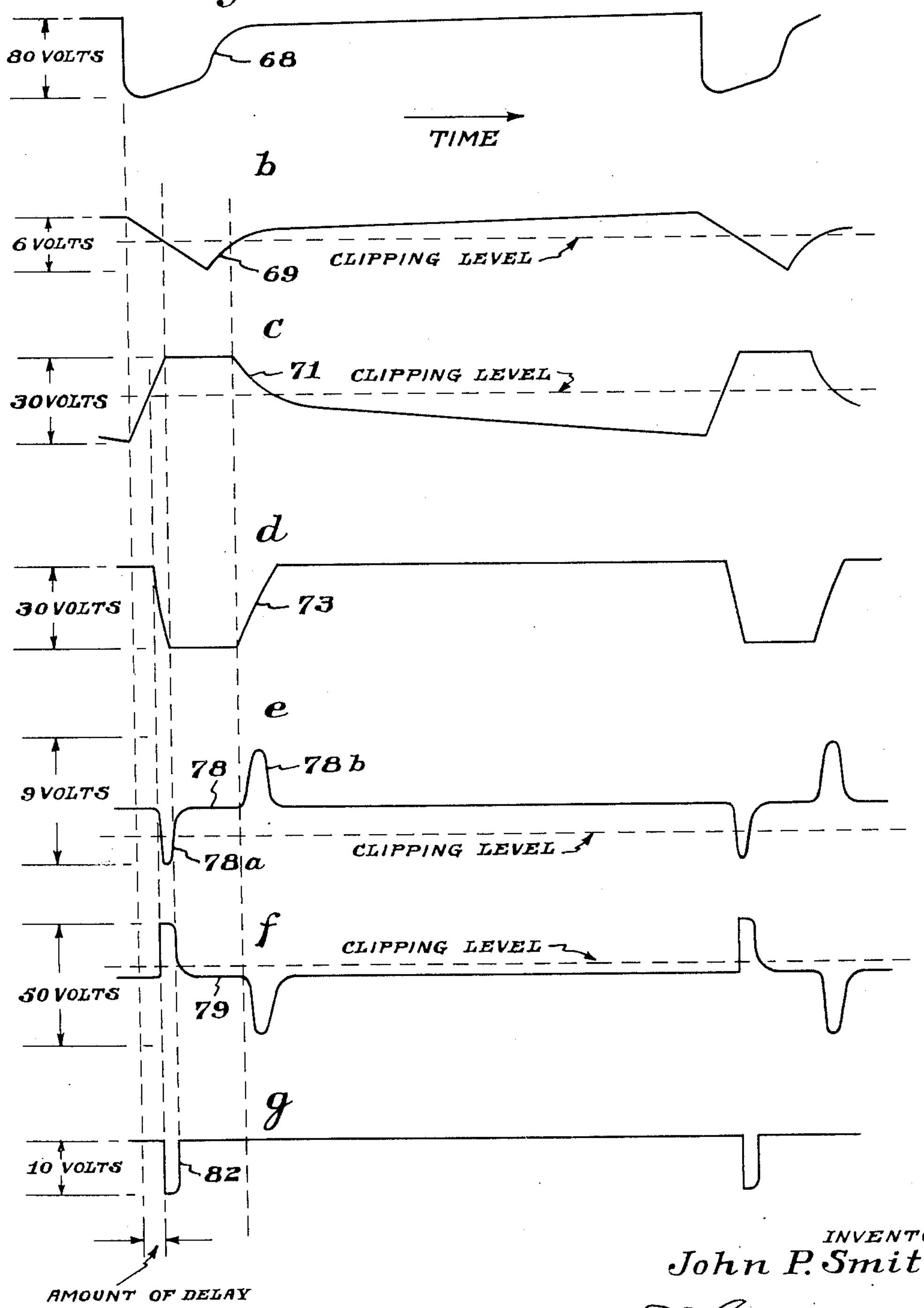
Fig. 21a.



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Patented Oct. 11, 1938 2,132,655

UNITED STATES PATENT OFFICE

2,132,655

SYSTEM FOR PRODUCING ELECTRICAL IMPULSES

John P. Smith, Erlton, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application February 28, 1935, Serial No. 8,659

21 Claims. (Cl. 178—7.2)

My invention relates to circuits and systems for producing electrical impulses having desired characteristics and particularly to systems for producing synchronizing impulses and the like for use in a television system.

In application, Serial No. 728,147, filed May 29, 1934, in the name of A. V. Bedford and assigned to the same assignee as this application, there is described and claimed an improved television system which employs interlaced scanning. In the Bedford system the various voltage impulses, such as synchronizing and blanking impulses, are generated by means of photoelectric cells and rotating discs having openings therein through which light beams are projected onto the said cells.

An object of my invention is to provide a generator free from moving parts for generating electrical impulses of the character described in the above-mentioned Bedford application.

A further object of my invention is to provide an improved circuit including an electric discharge tube oscillator and associated circuits for producing square-topped electrical impulses having the desired width and having the desired time relation to each other.

A further object of my invention is to provide an improved "peak clipping" circuit.

A further object of my invention is to provide an improved method of and means for narrowing electrical impulses.

