Oct. 20, 1931. J. R. BALSLEY 1,827,735

VOLUME CONTROL IN SOUND RECORD REPRODUCTION

Filed Oct. 14, 1929 4 Sheets-Sheet 1

Fig. 2

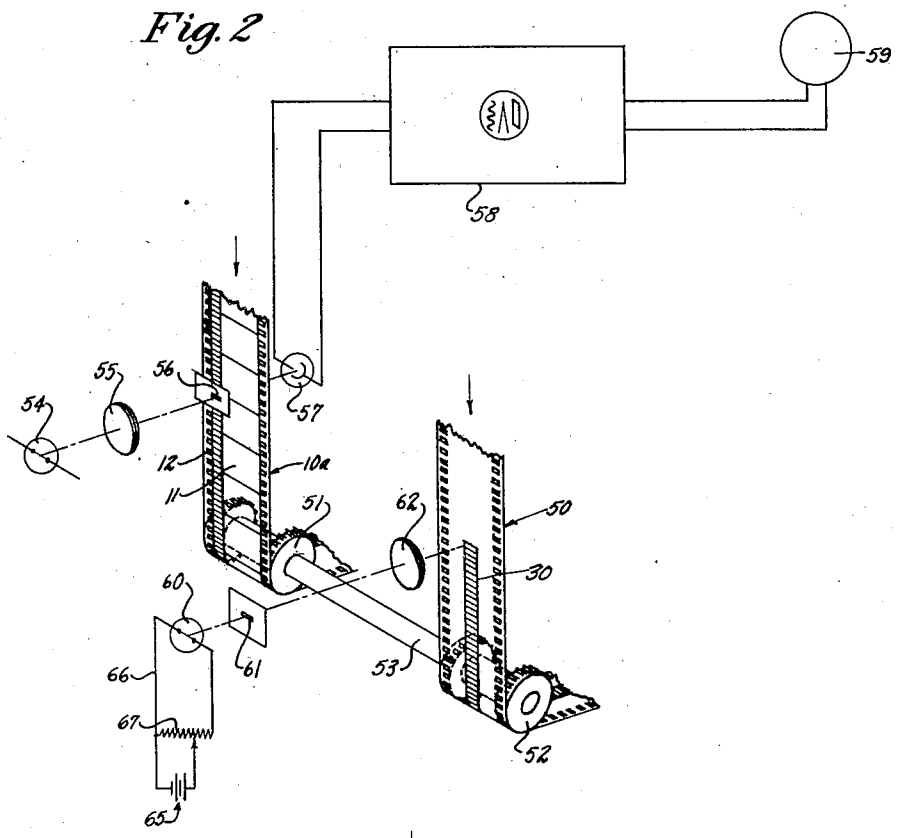
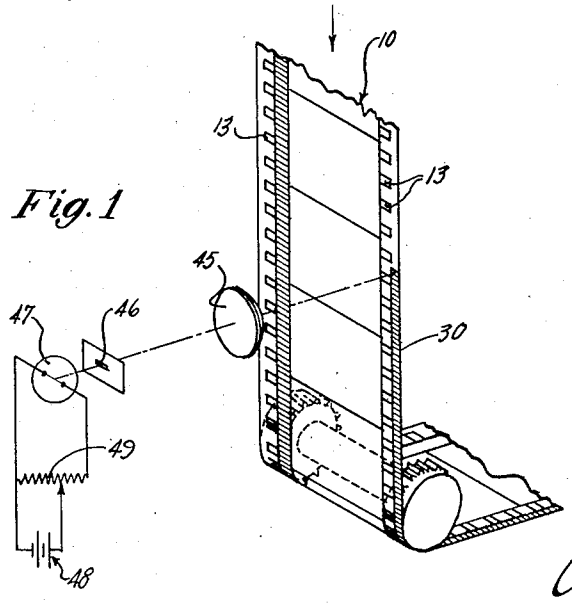


Fig. 1



Inventor
James R. Balsley.

Attorney.

