

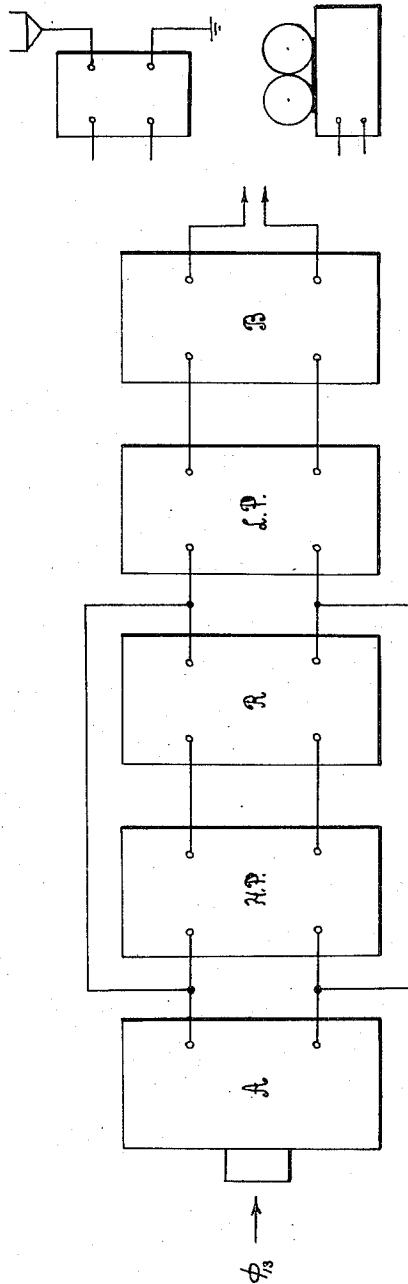
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PSEUDO-EXTENSION OF FREQUENCY BANDS

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PSEUDO-EXTENSION OF FREQUENCY BANDS

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This invention deals with the method and means of pseudo-extending the fidelity band of modulated circuits.

By pseudo-extension is meant the utilization of a psychological phenomenon, such as that of the non-linearity of amplitude vs. response characteristic of the ear, to increase the apparent frequency range of a transmitted signal. A fidelity band is that portion of the sensory spectrum which is necessary to faithfully reproduce the transmitted signal to the brain.

One object of the invention is to provide a general method whereby faithful transmission and reproduction of voice currents may be accomplished with systems having a narrower fidelity band than now necessary.

Another object of the invention is to provide a method whereby the fidelity reproduction of radio receivers may be increased thru circuit modification of broadcast transmitters.

Another object of the invention is to enable more faithful sound recording and reproduction with amplifier systems having linear characteristics of limited range.

Further objects and advantages will appear more fully hereinafter.

The method and means of this invention are based on the following:—

Given a system reactive to the stimulus $y=C_{\omega}$ in the angular frequency range $\omega_2 > \omega > \omega_1$ only. Then, in general, its response to the stimulus:

$$\phi_{12}(t) = \frac{1}{\pi} \int_{\omega_1}^{\omega_2} d\omega \int_{-1}^{+1} \phi(x) C_{\omega(t-x)} dx$$

will differ from:

$$\phi_{12}(t) = \frac{1}{\pi} \int_{\omega_1}^{\omega_2} d\omega \int_{-1}^{+1} \phi(x) C_{\omega(t-x)} dx$$

even tho $\omega_3 > \omega_2$.

The explanation offered for this phenomenon is that cross-modulation and an analogous Raman effect take place. If $\psi_{rs} = \Omega_{rs} \phi_{rs}$ is the response to ϕ_{rs} ,

then

$$\psi_{13} = \psi_{12} + \psi_{23}$$

where:

$$\psi_{23}(t) = \frac{1}{\pi} \int_{\omega_1}^{\omega_2} d\omega \int_{-1}^{+1} [\Omega \phi(x)] C_{\omega(t-x)} dx$$

