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VIDEO AND SYNCHRONIZING SIGNAL COMBINING AMPLIFIER

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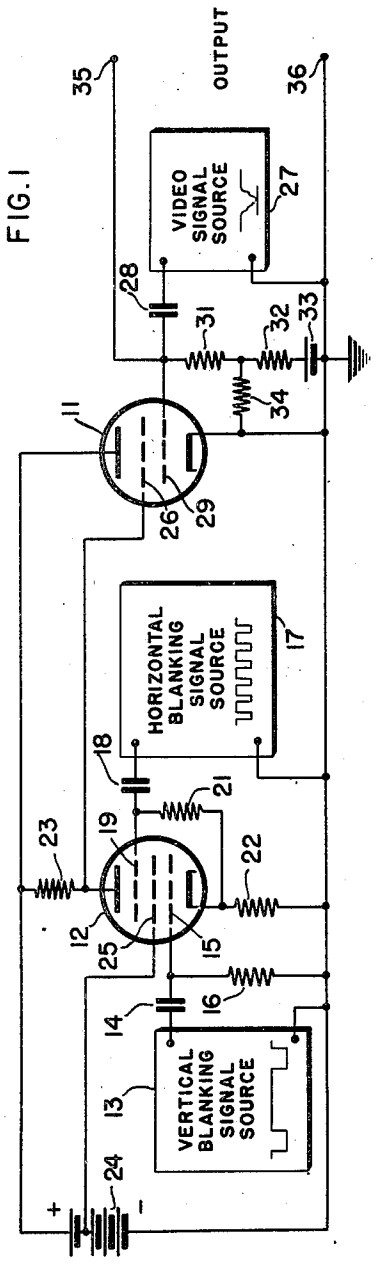


FIG. 1

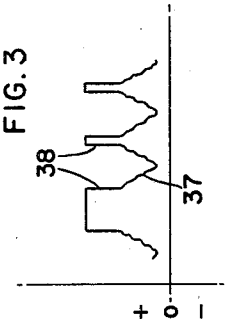


FIG. 3

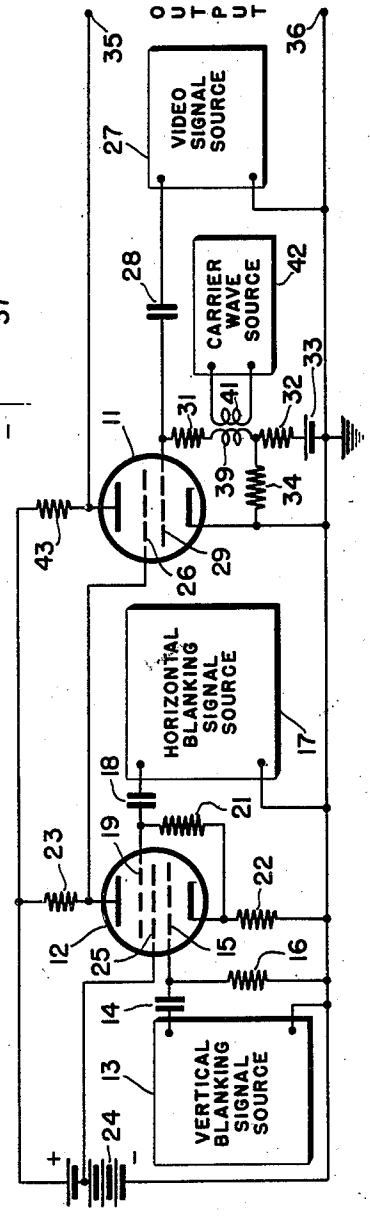


FIG. 2

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VIDEO AND SYNCHRONIZING SIGNAL COMBINING AMPLIFIER

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This invention relates to signal combining amplifiers and particularly to amplifiers of this character for combining a plurality of intelligence signals to form a composite television signal.

