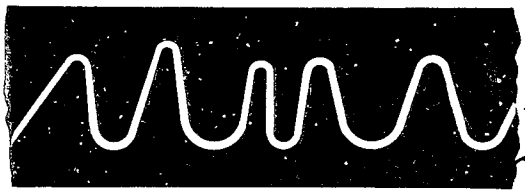
Oct. 30, 1945. J. R. COONEY 2,387,832

REPRODUCTION OF SOUND

Filed April 18, 1944

Fig. 1.



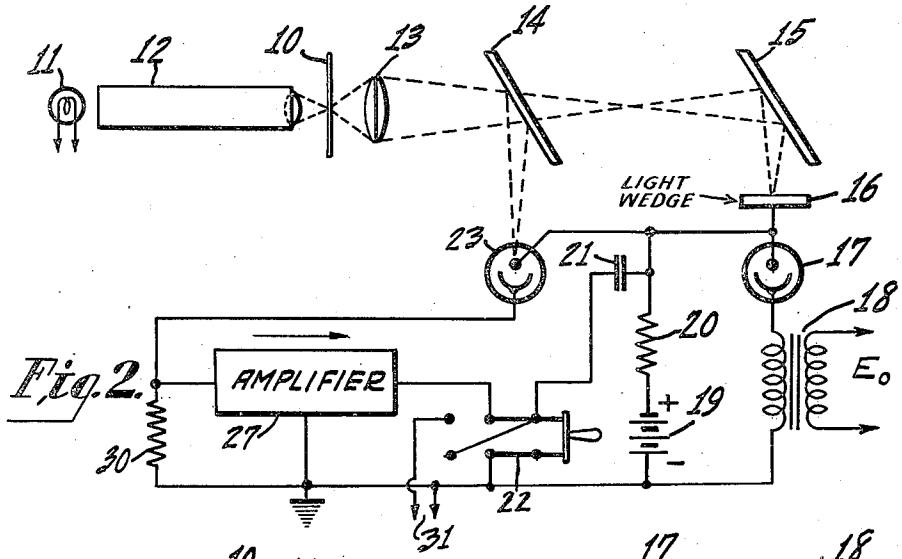


Fig. 2.

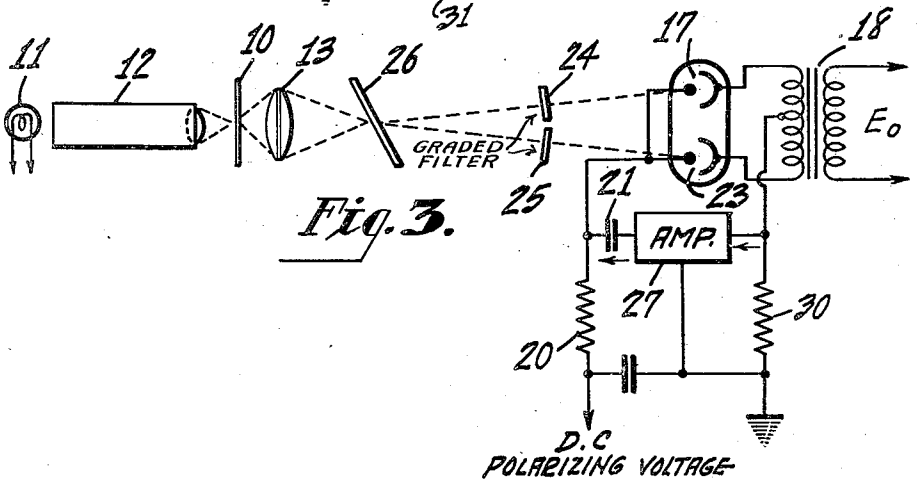


Fig. 3.

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REPRODUCTION OF SOUND

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7 Claims. (Cl. 179—100.3)

This invention relates to the reproduction of sound from sound records which tend to produce undesirable background noise due to lack of homogeneity or other imperfections in the record medium. It has for its principal object the provision of an improved apparatus and method of operation whereby such background noise may be minimized or obviated during the reproduction of sound from the record.

The record itself may be a narrow transparent line which is produced by a galvanometer or the like energized by the recorded audio frequency current. Such a line is commonly known as a sound record of the snake type. In such a record, the position of the transparent line at any point transversely of the record is determined by the polarity and amplitude of the recorded audio impulses.

Various means for reproducing sound from records of the snake track type have been proposed. The present invention differs from these prior proposals in that it provides means whereby the electrical impulses tending to produce background noise are obviated in the sound reproducer and do not appear in the output delivered to the loudspeaker or other utilization device.

