

Sept. 29, 1942.

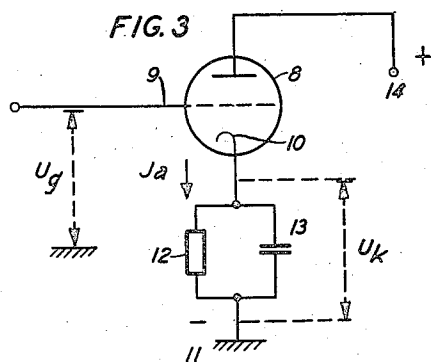
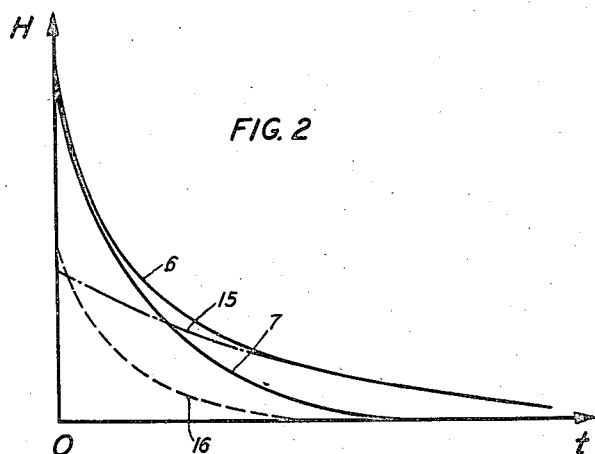
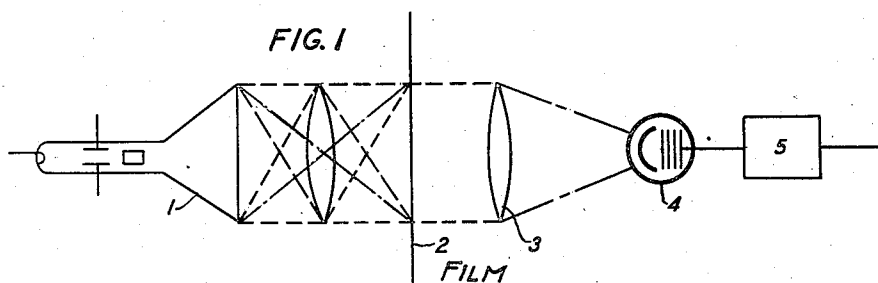
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2,297,456

SIGNAL AMPLIFIER

Filed July 20, 1940

2 Sheets-Sheet 1



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FIG. 4

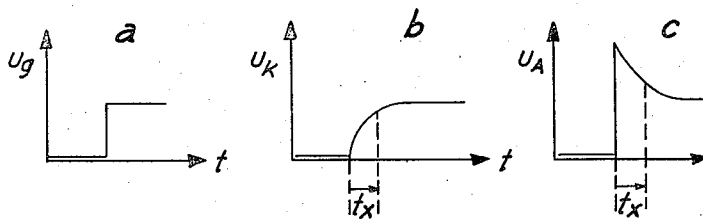
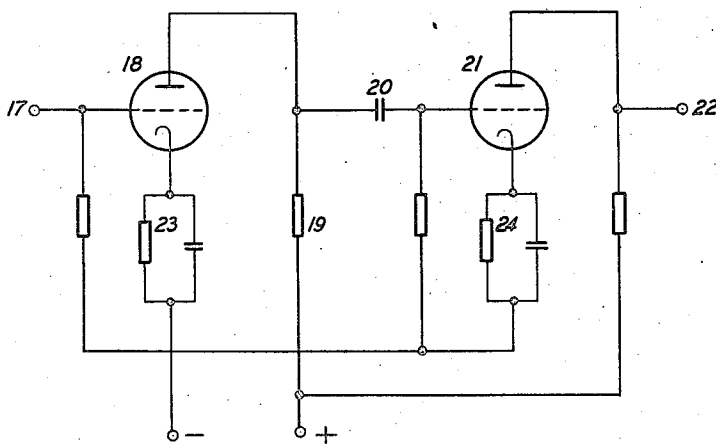


FIG. 5



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SIGNAL AMPLIFIER

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5 Claims. (Cl. 178-7.2)

The invention relates to arrangements for amplifying electrical signals and is particularly concerned with the amplification of signals containing distortions.

