April 12, 1932. L. T. ROBINSON 1,854,159

SOUND RECORDING

Filed June 24, 1929

Fig. 1.

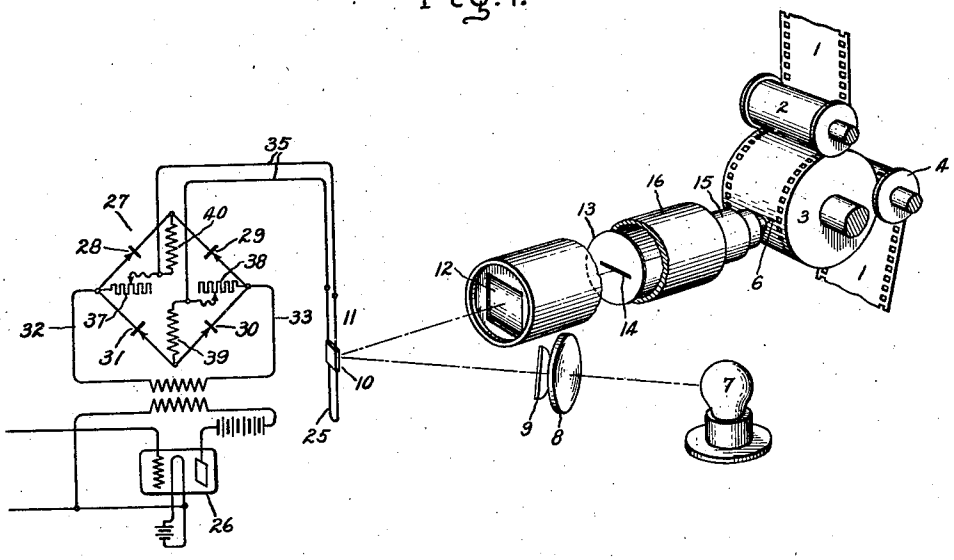


Fig. 2.

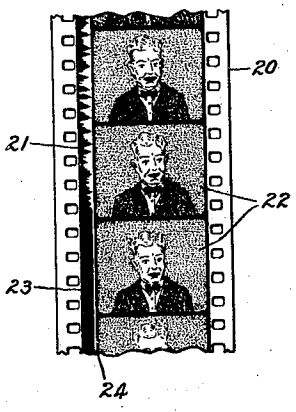
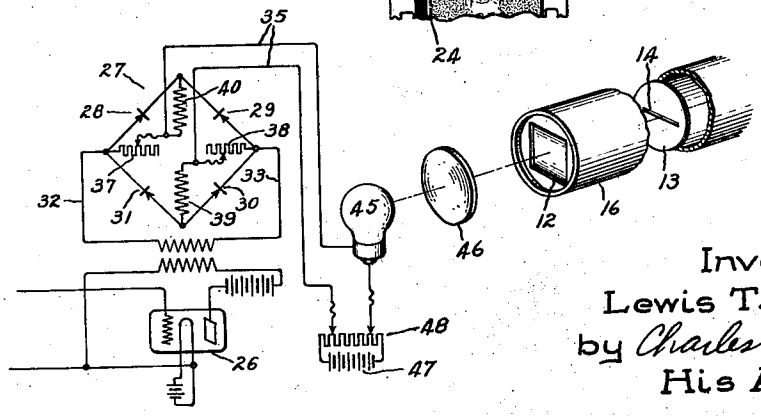


Fig. 3.



Inventor
Lewis T. Robinson,
by Charles E. Mullen
His Attorney.

Patented Apr. 12, 1932

1,854,159

UNITED STATES PATENT OFFICE

LEWIS T. ROBINSON, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK

SOUND RECORDING

Application filed June 24, 1929. Serial No. 373,232.

My invention relates to photographic sound records and to the method and apparatus for making such records. Photographic sound records usually are of one of two types, the variable density type and the variable width type, my invention being applicable to both types.

It is known that a considerable part of the "ground noise" heard when a record of either type is being reproduced is a result of the light passing freely into the photo-electric cell through the relatively clear or thin portions of the sound record. When relatively loud sounds are being reproduced the ground noise is not noticeable but as the amplitude of the sound waves decreases the ground noise by comparison becomes more and more apparent. It is particularly noticeable just before the sound starts and after it ceases.

It is one object of my invention to provide an improved sound record whereby the "ground noise" noticeable at any time during the operation of a reproducing apparatus using such a record is reduced to a negligible amount. Another object of my invention is the provision of an improved sound recording method and apparatus with which a minimum amount of ground noise will be produced when the record is reproduced.

