

April 29, 1941.

B. E. SCHNITZER

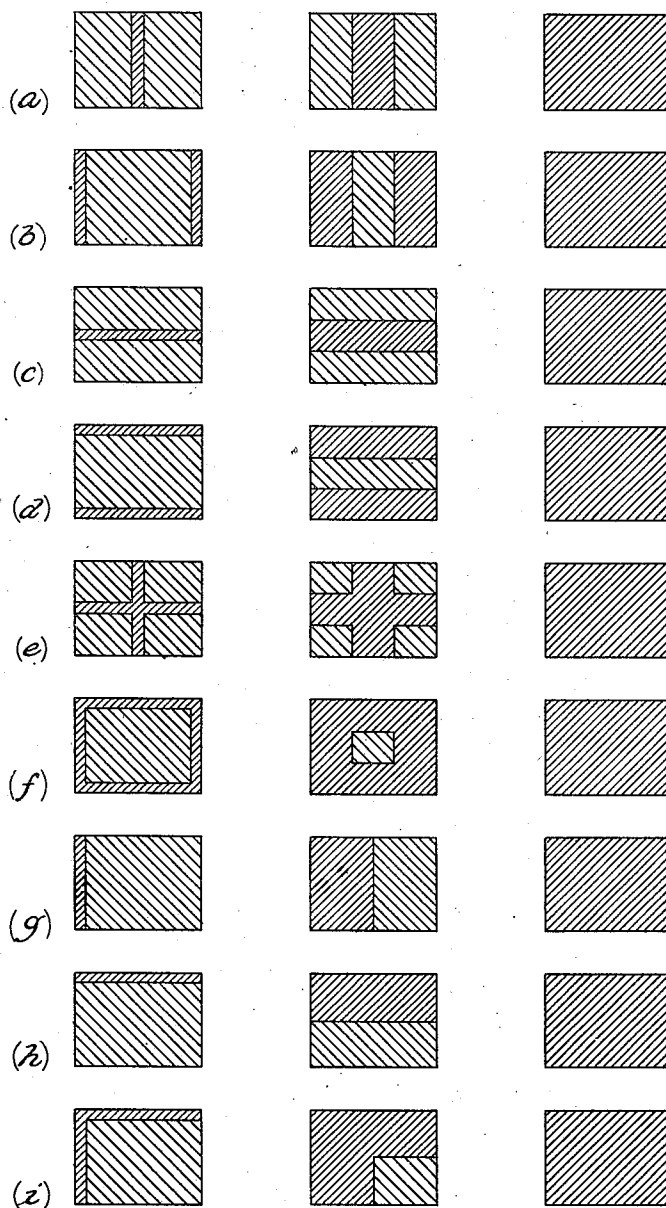
2,240,420

ELECTRICAL SYSTEM

Filed May 11, 1939

9 Sheets-Sheet 1

FIG. 1.



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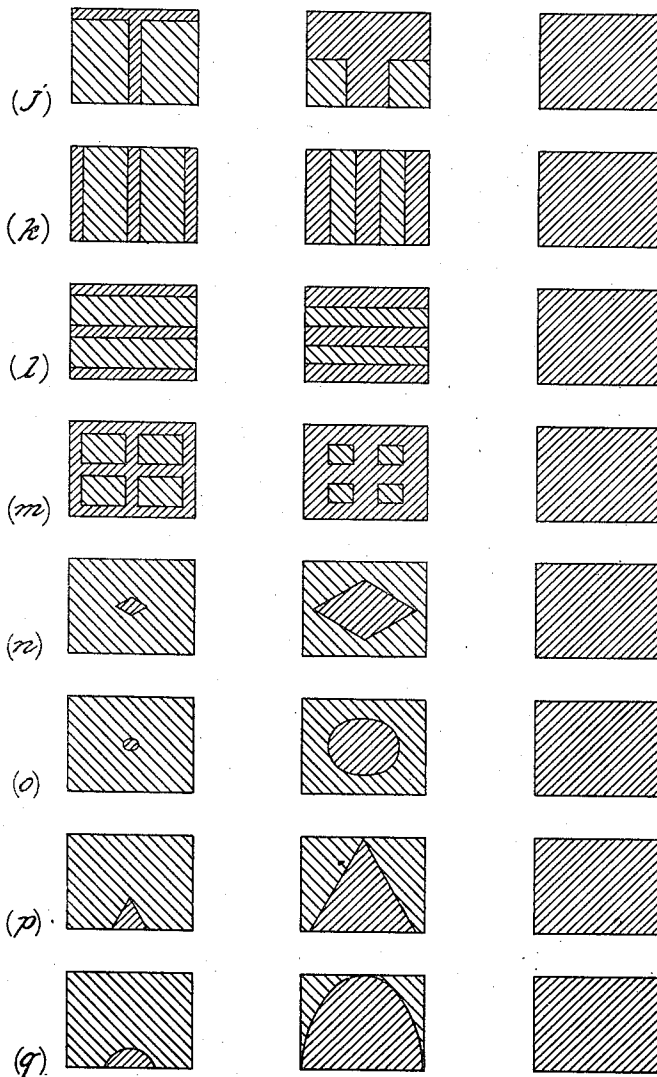
2,240,420

ELECTRICAL SYSTEM

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9 Sheets-Sheet 2

Fig. 1.
(continued)



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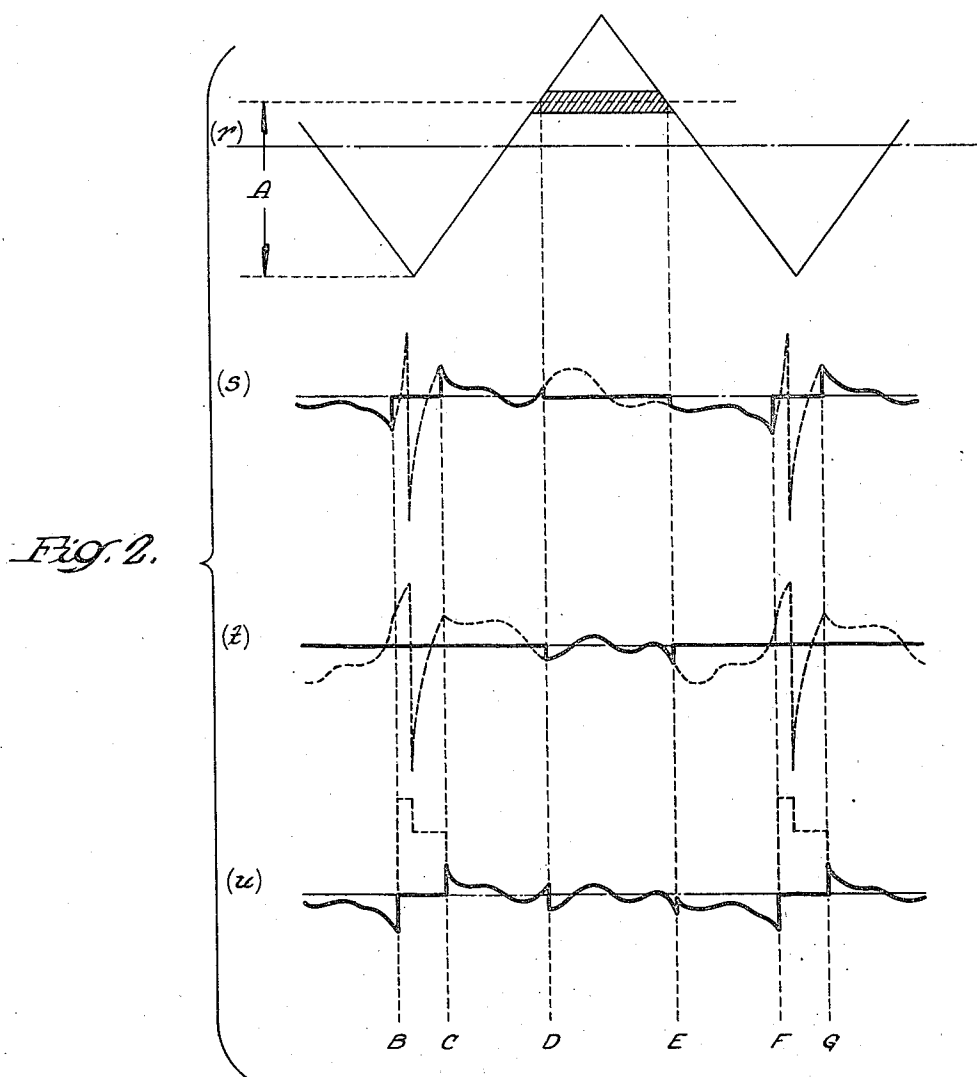
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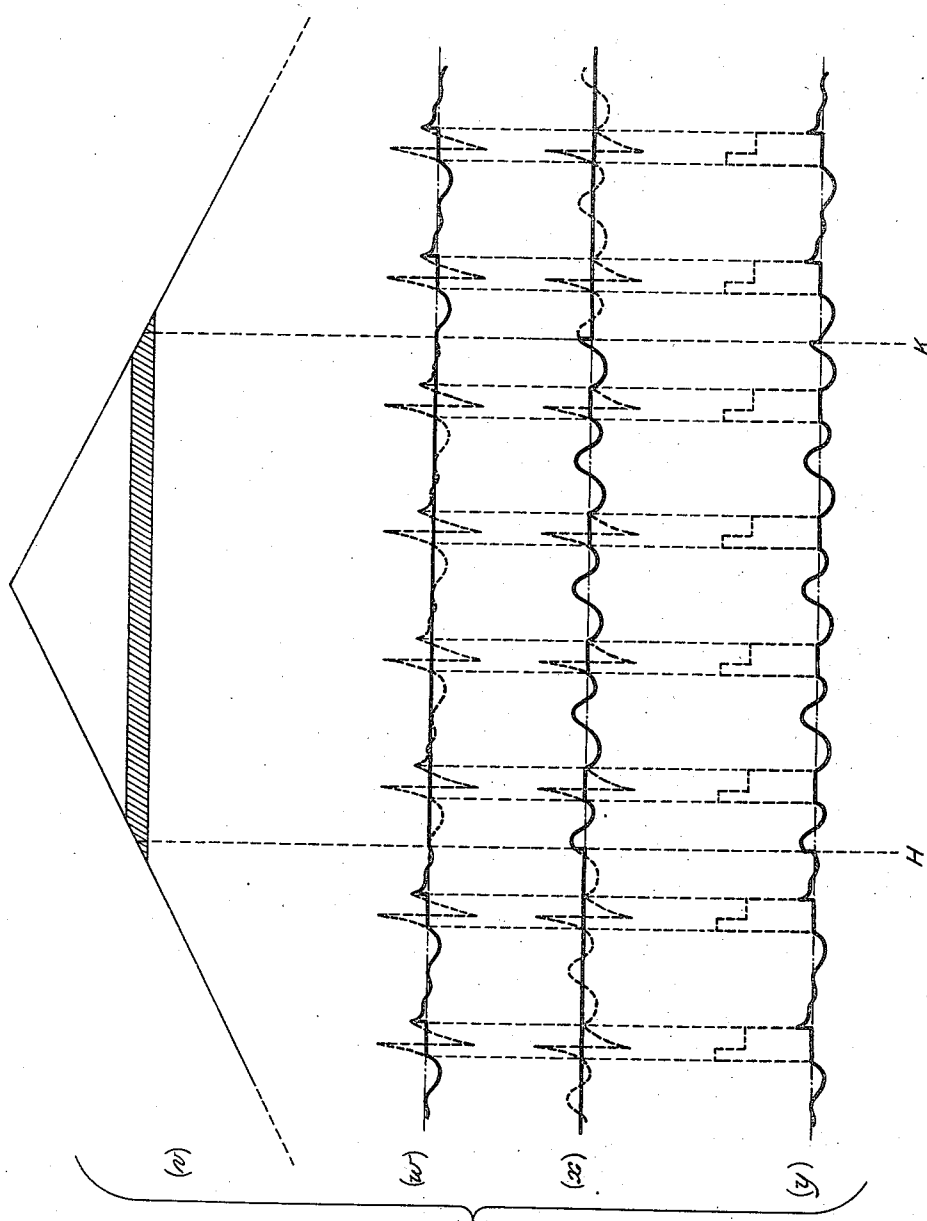


