May 9, 1939. W. J. ALBERSHEIM ET AL 2,157,880

RECORDING SYSTEM

Filed Dec. 3, 1937

FIG. 1

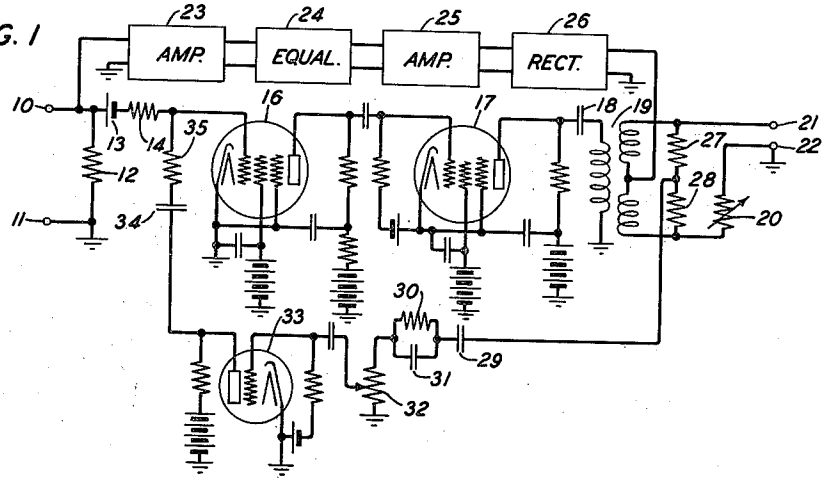


FIG. 2

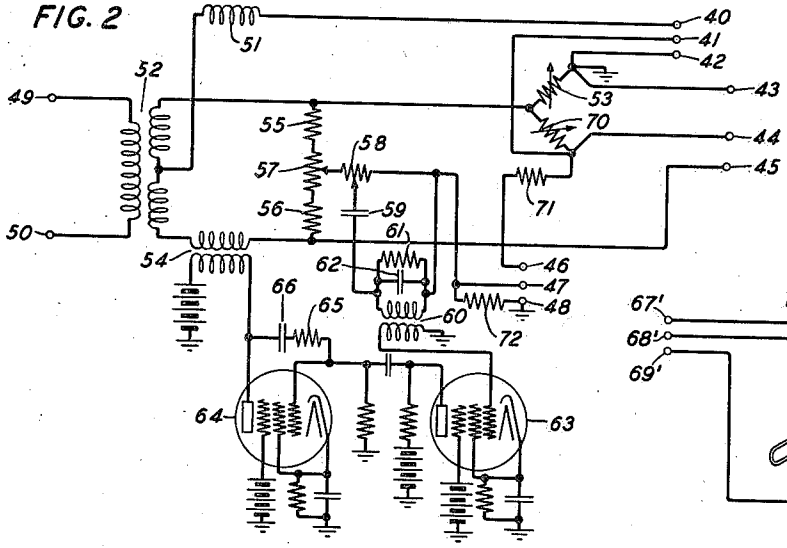


FIG. 4

FIG. 3

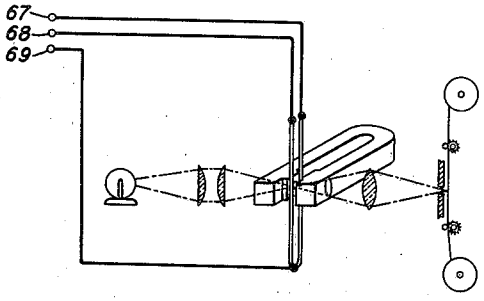
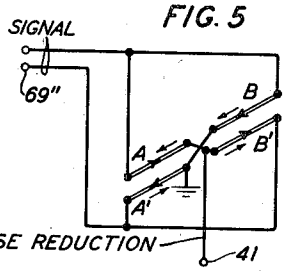


FIG. 5



INVENTORS: W. J. ALBERSHEIM
W. J. SETTE

BY G. H. Heydt.

ATTORNEY

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RECORDING SYSTEM

Walter J. Albersheim, Great Neck, and William J. Sette, Jackson Heights, Long Island, N. Y., assignors to Electrical Research Products, Inc., New York, N. Y., a corporation of Delaware

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In Great Britain January 22, 1937

21 Claims. (Cl. 179—100.3)

This invention relates to a method and means for recording modulated electric currents upon a photographic medium, and more particularly to a method and means of damping the recording device to improve the fidelity of the record produced. The invention is applicable to light valves in which the modulated electric currents are supplied to a ribbon or ribbons supported under tension in a constant magnetic field so as to vibrate in accordance with the currents and control the transmission or deflection of the recording beam of light.

