April 15, 1941. E. W. HULLEGÅRD 2,238,733

RECORDING AND REPRODUCING SOUND

Filed March 17, 1938 2 Sheets-Sheet 1

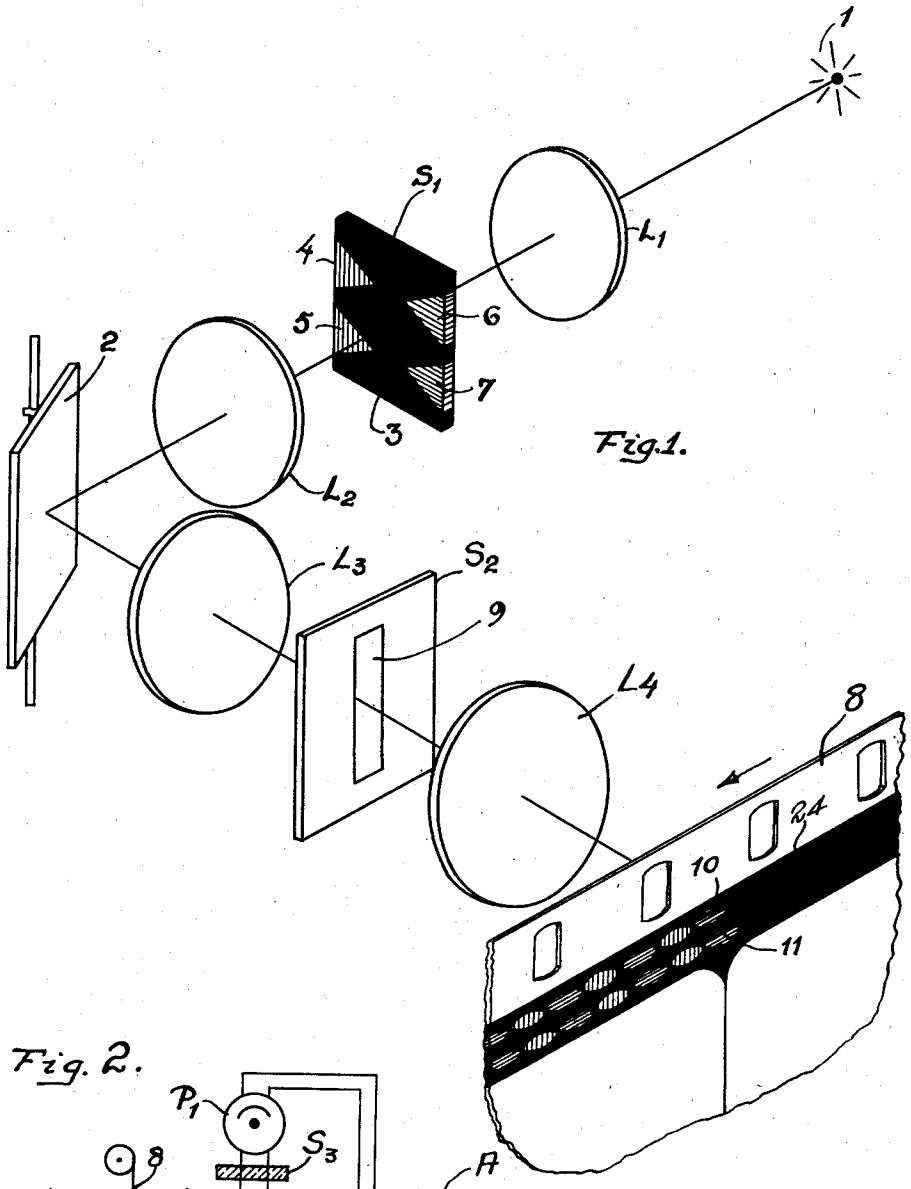
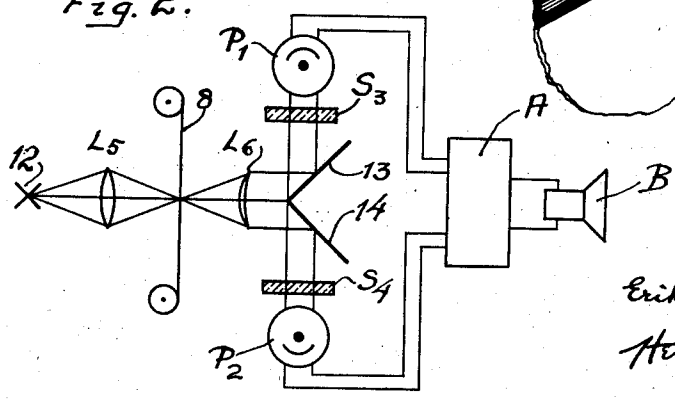