Fig. 3.

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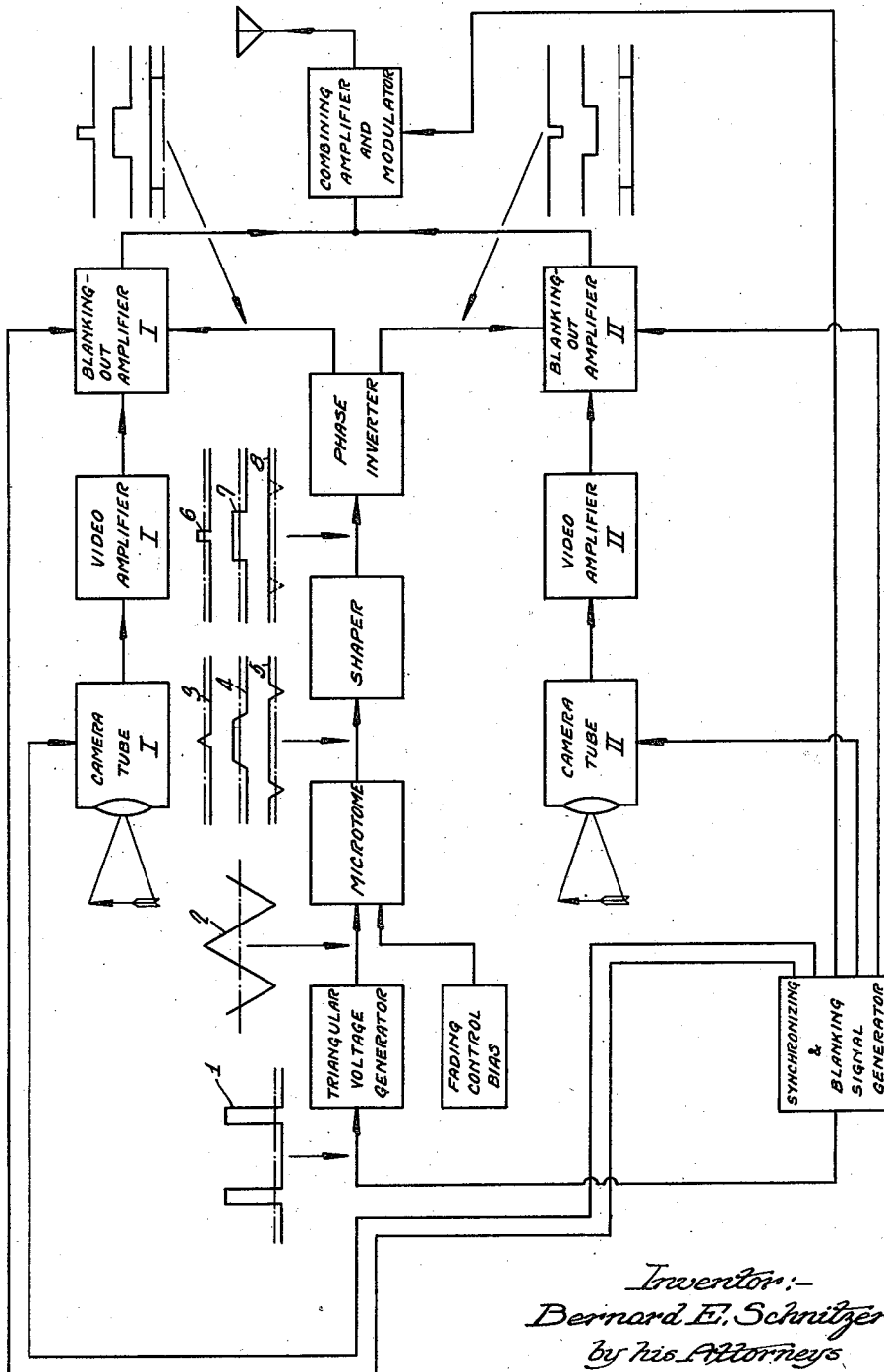
2,240,420

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Fig. 4.