The object of the invention is to increase the accuracy of the record of the modulated currents, particularly currents of the higher frequencies, and to reduce the free vibrations of the light valve ribbons due to transient currents or to the ribbons clashing against each other.

A feature of the invention is a circuit connection whereby the electromotive force generated in the ribbons due to their motion is fed back in proper phase relation to the circuit supplying the modulated currents.

A further feature of the invention is a circuit connection whereby the generated electromotive force is fed back, while voltages due to noise reduction biasing currents applied to the valve are controlled so as to have no deleterious effect.

Another feature of the invention is a light valve in which the ribbons are tuned to a frequency of mechanical resonance lying within the range of frequencies of the modulated currents to be recorded, and the feedback is so adjusted that the response of the light valve is equalized throughout the frequency range.

A further feature of the invention is the inclusion of frequency discriminative elements in the feedback path whereby the feedback is modified so that the displacement of the movable member has a predetermined relationship to the amplitude of the modulated currents.

Preferably the system includes elements for forming with said movable member or members a normally balanced bridge, the source of modulated currents being connected to one diagonal of the bridge, and a feedback path being connected to the other diagonal of the bridge so as to feed back to the source of modulated currents a current in accordance with the electromotive force generated in said movable member by its motion in the magnetic field.

According to a further aspect of the invention there is provided in a sound recording system for producing a variable area or density sound record, a normally balanced bridge adapted to include a sound recording device, a source of sound modulated currents connected across two elements of said bridge, and a source of biasing current connected to the junction of said two elements of said bridge and forming a diagonal of the bridge for supplying to the recording device currents varying as the envelope of the sound modulated currents.

The displacement of the ribbon of a light valve for a given amplitude of the modulated current applied to the ribbon will depend upon the material of the ribbon, the mass of the ribbon, the intensity of the magnetic field in which the ribbon is immersed, and the tension to which the ribbon is stretched. Thus, if the displacement of the ribbon of the valve is plotted against the frequency of the applied current, the resulting efficiency curve will show a peak of highest efficiency at the frequency of the applied current which equals the frequency of mechanical resonance of the ribbon. To reduce the effect of this variation in efficiency, the known light valves are tuned so that the frequency of mechanical resonance lies outside the range of the frequencies to be recorded. In one aspect of the present invention, the ribbons may be tuned so that the frequency of mechanical resonance falls within the range of frequencies of the currents to be recorded, thereby increasing the response of the ribbons to the applied currents throughout the whole range of frequencies recorded, and the variation in efficiency is equalized by feeding back the generated electromotive force in proper phase relation into the input circuit. By suitable control of the feedback circuit, the resonance peak may be substantially eliminated, and, independently of this effect, the efficiency may be arranged to rise for the lower or the higher frequencies. The generated electromotive force may be amplified if desired, and fed back to the input of the light valve itself, or to a suitable stage of the usual recording amplifier.

In order that the invention may be better understood, reference will now be made to the drawing, in which:

Figs. 1 and 2 illustrate in diagrammatic form alternative methods for carrying the invention into practice;

Fig. 3 diagrammatically shows one form of light valve adapted for use with the invention;

Fig. 4 shows the invention applied to the control of a pair of light valves which may be, if desired, a compound light valve of the four-ribbon type, such as shown, for example, in an

application Serial No. 140,598, filed by J. G. Frayne, May 4, 1937; and

Fig. 5 shows the invention applied to a double or four-string light valve with an interconnection between the strings such that certain advantages in the application of noise reduction currents may be attained.

Referring to Fig. 1, modulated currents from any desired source, such as a microphone, pick-up, radio set, suitably amplified if desired, are supplied to the terminals 10, 11 and produce a voltage drop across the resistor 12. The voltage drop across the resistor 12 is applied through the biasing battery 13 and resistor 14 to the thermionic amplifier 16, shown as a known suppressor grid pentode. The pentode 16 is resistance-capacitance coupled in known manner to the pentode 17. The output of the pentode 17 is supplied through capacitor 18 to the primary winding of transformer 19. The secondary winding of the transformer 19 is connected through a variable resistor 20 to the terminals 21, 22 which may be connected to a two-ribbon light valve.