A photocell can recover modulation from a snake track by virtue of a "light wedge" which allows it to discriminate between the various positions occupied by the trace, and to produce a different output voltage for every different position of the trace. However, because the width of the snake track remains constant, the actual amount of light passed by the film is always constant except insofar as affected by variations in transmission of the clear area of the film. These variations produce "noise" in the photocell output. It is apparent that if every time the transmission of this sound track decreased, the intensity of the exciter lamp is raised, and vice-versa, compensation of these variations in transmission is realized, and the light passed by the sound track appears to be constant. However, because of the wedge, the photocell still produces different outputs for different positions of the sound track.

Thus if there is provided an auxiliary photocell which is independent of the sound reproducing photocell and is arranged so as to observe the snake track directly, the output of this photocell may be amplified in an entirely separate amplifier and returned so as to modulate the light source in a degenerative sense. The effect of this auxiliary regulating or monitoring system is merely to maintain a constant illumination on the photocell side of the track; i. e., when the transmission of the sound track decreases the monitoring photocell current decreases and the decrease is amplified by the feedback amplifier and applied to the light source in such phase that the light increases, and vice versa. If the amplifier has a large gain the light received by the auxiliary photocell will thus be maintained practically constant, regardless of variations in transmission of the film. Motion from side to side produces no effect on this monitoring photoelectric system, but does on the sound reproducing photocell which is illuminated through a wedge and appears to observe a perfectly clear, steadily illuminated sound track, which weaves from side to side and produces sound by virtue of its position alone.

The compensating voltage produced by the auxiliary photocell and degenerative amplifier may be applied to elements other than the exciter lamp with very much the same result.

For example, the current in a gas-filled photocell is a function of both the incident light and the anode potential. Likewise the current in a multiplier-type photocell can be modulated by varying the potential of one or more of its dynodes. Assuming that both these effects are substantially linear, the output of either of these devices is proportional to the product of the incident light and the potential applied to this control electrode. If no light is falling on the device, no current flows through it, and any variation of the control potential produces no effect on the output. When a photo-current is present, variation of the control potential produces a variation in the output current of the device, and the A. C. output depends on the magnitude of the photo-current. (In all cases it is assumed that the control-potential variations are unable to reach the output circuit directly. This is possible in a gas-filled cell by varying the anode potential and taking the output from a resistor on the cathode side, etc., and is inherent in a multiplier type tube.)

Now if we allow one of these photo-sensitive devices to observe a fluctuating light source, amplify its output and return the amplified output in a degenerative sense to the control electrode or anode, the potential at this point will be caused to vary in just the proper way as to tend to reduce the output to as low a value as possible. It will be seen on consideration that the A. C. voltage at the control electrode depends only on the percentage modulation of the inci-

dent light—i. e., this voltage remains practically constant for any given percentage modulation of the light, irrespective of the strength of the illumination. (Furthermore, whether or not the relation between control anode potential and output is linear is immaterial, as the feedback voltage will automatically be given the proper waveform to take care of this.)

If any auxiliary gas-filled photocell is illuminated through a moving snake track (without any wedge) and its output is amplified and returned to the anode as discussed above, in such a manner that the feedback potential cannot actually reach the amplifier input, but can merely modulate the anode potential, the anode potential of the photocell will now vary in such a way as to tend to maintain a constant, unvarying current through the photocell. As discussed above this A. C. anode voltage will only represent the percentage variation of the sound-track transmission. If the exciter lamp intensity should be increased, this voltage would still maintain the same wave-form and amplitude. In other words, the anode potential is varying in just the proper amount to compensate for the "noise" in the sound track regardless of the average illumination level.

If the control anode of a sound reproducing photocell is connected to the anode of the above auxiliary photocell and a "wedge" in front of this sound reproducing cell transmits light to it to observe the same from the snake track, the photo-current produced by this sound reproducing cell is then dependent on the position of the snake track. However the percentage variation due to noise is unaffected by the wedge, and as the anode potential of this sound reproducing cell is varied by the monitoring system just the proper amount (assuming the two photocells are exactly similar), the output of the sound reproducing cell represents the modulation of the sound track free of the noise.

Important objects of the invention are the provision of an improved sound reproducer and an improved method of the noiseless reproduction of sound.

The invention will be better understood from the following description considered in connection with the accompanying drawing, and its scope is indicated by the appended claims.

