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ELECTRICAL COMPRESSOR METHOD AND SYSTEM

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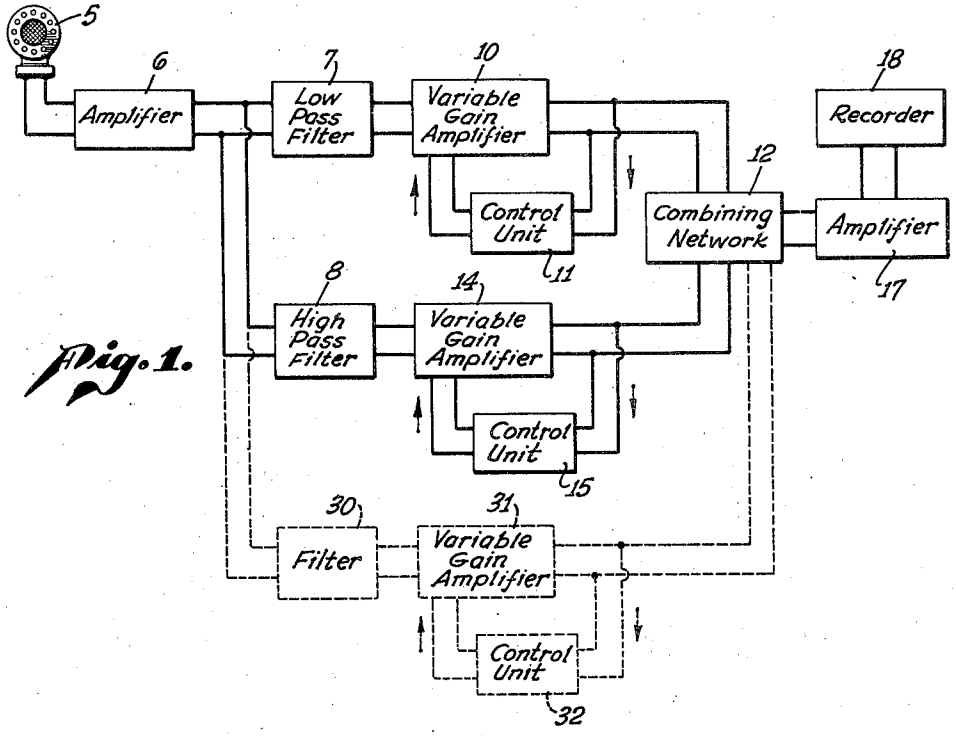


Fig. 1.

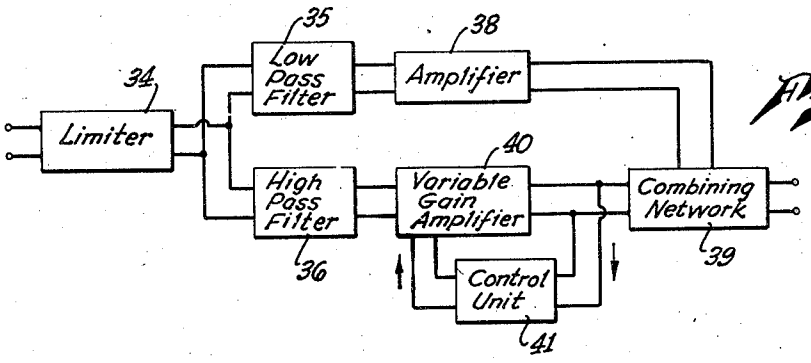


Fig. 2.

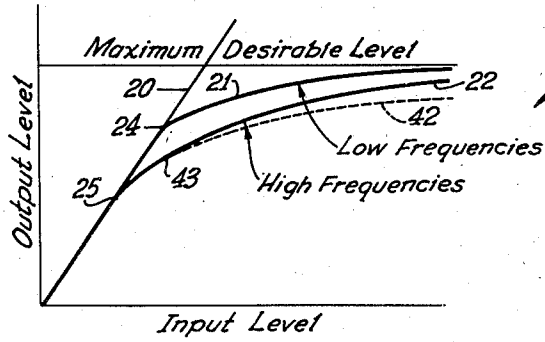


Fig. 3.

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ELECTRICAL COMPRESSOR METHOD AND SYSTEM

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8 Claims. (Cl. 179—100.1)

This invention relates to electrical current transmission systems and particularly to an amplifier or attenuator arrangement for varying the ratio of the amplitudes reproduced with respect to those of the original signal.

Although the invention is useful in broadcast and public address systems where compression is desired for various reasons, it is particularly useful in sound recording, wherein the sound track area of a film has definite physical limitations and can, therefore, accommodate only a certain amplitude range which is generally less than the amplitude range of the sound source. Thus, for this reason and others compression is introduced in systems for recording sound on film, a standard type of sound recording compressor being shown in Singer Patent No. 2,255,683 of September 9, 1941. In this patented system a portion of the output of a variable gain amplifier is rectified and impressed upon the gain control electrodes of the amplifier, the amplitude level at which compression begins being controlled as well as the rate or amount of compression obtained for any particular input level.

