July 25, 1944. F. G. ALBIN 2,354,295

SOUND RECORDING SYSTEM

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Fig. 1.

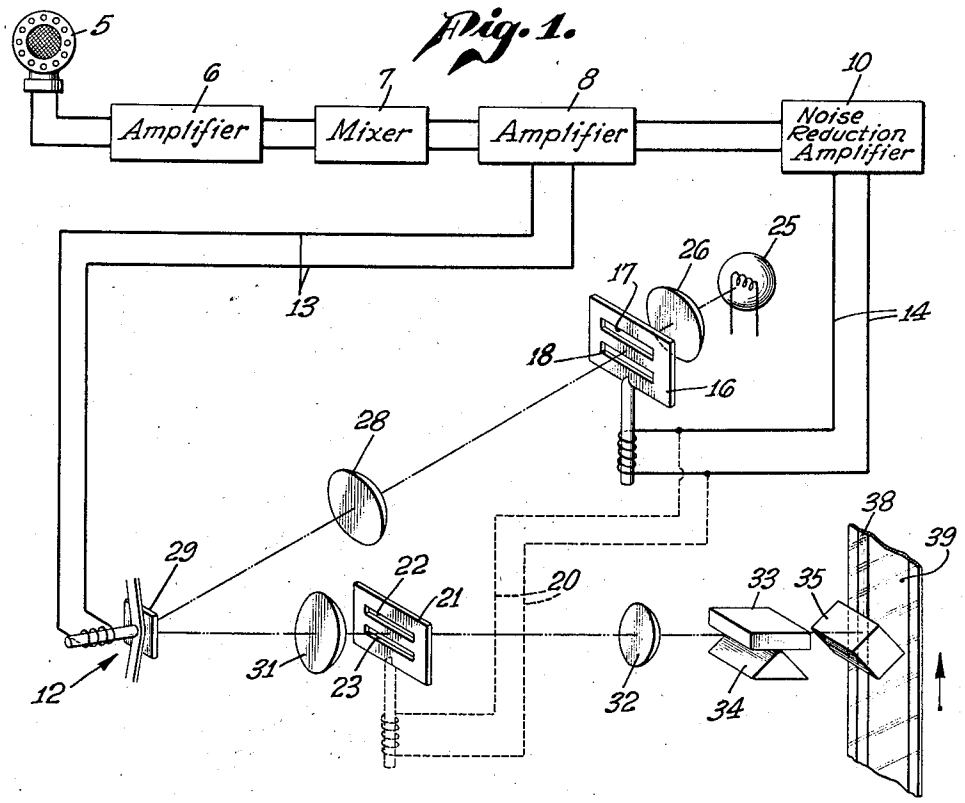
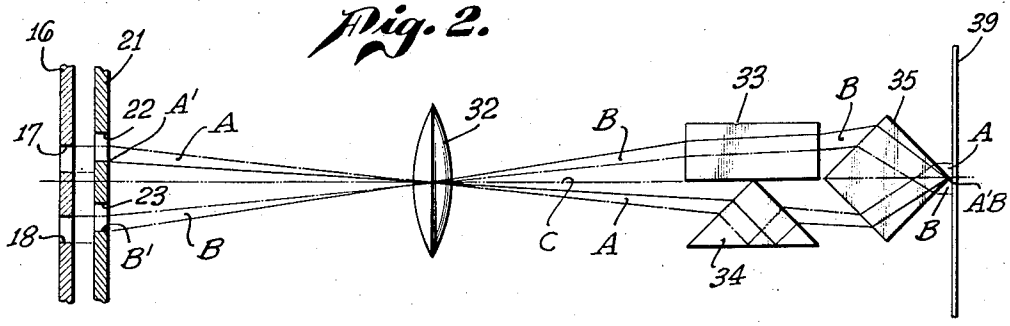


Fig. 2.



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Fig. 3.

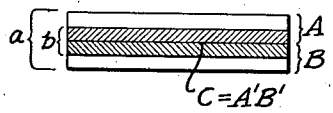
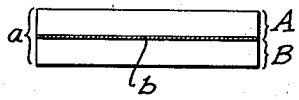


Fig. 4.



