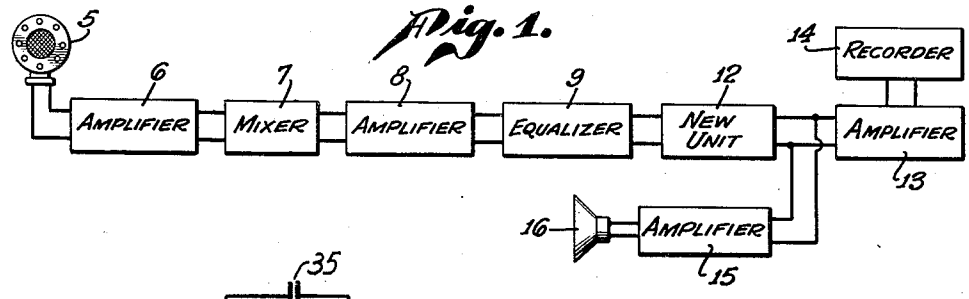
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COMPRESSOR AND VARIABLE EQUALIZER SYSTEM

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Fig. 1.



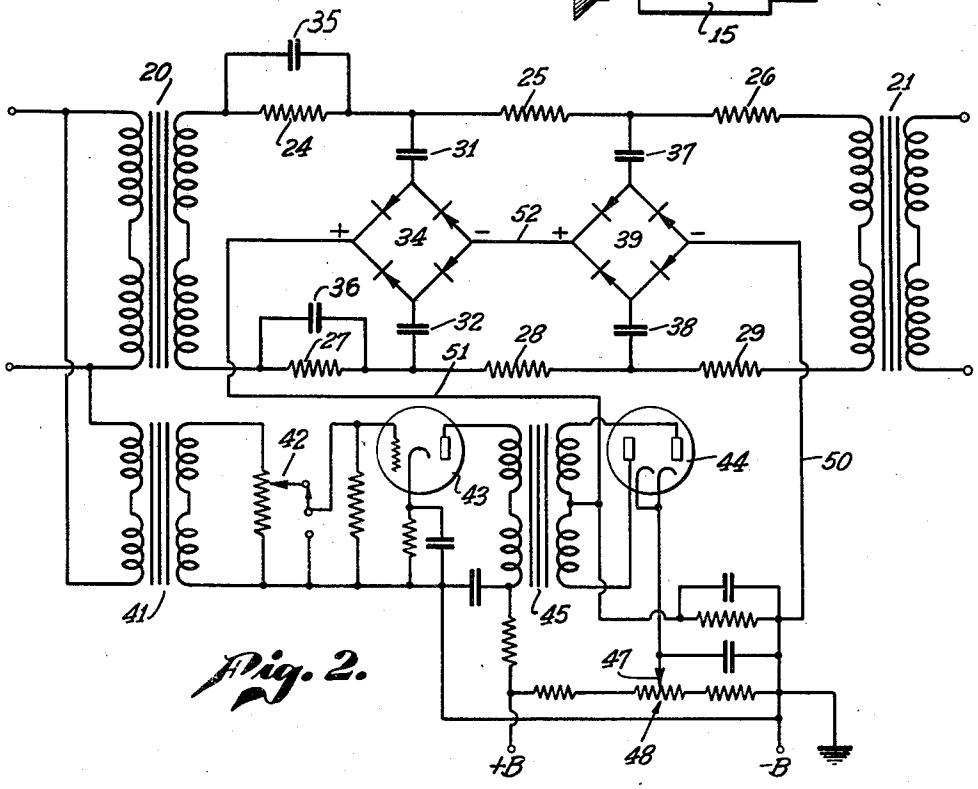


Fig. 2.

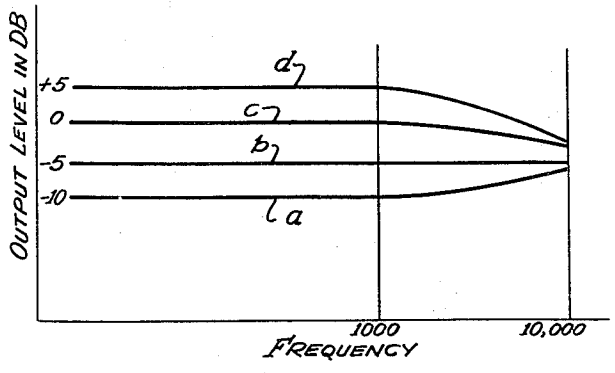


Fig. 4.