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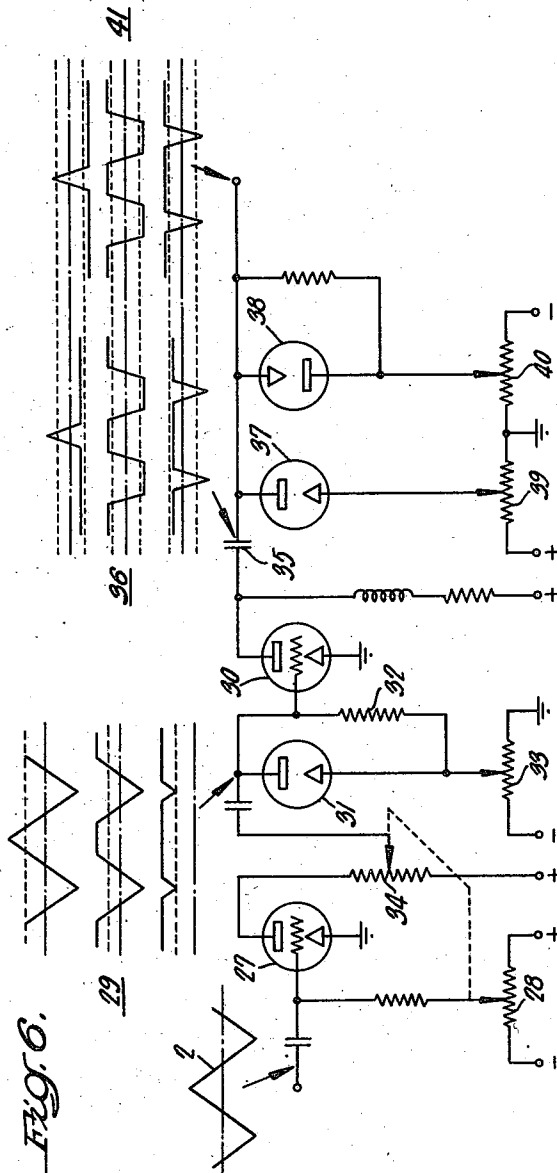
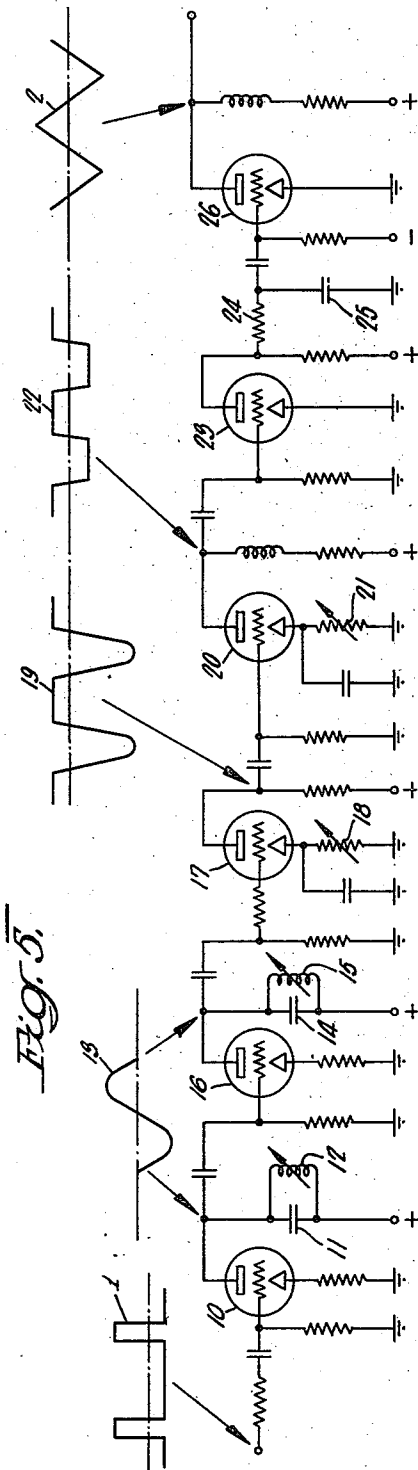
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9 Sheets-Sheet 6



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Fig. 6A.

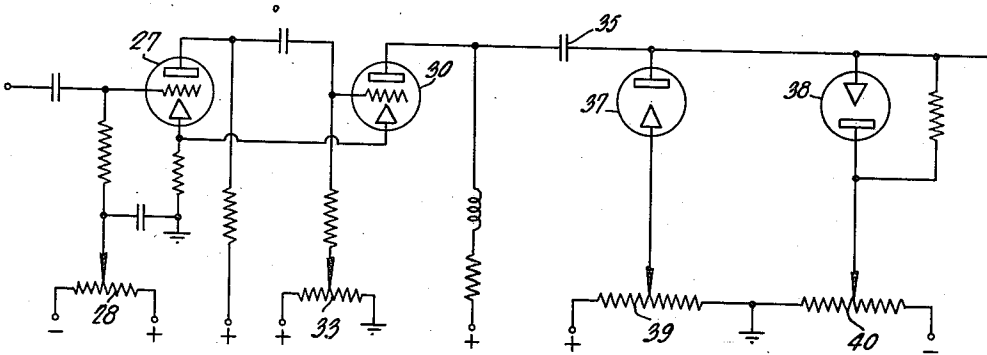


Fig. 7.

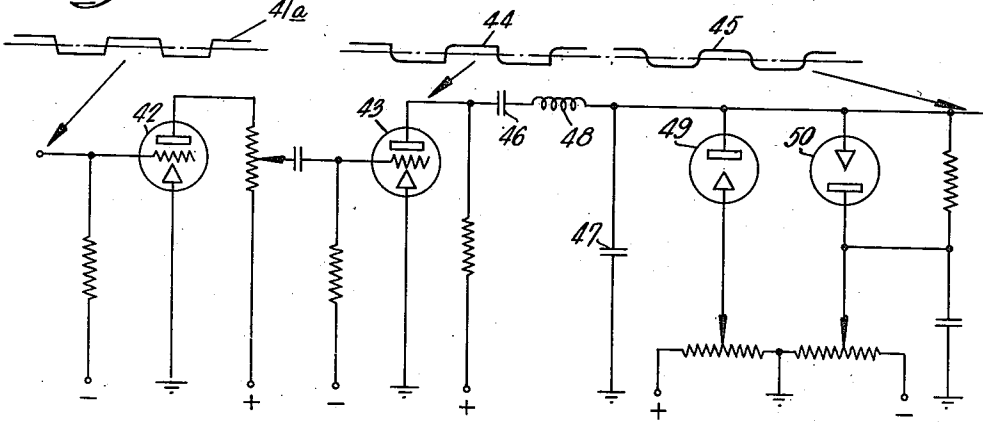
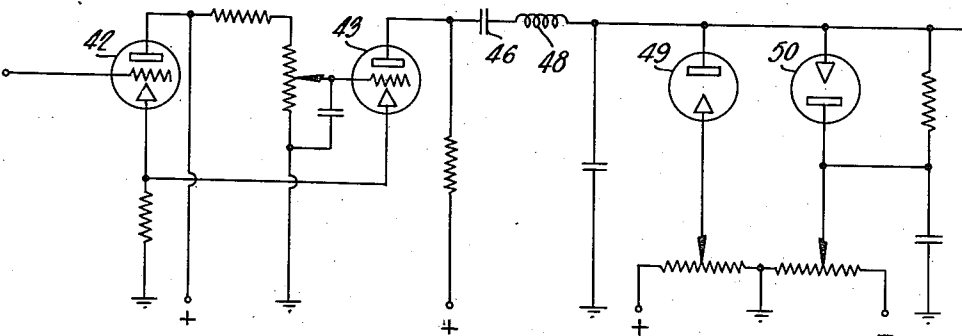


Fig. 7A.



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Fig. 8.

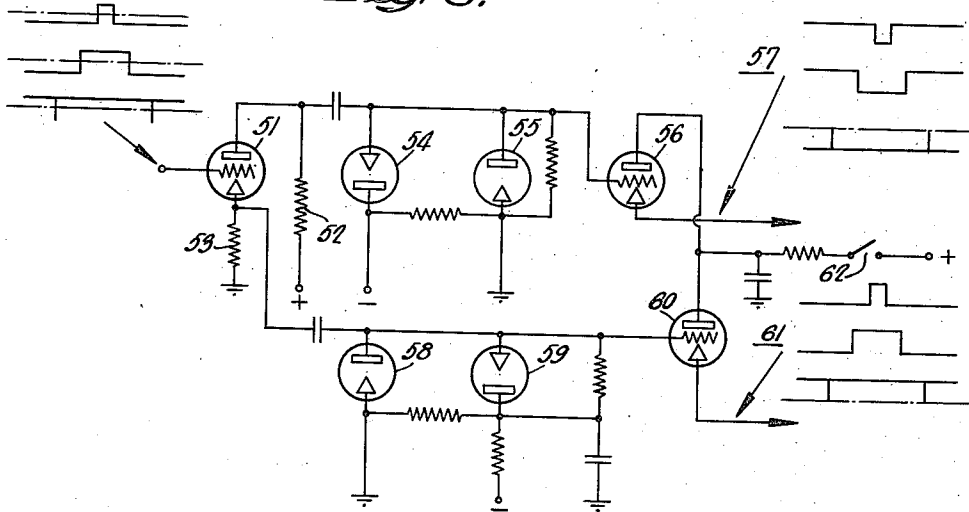


Fig. 9.

