March 14, 1933. A. KAROLUS 1,901,034

METHOD OF RECORDING AND REPRODUCING PHONOFILMS

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Fig. 1

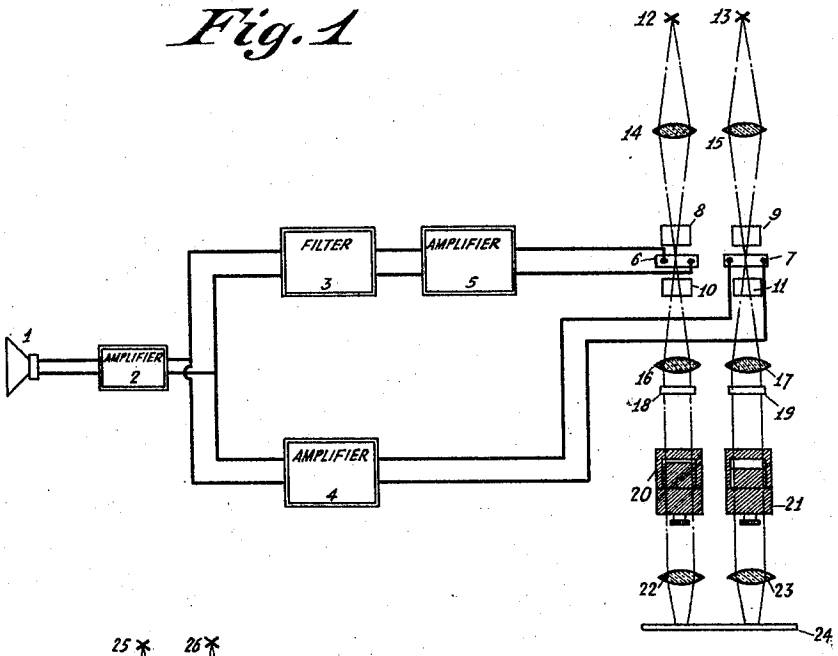
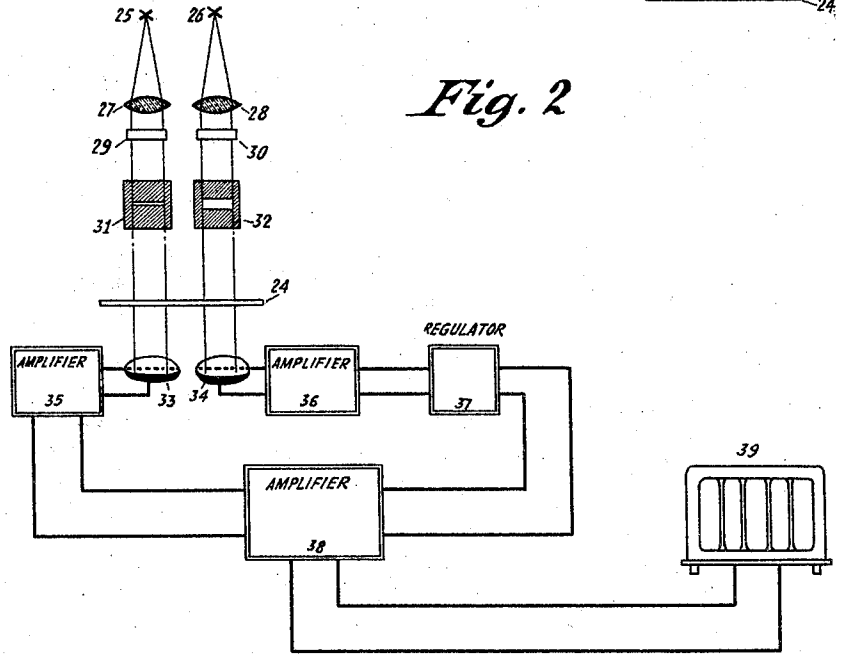


Fig. 2



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UNITED STATES PATENT OFFICE

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METHOD OF RECORDING AND REPRODUCING PHONOFILMS

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In the recording of sound upon moving films, it is the usual practice to retain the entire frequency band of voice or music to be recorded either in the form of portions of variable blackening or as variable line lengths in a single strip. As a result, both in recording as well as in reproduction, with a predetermined speed of film travel and for a predetermined upper frequency limit, the widths of the illuminating slit in the direction of the film movement should not exceed a certain value governed by these factors. However, by such a fixed size of the slit the highest possible aggregate luminous intensity for both exposure and reproduction is fixed and thus in reproduction also the relation between the amplitudes of currents obtainable photoelectrically, from the sound record, and the inevitable ground noise, due to the grain of the film, the amplifier noise, etc., are also fixed.