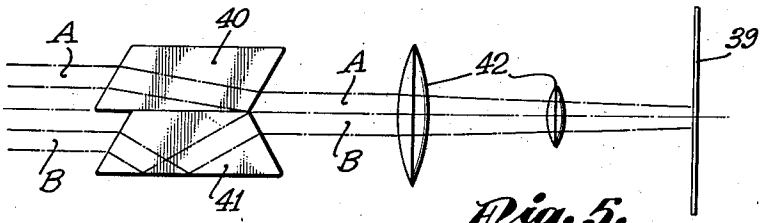


Fig. 5.

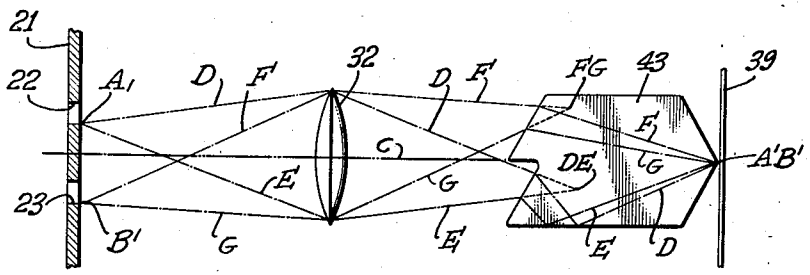


Fig. 6.

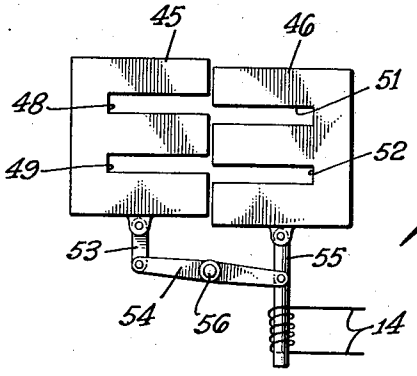


Fig. 7.

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2,354,295

SOUND RECORDING SYSTEM

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Application June 20, 1942, Serial No. 447,797

5 Claims. (Cl. 179—100.3)

This invention relates to sound recording apparatus and particularly to systems for the recording of variable density types of film photographic records.

Two standard types of commercial sound on film recording systems are well known, the variable area system producing a longitudinal trace or traces along the film to separate opaque and transparent areas, and the variable density system producing a series of transverse striations of variable density. The usual manner of recording the variable area type of sound record is with a galvanometer having a light reflecting mirror which deflects a beam of light in accordance with the instantaneous amplitudes of electrical currents being recorded. Such variable area systems generally shape the light beam before impression on the galvanometer mirror, the shaped beam being reflected to a mask having a slit through which a certain amount of light passes in accordance with the amplitude of the signal.

Although it is well known that a galvanometer may be used as a modulator for producing variable density records, as shown in Dimmick Patent No. 2,093,518, one commercial form of variable density modulator is a light valve having two ribbons between which the light passes in an amount depending on the amplitude of the signal being recorded. The ribbons are moved in opposite directions by the current passing therethrough which is in accordance with the instantaneous values of the signal currents, one ribbon always moving in the direction of film motion when the other ribbon is moving in the opposite direction.

The galvanometer, as a modulator, has certain advantages over the light valve and vice versa, the present invention being directed to a system which is adapted to utilize the best features of both systems. For instance, the present invention employs a galvanometer, which is the preferred modulator, the galvanometer being used in an optical system to simulate the desirable action of a double ribbon light valve. This eliminates the light valve, which is delicate, easily damaged by overloads and which requires constant checking and adjustment. The galvanometer on the other hand, is rugged and reliable and may operate for weeks and months without attention or adjustment.

In the light valve type of system, the light valve ribbons form a narrow slit which is imaged on the film by a light of constant intensity and uniform distribution over the area of the slit. When modulated by a signal, the spacing of the ribbons vary, resulting in a variation in width of the image. A point on the film passing through the image is exposed for a longer or shorter time period, depending on the distance through the image corresponding to the image width. Thus, the film exposure is a time function of constant intensity light and the maximum peak exposure is limited only by the maximum allowable instantaneous valve spacing which may exceed the average by many fold. Inherent in this type of system is a serious distortion of wave form and level as a function of mean image width and velocity of change in width relative to film velocity. Consequently, the mean slit width is operated at a low value except for brief intervals when quality may be sacrificed for higher levels to gain dramatic effect.