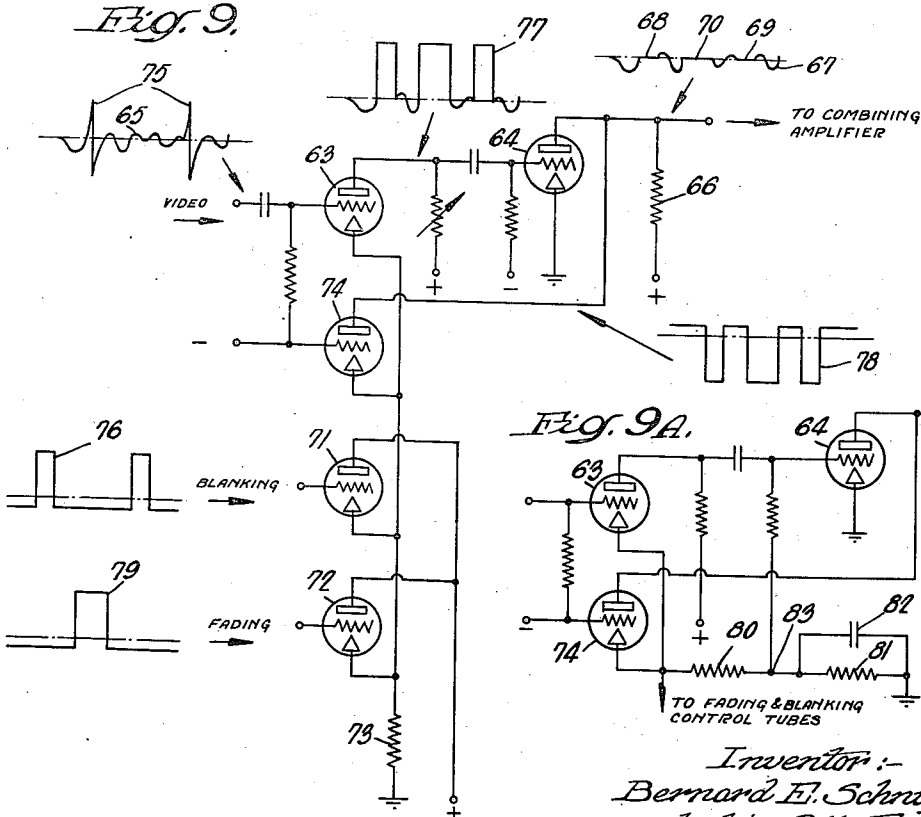
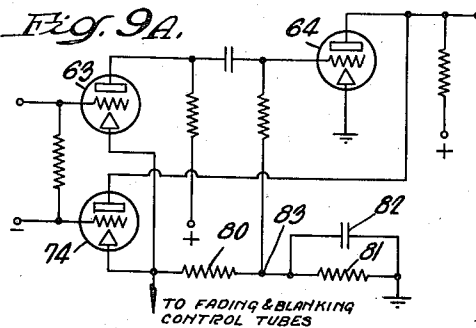


Fig. 9A.



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Fig. 10.

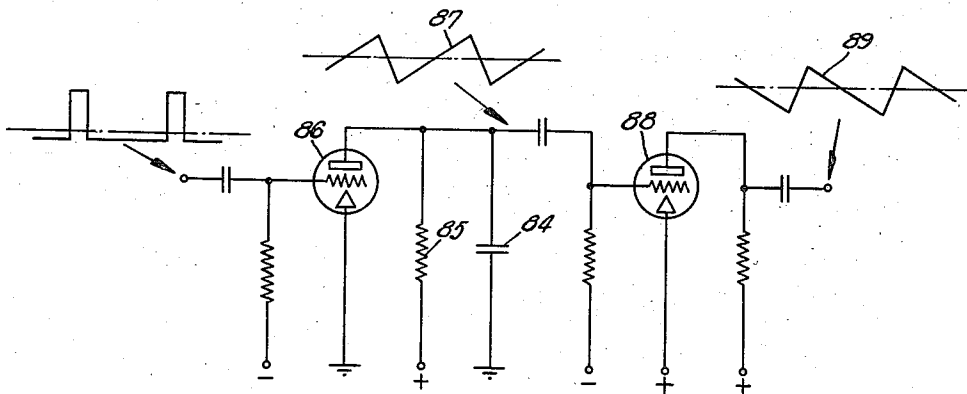


Fig. 11.

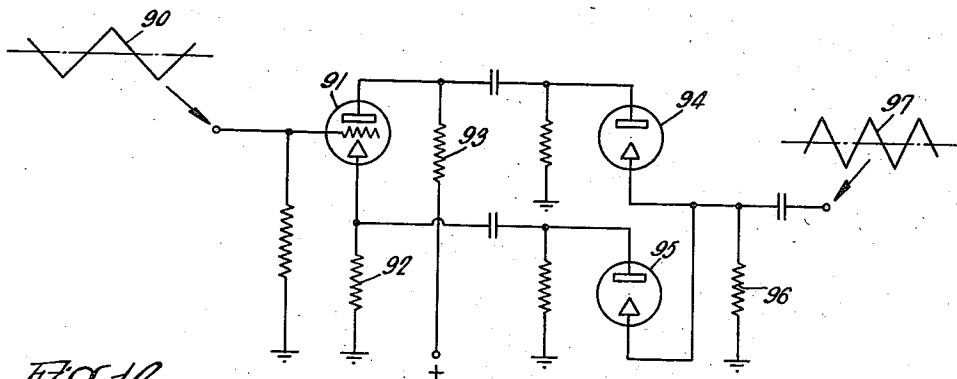
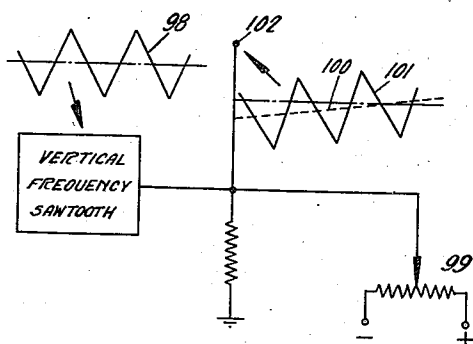


Fig. 12.



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UNITED STATES PATENT OFFICE

2,240,420

ELECTRICAL SYSTEM

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Application May 11, 1939, Serial No. 273,102

15 Claims. (Cl. 178—7.1)

This invention relates to a method of and means for controlling the transfer of signals in an electrical system and to a method of and apparatus for generating signals used in accomplishing this control. The methods and apparatus hereinafter to be disclosed are particularly useful in conjunction with systems used to generate television signals, and specific embodiments will be described as applied to such a system, although this should not be regarded as limiting the scope of the invention.

As is well known in the art, a television signal is generated by causing variations in the amplitude of an electric current or voltage to correspond to the variations in light intensity from point to point on a picture or scene to be televised. The signal thus produced in a manner which is well known is termed the video signal and may be combined with synchronizing and blanking components to produce a complete television signal. This may be transmitted by any convenient means, such as a modulated carrier wave transmission system, to distant points where it may be reconverted to reproduce the original picture or scene.

During the course of such transmission, it is frequently desirable to change the subject of transmission or, in other words, to shift from one scene to another, as is done in the production of an ordinary motion picture. This may be done conveniently by employing a plurality of camera or pick-up tubes, located in different places, which are the means of converting the light variations in the picture into variations in the magnitude of an electrical signal. These various pick-up devices may be connected by suitable signal transfer means to a central location where the television signal is being generated, and the signal obtained from any one of them may be used as the nucleus of the television signal. It will be apparent that by connecting all of the pick-up means to a central point a variety of different scenes are made available for inclusion in the signal to be broadcast, and that it is possible to shift from one scene to another at will.

Of course, it is possible to do this at any time by simply disconnecting one of the pick-up devices and connecting another to the signal combining means. This results in terminating one scene and beginning another at an arbitrary point in the picture depending upon when the switching operation is performed with respect to the time of the beginning of the particular frame or scan. Furthermore, if the switching

is not instantaneous, the video signal will momentarily be reduced to zero. In the case of a system employing negative modulation, where zero signal corresponds to maximum light, this results in the production of a light blotch in some portion of the reproduced picture. Neither of these effects is pleasing to the eye and they tend to reduce the pleasure derived from viewing the picture reproduced by a receiver.

One of the objects of the present invention is to provide novel means for systematically and gradually replacing one video signal by another so that the effect produced upon the receiver screen is a gradual fading of the new scene into the old one in a manner which is entirely pleasing to the eye and free from the above-stated objections.

Another object of the invention is to provide novel means whereby such fading may be achieved automatically and without the need for skill in manually controlling the system.

Still another object of the invention is to provide novel means for generating special signals and wave shapes required in the practice of the invention.

An important feature of the invention is that the system is exceedingly versatile and can readily be adapted to produce fading of one signal into another in a large variety of ways hereinafter to be described.

A further important feature is that it permits of transition from one video signal to another without the introduction into the composite signal of any objectionable extraneous, transient, or switching voltages which might tend to produce undesirable effects in equipment designed to receive the signals.

In general, the mode of operation of the invention is as follows. Where one video signal is being supplied to a combining amplifier in a television signal generator and it is desired to supplant this signal by a new one, the circuits are so arranged that each signal is conducted to the combining amplifier by a separate signal transfer means which may comprise vacuum tube amplifiers and transmission lines or other suitable equipment. Each of these signal transfer means is adapted to be so controllable that the level of signal transferred may be varied within wide limits preferably extending in one direction to complete cut-off and in the other direction to a condition of maximum gain. The transition from one signal to the other is preferably made to take place gradually from frame to frame of the picture. In order to produce

this transition, the transfer means are so controlled that while one is operative to transfer signal the other may be completely blocked. Before the transition has begun, one transfer means will be operative throughout the entire frame and the other will be blocked so that only one video signal is supplied to the combining amplifier. During the following frame the transfer means for the new signal is rendered operative during a small fraction of the frame while the transfer means for the original signal is accordingly rendered inoperative during that portion of the frame. The fraction of each frame during which the new signal is allowed to reach the combining amplifier and the old signal is excluded is gradually increased until the new signal is being supplied during the entire cycle and the old signal is completely excluded. Depending at what part or parts of the old signal corresponding to the scanning of a complete frame the new signal is first introduced, and in what manner it is introduced, various kinds of fading may be obtained.

