

Jan. 21, 1947.

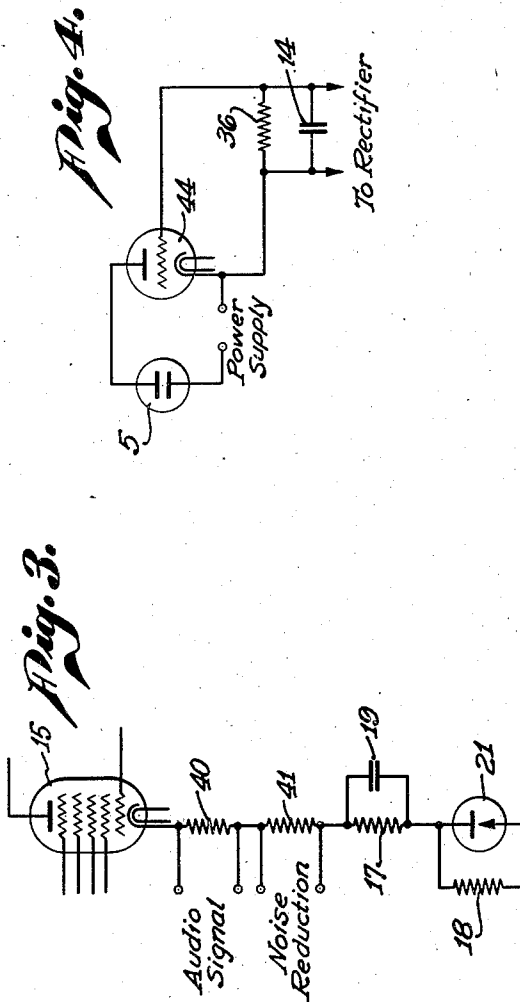
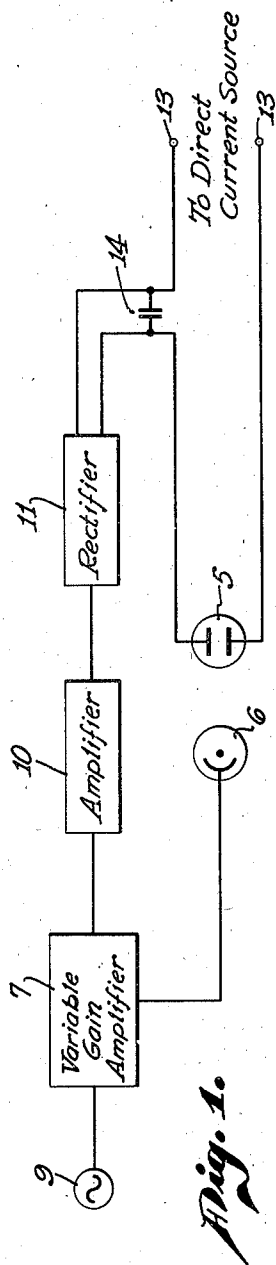
A. BADMAIEFF