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Fig. 5.

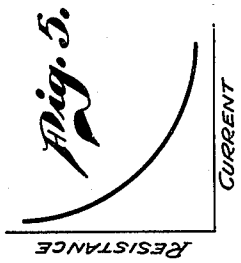


Fig. 3.

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COMPRESSOR AND VARIABLE EQUALIZER SYSTEM

Kurt Singer, North Hollywood, Calif., assignor to Radio Corporation of America, a corporation of Delaware

Application March 10, 1942, Serial No. 434,059

7 Claims. (Cl. 178—44)

This invention relates to sound recording and reproducing systems and particularly to a system wherein the reproduced volumes are varied with respect to the original sound volumes.

The use of compression in sound recording, broadcast and public address systems is well known, a typical sound recording compressor system being disclosed and claimed in my U. S. Patent No. 2,255,683, of September 9, 1941. Also Miller Patent No. 2,136,723, of November 15, 1938, discloses and claims both a compression and expansion system for sound films. These prior circuits operate on the original sound levels without regard to frequency or the frequency spectrum of the original signals.

Although the above-mentioned systems were and are satisfactory to a limited extent, they do not compensate for variations in intelligibility of the reproduced signal with volume. That is, it has been found necessary to vary the frequency characteristic of the reproduced sound in accordance with its reproduced level, regardless of whether the sound originates from an intermediate medium such as a sound film or record, or from an original sound source such as a public address system. Specifically, it has been found desirable to decrease the high frequency content of a signal at a high volume level of reproduction, as compared with a low level of reproduction. Thus, in the case of sound recording, the frequency characteristic of the signal as impressed upon the film should be varied in accordance with the relative level at which the sound is to be reproduced, to provide for optimum intelligibility at all levels. This problem was heretofore realized to a certain extent, as evidenced by U. S. Patent No. 2,162,875, of June 20, 1939, wherein an expansion circuit is disclosed which varies the rate of expansion in accordance with the frequency-sensitivity curve of the ear. The present invention is particularly applicable to variable density recording systems wherein a necessary high frequency compensation is not automatically obtained because of certain characteristics of recording elements.

The present invention, however, contemplates a system in which both a compressor action and the proper frequency characteristics are simultaneously obtained to provide the maximum intelligibility at all levels or volumes. In general, this is accomplished by the use of an arrangement of non-linear attenuators which vary not only the attenuation of the signal in accordance with amplitude, but also the frequency distribution of the signal in accordance with amplitude.

The principal object of the invention, therefore, is to provide means for the recording and reproducton of sound.

A further object of the invention is to provide means for obtaining variations in attenuation and frequency characteristics with a single transmission element.

A further object of the invention is to provide means for varying the attenuation of a signal in accordance with its volume, and for varying simultaneously the frequency response characteristic in accordance with the original volume of the signal.

A further object of the invention is to provide in a single transmission unit a fixed equalizer for a predetermined level range, a variable equalizer for a different level range and a compressor acting over the latter level range.

A further object of the invention is to provide a level attenuating variable equalizer.

Although the novel features which are believed to be characteristic of this invention are pointed out with particularity in the appended claims, the manner of its organization and the mode of its operation will be better understood by referring to the following description, read in conjunction with the accompanying drawings forming a part thereof, in which:

Fig. 1 is a block diagram of a sound recording system embodying the invention;

Fig. 2 is a schematic circuit diagram of one form of the invention;

Fig. 3 is a schematic circuit diagram of a modification of the invention;

Fig. 4 is a graph showing the overall frequency characteristics of the system of Fig. 1; and

Fig. 5 is a graph showing the characteristic of one of the non-linear resistance elements employed in the invention.

Referring now to Fig. 1, a microphone 5 feeds a preamplifier 6, which in turn feeds a mixer 7, the output of which is amplified in an amplifier 8 and then impressed upon an equalized unit 9.

The output of the equalizer is impressed upon an element 12, the output of which is amplified in amplifier 13 before impression on a recorder 14. Bridged across the input of amplifier 13 is an isolation amplifier 15 feeding a loudspeaker 16, the loudspeaker being either a recording monitor or the speaker of a public address system.

