Jan. 18, 1938. E. H. HANSEN 2,105,769

METHOD AND MEANS FOR ELECTRO-PHOTOGRAPHICALLY RECORDING SOUND

Filed May 4, 1931 2 Sheets-Sheet 1

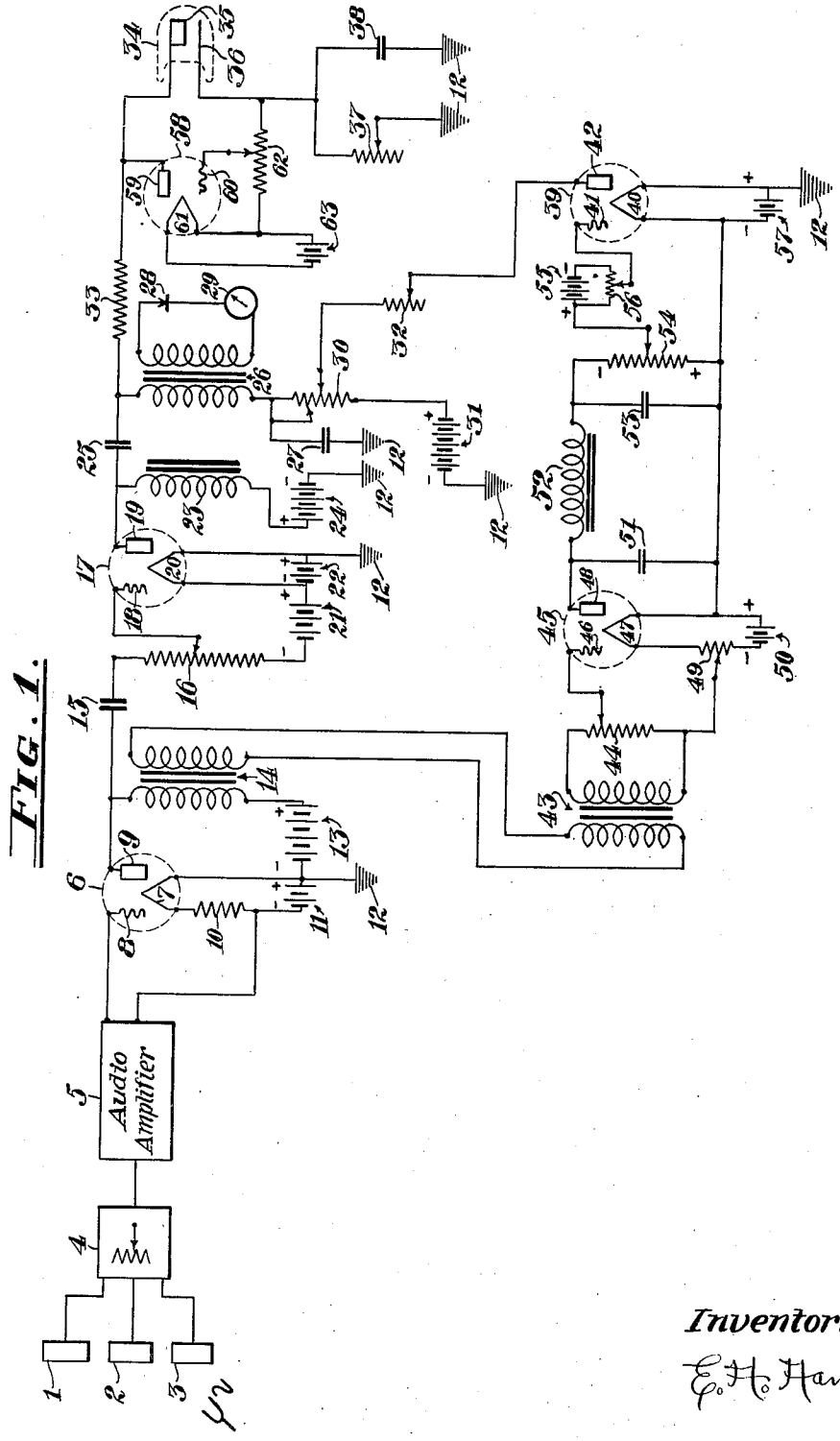


FIG. 1.