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Fig. 3

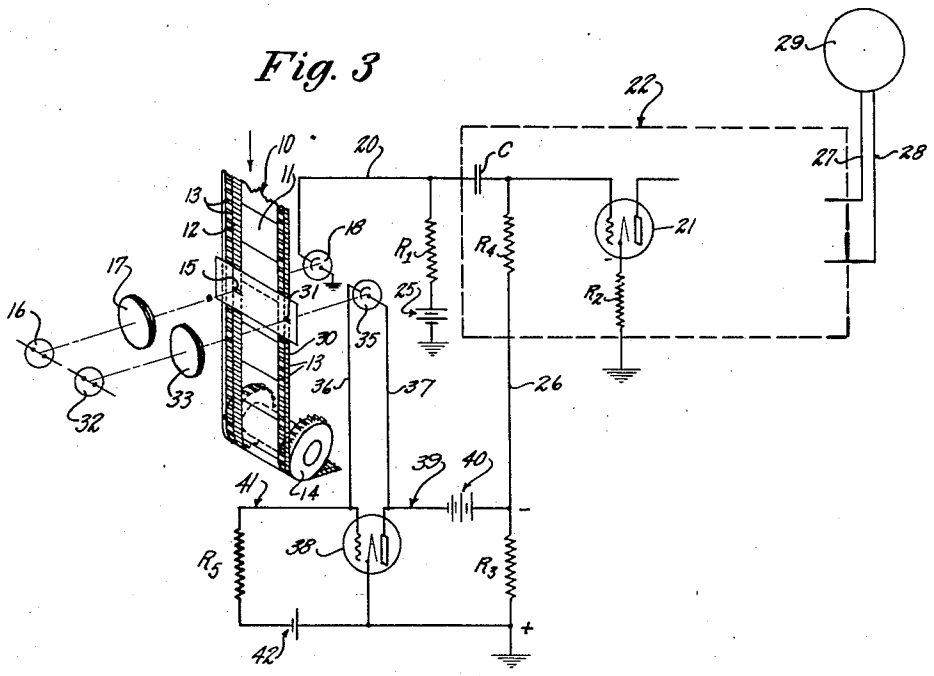
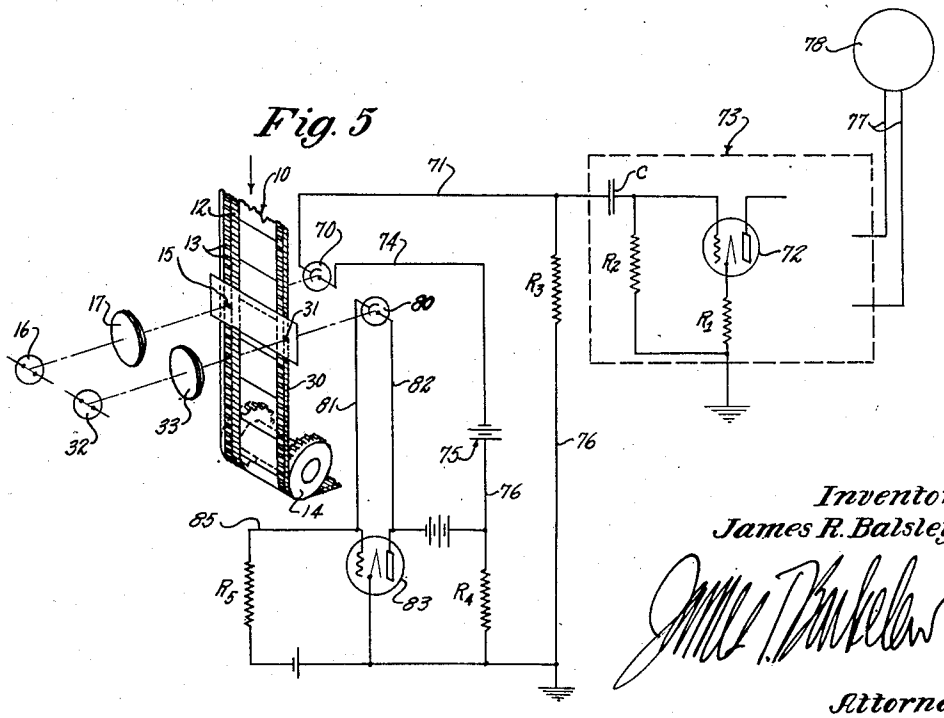


Fig. 5



Inventor
James R. Balsley.