My invention will be better understood from the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

Referring to the drawings, Fig. 1 is a combined circuit diagram and perspective view of apparatus embodying my invention for making a variable width sound record; Fig. 2 shows a portion of a positive motion picture film having at one side a sound record made with the apparatus shown in Fig. 1; and Fig. 3 illustrates apparatus similar to that shown in Fig. 1 for making a variable density sound record.

A preferred method of making a sound record of the variable width type is to employ an oscillograph galvanometer connected to a suitable sound pick-up device through one or more thermionic amplifiers and arranged to reflect a light beam on the moving film. The beam reaching the film should be a very narrow line of light extending transversely of the direction of motion of the film. The galvanometer is arranged to cause the light beam to vibrate in a direction also transverse to the direction of motion of the film, the length of the light line which impinges on the film varying in accordance with the vibrations of the beam. Since the current which actuates the galvanometer is alternating in character the reflected light beam swings on both sides of its normal or zero deflection position. With the moving element of the galvanometer at rest the latter heretofore usually has been adjusted to cause the light line on the film to cover approximately one half of the width of the sound track, which is the strip on the film reserved for the sound record, hence in the recording operation the portion of the film exposed by the light line has varied each side of the center line of the sound track.

In Fig. 1 of the drawings I have shown the unexposed film 1 upon which the sound record is to be photographed passing from a take-off reel, not shown, under guide roll 2, over the drum 3 and over a second roll 4 from which it passes to a take-up reel, not shown. In order to simplify the drawings I have purposely omitted the various sprockets, film driving means, magazines, enclosing casings, etc., which constitute parts of the complete apparatus, as they form no part of my present invention. At the point of exposure, the film is supported on the surface of the drum and may be moved either by the drum through suitable connection with a driving motor or be moved by sprockets connected with the motor.

The optical system by means of which the narrow line of light 6 is focused on the film is shown, for example, as comprising the electric lamp 7 forming the light source, the condensing lens 8, the light stop 9, the mirror 10 of the oscillograph galvanometer 11 of standard construction, the cylindrical lens 12, screen 13 having a narrow opening 14 therein and the microscope objective 15. Elements 12 to 15 inclusive, it will be noted, are mounted for convenience in the tube 16, the objec-

tive 15 being adjustable therein to facilitate focusing the light beam on the film. The light beam which passes the vertical edge of the stop 9 is reflected by the mirror 10 into the tube 16 on screen 13 being concentrated in one meridian by the cylindrical lens 12. As the mirror vibrates the reflected beam vibrates in the direction of the opening 14 in screen 13 illuminating more or less of the opening. That part of the opening which at any instant is illuminated is imaged on a reduced scale on the film forming the light line 6. As the film moves uniformly past the focused beam forming the light line the variation in length of the line in accordance with the sound waves exposes the film in a manner to form a sound record of the variable width type, as shown, for example, at the left side of the positive film illustrated by Fig. 2.

In making such a record, as has already been pointed out above, the zero deflection position of the galvanometer heretofore has been adjusted to cause the dividing line between the exposed and the unexposed portion of the sound track to vibrate equally on both sides of the center line of the sound track. Accordingly when no sound is being recorded, substantially one half of the sound track is exposed and the other half is unexposed. The unexposed half of the negative and the opposite half of the positive print therefore are clear. It is this portion when the record is being reproduced which gives rise to the objectionable ground noise. I have found that the clear area of the positve sound record may be reduced to a minimum bv adjusting the galvanometer to cause the exposing light beam to take a position scarcely covering any portion of the width of the sound track when no sound is being recorded and by causing the zero position of the galvanometer when it is vibrated in response to the sound, to move toward the center of the sound track. The resulting sound record when printed has a minimum amount of clear area, which area also decreases as the volume of the sound decreases so that when no sound is being recorded the sound track is almost entirely black. In Fig. 2 I have shown a small section of a positive motion picture film 20 having a sound record 21 thereon, in accordance with my invention, arranged between the pictures 22 and one row of sprocket holes. It will be noted that in the lower portion of the film section illustrated, where no sound is recorded, the sound track 23 is all black except the narrow clear band 24.

As seen from Fig. 2 the opaque portion of the sound record has a series of peaks which extend substantially to but not beyond the boundary of the clear portion of the sound track. The axis of the record or line of separation between the opaque and clear portions during the recording of sound is not straight as in the former variable width records but on the contrary is irregular and at varying distances from the straight boundary line of the sound track in accordance with the volume characteristic of the sound being recorded. For example, when there is no sound the axis is parallel with and close to the track boundary of the clear portion; when, however, there is sound the axis recedes from that boundary in accordance with the volume of the sound.