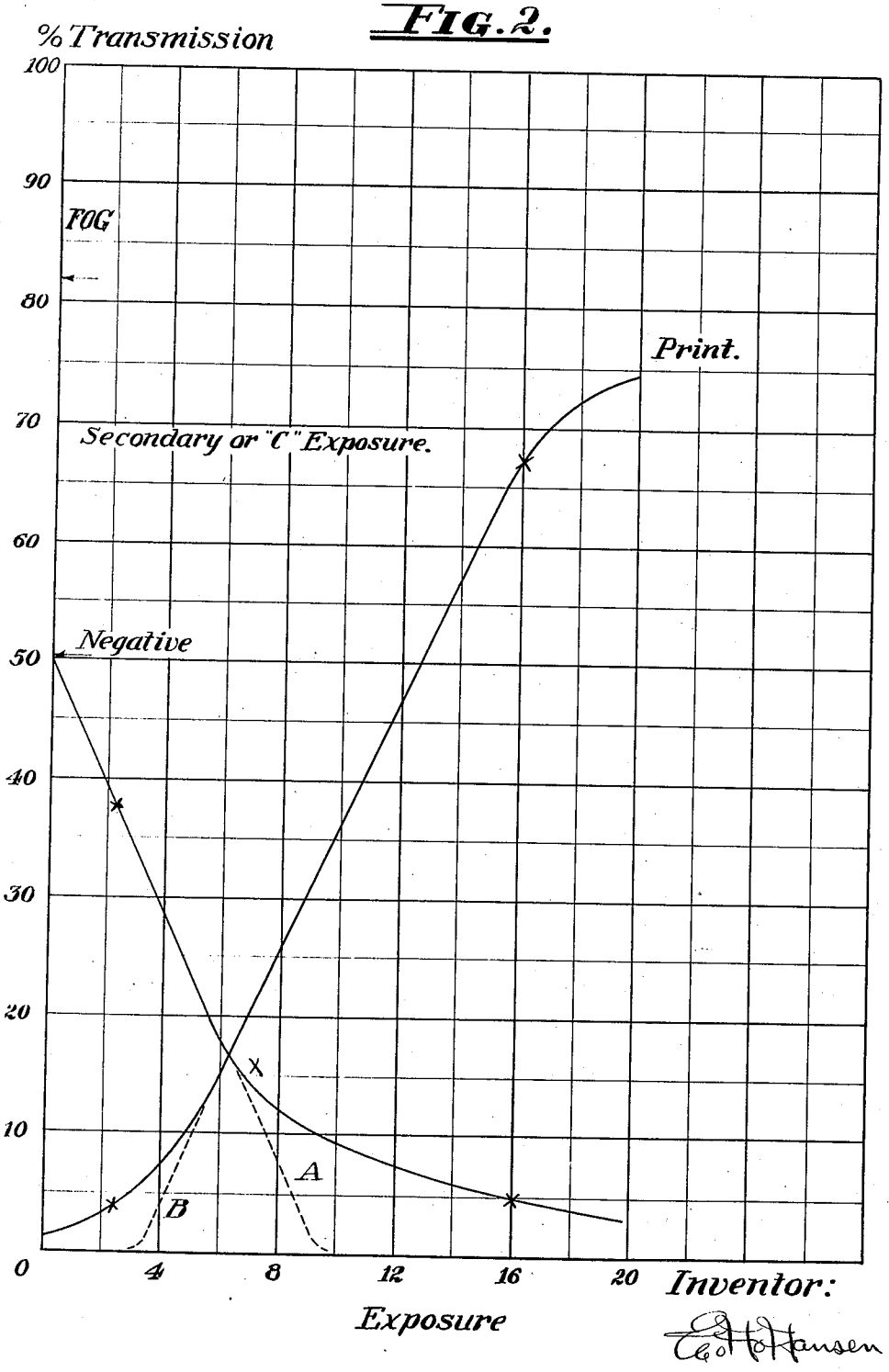
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METHOD AND MEANS FOR ELECTRO-PHOTOGRAPHICALLY RECORDING SOUND

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FIG. 2.