On the other hand, the galvanometer type of system is one of variable light intensity wherein the slit image width on the film is constant and the distortion inherent in the variable slit width system due to velocity effects is avoided. With fixed slit image width and constant light intensity, the maximum possible exposure is established at a certain value by the limitation of the light intensity and the choice of a slit image width determined by the optimum resolution of high frequency recording. Thus, the fixed image system does not possess the capability of high peak exposures enjoyed by the variable time system when light intensities and mean slit sizes for the two systems are comparable.

A further feature of the variable slit system is in providing the maximum of high frequency resolution at low levels, thereby improving articulation and intelligibility and providing attenuation of the high frequencies at high levels when they are not required for intelligibility and their presence is irritating and generally unpleasant.

The present invention obtains the desirable variable time feature of the light valve by the use of the favored galvanometer structure in the recording of variable density records. It may be used in the production of both a standard type of record and records of the push-pull type, while noise reduction may be incorporated in the system in any standard manner, such as will be disclosed hereinafter.

The principal object of the invention, therefore, is to facilitate the recording of photographic sound records.

Another object of the invention is to facilitate and simplify the recording of variable density sound records of high intelligibility.

A further object of the invention is to provide

a system of recording variable density sound records having high intelligibility.

A further object of the invention is to provide a variable density recording system employing a galvanometer as the modulating element.

A further object of the invention is to produce a sound recording light beam in which the dimensions thereof longitudinally of the film vary in opposite directions during a single directional movement of a galvanometer mirror.

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, forming a part hereof, in which:

Fig. 1 is a combination block and diagrammatic view of the film sound recording system embodying the invention;

Fig. 2 is a detailed view of the optical portion of the invention showing the path of the principal light rays;

Figs. 3 and 4 are detailed views of a cross-section of the light beam or beams as impressed on the film;

Fig. 5 is a view of a modification of a portion of the optical path of the invention;

Fig. 6 is a view of another modification of the optical portion of the system showing the paths of the extreme rays; and,

Fig. 7 is a detailed view of a modified mask for producing a push-pull type of record.

Referring now to Fig. 1, the electrical portion of the recording system includes a microphone 5 connected to an amplifier 6, the output of which is varied by a mixer 7 before being fed into an amplifier 8. The output of the amplifier 8 is divided, one portion going to a noise reduction amplifier 10 and another portion being impressed upon a galvanometer 12 over conductors 13. The output of the noise reduction amplifier 10 is impressed over conductors 14 on a solenoid adapted to move a mask 16, the mask having rectangular apertures 17 and 18 therein. As shown by the dotted lines 20, the output of the noise reduction amplifier may either be connected to the solenoid for operating the mask 16 or to a solenoid for similarly operating a mask 21 having rectangular slit apertures 22 and 23 similar to apertures 17 and 18 of mask 16. The dotted line portion may be substituted for the full line portion, so that the noise reduction may be obtained by either operating mask 16 with mask 21 fixed, or by operating mask 21 with mask 16 fixed.

Referring now to the optical portion of the recording system, a light source 25 produces a light beam which is collected by a lens 26 and projected onto mask 16, the light emerging through apertures 17 and 18 being projected on a mirror 29 of galvanometer 12 by a lens 28. The lenses 26 and 28 image the filament of lamp 25 on the mirror 29 of galvanometer 12. The light reflected from the mirror 29 is projected by a lens 31 onto the mask 21, the lenses 28 and 31 imaging the apertures 17 and 18 on the slit mask 21. The light emerging from the slit 23 is projected by a lens 32 to a rectangular optical unit 33 having zero optical power. The light emerging from the slit 22 is projected by lens 32 to a triangular prism element 34 which element inverts the light beam before passing it to a rectangular parallelepiped 35. The light from the element 33 also strikes the element 35 and the two light beams cross one another within the element 35 before being impressed on the sound track portion 38 of a film 39, the fixed sides of the beams coinciding at the film 39.

