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2,514,633

VARIABLE-DENSITY, PUSH PULL SOUND RECORDING SYSTEM

Filed May 7, 1946

2 Sheets-Sheet 1

FIG. 1

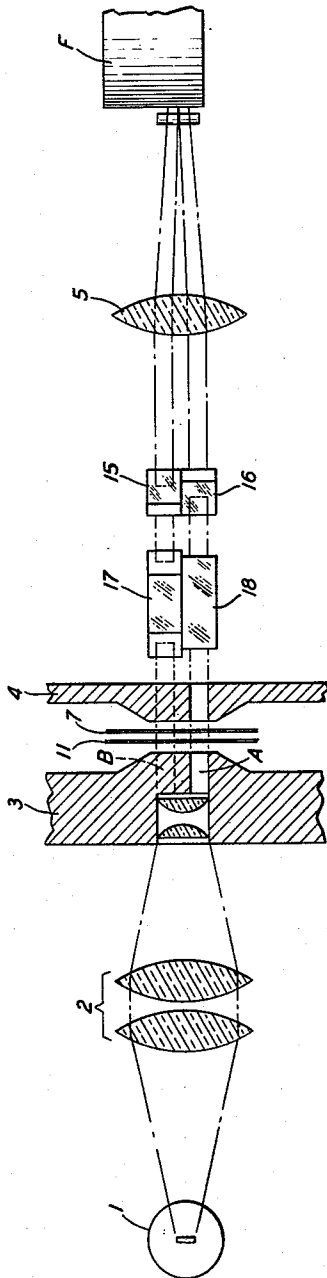
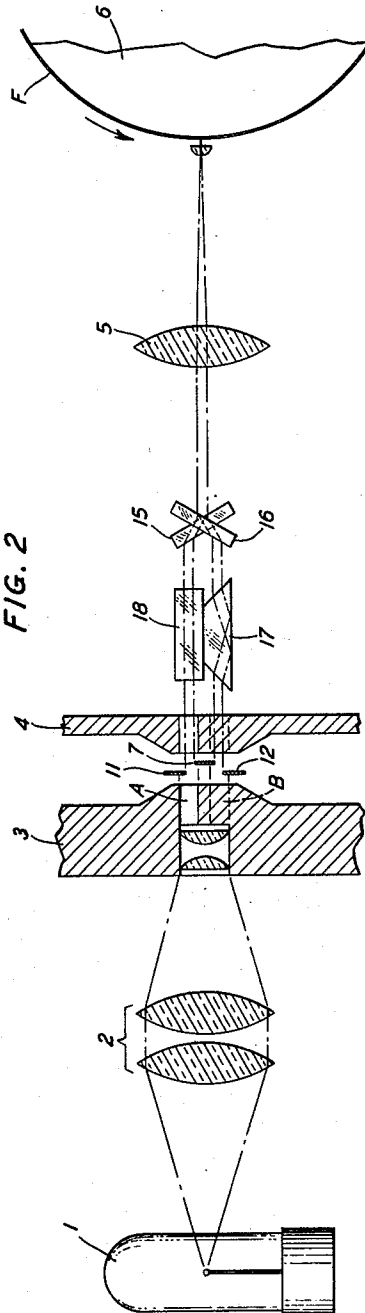