A further object of my invention is to provide an improved method of and means for delaying or shifting the phase of an electrical impulse.

A further object of my invention is to provide an improved method of and means for slotting an electrical impulse or a group of electrical impulses.

A still further object of my invention is to provide an improved method of and means for selecting a desired number or group of electrical impulses from electrical impulses which are generated continuously.

In a preferred embodiment of my invention a chain of multi-vibrators is utilized for producing electrical impulses occurring at the horizontal scanning frequency, electrical impulses occurring at double this frequency, and electrical impulses occurring at the frame or vertical scanning frequency. Certain of the last-mentioned impulses, which in the example being described occur at the rate of 60 per second, are squared up by clipping and utilized without change in width or phase for blanking and slotting.

Other 60 cycle impulses are delayed and narrowed for use as the vertical synchronizing impulses.

Certain of the impulses occurring at the horizontal scanning frequency, 10,290 cycles per second in the example being described, are squared up by clipping and utilized without change in width or phase for blanking.

Other 10,290 cycle impulses are narrowed to be utilized without change in phase as horizontal synchronizing impulses, and a group of these 10,290 impulses are eliminated each time a 60 cycle slotting impulse occurs, that is, the 10,290 cycle impulses are "slotted", in order to permit the insertion of a group of double frequency impulses.

Certain of the double frequency or 20,580 cycle impulses are delayed a slight amount for use without any change in width for slotting the vertical synchronizing impulses. Other 20,580 cycle impulses are delayed a greater amount and narrowed to the same width as the narrowed 10,290 impulses and a group of these 20,580 cycle impulses is selected to fit into the "slot" cut in the 10,290 cycle impulses for use as the double frequency synchronizing impulses.

The relative delay of the two groups of 20,580 cycle impulses is such that the narrowed 20,580 cycle impulses fit into the slots cut in the vertical synchronizing impulses by the other 20,580 cycle impulses.

The "slotted" 10,290 cycle impulses, the selected double frequency impulses, and the slotted vertical synchronizing impulses are added together and transmitted with the picture signal to the receiver. As explained in the Bedford application referred to, by transmitting synchronizing impulses of the character described a picture is produced which is always properly interlaced.

Where an impulse must be delayed, as mentioned above, the delay is preferably obtained by passing it through what will be referred to as an integrating circuit and then clipping the resulting electrical impulse successively. Where it is desired to narrow an impulse, it is passed through what will be referred to as a differentiating circuit and then the resulting impulse is clipped successively.

Other objects, features and advantages of my invention will appear from the following description taken in connection with the accompanying drawings, in which

Figure 1 is a diagram illustrating a television transmitter to which my invention is applied;

Fig. 2 is a circuit diagram of an amplifier shown in Fig. 1;

Figs. 3 and 4 are a circuit diagram of the impulse generator shown in Fig. 1, the diagram to be read with the two sheets of drawings placed end to end;

Figs. 5 to 19 are curves which are referred to in explaining my invention;

Fig. 20 is a curve showing certain characteristics of a peak clipper tube utilized in my impulse generator; and

Figs. 21a to 21g are curves which are referred to in explaining the operation of my impulse delay circuits and my impulse narrowing circuits.

Referring to Fig. 1, the television transmitter which is illustrated is of the type disclosed in the above-mentioned Bedford application and includes a cathode ray transmitter tube 1 consisting of an evacuated envelope 2 having therein an electron gun and a mosaic 3 of light sensitive elements. The cathode 4, the control electrode 6 and the first anode 7, which form the electron gun, are supplied with suitable potentials through leads which are connected to the voltage divider 8 of a power supply unit 9. As indicated, the power supply unit 9 is preferably supplied with power from a 60 cycle line 11.

A second anode 12 is included in the tube 1, this electrode being connected to ground and functioning both to focus and to accelerate the electron beam and to collect photoelectrons which are released from the light sensitive mosaic 3. The mosaic 3 is of a well known type comprising a great number of minute light-sensitive elements which are electrically insulated from each other and from a metallic back plate or signal plate upon which they are supported. Vertical deflecting coils 13 and horizontal deflecting plates 14 are provided for causing the electron beam to scan the mosaic 3 whereby picture signals flow through an output resistor 16 in accordance with conditions of light and shade on the mosaic.

The impulses for controlling the vertical and horizontal scanning are produced by an impulse generator 17, the circuit diagram of which is shown in Figs. 3 and 4. In the specific transmitter being described, the impulse generator supplies impulses occurring at the rate of 60 per second to a vertical deflecting circuit 18 which causes saw-tooth current impulses to flow through the deflecting coils 13 at this same rate. The impulse generator 17 also supplies impulses occurring at the rate of 10,290 per second to a horizontal deflecting circuit 19 which supplies saw-tooth voltage impulses occurring at this same frequency to the deflecting plates 14.

The impulse generator 17 is connected to the 60 cycle line 11 through conductors 21 for the purpose of keeping the impulse generator in synchronism with 60 cycle supply as described in my copending application, Serial No. 748,773, filed October 18, 1934, and assigned to the same assignee as this application.

