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SOUND RECORDING AND REPRODUCING

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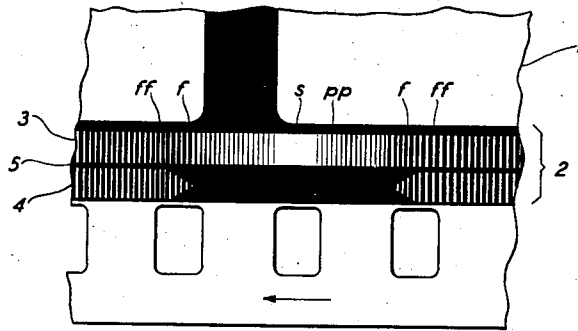


FIG. 1

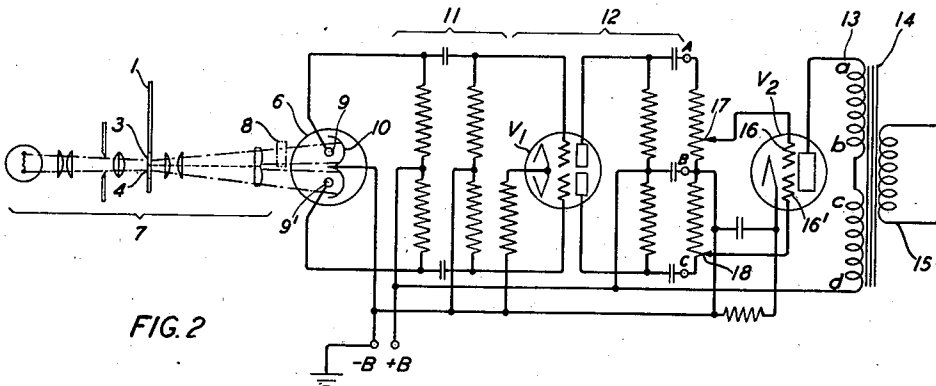


FIG. 2

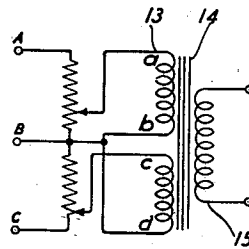


FIG. 2a

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SOUND RECORDING AND REPRODUCING

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This invention relates to an improvement in photographic sound recording and reproducing with particular reference to sound films of the variable density type.

From the earliest days of sound recording it has been recognized that the sound volumes successfully recorded and reproduced were confined within limits fixed for the louder sounds by the operation of the recording device and for the fainter sounds by the noise level inherent in the recording medium. In most photographic sound records noise reduction is employed to reduce film noise during periods otherwise silent and during the recording of fainter sounds. The application of noise reduction to variable density sound films is described in my United States Patent 1,921,037, issued August 8, 1933. Another expedient known as "squeeze track" recording is commonly used in variable density sound film work and is described by G. R. Crane in the Journal of the Society of Motion Picture Engineers, volume 31, page 531, November 1938. The latter expedient makes it possible to record dialog and minor sound effects at full modulation of the recording exposure but over a width of sound track narrower than is used for the recording (again at full modulation) of music and major sound effects at maximum volume. If, for example, dialog is recorded over a width of track half that used for music, dialog will be reproduced at a level 6 decibels below the music and the signal-to-noise ratio during dialog reproduction will be only 3 decibels less than the corresponding ratio for the music. Although this difference of 6 decibels in reproduced levels of dialog and music is much less than necessary for realistic presentation, practical considerations usually preclude track squeezing further than to this extent.

Accordingly, it is an object of the present invention to provide a method whereby the differential between dialog and music levels in reproduction can be significantly increased say from 6 decibels to 12 decibels with only a trifling sacrifice in signal-to-noise range during fortissimo passages.

Another object of the invention is to provide a sound film record suitable for the application of the method of the invention and at the same time capable of successful reproduction wherever the usual sound film can be reproduced.

A further object of the invention is to provide a reproducing circuit involving a minimum of alteration in existing theatre sound film reproducers and adapted to realize the full advantage offered by the method of the invention permitting

as well the reproduction of ordinary sound films without impairment.