A portion of the input supplied to the terminals 10, 11 is tapped off through a circuit for producing a noise reducing bias upon the light valve, including an amplifier 23, equalizer 24, amplifier 25, and rectifier 26, supplying current to the mid-point of the secondary winding of the transformer 19, and, through ground, to the terminal 22, in the same manner as disclosed in United States Patent 1,923,757, patented August 23, 1933 to H. C. Silent. The resistance 20 may be adjusted to equal the resistance of the light valve ribbons connected to terminals 21, 22.

Two equal resistors 27, 28 are connected across the secondary winding of the transformer 19, and together with the resistor 20, and the ribbons of the light valve form a balanced Wheatstone bridge. The junction of the resistors 27, 28 and the terminal 22, which is the junction of the resistor 20 and the ribbons of the light valve, form the terminals of one diagonal of the bridge. The outer ends of the resistors 27, 28 form the terminals of the other diagonal of the bridge, and the circuits connected to the diagonals will, of course, be conjugate to each other. Thus, the modulated currents from the secondary of the transformer 19, attached to the outer end of the resistors 27, 28 will not produce any difference of potential between the junction of the resistors 27, 28 and the terminal 22. The feedback path is connected to the junction of the resistors 27, 28 thence through capacitor 29, resistor 30 in parallel with capacitor 31, and input potentiometer 32 to ground and thence to terminal 22. Due to the conjugate relationship, the modulated currents will not flow into the feedback circuit. But the ribbons of the light valve attached to the terminals 21, 22 form one arm of the bridge, thus any electromotive force induced in these ribbons due to their motion will unbalance the bridge and produce a current in the feedback circuit.

A portion of the voltage developed across the potentiometer 32 is amplified in the amplifier 33, and applied through the capacitor 34 and resistor 35 to the control grid of the pentode 16, to modify the modulated currents supplied to the light valve. This invention is not limited to a system in which the feedback voltages are supplied to the control grid of the amplifier, as this voltage may be applied to other elements of the amplifier, or even to the windings of the transformer 19.

The present invention is adapted for use with many types of light valves. For variable density recording, a light valve of the type disclosed in United States Patent 1,914,186, June 13, 1933, E. C. Wente may be used, and for variable area recording a light valve of the type disclosed in United States Patent 1,820,785, August 25, 1931, G. L. Dimmick, or of the type disclosed in United States Patent 1,838,447, December 29, 1931, R. J. Pomeroy may be used, though the invention is not limited to these types of light valves. When using a light valve of the type disclosed in United States Patent 1,820,785 the resistor 20 may be replaced by an inductive resistance to balance the inductive resistance of the operating coil of the light valve when at rest.

In light valves of these types, the deflection or displacement of the moving element should vary directly with the amplitude of the modulated currents supplied to the light valve. Thus, for equal amplitudes of the currents which produce equal displacements of the moving elements, the velocity of the moving elements must increase directly with the frequency of the modulated currents. Light valves differ in this respect from such devices as loud-speakers, wax recorders and phonograph pick-ups which are usually arranged to be substantially constant velocity devices. Now, the voltages generated by the motion of the moving element of the light valve will vary directly with the velocity of the element, thus the feedback voltages tend to increase with frequency and to reduce the sensitivity of the light valve at higher frequencies but below the frequency of mechanical resonance. This reduction in sensitivity is modified to some extent by the change in the phase relation between the voltages applied to the moving elements and the generated voltages. At low frequencies, the generated voltages are approximately 90 degrees out of phase with the applied voltages thus the voltages fed back to the input of the amplifier are not fully effective in reducing the sensitivity. This phase difference varies with frequency (as resonance is approached) until at resonance, the generated voltages are substantially in phase with the applied voltages. This phase relation is reversed in the feedback channel so that the voltages fed back to the input of the amplifier are 180 degrees out of phase with the voltages applied to the amplifier and are effective to materially reduce the extreme sensitivity normally present at resonance. At frequencies materially above resonance the generated voltages are again 90 degrees out of phase with the voltages applied to the elements. There will, also, generally be a change in the phase relation of the output voltage of the transformer 19 as the frequency increases. And, due to the use of the noise reduction channel, the amplification of the feedback channel should be reduced at low frequencies so that any noise reduction currents that leak into the feedback channel will not be appreciably amplified. The capacitors, such as 29 and 34, modify the transmission of the feedback channel so as to discriminate against low frequency currents, such as the noise reduction currents, and also act to reduce the feedback currents of low frequency thus increasing the relative amplitude of the low frequency currents as recorded. The capacitor 31 and resistor 30 introduce a positive phase shift which neutralizes the negative phase shift

due to the transformer 19, thus reducing the tendency of the system to oscillate or sing.