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Patented Jan. 18, 1938

2,105,769

UNITED STATES PATENT OFFICE

2,105,769

METHOD AND MEANS FOR ELECTRO-PHOTOGRAPHICALLY RECORDING SOUND

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Application May 4, 1931, Serial No. 535,054

21 Claims. (Cl. 179—100.3)

This invention relates to the art of electro-photographically recording sound, and is directed principally to an improvement in the variable density method. However to those skilled in the art various adaptations to the variable area method employing either a shutter or an oscillograph will be obvious.

In the recording of sound by the variable density method, one of the usual methods is to employ a glow lamp and expose a light sensitive film to varying intensities of the glow lamp. In practice, the glow lamp is excited by a composite current which is composed of a direct current having a fixed potential that forms the unmodulated portion of the sound track and may be termed the glow lamp direct current component and an alternating current superposed on the direct current. The alternating current carries the sound modulations affected by a microphone and amplified through a conventional amplifying system and forms the modulated portion of the sound track. It thus becomes obvious that the sound striations formed on the sound track are the result of two component light intensities, namely; the intensity of the glow lamp caused by the direct current which is uniform and the variable intensity caused by the speech current. The purpose of this invention is to control the composite current flowing through the glow lamp by means of the speech current to compensate for non-linear response of film emulsions to light intensities as the speech current drops below a certain level.

Accordingly this invention deals with the characteristics resulting from exposing an emulsion on films to light. The work of Huerter and Driffield shows that in exposing film to light the results are not uniform. A curve plotted with densities as ordinates and the logarithm of the time of exposure as abscissae is not a straight line but has what is known as a toe and shoulder portion; the toe portion being that portion which may be said to be due to underexposure and the shoulder portion being due to overexposure. Between the shoulder and the toe portion there is a substantially straight line portion having an angle with the abscissae which in the art is known as gamma. Up to the present time, exposures have been confined to the straight portions of the curve, which results in a linear response of density to intensity of light exposure. In so far as I know no one has shown a method or a means for utilizing the toe portion of the curve in conjunction with the straight line portion. This invention provides a method and means for this purpose. As a means toward this end I provide a distortion tube which is used as a shunt path around the glow lamp and operates to control the current flowing through the glow lamp so that it becomes possible to extend the working range of exposure on films into the so-called toe portion of the curve and maintain substantially linear characteristics throughout the entire range of exposure. The result is that the heretofore underexposed portion of the negative film which corresponds to the toe portion shown in the Huerter and Driffield curve above mentioned may be utilized when properly printed for low intensity sound and avoid the objection of back ground noise. It accordingly becomes an object of this invention to provide a method and means for extending the working range of exposure in a light sensitive film from the straight line portion of the curve into the under exposed portion and maintain substantial linear characteristics throughout the entire range of exposure. Other objects and advantages will become apparent as the description proceeds in conjunction with the drawings in which:

Figure 1 is a diagrammatic illustration showing the application of my invention in electro-optically recording sound;

Figure 2 is curve showing the characteristics of a negative and positive produced under the method disclosed in this invention.

With this sound recording system there is employed the conventional sound pickup device, such as, condenser or carbon microphones 1, 2, and 3, shown in Figure 1, which are balanced and mixed in a mixing device 4. From this point they pass through an audio amplifier 5 of sufficient gain to an intermediate stage as illustrated by the vacuum tube 6. The plate circuit of this tube 6 is energized from the battery 13 through the primary winding of the coupling transformer 14. The alternating current path from plate 9 passes through condenser 15 to a potentiometer 16 and thence to the grid 18 of a vacuum tube 17, the other leg being through the ground 12. Vacuum tube 17 is a final power stage capable of supplying sufficient power through a condenser 25 and a ballast resistor 33 to modulate the glow lamp 34 to the extent of the polarizing current flowing therein.