Conventionally, in the operation of television transmitting and receiving apparatus, a composite signal is transmitted from the transmitting station to the receiving station. This composite signal includes, in addition to the video signals, other intelligence signals such as blanking and synchronizing signals for controlling the receiving device. The composite television signal is formed at the transmitter by a process commonly called signal combining or mixing, whereby the blanking and synchronizing impulses are interspersed suitably with the video signals. This signal mixing, or more particularly the injection of the blanking and synchronizing impulses into the generated video signals, usually is accomplished in the video amplifier chain. Heretofore, it has been customary to accomplish the signal mixing by either the so-called grid injection method or the so-called plate injection method.

When using the grid injection method of signal mixing, at the end of each scanning line and also at the end of each scanning field, the grid of one of the video amplifier stages is biased sufficiently negative with respect to its associated cathode to effect the complete cutoff of space current for a period equal at least to the retrace time of the scanning apparatus. In this manner any disturbance signal created by the retrace of the scanning apparatus is rendered ineffective. In some cases the biasing of the video amplifier is only sufficient to shift the reference axis about which the video signal voltages alternate. In this latter case the disturbance voltage is superimposed upon the biasing voltage and therefore is reproduced in the output circuit of the amplifier. In either case, however, the modification of the grid bias of the amplifier in the direction of plate current cutoff develops an impulse of substantial magnitude in the output circuit.

A commonly used arrangement for carrying out the plate injection method of signal mixing is one in which the anode of an injector tube is directly connected to the anode of one of the video amplifier tubes so that a common load resistor may be employed in which the composite signal is developed.

As is well known in the art, however, a signal limiter must also be used in connection with a

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signal mixing amplifier operated by the grid injection method so that the amplitude of the impulses developed in the output circuit of the amplifier may be suitably reduced. In limiting the amplitude of these impulses there also is eliminated any disturbance effect which may be superimposed on the impulses. It is desirable, in the interest of utilizing the tube complement of a television transmitter at maximum efficiency, to accomplish signal mixing in a manner which will not require the use of signal limiters. While a mixer employing the plate injection method accomplishes such a result, it is not frequently used for the reason that it increases the capacitance in shunt with the common load resistor. The interelectrode capacitances of both the amplifier and injector tubes are connected in shunt across this resistor. When operating electronic amplifiers at the relatively high frequencies necessary in television systems, it is desirable to maintatin this shunt capacitance at a minimum value in order not to detrimentally affect the gain of the amplifier.

There are arrangements which have been proposed to couple the anodes or plates of the amplifier and injector tubes in such a manner that the interelectrode capacitances of the tubes are not additive across the load resistor. However, these arrangements make use of additional coupling elements which require very careful adjustment. Consequently, they have met with little favor and are not widely used.

An object of the present invention, therefore, is to provide a novel signal combining amplifier for forming a composite signal of two or more intelligence signals which is capable of utilizing the tube complement at maximum efficiency without reducing the amplifier gain substantially from the maximum realizable amplification.

Another object of the invention is to provide a novel signal combining amplifier for forming a composite signal of two or more independent intelligence signals wherein the amplifier shunt capacitance is minimized and whereby the use of additional signal limiting devices is obviated.

In accordance with the present invention there is provided a vacuum tube which is provided with an input circuit comprising a cathode and a space current control grid. Associated with the input circuit there is provided means to maintain the control grid at a normal potential relative to a predetermined point in the cathode circuit for the purpose of permitting a current flow to the grid. There also is provided means controlled by signals of one type to periodically modify the

impedance of the input circuit in a manner to change the control grid potential to a predetermined value. There also are provided facilities for injecting the control grid potentials into signals of another type in a manner whereby the other type of signal is substantially suppressed for the time during which the control grid voltage is maintained at the predetermined value. Preferably, the modification of the vacuum tube input circuit impedance is effected under the control of a screen grid with which the tube also may be provided. Also, if desired, carrier wave energy may be introduced in the vacuum tube input circuit for the production of a carrier wave modulated in amplitude in accordance with a combination of the two types of signals.

For a better understanding of the invention, together with other and further objects thereof, reference is had to the following description, taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

In the accompanying drawing:

Fig. 1 is a schematic illustration of one form of a signal combining amplifier embodying the invention;

Fig. 2 is a schematic representation of a modified amplifier also embodying the invention; and,

Fig. 3 is a curve representing the composite signal formed by means of apparatus embodying the invention.

