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SOUND REPRODUCTION
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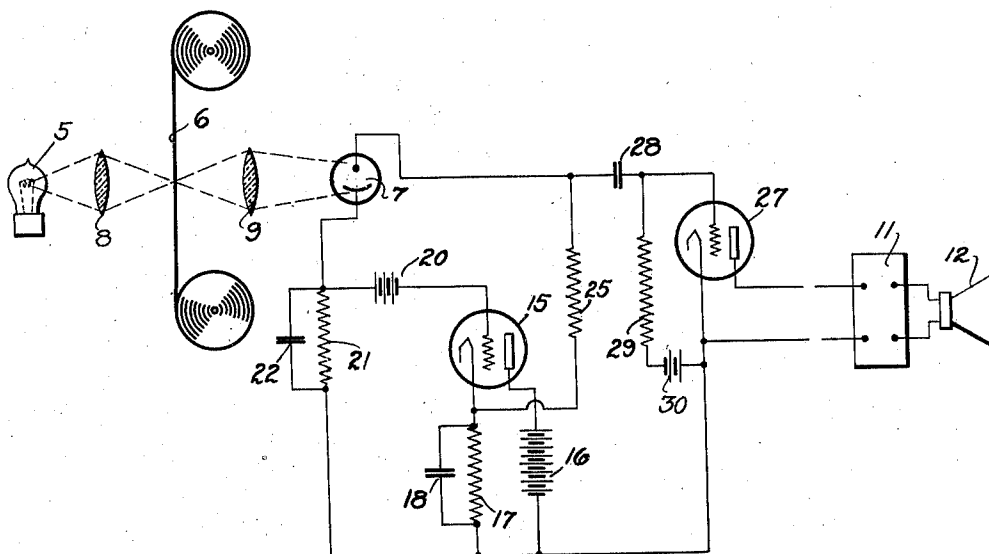


FIG. 1.

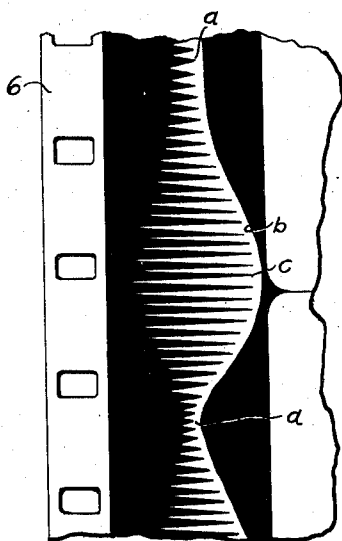


FIG. 2.

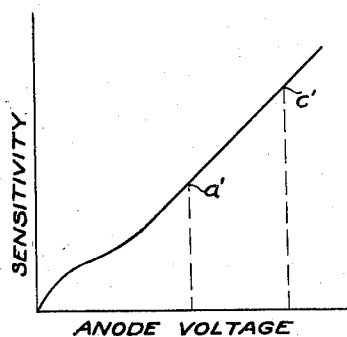


FIG. 3.

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SOUND REPRODUCTION

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This invention relates to sound reproduction and particularly to the reproduction of sound from a record thereof, which reproduction follows a predetermined volume expansion characteristic, such as that found in the standard anti-ground noise sound record, such characteristic being determined by the variations in the average print transmission of the record.

Volume compression and expansion circuits are well known in the art and the present invention is related thereto only insofar as the final result is concerned. In the former systems the ratio of volume expansion is proportional to the rectified variations in amplitude of the sound modulations while in the present invention this ratio is determined by the average transmission of the sound track longitudinally thereof. The invention eliminates the use of rectifiers and obtains its variations in transmission or amplification by varying the sensitivity of the translating device which generates or produces electrical currents from the light variations.

The invention therefore in its specific aspect is directed to the obtaining of variations in transmission according to volume changes by varying the sensitivity of a translating device such as the photo-electric cell. The sensitivity is varied in accordance with the variation in average current flow through the cell, or in other words, the direct current component of the cell output which varies directly in accordance with the average transmission of the sound track. The output of the photo-electric cell contains alternating current components due to the frequency and amplitude modulations of the sound track, and direct current, generally sub-audible components, due to the variation in ratio between the opaque and transparent portions of the sound track in the case of a dia-positive record. The alternating current components are impressed upon the reproducer circuit while the voltage produced by the direct current components is impressed upon the electrodes of the photo-electric cell and varies the sensitivity of the cell. It is realized, therefore, that for large volume outputs the transparent to opaque ratio is larger, thus increasing the direct current components and consequently increasing the voltage on the cell. The cell being thus more sensitive, it generates greater alternating current components at the larger amplitudes of light variations than would normally be generated without change in sensitivity. The reverse action occurs at the lower amplitudes of light variations or volume and there is thus obtained volume expansion,

the degree thereof being dependent on the voltage-sensitivity characteristic of the cell.