When a current of large amplitude is supplied to the light valve, the moving element may be so widely displaced that it strikes on some part of the mounting, or, in the case of a two-ribbon valve, the ribbons may be driven together or clashed. After clashing, the ribbons tend to vibrate at their frequency of mechanical oscillation for some time until the energy received is dissipated. In the present invention, after the ribbons clash, the subsequent vibration at the resonant frequency induces an electromotive force which is fed back through the feedback path, and then forward to the light valve in such phase as to oppose the free motion of the ribbons and damp out the oscillations, thus reducing the distortion due to clash.

The recording system shown in Fig. 2 is adapted for recording constant width, variable density records, or constant density, variable area records, or constant width, variable alignment records, and may be easily modified for use with other systems. For constant width, variable density recording, a light valve of the type shown in United States Patent 1,914,186 is connected to terminals 43, 45, terminal 44 being unconnected. For constant density, variable area recording, a light valve of the type shown in United States Patent 1,820,785 or the type shown in United States Patent 1,838,447, is connected to terminals 43, 45, terminal 44 being unconnected. In all these cases, the output of the usual noise reduction biasing circuit is connected to terminals 40, 42 and terminals 47, 48 may be strapped together. The noise reduction currents will flow from terminal 40, through inductor 51 to the mid-point of the secondary winding of the transformer 52, and will there divide through the upper and lower half windings respectively, one half flowing through variable resistor 53 back to the noise reduction circuit at terminal 42, the other half flowing through the secondary winding of transformer 54, to terminal 45, through the light valve to terminal 43, and thence through terminal 42 back to the noise reduction circuit. The resistor 53 has essentially the same function as the resistor 20 in Fig. 1 and the biasing currents operate in the same manner as described in connection with Fig. 1. The inductor 51 is not always essential, but aids in smoothing the current from the noise reduction circuit and in preventing other currents from flowing back into the noise reduction circuit.

Modulated currents from the output of the recording amplifier are supplied to the terminals 49, 50 and thence through transformer 52 to the resistor 53 and the light valve connected to terminals 43, 45.

The resistors 55, 56 and the potentiometer 57 are bridged across the secondary winding of the transformer 52 and serve the same purpose as the resistors 27, 28 bridged across the secondary winding of the transformer 19 in Fig. 1. The potentiometer 57 assists in securing an accurate balance point.

The feedback path is connected from the balance point on potentiometer 57 through potentiometer 58, terminals 57, 48 to ground and thence to terminal 43, thus forming the diagonal of the Wheatstone bridge comprising the resistors 55, 56 and potentiometer 57, the resistor 53 and the light valve connected to terminals 43, 45. The currents due to the electromotive force generated by the motion of the moving element of the light valve will thus flow through the potentiometer 58. A controllable portion of these currents is tapped off and flows through the capacitor 59 and the primary winding of the transformer 60. The resistor 61 and capacitor 62 shunted across the primary of transformer 60 modify the phase relation at high frequency so that the effective response of the light valve at high frequencies is raised relative to the response at low frequencies. The capacitor 59 reduces the input at low frequencies so that there will be substantially no amplification of noise reduction currents in the feedback path. The capacitor 59 also blocks direct current from the primary winding of transformer 60.

The output of transformer 60 is amplified by the pentodes 63, 64 and supplied to the transformer 54. The transformer 54 is of low impedance, as it is in series with the secondary winding of the transformer 52, and reduces the input of modulated currents from transformer 52 to the light valve. The resistor 65 and capacitor 66 are connected from control grid to anode of the amplifier 64, the local negative feedback reducing the impedance of the anode-cathode circuit of the amplifier 64, and reducing harmonic distortion. The low impedance of the transformer 54 also tends to discriminate against low frequencies.

The light valve shown in Fig. 3 may be structurally similar to the light valve shown in United States Patent 1,838,447 except that a connection is made to the loop forming the mid-point of the ribbons. The terminals 67, 68, 69 are respectively connected to the terminals 43, 44, 45 of Fig. 2. The noise reduction circuit is disconnected from terminal 40 and connected to terminal 41, and terminal 47 is disconnected from terminal 48 and connected to terminal 46.