The picture signals which appear across the output resistor 16 of the transmitter tube 1 are supplied to an amplifier 22 and then to an amplifier 23, shown in detail in Fig. 2, in which blanking impulses are mixed with the picture signals. These blanking impulses are supplied from the impulse generator 17 through a conductor 20 and a resistor 25 for a purpose which will be understood by referring to Fig. 2.

As shown in Fig. 2, the amplifier 23 comprises four resistance coupled amplifier tubes 24, 26, 27 and 28. The picture signals which are impressed upon the amplifier tube 26 have the general character indicated by the curve 29. The signals of comparatively large amplitude, indicated by the peaks 29a, are transient which occur at the end of each scanning line. The picture signals 29 and the blanking impulses 31 are added together in the input circuit of the amplifier tube 27 so that they appear in the input circuit of the amplifier tube 28 with the wave shape shown by the curve 32.

The bias on the grid of the tube 28 is such that the lower portion of the curve 32 is clipped off at a point indicated by the dotted line 33 and the resulting output has the characteristic shown by the curve 34. To this output are added synchronizing impulses which are transmitted with the picture signal for the purpose of maintaining the scanning at the receiver in synchronism with the scanning at the transmitter.

The synchronizing impulses, also, are supplied by the impulse generator 17 and it is the method of and means for generating these synchronizing impulses that constitute the main part of my invention.

Referring to Figs. 3 and 4, the impulse generator comprises a chain of multivibrators which is described and claimed in my above-mentioned copending application. The main unit 36 (Fig. 4) of this multivibrator chain generates impulses occurring at the rate of 20,580 cycles per second and this main multivibrator is coupled to a similar multivibrator 37 adjusted to oscillate at a frequency such that it locks in to produce impulses occurring at one half the frequency of the main oscillator output, that is at the rate of 10,290 per second.

The main multivibrator 36 is also coupled to a multivibrator chain indicated by the block 38 in Fig. 3 which divides the frequency of 20,580 by small odd numbers to produce impulses which occur at the rate of 60 cycles per second. The 60 cycle impulses are indicated by the curve 39, this curve being drawn mainly to indicate the width of the impulses and their general shape. Attention is called in particular to the fact that the impulses would not occur as close together as indicated on the drawings. In all curves shown in Figs. 3 and 4, the voltage is indicated by a legend and not by the relative amplitudes of the curves. The relative widths of impulses, however, is substantially as shown by the curves.

The 60 cycle impulses are supplied through a coupling condenser 41 to the input circuit of an electric discharge tube 42 which is so adjusted that the lower part of each impulse is clipped off as shown by the dotted line 43 marked "clipping level". The impulse which appears in the output circuit of the tube 42 is indicated by the curve 44. This impulse is next impressed upon the input circuit of a second tube 46 through resistance coupling and the impulse is clipped a second time at a point indicated by the dotted line 47. The resulting impulse, which appears in the output circuit of the tube 46, is indicated by the curve 48.

The tubes 42 and 46 and all the tubes which will be referred to hereinafter are preferably one triode section of a tube of the 79 type, this type of tube being designed to operate with zero bias and having a sharp cut-off point. Utilizing these tubes, an impulse may be clipped a few volts below the alternating current zero axis or the impulse may be clipped above the alternating current axis if the constants of the input circuit are properly selected. More specifically, positive impulses of comparatively large amplitude will cause a flow of grid current which will apply a negative bias to the grid. If the grid resistor is given a high resistance value this bias will hold over between positive impulses so that the tube will be operating with a substantially steady negative bias on its grid.

The resistors 49 and 51, through which voltage is supplied to the plates of tubes 42 and 46, respectively, and the condensers 52 and 53 are the usual filter elements for preventing ripple voltages from reaching the said plates. Similar filter elements are shown for the other tubes in the impulse generator, and all filter elements have the same values of resistance and capacity. The various resistance and capacity values are indicated on the drawings in ohms, microfarads, and megohms.

The impulse appearing in the output of the tube 46 is supplied to two resistance coupled tubes 54 and 56 which again clip the impulse in the manner described above to produce a square-topped impulse which has substantially perpendicular sides and no rounded corners as indicated by the curve 57. This impulse is utilized for selecting double frequency impulses as will be described later. It will be noted that the grid resistor of tube 54 has been given a comparatively high value so that tube 54 clips at a higher level than tube 56.

The impulse occurring in the output of the tube 46 is also impressed upon clipping tubes 58 and 59. The tube 58 inverts the impulse and squares it up as indicated by the curve 61 so that it may be used for "slotting" the 10,290 cycle impulses as will be described later.

The tube 59 also inverts the impulse and squares it up to produce an impulse like that shown at 61 for use as a blanking impulse. This blanking impulse is added to blanking impulses occurring at the rate of 10,290 per second as will be described later.

It will be noted that the impulses produced thus far have not been changed in phase or in width. For reasons which will appear later, the vertical synchronizing impulses, that is, the beginning of the impulses, must occur at a later time than the other 60 cycle impulses and they must be narrower.