The present invention is directed to a compressor system of this general type, but one wherein the signal is divided into mutually exclusive frequency bands to which are applied different rates of compression. The break-away amplitude level at which compression begins is also individually controlled to provide compression in accordance with frequency. In this manner not only is the original signal range compressed within the film range, but intelligibility is improved by varying the proportion of high to low frequencies in accordance with amplitude level. It has been found in sound recording that intelligibility during reproduction is enhanced if the proportion of high to low frequencies is larger at the lower amplitudes of reproduction than at the higher amplitudes and the present invention permits controlling this ratio to the optimum extent.

The present use of compressors in the recording of dialogue or music is such that the compression of the composite sound level is the result of the level of the composite level. In any composite sound level, the power levels of the individual frequencies add together arithmetically to produce the composite power level. In the case of speech, the frequency components for the larger part lie in the same band, and the ear does not differentiate between frequencies when judging level, but recognizes only the composite level. Thus, compression as used in the present manner is acceptable.

On the other hand, a musical recording such as a solo with accompaniment, consists of widely separated frequency bands. An example is a soprano voice, or flute or other high register instrument with accompaniment by a low register instrument such as a guitar, double bass viol, etc. In this case, the ear of the auditor may easily recognize the individual power levels of the solo and the accompanying instrument. When a single compressor is used in the recording system, the level of the solo frequency is compressed at a rate determined by its level, but at the introduction of the added power from the accompanying instrument, the solo frequency suffers added compression in accordance with the power level of the solo frequency plus the power level of the accompanying instrument. Frequently the level from the accompanying instrument may be the larger and produce a serious fluctuation of the solo frequency level, which fluctuation is clearly distinguishable by the auditor.

It is the avoidance of this interacting effect which is an important feature of this invention, wherein the widely separated frequencies are passed through separate compressor branches where each is compressed in accordance with its own level, and independently of the level in the other branch or branches.

The principal object of the invention, therefore, is to provide improved means for facilitating the compression of signals being transmitted.

Another object of the invention is to provide an improved compression system which not only produces a predetermined amount of compression of a given signal, but varies the compressed amplitude ratio in accordance with frequency.

A further object of the invention is to provide improved means for facilitating the compression of signals being recorded on a sound track.

A further object of the invention is to provide an improved compressor system for sound recording wherein the signal range is compressed within the film range and the ratio of high to low frequencies is varied with signal amplitude.

Although the novel features which are believed to be characteristic of this invention are pointed out with particularity in the claims appended herewith, 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 drawing, in which:

Fig. 1 is a diagrammatic arrangement of a

sound recording system embodying the invention;

Fig. 2 is a modification of the system of Fig. 1; and

Fig. 3 is a graph showing the variation of high to low frequencies with signal level.

Referring now to Fig. 1 in which a sound recording system is shown diagrammatically, a microphone 5 feeds an amplifier 6, the output of which is impressed upon a low-pass filter 7 and high-pass filter 8. The output of the low-pass filter is fed to a variable gain amplifier 10 with its associate control unit 11 and then to a combining network 12, such as a hybrid coil, well known in the art. The output of high-pass filter 8 is impressed upon a variable gain amplifier 14 with its associate control unit 15 and is then impressed upon the combining network 12. The units 10—11 and 14—15 may be identical with the compressor unit shown in the above-mentioned Singer patent.

The output of the combining network is impressed upon an amplifier 17 and then on a sound recorder 18 of any standard type. The low-pass filter may be adjusted to pass a band of frequencies in the neighborhood of zero to between 1,500 to 2,000 cycles, while the high-pass filter will pass the remaining frequencies in the audio spectrum. Thus, the division in the audio frequency spectrum may be somewhere in the neighborhood of between 1,500 and 2,000 cycles when only two mutually exclusive frequency bands are employed although the frequency spectrum may be divided at other points if desired. The variable gain amplifier 10 and control unit 11 compress the low frequency band to any predetermined extent while the variable gain amplifier 14 and control unit 15 varies the high frequency band in a predetermined amount.

To illustrate one preferred adjustment of the unit just mentioned, reference is made to Fig. 3, wherein the relationship between the input and output levels for two frequency bands is illustrated. The straight-line curve 20 shows a linear relationship between input level and output level and which will be followed for all frequencies of low amplitudes. The solid curve 21 shows the compression applied to the low frequencies while solid curve 22 shows the compression applied to the high frequencies. To obtain curve 21, the variable gain amplifier 10 and control unit 11 are set so that the break-away point occurs at an input level shown at 24, with a compression action which approaches that of a limiter. The variable gain amplifier 14 and control unit 15 are adjusted so that the break-away point for the high frequency band occurs at a lower input amplitude level shown at 25 while the compression rate is more gradual as shown by the curve 22. The manner of selection of the break-away points 24 and 25 and the manner of obtaining the desired degree of compression thereafter is explained in detail in the above-mentioned Singer patent.

Analyzing what occurs with the adjustments shown in Fig. 3, it is to be noted that compression is applied to the high frequencies at a much lower input level than that at which compression is applied to the low frequencies, so that the amplitude ratio of the high frequencies to the low frequencies at any particular instant after compression begins will be less than the ratio below the compression level shown at 25. In this manner the intelligibility of reproduction in theaters is improved as described in my copending application, Serial No. 447,797, filed June 20, 1942, now Patent No. 2,354,295, granted July 25, 1944.