The invention will be fully understood from a detailed description of the accompanying drawing in which:

Fig. 1 shows a fragment of a preferred form of sound record adapted to be reproduced with increased volume range;

Fig. 2 shows schematically a preferred form of photocell circuit according to the invention; and

Fig. 2a shows a mixing circuit alternative to that of Fig. 2.

In Fig. 1 film 1 has in the customary location a positive sound record 2 of the variable density type. Record 2 has an overall width equal to that of the usual sound track but in the practice of this invention is divided longitudinally into two portions 3 and 4 of approximately equal width. Portions 3 and 4 may be separated by a narrow opaque system line 5 as is usual in the case of push-pull records. As drawn, the emulsion surface is up and the film travels in the direction of the arrow. Therefore, a later instant of time is represented at the left end of film 1 than at the right end. It will be noted that portion 3 of record 2 is a continuous record of fortissimo sound ff, through intermediate sound levels f, pianissimo pp and silent intervals s, whereas portion 4 duplicates the fortissimo record of portion 3 but is opaque during the silent interval s and the pianissimo passage pp. The width of portion 4 on which the sound record appears varies from very narrow at f, which may correspond to the dialog level, to the same width as portion 3 at ff.

Such a variable density sound record may be produced using a standard light valve and modifying in a simple way a standard manual or automatic squeeze-track masking device to control the width of portion 4 exposed to the light modulation. The masking device ordinarily used in push-pull recording comprises a mask in the form of a W each half of which effects the masking of the corresponding portion of the push-pull record. For the purpose of this invention the W mask may readily be altered to a V-shaped mask operating to squeeze only one-half of the sound track. This masking device may, if desired, permit the abrupt inclusion or exclusion of the whole width of portion 4 but the gradual operation indicated in Fig. 1 permits a smoother transition and is therefore preferred.

In the practice of squeeze-track recording described by Crane in the publication referred to, the recording apparatus is so designed that as the

sound record is reduced in width the gain of the recording amplifier is reciprocally increased. For example, a sound level 6 decibels below the highest recordable level is raised 6 decibels at the same time that the record width is halved. A similar procedure is to be followed in making the record of Fig. 1. During the recording of dialog on portion 3 of record 2 recording amplification is so chosen that the louder dialog levels effect full modulation of the recording device, a light valve, for example. As the recordist unmask portion 4 recording sounds louder than have already been recorded in portion 3, recording gain is controlled reciprocally with the increase in sound level to the end that between the dialog and music levels corresponding to *f* and *ff*, respectively, of Fig. 1 the sound track exposure is fully modulated and the two portions of record 2 cooperate in the recording.

In Fig. 1 is represented the obscuration of portion 4 as the level to be recorded falls to that of dialog followed by the unmasking of this portion as higher sound levels again present themselves. It is to be understood that the conventional noise reduction is preferably used throughout the making of the record. It is further to be understood that between levels *f* and *ff* the recording is altered reciprocally with the width of portion 4, as described by Crane in the publication cited above.

In the standard squeeze track, masking is symmetrical on both sides of the central line so that as the sound level to be recorded falls, the width of modulated sound track narrows symmetrically until when the level to be recorded has fallen 6 decibels the sound track has been obscured inward from each edge over one-quarter of its total width. It will be seen that on the record of Fig. 1 the portion masked is all on one side of the longitudinal central line of the record and that the masking of this half record is carried to completion. The masked track should be adjacent to sprocket holes in order to reduce sprocket hole modulation noise to a minimum during *f*, *pp*, and *s*. It is apparent that record 2 is functionally equivalent to the customary squeeze track record with 6 decibel squeeze, and will be reproduced identically as the latter record by sound film reproducing apparatus of the usual type.

While for the sake of illustration there has been described a sound record of the variable density type, those skilled in the art will recognize that a variable area record of similar character may readily be made except that for this type of record the masking must be abrupt or two modulators used one for each half of the sound track. The invention is not restricted to either type of sound record alone.