The modulated currents from the transformer 52 divide and flow equally through the resistors 53 and 70, thence through terminals 43, 67 and 44, 68 through the ribbons of the light valve, and back through terminals 69, 45 and transformer 54 to transformer 52. The modulated currents flowing in the same direction through the ribbons of the light valve will react with the magnetic field of the light valve to displace both ribbons laterally in the same direction. In the absence of noise reduction biasing currents, the light valve will produce an exposure having a width limited by the spacing of the ribbons, which is laterally varied in alignment or position on the record in accordance with the variations in the modulated currents.

The noise reduction biasing currents flow from terminal 41, through terminals 44, 68 and the light valve ribbons in series, to terminals 67, 43 to terminal 42. As these currents flow through the ribbons in series they will react with the magnetic field to draw the ribbons together and reduce the width of the exposure on the film.

The resistors 53 and 70, with the two ribbons of the light valve form a Wheatstone bridge, which may be balanced by adjusting the resistors 53 and 70. The noise reduction currents are supplied to the diagonal formed by the outer ends of the resistors 53 and 70, while the modulated currents are supplied to the diagonal formed by the junction of the resistors 53 and 70 and the mid-point of the ribbons of the light valve. These diagonals are conjugate to each other so that the currents from either circuit cannot flow back into the other circuit.

The resistors 71, 72 are connected across the

diagonal of the bridge formed by the outer ends of the resistors **53**, **70** and, when the bridge is balanced, no modulated currents will flow in these resistors. The electromotive forces produced due to the motion of the ribbons will unbalance the bridge and cause currents to flow in resistors **53**, **70**. These currents flow through the potentiometer **58**, potentiometer **57**, resistor **56**, and terminals **45**, **69** to the mid-point of the ribbons. The resistors **55**, **56** and potentiometer **57** may be balanced to the mid-point of the circuit supplying modulated currents.

As previously described, the currents in the potentiometer **58**, amplified and modified by the feedback channel, are fed back into the circuit through the transformer **54**.

Light valves of the type described herein are adapted to record many types of modulated currents, though they are most commonly used in recording sound. Heretofore, in recording sound, the light valves have been tensioned to a frequency of mechanical resonance just above the highest frequency to be recorded, usually about 9,000 cycles. In the lower frequency range, the sensitivity of the valve is nearly constant, then rises and reaches a maximum at the tuning frequency. The rate of the rise in sensitivity is primarily fixed by the mechanical and electrical constants of the light valve. In accordance with the present invention, the feedback path may be designed so that there is substantially no feedback at low frequencies, so that the sensitivity at low frequencies is not reduced. The feedback at the higher frequencies may be designed so that the sensitivity at all frequencies is the same, thus giving a flat characteristic, or the sensitivity rises at the higher frequencies so as to reduce the effect of film scanning losses, and, at the same time, to eliminate the distortion due to ribbon clash and transients. In other words, the valve and circuit may be designed to have a desired rise in sensitivity at high frequencies, in place of having a rise which is determined solely by the inherent mechanical and electrical characteristics of the valve.

The present invention affords a further advantage. The valve may be tensioned to a frequency of mechanical resonance that lies within the range of frequencies to be recorded. This will produce a considerable increase in sensitivity at the lower frequencies. The feedback path is then designed to reduce the peak in sensitivity at the resonant frequency, and to give either a flat characteristic, or a gradual increase in sensitivity at the higher frequencies. The circuit shown in Fig. 2 was connected to a D-91947 light valve, manufactured by the Western Electric Company, Incorporated, and having the full length of ribbons $1\frac{1}{16}$ inches long and tensioned to resonate at 6,000 cycles. The resistors **53**, **70** were about 2 ohms, the resistors **71**, **72** about 200 ohms, the resistors **55**, **56** about 75 ohms, and potentiometer **57** about 50 ohms, potentiometer **58** about 200 ohms, capacitor **59** about 1 microfarad, resistor **61**, about 100 ohms, transformer **60** a Western Electric 247-A input transformer having an impedance ratio of 62 ohms to 159,000 ohms, the amplifier **63** was a Western Electric 310-A vacuum tube, the amplifier **64** was a Western Electric 294-A vacuum tube, the resistor **65** about 0.25 megohm, capacitor **66** about 0.01 microfarad, and the transformer **54** had a primary inductance of 0.4 henry and a secondary inductance of 0.053 henry. The capacitor **62** was about 0.1 microfarad. Using the variable density connection, the system showed a uniform rise in sensitivity of about 1 decibel from 30 to 1,000 cycles, and a smooth rise of about 6 decibels from 1,000 cycles to 8,000 cycles, in place of a peak of about 20 decibels at 6,000 cycles. Using the variable alignment connection (with suitable values for the circuit elements) the system showed a uniform rise in sensitivity of about 0.5 decibel from 30 to 3,000 cycles, and a smooth rise of about 3 decibels from 3,000 to 8,000 cycles. A small capacitor may be connected across the primary winding of the transformer **60** to increase the rise at high frequencies. Using the circuit connected for variable density and a valve tuned to 9,500 cycles, and putting a resistance of 150,000 ohms across the primary winding of transformer **60**, a smooth rise in sensitivity of 6 decibels at 12,000 cycles was obtained, with a smooth fall of 1 decibel at 15,000 cycles.