It is an object of the invention to amplify signals in such a manner that they are free from distortions so that these distortions can not be noticed in the receiving arrangement.

It is a further object to provide an amplifier circuit, for example, for controlling purposes in which undesired voltages of slowly decreasing amplitude are excluded from the amplification. It is a further object to suppress disturbing signals in television cathode ray tube light spot scanners in which a disturbing signal is produced by the use of fluorescent screens showing afterglow effects. The signals produced by the afterglow of the luminescent material are particularly detrimental in transmissions with high definition because they cause blurred edges in the picture.

According to the invention the input of the amplifier is fed with the signals and additionally with a control voltage for compensating the disturbing signals. The signals produced in the photoelectric cell of a television transmitter operating with a cathode ray tube as source of light are applied to an amplifier stage controlled by an additional input voltage for compensating a part of the signal voltage so that the voltages produced by the afterglow of the fluorescent material of the cathode ray tube are compensated.

According to the invention an element containing in parallel a condenser and a resistance is arranged in the cathode lead of the amplifying tube and the voltage produced at the ends of this element is used for controlling additionally the grid electrode of the amplifying tube.

It is a particular feature of the invention to arrange elements including a condenser and a resistance in the cathode leads of a number of amplifier tubes. For compensating distortion signals of slowly decreasing amplitude the compensating elements are so dimensioned that the compensating effect lasts as long as the disturbing signals are existent. The compensating elements are so dimensioned in connection with the amplifying tubes that the overcompensation which may eventually arise is very short.

Other aspects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but I do not limit myself to the embodiment of the invention herein described, as various forms

may be adopted within the scope of the claims. Referring to the drawings,

Fig. 1 shows an arrangement for scanning an image by means of a cathode ray tube light spot scanner;

Fig. 2 is a curve showing the afterglow as a function of time;

Figs. 3 and 5 are circuit arrangements of amplifiers according to the invention; and

Fig. 4 a diagram of voltage existing in these circuits as a function of time.

Fig. 1 shows a cathode ray tube 1 having a luminescent screen. The screen is scanned by a cathode ray produced in the electron gun system of conventional design. The moving light spot produced by the luminescent screen is projected on a film 2 containing a picture to be transmitted and the light passing through the film is concentrated by a lens 3 upon a photoelectric cell 4. The signals produced in the output circuit of the photoelectric cell are amplified in an amplifier 5.

The luminescent screen of a cathode ray tube produces light not only in the moment when the cathode ray impinges upon the particular point of the screen but also after the bombardment of this point with electrons has ceased. The light produced after the excitation decreases slowly according to a curve 6, represented in Fig. 2 showing the brightness H as a function of time t and is usually called afterglow light. It can be seen that the afterglow curve has a form similar to that of a logarithmic curve, represented by curve 7. Every logarithmic curve can be characterized by a magnitude which is known as the time constant of the logarithmic curve and which represents the time after which the amplitude of the e -function is decreased to $1/e$ of the original value.

Fig. 3 shows a circuit arrangement for the amplifier 5. The control grid 9 of the amplifier tube 8 is connected to the output electrode of the photocell 4. The cathode lead of the tube 8 includes an element consisting of a condenser 13 and a resistance 12 between the cathode 10 and the negative pole 11 of the source of potential. The anode of the tube is connected to a point 14 having positive potential. The image signals are taken off at point 14 and may be further amplified as is known in the art. The element consisting of the condenser 13 and resistance 12 has a time constant equal to the product $R \cdot C$ in which R is the resistance of element 13 and C the capacity of the condenser 13.

Experiments have shown that if the time constant of the logarithmic function 7 in Fig. 2 and the time constant of the elements 12, 13 are made equal a compensation of the disturbing afterglow signals can be obtained by applying the voltage across the elements 12, 13 additionally to the grid 9 of a tube 8.