In order to produce such a vertical synchronizing impulse, the impulse appearing in the output of the tube 42 is supplied through a conductor 62 and a coupling condenser 63 to what may be described as an integrating circuit. The integrating circuit comprises a condenser 64 which is shunted by a grid biasing resistor 65 having a high resistance value and which is supplied with signal through a resistor 66 which also has a high resistance value. The condenser 64 is coupled across the input electrodes of an electric discharge tube 67 which, like the tubes previously described, is adjusted to function as a clipping tube.

The impulse which is impressed upon the integrating circuit is indicated by the curve 68. The integrating circuit distorts the wave form of the impulse to produce an impulse of the character indicated by the curve 69. This distorted wave form is due to the fact that it takes a certain period for the comparatively large capacity condenser 64 to charge up through the high resistance unit 66. Or, putting it in a different way, the distortion is due to the loss or high frequency components from the rectangular impulse. The tube 67 clips the distorted impulse at a point indicated by the dotted line whereby an impulse of the character indicated at 71 appears in the output circuit of the tube. The tube 67 is resistance coupled to a second tube 72 which acts as a peak clipper. The tube 72 clips the impulse 71 as indicated by the dotted line to produce the impulse indicated at 73.

With a given distorted wave form, the clipping level in the second clipping stage determines the time at which the impulse 73 begins. This will be better understood by referring to Figs 21*a* to 21*d*. It will be seen that the integrating circuit acts to give the leading edge of the impulse 69 a slope as indicated in Fig. 21*b*. The impulse shown in Fig. 21*b* is squared up to a certain amount by the first clipping action to give the impulse 71 shown in Fig. 21*c*. It is evident from Fig. 21*d* that, with a given wave distortion by the integrating circuit, the clipping level of the second clipping tube determines how much the impulse 73 will be delayed with respect to the original impulse. The delay may be increased or decreased by adjusting the relative values of the integrating condenser and resistor through which signal is fed to the condenser.

It should be understood that, in place of the specific integrating circuit illustrated, other circuits may be employed for giving the first occurring edge of an electric impulse the necessary slope. For example, the condenser 64 may be omitted and the resistor 66 replaced by an inductor to cause the loss of high frequency components. The circuit illustrated is preferred, however, as it has no resonant points such as are found in a circuit containing inductance.

Referring again to Fig. 3, the delayed impulse 73 must now be narrowed and this is accomplished by impressing it upon a clipping tube 74 through what will be described as a differentiating circuit. This circuit comprises a coupling condenser 76 having a very small capacity and a resistor 77 having comparatively low resistance connected across the input electrodes of the tube 74. Since only the high frequency components of an impulse can pass through this differentiating circuit, the signal appearing across the resistor 77 has a wave form shown by the curve 78. The negative impulse of this signal is clipped as indicated by the dotted line so that the signal appearing in the output circuit of the tube 74 has the character indicated by the curve 79. The next tube 81 clips the signal impulse 79 at the level indicated by the dotted line whereby a narrowed and delayed 60 cycle impulse appears in the output circuit of the tube 81, this impulse being indicated at 82.

The way in which the delayed impulse 73 is narrowed is shown more clearly by the curves in Figs. 21*e* to 21*g*. It will be seen that the first occurring edge of the delayed impulse 73 produces a narrowed negative impulse indicated at 78*a* in the differentiating circuit and that this negative impulse is the one which is utilized, after being passed through two clipping stages, as the delayed and narrowed vertical synchronizing impulse 82. The amount the delayed impulse is norrowed may be varied by changing in the differentiating circuit the ratio of the coupling condenser capacity to the grid resistor resistance.

In place of the specific circuit illustrated, other circuits may be employed for permitting only high frequency components of the impulse 73 to be impressed upon the tube 74. For instance, the coupling condenser may be given a much larger capacity and the grid resistor 77 replaced by an inductance coil which has a low impedance to low frequency components. When utilizing such a circuit, care must be taken to avoid resonant effects.

From the preceding description and from an inspection of Fig. 21*e*, it will be apparent that in some cases the desired delay and narrowing of an impulse may be obtained by utilizing the positive or second occurring impulse 78*b*. It will be noted that the positive impulse 78b starts at the second occurring or lagging edge of the impulse which is fed into the differentiating circuit. Therefore, when utilizing the positive impuse, the amount of delay is determined by the time at which the second edge of the impulse, such as impulse 73, occurs.

Where the original impulse, such as impulse 68, is not of the proper width to give the delay desired, the impulse may be distorted and the clipping of the distorted wave done at the proper point on the second occurring or lagging sloped edge. In that case, the amount of delay is determined by the first clipping as will be evident by comparing Figs. 21b, 21c, 21d and 21e. The manner in which clipping circuits may be adjusted for clipping off the negative impulse instead of the positive impulse will be obvious to those skilled in the art in view of the preceding explanations and in view of the description of the clipping circuits given hereinafter.

The delayed and narrowed impulse 82 is passed through two more clipping tubes 83 and 84 in order to obtain a more perfectly rectangular wave, the resulting impulse being indicated at 86. This impulse is the one which is supplied to the vertical deflecting circuit 18 shown in Fig. 1.