The energy for the plate of the vacuum tube 17 is supplied through an impedance 23 from a battery 24, having its negative leg grounded at 12. The alternating current path supplied across glow lamp 34 is completed through an alternating

current ground consisting of a condenser 38 and the ground 12. The secondary of transformer 14, which is coupled to the plate circuit of the intermediate tube 6, passes through a further coupling transformer 43 to a control potentiometer 44, which in turn controls the amount of alternating current on the grid 46 of a rectifying tube 45, the other leg of the circuit being through the resistor 49 and the battery 50. The output of this tube is further rectified by the action of the filter circuit consisting of condensers 51 and 53, and a reactance 52, and passes through the potentiometer 54, (the voltage across the terminals of the potentiometer 54 being practically pure direct current), then through potentiometer 56, controlling potential 55 and thence to control grid 41 of a tube 39. The polarizing voltage across the glow lamp 34 is supplied by a battery 31, having its negative terminal grounded at 12. The positive side of battery 31 flows through a balancing resistor 30, the primary of a volume indicating device 26, the ballast resistor 33, the plate and filament circuit of the glow lamp 34, and a leakage resistor 37, back to the ground 12. The control of this circuit is accomplished by varying the internal resistance of the tube 39 by means of the grid 41 which is biased by a rectified part of the speech current so that a speech controlled shunt path is provided from the positive side of the battery 31 to the ground through a tap from the resistor 30, a variable compensating resistor 32, the plate 42 of the tube 39, the filament 40 of the tube 39 and thence to the ground 12. The tube 39 under this arrangement operates to shunt a part of the glow lamp direct current component from the battery 31 when the speech current is low.

One of the objectives of this method of recording being to reduce the inherent ground noise of the reproducing film, this ground noise as before stated consisting of emulsion grain, dirt and dust accumlating thereon in the process, scratches and other ramifications of a like nature, this sound recording system is so arranged that during periods of silence the unmodulated portion corresponding to the illumination emitted from the direct current component only is high in transmission, and during varying levels of impressed alternating current, and as representing the increase in sound, this unmodulated portion becomes increasingly darker and lower in transmission. The print therefrom will have during silent portions a sound track which permits a very small portion of the exciting lamp illumination to be transmitted through the film to the photo-cell, in other words, the density of the print will increase during silent periods and decrease during periods of modulation. The amount of swing is dependent upon the photographic characteristics of the film, and also upon the development. This swing will be previously determined, and the proper value of polarizing voltage for the point of no sound and the point of greater sound will be determined and set. Inasmuch as the polarizing voltage must be of a certain value for the impressed alternating current voltage, this is an operation of extreme importance.

At the present time with the glow lamp the fixed polarizing voltage is such that during the unmodulated portions of recording, a transmission of between 40 and 50 per cent is obtained when using positive stock for negative purposes. In making a print there is practically a one-to-one transfer with a resultant print transmission of the same value as the negative. In the adjustment of the circuit, as shown on Figure 1, a proper minimum current, or zero current, and a proper maximum current has been previously determined. At the time of no special modulation, the direct current component in the glow lamp will be that of the zero current, and at the time of maximum modulation it will be at a maximum current value. As before stated the control tube 39 is used as a shunt path for the direct current flowing in the glow lamp. When the negative bias on the grid of this tube is small, most of the current instead of flowing into the flashing lamp circuit is by-passed by this tube to the minus B terminal. When the bias on this tube becomes more negative, the shunt path has higher resistance and more of the current will flow through the glow lamp. The bias of the control tube 39 is in turn controlled by the plate current of tube 45. This plate current depends upon the amount of signal supplied to the grid 46, through the transformer couplings 43 and 14, the transformer coupling 14 being shunted across the alternating current path of the main amplifier. During the silent intervals there is no alternating current voltage applied to the grid of tube 45, but a certain amount of plate current does flow, however, the amount depending entirely upon the setting of the potentiometer 44. The grid voltage on tube 39 depends upon the plate current in the tube 45, and also upon the bias controllable through potentiometer 56. Potentiometer 56 can be adjusted in such a way that the current through the glow lamp is a specified zero current. When an alternating current is flowing in the plate circuit of tube 6, and proceeds in two directions, most of it goes to the grid of the power amplifier tube 17, and from there through the alternating current path provided to the glow lamp, and a small part of it passes through the transformer coupling consisting of transformers 14 and 43. There is an increase in the plate current of tube 45, which after a delay dependent upon the constants of the filters 51, 52, and 53 changes the bias on the grid of tube 39, and this in turn changes the plate to filament resistance, thus controlling the direct current component flowing through the glow lamp 34. The amount of change in the direct current component flowing through the glow lamp 34 will thus be seen to depend upon the strength of the alternating current flowing, also on the setting of the control potentiometers 44, 54, and 56.