The above system is a standard type of sound recording channel for sound motion picture production, the invention residing in the element 12 which provides a new form of sound track or a new characteristic to the sound being recorded

at 14 and reproduced at 16. As disclosed in my above-mentioned Patent No. 2,255,683, the unit 12 is a compressor wherein certain sound levels above a predetermined level are varied in amplitube in accordance with their volume at a predetermined rate. The present invention not only accomplishes this result, but also varies the relative frequency distribution of the original signal as impressed upon the film or loudspeaker in accordance with the optimum reproduced volume of the signals.

Referring now to Fig. 2, the output of the equalizer 9 of Fig. 1 is impressed upon the transformer 20, the secondary of which is connected to the primary of an audio transformer 21, in series with a plurality of resistors 24 to 29, inclusive. Connected between the junction of the resistors 24 and 25 and the junction of resistors 27 and 28 is a variable impedance unit comprising condensers 31 and 32 connected in series with a bridge arrangement 34 of non-linear resistance elements such as Rectox, Thyrite or Rexselen units. A similar shunt unit is connected between the junction of resistances 25 and 26, and the junction of resistances 28 and 29, this unit comprising condensers 37 and 38 and a bridge arrangement 39 of similar non-linear resistance elements. The secondary of transformer 21 is connected to amplifier 13 and amplifier 15, as shown in Fig. 1.

A portion of the energy impressed upon the primary of transformer 20 is impressed on an audio transformer 41 and then through a potentiometer 42 on an A.-C. amplifier including a vacuum tube 43. The output of the amplifier is impressed upon a rectifier 44 through transformer 45, the amplitude at which compression occurs being controlled by the slider 47 on potentiometer 48 as described in detail in my above-mentioned patent. The output of the rectifier 44 is impressed upon the non-linear resistance bridges 34 and 39 in a series arrangement over conductors 50, 51 and 52. The settings of the potentiometers 47–48 and the potentiometer 42 is such that at a predetermined signal level, direct current will flow through the bridges 34 and 39, this flow of current decreasing the resistance thereof, and thus inserting loss or, in other words, attenuating the signal being transmitted by the channel.

To further illustrate this action, reference is made to Fig. 5, wherein is shown the general characteristic of the non-linear resistances used in bridges 34 and 39. The graph shows that as the current increases the resistance decreases, thus reducing the shunt arm impedance of the network between the transformers 20 and 21. This action provides compression of the signal similarly to the result obtained in my above-mentioned patent.

In the above-described circuit, each of bridges 34 and 39 is in series with the respective condensers 31, 32, 37 and 38. These reactances in association with the variable resistances, also vary the frequency characteristic of the signal in accordance with the amount of attenuation obtained. To further illustrate this action, reference is made to Fig. 4 wherein four characteristics, *a b, c, d,* are shown which are plotted as frequency characteristics in terms of output level in db. By the action of the equalizer element 9 in Fig. 1, the rising frequency characteristic of the general nature shown in curve *a* is obtained in order to compensate for microphone and film losses. That is, from a thousand cycles up, the ouput level increases. Thus, for a level shown by curve *a*, this particular frequency characteristic is desirable to produce the optimum intelligibility. This curve also represents the frequency characteristic up to the level of compressor operation. However, as the level increases, it is desirable to decrease the high frequency content of the signal with respect to the low frequencies involved, in order to maintain this optimum intelligibility. Thus, the curbes *b, c* and *d* illustrate the desirable frequency characteristics for the particular levels indicated for a certain recording system.

In curves *b, c* and *d*, the decrease in resistance caused by an increased direct current through bridges 34 and 39 lowers the impedance of the shunt arms composed of bridges 34 and 39 in association with the respective condensers 31, 32, 37 and 38 according to the expression $Z=\sqrt{X^2+R^2}$ where $X=\frac{1}{2}\pi fc$. Thus a substantially straight frequency characteristic for a reproduced level in the neighborhood of −5 db. is obtained as shown in curve *b* while at higher levels dropping characteristics are obtained as shown by curves *c* and *d*. Thus, the channel, whether used for sound recording or for broadcast or public address systems, will provide not only a compression action beginning at a predetermined level, but will provide a varying frequency characteristic to insure the optimum in intelligibility during reproduction.