An increase in the control potential obtainable photoelectrically, in the presence of a given surface of intrinsic brightness of the luminous source used for reproduction is possible only by enlargening the size of the slit used for illumination, though this is attended with a limitation of the available frequency band in the upward sense.

It is an object of this invention to provide a method of photo-phonographic recording and reproduction which will be free from these limitations.

It is a further object of this invention to produce a method of and means for recording and reproducing of phono films in which the reproduction will be more faithful.

It is a still further object of this invention to record and reproduce sound upon and from moving pictures in such a manner that in reproduction the energy derived from the low frequency sounds will be in the proper proportion to that derived from the high frequency sounds.

These and other objects will become clear from the following specification taken in connection with the appended drawing.

The necessary compromise between the width of the slit, luminous intensity, and the frequency band which can be reproduced, can be obviated in accordance with my invention by dividing the entire frequency band to be recorded into a number of partial bands in the form of adjacent strips simultaneously recorded upon the film. These simultaneous records may be reproduced simultaneously by the aid of separate slits.

The slit widths for the various parts of the frequency band can be adapted to the size of the band, in other words, for the lower ranges the permissible width of the slit can be chosen substantially larger than for the higher ranges. For vocal and instrumental recording it would generally be sufficient to accommodate the entire frequency band between 25 and 10,000 cycles in two strips. Preferably the low frequency band should be between 25 and 1,000 cycles and the high frequency band should be between 2,500 and 10,000 cycles. In this case, the slit for the low frequency band may be 10 times wider than for the recording and reproduction of the high frequencies, at the same time giving corresponding exactness of reproduction. At the same intrinsic brilliancy of the two light sources used for reproduction of the two frequency bands, the useful photoelectric current for the lower range band may have values 10 times larger than has heretofore been feasible in the old methods. However, in order that in this method there may be no amplitude predominance of the lower ranges over the higher ones, it may be necessary to produce a correspondingly greater amplitude of the higher frequencies compared with the lower ones, at the time that the record is made, by means of increased amplification. Ultimately, of course, the original relationship between the amplitudes of the separate frequency ranges must be restored in reproduction and this may be insured either by the proper proportioning of the slit widths in reproduction, by the variation of the light volume, or by selective amplification.

The separation or division of the various frequency bands to be recorded may be affected even at the recorder microphone or in the case of a joint recording microphone and input amplifier, by the aid of a filter network arranged before the recording means. In the

latter case, only one filter chain is required by means of which the low frequencies are kept away from the narrower slit intended for the recording of the higher frequency ranges, while inversely the higher frequencies are suppressed optically, by the other slit which records the lower frequencies. In reproduction the combining of the frequency bands can be either affected by the use of a joint single photoelectric cell in conjunction with all of the record strips as described in my co-pending application Serial No. 357,859, filed concurrently herewith, or by the use of separate photoelectric cells and joint amplifier or reproducer means. Moreover, the separation of frequency bands may be maintained to the loud speaker itself so that the recombination is effected only with respect to the ear.

The present invention deals particularly with that form of reproduction in which separate photoelectric cells are provided for reproducing each of the frequency bands.

The present method is useful for all kinds of photo films, that is to say, those in which a slit of variable brightness is photographed upon the film, as well as those in which a line of varying length producing a saw-tooth record is recorded, and also the combinations of both methods.

Having thus briefly described my invention, attention is invited to the accompanying drawing in which:

Fig. 1 is a diagram illustrating the preferred method of recording sound in accordance with the present invention; and,

Fig. 2 is a diagram illustrating the preferred method of reproducing in accordance with my invention from the record produced in accordance with the method shown in Fig. 1.