Having reference now particularly to Fig. 1, there are shown two vacuum tubes 11 and 12, coupled together and to suitable signal sources in a manner to be described, for the purpose of forming a composite television signal including, for example, video and horizontal and vertical blanking signals.

The tube 12 is a multigrid tube, preferably a 6AC7 type or its equivalent. A source of vertical blanking signals 13 is coupled by means of a condenser 14 to the control grid 15 of the tube 12. A leak resistor 16 is provided for the coupling condenser and is connected between the control grid of the tube and ground. A source of horizontal blanking signals 17 is coupled by means of a condenser 18 to the suppressor grid 19 of the tube 12. A leak resistor 21 is provided for the coupling condenser and is connected between the suppressor grid and the cathode of the tube. The cathode also is connected to ground through a self-biasing resistor 22. The anode of the tube 12 is connected through a load resistor 23 to the positive terminal of a source of unidirectional energy such as a battery 24, the negative terminal of which is connected to ground. The tube 12 also is provided with a screen grid 25 which is maintained at a suitable positive potential by means of a connection to an intermediate point of the battery 24.

The output circuit of the tube 12 is coupled by means of a connection from the anode of the tube to the screen grid 26 of the tetrode 11. This tube may be a 832 type or its equivalent. A source of video signals 27 is coupled by means of a condenser 28 to the control grid 29 of the tetrode. A suitable biasing potential for the input circuit of this tube is provided by a series arrangement of resistors 31 and 32 and a source of unidirectional energy such as the battery 33. The terminals of this series arrangement are connected respectively to the control grid 29 of the tetrode and ground. The cathode of the tube 11 also is connected to ground and an additional resistor 34 is connected between the junction point of resistors 31 and 32 and the grounded cathode. The anode of the tube is connected directly to the positive terminal of the battery 24. In this form of the invention the output circuit for the composite signals is derived from the control grid 29 of the tube 11 and is connected to the output terminals 35 and 36 which in turn may be connected in any desired manner to a suitable utilization circuit.

Referring now to the operation of the embodiment of the invention shown in Fig. 1 it is assumed that the biasing arrangement for the input circuit of the tube 11 is adjusted so that the voltage of the control grid 29 has a normal value with respect to the junction point of the biasing resistors 31 and 32. It appears that the successful operation of the device requires that the input circuit biasing be of such a character that normally the control grid 29 draws current. In this connection it has been found that the polarity of the source of biasing energy 33 is immaterial so long as it permits the flow of grid current during the periods of development of the video signals. These signals are impressed upon the input circuit of the tube 11 in such polarity that the grid potential representative of picture white is less positive than that representing picture black.

The horizontal and vertical blanking signals are impressed in negative polarity upon the respective space current control grids 19 and 15 of the tube 12. Consequently, there are developed at the anode of this tube periodically positive voltage impulses of amplified magnitude during the development of the blanking signals. These positive impulsive voltages are impressed upon the screen grid of the tetrode 11 and so control the functioning of the tube that the control grid 29 develops an impulsive voltage of positive polarity and of considerably greater magnitude than the voltage representing picture black. At the same time the effect of any video signals impressed upon this electrode during retrace periods is eliminated from the voltages developed at the control grid.

It has been found in practice that, when using apparatus as described and impressing the different component signals upon the grid electrodes of the apparatus in the polarities specified, the wave form of the composite signal developed at the output terminals 35 and 36 is substantially as shown in Fig. 3. The video signals represented at 37 are of such a character that the greatest positive amplitude thereof represents picture black and the minimum positive amplitude represents picture white. The blanking signals 38 constitute substantial increases of the positive magnitude of the voltage of the control grid 29 of the tube 11. It is to be particularly noted that during the time of development of the blanking impulses 38 all traces of the video signals are substantially suppressed.

