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SOUND RECORDING SYSTEM

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FIG. 1

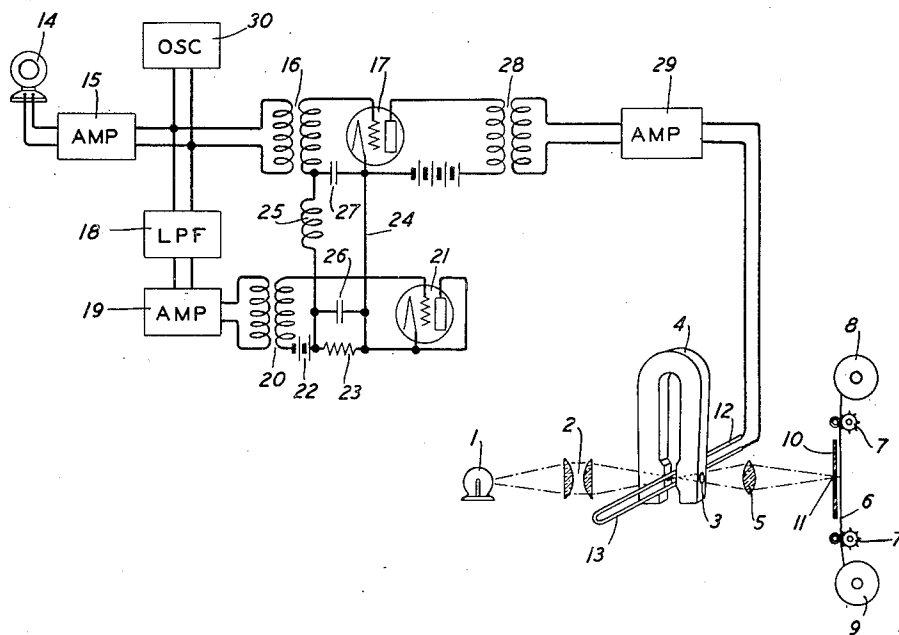
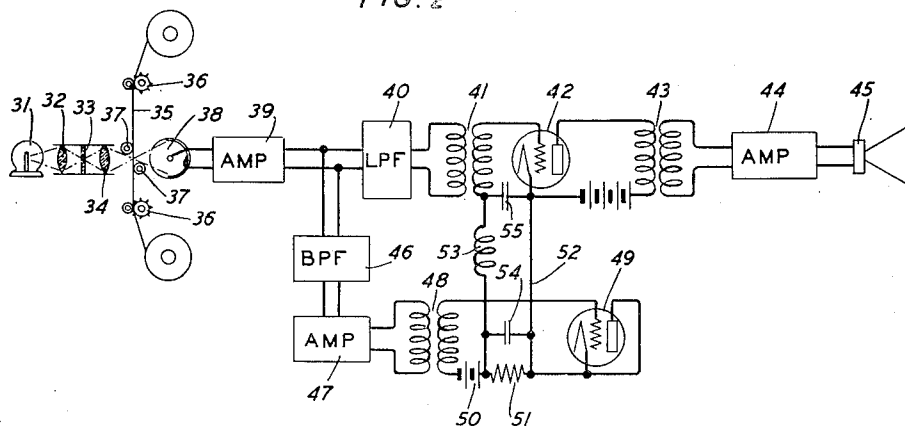


FIG. 2



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SOUND RECORDING SYSTEM

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4 Claims. (Cl. 179—100.3)

This invention relates to recording and reproducing systems and particularly to an arrangement whereby a system capable of recording only a narrow range of volume is enabled to produce at the reproducing end a wider range of volume than the medium is normally able to record.

An object of the invention is a method and means of modifying the variations in volume of the signal energy to a substantially constant volume of the order of the maximum volume which the medium can record.

A further object of the invention is a method and means of controlling the reproducing channel to restore the original variations in volume to the reproduced signal currents.

A feature of the invention is the transmission of a current of constant frequency through the recording channel which forms a record of the modifications made in the original volume in the same track as the record of the signal currents and which is reproduced to control the reproducing amplifier to restore the original variations in the volume of the signal currents.

The invention is applicable to recording and reproducing channels, such as are employed in the production of phonograph records and sound picture films.