To illustrate in detail the paths of the principal light rays through the elements 33, 34 and 35, reference is made to Figs. 2, 3 and 4, wherein in Fig. 2 the mask 16 is shown, for purposes of explanation, adjacent the slit mask 21. The action of the mirror 29 in vibrating the light beams is the same as though the mask 16 were moved up and down in a vertical direction in front of the mask 21. To illustrate, the upper beam passing through aperture 17 and aperture 22 will be called the A beam, and the beam passing through apertures 18 and 23 will be called the B beam. Assuming for the moment that noise reduction is not employed, the normal adjustment of the galvanometer 12 for no signal would be such that half of the possible total width of the light beams A and B are transmitted to the optical elements 33, 34 and 35. With the mask 16 moved upwardly so that slits 17 and 18 are in optical alignment with slits 22 and 23, the full widths of the beams are obtained corresponding to 100% transmission of light, while an equal downward movement of mask 16 will substantially eliminate the beams from the film.

Thus, the illustration of the beams A and B as they pass through the elements 23, 24 and 25 is for a no signal condition without noise reduction. It is to be noted that the beam B passes directly through the element 33 with only a slight change in position while the beam A is inverted as it passes through the prism 34. The element 33 is used for the purpose of equalizing the light intensity and providing equal path lengths for both of the beams. After inversion and equalization of the beams, the parallelepiped 35 brings the beams together and reverses their position so that the A and B beams as projected upon the film are now in the same relative position with respect to each other as they were at slits 22 and 23, except that the A beam has been inverted. It will be noted that the fixed side A' of beam A at slit 22 and fixed side B' of beam B at slit 23 coincide on the film 39 at the optical axis C.

A cross-section of the beams as projected upon the film is illustrated in Fig. 3, wherein the dimension a represents the full possible width of the two beams A and B, while the dimension b is the actual width at no signal as illustrated in Fig. 2. Beam A is the upper half and beam B the lower half, the line C being the center or axis of the combined beams and the line A'B' of coincidence. As the galvanometer mirror vibrates, the beams A and B will increase and decrease in width, the result being a single recording beam in which the width varies equally from the axial line C. Thus, one direction of motion of the mirror 29 causes the upper and lower boundaries of the beam or beams to separate, while the reverse motion of the mirror causes these boundaries to approach each other. This variation of the combined beams is the same as that of the image produced by the light valve ribbons. For low amplitude signals, therefore, the beams will be narrow and for signals of higher amplitude, the beams will be wider, but regardless of width of the full recording beam, the long sides thereof will be equally spaced from the center axial line C.

Although this action is the same as that of a light valve, the galvanometer produces a more accurate action than that of the light valve. In

the present system the increase and decrease in width of the complete beam are each produced by the movement of a single element in a single direction and the outer edges of the beams must therefore move the same distance. In a light valve, each edge of the beam is controlled by a different ribbon which, if not identical in size and tension, will move differently even when conducting the same current. Thus, the galvanometer is not only more rugged than the light valve, but produces a more uniform widening and narrowing of the recording beam about a central axis.

For the application of noise reduction to the system just described, it is only necessary, as mentioned above to control either mask 16 or mask 21 with rectified currents corresponding to the average amplitude of the signal currents. When impressed upon the mask 16 or upon the mask 21, the adjustment is such as to permit a narrow beam of light to strike the film during times of no signal, such a narrow strip of light being shown by the dark portion of Fig. 4. The adjustment may be accomplished by either mechanically or electrically biasing the mask 16 or mask 21 to this no signal position. Now, as the amplitude of the signal increases, the mask 16 will be moved with respect to mask 21 or vice versa, so that for 100% modulation the average width of the beam is as shown in Figs. 2 and 3. Thus, the application of noise reduction produces a final print which is highly opaque during times of no signal or low modulations and has an average exposure of 50% during 100% modulation.

The invention has so far been described as a system using three separate optical elements 33, 34 and 35, which if so used would be difficult to adjust and maintain in their proper optical relationship with one another and with the remaining elements of the optical system. Thus, as shown in Fig. 5, a two-element arrangement is provided wherein an upper parallelepiped element 40 transmits beam A and a trapezoidal optical element 41 inverts and transmits beam B. These optical elements are so arranged that the beams A and B do not cross as in Fig. 2, but maintain their same relative positions with respect to one another on the entrant and emergent sides of the elements. The same operation is obtained, however, with elements 40 and 41 as with elements 33, 34 and 35; that is, the outer edges of the combined beams move away from and toward one another with variations in amplitude of the signal. In this arrangement objective lens 42 may be used intermediate the film 39 and elements 40 and 41.