While details of a specific system are given above, it will be understood that these details are merely illustrative of one practical embodiment of the invention and do not limit the invention to these particular conditions, as many changes may be made in the values of the components, within the scope of the claims.

Referring now to Fig. 4, there is disclosed an arrangement in which two light valves may be operated in parallel. The circuit connection is identical with that of Fig. 3 except that two complete valves are now operated in parallel in response to signal currents and in series in response to noise reduction control current. The light valves may be independent physical structures or may be a unit structure including four individual ribbons immersed in a common magnetic field and cooperating with suitable apertures as disclosed in the Frayne application previously identified. The connection shown in Fig. 4 will produce a pair of complementary push-pull records since current flow in the light valve ribbons will be in opposite directions for the corresponding elements of the right and left-hand valves.

Fig. 5 discloses an interconnection of the light valve ribbons of such a nature that an advantage in the application of noise reduction current is obtained, since the ribbons of the two valves are in parallel relation with respect to both signal and noise reduction currents. The light valve ribbons of the left-hand valve have been designated A and A', respectively, while those of the right-hand valve have been designated B and B', respectively. The application of signal currents to the valve will produce current flow through the ribbons of the respective valves in the directions indicated by the arrowheads on the ribbons. The direction of current flow of the noise reduction currents is indicated by arrows external to the ribbons. In utilizing this interconnection, ribbons A and B will be substituted for the adjustable resistors **70** and **53** of Fig. 2, respectively, and ribbons A' and B' will replace the individual ribbons of the light valve shown in Fig. 3. Signal currents will flow from the upper terminal of the secondary of transformer **52** and divide between ribbons A and B and reunite to flow to terminal **69''** which will be connected to terminal **45** of Fig. 2 in the same manner that terminal **69** of Fig. 3 was formerly used. Noise reduction currents will be applied to the circuit of Fig. 5 from terminal **41** of Fig. 2 to the connection point indicated in Fig. 5. The connection from this point via resistance **71** of Fig. 2 to terminals **46** is, of course, retained. The ground connection shown

in Fig. 5 corresponds to the ground connection to terminal 43 of Fig. 2 and has a corresponding connection to terminal 42 leading to the noise reduction control channel. This circuit maintains a conjugate relation between the points of application of signal currents and the points of application of noise reduction control currents, while maintaining a balance of both with respect to the feedback circuit in the same manner as has been previously described in connection with Figs. 2 and 3.

What is claimed is:

1. In a recording system, a light valve, a plurality of resistors forming a balanced bridge including said light valve as an arm, a source of modulated currents connected to one diagonal of said bridge, a feedback path connected to the other diagonal of said bridge and feeding back the electromotive force generated by the motion of the movable element of said light valve to said source of modulated currents whereby the response of said light valve is modified.

2. In a sound recording system, a source of light, a light sensitive medium moved at constant speed, a source of sound modulated currents, a light valve actuated by currents from said source to control the light from said source impressed on said medium, means for deriving a current varying in proportion to the velocity of the moving element of said light valve, a circuit for feeding back said current to react upon said source of modulated currents, and frequency discriminative elements in said circuit for modifying the currents fed back, whereby the displacement of the movable element of said light valve has a predetermined relationship to the amplitude of the modulated currents.

3. The method of recording sound which comprises the steps of converting acoustic energy into modulated electric currents, actuating a light valve with said currents, deriving a voltage varying with the velocity of the moving element of said light valve, feeding back said voltage to react upon said modulated currents, modifying the voltage fed back to cause the displacement of the movable element of the light valve to have a desired relationship to the amplitude of the modulated currents, and using said light valve to control the light impressed on a light sensitive medium.

