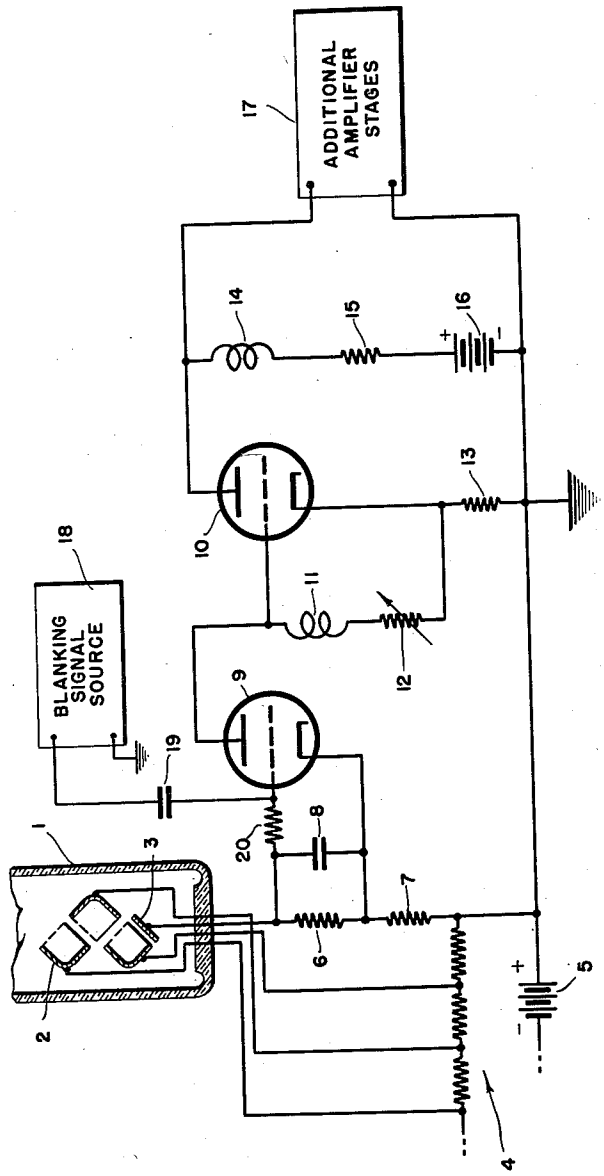
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AUTOMATIC GAIN CONTROL

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AUTOMATIC GAIN CONTROL

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This invention relates to signal control systems and particularly to systems for effecting automatically the control of signal level.

In conventional practice it is common to represent intelligence by amplitude-modulated signal effects. In such systems the extremes of intelligence of any character such as light or sound are represented by the maximum and minimum instantaneous amplitudes of the signal effects. If the difference between maximum and minimum, or peak-to-peak value as it is sometimes called, of the signals does not change in magnitude over a period of time, then the average value of the signal effects remains substantially constant.

However, the peak-to-peak value of signal effects very often does change for any one of numerous reasons. In the case where one intelligence extreme always is represented by the same amplitude, any change produced in the peak-to-peak value of the signal effects introduces distortion. For example, where the intelligence to be conveyed by means of signal effects has the character of light, a black object always is represented by the same signal amplitude for the reason that, regardless of the intensity of illumination projected onto the object, it does not reflect any light. A white object, on the other hand, reflects light in proportion to the illumination to which it is subjected. If there is an increase in the illumination, there is effected a corresponding increase in the light reflected from the object and a consequent increase in the representative signal amplitude. The relation between the black and white objects is not changed but there is produced a change in the relationship between the respective representative signals. Hence, there is effected a variation of the average value of the signal effects.

In order to eliminate the type of distortion referred to, it is necessary to control the signal level in such a manner as to maintain the peak-to-peak value thereof substantially constant. One manner in which such a control usually is effected is by the use of an amplifier provided with automatic gain control facilities. These usually comprise the connection of a rectifier in the output circuit of the amplifier, whereby a small portion of the output circuit energy is converted into a unidirectional voltage varying in magnitude in accordance with the average peak-to-peak value of the signal effects impressed upon the amplifier input circuit. This unidirectional voltage is fed back to the input circuit, usually as a grid bias, in order to effect the desired gain control. However, in devices of this character the gain control of the amplifier, whereby the signal level is maintained substantially constant, is achieved by first permitting the signal level to increase somewhat in the output circuit of the amplifier. A more effective system would be to prevent the signal level from increasing before impression on the amplifier.