In Fig. 2 it is to be noted that condensers 35 and 36 are shown connected across resistance elements 24 and 27, respectively. By the use of reactive shunt elements across these particular resistances or all of the series resistances, the unit may provide a fundamental frequency characteristic of any desired form, which will eliminate the use of the equalizer unit 9 shown in Fig. 1. Thus, the element 12 of Fig. 1 may simultaneously function as a compressor, as a volume controlled variable frequency discriminator and as an equalizer for providing a fixed initial characteristic.

Referring now to Fig. 3, a modification of the circuit of Fig. 2 is shown wherein like numerals identify like elements. In the system of Fig. 3, vacuum tubes are used as the variable shunting resistances instead of the bridges 34 and 39. The first shunting unit comprises two three-element vacuum tubes 55 and 56, plate potential thereto being supplied over resistances 57, 58, and 59, while the second shunting resistive unit comprises vacuum tubes 60 and 61 supplied with plate potential over resistances 62, 63 and 64. The impedance of the tubes is determined by the grid potential applied over conductors 66 and 67 through resistances 68 and 69. The operation of the circuit of Fig. 3 produces the same overall result as that of Fig. 2, explained above, but has the advantage over the first-mentioned circuit, of being more stable. That is, the resistance of the units used in Fig. 2 tends to vary with the ambient temperature, while the resistance of the vacuum tubes used in Fig. 3 remains constant.

In Fig. 3, two condensers 49 and 54, similarly to those shunting resistances 24 and 27, in Fig. 2 are shown shunting fixed resistances 25 and 28, respectively. These condensers represent any type of reactive elements which may be used to provide any desired initial frequency characteristic adjustments as described above, and may be used across any of the fixed resistances, as pointed out above.

It is to be understood that although the inven-

tion is described in connection with a balanced line, that the invention may be embodied in an unbalanced line. Furthermore, the control potential for the non-linear resistances and tubes may be obtained from the secondary of transformer 21 as well as from the primary of transformer 20.

What I claim as my invention is:

1. An electrical current control system comprising a source of electrical currents having varying amplitudes and a predetermined frequency spectrum, means for transmitting said currents, and means for simultaneously attenuating different frequency ranges of said currents in accordance with their amplitude, the attenuation of the higher frequencies of the transmitted currents being greater than that of the lower frequencies as the amplitude of said currents increases.

2. An electrical current control system in accordance with claim 1 in which resistances and condensers in shunt with each other are provided in series with said transmitting means for establishing an initial frequency response characteristic for said currents, wherein the attenuation of the lower frequencies is greater than that of the higher frequencies.

3. An electrical current control system in accordance with claim 1 in which said last-mentioned means includes a plurality of variable resistance elements in association with a plurality of reactive elements, the resistance of said resistance elements being varied by a control potential derived from said electrical currents on the imput side of said resistance elements.

4. An electrical compression unit for signal currents comprising a transmission line, a plurality of fixed resistance elements in series with said line to obtain an initial frequency response characteristic wherein the lower frequencies are attenuated to a greater degree than the higher frequencies, a plurality of variable resistance elements connected in shunt to said line, the resistance of said variable resistive elements varying in accordance with the amplitude of a control potential derived from said current passing through said line, a rectifier for rectifying said signal currents for providing said control potential, means for impressing said signal currents on the input of said rectifier, and means connected to said variable resistance elements for obtaining a frequency response characteristic whereby the higher frequencies are attenuated to a greater degree than the lower frequencies as the current level increases.

5. An electrical compression unit in accordance with claim 4 in which said last mentioned means includes condensers in series with said variable resistance elements to vary the shunt impedance across said line in accordance with the variation in said control potential and frequency.

6. An electrical compression unit in accordance with claim 4 in which condensers are provided across at least one of said fixed resistance elements for establishing said initial frequency response characteristic for said signal currents.

7. An electrical current transmission element comprising a line, means in said line for obtaining an initial frequency response characteristic for current levels below a predetermined level whereby the lower frequencies are attenuated to a greater degree than the higher frequencies, means in said line for attenuating current levels above said predetermined level in a predetermined ratio, and means included in said last-mentioned means for varying the initial frequency response characteristic for current levels above said predetermined level in accordance with the current level increases above said predetermined threshold level, said means attenuating the higher frequencies to a greater degree than said lower frequencies as said current level increases.

KURT SINGER.