2,414,686

ELECTRO-OPTICAL FEEDBACK SYSTEM

Filed Nov. 30, 1942

2 Sheets-Sheet 1



ALEXIS BADMAIEFF,
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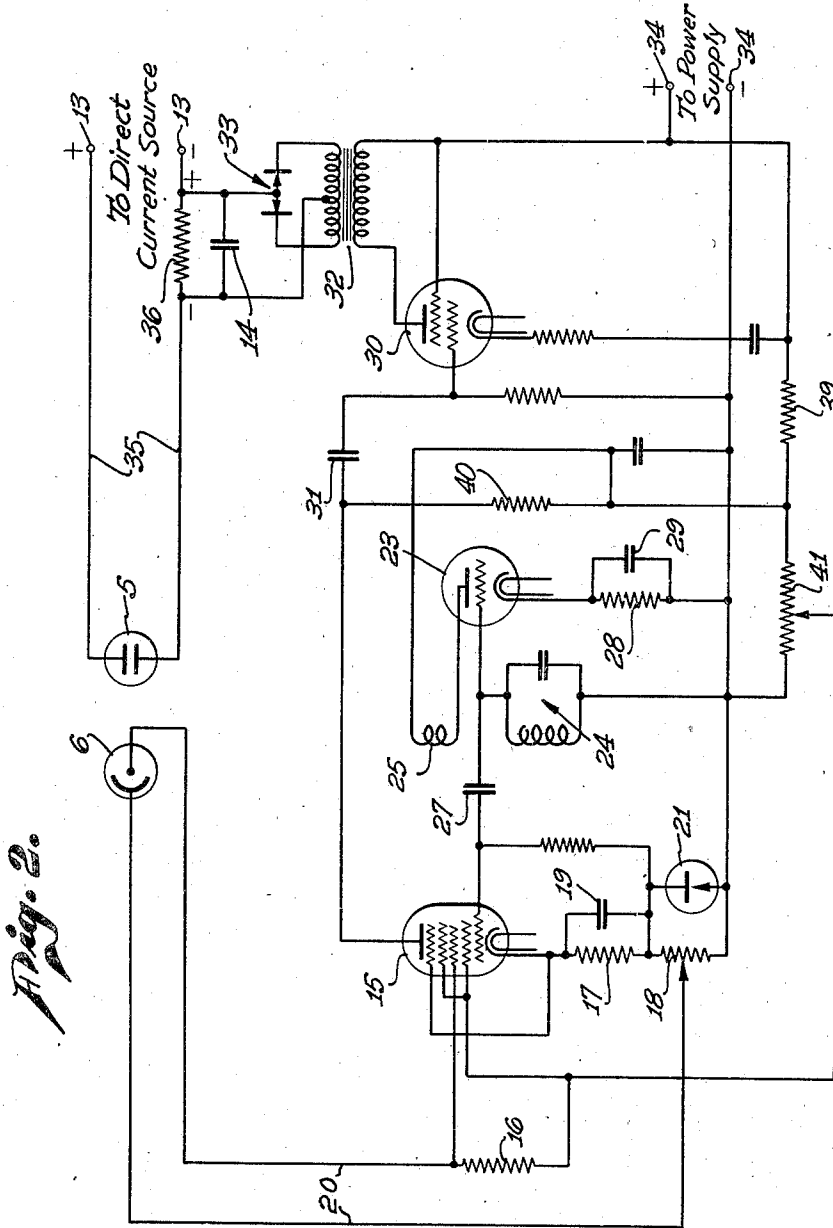
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2 Sheets-Sheet 2



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2,414,686

ELECTROOPTICAL FEEDBACK SYSTEM

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13 Claims. (Cl. 250—41.5)

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This invention relates to photographic sound recording and reproducing systems and particularly to a system for stabilizing the light sources used in such systems.

It is well known that in photographic sound recording systems, light sources such as lamps are employed to produce light beams which may be either directly modulated by varying the energy supplied to the lamps in accordance with sound waves to be recorded or which may be modulated by vibrating the beam in accordance with the sound waves. Light sources of constant intensity are used for recording both variable area and variable density sound tracks, the light beam being vibrated by a galvanometer mirror. Light sources which vary in intensity are, however, usually employed for recording variable density records. For reproducing either type of record, a light source of constant intensity is used to produce the scanning beam. In all cases, however, the light output of the source should remain constant and uniform during the recording or reproducing period to prevent undesired variations in the sound levels and the introduction of distortion in the recorded or reproduced sound.

The present invention is directed to a feedback circuit which will compensate for variations in the light intensity due to variations in the supply energy, blackening of the lamp envelope, deterioration in the light producing elements of the lamp or anything tending to change the light intensity from a predetermined value. Systems of this general type are known in the art, one being disclosed in Balsley Patent No. 2,242,638 of May 20, 1941. In this patent the electrical energy for the lamp is connected in series with a vacuum tube, the impedance of which is varied by the variations in light intensity, thus providing direct current feedback. In this arrangement, the amount of energy which can be supplied to the light source is limited by the size of the vacuum tube in series with it. Another light source stabilizing system is disclosed and claimed in Collins Patent No. 2,274,530 of February 24, 1942, in which an opening in a shutter is controlled by the light intensity.

The present invention is directed to a light stabilizing system which utilizes two sources of energy for the light source, one being a primary source and the other a source varying in accordance with lamp intensity to compensate for variations in the light output of the lamp. Since these energy sources are connected in series and the primary source supplies the major amount

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of energy, the control circuit may be used for lamps having a wide range of light outputs.

Another feature of the invention is the use of an oscillator as the secondary source of energy, the rectified output thereof being controlled by the fluctuations in light output of the lamp source. This provides a sensitive and quick acting control of the energy supplied to the lamp while amplification of the detected variations is simple and efficient.

The principal object of the invention, therefore, is to improve optical feedback stabilizing systems for light sources.

Another object of the invention is to provide an optical feedback stabilizing system which is applicable to light sources of different capacities.

A further object of the invention is to provide an optical feedback system for stabilizing a light source which is capable of responding to rapid changes in light output as well as to slow variations therein.

A further object of the invention is to provide an optical feedback system for stabilizing a light source which utilizes a high frequency oscillator whose output is varied in accordance with the variations in the light intensity of said source.