To further decrease the number of optical elements, reference is made to Fig. 6, which shows a single optical unit 43 which performs in the same manner as the three optical elements 33, 34 and 35 in Fig. 2. Beam B of Fig. 2 strikes the upper left-hand surface of the element 43 and is deflected downwardly to be refracted from the lower right-hand surface of the element 43. Beam A of Fig. 2 strikes a similar surface as the surface struck by beam B but is inverted by the lower surface of the element 43 and reflected upwardly to cross beam A and be reflected by the upper right-hand surface of the element 43. The beams A and B, therefore, are reversed as to position in the same manner as in Fig. 2, while the beam A is inverted in the same manner as in Figs. 2 and 5 by the use of a single optical element. The problem of adjustment of several optical elements is thus avoided.

To illustrate the light transmission through element 43 as well as the elements in Figs. 2 and 5, the extreme rays have been traced through the element 43 from fixed points A' and B' on slits 22 and 23. From the point A' at the lower side of slit 22, rays D and E form the virtual image thereof at point DE in the lower section of element 43 while a virtual image FG of point B' on the lower side of slit 23 is formed by extreme rays F and G in the upper section of 43. The rays D, E, F, and G are refracted through element 43 as illustrated, to form the axial line A'B' along the optical axis C of Figs. 3 and 4.

As mentioned above, the system is suitable for the recording of a push-pull type of sound record, such recording being accomplished by substituting the two-mask elements 45 and 46 of Fig. 7 for the mask 16 of Fig. 1. In this mask modification, the mask 45 has a pair of apertures 48 and 49 while the mask 46 has a similar pair of apertures 51 and 52. To provide a push-pull record, however, the sections of the mask unit 45—46 are moved in opposite directions by a link connection 53, 54 and 55, the link 54 being pivoted at 56 to provide the reversal of movement of the apertures 48—49 with respect to apertures 51—52. It will be observed that in this arrangement when the beams through apertures 51 and 52 are being increased in width upon half of the film track, the beams through apertures 48 and 49 are being decreased in width as they strike the other half of the film track. This opposite and equal reaction produces the well known type of push-pull sound record, each half operating to produce a record of the same type as the record just described. Also, each half of the track will have all the advantages of the single track described in connection with the Figs. 1 to 6, inclusive.

The above-described system, therefore, is a variable density sound recording system which utilizes a galvanometer to produce a variable time light beam varying in width upon a film. In addition to these advantages attendant upon the use of this particular type of expanding and contracting light beam, the system also has the advantages attendant upon the use of a galvanometer as the light modulating instrumentality.

I claim as my invention:

1. A variable density sound recording system comprising means for generating electrical currents corresponding to sound waves, means for forming a plurality of light beams, a moving film to which said beams are adapted to be projected, means for simultaneously varying the width of said beams in the direction of the motion of said film in accordance with the instantaneous values of said electrical currents, one side of each of said beams remaining fixed, means for inverting one of said beams, and means for combining said beams into a single beam, the fixed sides of said beams being coincident at the center axis of said single beam.

2. A variable density sound recording system in accordance with claim 1 in which said beam forming means is adapted to vary the average width of said beams in accordance with the average amplitude variations of said electrical currents.

3. A sound recording system in accordance with claim 1 in which said last mentioned means includes at least one optical element for inverting one of said beams and deflecting said plurality of beams to form said single beam.

4. The method of recording a variable density record comprising generating electrical currents corresponding to sound waves, generating a plu-

rality of light beams, vibrating said plurality of light beams in accordance with the instantaneous values of said electrical currents, said vibration increasing and decreasing the width of said beams in the direction of motion of a record medium along one side only of each of said beams, and deflecting said beams to form a single beam adapted to vary in width uniformly in both directions about a fixed central axis in accordance with the instantaneous value of said electrical currents.

5. The method of claim 4 in which the average width of said plurality of beams and said single beam is varied in accordance with the average value of said electrical currents.

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