The vertical synchronizing impulse which is supplied for transmission to the television receiver is slotted for reasons which will hereinafter appear, this slotting being done in the branch of the circuit including tubes 87 and 88 which are resistance coupled. The impulse 82 appearing in the output circuit of the tube 81 is impressed through a coupling condenser 89 upon the tube 87 which is adjusted to clip the impulse in order to make it square-topped, as indicated at 91.

The slotting of the impulse 91 is accomplished by mixing negative double frequency impulses with it in the output of the tube 87 to produce a signal having the wave form indicated by the curve 92. This signal is then clipped by the next tube 88 at the level indicated whereby the slotted vertical synchronizing impulse indicated at 93 appears in the output circuit of the tube 88.

The way in which double frequency impulses of the proper width and phase for slotting are produced will be described in connection with the other portion of the impulse generator circuit shown in Fig. 4.

It will be noted that the signal indicated at 92 is clipped at a point well above the alternating current axis. In order to raise the clipping level to the desired point the grid resistor of the tube 88 was given the high resistance value of 5 megohms. As a result, the tube is caused to clip with a comparatively high negative bias on its grid.

This clipping action will be better understood by referring to Fig. 20 in which the characteristic curve of a 79 tube is shown at 94. The signal 92 is to be clipped at a point above its alternating current axis as indicated. It will be seen that the signal is clipped at the desired level by making the negative bias on the grid sufficiently high, the value being indicated on the drawings as the "grid leak bias." With a given value of grid condenser, the negative bias on the control grid is increased by increasing the resistance of the grid resistor. For the most part, it is the ratio of the grid or coupling condenser capacity to the resistance of the grid resistor that determines the clipping level.

The clipping level of a given tube is determined to a certain extent, also, by the value of the plate resistor of the preceding tube since by increasing the value of this plate resistor the magnitude of the positive impulses applied to the grid of the clipping tube may be increased. This means that, unless grid current saturation is reached, the charge on the grid condenser is increased with an increase in the plate resistance whereby, at the end of a positive impulse, a larger biasing current is discharged through the grid resistor to increase the negative bias on the clipping tube.

Particular attention is called to the fact that the time constant of the circuit including the grid condenser and grid resistor of a clipping tube is great enough to hold over the charge of the grid condenser between successive 60 cycle or other positive impulses if the tube is to clip above the alternating current axis.

Referring now to the portion of the circuit shown in Fig. 4 in which the 10,290 cycle impulses and the double frequency or 20,580 cycle impulses are generated, it should first be noted that the 10,290 cycle impulses are delayed slightly with respect to the double frequency impulses supplied from the main multivibrator 36. The phase relation of the two groups of impulses will be seen by referring to Figs. 5 and 6. The amount which the 10,290 cycle impulses are delayed may be varied by adjusting the grid resistor 96 in the 10,290 cycle multivibrator. This delay appears to be inherent in a multivibrator chain and, as will be apparent from the following description, the delay is useful rather than objectionable in slotting and combining impulses.

The 10,290 cycle impulses indicated at 95 are supplied through a coupling condenser 97 to a clipping tube 98 which clips the impulses as indicated at 99. These impulses are again clipped in a second tube 101 whereby substantially rectangular impulses shown at 102 appear in the output circuit of the tube 101. These impulses are utilized without change in width or phase for blanking, but before being utilized as blanking impulses they are further squared up by sending them through two additional clipping tubes 103 and 104 whereby almost perfectly rectangular impulses appear in the output circuit of the tube as indicated at 106.

These blanking impulses are supplied over the conductor 107 to the output circuit of the clipping tube 59 shown in Fig. 3 where they are added to the 60 cycle blanking impulse to produce the combined 60 cycle and 10,290 blanking impulses indicated at 31. The phase relation of 60 cycle blanking impulse and the 10,290 cycle blanking impulses will be seen by comparing Figs. 6 and 7. The combined blanking impulses are indicated in Fig. 16, the break in the curve indicating that the 60 cycle blanking impulse lasts for the duration of twenty-four 10,290 impulses.

The 10,290 cycle impulses appearing in the output circuit of the clipping tube 101 are also supplied through a differentiating circuit to the input terminals of a clipping tube 109, the differentiating circuit consisting of a small capacity coupling condenser 111 and a resistor 112 of comparatively low resistance value which is connected across the input terminals of the tube, the differentiating circuit functions to narrow the impulses in the manner previously described in connection with Fig. 3. The signal impressed upon the input electrodes of the clipping tube 109 has the wave form indicated at 113 and is clipped by this tube at the level indicated. The signal which appears in the output circuit of the tube

109 is indicated at 114 and this signal is clipped by the next tube 116 at the level indicated by the dotted line. As a result, narrow 10,290 cycle impulses appear in the output circuit of the clipping tube 116 as indicated at 117, these impulses being the ones which are supplied to the horizontal deflecting circuit 19 shown in Fig. 1.

I shall now describe the part of the circuit which generates the horizontal synchronizing impulses and the double frequency impulses which are transmitted to the television receiver. These are the impulses which are combined with the slotted vertical synchronizing impulses which have been described in connection with Fig. 3.