The operation of the device will be better understood in connection with the following explanations: The voltage U_g of the photoelectric cell which is applied between grid 9 and the cathode of tube 8 contains two components. Equation 1 below shows that the voltage U_g consists of a value U_g^1 which is constant and corresponds to the brightness of the picture element and a second value U_g^2 (afterglow voltage) of an amplitude decreasing according to a logarithmic law

$$U_g = U_g^1 + U_g^2 \cdot e^{-\frac{t}{t_0}} \quad (1)$$

The voltage U_k produced at the ends of resistance 12 is used for compensating the second part of the voltage U_g , namely

$$U_g^2 \cdot e^{-\frac{t}{t_0}}$$

The equation for the anode current J_a is

$$J_a = S \cdot (U_g - U_k) = \frac{U_k}{R} + C \cdot \frac{dU_k}{dt} \quad (2)$$

in which S is the slope of the characteristic curve of the tube. Equation 2 gives in connection with Equation 1 a differential equation, the general solution of which is represented by Equation 3 in which U_a is the anode voltage expressed by the product $R \cdot J_a$.

$$U_a = U_g^1 \cdot \frac{R_a}{R + \frac{1}{S}} + U_g^2 \cdot R_a S \cdot \frac{\frac{1}{R} - \frac{1}{t_0}}{S + \frac{1}{R} - \frac{1}{t_0}} \cdot e^{-\frac{t}{t_0}} + R_a S e^{-\frac{t}{t_0}} \cdot \left[U_g^1 \cdot \frac{S}{S + \frac{1}{R}} + U_g^2 \cdot \frac{S}{S + \frac{1}{R} - \frac{1}{t_0}} - U_{k_0} \right] \quad (3)$$

Equation 3 shows that the afterglow is compensated in case the second member of the equation is equal to 0, i. e. if the equation

$$\frac{1}{R} - \frac{1}{t_0} = 0 \quad (4)$$

is fulfilled. Equation 4 can be expressed by the known formula $R \cdot C = t_0$. Equation 3 shows furthermore that the condition 4 alone does not suffice for exact compensation because a third member is present depending also from R and C . The third member represents an additional disturbing voltage resulting in an overcompensation. It is produced by the manner of compensation itself and must be kept as small as possible. If it is assumed that the disturbing voltage produced by the compensation and represented by the last member of Equation 3 has decreased after a time t_x to $1/e$ of its original value the expression

$$\left(\frac{S}{C} + \frac{1}{t_0} \right) \cdot t_x \geq 1 \quad (5)$$

must be fulfilled which is obtained by a simple transformation of the last member of Equation 3. As the value $1/t_0$ is positive and small in most

cases against S/C the Equation 5 can be written as follows:

$$\frac{S}{C} \cdot t_x \geq 1 \text{ bzw. } \frac{S/\frac{mA}{V}}{C/nF} \cdot t_x/\mu \text{ sec.} \geq 1 \quad (6)$$

The time t_x is made if possible not larger than the duration of an image point. Equation 6 means that the dimensioning of the RC element should be made in such a manner that the value of S/C is as large as possible, i. e. a tube with a steep slope S and a condenser 13 with small capacity C is used. It should be taken into consideration that the anode current and, for an indirectly heated cathode also the drop of voltage at the cathode resistance, i. e. the voltage between the filament and the effective cathode, should not be larger than a certain maximal value. The resistance R is therefore dependent upon the permissible operating characteristics of the tube 8. In consequence of the relation

$$\frac{S}{C} = \frac{S \cdot R}{t_0} \quad (7)$$

the value of C is dependent upon the type of the tube and therefore upon the value of S . Furthermore it can be seen that it is not sufficient to use a tube with a high value of S or a condenser with small capacity; the arrangement must be made in such a manner that the ratio S/C is as large as possible while at the same time the above mentioned conditions are fulfilled.