It is well known that many sources of signal currents produce a variation in volume which is much larger than the variation in volume which may be recorded on the available recording mediums. For example, a modern symphony orchestra may produce a variation in the signal current of a microphone of the order of 70 decibels, or even more. A modern sound picture film can not ordinarily record a variation in volume exceeding about 35 or 40 decibels without either exceeding the upper limit of the characteristic of the medium, or, having the smallest volumes masked by the ground noise due to irregularities in the recording medium or the recording and reproducing channels.

In accordance with the present invention, the signal currents are transmitted through an amplifier, so controlled by the signal currents that the output of signaling currents to the recording device is of substantially constant volume. A constant amplitude current of constant frequency outside the frequency range of the signal currents is also supplied to the amplifier. The amplitude of the constant frequency current will be varied by the changes in the gain of the amplifier. The signal currents and the constant frequency current are recorded as a single record

on the medium. The composite current reproduced from the record, is filtered to separate the signal current from the constant frequency current. The signal current is transmitted through an amplifier to the reproducing device. The constant frequency current is rectified and filtered and controls the gain of the reproducing amplifier to restore to the signal currents the original variations in volume.

In the drawing:

Fig. 1 shows in diagrammatical form a preferred embodiment of the invention applied to a film sound recording system.

Fig. 2 shows in diagrammatical form a film sound system for reproducing the sound records produced by the system shown in Fig. 1.

Light from a suitable source 1 is focused by the lens system 2 on aligned orifices 3 pierced in the pole faces of a permanent magnet 4. The light emerging from the orifices 3 is focused by the lens 5 on a photographic film 6 traversed in known manner by the sprockets 7, 7 from reel 8 to reel 9. An opaque plate 10 pierced by a small aperture 11 limits the exposure of the film 6. A pair of flat, conductive ribbons 12, 13 stretched between the pole faces of the magnet 4 limit the height of the recording beam lengthwise of the film. When an electric current flows in the ribbons 12, 13, the reaction of the magnetic field due to the current with the constant magnetic field due to the magnet 4 will displace the ribbons 12, 13 and vary the height of the image on the moving film 6, that is, the time of exposure of the film. While a particular type of light valve has been illustrated, it is obvious that the invention is applicable to many other types of light valves, such as the internally modulated or so-called "flashing" lamps, the mirror galvanometers, corona discharges, X-ray tubes and many others.

Signal currents from any desired source, such as a microphone 14 actuated by acoustic waves, are amplified as desired in the amplifier or amplifiers 15, and applied through a transformer 16 to the input circuit of a controlled amplifying device 17, which, for convenience, is shown as a thermionic triode. A portion of the signal currents are tapped off the output of the amplifier 15 and pass through a low-pass filter 18, which passes all frequencies contained in the signal currents. In sound recording, for example, the filter 18 may pass all frequencies from 0 to 10,000 cycles per second and reject all frequencies above 10,000 cycles per second. Filters of this character are well known in the art. The signal currents, suit-

ably amplified, if desired, in the amplifier 19 are applied through a transformer 20 to a rectifier 21. The rectifier 21 has, for convenience, been shown as a thermionic triode but many other types of rectifiers may be used. The cathode of the triode 21 is heated in any suitable manner. A source of potential 22 applied between the cathode and another electrode of the triode 21 controls the current which will flow through the resistor 23 in the absence of signal currents. The resistor 23 is connected through wire 24 to the cathode of the controlled amplifier 17, and through the inductor 25 and the secondary winding of transformer 16 to the control electrode of the controlled amplifier 17. The potential developed across the resistor 23 will thus control the gain of the controlled amplifier 17. When signal currents are applied to the rectifier 21, rectified current will flow to the cathode, thence through the resistor 23, battery 22, secondary winding of transformer 20 to the other electrode. The potential developed across the resistor 23 will increase, and this increased potential will reduce the gain of the amplifier 17. The other electrodes of the device 21 may be connected to the cathode as they have little effect on the rectifying action. The capacitor 26 and inductor 25 smooth out the controlling action, so that the gain of the amplifier 17 tends to vary with the envelope of the amplitude variations of the signal currents and not with the variations of the individual frequencies. A capacitor 27 aids in this smoothing action and also provides a path of low impedance for the signal currents from the transformer 16 applied to the input of the amplifier 17.