The advantages of expanding sound in accordance with the invention will be more fully realized and the invention more fully understood by reference to the following description read in conjunction with the accompanying drawing in which:

Fig. 1 is a schematic circuit diagram of a reproducing circuit embodying the invention.

Fig. 2 is a section of a diapositive sound record of the anti-ground noise type; and

Fig. 3 is a curve showing the relation between the voltage on the electrodes on a photo cell and the sensitivity thereof.

Referring now to Fig. 1, the well known type of film sound track light modulating system is shown. This portion of the system includes a constant light source 5, a film 6 containing a sound record of the anti-ground noise type such as shown in Fig. 2, light sensitive device such as a photo electric cell 7, together with lenses 8 and 9 for focusing the light beam and for the projection thereof upon the photo-electric cell 7. After passing through the circuit of the invention the sound may be amplified in the usual type of amplifier 11 and fed to a sound reproducer such as a loud speaker 12.

The electrical circuit which produces volume expansion includes a vacuum tube amplifier 15 of any suitable type, having a plate circuit including a direct current source 16 and a load resistance 17 shunted by a by-pass condenser 18. The grid circuit of the amplifier 15 also includes the resistance 17 shunted by the condenser 18 and in addition, a grid biasing battery 20, a resistance 21 shunted by a by-pass condenser 22. The variations in potential produced across the resistance 17 are impressed upon the anode of cell 7 over a resistance 25, this resistance also serving as the voltage producing element for an amplifier 27. Only the variations produced by the tube 15 cause variations across the resistance 17 inasmuch as any varying potentials of audio frequency appearing at the terminals of resistance 17 are short-circuited thereacross by by-pass condenser 18. The inter-connecting element between resistance 25 and amplifier 27 is a condenser 28 which passes only the alternating components desired. The direct current grid circuit of the amplifier 27 includes a resistance 29 in grid biasing battery 30. The output of the amplifier 27 is impressed on the amplifier 11 in the usual manner.

From Fig. 3 it will be observed that as the anode

voltage on the photo cell 7 increases, the sensitivity of the cell likewise increases and after a slight irregularity at the lower voltages the curve becomes substantially a straight line after which the cell can be operated without introducing distortion caused by anode voltage variations. This curve indicates that any variations in light of a certain amplitude occurring when a high voltage is on the cell, will cause a greater variation in output current than when a lower voltage is on the cell. Standard photo cells which will provide such a characteristic are RCA photo tubes 868 and 918 provided with proper load impedances and impressed with the proper light intensities. Keeping this principle in mind, the operation of the circuit will now be explained.

Assuming the sound track of Fig. 1 shown enlarged in Fig. 2 is being reproduced at times of low volumes such as indicated at points *a* on the section in Fig. 2, the variations in light impinging on the cell 7 are of small amplitude for two reasons. First, the sound modulations themselves are of small amplitude and second, the ratio of transparent section to opaque section is small. Since the first reason is old and well understood and the invention resides in the second, the second reason will now be considered in detail.

It is seen from Fig. 2 that the ratio of the transparent portion of the sound track to the opaque portion for a given cross section is smaller at points *a*, or points of low volume, than at a point *c*, or a point of large volume. This ratio variation will follow the line *b* which may or may not be directly proportional to the envelope of the sound modulations but will always be substantially proportional thereto. The output of cell 7 will therefore contain currents varying in accordance with the sound modulations and currents varying in accordance with line *b*. Now condenser 22 and condenser 18 are of such value that the components produced by the frequency of the sound modulations are by-passed across resistance 21 and resistance 17. The by-passing of the modulation components by condenser 22 permits the impression on the grid of amplifier 15 of only those components produced by the line *b*. These latter components are then amplified in amplifier 15 and appear amplified as voltage fluctuations across resistance 17 which, since this resistance is in the electrode circuit of cell 7, the fluctuations are impressed on the electrodes of the cell as voltages proportional to the variations in the average transmission current. These variations in voltage vary the sensitivity of the cell 7 as shown in Fig. 3, point *a* corresponding to points *a* of record 6 and point *c* corresponding to point *c* of the record. Thus the alternating components caused by volume *c* are larger than they would normally be because the sensitivity of the cell is greater when these modulations are impressed on the cell than when modulations at points *a* are impressed thereon.