The characteristic photographic curves of the negative and print produced by my invention is shown in Figure 2. It will be noticed that due to the residual direct current in the glow lamp, at no time does the transmission of the negative fall below a pre-determined value. It will also be observed that in printing there is a compensation of the curve portion of the photographic characteristics so that there is a resultant non-distorted print produced. In order to accomplish this, it is necessary to swing the lower portion of the negative in such a way that the product of the slope between the negative and positive will be unity. In order to accomplish this I provide what may be termed a distortion tube 58 shunted across the glow tube 34. This tube has its element connected in shunt with the anode and cathode of the glow tube 34. Means are provided for varying the internal resistance of the tube 58 so that when the current in the glow lamp 34 reaches an optimum the resistance from the plate

59 to the filament 61 of the tube 58 decreases rapidly, thus causing an absorption of current from the glow lamp proportionate to the change in impedance, in the circuit through plate 59 and filament 61. The control of tube 58 is accomplished through grid 60, which is adjusted through a potentiometer 62 so that a high impedance exists in the plate to filament circuit until the resulting density of the negative reaches that part of the characteristic curve designated X shown in Figure 2, or in other words until the negative film characteristic fails to compensate for the print curvature. As shown in Figure 2 the result is a swing in the characteristic curve of the negative film which corresponds to the dotted portion shown at A. This curvature when the negative is printed produces a print having linear characteristic throughout the range of exposure including both the straight line portion of the characteristic curve and the toe portion.

Another object of this invention is to produce a negative having the characteristics resulting from practicing my invention.

Although I have shown and described my invention as embodying specific means for practicing my invention nevertheless I am aware that various modifications may be made therein without departing from the inventive principle involved. I therefore intend this inclosure to include all such alterations and refinements as do not depart from the scope of the disclosure and the essence of the invention as expressed in the appended claims.

I claim:

1. A method for electro-photographically recording sound wherein a glow lamp is excited by a speech modulated alternating current and a direct current component consisting in: modulating the direct current component proportionally to the envelope of the alternating component, and progressively decreasing the amount of current flowing through said glow lamp as the modulated alternating current passes a predetermined level.

2. In a system for electro-photographically recording sound: a glow lamp; means for supplying said glow lamp with a speech modulated alternating current; means for supplying a direct current component to said glow lamp, and means for absorbing progressively decreased portions of said direct current component before it passes through said glow lamp as the speech modulated alternating current component passes a predetermined level.

3. In a system for electro-photographically recording sound: a glow lamp; means for supplying said glow lamp with a composite current comprising a speech modulated alternating current component and a direct current component, and means for by-passing progressively decreased portions of said composite current around said glow lamp as the speech modulated alternating current component passes a predetermined level.

4. In a system for electro-photographically recording sound: a glow lamp; means for supplying said glow lamp with a composite current comprising a speech modulated alternating current component and a direct current component, and means controlled by the current flowing through said glow lamp for by-passing progressively decreased portions of said current around said glow lamp when said current reaches a predetermined value.

5. In a system for electro-photographically recording sound: a glow lamp; means for supplying said glow lamp with a composite current comprising a speech modulated alternating current component and a direct current component; an impedance connected in parallel with said lamp and means for varying the value of said impedance by the current flowing through said glow lamp to progressively decrease the value of said impedance when the current flowing through said glow lamp reaches a predetermined level.

6. In a system for electro-photographically recording sound: a glow lamp; means for supplying said glow lamp with a composite current comprising a speech modulated alternating current component and a direct current component, and a triode shunted across said lamp and means for varying the internal impedance of said triode to bypass current around said lamp, said triode being arranged to pass progressively increased portions of said composite current when the current flowing through the glow lamp reaches a predetermined level.

7. In a system for electro-photographically recording sound: a glow lamp; means for supplying said glow lamp with a composite current comprising a speech modulated alternating current component and a direct current component, and a triode having its plate to filament circuit connected in parallel with said lamp and means for varying the impedance in said circuit when the current flowing through said lamp reaches a predetermined value to pass progressively increased portions of said composite current.