For reproducing the record shown in Fig. 1 a photo-sensitive circuit is required, preferably that of Fig. 2. Many moving picture theaters have installed in their sound-heads a push-pull cell, of which Western Electric 9A cell is an example, so connected in circuit that either push-pull or standard sound records can be reproduced. For other theaters it is an inexpensive change to install the push-pull cell, its associated optical system and electrical connections. Fig. 2 shows a push-pull cell 6 connected for standard reproduction, a light source and an optical system indicated generally by the numeral 7 serving to scan the film 1 here shown in section and understood to be propelled downward perpendicularly to the plane of the drawing. Light beams modulated by portions 3 and 4 of record 2 are translated by cell

6 into electrical currents. Between cell 6 and the light from portion 3 of film 1 is shown in dotted outline a neutral light absorbing screen 8, the alternative use of which will be later described. The customary circuits supplying voltage to the anodes 9 and 9' and ground connection to cusped cathode 10 of cell 6 are indicated generally by the numeral 11 including under this bracket the usual coupling capacitors and grid leaks of the preliminary amplifying tubes concerned in the amplification of the alternating currents generated in the two anode-cathode paths of cell 6 by the light signals of record 2. The preliminary amplifying tubes referred to are preferably included in a common glass envelope for the sake of compactness. For this purpose a double triode amplifying tube such as the 6A6 is appropriate and is represented by V_1 in Fig. 2. The anode supply circuit, coupling capacitors and load resistors of tube V_1 are indicated generally by the numeral 12. Up to the load resistors AB and BC the circuit is wholly conventional and unnecessary details are omitted from this description. The load resistors AB and BC are, according to the invention, potentiometers by means of taps on which the outputs of the two triodes of V_1 may be supplied in any desired ratio to the grids of the succeeding tube V_2 herein called a mixing tube.

Mixing tube V_2 is suitably a 6SC7 of which the anodes are joined electrically by an external connection to each other and to one terminal of the primary winding 13 of transformer 14. The other terminal of winding 13 is connected as shown to the positive terminal of the polarizing and plate supply battery so that winding 13 serves to supply plate voltage to tube V_2 . The secondary winding 15 is connected to the input of the subsequent main amplifier.

It will be observed that the alternating voltages of both light signals of record 2 are in phase on anodes 9 and 9' of cell 6 since the sound record portions 3 and 4 are not push-pull but are identical in all respects save transverse width. These voltages continue in phase through the circuit of Fig. 2 appearing in phase on the grids 16 and 16' of V_2 , but the relative amplitudes of these voltages as applied to the grids of V_2 are determined by the settings of taps 17 and 18 of potentiometers AB and BC respectively and the method of this invention requires that tap 17 be set to reduce in any desired ratio the signal from portion 3 of record 2 relative to the signal of portion 4, say by 10 decibels when expressed in transmission terms. It will be clear that this reduction of the signal from portion 3 may be effected by using either neutral filter 8 in the path of the light transmitted through portion 3 to the corresponding half of photocell 6, omitting taps 17 and 18 or leaving them in their extreme settings at A and at C, respectively, or by omitting the neutral density filter and adjusting tap 17. A density of 0.5 for filter 8 means a 10 decibel reduction in the transmitted signal from portion 3. The use of the neutral density filter eliminates electrical circuit changes in existing theaters. It will be seen that the circuit of Fig. 2 is balanced to ground except for the settings of taps 17 and 18.

Fig. 2a shows a mixing circuit obviously alternative to that of Fig. 2 and suitable to use where the amplification afforded by V_2 is unnecessary. In Fig. 2a the coils *a-b* and *c-d* of primary winding 13 are connected in parallel aiding, whereas in Fig. 2 these coils are connected in series aiding. The reproduction of sound record 2 by the

circuit of Fig. 2 will now be explained. Portion 3 is reproduced with less gain than portion 4, whether this reduction is effected optically by neutral filter 8 or electrically by adjustment of taps 17 and 18. In order that the dialog of portion 3 at f shall be heard by an audience as loud as usual this gain reduction in the photocell circuit is compensated by an increase in the gain of the succeeding main amplifiers effected by well-known means.