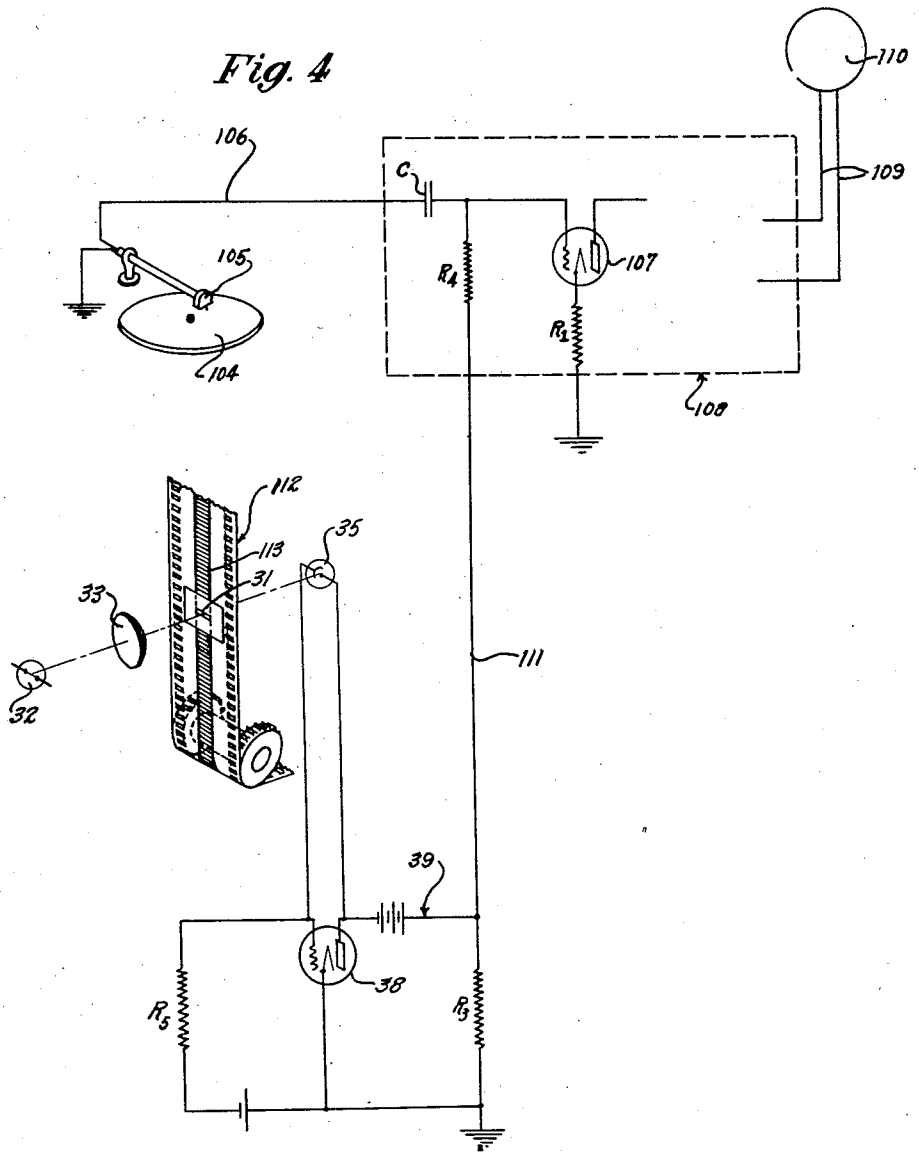
Attorney.

Oct. 20, 1931. J. R. BALSLEY 1,827,735

VOLUME CONTROL IN SOUND RECORD REPRODUCTION

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Fig. 4



Inventor
James R. Balsley.