4. The method of recording sound which comprises the steps of converting acoustic energy into modulated electric currents, actuating a light valve with said currents, deriving a voltage varying with the velocity of the moving element of said light valve, feeding back said voltage to react upon said modulated currents, modifying the voltage fed back to discriminate against the lower frequencies of said currents, whereby the displacement of the movable element of the light valve for a given amplitude of the modulated currents is greater for the higher frequencies of said modulated currents, and using said light valve to control the light impressed on a light sensitive medium.

5. In a film sound recording system, a source of modulated currents, a light valve comprising a pair of stretched conducting ribbons immersed in a constant magnetic field, a pair of equal resistors forming with said ribbons a balanced bridge connected to one side of said source, the other side of said source being connected to the mid-point of said ribbons, a source of currents varying in accordance with the envelope of said modulated currents connected to a diagonal of said bridge in conjugate relationship to said source of modulated currents, a pair of equal resistors in serial relationship connected across said diagonal, a plurality of resistors shunted across said source, a potentiometer connected from the mid-point of said shunted resistors to the mid-point of said pair of resistors, and a feedback path from said potentiometer to said source of modulated currents.

6. In a film sound recording system, a source of light, a light sensitive medium moved at constant speed, a source of sound modulated currents, a light valve actuated by currents from said source to control the light from said source impressed on said medium and including a plurality of conducting ribbons immersed in a constant magnetic field and tensioned to have a frequency of mechanical resonance within the band of frequencies to be recorded, means for deriving a current varying with the electromotive force induced by the velocity of motion of the ribbons, a negative feedback channel to cause said currents to modify the modulated currents from the source, and means in said channel to adjust the transmission characteristic within the range recorded.

7. In a film sound recording system, a source of light, a light sensitive medium moved at constant speed, a source of sound modulated currents, a light valve actuated by currents from said source to control the light from said source impressed on said medium and including a plurality of conducting ribbons immersed in a constant magnetic field and tensioned to have a frequency of mechanical resonance within the band of frequencies to be recorded, means for deriving a current varying with the electromagnetic force induced by the velocity of motion of the ribbons, a negative feedback channel to cause said currents to modify the modulated currents from the source, and means in said channel to adjust the transmission characteristic within the range recorded whereby the sensitivity of said light valve increases with frequency throughout the whole of the useful range of frequencies recorded.

8. In a film sound recording system, a source of light, a light sensitive medium moved at constant speed, a source of sound modulated currents, a light valve actuated by currents from said source to control the light from said source impressed on said medium, said valve including a movable element immersed in a constant magnetic field and so proportioned and suspended as to have a frequency of mechanical resonance within the band of frequencies to be recorded, means for deriving a current varying with the electromotive force induced by the velocity of motion of said movable element, a negative feedback channel to cause said induced currents to modify the modulated currents from said source, and means in said channel to discriminate against the transmission of the lower frequencies within the range recorded whereby the sensitivity of said light valve increases regularly throughout the whole range of frequencies recorded.

9. In a film sound recording system, a source of light, a light sensitive medium moved at constant speed, a source of sound modulated currents, a light valve actuated by currents from said source to control the light from said source impressed on said medium, said valve including a movable element immersed in a constant magnetic field and so proportioned and suspended as

to have a frequency of mechanical resonance within the band of frequencies to be recorded, means for deriving a current varying with the electromotive force induced by the velocity of motion of said movable element, a negative feedback channel to cause said induced currents to modify the modulated currents from said source, and means in said channel to uniformly and increasingly discriminate against the lower frequencies within the range recorded whereby the sensitivity of said light valve is equalized throughout the whole range of frequencies recorded.

10. The combination in claim 8, in which a series capacitor is included in the feedback channel.

11. The combination in claim 8, in which the feedback channel terminates in a low impedance transformer connected in serial relationship with said source of modulated currents.

12. In a sound recording system, a light valve, an impedance, a pair of resistors forming with said valve and said impedance a balanced bridge, a sound signal channel connected to one diagonal of said bridge, a biasing channel containing currents varying as the envelope of the signal currents connected to the other diagonal of said bridge, a negative feedback channel having its input also bridged in balanced relation to the sound signal channel and its output connected to modify the currents in said sound signal channel, said feedback channel having a transmission characteristic which discriminates against the lower frequencies.