For the sake of illustration let it be assumed that the gain reduction in the photocell circuit corresponding to portion 3 of record 2 is 10 decibels and that the gain of the main amplifier has been increased 10 decibels, the sound record of portion 3 will then be reproduced at the usual theater level, but the record of portion 4 will be reproduced 10 decibels more loudly than by the standard circuit. It is well understood that in variable density sound records where the modulation is in the same phase across the width of the sound track the sound records of the two longitudinal divisions of the track are additive in amplitude, whereas the film noise contributions of these portions are additive in power. In the example chosen, the results may be readily computed by those familiar with this type of recording and the detailed calculation is omitted here. The calculated result confirmed by experiment is that the fortissimo passages f recorded at full modulation on both portions of record 2 are reproduced at a level 12 decibels higher than dialog portions f , recorded also at full modulation on portion 3 alone. This permits recording on film a wider range of sound volumes than has been heretofore possible. Where squeeze track recording permits a differential of 6 decibels for a reduction in track width of 50 per cent the method of this invention doubles this differential.

It is appropriate to consider here the noise levels accompanying the reproduced signal. The fine grain films recently brought into commercial use have, in variable density recording, a range of 40 decibels between a fully modulated signal and the accompanying noise level for the usual track width. Where 6 decibel track squeezing is employed the signal-to-noise range for the squeezed dialog is 37 decibels and this range is preserved in reproduction by the circuit of Fig. 2. For the fortissimo passages the range of signal-to-noise, normally 40 decibels, becomes 39 decibels when the two record portions of Fig. 1 are reproduced by the use of the circuit of Fig. 2.

At the same time the circuit of Fig. 2 is capable of reproducing either the standard record or the squeeze track record. Since each of the records just mentioned is symmetrical about the longitudinal central line of the sound track the circuit of Fig. 2 will permit their reproduction with the customary result.

It will therefore be apparent that the record of Fig. 1 may be successfully reproduced in the usual sound film reproducer but to greater advantage by means of the circuit of Fig. 2, while at the same time the circuit of Fig. 2 is capable of reproducing conventional records without impairment.

The invention has been described with particular reference to variable density sound films, but the method of the invention is equally applicable to other types of sound record with modifications that will be obvious to those skilled in the art of sound recording.

What is claimed is:

1. The method of increasing the reproduced

volume range of a sound record comprising two longitudinal portions, which consists in electrically reproducing said portions with unequal efficiencies and combining said reproductions in additive relation but with unequal amplitudes.

2. The method of increasing the reproduced volume range of a sound record comprising two longitudinal portions, one of said portions being an incomplete record of the sound recorded on the other of said portions, which consists in electrically reproducing said portions with unequal efficiencies and combining said reproductions in additive phase relation but with unequal amplitudes.

3. The method as in claim 2 of increasing the reproduced volume range of a sound record comprising two longitudinal portions, wherein sounds of and below a selected volume level are recorded on one only of said portions, said one portion being the portion which is electrically reproduced with the lower efficiency.

4. The method of increasing the reproduced volume range of a sound record comprising two longitudinal portions, which consists in electrically reproducing said portions with different amplifications and combining in additive phase relation the amplified reproductions of said portions.

5. The method of increasing the reproduced volume range of a sound record comprising two longitudinal portions, one of said portions being an incomplete record of the sound recorded on the other of said portions, which consists in electrically reproducing said portions with different amplifications and combining in additive phase relation the amplified reproductions of said portions.

6. The method as in claim 5 of increasing the reproduced volume range of a sound comprising two longitudinal portions, wherein sounds of and below a selected volume level are recorded on one only of said portions, said one portion being the portion which is electrically reproduced with the less amplification.