FIG. 2



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FIG. 3

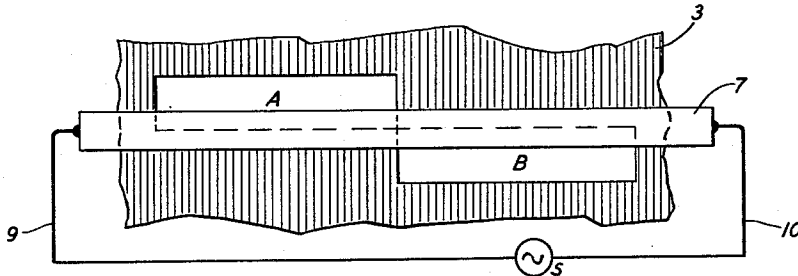


FIG. 4

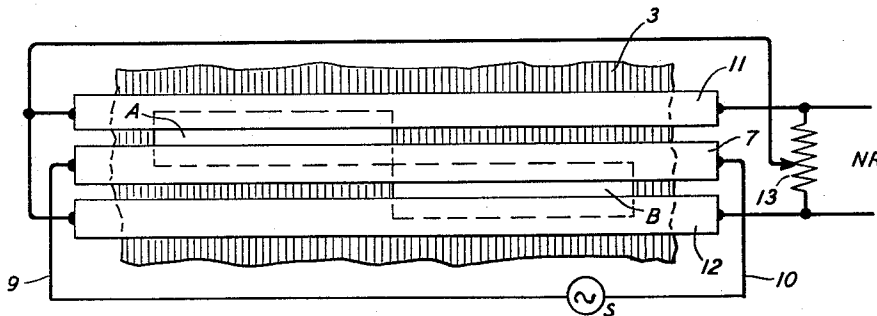


FIG. 5

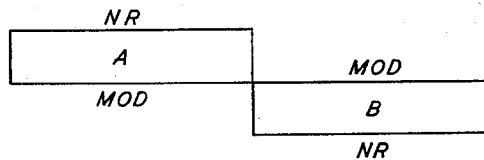


FIG. 6

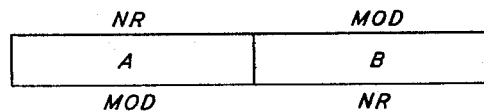
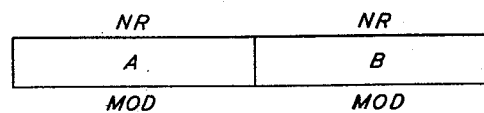


FIG. 7



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VARIABLE-DENSITY PUSH-PULL SOUND
RECORDING SYSTEM

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4 Claims. (Cl. 179—100.3)

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This invention relates to sound film recording and more particularly to systems for recording a push-pull variable density sound track on photographic film.

It is the object of this invention to provide a distortion-free variable density recording system employing a light valve incorporating a single speech current responsive ribbon.

It is the usual practice in making an original recording of sound accompanying a picture to record the sound in the form of a push-pull, variable density track in which the sound waves in the two separate tracks are recorded 180 degrees out of phase. The light modulator employed is a four-ribbon light valve of the type disclosed in my United States Patent 2,199,070, issued April 30, 1940. This four-ribbon valve is in effect two separate two-ribbon light valves in which both signal and bias currents are applied to the ribbons. A four-ribbon light valve requires accurate alignment and almost identical tuning of four separate ribbons. Further, it is necessary to connect the four-ribbon valve to the source of sound modulated current through a high impedance simplex circuit which produces a relatively high resonance peak of the valve. Also, the bias current traversing the ribbons produces a heating effect which adversely affects the tuning frequency of the ribbons.

It was recognized by applicant that the above-mentioned disadvantages incident to the use of a four-ribbon light valve could be avoided in recording a push-pull variable density sound track by utilizing a modulator in the form of a light valve incorporating but one speech current responsive ribbon, the opposite edges of which are adapted to modulate the separate light beams in a push-pull manner. Noise reduction could be obtained if desired by incorporating into the modulator two ribbons electrically isolated from the single speech ribbon, the two ribbons serving to define the fixed edge of each recording light beam and movable in accordance with the impressed noise reduction currents. However, while the suggested simplification of the modulating device or light valve avoids the disadvantages incident to the use of a four-ribbon light valve, even order harmonic distortion will be introduced due to the fact that the proposed light valve is essentially two single ribbon light valves each of which, per se, has a high second harmonic introduced by the well-known ribbon velocity effect.

In a light valve of the type discussed above the modulating edges of the signal ribbon are

in opposite positions with respect to the separate light beams. The instantaneous relative motion of the signal ribbon edges to the film is in the same direction in both cases which brings about a condition where the even harmonics of the two stacks thus exposed are additive. Also the center lines of the exposed area of the two tracks are only in line for zero modulation and move apart with increasing modulation. It will be obvious that to be a practical push-pull modulator, the proposed simplified light valve must be capable of recording on a moving film a sound track in which the even harmonics may be canceled out in reproduction.

Applicant conceived the idea that a distortion-free, push-pull variable density sound track could be successfully recorded on a moving film by a single ribbon light valve by the utilization of optical means between the light valve and film producing an inversion of one of the ribbon modulated light beams. By so inverting one of the modulated light beams, the modulating edges of the signal ribbon move in opposite directions at any instant with respect to the film motion for the two component tracks, thus producing a condition where the even harmonics are completely canceled by reason of the fact that these components from the two light beams are recorded in opposite phase relative to their respective fundamentals. By the use of additional optical means in the form of refractor plates, commonly known as "sawbucks," the two images may be transversely aligned at the film.