Although the novel features which are believed to be characteristic of this invention are pointed out with particularity in the claims appended herewith, the manner of its organization and the mode of its operation will be better understood by referring to the following description, read in conjunction with the accompanying drawings, in which:

Figure 1 is a block diagram of a light stabilizing system embodying the invention;

Figure 2 is a schematic circuit diagram of the system of Fig. 1; and

Figs. 3 and 4 are schematic diagrams of modification details of the circuit of Fig. 2.

Referring now to Fig. 1, a light source 5 of the two electrode gaseous type is adapted to have its light output maintained constant. A portion of the light from the source 5 is detected by a photoelectric cell 6, the output of which is impressed on a variable gain amplifier 7. The input to the variable gain amplifier 7 is connected to an oscillator 9 while the output is connected to a power amplifier 10. The output current from the amplifier 10 is rectified by a rectifier 11 and then impressed upon the light source 5 in series with a primary direct current power source connected across terminals 13, the output of rectifier 11 being filtered by a condenser 14. In general, therefore, the light source 5 is sup-

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plied with energy from both a fixed primary direct current source and a controllable secondary source, the latter being the oscillator 9, the output of which is rectified by the rectifier 11. Should the light quanta of lamp 5 decrease, the gain of the variable gain amplifier 7 is increased by the decreased output from cell 6, and the rectifier 11 increases its energy supply to the lamp 5. Should the light quanta from lamp 5 increase, the rectifier output is proportionally decreased to return the lamp to its predetermined adjustment.

In Fig. 2 the details of the system of Fig. 1 are shown, the light source 5 illuminating photo-cell 6 as in Fig. 1. In this circuit the photoelectric cell 6 is connected over conductors 20 to the input of a variable gain amplifier tube 15 across an input resistance 16. Biasing resistance 17 shunted by a by-pass condenser 19 are shown in the cathode return circuit while a resistance 18 is provided with a variable tap for controlling the output of cell 6. The resistance 18 is shunted by a voltage regulator tube 21.

An oscillator 23 with its tank circuit 24 and feedback inductance 25 is coupled through condenser 27 to the control grid of tube 15. The oscillator is provided with a biasing resistor 28 shunted by a by-pass condenser 29. The output of the tube 15 is impressed, through condenser 31, upon a power amplifier tube 30, the output of amplifier 30 being connected to the primary of a transformer 32. The low impedance secondary of transformer 32 is connected to any suitable type of rectifier 33 such as RCA type 5Z4 or a full-wave Rectox dry rectifier, the rectifier being loaded by a resistance 36 which is in series with conductors 35 of the main direct current supply source connected across terminals 13. The amplifiers 15 and 30 and oscillator 23 are supplied with plate potentials from any suitable direct current supply source connectable to terminals 34 over potentiometer resistances 39 and 41, as is standard practice, resistance 41 being tapped to vary the anode potential on cell 6.

From the above it is to be noted that the oscillator 23 normally supplies a constant output to the amplifier 15 which produces a certain voltage across resistance 36 in series with the main direct current supply source connected at terminals 13. To prevent any oscillator ripple reaching the voltage supply to cause fluctuations in the light source, the oscillator frequency is preferably adjusted to be in the neighborhood of 20,000 cycles, which frequency is doubled by the full-wave rectifier and filtered by condenser 14. Any frequency between 15,000 and 100,000 cycles will be satisfactory, however, the high frequency limit being that fixed by the distributed capacity in the rectifier if it is a dry disc type. The voltage created across resistance 36 is additive to that connected across terminals 13 so that the sum of voltages of each source is applied to the lamp 5.

Now, should the light falling on cell 6 from lamp 5 decrease in quanta, the gain of amplifier 15 is increased by the decreased output of cell 6 and the increased output of amplifier 15 is impressed upon power amplifier 30 which increases the rectified output of the rectifier 33. The increased output of the rectifier increases the voltage across resistance 36, thus supplying more energy to the lamp 5 to compensate for the decrease in light quanta. Likewise, any increase in light output due to an increase in voltage across terminals 13 or for other reasons, will

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decrease the gain of amplifier 15 which will correspondingly decrease the voltage across resistance 36 to bring the lamp 5 back to its normal output.

In the above system the voltage variations obtained across resistor 36 will follow either slow or fast changes in the light variations falling on the photoelectric cell 6 and the system will, therefore, respond to both alternating current and direct current components, to provide a particularly sensitive stabilizing system. By utilizing the light output of the lamp for controlling its output, the system will function regardless of whether or not the cause of the variations in light are due to energy variations in the primary source, blackening of the lamp envelope or other reasons. Furthermore, since the major portion of the energy for the lamp is from an independent source, lamps having a wide range of capacities may be controlled.