The output of the controlled amplifier 17 is applied through transformer 28 and amplifier 29 to the ribbons 12, 13 of the light valve. The ribbons 12, 13 are displaced in accordance with the output of amplifier 17 and vary the time of exposure of the film 6. The effect of the control exercised by the rectifier 21 on the amplifier 17 is to tend to keep the output of the amplifier 17 more constant. For example, if the volume range of the signal currents is, say, 60 decibels the volume range of the output from the amplifier 17 may be reduced to, say, 30 decibels, and distortion due to overloading the recording device or film is avoided. The range of volume as recorded is, however, compressed.

A constant frequency current is generated by an oscillator 30 and applied to the input of the amplifier 17. This current will be amplified by the amplifier 17 to a degree depending on the gain of the amplifier 17, and is then supplied to the recording device through transformer 28 and amplifier 29. The amplitude of this constant frequency current is thus a measure of the gain of the amplifier 17 and will vary with the variations in the gain of the amplifier 17. The frequency of the current is outside the range of frequencies of the signal currents and thus can not pass through the filter 18. For present day sound recording, a frequency of the order of 12,000 cycles per second is satisfactory. The recording device will cause a record to be made of this current in the same track as the record of the signal currents.

Referring now to Fig. 2, light from a suitable source 31 is focused by a lens 32 on a small aperture in an opaque plate 33. An image of the aperture is formed by the lens 34 on the sound track of a moving film 35. The film 35 will, in general, be a positive copy of the film 6 used in Fig. 1. The film 35 is traversed through the light

image in the usual manner by sprockets 36, 36. Rollers 37, 37 hold the film steady and flat at the point where the image is formed. The modulated light passing through the film 35 excites a photoelectric cell 38 and produces currents in the output of the cell varying in accordance with the currents originally applied to the recording device. The output of the photoelectric cell 38, suitably amplified by the amplifier 39 is applied to the low-pass filter 40. This filter will pass all frequencies within the range of frequencies of the signal currents but will reject all other frequencies. For sound recording, this filter may pass all frequencies from 0 to 10,000 cycles per second. The signal currents pass through the filter 40, transformer 41, controlled amplifier 42, transformer 43, amplifier 44, and are reproduced by the reproducer 45. The volume of the reproduced sound at any instant will depend upon the volume recorded on the film 35 and the gain of the amplifier 42.

The component in the output of the amplifier 39 corresponding to the record of the constant frequency current from the oscillator 30 in Fig. 1 is of too high a frequency to pass through the filter 40. This component thus passes through the band-pass filter 46. The band-pass filter 46 will not pass the signal frequencies, however, but should pass a narrow range of frequencies extending from slightly above to slightly below the frequency of the oscillator 30 in Fig. 1. If the range of frequencies of the signal currents is, say, 0 to 10,000 cycles per second, and the frequency generated by the oscillator 30 in Fig. 1 is, say, 12,000 cycles per second, then the filter 46 should pass a band from, say, 11,500 to 12,500 cycles per second. By using a filter having an upper cut-off at 12,500 cycles per second in place of a simple high-pass filter, undesired products due to cross-modulation of the various frequencies are eliminated.

The currents passed by the filter 46 after suitable amplification in the amplifier 47 are applied through transformer 48 to the rectifier 49. In the absence of control currents, current flows from battery 50 through the secondary winding of transformer 48, through rectifier 49 to its cathode, thence through resistor 51 to battery 50. Resistor 51 is connected by wire 52 to the cathode of amplifier 42, and through inductor 53 and the secondary winding of transformer 41 to the control electrode of amplifier 42. The potential difference developed across the resistor 51 will cause the control electrode of amplifier 42 to be more negative than the cathode. When control currents are applied to the rectifier 49, the rectified currents increase the negative bias on the control electrode of the amplifier 42 and thus reduce the gain of the amplifier 42. The inductor 53 and capacitor 54 smooth out the action so that the gain of the amplifier 42 only varies with the slow variations of mean amplitude and not with sudden changes. Capacitor 55 aids the action of inductor 53 and capacitor 54 and provides a path of low impedance for the signal currents applied to the input circuit of the amplifier 42.