I shall now describe the means which I have devised and illustrated in Fig. 1 for causing the oscillograph galvanometer to vibrate the exposing light beam in the manner described. Connected between the bifilar moving element 25 supporting the mirror 10 of the galvanometer and the last amplifier 26 of which there may be several connected with the pick-up microphone (not shown) is the rectifying apparatus 27. The purpose of this apparatus is to superimpose upon the normal sound responsive current fed to the galvanometer a suitable rectified component thereof. I employ an arrangement comprising four contact rectifiers 28, 29, 30 and 31, such, for example, as those described and claimed in the Grondahl Patent 1,640,335, August 23, 1927, connected in the manner shown by the leads 32 and 33 with the filament and plate circuit of the amplifier 26 and by the leads 35 with the moving element 25 of the galvanometer. These connections include the variable resistances 37 and 38 and the inductances 39 and 40. Preparatory to using this apparatus to make a sound record I prefer first to adjust it by varying the values of resistances 37 and 38 while employing, for example, a 500 cycle steady signal from the amplifier 26 until the half cycle deflection of the light beam due to the alternating signal current is substantially equal to the deflection due to the rectified current. I then adjust the zero deflection position of the galvanometer so that when there is no sound being recorded the light beam laps over a small fraction only of the sound track which in the positive appears as the narrow clear line 24. In some cases I may adjust the galvanometer so that there shall be no overlap of the beam, hence no line 24 when there is no sound, but to avoid unnecessarily cutting off the peaks of high amplitude waves I prefer to have the slight overlap described. The rectifier may be adjusted so that the rectified current equals the normal alternating current sound current, is greater, or is less than the same as conditions require. By reason of the inductance in the circuit of the rectified current the wave form is smoothed out to the desired extent and while I have obtained satisfactory results using the arrangement shown whereby I believe the value of the rectified current which displaces the zero deflection position of the galvanometer corresponds approximately to the average value, I may in certain cases prefer

to make use of any of the well known arrangements to make the shifting of the zero responsive to the peak value of the sound current instead of the average value or to even use the R. M. S. value. It will be understood that the circuit constants may be varied at will to suitably delay the time change of the rectified component of the current to give any desired operation of the galvanometer. It will be understood that in any case the frequency of variation of the rectified current should be below the audible range.

In reproducing from sound records as heretofore constructed where the ground noise prior to the beginning of the sound or after the termination thereof has been objectionable the operator sometimes has operated the fader to cut off the light beam directed on the film during the times of silence. With a film made in accordance with my invention the light reaching the cell is almost entirely cut off automatically whenever there is no sound, the quantity of light reaching the cell is also reduced as the volume of the sound is reduced.

In the arrangement which I have shown the exposing light beam has a sharp edge, called the working edge, due to the straight side of stop 9 and the focal position thereof, hence the serrated edge of the sound record 21 is sharply defined. If, however, the sound record is made with a graded edge produced, for example, by using a graded edged stop 9 or by merely placing the stop at the proper out-of-focus position and allowing the wave peaks to over-shoot the limits of the sound track a record is obtained which resembles the variable density or ladder type of record. Here again the ground noise is reduced by the use of the rectifying apparatus already described to shift the zero position of the galvanometer.

For making a record such as shown in Fig. 2, initial setting of the galvanometer resulting in the clear band 24 of the print will depend to a certain extent on the relative value of the rectified current, it being desirable to start with the galvanometer zero spaced from the adjacent edge of the sound track only so far as to insure against the possibility of the peaks of the recorded waves excesively overshooting the limit of the sound track at that edge since it has been found that any material cutting off of the peaks at one edge results in a noticeable distortion of the reproduced sound.

In the form of my invention illustrated in Fig. 3 for making a sound record of the variable intensity type, the film, the supporting drum therefor, and the means for focusing on the film a narrow light line are similar to what is shown in Fig. 1. Instead of employing a light source of constant intensity and reflecting a light beam therefrom by an oscillograph mirror as in that figure there is shown the variable intensity discharge lamp 45 whose rays are condensed by the spherical lens 46 and the cylindrical lens 12 on the screen 13 having the narrow opening 14. The entire opening is constantly illuminated, the degree of illumination being variable in accordance with the sound waves to be recorded. Lamp 45 is illuminated partly by direct current from the battery 47 to which it is connected through the potentiometer device 48 and partly by combined alternating and direct currents from the rectifying apparatus 27. The latter is shown as similar to that illustrated in Fig. 1, the circuit 35 being connected in series with the lamp 45 and the potentiometer 48 so that the rectified current shall assist the battery current. In using this apparatus to record sound, the potentiometer is adjusted so that when there is no sound the illumination of lamp 45 is somewhat below that required for good sound recording, the light being preferably so dim at such times that the film is substantially unexposed. During the recording of sound the rectified current brings up the illumination of the lamp to a proper or intermediate recording intensity such as that which would be used were no rectifier employed. The alternating current corresponding to the sound waves being recorded then modifies the illumination of the lamp causing it to vary above and below said intensity in the well understood manner.