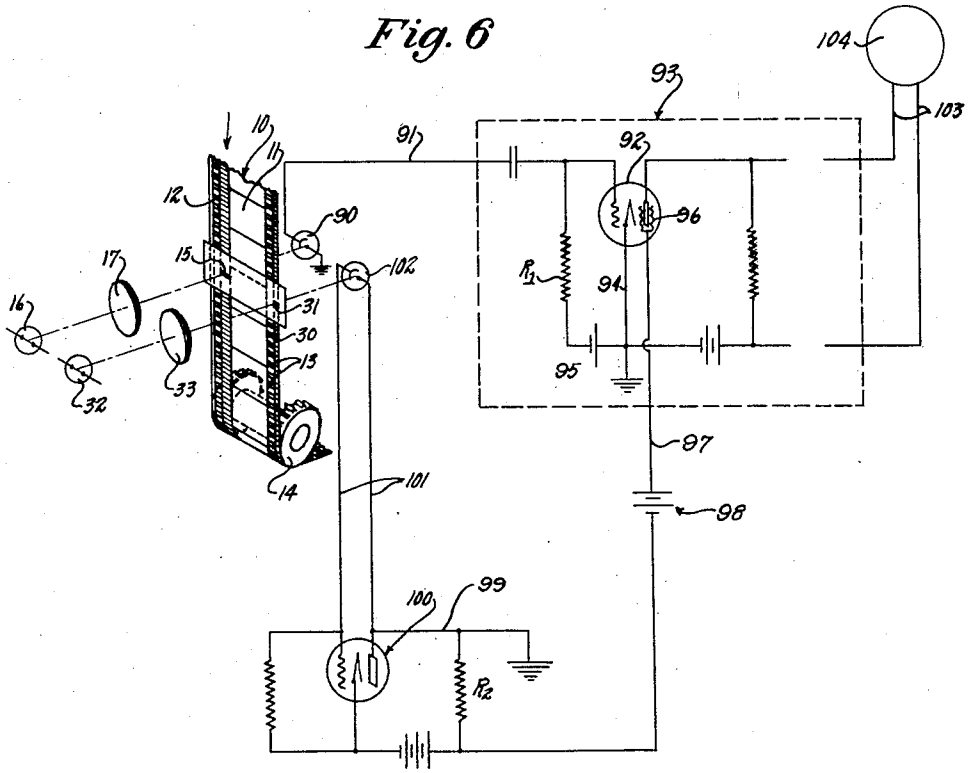
Attorney.

Oct. 20, 1931. J. R. BALSLEY 1,827,735

VOLUME CONTROL IN SOUND RECORD REPRODUCTION

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Fig. 6



Inventor
James R. Balsley.

Attorney.

Patented Oct. 20, 1931

1,827,735

UNITED STATES PATENT OFFICE

JAMES R. BALSLEY, OF BEVERLY HILLS, CALIFORNIA, ASSIGNOR TO FOX FILM CORPORATION, OF HOLLYWOOD, CALIFORNIA, A CORPORATION OF NEW YORK

VOLUME CONTROL IN SOUND RECORD REPRODUCTION

Application filed October 14, 1929. Serial No. 399,464.

This invention relates generally to the reproduction of sound from sound records, and is more particularly concerned with means for controlling the volume of sound reproduced from sound records. The invention is particularly applicable to systems in which the photographic type of sound records are utilized, and will therefore be hereinafter described with that type of sound record chiefly in view; but it will readily be understood that this particularization constitutes no limitation on the invention, for the invention may also be practiced in connection with other types of sound records such as the mechanical disk type.

In sound reproduction from photographic sound records of the varying width type, the volume of the reproduced sound is proportional to the amplitude of the serrations along the record. The volume range of the reproduced sound is limited on the lower side by ground noise, and on the upper side by the physical characteristics of the film and the electrical and mechanical limitations of the system. In reproduction from photographic records of the varying density type, the volume of the reproduced sound is proportional to the change in transmission of the sound record. In the latter system the practical volume range is limited for undistorted quality by the length of the straight line portion of the light-transmission characteristic of the film, and is further limited on on the lower side by the ground noise level of the film, and on the upper side by the physical characteristics of the film, plus the electrical and mechanical limitations of the recording and reproducing units.

Corresponding factors similarily limit the practical available volume range in sound reproduction systems utilizing other types of sound records.

It is a primary object of the present invention to provide means for expanding the practical volume range available in the reproduction of sound records.

It is a further object of the invention to provide means whereby the volume of sound in final audible reproduction from a sound record may be controlled at predetermined levels, irrespective of the levels at which the sound was originally recorded.

According to the present invention, these objects are accomplished by the provision of a "volume-control" record driven in synchronism with the sound record, and adapted to control the volume level of the sound reproduced from the sound record. In my preferred embodiment this volume control record may be simply a varying density photographic record, which may be prepared by reference to the volume level of the sound record as recorded, as may be determined by ordinary reproduction thereof. This volume control record, which may be printed on the same film that carries the pictures and sound record, for instance outside the sprocket perforations thereof, or on a separate film if more convenient, is operated in conjunction with a light beam and photoelectric cell to produce a varying electrical current which is utilized to control the level of reproduction, and to do this irrespective of the level at which the sound record was recorded.