While, in the above description, the amplification of the controlled amplifiers has been controlled throughout the whole range of amplitudes of the signal currents, it will be obvious that the amplifier may be controlled throughout a part only of the range of amplitudes. For example, the amplification may be constant throughout a part of the normal range of amplitudes, and be controlled only for amplitudes larger than or

smaller than the part of the range selected. Such controlled amplifiers are well known in the art.

The action of the recording system may be briefly described as follows:

- 5 Let K = The amplification of the controlled amplifier
 S = The signal power applied to the controlled amplifier
 O = The oscillator power applied to the controlled amplifier.

10 Then, throughout the controlled range, the output of signal power equals KS , and this is substantially constant. Thus, when the signal power is small, the rectified currents in resistor 23, Fig. 1, are small, the amplification of amplifier 17 is large and the signal is recorded as if it were of large power. The output of the controlled amplifier will be $K(O+S)$, the constant frequency power which is recorded will be KO and, as K is large, the constant frequency power will be recorded as if the input were of large volume. Now, when this record is reproduced, the output of constant frequency power will be large, thus the rectified currents in resistor 51, Fig. 2, will be large and the amplification of the controlled amplifier 42 will be small. The output of signal power from the record will be too large, but, due to the small amplification of amplifier 42, will be supplied to amplifier 44 reduced to the correct relative magnitude. Similarly, when S is large, K will be small, and KS will be practically the same as before. The signal power will thus be recorded as if the signal were of less than its real volume. The recorded constant frequency power is proportional to KO and, as K is small, the constant frequency power is recorded as if it were of less than normal volume. In this case, when the record is reproduced the output of constant frequency power will be small, the rectified currents in resistor 51, Fig. 2, will be small, and the amplification of the controlled amplifier 42 will be large. The output of signal power from the record will be too small, but, due to the large amplification of amplifier 42, will be supplied to amplifier 44 increased to the correct relative magnitude.

What is claimed is:

1. In a recording and reproducing system, a source of signal currents an amplifier connected to amplify said signal currents, a detector responsive to a change in amplitude of said signal currents to vary the amplification of said amplifier inversely with said change, means to impress a control current of constant amplitude having a frequency outside the frequency range of said signal current upon the input of said amplifier, a recording device for producing a combined record of said signal currents and said control currents, means for reproducing from said record the signal and control currents, a signal channel and a control channel associated with said reproducing means, frequency selective means to select the signal currents only into the signal channel and the control currents only

into the control channel, a compensating amplifier in said signal channel, a detector responsive to a change in the amplitude of the selected control current to produce a compensating change in the amplification of the compensating amplifier, and means for reproducing the output of said compensating amplifier.

2. In a recording and reproducing system, a recording device, a recording medium affected by said device, an amplifier connected so that its output actuates said device, means to impress signal currents on the input of said amplifier, a detector responsive to changes in amplitude of said signal currents to vary the amplification of said amplifier, a circuit to impress a control current upon said device through said amplifier so that said control current is recorded on said medium with an amplitude determined by the change in amplification of said amplifier, means for reproducing from the record the signal and control currents, a compensating amplifier actuated by the reproduced signal currents, a reproducer actuated by the output of said compensating amplifier, and a detector responsive to changes in the amplitude of the reproduced control currents to produce a complementary change in the amplification of the compensating amplifier.

3. In a recording system, a source of signal current, a source of current of constant amplitude having a frequency outside the frequency range of said signal current, an amplifier, having an input and an output circuit, means for applying both said signal current and said constant amplitude current to the input of said amplifier, a recording device actuated by the output of said amplifier, a control circuit energized by said signal current to impress a potential upon the input circuit of said amplifier varying with the amplitude of said signal current and a network to exclude said constant amplitude current from said control circuit.

4. In a recording system, a source of signal current, a source of current of constant amplitude having a frequency outside the frequency range of said signal current, an amplifier having an anode, a cathode and a control electrode, means for energizing said cathode, a source of current connected between said anode and said cathode, a circuit for impressing a potential varying with the sum of said signal and said constant amplitude currents between the cathode and the control electrode of said amplifier, a recording device actuated by the output of said amplifier, a control circuit containing a rectifier energized by said signal current to impress a potential between said cathode and said control electrode whereby the amplification of said amplifier is varied inversely with a selected range of the amplitudes of said signal current and a network in said control circuit to exclude said constant amplitude current from said control circuit.

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