Referring to the drawing:

Figure 1 illustrates a type of sound record suitable for use in connection with the present invention,

Figure 2 illustrates one embodiment of the invention, and

Figure 3 illustrates a modified form of the invention.

As previously indicated, the record 10 of Fig. 1 is in the form of a narrow transparent line which has its position transversely of the record determined by the polarity and amplitude of the recorded sound. Since the width of this transparent line is constant, it is apparent that it transmits a constant amount of light so long as its transparency and intensity of illumination are kept constant. When the intensity of illumination or the transparency of the line varies, however, the amount of light transmitted by the line varies and background noise results. This background noise is minimized by the system of Fig. 2.

The sound reproducing apparatus of Fig. 2 includes an exciter lamp 11 and an optical unit 12 through which a narrow line of light is applied transversely of the record 10. The light modulated by the record 10 next passes through an optical unit (indicated as a lense 13) and is thereafter applied to a semi-transparent reflector 14 and a total reflector 15. It is apparent that means other than the reflectors 14 and 15 may be provided to separate the modulated light into two separate beams. From the reflector 15, light is passed through a light wedge, a graded filter 16 or the equivalent, to a photosensitive device 17 from which the reproduced audio impulses are delivered through an output transformer 18.

Connected in circuit with the transformer 18 are a potential source or battery 19 and a resistor 20. The battery 19 and resistor 20 are arranged also to be connected through a coupling capacitor 21 and a double throw switch 22 to the output circuit of a degenerative amplifier 27. Potential is applied to the input of the amplifier 27 from the cathode of an auxiliary or control photosensitive device 23 through a resistor 30. The leads 31 may be interconnected with the exciter lamp 15 in any manner suitable for modulating the intensity of this lamp in response to variation in the output of the amplifier 27. Neutralization of the capacity of the photosensitive devices 17 and 23 may be accomplished by the provision of a neutralizing capacitor bridge circuit as is well known.

Assuming the switch 22 to be in its left hand closed position and the leads 31 to be connected to the exciter lamp 11 as previously indicated, the output of the photosensitive device 23 is amplified by the alternating current amplifier 27 and the amplified output is utilized to modulate the intensity of the light source 11 in such phase as to oppose any change in the current of the device 23. Then if the gain of the dengenerative feedback amplifier 27 be sufficiently large, the light received by the device 23 will be approximately constant regardless of low percentage alternations or variations in the density of the record through which light is applied to the device. The same obviously is true of the photosensitive device 17.

Due to the fact that it receives light through the wedge 16, the device 17 delivers a current which varies with change in the position of the transparent line transversely of the record and is truly representative of the sound impulses recorded on the record. Thus background noise is substantially eliminated in the absence of recorded sound and regardless of the degree to which the recorded sound is modulated.

The same result can be achieved in other ways. If the photosensitive devices 17 and 23 be of the gas-filled type, for example, their outputs are a function of both the incident light and the anode potential, varying approximately as the product of the two.

With the switch 22 closed to the right, variation in the output of the photosensitive device 23 functions through the amplifier 27 to modulate the anode potential of the devices 17 and 23 as explained above in connection with the modulation of the light source 11. Thus the anode potential is increased when the light passed by the transparent line tends to decrease and vice versa. Under these conditions the space current of the two cells is maintained substantially independent of variation in the transparency of the record. As before, the audio output is determined by the position of the transparent line transversely of the record.

The modification of Fig. 3 differs from that of Fig. 2 in that it includes a pair of light wedges.

graded filters or the equivalent (indicated as 24 and 25) to different parts of which the modulated beam is applied through a beam splitting device 26 which is equivalent to the reflectors 14 and 15 of Fig. 2. The light filters 24 and 25 are constructed to give a transmission varying linearly along their length from zero to full transmission. These two light filters are identical but are reversed with respect to each other so that their transmission varies in opposite directions.

The modification of Fig. 3 further differs from that of Fig. 2 in that the photosensitive elements 17 and 23 are connected in push-pull to provide a higher output voltage. In this case, the illumination of the elements 17 and that of the element 23 are the same when the transparent line is on the median line of the record so that the output voltage E_0 is zero and independent of light transmitted through the sound track. As the transparent line moves toward one side of the record, the filter 24 transmits more light than the filter 25 so that the currents of the elements 17 and 23 become unbalanced in the transformer 18 and an output current representative of the displacement or position of the transparent line is developed.