With the foregoing in mind, the invention will best be understood from the following detailed description of a present preferred embodiment thereof, reference for this purpose being had to the accompanying drawings, in which:

Fig. 1 shows in diagrammatic form a system for producing a volume control record on the same film that carries the sound record and pictures;

Fig. 2 shows a system in which the volume control record is printed on a separate film from that which carries the sound record pictures, and in which the volume control record is made while listening to an unmodi-

fied reproduction of the original sound record;

Fig. 3 shows a system for reproducing sound from a photographic sound record and controlling the volume level thereof in accordance with the present invention;

Fig. 4 shows a system for reproducing sound from a mechanical disk record and controlling the volume level thereof by means of a photographic volume control record;

Fig. 5 shows a variational system for reproducing sound from a photographic sound record and controlling the volume thereof in accordance with the present invention, and

Fig. 6 shows another variational system for reproducing sound from a photographic sound record and controlling the volume thereof in accordance with the present invention.

The sound reproducing and sound controlling system, diagrammatically illustrated in Fig. 3, will be described first, after which will be explained how the volume controlling record therein utilized can be prepared.

Referring therefore to Fig. 3, the numeral 10 indicates the moving sound-picture film having thereon the usual pictures 11 and sound record 12 between the two rows of sprocket perforations 13, as usual, and conventionally illustrated as driven by means of a sprocket 14. The reproducing elements for the sound record 12 include typically a light-slit 15 located before the sound record, an illuminant 16, a lens 17 for throwing light rays from illuminant 16 through slit 15 to the sound record 12, and a photoelectric cell 18 positioned to be impinged by the light rays which are transmitted through the sound record. These transmitted light rays are modulated in passing through the sound record on the film by the sound-wave-representing density variations thereon, and, striking the photo-electric cell, generate therein a varying electrical current corresponding to the original sound waves. One side of the photoelectric cell is grounded, as shown, while the other side is connected by means of a lead 20 to the grid of the first tube 21 of the vacuum tube amplifier, conventionally illustrated at 22. Only the first stage of the amplifier is shown, the balance of the circuit being of any suitable or well known type. A battery 25 is connected at one side through a resistance R_1 to lead 20 and at the other side to ground, for the purpose of providing a constant potential across the photoelectric cell 18.

A condenser C is provided in lead 20 between the connections therewith of resistance R_1 and the grid of tube 21. A resistance R_2 is connected at one side to the negative terminal of the filament of tube 21, and at the other side to ground. A grounded lead 26 having therein resistances R_3 and R_4 is connected to lead 20 between condenser C and the grid of tube 21, this lead and the resistance R_2 providing for a negative bias on the grid. The output leads 27 and 28 of amplifier 22 are shown connected to a usual speaker 29.

A photographic volume control record is made by reference to the volume level of the sound record 12, as hereinafter described, this volume control record consisting in the present case of a varying density band 30 printed on film 10 outside of the sprocket perforations 13, and its variations in density representing the predetermined volume changes desired. A light-slit 31 is provided before record 30, slit 31 being illuminated, for instance, by means of an illuminant 32 and lens 33. The light-rays passing through slit 31 strike the record 30 on film 10, and the rays transmitted therethrough, which, of course, are proportional to the transmission of the record, impinge upon a photoelectric cell 35 to generate an electrical current therein inversely proportional to the density of record 30. Photoelectric cell 35 is connected by means of lead 36 and 37 directly across the grid and plate of vacuum tube 38. Included in the plate circuit 39 of tube 38 is a battery 40 and the resistance R_5 of lead 26, and included in the grid circuit 41 of the tube is a resistance R_5 and a battery 42.

The plate circuit 39 of tube 38 is so connected with respect to resistance R_5 that when tube 38 has normal plate current (no light on photoelectrical cell 35), the plate current creates a drop across R_5 such as to oppose the normal drop therein, and thus reduce the bias on the grid of tube 21 to such a value that amplification is at a maximum. When, however, light impinges on cell 35, a current flows in leads 36 and 37 which, when the cell is connected in the circuit with proper regard to polarity, reduces the potential of the plate, and this in turn causes the plate current to be reduced, which accordingly allows the drop across R_5 to increase. This causes an increased negative bias on the grid, which finally means a reduction of amplification, as is well understood in the art.

It is possible to operate with the polarity of the photoelectric cell reversed, in which case an increase in cell current operates to decrease the drop across R_5, and hence to increase the amplification of the system. In such a case the system is, of course, so designed that minimum amplification is obtained when there is no light on the cell.

The bias on the grid of the amplifier tube 21, and therefore the amplification of the system, is thus under the direct control of the light impinging on cell 35, which light is in turn controlled by the light transmission characteristics of the valume control record 30. The volume level of the final reproduced sound can obviously, therefore, be predetermined and controlled irrespective of the level

of recording or the nature of the sound record by merely preparing and utilizing the proper volume control record.