8. In a system for electro-photographically recording sound embodying a glow lamp supplied with a speech modulated alternating current and a direct current component the combination of: means for controlling the value of said direct current component by said speech current, and means for controlling the composite current flowing through said glow lamp to progressively decrease the current flowing through said glow lamp when said composite current reaches a predetermined level.

9. In a system for electro-photographically recording sound: a glow lamp; means for supplying said glow lamp with a composite current comprising a speech modulated alternating current component and a direct current component, and means for controlling the current flowing through said glow lamp to progressively decrease the effective value of said current when said composite current reaches a predetermined value.

10. In a system for electro-photographically recording sound: a glow lamp; means for supplying said glow lamp with a speech modulated alternating and a steady direct current, and means for diverting portions of the composite current before it passes through said glow lamp proportionally to the amount of speech modulated alternating current passing through said lamp.

11. In a system for electro-optically recording sound: a glow lamp; means for supplying said glow lamp with a speech modulated alternating current; a steady source of direct current connected to said lamp; a triode having its plate also connected to said source of direct current, and means for supplying a rectified portion of said speech current to the grid of said triode to vary the internal impedance of said triode to pass a modulated mean amplitude current from the direct current source around said glow lamp.

12. A method for electro-optically photographing sound wherein a glow lamp is excited by a speech modulated alternating current and a direct current component consisting in: regulating the amount of current flowing through said glow lamp by progressively decreasing the same after it passes a predetermined value.

13. A method for electro-photographically recording sound wherein a glow lamp is excited by a speech modulated alternating current and a direct current component consisting in: utilizing the exciting current flowing through said glow lamp to progressively decrease the same after it passes a predetermined value.

14. A method for electro-photographically recording sound wherein a glow lamp is excited by a speech modulated alternating current and a direct current component consisting in: feeding the composite current to a recording path and a variable shunt resistance path and controlling the value of the resistance path by the amount of current passing through said recording path to by pass progressively increased portions of said composite current through said resistance path when the composite current reaches a predetermined value.

15. A method for electro-photographically recording sound wherein a glow lamp is excited by a speech modulated alternating current and a constant direct current component consisting in: by-passing portions of said direct current and said speech modulated alternating current so as to progressively decrease the effective strength of each after their combined strength passes a predetermined value.

16. In a system for electro-photographically recording sound: a glow lamp; means for supplying said glow lamp with a composite current comprising a speech modulated alternating current and a direct current component; a triode having its plate to filament circuit connected in parallel with said glow lamp and means for connecting the grid of said triode in said lamp circuit so that the grid will be biased by the current flowing through said lamp.

17. Apparatus for use in sound recording comprising a photographic recording surface having at least a portion of its characteristic curved, a recording device, a signal to be recorded, and means to by-pass said signal at intensity levels corresponding to the curved portion of said emulsion characteristic to produce the effect of an over-all straight line characteristic.

18. A method for electro-photographically recording sound wherein a glow lamp is excited by a speech modulated alternating current and a direct current component consisting in: modulating the direct current component proportionally to the amount of the alternating component and regulating the amount of current flowing through the glow lamp to compensate for non-linear response of a light sensitive film to light exposure.

19. In a system for electro-photographically recording sound: a glow lamp; means for supplying said glow lamp with a composite current comprising a speech modulated alternating current component and a direct current component, and means for by-passing a portion of said composite current around said glow lamp to compensate for non-linear response of a light sensitive film to varying light intensities of said glow lamp.

20. In a system for electro-photographically recording sound embodying a glow lamp supplied with a speech modulated alternating current and a direct current component the combination of: means for controlling the value of said direct current component by said speech current, and means for controlling the composite current flowing through said glow lamp to compensate for the non-linear response of a light sensitive film to varying light intensities of said glow lamp.

21. In a system for electro-photographically recording sound: a glow lamp; means for supplying said glow lamp with a composite current comprising a speech modulated alternating current component and a direct current component, and means for controlling the current flowing through said glow lamp to compensate for non-linear response of light sensitive films to varying light intensities.

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