13. In a sound recording system, a light valve, an impedance, a pair of resistors forming with said valve and said impedance a balanced bridge, a sound signal channel connected to one diagonal of said bridge, a biasing channel containing currents varying as the envelope of the signal currents connected to the other diagonal of said bridge, a negative feedback channel having its input also bridged in balanced relation to the sound signal channel and its output connected to modify the currents in said sound signal channel, said feedback channel having a transmission characteristic which discriminates against the lower frequencies.

14. In a sound recording system, a light valve, an impedance, a pair of resistors forming with said valve and said impedance a balanced bridge, a sound signal channel connected to one diagonal of said bridge, a biasing channel containing currents varying as the envelope of the signal currents connected to the other diagonal of said bridge, a negative feedback channel having its input bridged across the same diagonal as said biasing channel, a series capacitor in the input of said feedback channel, and a low impedance transformer in the output of said feedback channel connected so that the feedback currents modify the currents in said sound recording channel.

15. In a sound recording system, a source of light, a light sensitive medium moved at constant speed, a source of sound modulated currents, a light valve actuated by currents from said source to control the light from said source impressed on said medium, said valve including a pair of conducting ribbons immersed in a constant magnetic field, and stretched to define a light transmitting slit, a pair of resistors in serial relationship shunted across like terminals of said ribbons, the other terminals of said ribbons being connected together, means for connecting said source of sound modulated currents to the junction of said resistors and the junction of said ribbons to cause currents to flow in the same direction in said ribbons, a biasing channel carrying currents varying as the envelope of said modulated currents, and means for connecting said biasing channel to the junctions of said resistors and said ribbons to cause biasing current to flow in said ribbons in opposite directions.

16. In a sound recording system, a transformer energized by sound modulated currents and having a center tapped secondary winding, a pair of equal resistors in serial relationship, the junction of said resistors being connected to one end of said secondary winding, the free ends of said resistors being connected to terminals, a third terminal connected to the free end of said secondary winding, means for connecting a variable density ribbon light valve to one of said first terminals and said third terminal, or, at will, connecting a push-pull light valve to both said first terminals and said third terminal, a biasing channel carrying currents varying as the envelope of said modulated currents connected to one of said first terminals, and means for connecting said channel at will to the mid-point of said transformer or the other of said first terminals.

17. In a sound recording system, a source of sound modulated currents, a pair of equal resistors in serial relationship, the junction of said resistors being connected to said source, the free ends of said resistors being connected to terminals, a third terminal connected to the other side of said source, means for connecting a variable density, ribbon light valve to one of said first terminals and said third terminal, or, at will, connecting a push-pull, ribbon light valve to both said first terminals and said third terminal, a potentiometer bridged across said source of modulated currents, a negative feedback channel connected to the wiper of said potentiometer, a second pair of equal resistors connected to said first terminals, and means to connect said feedback channel to one of said first terminals, or, at will, to connect said second pair of resistors in serial relationship, thus connecting said feedback channel to the junction of said second pair of resistors, and means for connecting the output from said feedback channel to modify the currents from said source.

18. In a sound recording system, a light valve, an impedance, a pair of resistors forming with said valve and said impedance a balanced bridge, a sound recording channel connected to one diagonal of said bridge, a negative feedback channel having its input connected to the other diagonal of said bridge, a thermionic amplifier connected in said feedback channel, a low impedance transformer connected to the output of said thermionic amplifier and having its secondary winding intercalated in serial relationship in said recording channel to modify the currents in said channel, and a local negative feedback connection from the output to the input of said thermionic amplifier, to reduce the apparent output impedance of said amplifier.

19. In a recording system, a light valve comprising a plurality of conducting elements connected to form a balanced bridge, a source of signal currents connected to one diagonal of said bridge, a network connected across said diagonal and a feedback path connected from one end of the other diagonal of said bridge to a central point of said network and feeding back the electromotive force generated by the motion of said elements to said source of signal currents where-

by the response of said light valve to said signal currents is modified.

20. The combination in claim 19 in which the elements of said light valve are four similar ribbons.

21. In combination, a light valve comprising four similar conducting ribbons connected to form a balanced bridge, a signal channel connected to one diagonal of said bridge, a biasing channel carrying currents varying as the envelope of the signal currents connected to the second diagonal of said bridge, a network connected across the first diagonal of said bridge and a feedback channel connected from one end of the second diagonal of said bridge to a central point of said network to feed back the electromotive force generated by the motion of said ribbons to said signal channel.

WALTER J. ALBERSHEIM.
WILLIAM J. SETTE.