The volume control record 30 may be made in a system such as is illustrated in Fig. 1. As there illustrated, the traveling sound-picture film 10 is intercepted in a band outside its perforations 13 by a light beam cast from an illuminated light-slit 46 by means of a lens 45, slit 46 being illuminated by an incandescent lamp 47. Lamp 47 is lighted by means of a battery 48, a variable potentiometer 49 being included in the lighting circuit for the purpose of varying the potential impressed upon the lamp, and hence the light intensity thereof and the density of the record 30 printed on film 10. Potentiometer 49 may be regulated either manually in accordance with predetermined data or automatically in accordance with predetermined settings of suitable devices. The operation may conveniently be carried on during the printing of either the pictures or the sound record on the film 10, utilizing for this purpose devices and methods similar to those now commonly employed for varying the intensity of the printing light as the changing scenes require.

In Fig. 2 is shown a variational sys em for making the volume control record. In this case the volume control record 30 is printed upon a film 50 separate from the film 10*a* which carries the pictures 11 and sound record 12. In this figure there is shown a system by which the volume control record 30 can be made under manual control by an operator while listening to a reproduction of the sound record 12 at the levels of original recording. The films 10*a* and 50 are conventionally illustrated as synchronously driven by sprockets 51 and 52 mounted on a driving shaft 53, shaft 53 being driven by any convenient means, not shown. The sound record 12 on film 10*a* is reproduced as audible sound in any usual manner, for instance, by means for an illuminant 54, lens 55, slit 56, photoelectric cell 57, amplifier 58 and speaker 59. An optical system is provided for printing a varying density record on the moving film 50, and comprises typically an incandescent lamp 60, a slit 61 illuminated thereby, and a lens 62 for casting an image of slit 61 on the moving film 50. A battery 65 is connected by means of circuit 66 with lamp 60, a variable potentiometer 67 being provided in the circuit for the purpose of controlling the potential impressed on the lamp, and hence the intensity of its light and the density of the volume record 30. The operation of this system is as follows: A trained operator listens to the reproduction of record 12, and simultaneously controls the variable potentiometer 67, which governs the density of the volume control record which is being produced. Knowing from experience how the settings of potentiometer 67 govern the volume modifying characteristics of the record 30 which he is producing, the operator is able to listen to the sound reproduced by speaker 59 and simultaneously set or control his potentiometer 67 in accordance with the volume changes which he desires to be finally effected, in such a way that in final reproduction the volume control record which he has made will modify or control the volume of the reproduced sound at the levels which he has thus predetermined.

In Fig. 4 is shown a system for controlling volume level in reproduction from a sound record of the mechanical disk type. The mechanical disk record is shown at 104, and an electro-magnetic pick-up therefor at 105. One side of the pick-up is grounded, while the other side thereof is connected by lead 106 to the grid of the first tube 107 of the vacuum tube amplifier, conventionally illustrated at 108. Only the first stage of the amplifier is shown, the balance of the amplifying circuit being of any suitable or well known type. The output leads 109 of the amplifier are connected to a speaker unit 110, as usual. The negative terminal of the filament of amplifier tube 107 is connected through a resistance R_1 to ground, and a condenser C is included in lead 106. A lead 111 having therein resistances R_3 and R_4 is connected to lead 106 between condenser C and the grid of tube 107.

The moving film 112 having thereon the volume control record 113 is passed before the photoelectric cell 35, and an optical system consisting of an illuminant 32, lens 33 and a light-slit 31 is utilized to transmit light rays through record 113 to impinge upon photoelectric cell 35. Cell 35 is connected across the grid and plate of a vacuum tube 38, the plate circuit 39 of which include the resistance R_2, and the grid circuit of which include a resistance R_5. The operation of the volume controlling portion of this system is identical with that of the systems illustrated in Fig. 3, and will be understood without further explanation.

Various other schemes for controlling the volume level of reproduced sound in accordance with an electrical current produced from a volume control record are possible. For instance, as illustrated in Fig. 5, the property of a photoelectric cell by virtue of which its sensitivity varies in accordance with the applied potential, may be utilized to this end. The system illustrated in Fig. 5 has the film 10 with its sound record 12 and optical system therefor 15, 16, 17, and also with the volume control record 30 and optical system 31, 32, 33, all similar to the previously described system of Fig. 3. Here, however, one side of the photoelectric cell 70, provided for sound record 12, is connected by means of lead 71 to the grid of the first tube 72 of the vacuum tube amplifier, conventionally illustrated at 73. The other side of the cell is connected

by lead 74 to a battery 75, and the other side of the battery is connected by lead 76 to lead 71, lead 76 having therein resistances R_4 and R_3, and being grounded between the two resistances, as shown. The output leads 77 of the amplifier are connected to a usual speaker 78. A condenser C is located in lead 71 between the connection therewith of lead 76 and the grid of tube 72, and a resistance R_2 is connected at one side to lead 71 between condenser C and the grid, and at the other side to the grounded side of resistance R_1.