In order more fully to understand the nature and the mode of operation of the invention, reference may be had to the accompanying drawings, in which:

Fig. 1 illustrates various fading patterns which may be produced, the different patterns being designated *a* to *g* respectively;

Figs. 2 and 3 are graphic illustrations of the method involved;

Fig. 4 is a block diagram showing the general arrangement of the elements in a complete signal combining system operating according to the method of the invention; and

Figs. 5 to 12 are diagrammatic illustrations of various circuits which may be employed in the practice of the invention.

Referring first to Fig. 1, it will be observed that the blocks are so shaded as to indicate the effects produced upon the reproduced picture by various modes of transition from one video signal to another. In the illustrations, the darker shaded portions having shade lines sloping downward toward the left represent that portion of the picture produced by the new signal, while the lighter shaded portions having shade lines sloping downward toward the right represent that portion produced by the old signal. Each illustration comprises three horizontally-spaced patterns. The one on the left represents an initial stage transition, the middle one represents a more advanced stage, and the one on the right represents the final stage in which the old signal is completely replaced by the new one. Thus the new picture may be brought in and the old one faded out in a variety of different ways. For example in illustration *a*, the new picture first exhibits itself as a narrow line in the center of the old picture, which gradually widens toward the sides until the entire screen is occupied by the new picture. In illustration *b*, the new picture first appears as two narrow vertical lines on either side which widen toward the center until the entire screen is covered by the new picture. The manner in which the transition progresses in each case will readily be understood from the illustrations and does not require detailed description at this time. The manner of obtaining fading according to the various patterns illustrated in Fig. 1 will become clear as the description proceeds, and it will be apparent that many other varieties are conceivable within the scope of this invention.

It may be well to observe at this point that the particular fading patterns here shown are those which are most readily obtained when the usual type of scanning is employed, in which the picture is scanned from side to side and in successive lines from top to bottom and may be interlaced in the well-known manner. Were another mode of scanning to be employed, other, but equally satisfactory scanning patterns, might result. Thus, it will be seen that the method of the invention is not restricted to use with only one form of television system, but is broadly applicable regardless of the routine which may be followed in scanning the picture.

Referring now to Fig. 2, *r* illustrates a triangular wave having the same frequency as that of horizontal scanning; *s* is a representation of one video signal; and *t* is a representation of a second video signal to be faded into the first in the manner illustrated in Fig. 1. The signals, as they are generated by the pick-up tubes, are represented by the solid and broken line portions of the curves, while the signals as they are modified at one transition stage in the practice of the invention are represented entirely by the solid line portions.

The resulting signal produced by combining the two modified video waves is shown in solid lines at *u*, and to this signal has been added the broken line representation of the synchronizing and blanking pulses which may later be added to produce the complete television signal. The modification to which the video signal *s* is subjected consists in reducing it during the intervals BC and FG to a level corresponding to its average value. These intervals correspond to the scanning wave return times during which transients occur, which may be caused by the slowing up of the cathode ray beam in the pick-up device. These transients are depicted by the broken line curves occurring in these intervals. Further, according to the method of the invention, the signal is reduced to its average value during the interval DE to permit of the insertion of the other video signal in this interval. The modification of the other signal *t* is substantially the same except that the reduction to average value occurs during the intervals CD and EF instead of during the interval DE. In order to effect the reduction to zero amplitude in the desired manner, the amplifiers through which the two video signals are transferred have their gain reduced to zero during the proper intervals. This is accomplished by means of control signals applied to the respective amplifiers, as described hereinafter.

The control signal is conveniently derived from a voltage wave of triangular form as indicated at *r* by clipping off the upper and lower portions at distances slightly above and below a particular amplitude level *A* to produce a signal corresponding to the shaded area. The mean duration of a signal so derived is dependent upon the amplitude level at which it is derived, as will readily be seen from the figure. By varying the amplitude level, it is possible to vary the duration of the derived signal, which will hereinafter be referred to as the fading or blanking control signal. Preferably this signal is variable from zero to a length approximating the period of the horizontal scanning. It will also appear that, in order to obtain a control signal for the purpose of blocking the second transfer circuit during the time the first circuit is unblocked, the originally obtained fading signal

may simply be reversed in phase to give a control signal which (referring still to the illustrations of Fig. 2) will be of a polarity to block the amplifier during the intervals CD and EF, whereas the originally derived signal was effective to produce blocking during the interval DE. Now it will be seen that if the voltage wave from which the control signal is derived is of the triangular form shown at *r* and repeats itself at the horizontal scanning frequency, the result of applying the derived control signal to one transfer circuit and its inverse to the other transfer circuit, and combining the signals transferred by the two circuits, will be to insert a portion of one signal into the other signal during the time corresponding to the middle of each scanning period. The new effect upon the picture produced is to insert a vertical section from one picture into the middle of the other, the amount inserted depending, of course, on the amplitude level at which the control signal is derived. Thus by gradually varying the level, a gradual fading of one picture into the other may be obtained in the manner shown at *a* in Fig. 1. The rate at which the fading occurs is dependent upon the shape of the wave from which the control signal is derived and the rapidity with which the amplitude level is changed, either of which may be chosen in any convenient manner to obtain satisfactory results.

Fig. 3 is similar to Fig. 2 but illustrates the results obtained by deriving the control signal from a triangular wave *v* of vertical frequency. One video signal is shown at *w*, another at *x*, and the combined signal at *y*. The shaded portion on the triangular wave shows the derivation of the control signal and the transition points from one wave to the other occur at H and K. The effect of this method is to insert a horizontal portion of one picture into the middle of the other, as shown at *c* in Fig. 1.

Having now described generally the methods and results obtained by the invention, reference may be had to the other figures illustrating the equipment and circuits employed. Referring first to Fig. 4, there is shown a block diagram of that portion of a television transmitter which employs specific apparatus according to the method of the invention. Two separate video channels are shown and are designated by Roman numerals I and II on their respective components which are labeled "Camera tube," "Video amplifier," and "Blanking-out amplifier." The camera tubes I and II serve to generate the two video signals which are amplified in the video amplifiers I and II and are then fed to the blanking-out amplifiers I and II. Here they are modified in the manner illustrated in Fig. 2 or Fig. 3 and are subsequently fed to a combining amplifier, as shown, where they are combined with each other and with the synchronizing signals from the source indicated, which also serves to supply synchronizing signal to the respective camera tube deflecting circuits. Here, too, the background level is supplied in accordance with the average light intensity of the picture or scene televised. The combined signal may be modulated upon a suitable carrier wave and fed to an antenna for transmission. Except for the adaptation of the blanking-out amplifiers to the purposes of the present invention, as described hereinafter, the aforesaid components of the system of Fig. 4 are known devices which do not require detailed illustration or description. The other elements of the system are provided in

accordance with the present invention and will be described in detail.

For the purpose of generating a triangular wave 2 of the same frequency as that of horizontal scanning, it is convenient to make use of the horizontal frequency blanking pulses 1 which are derived from the synchronizing signal generator and fed to a triangular voltage generator as shown. The triangular wave thus generated may be fed to a circuit which is commonly referred to as a "microtome" because of its mode of operation. The microtome, in accordance with the control bias applied to it from the source shown, performs the operation of "removing a slice" of the triangular wave in the manner hereinbefore described to produce the control signal. Three different control signals are represented at 3, 4, and 5 and correspond respectively to signals derived at high, intermediate, and low levels with respect to the triangular waveform. The signals thus obtained are not suitable for immediate use in controlling the blanking-out amplifier, since they possess sloping sides and would tend to produce an intermixing of the two signals, rather than a sharp change from one signal to another, at the points corresponding to D and E in Fig. 2 or the boundaries between the picture sections as represented in Fig. 1. The signals are accordingly fed to a shaper which improves their wave shape by steepening their terminations as shown at 6, 7, and 8. The signals thus obtained may be inverted and fed to one of the blanking-out amplifiers in the original phase, and to the other blanking-out amplifier in inverted phase.

Considering the operation of the system as a whole, it will be seen that by varying the level at which the control signal is derived in the microtome the two signals may be faded in and out at will. It may be mentioned here that the system is not necessarily restricted to the use of two blanking-out amplifiers and their associated equipment. Any number may be employed and the signal supplied to any one from its associated camera tube may be made to replace any other according to the method of the invention.