7. The method of increasing the volume range of sound reproduced from a variable density sound film comprising two parallel longitudinal portions, the first of said portions containing a record of all sound volumes recorded on said film, the second of said portions containing a sound record cooperative with that contained in said first portion only during the recording of sounds louder than a selected volume level and being elsewhere opaque, which consists in electrically reproducing said portions with different efficiencies and combining in additive phase relation the reproductions of said portions.

8. The method of increasing the volume range of sound reproduced from a variable density sound film comprising two parallel longitudinal portions, the first of said portions containing a record of all sound volumes recorded on said film, the second of said portions containing a sound record cooperative with that contained in said first portion only during the recording of sounds louder than a selected volume level and being elsewhere opaque, which consists in electrically reproducing said first portion, electrically reproducing said second portion with greater efficiency than said first portion, and combining in additive phase relation but with unequal amplitudes the reproductions of said portions.

9. The method of increasing the volume range of sounds recorded on and reproduced from photographic sound records, which consists in making a first photographic sound record of all sound

volumes to be recorded, making a second photographic sound record comprising only sound volumes above a selected level and cooperating with said first record in the recording of sound volumes above said selected level, reproducing said records with greater efficiency for said second record than for said first record, and combining in additive phase relation the reproductions of said records.

10. The method of recording a variable density photographic sound record capable of being reproduced with increased volume range which comprises dividing the sound track area of said record into two longitudinal portions of approximately equal width, recording on one only of said longitudinal portions sounds of and below a selected volume level, masking the other of said longitudinal portions during the recording of sounds of and below said selected volume level, progressively unmasking said other longitudinal portion during the recording of sounds louder than said selected volume level, varying the recording gain during the recording of said louder sounds reciprocally with the unmasking of said other longitudinal portion, and recording said louder sounds cooperatively on each of said longitudinal portions.

11. A photographic sound record of the variable density type comprising two parallel longitudinal portions, of which the first of said portions contains a record of all sounds recorded and the second of said portions contains a record only of sounds louder than a selected volume level.

12. A photographic sound record as in claim 11, wherein the second of said longitudinal portions is substantially wholly opaque throughout that portion of its longitudinal extent whereon no sound is recorded.

13. A photographic sound record as in claim 11, wherein the first of said longitudinal portions is of substantially constant width, and the second of said longitudinal portions is substantially wholly opaque throughout that portion of its longitudinal extent whereon no sound is recorded.

14. A photographic sound record comprising two parallel longitudinal portions, the first of said portions being of substantially constant width and containing a record of all levels of sound recorded, the second of said portions con-

taining cooperatively with the first of said portions a record only of sounds louder than a selected volume level and being substantially wholly opaque throughout that portion of its longitudinal extent whereon no sound is recorded.

15. In a sound film reproducing circuit including a photoelectric cell having dual anodes and a cathode common to said anodes, means for cooperatively reproducing with unequal amplitudes light signals individual each to one of said anodes comprising a first electrical channel coupled to said common cathode and to the first of said anodes, a second electrical channel coupled to said common cathode and to the second of said anodes, a mixing circuit combining in additive phase relation the outputs of said channels and means for reducing the signal in one of said channels relative to that in the other of said channels.

16. In a sound film reproducing circuit including a photoelectric cell having dual anodes and a cathode common to said anodes, means for cooperatively reproducing with unequal amplitudes light signals individual each to one of said anodes comprising a first electrical channel coupled to said common cathode and to the first of said anodes, a second electrical channel coupled to said common cathode and to the second of said anodes, optical means for reducing the light flux in the light signal individual to the first of said anodes relative to that in the light signal individual to the second of said anodes, and a mixing circuit combining in additive phase relation the outputs of said channels.

17. In a sound film reproducing circuit including a photoelectric cell having dual anodes and a cathode common to said anodes, means for cooperatively reproducing with unequal amplitudes light signals individual each to one of said anodes comprising a first electrical channel coupled to said common cathode and to the first of said anodes, a second electrical channel coupled to said common cathode and to the second of said anodes, electrical means for reducing the output of said first electrical channel relative to that of said second electrical channel, and a mixing circuit combining in additive phase relation the outputs of said channels.

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