The invention may be more readily understood by reference to the following specification when read in connection with the accompanying drawing, in which:

Fig. 1 is a plan view, partly in section, of the recording optical system in accordance with this invention;

Fig. 2 is a side elevation of the optical system shown in Fig. 1;

Fig. 3 is an enlarged elevation of the pole face of one apertured pole-piece of a light valve with a signal modulated ribbon disposed in front thereof;

Fig. 4 is similar to Fig. 3 but shows an arrangement of a signal modulated ribbon and two noise reduction ribbons disposed in front of the apertured pole-piece;

Fig. 5 is an enlarged diagrammatic showing of the image of the light beams on the film as defined by the light valve ribbons in an optical system in which neither an inverting prism nor refractor plate is employed;

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Fig. 6 is an enlarged showing of the images of the light beams at the film in a system employing only refractor plates for transversely aligning the images; and

Fig. 7 is an enlarged showing of the images of the light beams at the film when both refractor plates and optical inverter are employed in accordance with the invention.

Referring to Fig. 1, light rays of constant intensity from a light source 1 are projected by means of a condensing lens system 2 to focus at a point between pole-pieces 3 and 4 of a light valve. The remaining structure of the light valve is not shown but, as is well known, it comprises either a permanent magnet or an electromagnet producing a magnetic field in the air-gap between the opposed faces of the pole-pieces 3 and 4. The light rays emerging from the light valve are projected by means of an objective lens system 5 to a moving film F, supported in the optical system by a rotatable drum 6.

The pole-piece 3 is provided with two transversely separated, longitudinally offset recording apertures A and B. Pole-piece 4 is provided with similar offset apertures aligned with the apertures A and B in pole-piece 3.

The constant intensity light beam from source 1, which passes through the aligned apertures in pole-pieces 3 and 4, is modulated by means of vibrating ribbon 7 in a push-pull manner. Referring to Fig. 3, it will be seen that the upper edge of ribbon 7, which vibrates in the magnetic field in response to speech currents passing there-through, moves the position of the lower edge of the light beam formed by aperture A while the lower edge of ribbon 7 moves the position of the upper edge of the light beam formed by aperture B. The ribbon 7 is electrically connected to a source of modulated currents by leads 9 and 10.

Ribbons 11 and 12, which are adapted to carry the bias current, are mounted in the air-gap in a separate but parallel plane to the plane of ribbon 7, as shown in Figs. 2 and 4. As shown in Fig. 4, ribbon 11 moves the position of the upper edge of the light beam formed by aperture A while ribbon 12 moves the lower edge of the light beam formed by aperture B. The bias current travels in opposite directions in ribbons 11 and 12 thus causing them to move toward and away from each other in accordance with variations in bias current. Ribbons 11 and 12 are shunted by a potentiometer 13 which is used to correct for any variation in sensitivity of either noise reduction ribbon, the bias currents in each ribbon being adjusted in order to obtain equal biased spacing for each aperture.

As pointed out above, Fig. 5 discloses diagrammatically an enlarged view of the images at film F of the apertures defined by the light valve ribbons for a recording system thus far described. Movement of ribbon 7 of Fig. 3 or 4 will produce simultaneous movement of the modulated edge of the image of Fig. 5 in the same direction at any instant relative to the motion of the film. The opposite edges of each image for the single ribbon valve of Fig. 3 will remain fixed. For the light valve as shown in Fig. 4, the opposite edge of each image as shown in Fig. 5 will move in opposite directions in accordance with the bias currents. In this case we have the maximum displacement of the centers of the exposed areas for zero modulation and the distance between the centers increases as the modulation is increased. It can be shown that while the exposure of each sound track is 180 degrees out of

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phase in respect to each other, no cancelation of the even harmonics results when the two tracks are reproduced in push-pull. This is because the even harmonics introduced by the ribbon velocity effect in each sound track are recorded in the same phase relative to their respective fundamentals and direct addition of the even harmonics occurs in the same way as for the fundamentals.

Referring back to Figs. 1 and 2, refractor plates or "sawbucks" 15 and 16 are disposed one in each light beam for the purpose of transversely aligning the images of the offset apertures at the film F. Optical elements of this type are disclosed and described in my above-mentioned United States Patent 2,199,070.

Fig. 6 discloses diagrammatically an enlarged view of the images at film F of the apertures defined by the light valve ribbons for a recording system as described above but including the refractor plates 15 and 16. In this case the noise reduction edge of one image is aligned with the modulating edge of the second image. The images will only remain aligned for the unbiased condition, becoming more and more out of alignment as the bias current is increased. In this case the same condition prevails as in Fig. 5, that is, the even harmonics introduced by ribbon velocity effect in each sound track are recorded in the same phase relative to their respective fundamentals and are, therefore, additive in reproduction.