Having considered generally a complete system, its various parts may now be considered in detail. The following description of the detail figures should be read in connection with the block diagram of Fig. 4 as well as the detailed illustrations of the other figures. Referring first to Fig. 5, which is a diagram of the triangular voltage generator, the blanking pulses 1 are supplied to the grid of the space discharge device 10, the plate circuit of which includes a parallel resonant circuit comprising a condenser 11, and a variable inductor 12 and across which is generated a sine wave voltage 13 in response to the blanking pulses. The inductor 12 is made variable in order that the phase of the sine wave with respect to the occurrence of the blanking pulses may be varied for reasons which will appear later. Since it is preferred not to detune this circuit too greatly, a further parallel circuit comprising the condenser 14 and the variable inductor 15 in the plate circuit of a second tube 16, may be employed to accomplish further shifting of the phase. The sine wave is then fed to the tube 17 which may have its bias so adjusted by means of the variable resistor 18 that it is operative to limit the amplitude of the sine wave in one direction as shown at 19. A third tube 20 whose bias is adjustable by means of the resistor 21 limits the wave in the other direction

thus producing a substantially square wave 22. This is supplied through the tube 23 to a discharge circuit comprising the resistor 24 and the condenser 25, across which is developed the triangular wave 2 which, after amplification in the tube 26, appears across the resistive-inductive load.

The microtome circuit of Fig. 4 is shown in detail in Fig. 6. The waveform 2 from which the control signal is to be derived, is supplied to the grid of the tube 27 through a coupling condenser. The grid bias of this tube is made variable to determine the level at which the control signal is derived with respect to the axis of the triangular wave. This may be accomplished either manually by means of the potentiometer 28 or by the application of a suitable voltage from any convenient source as will be explained later. The operation of tube 27 is such that it passes only that portion of the wave supplied to it which exceeds a particular amplitude level determined by the magnitude of the grid bias. Thus, there are produced the decapitated wave forms shown generally at 29, different degrees of decapitation being shown. By means of a coupling condenser, the decapitated wave is supplied to the grid of the tube 30 across the parallel combination of a diode 31 and a resistor 32 which serves to restore to the wave the D. C. component removed by the coupling condenser. The D. C. level is represented by the dot-dash lines of the illustration 29. By means of the potentiometer 33, the cut-off of the tube 30 may be adjusted to pass only that portion of the wave supplied to its input which exceeds the level determined by this bias. This level is represented by the dashed lines of the illustration 29. In the operation of the device, it is merely necessary to manipulate the potentiometer in order to vary the cut-off levels of both tubes, although the operation of the device may sometimes be improved by simultaneously varying the tap on the potentiometer 34. For convenience in simultaneous operation, this potentiometer may be ganged with potentiometer 28, as indicated by the broken line connecting the two. The wave produced by the operation of the tubes 28 and 30 will be substantially constant in amplitude regardless of the level at which it is derived. However, due to the varying durations of the successive portions of this signal when the bias on the grid of the tube 27 is varied, and by reason of the action of the condenser 35 in removing its D. C. component, the signal so obtained will tend to vary up or down with respect to the axis of zero signal as shown at 36. To avoid this there may be interposed, as shown in Fig. 6, the diodes 37 and 38. With suitable bias applied to these, by means of the potentiometers 39 and 40 for example, they act to restore the D. C. component to the signal. One diode acts to prevent overswing in one direction and the other to prevent overswing in the opposite direction. The resistance placed in series with the diodes by sections of the potentiometers 39 and 40 may be made large enough to keep any appreciable current from flowing in the diodes except on positive and negative signal peaks when small current will flow until the proper D. C. component has been restored. The resulting signal is shown at 41, dashed lines being used to indicate the manner in which position of the signal of 36 is altered with respect to a fixed axis denoted by the dash-dot lines.

An alternative and preferred form of a device for producing the same result as that of Fig. 6 is

shown at Fig. 6A. Two triodes are used to select the desired section from the wave 2 and are designated by the reference characters 27 and 30 as in Fig. 6. The cathodes of these tubes may be connected together and a common cathode resistor used as shown. The cut-off level in the tube 27 is determined by the bias applied to its grid from the potentiometer 28. That of the tube 30 depends upon the setting of the potentiometer and also upon the potential of its cathode which in turn is a function of current in the common cathode resistor. Current does not begin to flow in this resistor until the signal applied to the grid of the tube 27 has exceeded that predetermined cut-off level. It then increases until the cathode of the tube becomes sufficiently positive to cut-off tube 30. Thus the cut-off of both tubes is a function of the bias applied to tube 27 and the output from the tube 30 will be of substantially constant amplitude except insofar as this may be modified by the tube characteristics. Although capacitive coupling is shown in Fig. 6A between tubes 27 and 30 this may be omitted as shown in a similar circuit comprising the tubes 42 and 43 in Fig. 7A. Similar means to those of Fig. 6 are used to restore the D. C. component.

Although the signal 41 may be supplied directly to the blanking-out amplifier to control the gain thereof, it will be noted that the wave terminations are not as steep as might be desired for clear-cut fading. For this reason, they are fed through a further microtome circuit (see Fig. 7) which is generally similar to that shown in Fig. 6 but which is not variable as to its cut-off levels. For the purpose of illustration, a signal 41a is illustrated which corresponds to the intermediate signal of illustration 41. The circuit of Fig. 7 comprises the tubes 42 and 43 which need not be described in detail, since their operation is similar to that of the tubes 27 and 30 in Fig. 6. The effect of this treatment is further to increase the steepness of the wave-fronts in the control signal, as shown by the illustrations 44 and 45. This treatment may be repeated as many times as necessary in order to obtain any degree of steepness which might be desired.

Although it has not heretofore been mentioned or shown, the control signal will have been subjected to further distortion in the course of passing through these various wave-shaping circuits, and the net result will be to produce the current wave 44 in the plate circuit of the tube 43, which is essentially rectangular but which has its alternate corners rounded off as shown. By means of a filter circuit which may comprise the condensers 46 and 47 and the inductor 48, the unrounded corners are rounded off in such a fashion as to produce a wave which, after limitation in both directions by means of the biased diodes 49 and 50, appears as the symmetrical wave form shown at 45.

An alternative form of wave-shaping circuit which may be employed is shown in Fig. 7A, which is substantially similar to that of Fig. 7 and operates in substantially the same manner.

As has already been observed, the control signal to be applied to one of the blanking-out amplifiers is conveniently obtained by inverting the signal applied to the other. The phase inverter whereby this is accomplished is shown in Fig. 8. The control signal is applied, as shown, to the grid of the tube 51 which is loaded in its anode circuit by means of the resistor 52 and in its cathode circuit by means of the resistor 53. One

of the signals is derived across the anode resistor and, after being limited by means of the diodes 54 and 55, is applied to the grid of the tube 56 and produces in this tube a current of the form shown at 57. The other signal is derived across the cathode resistor 53 and after similar treatment by diodes 58 and 59 appears as a current in the tube 60 of the form shown at 61, which is the inverse of that shown at 57. The signals are applied to the blanking-out amplifiers for purposes of fading by completing the circuit to the plates of the tubes 56 and 60 through the switch 62.

The blanking-out amplifier is shown in the schematic diagram of Fig. 9. The amplifier itself comprises the tubes 63 and 64, the video signal 65 obtained from the camera tube being applied to the grid of the tube 63 and appearing across the resistor 66 in its modified form 67 blanked out during the intervals 68 and 69, which correspond to the return time, and during the interval 70 corresponding to that in which the other signal is to be inserted. The tubes 71 and 72 serve as means for applying the blanking and fading control signals across the resistor 73 in the cathode lead of the tube 63 to control the gain thereof. The tube 74 serves to supply a signal to the plate of the tube 64 which is effective to balance out the blanking and fading control pulses which come through the tube 63. The manner in which this obtains is fully described in Patent No. 2,081,127, issued May 18, 1937, to P. J. Konkle.

In general, the operation of the blanking-out amplifier as here shown is as follows. The signal 65 includes the transients 75 which are produced at the end of each scanning line where electronic scanning means are employed, and which may appreciably exceed in amplitude any of the peaks of video signal. It is desirable that these transients be eliminated in order that synchronizing signals may be inserted in these intervals. In order to do this, the gain of the amplifier tube 63 is reduced to zero during the interval by applying a suitable bias to the tube. This may be done by applying blanking impulses 76 to the grid of tube 71 to thus increase the positive voltage which appears across the resistor 73. The impulses 76 may be coincident with the transients in the video signal and will tend to increase the current in the resistor 73 thereby effectively increasing the bias on the tube 63 and reducing its gain. As explained in Patent No. 2,081,127 aforementioned, the impulses 76 will appear as shown at 77 in the output of the tube 63 but are balanced out in the output of the tube 64 by virtue of the connection comprising the tube 74 whereby impulses of opposite polarity, shown at 78, are supplied to the plate of tube 64.

In accordance with the method of this invention, a further blanking impulse 79 is introduced during some portion of the scan for the purpose mentioned. This signal may be applied to the tube 72 and produces results similar to those produced by the blanking impulses 76, thus blanking out the video signal 67 during the interval 70. In the practice of the invention, of course, the pulses 79 may be of variable width and may be obtained in the manner hereinbefore described in connection with Figs. 5 to 8. These pulses also are transmitted by the tube 63 and would appear in the output of the tube 64 were it not for the fact that the pulses supplied from tube 74 balance them out in the manner described and shown at 77 and 78.