Fig. 1.

Fig. 2.



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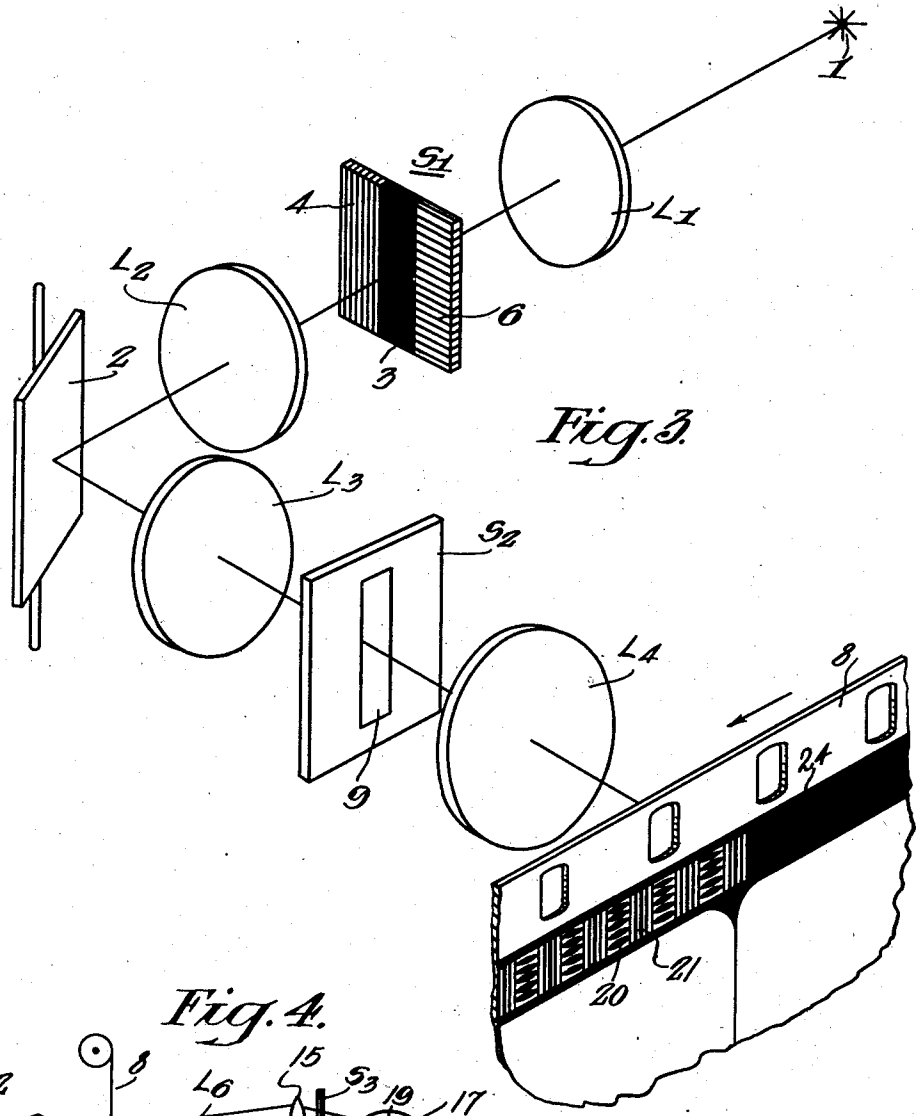
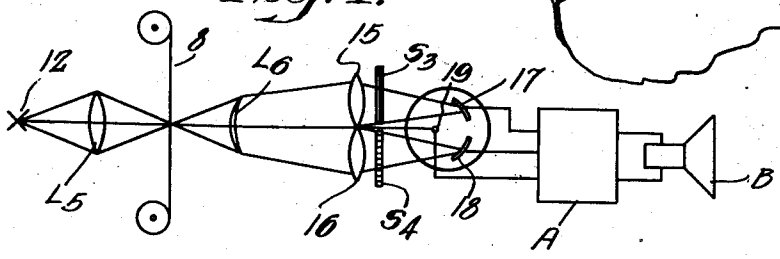