It may aid in understanding the operation of the circuit to first note the character of the synchronizing signal which is desired. This signal, which is indicated at 118 at the right hand side of Fig. 4 and in Fig. 15, consists of the 10,290 cycle impulses and a group of 20,580 cycle impulses which have been so combined with the slotted 60 cycle impulse that two of the double frequency impulses fit into the two slots which have been cut in the 60 cycle impulse. A synchronizing signal of this character is desired in order to obtain good interlacing as is explained in the above-mentioned Bedford application.

To produce the desired 10,290 cycle impulses, a portion of the signal which appears across the resistor 112 in the differentiating circuit is supplied through a conductor 119 to a clipping tube 121. The signal which appears in the output circuit of this tube is the same as the signal indicated at 114.

Since it is desired to substitute double frequency impulses for a portion of the 10,290 cycle impulses, the negative 60 cycle impulse 61 supplied by the tube 58 in Fig. 3 is transmitted through a conductor 122 to the output circuit of the tube 121 where it is added to the 10,290 cycle impulses to produce a signal of the character indicated at 123. This signal is impressed upon a second clipping tube 124 which clips a signal at the level indicated whereby 10,290 cycle impulses are produced which have a "slot" therein in which a group of double frequency impulses may be inserted. These "slotted" 10,290 impulses are indicated at 126 in Fig. 4 and in Fig. 10.

Referring now to the portion of the circuit in which the group of double frequency impulses is produced for insertion in the "slot" in the 10,290 cycle impulses, double frequency impulses of the character indicated at 127 are supplied from the 20,580 cycle multivibrator 36 through the conductor 128 and coupling condenser 129 to an integrating circuit for the purpose of delaying the impulses. The integrating circuit is similar to the one described in connection with Fig. 3 and comprises a resistor 131 of high resistance value through which the signal is fed to a condenser 132 of comparatively large capacity which is shunted across the input electrodes of a clipping tube 133. Also, a grid bias resistor 134 is connected in shunt to the condenser 132.

The signal appearing across the condenser 132 has the character indicated by the curve 136. This signal is clipped by the tube 133 at the level indicated to produce the signal indicated at 137 and this signal is clipped, at the level indicated, by a second clipping tube 138 to produce delayed rectangular impulses as indicated at 139. The method by which these impulses are delayed is identical with the method previously described. The amount that the double frequency impulses are delayed may be seen by reference to Fig. 8. It will be noted that they have been delayed sufficiently to make them start at exactly the same time as the 10,290 cycle impulses.

The delayed impulses 139 are next narrowed to the same width as the narrowed 10,290 cycle impulses. They are narrowed by impressing them upon a differentiating circuit comprising a small capacity coupling condenser 141 and a grid resistor 142 of low resistance value. The signal appearing across the resistor 142 has the same wave shape as shown by the curve 113 for the 10,290 cycle impulses and, after being clipped by a clipping tube 143, it has substantially the same wave shape as indicated by the curve 114 for the 10,290 cycle impulses.

In order to select the desired group of double frequency impulses for insertion in the "slot" in the 10,290 cycle impulses, the positive 60 cycle impulse 57 appearing in the output circuit of the tube 56 shown in Fig. 3 is transmitted over a conductor 144 to the output circuit of the tube 143 where the 60 cycle impulses are added to the double frequency impulses to produce a signal of the character indicated at 146. This signal is then impressed upon another clipping tube 147 which clips the signal at the level indicated. Since only the signals which have been raised up by the 60 cycle impulse pass through the clipping tube 147, the signal occurring in the output circuit of that tube is a group of double frequency impulses as indicated at 148, and as shown in Fig. 9. Fig. 9 also shows the amount that the double frequency impulses are narrowed by the differentiating circuit.

Considering now the production of the double frequency negative impulses which cut the slots in the 60 cycle vertical synchronizing impulse, it will be seen that double frequency impulses from the main multivibrator 36 are also supplied through a coupling condenser 149 to another integrating circuit which comprises a series resistor 151 and a condenser 152 connected across the input terminals of a clipping tube 153. A grid biasing resistor 154 is connected across the condenser 152. This integrating circuit, the clipping tube 153 and a second clipping tube 156 function in the same way as circuits previously described to produce rectangular slotting impulses indicated at 157 which are delayed, but these slotting impulses are delayed less than the double frequency impulses which are passed through the integrating circuit comprising elements 131 and 132. Also, it will be noted that the slotting impulses 157 are not narrowed.

The slotting impulses 157 are transmitted over a conductor 158 to the output circuit of the tube 87 shown in Fig. 3 where they are added to the 60 cycle vertical synchronizing impulse 91 to produce the signal indicated at 92. This signal is then clipped, at the level indicated, by the tube 88 as previously described to produce the slotted vertical synchronizing impulse 93.

The amount that the slotting impulses 157 are delayed will be seen by referring to Fig. 12. The width and phase of the unslotted 60 cycle vertical synchronizing impulse are indicated in Fig. 13. When this unslotted 60 cycle impulse is given a positive polarity and added to the negative slotting impulses and clipped, as previously described, the slotted vertical synchronizing impulse 93 shown in Fig. 14 is obtained.