It has been found that there is a tendency for the pulses not to balance out completely because they are of variable duration and their direct current component is removed by the coupling condenser between the amplifier stages (for example between the tubes 63 and 64). As a result the peaks of the signal applied to the grid of the final tube are not leveled whereby the amplification in this tube varies with the average value of the grid voltage. Since the amount by which this is varied is a function of the duration of the pulses, it is possible to integrate the pulses to obtain a gain control voltage which may be applied to the grid of the tubes to compensate for this tendency by keeping the gain and hence the pulse-size constant. The circuit for accomplishing this is shown in Fig. 9A where tube numbers are made to correspond to those of Fig. 9. The pulses are supplied through an isolating resistor 80 to the time circuit comprising the resistor 81 and the condenser 82 which integrates them to produce the required control voltage. This may be supplied to the grid of the tube 64 from the point 83. It will, of course, be understood that other means might be used for so controlling the gain or alternatively for restoring the D. C. component.

As will be understood from the foregoing description, the modified video signals from the blanking-out amplifiers (see Fig. 4) are combined in the combining amplifier.

Having now described in detail the manner in which fading may be obtained according to the pattern *a* of Fig. 1 and the equipment which may be employed to accomplish it, various other fading patterns shown in Fig. 1 may be given brief consideration which will be sufficient to enable a clear understanding by those skilled in the art.

At *b* in Fig. 1 is shown a form of fading in which the new picture appears first at the two sides of the screen and moves gradually toward the center until the entire picture has been replaced. The same apparatus is used as is used to obtain the pattern *a* the difference being achieved by merely shifting the phase of the saw-tooth signal shown at 2 in Fig. 5 with respect to the video signal. This shift is most readily obtained by transposing connections to the phase inverter of Fig. 8.

Fading of the type shown at *c* in Fig. 1 is obtained by commencing the blanking in the middle of a vertical scan and gradually broadening it to include the whole scan. This is accomplished in the manner above described using, however, signals of vertical frequency rather than signals of horizontal frequency, according to the method of Fig. 3.

Fading of the type shown at *d* in Fig. 1 is obtained by shifting the phase of the vertical frequency wave with respect to the video signal, so that the peaks of the triangular wave occur at the ends rather than at the middle of the vertical scan. The shift may be produced in the same way as explained above.

A pattern such as that shown at *e* in Fig. 1 results when both the blanking signal used to obtain pattern *a* and that used to obtain pattern *c* are applied to the fading tube.

The pattern *f* obtains when blanking of the types used in *b* and *d* are combined.

To obtain the pattern *g* the fading signal is derived from a saw-tooth wave rather than from a triangular wave with the result that the new picture starts from one side and moves across

to the other. The saw-tooth wave may be generated in response to horizontal blanking pulses by using the circuit shown in Fig. 10 in which a condenser 84 is alternately charged through the resistor 85 and discharged through the tube 86 to form a saw-tooth voltage 87 which is subsequently amplified by the tube 88 and appears as shown at 89.

A saw-tooth wave of vertical frequency would yield a signal which would produce fading of the type shown at *h* in Fig. 1; a combination of signals derived from both horizontal and vertical frequency saw-tooth waves would give the pattern *i*; and a combination obtained from a vertical frequency saw-tooth and a horizontal frequency triangular wave would give that of *j*.

In order to obtain the pattern *k*, a triangular wave of double the horizontal frequency is used which may be obtained from a triangular wave of horizontal frequency by applying it to the circuit shown in Fig. 11 which accomplishes a full-wave rectification of the wave. This is done by feeding the horizontal frequency wave 90 to the grid of the tube 91 which acts as a phase inverter. A triangular wave of the same phase is taken across the cathode load resistor 92 and one of opposite phase across the resistor 93 in the anode circuit. These are rectified by the diodes 94 and 95 and add across the resistor 96 to give the double frequency wave 97.

In a similar manner a wave of double the vertical frequency might be obtained and from it a fading signal derived to give the pattern shown at *l* in Fig. 1.

A combination of such signals produced from both vertical and horizontal frequency waves will give the pattern *m*.

As has heretofore been explained, the gradual transition from one picture to another is obtained by changing the D. C. bias applied to the grid of the tube 27 in the microtome circuit shown in Fig. 6, where a variable voltage divider 28 is provided for doing this manually. It will be seen that automatic means, such as a time circuit or any other suitable device, may be employed to accomplish this, as shown schematically in Fig. 4 and labeled "Fading control." By causing this control to vary in a manner which bears a predetermined time relation to the video signal, it is possible to obtain additional interesting and useful fading patterns. For example, by applying a fading control wave which comprises a vertical frequency wave of a particular shape and a gradually increasing D. C. component, fading patterns may be obtained such as those shown at *n* to *q* in Fig. 1. The pattern shown at *n* is produced when the fading control signal is a triangular wave of vertical frequency. The new picture appears in the form of a parallelogram whose size increases as the D. C. bias component is increased.

The apparatus employed for this purpose is shown in Fig. 12. The vertical frequency saw-tooth source shown may comprise a circuit the same as that of Fig. 5 except that it would be actuated by vertical frequency pulses supplied to the grid of tube 10. To the vertical frequency sawtooth shown at 98 in Fig. 12 might be added a D. C. component obtained from the potentiometer 99 and represented by the dashed line at 100. By varying the magnitude of this component at a relatively slow rate by comparison with the vertical scanning frequency, the waveform 101 would be produced and could be used to control the bias applied to the grid of the tube

27 of Fig. 6. When this is desired, the potentiometer 28 would be removed and its movable contact connected instead to the terminal 102 of the device of Fig. 12.

The pattern *o* of Fig. 1 obtains when the vertical frequency sawtooth source of Fig. 12 is replaced by a source of a vertical frequency wave of parabolic form; that of *p* when the wave is of sawtooth form but displaced in phase; and that of *q* when it is of exponential form.

Although the invention has been described with particular reference to its application in a television system, and although various specific forms of apparatus have been shown and described whereby the method of the invention may be practiced, it will be understood, of course, that the invention is not limited thereto. Briefly stated, the invention comprises the method of deriving control signals of varying duration in which the duration of the derived control signal is equal to the length of time during which a wave signal of predetermined form exceeds a particular amplitude level determined in accordance with the instantaneous value of another signal varying in a predetermined manner with time. It also contemplates the use of such a control signal to control the gain of an amplifier or other signal transfer means.

I claim:

1. In an electrical signalling system, a source of an intelligence signal, means for utilizing said signal, a controllable signal transfer means connected between said source and said utilization means, a source of a wave signal whose form is a predetermined function of time, means for deriving from said wave a control signal comprising controlling impulses whose durations are substantially determined by the intervals during which said wave exceeds a particular amplitude level, means for applying said derived control signal to said signal transfer means thereby to control the transfer of said intelligence signal, and means for varying said amplitude level thereby to vary the durations of said controlling impulses as a function of the form of said wave and the amplitude of said level, whereby the durations of the time intervals during which said signal transfer means is operative to transfer said intelligence signal are controlled.

2. In an electrical signalling system, a source of an intelligence signal, means for utilizing said signal, a controllable signal transfer means connected between said source and said utilization means, a source of a wave signal whose form is a predetermined function of time, means for selecting a portion of said wave with reference to a particular amplitude level, means for deriving from said selected portion a control signal comprising controlling impulses whose durations are substantially determined by the amplitude level with reference to which said portion is selected, means for applying said derived control signal to said signal transfer means thereby to control the transfer of said intelligence signal, and means for varying said amplitude level thereby to vary the durations of said controlling impulses as a function of the form of said wave and the amplitude of said level, whereby the durations of the time intervals during which said signal transfer means is operative to transfer said intelligence signal are controlled.

3. In an electrical signalling system, a source of an intelligence signal, means for utilizing said signal, a controllable signal transfer means connected between said source and said utilization

means, a source of a wave signal whose form is a predetermined function of time, means for selecting a slice of said wave at an amplitude level determined with reference to the time axis of said wave, thereby to derive a control signal comprising controlling impulses whose durations are substantially determined by the amplitude level at which said slice is selected, means for applying said derived control signal to said signal transfer means thereby to control the transfer of said intelligence signal, and means for varying said amplitude level thereby to vary the durations of said controlling impulses as a function of the form of said wave and the amplitude of said level, whereby the durations of the time intervals during which said signal transfer means is operative to transfer said intelligence signal are controlled.