Photoelectric cell 80, in which is generated an electromotive force proportional to the volume control record 30, is connected by leads 81 and 82 with the grid and plate respectively of the vacuum tube 83. The plate circuit 84 of the tube 83 includes the resistance R_4, and the grid circuit 85 thereof includes a resistance R_5. The connections of the circuit may be made to such that an increase in the photoelectric cell current in circuit 81, 82 will cause either an increase or a decrease in the drop across resistance R_4, depending merely upon the polarity of various connections of the circuit, as will be understood. If the system is so arranged that an increase in photoelectric cell current will cause an increased drop across resistance R_4, then the constants of the system will be so balanced that with no light on photoelectric cell 80, and hence a minimum drop across resistance R_4, a maximum potential will be impressed by battery 75 across photoelectric cell 70. The sensitivity of photoelectric cell 70, and hence the volume level of reproduction, will then be at a maximum. When, however, cell 80 is impinged upon by a beam of light the drop across resistance R_4 is increased and the potential applied to cell 70 correspondingly decreased, to the end that the sensitivity of cell 70 and hence the volume level of reproduction are correspondingly lowered. If, on the other hand, the connections are so arranged that an increase in the photoelectric cell current in circuit 81, 82 causes a decrease in the drop across resistance R_4, then the sensitivity of cell 70, and correspondingly the volume level of reproduction, will be at a maximum when the light impinging on cell 80 is at a maximum, and a decrease in the light impinging on cell 80 will produce a decrease in the volume of reproduction, as will be understood.

In Fig. 6 is shown a system for controlling the amplifier by means of a screen grid. Here again, the film 10 with its sound record 12 and optical system 15, 16, 17, and also with the volume control record 30 and optical system 31, 32, 33, are similar to the system of Fig. 3. The photoelectric cell 90 for sound record 12 is grounded at one side, and is connected at its other side by lead 91 to the grid of the first tube 92 of the vacuum tube amplifier, conventionally illustrated at 93. The filament of tube 92 is connected by lead 94 to ground, and also to battery 95, the other side of which is connected through resistance R_1 to the grid of the tube. A screen grid 96 provided in tube 92 is connected by a lead 97 to one side of a battery 98, and the other side of battery 98 is connected to one side of a resistance R_2, the other side of which is connected to ground, as indicated. Resistance R_2 is included in the plate circuit 99 of a vacuum tube 100, across the grid and plate elements of which are connected leads 101 from a photoelectric cell 102 provided for the volume control record 30 on film 10. The output leads 103 of amplifier 93 are connected to a usual speaker unit 104.

The light transmitted through volume control record 30 affects the photoelectric cell 102 to generate a proportional current therein, which current acts upon the vacuum tube circuit to vary the drop across resistance R_2 in the plate circuit 99. Variation of the drop across R_2 then varies the potential on the screen grids, as will be understood; and since the conductance of the tube is controlled on a straight line characteristic by the potential of the screen grid, the amplification constant of amplifier 93 is varied in exact accordance.

This latter system has the advantage that the amplification is in exact direct proportion to the potential applied to the screen grid, and the volume control therefore follows a straight line characteristic.

From what has now been said, it will be recognized that the invention in all of its described forms provides means for greatly enlarging the practicable volume range in reproduction of sound records, whatever may be the nature or characteristics of the sound records utilized. In another aspect, it provides for the adjustment or modification of the level of reproduction of the original sound record.

An advantage in the use of the present invention resides in the possibility of reducing ground noise to negligible proportions. Ground noise is only audible or objectionable when the ratio of recorded sound to ground noise is low. Therefore, by merely recording all sound at higher than usual levels and reducing these levels in reproduction according to the methods of the present invention, ground noise can be made relatively so small as to be entirely negligible.

The system will in many cases eliminate the necessity for retakes, which are now often required for the reason that when a picture is completed it is found that certain scenes must be rejected because they are recorded at an improper level to match up with the balance of the picture. The application of the present invention to such a situation is obvious.