The "slotted" 10,290 cycle impulses shown in Fig. 10, the selected group of double frequency impulses shown in Fig. 9, and the slotted 60 cycle impulses shown in Fig. 14 are all combined or added in a common plate resistor 159 (Fig. 4), the potential for tubes 124, 147 and 88 being supplied through the plate resistor 159 and the conductors 161, 162 and 163. The combined impulses, which are indicated in Fig. 15, are then amplified by the two resistance coupled amplifier tubes 164 and 166 and the final synchronizing output 118 is supplied (as shown in Figs. 1 and 2) to the output circuit of the picture signal amplifier 23 where the synchronizing impulses and the picture signals are combined, impressed upon a transmitter 167, and transmitted to the receiver.

While the horizontal synchronizing impulses, the double frequency impulses and the "slotted" vertical synchronizing impulses are combined at the same time in the common plate resistor 159, for the purpose of explanation, the horizontal synchronizing impulses and the double frequency impulses are shown combined without the "slotted" 60 cycle impulse in Fig. 11. It will be apparent by comparing Fig. 11 and Fig. 14 that the phase delays and the widths of impulses have been so selected that certain double frequency impulses fall in the middle of the slots in the 60 cycle impulses, as shown in Fig. 15.

It may be noted that since the vertical deflecting frequency of 60 cycles per second goes into the horizontal deflecting frequency of 10,290 cycles per second 171½ times, the phase of the 10,290 cycle impulses with respect to the 60 cycle impulses will be different for alternate vertical deflecting impulses. This is indicated in Fig. 6 where the phase of the horizontal deflecting impulses for one deflection is shown by the solid line curve, while the phase of these impulses for the next deflection is shown by the dotted line curve. The curves shown in the other figures are, of course, for the deflection represented by the solid line curve in Fig. 6.

Considering now the manner in which the synchronizing impulses 118 are combined with the picture and blanking signals, the blanking impulses 31, shown in Figs. 2 and 16, are combined with the picture signals 29, shown in Figs. 2 and 17, and impressed upon the input circuit of the amplifier tube 27. They are then clipped by the tube 28 to produce the combined picture and blanking signal 34 shown in Figs. 2 and 18.

The synchronizing impulses shown in Fig. 15 are added to the signal shown in Fig. 18 to produce the final signal output shown in Fig. 19 which is impressed upon the transmitter 167. It will be seen that the narrow synchronizing impulses appear on the top of a "pedestal" which is formed by the clipped blanking impulses.

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 television transmitter for the production of a picture at a certain frame frequency and at a certain scanning line frequency, an electric discharge tube oscillator for producing impulses at double said scanning line frequency, means including a second oscillator for dividing the frequency of said first oscillator output by two to produce impulses occurring at said scanning line frequency, means including a chain of frequency dividers for dividing the frequency of said output to produce impulses at a frame frequency such that the frame frequency goes into the scanning line frequency a whole number of times plus one-half, means for delaying, narrowing and slotting said frame frequency impulses, means for selecting and so delaying and narrowing a group of said double frequency that they fit into said slots, and means for eliminating said scanning line frequency impulses for the duration of said selected double frequency impulses and for combining the remaining scanning line frequency impulses with said selected double frequency impulses and said slotted frame frequency impulses.

2. In a television system for the production of pictures at a certain frame frequency and at a certain scanning line frequency, means including an electric discharge tube oscillator for producing rectangular impulses occurring at said scanning line frequency, means including an electric discharge tube oscillator for producing rectangular impulses occurring at a frequency which is a multiple of said scanning line frequency, means for narrowing said scanning line impulses and said multiple frequency impulses to the same width, and means for so shifting the phase of one of said groups of impulses that certain of said multiple frequency impulses begin at the same time as the scanning line impulses.

3. In a television system for the production of pictures at a certain frame frequency and at a certain scanning line frequency, means including an electric discharge tube oscillator for producing rectangular impulses occurring at said frame frequency, means including an electric discharge tube oscillator for producing rectangular impulses occurring at a frequency which is a multiple of said scanning line frequency, means for so combining and clipping said frame frequency impulses and said multiple frequency impulses that said frame frequency impulses have slots cut therein which have a width equal to the width of said multiple frequency impulses, means for deriving from said multiple frequency impulses impulses which are narrowed and delayed sufficiently to fit into said slots, and means for combining said last impulses with said slotted impulses.

4. In a system for generating control impulses for the production of pictures at a certain frame frequency and at a certain scanning line frequency, means for producing wide rectangular impulses occurring at said frame frequency, means for producing narrow rectangular impulses occurring at said scanning line frequency and in a fixed time relation to said wide impulses, means for producing narrow rectangular impulses occurring at a frequency which is a multiple of said scanning line frequency and in a fixed time relation to said wide impulses, means for combining said wide impulses with said scanning line impulses and eliminating a group of said scanning line impulses for the duration of a wide impulse whereby said scanning line impulses are slotted, means for combining said wide impulses with said multiple frequency impulses and selecting a group of multiple frequency impulses lasting for the duration of a wide impulse, and means for combining said slotted scanning line impulses and said group of multiple frequency impulses.

5. The invention according to claim 4 characterized in that the rectangular impulses are produced by electric discharge tube oscillators.