Shown in dotted lines in Fig. 1 is a filter 30, a variable gain amplifier 31 with its associate control unit 32 connected between the output of amplifier 6 and combining network 12. This dotted line circuit is shown to illustrate that the signal may be broken up into more than two frequency bands. In such a three-band system one frequency band, through a low-pass filter, may extend from zero to 1,000 cycles, the second frequency band through a band-pass filter may extend from 1,000 to 2,000 and a third frequency band, through a high-pass filter, extend from 2,000 cycles upward. With such a band-pass compressor system, each band may have a different rate of compression and starts at a different amplitude level.

A modification of the system of Fig. 1 is shown in Fig. 2, wherein the output of amplifier 6 is fed to a limiter 34, the output of which is impressed upon a low-pass filter 35 and a high-pass filter 36 similar to filters 7 and 8 in Fig. 1. The output of low-pass filter 35 is impressed upon a standard amplifier 38 and then upon a combining network 39, while the output of the high-pass filter 36 is impressed upon a variable gain amplifier 40 with its associate control unit 41. The combining network 39 may be connected to an amplifier similar to amplifier 17 of Fig. 1. In this arrangement the limiter 34 will be adjusted to function at a certain input level and will simultaneously limit both the high and low frequency components of the signal, the low frequency band being given a certain amplification at 38 in accordance with the amplification of the high frequencies before impression on the connecting network 39. The high frequency band is given a predetermined compression in addition to the limiting action, to provide an amplitude differential between the high and low frequencies at the higher amplitude levels.

The action of the system of Fig. 2 may also be illustrated in Fig. 3 which shows that the limiter may be adjusted to start its limiting action at 24 for all frequencies, and the compressor set to start compression of the higher frequencies at the lower input level shown at 25. Thus, the high frequencies will follow the solid curve from 25 to 43 at which level the limiter also affects the high frequency band which is given additional compression, the output level thereof following the dotted curve 42 instead of the solid curve 22, as in Fig. 1.

From the above description it will be noted that either system of Fig. 1 or Fig. 2 will introduce different amounts of compression between the mutually exclusive frequency bands, the original signal not only being compressed to within any desired overall range, but the amplitude proportions of the frequencies within the signal are varied with amplitude to accomplish the results set forth above.

I claim as my invention:

1. A sound recording system comprising a source of signal currents in the audio frequency spectrum, a plurality of filters for dividing said spectrum into mutually exclusive frequency bands, a separate transmission circuit for each of said bands, an individual compressor in each of said circuits for each of said frequency bands, a combining network connected to said circuits for combining the output of said compressors into a single signal, and a sound recorder connected to said combining network for recording said sig-

nal currents into a single record, said combined signal being adapted to be reproduced in compressed form.

2. A sound recording system in accordance with claim 1 in which said individual compressors begin compressing said frequency bands at different amplitudes thereof, the rate of compression for each respective band being different to increase the amplitude ratio of the high frequencies to low frequencies at the higher amplitudes of said signal currents.

3. The method of varying the amplitude ratio of high frequencies to low frequencies in an audio signal during transmission and reproduction, comprising separating the frequencies of said audio signal into mutually exclusive frequency bands, introducing compression for each band individually at different amplitude levels of the frequencies of each band, varying the rate of compression for each individual band in accordance with the amplitude of the respective frequencies in said signal, and combining said compressed bands for reproduction of said audio signal as a single signal, said signal being adapted to be reproduced in compressed form.

4. The method of varying the amplitude ratio between high frequencies and low frequencies in an audio signal being transmitted, comprising simultaneously limiting the amplitude of all of said frequencies above a certain predetermined amplitude, separating said limited audio signal into mutually exclusive frequency bands, and compressing at least one of said frequency bands beginning at a predetermined amplitude thereof and at a predetermined rate above said predetermined amplitude.

5. A system of compressing audio signals comprising a source of said signals, a limiter for limiting the amplitude of said signals above a certain predetermined amplitude, a plurality of filters for dividing said signals into mutually exclusive frequency bands, and means for compressing the frequencies in at least one of said frequency bands, said compression beginning at a lower amplitude than said predetermined limiter amplitude, said compression varying at a different rate than the limiting action of said limiter.

6. A system in accordance with claim 5 in which the difference between the rate of compression and the rate of said limiting action varies the ratio between the amplitudes of the high and low frequencies of said signals.

7. The method of recording an audio signal comprising limiting the amplitude of said signal to a certain predetermined amplitude separating the frequencies of said limited audio signal into mutually exclusive frequency bands, introducing compression in each band individually at different amplitude levels of the frequencies of each band, varying the rate of compression for each individual band in accordance with the amplitude of the respective frequencies in said signal, and combining said compressed bands for recording into a single record for direct reproduction without expansion.

8. The method of recording in accordance with claim 7 in which the high frequency band is compressed at a higher rate than the low frequency band at the higher amplitudes.

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