Attention is now more particularly invited to Fig. 1 wherein 1 represents a microphone for converting the audio waves into electrical waves, 2 is an input amplifier for amplifying all of the frequencies produced by the microphone 1, and 3 is a filter adapted to exclude the lower frequencies from the narrow slit. 4 and 5 are amplifiers, the former of which serves to amplify the low frequencies and the latter of which serves only to amplify the high frequencies. The latter amplifier acts upon a photo relay or valve such as a Kerr cell 6, while the low frequencies serve to control another light valve 7 which may be suitably of the same sort. The requisite polarizers and analyzers in the case of a Kerr cell are denoted by 8 and 9, and 10 and 11, respectively. The light of two luminous sources 12 and 13 is projected through the lenses 14 and 15 upon the Kerr cells 6 and 7, so that the brightness of the light passed through the analyzers 10 and 11 is subject to electrical control by the current transmitted by the amplifiers 5 and 4, respectively. The light passing through these analyzers may, in turn, be regarded as varying light sources for the recording of acoustic impressions upon the film 24. For this purpose there are provided two optical systems including spherical lenses 16 and 17, and cylindrical lenses 18 and 19 for the purpose of producing a homogeneous illumination of the slits 20 and 21. These last mentioned slits are arranged to be accurately adjusted, and the width of the slit 20 is small as compared with the width of slit 21, as shown upon the drawing. The image of these uniformly illuminated slits is then thrown upon the moving film by means of the objectives 22 and 23, where they simultaneously produce separate acoustic records. The record produced by means of light passing through the slit 20 contains the higher range of frequencies which has been suitably strongly amplified, while the record produced by the light passing through the slit 21 comprises only the low frequencies.

Referring now more particularly to Fig. 2, there are shown means for reproducing or converting the acoustic record produced by the method illustrated in Fig. 1 into sound. The film 24, for instance, by the use of the narrow slit or gap 31 in connection with a record bearing the high frequency ranges and another slit 32 in connection with the record bearing the low frequency ranges is traversed by light, for which purpose there are provided the luminous sources 25 and 26, spherical lenses 27 and 28, and cylindrical lenses 29 and 30. It is to be understood that this arrangement is merely illustrative and need not be restricted to the specific form shown in order to fall within the scope of my invention. The light caused to fall separately upon the photoelectric cells 33 and 34 through the separate accoustic records and which is varied in intensity by the action of the records, occasions corresponding fluctuations in the current regulated by these photoelectric cells which fluctuations are amplified by means of the amplifiers 35 and 36. In order to regulate the intensity relationship between the currents thus amplified, a regulator 37 of any known kind may be provided before the separate frequency bands are combined in the common amplifier 38, and are further amplified. Connected with the output end of the amplifier 38 is a loud speaker 39 for reproducing the entire frequency of the composition.

Having thus fully described my invention, I will now briefly describe its operation. The sound to be recorded is picked up by the microphone 1 and amplified in the usual and well known manner. The frequency range of the audio sounds is divided by means of the filter 3 which is adapted to filter out the low frequencies and permit only the high frequencies to be amplified by the amplifier 5. The high frequencies thus am-

plified control the light from the source 12 which is permitted to fall upon the film 24 through the narrow slit 20. The low frequencies which are amplified by the amplifier 4 control the light from the source 13 which is permitted to fall upon the film 24 through the wide slit 21. There is thus produced a film record composed of two separate film records, one comprised of the high frequencies and the other of low frequencies. This film is reproduced in a reverse manner as is shown in Fig. 2. The light from the source 25 is allowed to pass through the film after passing through the narrow slit 31 and then falls upon the photoelectric cell 33 thus controlling its resistance in accordance with the high frequency sound record of said film. Similarly, the light from the source 26 passes through the film 24 after passing through the said slit 32 and falls upon the photoelectric cell 34 controlling its resistance and thereby producing a current in accordance with the low frequencies recorded upon the film 24. The current controlled by the photoelectric cells is independently amplified by means of the amplifiers 35 and 36 and the current produced by the low frequency part of the record is controlled by the regulator 37 in order that the amplitude of the currents produced by the high frequencies and low frequencies may be properly adjusted relative to each other before they are combined in the common amplifier 38. By the proper adjustment of the amplifiers both at the recorder and the reproducer, there is supplied to the amplifier 38 of the receiver the properly proportioned high and low frequency sound intensities, and the current thus properly balanced and amplified is reproduced by means of the loud speaking device 39.