From the above explanation, therefore, it will be seen that volume expansion is obtained by utilizing the variations in the average print transmission, which substantially follow the variations in volume of the sound recorded. The invention thus eliminates the use of rectifiers and other circuit elements usually required for obtaining a current proportional to the amplitude of the sound currents and simplifies the circuit required to produce volume expansion.

What is claimed is:

1. An electrical circuit for the reproduction of sound comprising a sound record having ampli-

tude and frequency variations thereon in accordance with sound, a translating element for translating light varying in accordance with said frequency and amplitude variations into electrical currents, said element also producing electrical currents substantially corresponding to the amplitude variations, and means for varying the sensitivity of said translation element by said last mentioned currents.

2. A sound reproducing system comprising a sound record having a sound track portion having sound modulations thereon and having a variation in light transmission therethrough substantially equal to the average variation in amplitude of said sound, a translating element for producing electrical currents corresponding to said sound modulations, said element also producing electrical currents corresponding to the variation in average light transmission through said sound track, means for producing a voltage corresponding to said last mentioned currents, and means for impressing said voltage on said translating element.

3. A system for varying the amplitude of reproduction of sound from a record thereof comprising a translating element for translating light variations into electrical current variations and whose sensitivity varies in accordance with the polarizing potential impressed thereon, means for obtaining electrical current from said element in accordance with the sound modulations on said record, and means for varying the potential on said element in accordance with the average light transmission through said record for changing the sensitivity of said element in accordance therewith.

4. A reproducing system comprising a sound record, a photo electric cell for translating the modulations of said sound record into corresponding electrical currents, the direct current component in the output of said photo cell varying in accordance with the average light transmission through said record, an amplifier for said average current and means for impressing the output of said amplifier on the electrodes of said photo cell for varying its sensitivity.

5. A reproducing system in accordance with claim 4 in which said record is an anti-ground noise sound record.

6. A sound reproducing system comprising a translating element for translating light variations varying in accordance with the frequency and amplitude of sound waves into electrical currents corresponding thereto, means for producing a voltage from said light variations substantially proportional to the average light variations, and means for impressing said voltage on said translating element.

7. The method of reproducing sound from a single photographic sound record wherein a single photo electric cell and a polarizing potential therefor are employed, which method comprises varying said potential in accordance with the average print transmission of said sound record.

8. A sound reproducing system comprising a sound record having an average print transmission varying substantially in accordance with the amplitude of the sound record thereon, a photo electric cell, means for modulating the light impinging on the said cell in accordance with the modulations on said sound track and the average light transmission therethrough, an amplifier connected to said photo electric cell, a resistance common to the grid and plate circuit of said amplifier, a connection from the anode of said

photo electric cell to said common resistance, a connection between the cathode of said photo electric cell and the grid of said amplifier, and the connection between said grid and said common resistance.

9. A circuit for translating light impulses into electrical variations comprising a photo electric cell having a cathode and an anode, a vacuum tube amplifier having a grid-cathode circuit and a plate-cathode circuit, a resistance in said grid-cathode circuit, a large condenser in shunt to said resistance, a second resistance in said plate-cathode circuit, a large condenser in shunt to said second resistance, a third resistance, circuits for connecting said first, second and third mentioned resistances in series between the cathode and anode in said photo electric cell, an amplifier having its input circuit connected across said second and third mentioned resistances, and a blocking condenser between said third resistance and said amplifier.

10. An electrical circuit for translating light impulses into electrical currents corresponding thereto, comprising a photo electric cell, an

amplifier having a grid-cathode circuit and an anode-cathode circuit, a circuit for connecting said photo electric cell to said amplifier, a resistance common to said photo electric cell circuit, said grid-cathode circuit and said anode cathode circuit, a second resistance common to said photo electric cell circuit and said grid-cathode circuit, a third resistance in said photo cell circuit, and a condenser shunting each of said first and second resistances.

11. A circuit for translating light variations into electrical currents corresponding thereto, comprising a photo electric cell having a cathode and an anode, three resistances in series with said cathode and anode, audio by-pass condensers in shunt to two of said resistances, an amplifier, means for connecting one of said shunted resistances in the grid circuit of said amplifier, means for connecting the other of said shunted resistances in both the plate and grid circuits of said amplifier, and means for amplifying the potential variations across the third of said resistances.

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