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It is an object of the present invention, therefore, to provide a signal control system whereby the signal level is maintained substantially constant by preventing the peak-to-peak signal values from exceeding a predetermined maximum value before impression of the signal upon an amplifier or other utilization circuit.

Another object of the invention is to provide, in a system according to the foregoing object, a novel means of mixing control signals with the intelligence signals.

In accordance with this invention there is provided a source of amplitude-modulated signal effects. The peak-to-peak value of these signals is subject to variation so that the average value of the signal effects also varies. Individual means, both connected to the signal source, are provided for developing respectively two voltages. The first voltage varies in accordance with the instantaneous values of the signal effects. The second voltage varies in accordance with the average value of the signal effects. Additionally, there is provided a utilization circuit and a variable impedance device. The means by which the first of the two voltages is developed is connected to the utilization circuit by a circuit which includes the impedance device. Also, there is provided a means utilizing the second of the two developed voltages for varying the impedance of the device in accordance with the average value of the signal effects. In this manner a tendency for the peak-to-peak value of the signal effects to increase causes a change of the impedance of the connecting device of such magnitude and sense that the peak-to-peak value of the signals impressed upon the utilization circuit is prevented from increasing above a predetermined value.

According to another feature of the invention, control signals may be mixed with the intelligence signals by changing the value of the impedance device to a predetermined magnitude.

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, the single figure is a schematic circuit diagram of a portion of a signaling system embodying the instant invention.

Referring now to the drawing, the signal source is represented by the final stages of an electron multiplier. The multiplier is mounted within an evacuated envelope 1, and comprises a series arrangement of a plurality of secondary emissive electrodes such as 2. The source of primary electrons for the multiplier has not been shown for the reason that it forms no part of the present invention and may be anything desired. Where apparatus embodying the invention is to be used in a television system, for example, the source of primary electrons may be an image dissector tube. In such case the electrons traversing the various multiplier stages will be representative of intelligence in the form of the light and shade values of a television subject. The multiplier also is provided with an output electrode 3, which serves as an electron collector.

Each of the multiplier electrodes is maintained at a more positive potential than its predecessor. These potentials or electron-accelerating voltages are derived from a conventional voltage divider 4, to which is connected a source of unidirectional energy such as a battery 5.

The collector electrode 3 is connected through a load impedance circuit comprising resistors 6 and 7 to the grounded positive terminal of the battery 5. The resistor 6 is shunted by a bypass condenser 8.

The ungrounded terminal of the relatively high-valued resistor 7 is connected through the space discharge path, including the cathode and anode of a control vacuum tube 9 to the control grid of an amplifying vacuum tube 10. The terminal of the relatively low-valued resistor 6, which is connected to the collector 3, also is connected to the control grid of the signal control tube 9. The anode of this tube is connected through an inductor 11, an adjustable resistor 12 and a fixed resistor 13 to ground. The ungrounded terminal of the resistor 13 also is connected to the cathode of the amplifier tube 10. The anode of this tube is connected through an inductor 14 and a resistor 15 to the positive terminal of a source of space current for the tube, such as the battery 16. The negative terminal of this battery is grounded. The output circuit for the tube 10, which includes the anode of the tube, is connected to any desired apparatus such as the additional amplifier stages represented at 17.

The apparatus in accordance with the present invention also is susceptible of use for injecting system control signals, such as blanking and/or synchronizing signals, into the video signals. For this purpose there is provided a conventional source of blanking signals 18 which, obviously, may also be a source of synchronizing signals or a source of combined blanking and synchronizing signals. The output of the signal source 18 is coupled by means of a condenser 19 to the control grid of the control vacuum tube 9. In order that the output circuit of the blanking signal source 18 be prevented from bypassing the high frequency component of the television signal derived from the multiplier, there is included an isolating resistor 20 in the connection from the collector electrode 3 and the control grid of the tube 9.

Referring now to the operation of the described apparatus embodying the invention, it will be assumed that this apparatus is used in a television system. Further, it will be assumed that the television apparatus includes an image analyzing tube of the type known as an image dissector. In this type of device the light reflected from elemental areas of the television subject is converted into electron energy varying in magnitude in direct proportion to the light variations. This electron energy is amplified in a conventional manner by means of an electron multiplier, such as the one of which a portion is illustrated in the drawing. The electron energy representing the signal effects which is derived from the collector electrode 3 is caused to traverse the load circuit, including the resistors 6 and 7 and the condenser 8. Thus, there are developed in the load circuit voltages representative of the different characteristics of the signal effects required for the operation of the present apparatus in a manner to be described.