6. The invention according to claim 4 characterized in that means is provided for deriving delayed and narrowed rectangular impulses from said wide impulses, and further characterized in that means is provided for combining said nar-

rowed impulses with said slotted scanning line impulses and said selected multiple frequency impulses.

7. The invention according to claim 4 characterized in that means is provided for deriving from said wide impulses impulses which are so delayed, narrowed, and slotted that, when added to the multiple frequency impulses, the components thereof fit between the multiple frequency impulses, and further characterized in that means is provided for combining said narrowed and slotted impulses with said slotted scanning line impulses and said selected multiple frequency impulses.

8. In a circuit for delaying a rectangular electrical impulse, means for eliminating high frequency components from said impulse whereby it is distorted to give a certain slope to the first occurring edge, and means for so clipping said distorted impulse as to produce a new impulse beginning at a predetermined point on said slope.

9. In a circuit for delaying a rectangular electrical impulse, an integrating circuit, means for passing said impulse through said integrating circuit whereby it is distorted to give a certain slope to the first occurring edge, means for clipping said distorted impulse to produce a square-topped impulse, and means for clipping off the base of said square-topped impulse.

10. In a circuit for delaying a rectangular electrical impulse, means for distorting said impulse to produce a negative impulse having a sloped first occurring edge, means for clipping off the lower part of said impulse and for amplifying the remaining part of said impulse to produce a square-topped impulse, and means for clipping off the lower part of said square-topped impulse and for amplifying the remaining part.

11. The method of delaying a rectangular electrical impulse which comprises removing certain high frequency components therefrom whereby the first occurring edge of said impulse is given a certain slope, clipping said impulse at one point on said slope to obtain an impulse with a square top, and clipping said impulse at another point on said slope, the location of said last point being determined by the amount of delay desired.

12. The method of narrowing an electrical signal of rectangular wave form which comprises removing certain low frequency components therefrom whereby a signal comprising two narrow electrical impulses of opposite polarity is produced, and then clipping the second signal twice, one clipping being such as to remove one of said two impulses from the second signal and the other clipping being such as to give the other of said two impulses a square top.

13. The method of narrowing a rectangular electrical impulse which comprises removing certain low frequency components therefrom whereby two narrow electrical impulses of opposite polarity are produced, clipping one of said two impulses to make it square-topped, and clipping said one impulse a second time to remove the other of said two impulses whereby a single narrowed rectangular impulse is produced.

14. In a circuit for narrowing a rectangular electrical impulse, a differentiating circuit, means for passing said impulse through said differentiating circuit whereby two narrow electrical impulses of opposite polarity are produced, means for clipping one of said two impulses to make it square-topped, and means for clipping said one impulse a second time to remove the other of said two impulses whereby a single narrowed rectangular impulse is produced.

15. In a circuit for clipping electrical impulses occurring at a certain frequency, an electric discharge tube having an output circuit and having an input circuit which includes a grid condenser and a grid resistor, a second electric discharge tube having an input circuit which includes a grid condenser and a grid resistor, said second input circuit being coupled to said output circuit, the relative values of the grid condenser and grid resistor in each input circuit being such that one of said tubes clips said impulses at a substantially higher level with respect to their alternating current axis than does the other of said tubes.

16. The method of producing a slotted rectangular electrical impulse which comprises generating at least one rectangular electrical impulse which is narrower than said first impulse and which is of opposite polarity, adding said impulses whereby said first impulse is slotted, and clipping said slotted impulse near its base.

17. A method according to claim 16 characterized in that said narrower impulse is generated with an amplitude greater than that of the first impulse.

18. The method of producing recurrent groups of electrical impulses which comprises continuously generating at a certain level electrical impulses of the character desired, generating an electrical impulse having a width several times the width of the desired impulses, adding said first impulses and said second impulse to place a group of said first impulses at a different level than the other first-mentioned impulses whereby they are removed from the region of the other first-mentioned impulses, and so clipping said resultant wave that only said group of impulses is obtained.

19. In an electrical system, means for continuously generating electrical impulses recurring at a desired frequency, means for generating blanking impulses each having a duration equal to several of said first impulses and being of the opposite polarity, said blanking impulses occurring at a comparatively low frequency, means for adding said first impulses and said blanking impulses whereby a gap is produced in said first impulses corresponding to the duration of a blanking impulse, and means for so clipping the combined impulses that only the first impulses which occur between blanking impulses remain.

20. The method of delaying and narrowing a rectangular electrical impulse which comprises removing high frequency components therefrom to distort it, clipping said distorted impulse twice to produce a delayed impulse, removing low frequency components from said distorted wave to produced a signal wave including two narrowed impulses of opposite polarity, and clipping said signal wave twice to select one of said narrowed impulses.

21. The method of delaying and narrowing a rectangular electrical impulse which comprises removing high frequency components therefrom to produce a distorted impulse having a sloping first occurring edge, clipping said distorted impulse successively to produce a delayed impulse, removing low frequency components from said delayed impulse to produce a signal including two narrowed impulses of opposite polarity, and clipping said signal successively to select the one of said narrowed impulses which begins at the same time as said delayed impulse.

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