Fig. 3.

Fig. 4.



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UNITED STATES PATENT OFFICE

2,238,733

RECORDING AND REPRODUCING SOUND

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4 Claims. (Cl. 274—41.6)

The present invention relates to such systems for recording and reproducing sound through the intermedium of light-sensitive media, such as photographic films, and photocells, in which the positive and negative half-waves of the sound-oscillation-curve are recorded on the light-sensitive medium independently of one another to facilitate their separation in the reproduction through the intermedium of the photocells. Hereby the advantage is afforded that no biasing illumination of the light-sensitive medium is required on which illumination the sound oscillations are optically superposed so that the "background" will be much more silent than in previous systems having such a biasing illumination. In a known system the positive and negative half-waves of the sound curve are recorded each in one of two co-extensive tracks which necessitates the provision of complicated apparatus having means for the simultaneous reproduction of two tracks. These two tracks require further a space of the light-sensitive medium, such as a film, which is double that of an ordinary single-track.

According to the present invention said inconvenience is eliminated by arranging that the positive and negative half-waves of the sound curve are not recorded in positions transversally displaced in relation to one another but in one and the same track while receiving such distinctive properties that the record of each half-wave could be separately reproduced. In case the film is color-sensitive the positive and negative half-waves of the sound curve could be converted each to a light bundle of a distinctive color, to which the film is exposed.

The invention will now be more fully described with reference to the accompanying drawings illustrating by way of example two embodiments of the invention. On the drawings, Fig. 1 is a perspective and diagrammatic view of a preferred embodiment of a recording device whereas Fig. 2 is a circuit diagram of a reproduction device, Fig. 3 is a similar diagram of a recorder adapted to produce a variable density record, and Fig. 4 illustrates a modified type of reproducer in which the two photoelectric elements are arranged with a single anode within the same container.

In Fig. 1, condensing lenses L_4 and L_5 and a diaphragm S_1 are positioned in a straight line between a source of light 1 and an oscillating mirror 2 as shown in Fig. 1. The diaphragm S_1 consists of an opaque or non-transparent portion 3 and four triangular transparent fields, i. e. 4, 5 on the left hand side of the diaphragm and 6 and 7 on the right hand side of the diaphragm. The fields 4 and 5 have one distinctive colour and fields 6 and 7 another distinctive colour. The triangular fields turn their points towards one another as shown while leaving an opaque zone between opposing points.

Further condensing lenses L_3 and L_4 and a slit device S_2 are positioned in a straight line between the oscillating mirror 2 and a light sensitive band 8 in such an angular relationship to the path between parts 1 and 2 that in an average position of the mirror 2 an image of the diaphragm S_1 is projected on the slit device S_2. The sharp-edged slit 9 provided therein has a width corresponding to the opaque zone between opposing points in the diaphragm S_1 so that in the mentioned position of the mirror the image of the opaque zone covers the slit 9 and no light can penetrate to the colour-sensitive film 8.

The mirror 2 is connected to an oscillograph responsive to the sound to be recorded and which is not shown on the drawings.