The total current of the resistor 30, however, remains substantially constant and any tendency for it to change because of variation in the sound track transmission is resisted by the degenerative feed-back through the amplifier 27 to the anodes of the elements 17 and 23. The feed-back voltage thus produced across the resistor 20 and applied to the anodes of the elements 17 and 23 should not reach the transformer 18 directly since it is a modulating voltage and is effective only insofar as there is a photo current present for it to modulate. When the filter 24 transmits more light than the filter 25, the photosensitive element 17 is supplying most of the output current and also most of the noise but receives the benefit of the feed-back voltage in proportion so that the net result is the cancellation of noise in the output.

The sum of the currents of the photosensitive elements 17 and 23 (Fig. 3) is always constant (except for noise and the like) irrespective of the position of the snake track. Together they act like a single element observing the transparent line without a wedge. The sum of their currents taken from the center tap of the transformer 18 can thus be utilized to provide a feed-back voltage. The advantage of the system of Fig. 3 over that of Fig. 2 is that the output voltage is doubled.

The outstanding feature of the invention is an improved sound reproducing apparatus wherein the noise resulting from defects in the record medium are segregated from the signal impulses delivered to the loudspeaker or other utilization device.

I claim as my invention:

1. The combination of means for producing a single light beam which varies in position along a predetermined line and has an intensity which varies only as a result of imperfection in said beam producing means, means for separating said beam into a pair of beams, a pair of photosensitive elements each arranged to receive light from a different one of said beams, means interposed in the path of one beam of said pair for producing in one of said photosensitive elements current of an amplitude dependent on the position of said beams, and means responsive to the output of the other of said photosensitive elements for regulating the intensity of said beams.

2. The combination of means for producing a single light beam which varies in position along a predetermined line and has an intensity which varies only as a result of imperfection in said beam producing means, means for separating said beam into a pair of beams, a pair of photosensitive elements each arranged to receive light from a different one of said beams, means interposed in the path of one beam of said pair for producing in one of said photosensitive elements current of an amplitude dependent on the position of said beams, and means responsive to the output of the other of said photosensitive elements for obviating the effect of variation in the intensity of said single light beam.

3. The combination of means for producing a single light beam which varies in position along a predetermined line and has an intensity which varies only as a result of imperfection in said beam producing means, means for separating said beam into a pair of beams, a pair of photosensitive elements each arranged to receive light from a different one of said beams, means interposed in the path of one beam of said pair for producing in one of said photosensitive elements current of an amplitude dependent on the position of said beams, and means including an amplifier having its input connected to the other of said elements for varying the anode potentials of said elements in response to variation in the intensity of said beams and in a direction to minimize the effect of such variation in intensity.

4. The combination of means for producing a single light beam which varies in position along a predetermined line and has an intensity which varies only as a result of imperfection in said beam producing means, means for separating said beam into a pair of beams, a pair of photosensitive elements each arranged to receive light from a different one of said beams, means interposed in the path of one beam of said pair for producing in one of said photosensitive elements current of an amplitude dependent on the position of said beams, and means including a degenerative amplifier having its input connected to the cathode of the other of said elements and its output connected to the anodes of said elements for minimizing the effect of variation in the intensity of said single light beam.

5. The combination of means for producing a light beam which varies in position and has an intensity which varies only as a result of imperfection in said beam producing means, means responsive to said beam for detecting its position, and means responsive to said beam for rendering said position detecting means independent of variations in said intensity.

6. The combination of means for producing a single light beam which varies in position and has an intensity varied only as a result of imperfections in said beam producing means, means for separating said single beam into a pair of beams, a pair of photosensitive elements each arranged to receive light from a different beam of said pair, means interposed in the paths of the beams of said pair for producing in said elements currents of an amplitude dependent on the position of said single beam, a push-pull transformer connected to the cathodes of said elements, and means connected between a midpoint terminal of said transformer and the anodes of said elements for minimizing the effect of varia-

tion in the intensity of said single light beam on the currents of said elements.

7. The combination of means for producing a single light beam which varies in position and has an intensity varied only as a result of imperfections in said beam producing means, means for separating said single beam into a pair of beams, a pair of photosensitive elements each arranged to receive light from a different beam of said pair, means interposed in the paths of the beams of said pair for producing in said element currents of an amplitude dependent on the position of said single beam, a push-pull transformer connected to the cathodes of said elements, and a degenerative amplifier having its input connected to a midpoint terminal of said transformer and its output connected to the anodes of said elements for minimizing the effect of variation in the intensity of said light beams on the currents of said elements.

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