Assume that the light with which the television subject is illuminated is of substantially constant intensity for an appreciable length of time. The signal effect representative of a white object of the subject will be of substantially the same magnitude for each scansion of the white object during the time that the illumination remains at its assumed normal value. The signal effect representative of a black object is of the same magnitude (but different from that representative of the white object) for each scansion of this object, regardless of the intensity of the subject illumination for the reason that there never is any light reflected from a black object. Intermediate light values of the television subject will effect the development of signal effects proportional to the light values. In this case the average value of the signal effects over the period of time during which the subject illumination remains at its assumed constant normal value also will be substantially constant.

The voltages representative of the television subject are developed in the load resistor 7. The peak-to-peak value of these developed voltages is determined by the illumination intensity of the television subject. The voltage developed in the load resistor 6, on the other hand, is representative of the average peak-to-peak value of the video signal effects. The instantaneous fluctuations of the video signal effects do not effect the traversal of this resistor by corresponding relatively high frequency currents for the reason that the bypass condenser 8 provides a relatively low impedance circuit around the resistor 6 for these currents. The voltage developed in the load resistor 6 is impressed upon the space current control electrodes of the tube 9 and, therefore, determines the impedance of the space discharge path of this tube.

The voltage developed in the load resistor 7 is impressed upon the input circuit of the amplifier tube 10 by a circuit which includes in series the space discharge path of the control tube 9. The space discharge path of this tube then serves as a series impedance element in the circuit connecting the multiplier load circuit to the utilization circuit, including the amplifier tube 10. The anode of the tube 9 is maintained at a sufficiently high positive potential with respect to its associated cathode to effect the flow of space current in the tube by the voltage developed in the resistor 13 connected to the cathode of the tube 10. Conduction of space current in this latter tube effects the development of a voltage at the cathode connected terminal of the resistor 13

which is positive with respect to ground. It is apparent, therefore, that the magnitude of the signal voltage effects impressed upon the input circuit of the amplifier tube 10 is determined by the magnitude of the voltage developed in the multiplier load resistor 7 and by the value of the impedance of the space discharge path of the tube 9.

Assume now that the television subject is illuminated by light of a greater than normal intensity. The voltage developed in the load resistor 7, representative of a black portion of the television subject, is the same as in the previously considered case. However, the voltage developed in the resistor representative of a white portion of the subject is considerably greater than in the previous instance. Similarly, voltages representing intermediate light values of the subject are correspondingly greater than before. As a result, the average peak-to-peak value of these signals also is greater. Thus, an increased voltage is developed in the load resistor 6. Inasmuch as the connections of the space current control electrodes of the tube 9 to the resistor 6 are such that the potential of the control grid is negative with respect to the cathode, an increase of the voltage developed in the resistor 6 effects an increase in the negative grid voltage with respect to the cathode. Hence, the impedance of the space discharge path of the control tube 9 is increased. By suitably choosing the values of certain of the circuit components, the increase of the impedance of the tube 9, resulting from an increase in the subject illumination, may be made sufficient to compensate for the increased peak-to-peak signal voltage developed in the load resistor 7. In this manner the peak-to-peak voltage impressed upon the input circuit of the amplifier tube 10 may be maintained at the same value as that obtained from a normal illumination of the television subject.

Obviously, if there is a decrease of the television subject illumination below the assumed normal value, the voltage representing the average peak-to-peak voltage which is developed in the load resistor 6 is decreased suitably to effect a compensatory decrease in the impedance of the space discharge path of the control tube 9. Thus, even though the peak-to-peak value of the signal effects developed in the load resistor 7 is less than the assumed normal value, the peak-to-peak voltage impressed upon the input circuit of the amplifier tube 10 remains substantially at the normal value.

With reference to the functioning of the described apparatus, in the case where system control signals such as blanking signals are to be mixed with the video signals, assume that the blanking signals are derived from the output circuit of the source 18 in negative polarity. When such a signal is impressed upon the control grid of the tube 9, the impedance of the space discharge path of this tube is materially increased. It is seen that this operation is equivalent to that resulting from the development in the multiplier output circuit of a signal representative of minimum light reflection from the television subject. In such a case the electron emission from the dissector tube cathode is a minimum, and therefore, the electron collection by the electrode 3 also is a minimum. There, thus, is developed in the multiplier output resistor 7 a minimum voltage. The signal voltage which is impressed upon the control grid of the amplifier tube 10, consequently, is at a maximum. Hence, in response to minimum light reflection from the subject, there is effected maximum conduction of space current in the tube 10 for a video signal period. Conversely, there is developed in the output resistor 7 a maximum voltage in response to maximum light reflection from the television subject, whereby to effect a corresponding decrease of the signal voltage impressed upon the control grid of the amplifier tube 10. Thus, for maximum light the space current conduction in the tube 10 is a minimum and for minimum light this space current conduction is a maximum.