In general, the system thus provides for the correction or adjustment of volume level

after the picture is completed. And in addition it makes reproduction possible at both higher and lower levels than have heretofore been consistent with substantially perfect or acceptable reproduction.

It will be recognized that the illustrative systems specifically described herein are capable of considerable modification and rearrangement without departing from the spirit and scope of my invention; and it is therefore to be understood that the following claims embrace all such modifications and equivalent arrangements as may fairly be construed to fall within the scope of my invention.

I claim:

1. In combination with a system for reproducing sound waves from a sound record, which system includes means for driving the sound record, means for producing from the sound record varying electrical current waves corresponding to the sound waves, and means for reproducing sound from said current waves; a volume control record moved synchronously with the sound record, means for producing from the volume control record electrical currents corresponding to volume variations recorded thereon, a vacuum tube and a circuit therefor, leads connecting the varying electrical current produced from the volume control record across the grid and plate of said vacuum tube, whereby a varying plate current corresponding thereto appears in the plate circuit of the tube, and means for modifying the volume level of the reproduced sound in accordance with the variations in said plate current.

2. In a system for reproducing sound waves from a sound record, means for driving the sound record, means for producing from the sound record varying electrical current waves corresponding to the sound waves, a vacuum tube amplifier for amplifying said current waves, a volume control record driven synchronously with the sound record, means for producing from the volume control record electrical currents corresponding to volume variations recorded thereon, a vacuum tube and a circuit therefor, circuiting connecting the varying electrical current produced from the volume control record across the grid and plate of said vacuum tube, whereby a varying plate current corresponding thereto appears in the plate circuit of the tube, means providing a varying grid bias on a tube of the amplifier in accordance with the variations in said plate current, and means for reproducing sound waves from the electrical current output of the amplifier.

3. In a system for reproducing sound waves from a sound record, means for driving the sound record, means for producing from the sound record varying electrical current waves corresponding to the sound waves, a vacuum tube amplifier for amplifying said current waves, a resistance between the filament and grid of a tube of said amplifier providing negative bias on said grid, a volume control record driven synchronously with the sound record, means for producing from the volume control record electrical currents corresponding to volume variations recorded thereon, a vacuum tube, a plate circuit therefor including the biasing resistance of the amplifier tube, leads connecting the varying electrical current produced from the volume control record across the grid and plate of said vacuum tube, in such a manner that a varying plate current corresponding thereto appears in the plate circuit of the tube to vary the voltage drop across the biasing resistance of the amplifier tube, thereby correspondingly varying the negative bias on the amplifier tube and therefore the amplification of the tube, and means for reproducing sound waves from the electrical current output of the amplifier.

4. In a system for reproducing sound waves from a sound record, means for driving the sound record, means for producing from the sound record varying electrical waves corresponding to the sound waves, circuiting including a vacuum tube amplifier for transmitting said varying electrical waves, a vacuum tube in said circuiting including filament, grid, plate and screen grid elements, a volume control record driven synchronously with the sound record, means for producing from the volume control record varying electrical currents corresponding to volume variations recorded thereon, a vacuum tube having grid and plate elements, a circuit therefor, circuiting connecting the varying electrical current produced from the volume control record across the grid and plate of the last mentioned vacuum tube, so that a correspondingly varying plate current appears in the plate circuit of the tube, circuiting connecting said plate circuit with the screen grid of the screen grid vacuum tube in such a manner that said varying plate current controls the amplification of the screen grid tube, and means for reproducing sound waves from the electrical current output of the amplifier.

5. In a system for reproducing sound waves from a sound record, means for driving the sound record, means including a source of light and a photoelectric cell for producing electrical waves from the sound record, a circuit for transmitting said electrical waves, means for reproducing sound waves from said electrical waves, a volume control record moved in synchronism with the sound record, means for producing from the volume control record electrical current waves corresponding to volume variations recorded thereon, a vacuum tube having grid and plate elements and a circuit therefor, circuiting connecting the vary-

ing electrical current produced from the volume control record across the grid and plate of said vacuum tube, so that a correspondingly varying plate current appears in the plate circuit of the vacuum tube, and circuiting associating said plate circuit with the photoelectric cell of the sound record reproducing means so that the output of said photoelectric cell is controlled in accordance with the plate current variations.

In witness that I claim the foregoing I have hereunto subscribed my name this 19th day of September, 1929.

JAMES R. BALSLEY.