It appears that the apparatus described functions to produce the composite television signal illustrated in Fig. 3 by reason of the particular manner of operating the tube 11 so that the control grid thereof is permitted to draw current during certain portions of the operating cycle. As described, current flows to the control grid 29 of the tube 11 while the video signal is being developed during the trace period of the television pickup device. As a consequence of the flow of grid current the voltage developed at the control grid electrode is less positive than it would be were there no grid current flowing.

The increase of the positive potential impressed upon the screen grid 26 under the control of the blanking signals increases the magnitude of the space current flowing between the anode and cathode of the tube 11. As a result there also is effected a corresponding decrease in the current flowing to the control grid 29. Consequently, the voltage developed at the control grid electrode increases in a positive sense. Thus, there are developed the blanking signals 38 of Fig. 3.

Coincidentally with the decrease of the current flow to the control grid 29 of tube 11 and the increased voltage developed thereat, the impedance of the path within the tube between the control grid and the cathode is modified suitably to effect the substantial suppression of the video signals at the control grid 29. Thus, any disturbance effects created during the retrace interval of the television pickup device are not reproduced in the signals developed in the output circuit of the signal combining amplifier. The crests of the blanking signals 39 of Fig. 3, therefore, are substantially flat.

Referring now to Fig. 2, there is shown apparatus embodying the invention whereby there is developed a carrier wave modulated in amplitude by a composite television signal. Generally, this apparatus is similar to and is arranged in the same manner as the previously described apparatus of Fig. 1. Similar circuit components of the two modifications are indicated by like characters of reference.

In the apparatus of Fig. 2, however, there is included in the biasing circuit for the tetrode 11 an inductor 39 connected in series between the resistors 31 and 32. There also is provided a second inductor 41 coupled to the inductor 39 and having its terminals connected to the output circuit of a source of carrier wave 42. The anode of the tube 11 is connected through a load resistor 43 to the positive terminal of the battery 24. In this case the output circuit of the combining amplifier is derived from the anode of the tube 11 and is connected to the output circuit terminals 35 and 36.

The operation of the modified form of the invention illustrated in Fig. 2 is substantially similar to the apparatus shown in Fig. 1. The horizontal and vertical blanking signals are impressed upon the grids of the tube 12 in negative polarity so as to develop amplified impulses of positive polarity for impression upon the screen grid 26 of the tetrode 11. Also, the video signals are impressed upon the control grid 29 of the tetrode in negative polarity as in the previous instance.

The introduction, in the biasing circuit, of the carrier wave energy excites the grid at the carrier frequency. The conduction of space current in the tube 11 is varied correspondingly so as to develop amplified carrier frequency energy at the anode of the tube. Inasmuch as the video signals are also impressed upon the control grid in the manner described, the amplitude of the carrier frequency energy developed at the tube anode is modulated in accordance with the video signals.

Periodically, the potential of the control grid 29 is increased in positive polarity as in the preceding instance, under the control of the blanking signals derived from the output circuit of the tube 12. During these intervals the signal effects derived from the video signal source 27 are substantially suppressed so that the carrier wave energy developed at the anode of the tube 11 is

modulated in amplitude only by the blanking signals.

It is evident that the derivation of the amplifier output circuit from either the control grid or the anode of the tetrode 11 is immaterial so far as the present invention is concerned. In some instances it may be desirable to derive the output circuit from the anode of the tetrode as indicated in Fig. 2 so that advantage may be taken of the amplification factor of this tube.

While it will be understood that the circuit specifications of a signal combining amplifier embodying the present invention may vary according to the requirements of the particular system in which it is to be employed, the following circuit specifications for the illustrative embodiments of an amplifier of this character are included by way of example only.