The effect of the circuit arrangement is represented in Fig. 4 in which the control voltage is represented as a function of time. If an impulse having the form of Fig. 4a is applied to grid 9 of tube 8 an anode current will flow charging the capacity 13 and producing a compensating voltage U_k having the form of Fig. 4b at the element 12, 13 of the circuit arrangement. The voltage U_a at the anode resistance will then have the form of Fig. 4c. It can be seen that the anode voltage U_a has in consequence of the arrangement of the compensating element an initial value which is larger than the control voltage. This means that an overcompensation is produced. If however Equation 6 is fulfilled the anode voltage is brought down after the time t_x to its original value and the further compensation of the afterglow takes place without being influenced by this component.

In the following examples the dimensioning of an amplifier stage is described. It is assumed that the time constant of the afterglow is equal to $t_0 = 10^{-4}$ sec.

(1) A commercial tube has, for example, an anode current $J_a = 40$ ma. and a slope $S = 9.5$ ma./v. If the voltage at the cathode resistance R is equal to $R \cdot J_a = 100$ v. the compensating resistance R may be maximally 2500 ohms (2500 ohms $\times$ 40 ma. = 100 v.) The formula $R \cdot C = t_0$ gives a capacity C of 40,000 pf. The ratio of S/C is in this case

$$2.4 \cdot 10^5 \frac{\text{amp.}}{\text{volt} \cdot \text{farad}}$$

(2) Another type of tube (pentode) has an anode current $J_a = 10$ ma. and a slope $S = 5$ ma./v. The voltage at the cathode resistance is 100 v. and the value of $R = 10,000$ ohms. This gives a value of $C = 10,000$ f. and for the ratio S/C a value of

$$5 \cdot 10^5 \frac{\text{amp.}}{\text{volt} \cdot \text{farad}}$$

The two embodiments show that it is not sufficient to use a tube with a large value of S but

that it is better to make the ratio S/C as large as possible. This condition is better obtained with a tube of embodiment 2 than with a tube of embodiment 1.

Fig. 2 shows that curve 6 is not exactly reproduced by the logarithmic curve 7. According to the invention the afterglow curve 6 is not reproduced by a single logarithmic curve but by a plurality of logarithmic curves. This case is represented in Fig. 2 by the two curves 15 and 16.

According to the invention the cathode leads of two successive amplifier stages contain compensating elements consisting of resistances and condensers which are so dimensioned in connection with the slope of the tubes that their time constants correspond to the time constants of curves 15 and 16.

An amplifier circuit of this type is represented in Fig. 5. The terminal 17 is connected to the output electrode of the photoelectric cell 4. The grid of tube 18 is connected to the terminal 17 and by way of a resistance to the cathode circuit 23 of this tube containing a resistance and condenser in parallel. The anode resistance 19 is connected by way of a condenser 20 to the grid of a second amplifier tube 21 having an output terminal 22. The cathode lead of the tube 21 contains also a resistance and a condenser in parallel forming a compensating element 24. The time constants of the elements 23 and 24 are so chosen that they correspond to the time constants of the curves 15 and 16 respectively in Fig. 2. The elements 23 and 24 are so dimensioned that the ratio of S/C is as large as possible.

The values for the various circuit elements of the arrangement of Fig. 5 are, for example, as follows: In both stages an amplifier tube is used having an anode current $J_a = 3$ ma. and a slope $S = 2.1$ ma./v. If with these tubes the voltage at the cathode resistance is $R \cdot J_a = 100$ v. the compensating resistance R will be equal to 33,000 ohms. The time constant t_0 of the two logarithmic curves represented in Fig. 2 by dotted lines are $t_0^1 = 3.4 \cdot 10^{-6}$ sec. and $t_0^2 = 17.9 \cdot 10^{-6}$ sec. From the known formula $R \cdot C = t_0$, it follows that the capacity C_1 of the element 23 is equal to 103 pf. and the capacity C_2 for the element 24 is equal to 543 pf. The ratio S/C for the element 23 is equal to $2.04 \cdot 10^7$ and for the element 24 equal to $3.87 \cdot 10^6$.

The afterglow curve 6 of Fig. 2 may also be reproduced by more than two logarithmic curves. In this case corresponding numbers of compensation elements are arranged in a corresponding number of amplifying stages and are dimensioned according to the invention. The invention is not limited to the use of compensating elements consisting of a resistance and a condenser in parallel. The compensating elements may be combinations of resistances, inductances and capacities producing a suitable compensating voltage. An amplifier of this type can not only be used for compensating the afterglow of television tubes but also for compensating disturbing voltages of other origin in amplifier and controlling arrangements.