It is seen that the voltages impressed upon the control grid of the amplifier tube are subject to the current conduction through the various impedance devices connected to the anode of the control tube 9. This current flow during the periods of video signal generation is dependent upon the light values of the portions of the television subject scanned. Between scansions the blanking signals are impressed upon the control grid of the tube 9 in negative polarity, as described, so that space current conduction in this tube is completely interrupted. As a consequence, the anode of the tube and also the control grid of the vacuum tube 10 develop their maximum potential values. Accordingly, space current conduction in the amplifier tube also is at its greatest magnitude.

Thus, it is apparent that the peak-to-peak value of the video signals is maintained substantially constant by means of the described functioning of the control tube 9. Also, signal mixing may be accomplished by effecting an additional control of the tube 9, as just described. Obviously, the system control signals may be mixed with the video signals in conjunction with the signal level control apparatus by other means which will be readily apparent to those skilled in the art. For example, these signals may be impressed in positive polarity between ground and a point on the multiplier output resistor 7.

The inductors 11 and 14, together with resistors 12 and 15 respectively, connected in the input and output circuits of the amplifier tube 10 are employed for the purpose of providing the amplifier with a response over the necessary band of frequencies required for the amplification of television video signals. In order to effect the proper operation of the control tube 9 so that its impedance is varied between the proper limits, the bias on the control grid of this tube, as determined by the value of the resistor 6, must be of suitable magnitude. The adjustable resistor 12 is of some use in effecting the operation of the tube 9 within the proper impedance limits. However, its main function is to suitably adjust the frequency band width of the input circuit of the amplifier tube 10. Such apparatus is conventional and has no appreciable effect upon the performance of the signal level control apparatus of this invention.

Apparatus arranged substantially in the manner shown and described herein has been found to operate satisfactorily with the essential circuit components of the signal level control apparatus having values substantially as follows:

Resistor 6	470 ohms
Resistor 7	14700 ohms
Condenser 8	25 microfarads
Vacuum tubes 9 and 10	6SN7

It will be obvious to those skilled in the art that the invention also may be practiced by connecting the control tube 9 in shunt with the load

resistor 7. In such a case suitable connections to the control grid of the tube 9 will be required to reverse the polarity of the grid control voltage from that disclosed in the described illustrative embodiment. In this manner an increase of the subject illumination will decrease the impedance of the control tube, whereby to effect the necessary decrease of the signal voltage impressed upon the amplifier tube 10.

It is seen that apparatus embodying the instant invention enables the more efficient operation of an amplifier than the prior art arrangements, wherein part of the amplifier output energy is fed back to the amplifier input circuit. It is obvious that an arrangement of this character is useful in substantially any type of signalling system wherein the signals are subject to variations in the peak-to-peak values thereof.

While there has been described what, at present, is considered the preferred embodiment 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. An automatic signal level control system comprising, a source of amplitude-modulated signal effects having a relatively high frequency and an average value varying at a relatively low frequency, means including a load impedance device connected to said signal source for developing a first voltage varying in accordance with the instantaneous values of said signal effects, means including another load impedance device connected to said signal source for developing a second voltage varying in accordance with the average value of said signal effects, a utilization circuit, means including a series connection of the space discharge path of a vacuum tube for impressing said first voltage upon said utilization circuit, and means for impressing said second voltage upon the space current control electrode of said vacuum tube.

2. An automatic signal level control system comprising, a source of signal effects consisting of an amplitude-modulated component having a relatively high frequency and an average value varying at a relatively low frequency, a load circuit including a plurality of impedance devices connected to said signal source, a utilization circuit, means including a series arrangement of the space discharge path of a vacuum tube for connecting said utilization circuit to one of said load circuit impedance devices, means connected to another one of said load circuit impedance devices for excluding said relatively high frequency component from said other impedance device, and a connection between said other impedance device and the space current control electrode of said vacuum tube.

3. An automatic signal level control system comprising, a source of signal effects consisting of an amplitude-modulated component having a relatively high frequency and an average value varying at a relatively low frequency, a load circuit including a plurality of serially connected impedance devices connected to said signal source, a utilization circuit, a vacuum tube having a space discharge path and a space current control electrode, means for connecting the space discharge path of said vacuum tube in series between said utilization circuit and one of said load

circuit impedance devices, means connected in parallel with another one of said load circuit impedance devices for by-passing said relatively high frequency component around said other impedance device, and a connection between said other impedance device and the space current control electrode of said vacuum tube.