When the mirror 2 starts oscillation the image of the diaphragm S_1 oscillates to and from over the device S_2 so that the translucent portions 4 and 5 alternating with the portions 6, 7 send light of corresponding colour through the slit 9 on to the film 8. The transversal width or, in this instance, the vertical extension of the bundle of rays reaching the film will apparently depend on the vertical dimension of the translucent portions 4 to 7 projected on to the slit device and thus on the angular deflection of the mirror 2 or the amplitude of the sound wave corresponding thereto. Provided the film band 8 is moving at a sufficient rate cross-wise to the slit 9 there will accordingly be recorded impressions which, when the film is developed, will appear as oblong traces 10, 11 of the one or the other colour on an opaque background 24 depending upon the translucent portions 4, 5 or 6, 7 which is operative at the moment.

In Fig. 2 is shown a reproduction device consisting of a light source 12, condensing lenses L_6 and L_7, stationary mirrors 13, 14, put at an angle to one another, colour filters S_3 and S_4, each letting through only light corresponding to the one colour of the translucent portions 4, 5 or 6, 7 respectively, and photo-cells P_1 and P_2. These latter are associated in push-pull-connection with an amplifier A and a loud-speaker B.

When the coloured film 8 is passed between the lenses L_6 and L_7 the bundle of light will pass alternately traces of the one or the other colour of the passing film band 8 and light of alternat-

ing colour will be reflected at the mirrors 13 and 14 on to the filters S_3 and S_4 to actuate the one and the other of the photo-cells P_1 and P_2 respectively, so that the amplifier A and loudspeaker B will respond.

In the shown embodiment there are two pairs of opposing translucent filter portions 4, 6, and 5, 7 respectively. Instead thereof only one pair or several pairs of opposing translucent portions can be used. The points of such portions need not be positioned exactly opposite one another, reckoned in a plane parallel with the path of movement of the film band, but may be staggered in which case the traces on the film band will be correspondingly staggered although grouped symmetrically in regard to an imaginary base line on the film which line is parallel with the path of movement of the film.

The two photo-cells shown in Fig. 2 could be combined as shown in Fig. 4 to a single one having for instance two cathodes 17 and 18 and one anode 19. In this arrangement, the lenses 15 and 16 perform the same function as the reflectors 13 and 14 of Fig. 2.

Whereas the above described apparatus refers to such sound films which are modulated according to the amplitude method the invention could likewise be applied to sound films, based on an intensity-modulation, and in systems, using a combination of amplitude- and intensity-modulation.

Thus, if the aperture plate S_1 be modified so that its center section 3 is opaque, its left hand section 4 passes only red light and its right hand section 6 passes only blue light, a variable density record is produced. This necessarily follows from the fact that when the mirror 2 is at rest no light is passed through the slit 9, and when the light beam is vibrated transversely of the slit a red penumbra shadow is produced for one direction of the vibration and a blue penumbra shadow is produced for the opposite direction of vibration. In this record the alternate half cycles 20 and 21 are of different colors, as indicated in the drawings. This type of record may evidently be reproduced by any reproducer involving a color selecting prism or other device suitable for causing light modulated by alternate half cycles to be applied respectively to the cathodes 17 and 18. The reproducer of Fig. 4 is suitable for this purpose. This reproducer is also capable of reproducing either of the two tracks of the record of Fig. 1.

The foregoing method and apparatus are particularly useful with the present type of color films wherein a plurality of color-sensitive layers are provided and the exposure and development produce appropriate colors in each of these layers, as distinguished from earlier types of color films in which each color was printed separately on to the positive.

What is claimed is:

1. A sound record of the photophonographic type including a film having images of opposite half cycles of sound waves thereon in different colors, and an opaque background surrounding said wave images.

2. A sound record of the photophonographic type including a film having images of opposite half cycles of sound waves thereon in alignment in different colors, and an opaque background surrounding said wave images.

3. A sound record of the photophonographic type including a film having symmetrical images of opposite half cycles of sound waves thereon in different colors in axial alignment, and an opaque background surrounding said wave images.

4. A sound record of the photophonographic type including a film having symmetrical images of opposite half cycles of sound waves thereon in axial alignment in different colors, and an opaque background surrounding said wave images.

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