In this specification the following units are used: the time constants, t_0 , t_0^1 , t_0^2 , are expressed in seconds, sec.; the slope, S , of the characteristic curve of the tube, in milliamperes per volt, ma./v.; the cathode resistance R , in ohms; voltages in volts; the capacities, C , C_1 and C_2 , of the compensating condensers in micro-microfarads, pf.; 75

and the ratios of the slope S to the capacities C , C_1 and C_2 in amperes per volt per farad,

$$\frac{\text{amp.}}{\text{volt} \cdot \text{farad}}$$

What I claim is:

1. A signaling system comprising an amplifier arrangement including an input circuit, means adapted to produce current including signaling components and disturbing signal components decreasing according to a fixed logarithmic law and feed said produced current to said input circuit, said amplifier also including a thermionic tube having anode, cathode and grid electrodes, a compensating element in the cathode lead of said tube, said element consisting of a condenser and a resistance connected in parallel, said element having a time constant equal to the time constant of said disturbing signal component.

2. A television light spot scanner including a cathode ray tube, having a luminescent screen, a photo-electric cell, a signal amplifier having a thermionic tube, an input circuit adapted to feed image signals and afterglow signals to the grid of said tube, a compensating element in the cathode lead of said tube, said element including a condenser and a resistance in parallel, said element having a time constant substantially equal to the time constant of the afterglow signal.

3. A signaling system comprising an amplifier arrangement including an input circuit, means adapted to produce current including signaling components and disturbing signal components decreasing according to a fixed composite logarithmic law and feed said produced current to said input circuit, said amplifier arrangement also including a plurality of amplifier stages including each a thermionic tube having anode, cathode and grid electrodes, a plurality of different compensating elements, arranged separately in the cathode leads of said tubes, each compensating element including a condenser and a resistance in parallel, each element having a time constant equal to that of a logarithmic component of said composite logarithmic law.

4. A television system comprising a cathode ray tube having a fluorescent screen which produces afterglow decreasing according to a composite logarithmic function, means to cause the beam of said tube to scan said screen at uniform intensity, means to illuminate an object in accordance with the pattern of illumination emanating from said scanned screen, a photo-electric cell energized by light received from said object, an amplifier including a plurality of amplifying stages having each a thermionic tube with cathode, anode and control electrode, means to impress television signals from said cell on the cathode and control electrode of the first stage of said amplifier, a compensating circuit in the cathode lead of one of said tubes including a resistance and a condenser connected in parallel having a time constant equal to that of one of the components of said composite logarithmic function, and a second compensating circuit in the cathode lead of another of said tubes including a resistance and condenser connected in parallel having a time constant equal to another of the components of said composite logarithmic function.

5. A television system comprising a cathode ray tube having a fluorescent screen which produces afterglow decreasing according to a composite logarithmic function, means to cause the beam of said tube to scan said screen at uniform

intensity, means to illuminate an object in accordance with the pattern of illumination emanating from said scanned screen, a photoelectric cell energized by light received from said object, an amplifier including a plurality of amplifying stages having each a thermionic tube with cathode, anode and control electrode, means to impress television signals from said cell on the cathode and control electrode of the first stage of said amplifier, a compensating circuit in the cathode lead of one of said tubes including a resistance and a condenser connected in parallel having a time constant equal to that of one of the components of said composite logarithmic function, and a second compensating circuit in the cathode lead of another of said

tubes including a resistance and condenser connected in parallel having a time constant equal to another of the components of said composite logarithmic function, said condensers respectively being so proportioned with respect to the slopes of the characteristic curves of the associated tubes that

$$\frac{S \text{ in mA. per V.}}{C \text{ in nF.}} \cdot t_s \text{ in } \mu \text{ sec} \geq 1$$

where S is the slope of the characteristic curve of the associated tube, C is the capacity of the condenser in microfarads and t_s is the time allotted to the scanning of one elemental area in microseconds.

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