In accordance with this invention, a recording optical system is provided in which the single speech current ribbon light valve may be successfully employed in recording a push-pull variable density sound track in which the even harmonics produced by the ribbon velocity effect are recorded in each track in opposite phase relative to their respective fundamentals and are thus completely canceled out when both tracks are scanned in push-pull in reproduction.

This is accomplished in accordance with the invention by the provision of an inverting prism 17 in the path of one of the light beams formed by the apertures in the light valve. As shown in Figs. 1 and 2, the inverting prism 17 is placed in the path of the light beam formed by aperture B. The passage of light from aperture B through inverting prism 17 is compensated by the addition of a rectangular prism 18 in the path of the light beam formed by aperture A.

Referring to Fig. 7, it will be seen that the image of the aperture B at the film F has been inverted thus producing transverse alignment of the fixed or noise reduction edges and transverse alignment of the modulating edges of the image for zero modulation. The centers of the images of the apertures A and B will stay in alignment at the film plane irrespective of the amount of bias applied to ribbons 11 and 12. The motions of the modulating edges of the image are in opposite directions at any instant thus producing a condition where the even harmonics produced by ribbon velocity effect in each track are recorded in opposite phase relative to their respective fundamentals. Therefore, in push-pull reproduction of the two tracks these even harmonic distortions are canceled out.

In accordance with this invention there is, therefore, provided a push-pull variable density recording system employing a simplified modulator or light valve incorporating but one speech responsive ribbon which must be tuned to a relatively high frequency. If noise reduction rib-

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bons are incorporated they can be tuned to a much lower frequency, thereby making a considerable saving in noise reduction current. The electrical separation of signal and noise reduction circuits eliminates the necessity of a simple coupling circuit thus further reducing the noise reduction current normally required.

What is claimed is:

1. A variable density, push-pull recording system comprising in combination, a moving film, a source of modulated current, means producing a pair of longitudinally offset light beams, optical means for projecting said pair of light beams to adjacent transverse areas of said film, a conducting ribbon disposed in a magnetic field and electrically connected to said source of current to produce movement of said conductor to simultaneously vary the width of each of said light beams from those transverse edges of said beams which are nearest to each other in a direction along the longitudinal axis of said film, the direction of motion of the width varying edge of each beam being in the same direction, means for transversely aligning said light beams at said film and means for inverting one of said light beams whereby the images of the width varying edges of said light beams move in opposite directions at the film in accordance with said current.

2. A variable density, push-pull recording system comprising in combination, a moving film, a source of sound modulated current, a source of current varying in accordance with the envelope of the amplitude variations of said modulated current, means producing a pair of longitudinally offset light beams, optical means for projecting said pair of light beams to adjacent transverse areas of said film, a conducting ribbon disposed in a magnetic field and electrically connected to said source of modulated current to produce movement of said conductor to simultaneously vary the width of each of said light beams from those transverse edges of said beams which are nearest to each other in a direction along the longitudinal axis of said film, the direction of motion of the width varying edge of each beam being in the same direction, a pair of conducting ribbons disposed on opposite sides of and in parallel relation with said first-mentioned ribbon, said pair of conducting ribbons being electrically connected to said source of envelope currents to produce simultaneous movement thereof in opposite directions to vary the width of said light beams from an edge opposite the first-mentioned edge of each of said light beams, means for transversely aligning said light beams at said film and means for inverting one of said light beams with respect to its initial position.

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3. A variable density, push-pull recording system comprising in combination, a moving film, a source of modulated current, means producing a pair of longitudinally offset light beams, optical means for projecting said pair of light beams to adjacent transverse areas of said film, a single means movable in response to said current to simultaneously vary the width of each of said beams from those transverse edges of said beams which are nearest to each other, the direction of motion of the width varying edge of each beam being in the same direction, means for transversely aligning said light beams at said film plane and means for inverting one of said light beams whereby the images of the width varying edges of said light beams move in opposite directions at the film in accordance with said current.

4. A variable density, push-pull recording system comprising in combination, a moving film, a source of sound modulated current, a source of current varying in accordance with the envelope of the amplitude variation of said modulated current, means producing a pair of longitudinally offset light beams, optical means for projecting said pair of light beams to adjacent transverse areas of said film, a single element movable in response to said sound modulated current to simultaneously vary the width of each of said beams from those transverse edges of said beams which are nearest to each other in a direction along the longitudinal axis of said film, the direction of motion of the width varying edge of each beam being in the same direction, a pair of elements movable simultaneously in opposite directions in response to said envelope currents to simultaneously vary the width of said light beams from an edge opposite the first-mentioned edge of each of said light beams, means for transversely aligning said beams at said film and means for inverting one of said light beams with respect to its initial position.

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