I have chosen the particular embodiments described above as illustrative of my invention and it will be apparent that various modifications may be made without departing from the spirit and scope of my invention which modifications I aim to cover by the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States, is,—

1. The method of making a photographic sound record adapted to produce a minimum amount of ground noise upon the reproduction of the recorded sound which comprises exposing a sensitive film to a light beam, varying the beam in accordance with the wave form of the sound being recorded and varying the zero of the beam in accordance with the volume of the sound.

2. The method of making a variable width photographic sound record in which the clear area varies with the volume of the sound being recorded which comprises exposing a sensitive film to a light beam, vibrating the beam laterally of the film in accordance with the wave form of the sound being recorded, and producing a lateral displacement of the zero position of the beam in accordance with the volume of the sound.

3. A film having a sound track containing variable width photographic record of sound waves the axis of the record varying in position relative to one side of the sound track in

accordance with the volume characteristic of the recorded sound.

4. A film having a sound track containing a variable width photographic sound record the peaks of the opaque portion of the record extending substantially to the side of the sound track irrespective of variations in the volume of the recorded sound.

5. A film having a sound track containing a sound record which record comprises relatively clear and opaque portions bounded by the respective opposite sides of the sound track, the axis of the record receding from the side of the sound track bounding the clear side of the record in accordance with the volume of the recorded sound.

6. Apparatus for photographically recording sound on a moving sensitive film comprising means for directing on the film a variable light beam, and means for supplying to said means for the control thereof an alternating current corresponding to the sound waves to be recorded and a direct current in response to the sound.

7. Apparatus for photographically recording sound on a moving sensitive film comprising means for directing a variable light beam on the film, and means for supplying to said means an alternating current corresponding with the sound waves to be recorded and a direct current variable in accordance with said sound waves.

8. Apparatus for photographically recording sound on a moving sensitive film comprising means for directing a variable light beam on the film, and means for supplying to said means an alternating current corresponding with the sound waves to be recorded and a superposed rectified component of said current.

9. Apparatus for photographically recording sound on a moving sensitive film comprising means for directing a variable light beam on the film, and means for supplying to said means an alternating current corresponding with the sound waves to be recorded, means for modifying the response of said first mentioned means to said alternating current in accordance with a rectified component of said current.

10. Apparatus for making a variable width photographic sound record in which the area of the clear portion thereof varies approximately with the sound volume including means for directing a light beam on a light sensitive film and means for vibrating the beam laterally in accordance with the sound waves to be recorded and for producing an additional lateral displacement of the beam in accordance with the volume of the sound.

11. Apparatus for photographically recording sound on a moving sensitive film comprising a source of light, means for directing a light beam therefrom on said film and for vibrating the beam transversely of the film in accordance with the sound to be recorded, and sound responsive means for shifting the zero deflection position of said beam transversely of said film.

12. Apparatus for photographically recording sound on a moving sensitive film comprising a source of light, means comprising an oscillograph galvanometer for reflecting a light beam from said source on said film and for vibrating it in accordance with the sound waves to be recorded to form a variable width sound record, and means responsive to said sound waves for shifting laterally of the film to zero deflection position of the vibrated light beam.

13. Apparatus for photographically recording sound on a moving sensitive film comprising a light source, an oscillograph galvanometer arranged to reflect a light beam therefrom to said film and adapted to be vibrated by an alternating current corresponding to the sound to be recorded thereby forming a variable width sound record, and means responsive to said sound for superposing a direct current on the alternating current input of said galvanometer.

14. Apparatus for photographically recording sound on a moving sensitive film comprising a light source, an oscillograph galvanometer arranged to reflect a light beam therefrom to said film to form a variable width sound record thereon, and means for supplying to said galvanometer an alternating current corresponding to the sound waves to be recorded, and a superposed rectified component thereof.

15. Apparatus for photographically recording sound on a moving sensitive film comprising a light source, an oscillograph galvanometer arranged to reflect a light beam therefrom to said film to form a variable width sound record thereon, a sound current amplifier having a connection with said galvanometer, and rectifier means in said connection for superposing on the alternating sound responsive current supplied to the galvanometer a direct current controlled in value by the sound being recorded.

In witness whereof, I have hereunto set my hand this 22nd day of June, 1929.

LEWIS T. ROBINSON.

DISCLAIMER

1,854,159.—*Lewis T. Robinson*, Schenectady, N. Y. SOUND RECORDING. Patent dated April 12, 1932. Disclaimer filed August 13, 1938, by the assignee, *General Electric Company*.

Hereby enters this disclaimer to claims 1, 6, 7, 8, and 9 of the said Letters Patent.

[*Official Gazette September 6, 1938.*]