Referring now to Fig. 3, the input circuit of variable gain amplifier tube 15 is shown as including resistances 40 and 41 in the cathode circuit. With this modification of Fig. 2, the lamp 5 may be both modulated with an audio signal across resistance 40 and a noise reduction signal applied across resistance 41, for sound recording purposes. Stabilization and a reduction of harmonic distortion due to non-linearity of the lamp will be obtained during recording by the optical negative feedback action as described above.

In Fig. 4 a power tube 44 is shown connected between the lamp 5 and the rectifier load resistance 36 and in series with the primary source of power. The power tube 44 functions as a variable resistor in series with the lamp to control it. It is to be understood that with a sufficiently large secondary power source the primary source across terminals 13 may be eliminated. Furthermore, with a heated filament type of lamp 5 the rectifier may be eliminated since the filament will not be sensitive to polarity reversals and if the frequency is high enough, the filament will not follow the oscillator frequency.

I claim as my invention:

1. The method of controlling the light quanta from a light source comprising energizing said light source from a circuit including a direct current energy supply, translating a portion of the light from said light source into corresponding electrical voltages, generating from a separate energy supply a substantially constant amplitude high frequency current for further energizing said light source circuit, amplifying said high frequency current and controlling by said translated voltages the amplification and impression of said high frequency current on said light source circuit to maintain said light quanta at a substantially constant value.

2. The method of maintaining the light output of a light source substantially constant comprising energizing said light source from a circuit including a direct current source of energy, generating from a separate energy source a high frequency current of substantially constant amplitude, amplifying said high frequency current, rectifying said high frequency current, impressing the products of rectification on said light source circuit, translating a portion of the light from said source into electrical voltages, and controlling by said translated voltages the amplification of said high frequency current and the amplitude of the products of rectification to main-

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tain said light output at a substantially constant value.

3. The method of maintaining the light output of a light source substantially constant comprising energizing said light source from a circuit including a direct current source of energy, generating from a separate energy source a high frequency current of substantially constant amplitude, amplifying said high frequency current, rectifying said high frequency current, further energizing said light source with said rectified current, detecting a portion of the light output of said light source, and controlling the amplification of said high frequency current with said detected light variations in a direction and in an amount to maintain the light output of said light source substantially constant.

4. The method in accordance with claim 3, in which the frequency of said high frequency current is above 15,000 cycles and below 100,000 cycles.

5. The method in accordance with claim 3, in which the light output of said light source is modulated by audio signals.

6. A light source stabilizing system comprising a light source, a direct current source of energy for said light source, a rectifier having its output connected in series with said source of energy and said light source, a separate source of energy comprising an oscillator, an amplifier connected between the output of said oscillator and the input of said rectifier, and means connected to the input of said amplifier for translating a portion of the light from said light source into corresponding electrical voltages for controlling the gain of said amplifier and the amplification of the output of said oscillator as impressed on said rectifier, variations in said translated light producing inverse variations in the energy supplied to said light source from said oscillator.

7. A light source stabilizing system in accordance with claim 6, in which said high frequency oscillator generates currents of approximately 20,000 cycles.

8. A stabilizing system for a light source comprising a light source, a direct current source of energy for said light source, a separate source of alternating current energy, means connecting

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said alternating current source of energy and said light source for rectifying said alternating current source of energy before impression on said light source, means for detecting light from said source, an amplifier connected intermediate said source of alternating current energy and said rectifying means and adapted to amplify said alternating current before impression on said rectifying means, and means interconnecting said light detecting means and said amplifier for controlling the gain of said amplifier by the output voltage of said detecting means.

9. A stabilizing system in accordance with claim 8, in which said alternating current source is a relatively high frequency oscillator adapted to generate currents of frequencies between 15,000 and 100,000 cycles.

10. A stabilizing system in accordance with claim 8, in which means are provided for impressing an audio signal on said amplifier for modulating said light source.

11. An optical feedback system for stabilizing a light source comprising a light source, means for translating a portion of the light from said source into electrical voltages, a direct current energy source connected to said light source, separate means for independently generating an alternating current, means for rectifying said alternating current, means for further energizing said light source with said rectified current, said rectifying means interconnecting said last mentioned means and said generating means, and means connected intermediate said translating means and said generating means for varying the amplification of said alternating current and thereby controlling the amount of said rectified current utilized for energizing said light source.

12. An optical feedback system in accordance with claim 11, in which said generating means includes a relatively high frequency oscillator generating currents of approximately 20,000 kilocycles.

13. An optical feedback system in accordance with claim 11, in which said last mentioned means includes means for impressing a signal thereon for modulating said light source.

ALEXIS BADMAIEFF.