4. In an electrical signalling system, a source of an intelligence signal, means for utilizing said signal, a controllable signal transfer means connected between said source and said utilization means, a source of a wave signal whose form is a predetermined function of time, means for deriving from said wave a portion thereof exceeding a particular amplitude level, means for supplying a D. C. component to said derived portion, means for selecting a portion of the resulting signal with reference to a second amplitude level, thereby to derive a control signal comprising controlling impulses whose durations are determined by the said amplitude levels, means for applying said derived control signal to said signal transfer means thereby to control the transfer of said intelligence signal, and means for varying said first amplitude level thereby to vary the durations of said controlling impulses as a function of the form of said wave and the amplitude of said level, whereby the durations of the time intervals during which said signal transfer means is operative to transfer said intelligence signal are controlled.

5. In an electrical signalling system, a source of an intelligence signal, means for utilizing said signal, a controllable signal transfer means connected between said source and said utilization means, a source of a wave signal whose form is a predetermined function of time, means for deriving from said wave a control signal comprising controlling impulses whose durations are substantially determined by the intervals during which said wave exceeds a particular amplitude level, means for supplying a D. C. component to said derived signal, means for applying said derived control signal to said signal transfer means, thereby to control the transfer of said intelligence signal, and means for varying said amplitude level thereby to vary the durations of said controlling impulses as a function of form of said wave and the amplitude of said level, whereby the durations of the time intervals during which said signal transfer means is operative to transfer said intelligence signal are controlled.

6. In an electrical signalling system, a source of an intelligence signal, means for utilizing said signal, a controllable signal transfer means connected between said source and said utilization means, a source of a wave signal whose form is a predetermined function of time, means for deriving from said wave a control signal comprising controlling impulses whose durations are substantially determined by the intervals during which said wave exceeds a particular amplitude level, said last-named means having an inherent frequency response characteristic such as to

produce unsymmetrical controlling impulses, means for applying said derived control signal to said signal transfer means thereby to control the transfer of said intelligence signal, said last-named means including a wave filter designed to attenuate certain frequency components of said control signal whereby the controlling impulses supplied to said signal transfer means are substantially symmetrical, and means for varying said amplitude level thereby to vary the durations of said controlling impulses as a function of form of said wave and the amplitude of said level, whereby the durations of the time intervals during which said signal transfer means is operative to transfer said intelligence signal are controlled.

7. In an electrical signalling system, a plurality of signal transfer means each adapted to transfer a different intelligence signal to a common signal utilization means, a source of a wave signal whose form is a predetermined function of time, means for deriving from said wave a control signal comprising controlling impulses whose durations are substantially determined by the intervals during which said wave exceeds a particular amplitude level, phase inverter means supplied with said derived signal for producing a second control signal comprising controlling impulses whose durations are substantially determined by the intervals during which said wave fails to exceed said amplitude level, means for applying said first control signal to one of said transfer means to control the transfer of the intelligence signal therein, means for applying said second control signal to another of said transfer means to control the transfer of the intelligence signal therein, and means for varying said amplitude level thereby to vary differentially the durations of said controlling impulses of the respective control signals as a function of the form of said wave and the amplitude of said level, whereby a gradual transition may be effected to render one or the other of said transfer means operable selectively.

8. In an electrical signalling system, a source of an intelligence signal, means for utilizing said signal, a controllable signal transfer means connected between said source and said utilization means, a source of a wave signal whose form is a predetermined function of time, means for selecting a portion of said wave exceeding a particular amplitude level, means for limiting the amplitude of said selected portion to produce a control signal comprising controlling impulses whose durations are substantially determined by said amplitude level, means for applying said derived control signal to said signal transfer means thereby to control the transfer of said intelligence signal, and means for varying said amplitude level thereby to vary the durations of said controlling impulses as a function of the form of said wave and the amplitude of said level, whereby the durations of the time intervals during which said signal transfer means is operative to transfer said intelligence signal are controlled.

9. In an electrical signalling system, a source of an intelligence signal, means for utilizing said signal, a controllable signal transfer means connected between said source and said utilization means, a source of a wave signal whose form is a predetermined function of time, means for selecting a portion of said wave exceeding a particular amplitude level, means for limiting the amplitude of said selected portion to produce a control signal comprising controlling impulses whose durations are substantially determined by said

amplitude level, capacitive means coupling said two last-named means, means interposed between said coupling means and said limiting means for supplying a D. C. component to said selected portion, means for applying said derived control signal to said signal transfer means thereby to control the transfer of said intelligence signal, and means for varying said amplitude level thereby to vary the durations of said controlling impulses as a function of the form of said wave and the amplitude of said level, whereby the durations of the time intervals during which said signal transfer means is operative to transfer said intelligence signal are controlled.

10. In an electrical signalling system, a source of an intelligence signal, means for utilizing said signal, a controllable signal transfer means connected between said source and said utilization means, a source of a wave signal whose wave form is a predetermined function of time, means including a space discharge device for deriving from said wave a control signal comprising controlling impulses whose durations are substantially determined by the intervals during which said wave exceeds a particular amplitude level determined by the bias applied to said device, means for applying said derived control signal to said signal transfer means thereby to control the transfer of said intelligence signal, and means for varying the bias applied to said space discharge device thereby to vary the durations of said controlling impulses as a function of the form of said wave and the amplitude of said level, whereby the durations of the time intervals during which said signal transfer means is operative to transfer said intelligence signal are controlled.

11. In a television system in which a television signal is produced by a process of horizontal and vertical scanning of the object to be televised at different scanning frequencies, a source of a television signal, means for utilizing said signal, a controllable signal transfer means connected between said source and said utilization means, a source of a wave signal of predetermined form periodically recurrent at one of said frequencies, means for deriving from said wave a control signal comprising controlling impulses whose durations are substantially determined by the intervals during which said wave exceeds a particular amplitude level, means for applying said derived control signal to said signal transfer means thereby to control the transfer of said television signal, and means for varying said amplitude level thereby to vary the durations of said controlling impulses as a function of the form of said wave and the amplitude of said level, whereby the durations of the time intervals during which said signal transfer means is operative to transfer said television signal are controlled.

12. In a television system in which a television signal is produced by a process of horizontal and vertical scanning of the object to be televised at different scanning frequencies, a source of a television signal, means for utilizing said signal, a controllable signal transfer means connected between said source and said utilization means, a source of a wave signal of predetermined form periodically recurrent at the horizontal scanning frequency, means for deriving from said wave a control signal comprising controlling impulses whose durations are substantially determined by the intervals during which said wave exceeds a particular amplitude level, means for applying said derived control signal to said signal transfer

means thereby to control the transfer of said television signal, means for varying said amplitude level periodically at the vertical scanning frequency, and manually-controlled means for varying the average amplitude of said level, thereby to vary the durations of said controlling impulses as a function of the form of said wave and the amplitude of said level, whereby the durations of the time intervals during which said signal transfer means is operative to transfer said television signal are controlled.

13. In an electrical signalling system including a source of an intelligence signal, means for utilizing said signal, and a controllable signal transfer means connected between said source and said utilization means, the method of controlling the transfer of said intelligence signal by said transfer means which comprises generating a wave signal whose wave form is a predetermined function of time, deriving from said wave a control signal comprising controlling impulses whose durations are substantially determined by the intervals during which said wave exceeds a particular amplitude level, applying said derived control signal to said transfer means thereby to control the transfer of said intelligence signal, and varying said amplitude level thereby to vary the durations of said controlling impulses as a function of the form of said wave and the amplitude of said level, whereby the durations of the time intervals during which said signal transfer means is operative to transfer said intelligence signal are controlled.

14. In an electrical signalling system including a plurality of signal transfer means each adapted to transfer a different intelligence signal to a common signal utilization means, the method of controlling the transfer of different intelligence signals by their respective transfer means which comprises generating a wave signal whose form is a predetermined function of time, deriving from said wave signal a control signal comprising controlling impulses whose durations are substantially determined by the intervals during which said wave exceeds a particular amplitude level, inverting the phase of said derived signal to produce a second control signal comprising controlling impulses whose durations are substantially determined by the intervals during which said wave fails to exceed said amplitude level, applying said first control signal to one of said transfer means to control the transfer of the intelligence signal therein, applying said second control signal to another of said transfer means to control the transfer of the intelligence signal therein, and varying said amplitude level thereby to vary differentially the durations of said controlling impulses of the respective control signals as a function of the form of said wave and the amplitude of said level, whereby a gradual transition may be effected to render one or the other of said transfer means operable selectively.

15. In a television system in which a television signal is produced by a process of horizontal and vertical scanning of the object to be televised at different scanning frequencies, and including a controllable signal transfer means adapted to transfer the television signal, the method of controlling the transfer of the television signal by said transfer means which comprises generating a wave signal of predetermined form periodically recurrent at one of said scanning frequencies, deriving from said wave a control signal comprising controlling impulses whose durations are

substantially determined by the intervals during which said wave exceeds a particular amplitude level, applying said derived control signal to said transfer means thereby to control the transfer of said television signal, and varying said amplitude level thereby to vary the durations of said

controlling impulses as a function of the form of said wave and the amplitude of said level, whereby the durations of the time intervals during which said signal transfer means is operative to transfer said television signal are controlled.

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