Vacuum tube 11, 832
Vacuum tube 12, 6AC7
Condenser 14, 0.1 microfarad
Resistor 16, 0.5 megohm
Condenser 18, 0.01 microfarad
Resistor 21, 20,000 ohms
Resistor 22, 200 ohms
Resistor 23, 5,000 to 10,000 ohms
Battery 24, 250 volts
Condenser 28, 0.01 microfarad
Resistor 31, 100,000 ohms
Resistor 32, 500,000 ohms
Battery 33, 6 volts positive
Resistor 34, 100,000 ohms
Resistor 43, 1,000 ohms

While there has been described what, at present, are considered the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and therefore, it is aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A signal combining amplifier comprising, a vacuum tube having a grid electrode and an auxiliary impedance controlling electrode, means coupled to said grid electrode for effecting normally a flow of current to said grid electrode, means coupled to said auxiliary electrode and responsive to a first type of signals for modifying said current flow to effect the development at said grid electrode of a voltage representative of said first type of signals, and means coupled to said grid electrode for impressing a second type of signals upon said grid electrode.

2. A signal combining amplifier comprising, a vacuum tube having two grid electrodes, biasing means coupled to a first one of said electrodes for effecting a current flow to said first electrode, a source of signals of one type coupled to a second one of said electrodes, means including the second of said electrodes responsive to said signals of one type for modifying said current flow to develop at said first electrode a voltage representative of said one type of signals, and a source of another type of signals coupled to said first electrode.

3. A signal combining amplifier comprising, a vacuum tube having an input circuit including a control grid and a cathode, and an auxiliary electrode, a source of a first type of signals coupled in parallel with said input circuit, and means including said auxiliary electrode and responsive to a second type of signals to modify the im-

pedance of said input circuit suitably to suppress said first type of signals and to develop potentials at said control grid representative of said second type of signals.

4. A television signal combining amplifier comprising, a vacuum tube having a screen grid and an input circuit including a control grid and a cathode, a source of video signals coupled in parallel with said input circuit, means for maintaining said control grid at a normal potential with respect to said cathode, means including said screen grid responsive to blanking signals to modify intermittently the impedance of said input circuit suitably to suppress the video signals, and an output circuit for said amplifier for the development of a composite television signal.

5. A television signal combining amplifier comprising, a vacuum tube having a control grid, a screen grid and a cathode, a source of video signals coupled to said control grid, means to effect normally a flow of current to said control grid, means for impressing upon said screen grid a varying voltage representative of blanking signals, whereby to interrupt intermittently the flow of current to said control grid and to modify the impedance within said tube between the control grid and cathode thereof suitably to suppress the video signals, and an output circuit for said amplifier for the development of a composite television signal.

6. A television signal combining amplifier comprising, a vacuum tube having a space current control grid, a screen grid and a cathode, a source of video signals coupled between said control grid and said cathode, means for biasing said control grid with respect to said cathode to effect normally a flow of control grid current, means including a source of blanking signals for impressing a cyclically varying voltage upon said screen grid, whereby periodically to interrupt the flow of said control grid current and to modify the impedance within said tube between the control grid and cathode thereof suitably to suppress the video signals and to increase the positive potential of said control grid with respect to said cathode, and an output circuit for said amplifier derived from said control grid and said cathode.

7. A television signal combining amplifier comprising, a vacuum tube having a space current control grid, a screen grid and a cathode, a circuit connecting said control grid and said cathode, a source of video signals coupled between said control grid and said cathode, means for biasing said control grid with respect to said cathode to effect normally a flow of grid current in said circuit, means including a source of blanking signals for periodically impressing positive impulsive voltages upon said screen grid, whereby to interrupt the flow of grid current in said circuit and to modify the impedance within said tube between the control grid and cathode thereof suitably to suppress the video signals and to increase the positive potential of said control grid with respect to said cathode, and an output circuit for said amplifier derived from said control grid and said cathode.

8. A television signal combining amplifier comprising, a vacuum tube having a space current control grid, a screen grid, an anode and a cathode, a circuit connecting said control grid and said cathode, means coupled to said circuit for exciting said control grid at a carrier frequency, a source of video signals coupled between said control grid and said cathode, means for biasing said control grid with respect to said cathode to effect normally a flow of grid current in said circuit, means including a source of blanking signals for periodically impressing positive impulsive voltages upon said screen grid, whereby to interrupt the flow of grid current in said circuit and to modify the impedance within said tube between the control grid and cathode thereof suitably to suppress the video signals and to increase the positive potential of said control grid with respect to said cathode, and an output circuit for said amplifier derived from said anode and said cathode.