When using the Kerr cell there is produced upon the film an acoustic record of constant width in which the brightness of the adjacent images of the slit changes in accordance with the instantaneous intensity of the light. However, as stated before, this invention is not confined to use in connection with this type of film, indeed, it is useful also in connection with the type of films in which a blackened strip of variable width is produced upon the film. For this, of course, light valves of a different kind such as oscillographic light relays, must be used in recording.

As pointed out above, it is also possible to have the photoelectric cell common for both frequency ranges in the reproducer and to insure the proper intensity relations only by controlling the amount of light passing through the film as pointed out in connection with my co-pending application mentioned above.

Furthermore, separate amplifier means may be used in conjunction with the amplifier 35 and the regulator 37 and with these, in turn, different loud speakers may be associated, say, one for the high frequency, and one for the low frequency.

Although in the preceding specification the recording and reproduction is accomplished by means of two separate record bands, it will be understood that the invention is not confined thereto, and it is possible to employ more than two record bands, each one of which would cover a specific audio frequency range.

Having thus described my invention, it is to be understood that I am not to be limited by the specific form shown and described for the purpose of illustration only, but by the scope of my invention as determined and set forth in the appended claims.

I claim:

1. In apparatus for recording and reproducing photophonographic sound records, means for dividing the frequency band of the sound to be recorded into a number of frequency bands, and means for separately recording said different frequency bands, said last mentioned means including slitted members having a width in the direction of the motion of the photophonographic record chosen in accordance with the frequency range being recorded through said slit.

2. In apparatus for the recording and reproducing of photophonographic records, means for dividing the sounds to be recorded into a plurality of frequency bands, means for separately recording each of said frequency bands, and sound reproducing means, both said recording means and said sound reproducing means including slitted members the length of which in the direction of motion of the sound record is chosen in accordance with the frequency range being recorded and reproduced through said slits, and means for varying the length of said slits.

3. A phonographic method including producing relatively large and relatively small light beams, modulating said relatively large light beam in accordance with a low frequency component of the sound to be recorded or reproduced, and modulating said relatively small light beam in accordance with a high frequency component of said sound.

4. A phonographic method including producing relatively large and relatively small light beams, modulating said relatively large light beam in accordance with a low frequency component of the sound to be recorded or reproduced, modulating said relatively small light beam in accordance with a high frequency component of said sound, and interposing light responsive means in the paths of said modulated beams.

5. A phonographic method including producing relatively large and relatively small

light beams, modulating said relatively large light beam in accordance with a low frequency component of the sound to be recorded or reproduced, modulating said relatively small light beam in accordance with a high frequency component of said sound, and moving a photographic record medium across the paths of said modulated beams.

6. A phonographic method including producing relatively large and relatively small light beams, modulating said relatively large light beam in accordance with a low frequency component of the sound to be recorded or reproduced, and modulating said relatively small light beam in accordance with a high frequency component of said sound by moving a photographic sound record across the paths of said beams.

7. A photographic sound recording method including separating the sound to be recorded into high and low frequency components, utilizing said low frequency components to modulate a light beam which is comparatively wide in the direction of the movement of the photographic record, and utilizing said high frequency components to modulate a light beam which is comparatively narrow in said direction.

8. The method of photographic recording which comprises producing a sound to be recorded, modulating an electric current in accordance with said sound, separating the high and low frequency components of said modulated electric current, controlling the intensity of a light beam in accordance with each of said frequency components, independently recording the intensity of the light beams upon a moving film record, restricting the light permitted to fall upon the moving film record from the light beam controlled by the high frequency to a small area with respect to the line of motion of said film, and restricting the light permitted to fall upon the moving film record from the light beam controlled by the low frequency to a relatively large area with respect to the line of motion of said film.

9. The method of photographic recording of sound which comprises separating the high and low frequency components of the electric impulses representing said sound, controlling the intensity of a light beam in accordance with each of said frequency components, independently recording the intensity of the said light beams upon a moving film record, and restricting the light permitted to fall upon said record from the light beams controlled by the high and low frequencies to a small and relatively large area, respectively, with respect to the line of motion of said film.

10. Photographic sound recording apparatus including means for separating the sound to be recorded into high and low frequency components, means for independently recording said components photoelectrically, and means for restricting the light used to record the high and low frequency components falling upon the film to relatively narrow and wide slots with respect to the direction of travel of the film.

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