4. An automatic signal level control system comprising, a source of amplitude-modulated signal effects having a relatively high frequency and an average value varying at a relatively low frequency, a load circuit including two serially connected resistors connected to said signal source, a utilization circuit, means including the space discharge path of a vacuum tube for connecting said utilization circuit to one of said load circuit resistors, a condenser connected in parallel with the other of said load circuit resistors, and a connection between said other resistor and the space current control electrode of said vacuum tube.

5. An automatic signal level control system comprising, a source of amplitude-modulated signal effects having a relatively high frequency and an average value varying at a relatively low frequency, a load circuit including two serially connected resistors connected to said signal source, a utilization circuit, a vacuum tube having an anode, a cathode and a control grid, said anode being connected to said utilization circuit and said cathode being connected to one of said load circuit resistors, a condenser connected in parallel with the other of said load circuit resistors, and a connection between said other resistor and the control grid of said vacuum tube.

6. An automatic signal level control system comprising, a source of amplitude-modulated signal effects having a relatively high frequency and an average value varying at a relatively low frequency, said source including a multistage electron multiplier having an electron collector electrode, a relatively high-valued resistor and a relatively low-valued resistor connected in series to said collector electrode, a utilization circuit, a vacuum tube having an anode, a cathode and a control grid, said anode being connected to said utilization circuit and said cathode being connected to the junction point of said resistors, a condenser connected in parallel with said relatively low-valued resistor, and a connection between said relatively low-valued resistor and the control grid of said vacuum tube.

7. An automatic signal level control system comprising, a source of amplitude-modulated signal effects having a relatively high frequency and an average value varying at a relatively low frequency, said source including a multistage electron multiplier having an electron collector electrode, a relatively high-valued resistor and a relatively low-valued resistor connected in series to said collector electrode, a control vacuum tube having an anode, a cathode and a control grid, an amplifier vacuum tube having an anode, a cathode and a control grid, an impedance device connected between the control grid and cathode of said amplifier tube, an additional impedance device connected in series with the cathode of said amplifier tube, the anode of said control tube being connected to the control grid of said amplifier tube and the cathode of said control tube being connected to the junction point of said resistors, a condenser connected in parallel with said relatively low-valued resistor, a connection between said relatively low-valued resistor and

the control grid of said control tube, and an output circuit connected to the anode of said amplifier tube.

8. In a television system, a source of amplitude-modulated video signals having a relatively high frequency and an average value, varying at a relatively low frequency, a source of system control signals, a utilization circuit, means including a high-valued unbypassed resistor connected to said video signal source for developing a voltage representative of the instantaneous values of said video signals, means including a low-valued bypassed resistor connected to said videon signal source in series with said high-valued resistor for developing a voltage representative of the average value of said video signals, means including a connection of the cathode and anode of a vacuum tube between said high-valued resistor and said utilization circuit for impressing the voltage representative of the instantaneous values of said video signals upon said utilization circuit, means including a resistor for impressing the voltage representative of the average value of said video signals upon the control grid of said vacuum tube to vary the impedance of the space discharge path between the cathode and anode of said vacuum tube, and means including a condenser for impressing said system control signals upon the control grid of said vacuum tube to vary the impedance of said discharge path.

9. In a signalling system, a source of amplitude-modulated signal effects of a first type having a relatively high frequency and an average value varying at a relatively low frequency, a

source of signals of a second type, a utilization circuit, means including an unbypassed resistor for developing a first voltage representative of the instantaneous values of said first type of signal effects, means including a bypassed resistor for developing a second voltage representative of the average value of said first type of signal effects, means including the space discharge path of a vacuum tube for impressing said first voltage upon said utilization circuit, means including a conductive coupling for varying the impedance of the space discharge path of said vacuum tube under the control of said second voltage, and means including a reactive coupling for varying the impedance of the space discharge path of said vacuum tube under the control of said second type of signal effects.

10. In a signalling system, a source of amplitude-modulated signal effects of a first type having a relatively high frequency and an average value varying at a relatively low frequency, a source of signal effects of a second type, a utilization circuit, means for developing a first voltage representative of the instantaneous values of said first type of signal effects, means for developing a second voltage representative of the average value of said first type of signal effects, means including a variable impedance device for impressing said first voltage upon said utilization circuit, means for varying the impedance of said device under the control of said second voltage, and means for varying the impedance of said device under the control of said second type of signal effects.

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