9. A signal combining amplifier comprising, a first vacuum tube having two grid electrodes, to effect normally the flow of current to a first one of said first tube electrodes, a second vacuum tube having a control grid and an output circuit, a source of signals of a first type coupled to said second tube control grid in such polarity to effect the development in said output circuit of voltages of positive polarity, means for impressing said positive voltages upon the second one of said first tube electrodes, a source of signals of a second type coupled to the first one of said first tube electrodes, and an output circuit for said amplifier derived from said first tube.

10. A signal combining amplifier comprising, a first vacuum tube having a control grid and a screen grid to effect normally the flow of current to said control grid, a second vacuum tube having a control grid and an output circuit, a source of signals of a first type coupled to said second tube control grid in such polarity to effect the development in said output circuit of voltages of positive polarity, a coupling between the output circuit of said second tube and the screen grid of said first tube, a source of signals of a second type coupled to the control grid of said first tube, and an output circuit for said amplifier derived from said first tube.

11. A television signal combining amplifier comprising, a first vacuum tube having a control grid, a screen grid and a cathode, means to bias said control grid with respect to said cathode to effect normally the flow of grid current, a second vacuum tube having two control grids and an output circuit, respective sources of two different types of system control signals coupled to said second tube control grids, said control signal sources being connected to the respective control grids of said second tube in such polarities to effect the development in said output circuit of impulsive voltages of positive polarity, a connection between the output of said second tube and the screen grid of said first tube, a source of video signals coupled to the control grid of said first tube, and an output circuit for said amplifier derived from said first tube.

12. A television signal combining amplifier comprising, a first vacuum tube having a control grid, a screen grid and a cathode, means to bias said control grid with respect to said cathode to effect normally the flow of grid current, a second vacuum tube having two space current control grids and an output circuit, two sources of blanking signals coupled respectively to said second tube control grids, said blanking signal sources being connected to the respective control grids of said second tube in such polarities to effect the development in said output circuit of impulsive voltages of positive polarity, a connection between the output circuit of said second tube and the screen grid of said first tube, a source of video signals coupled to the control grid of said first tube, and an output circuit for

said amplifier including the cathode of said first tube.

13. A television signal combining amplifier comprising, a first vacuum tube having a space current control grid, a screen grid and a cathode, a circuit connecting said control grid and said cathode, means to bias said control grid with respect to said cathode to effect normally the flow of grid current in said circuit, a second vacuum tube having two space current control grids and an output circuit including an anode, a source of horizontal blanking signals coupled to one of said second tube control grids, a source of vertical blanking signals coupled to the other of said second tube control grids, said blanking signal sources being connected to the respective control grids of said second tube in such polarities to effect the development in said output circuit of impulsive voltages of positive polarity, a connection between the anode of said second tube and the screen grid of said first tube, a source of video signals coupled to the control grid of said first tube, and an output circuit for said amplifier derived from the control grid and cathode of said first tube.

14. A television signal combining amplifier comprising, a first vacuum tube having a space current control grid, a screen grid, an anode and a cathode, a circuit connecting said control grid and said cathode, a source of carrier wave energy coupled to said circuit, means to bias

said control grid with respect to said cathode to effect normally the flow of grid current in said circuit, a second vacuum tube having two space current control grids and an output circuit including an anode, a source of horizontal blanking signals coupled to one of said second tube control grids, a source of vertical blanking signals coupled to the other of said second tube control grids, said blanking signal sources being connected to the respective control grids of said second tube in such polarities to effect the development in said output circuit of impulsive voltages of positive polarity, a connection between the anode of said second tube and the screen grid of said first tube, a source of video signals coupled to the control grid of said first tube, and an output circuit for said amplifier derived from the anode and cathode of said first tube.

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REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,115,881	Roosenstein	May 3, 1938
2,160,052	Banks	May 30, 1939
1,975,143	Farnsworth	Oct. 2, 1934
2,269,001	Blumlein	Jan. 6, 1942