Thus, it appears that the system exercises a distorting action:

$$\Omega_{23} \int_{\omega_1}^{\omega_2} d\omega \int_{-1}^{+1} \phi(x) C_{\omega(t-x)} dx = \int_{\omega_1}^{\omega_2} d\omega \int_{-1}^{+1} [\Omega \phi(x)] C_{\omega(t-x)} dx$$

Let now the responsive system be a normal human ear, and ϕ_{13} a complex sound, such as music voice or noise. Assuming a radiophone transmitter and receiver of linear characteristics and unit level adjustment, for the response to be the same at transmitter and receiver, the fidelity band must extend from ω_1 to ω_3 . If however a network is introduced at the transmitter such that while allowing free passage of ϕ_{12} , (postulating $\Omega_{12} \approx 1$), ϕ_{23} is converted into $\Omega_{23}\phi_{23}$, then ϕ_{13} can be heard equally well even tho the transmission band $\omega_3 > \omega > \omega_2$ may have been eliminated. Hence also, a receiver with linear response over $\omega_3 > \omega > \omega_1$ only, would still produce ϕ_{13} faithfully so far as the ear is concerned. In transforming audio frequencies, a Ω_{23} with a square law effect has been found suitable.

From the foregoing mathematical demonstration it will be obvious that frequencies lying outside the range of the apparatus that is used to bring those frequencies to the sensory organs may be replaced as regards their effect on the sensory organ in question.

The general technique here presented is both novel and fundamental, and of wide application. In various cases, even if $\Omega_{12} \neq 1$, the introduction of a modifying network Ω_{13} will often permit better results to be obtained from say an amplifying system of useful range $\omega_2 > \omega > \omega_1$ only.

Referring to the drawing, made schematic since all elements used are well known to those skilled in the communications art, ϕ_{13} is a complex sound which is picked up and faithfully translated into electrical variations by the microphone amplifier A. The frequencies $\omega_2 > \omega > \omega_1$ are blocked by the high-pass filter H. P., but permitted to pass freely to the power amplification sections B via the low-pass filter L. P. The frequencies $\omega_3 > \omega > \omega_2$, while blocked by L. P., are passed freely by H. P. into the rectifying network R where the (partial) conversion $\Omega_{23}\phi_{23}$ occurs. This component is thus also permitted to pass into B by L. P. From B, the currents are suitably transmitted as electromagnetic waves in the well-known manner, or made to record thru suitable apparatus.

The block diagram in the upper left section of the figure is intended to show a radio receiver or transmitter that may be coupled to the device (A—H. P.—R—L. P. and B). At the upper right, is shown a symbolic diagram for a sound recorder or reproducing apparatus which may also be connected to the device in such a manner as to utilize the characteristics of the invention to

pseudo-extend the fidelity band of such apparatus.

Other embodiments will readily suggest themselves to persons skilled in the art without departing from the spirit and scope of my invention. For example, after sub-division of the audio signal into two channels, namely one low frequency channel and one high frequency channel, in a manner similar to that indicated in the drawing, but if instead, the distortion is introduced in the low frequency channel by a detector circuit, and the resulting components in this low frequency channel which fall into the range of the high frequency channel are added to the high frequency channel and transmitted; a similar effect may be obtained to pseudo extend the low frequency spectrum. I therefore desire to have the illustrations included herewith and the descriptions specific thereto regarded in an illustrative rather than in a limiting sense. I do not desire therefore to be limited to specific details of design, construction, or instrumentalities employed, but having now set forth the object and nature of my invention, and described means embodying the principle thereof, and illustrated the method pertaining thereto, what I claim as new and useful and of my own invention and secure by Letters Patent is:—

1. A method of distortion compensation in an audio circuit comprising the steps of: dividing the signal current into high and low frequency bands, modifying the high frequency band by detection, selecting from the high frequency band the frequency components falling into the spectrum of the said low band, and adding said selected frequency components to the said low frequency band and transmitting the bands so added.

2. A method of distortion compensation in an audio circuit comprising the steps of: dividing a signal current into high and low frequency bands, modifying the low frequency band by detection, selecting from the low frequency band the frequency components falling into the spectrum of the said high frequency band, adding said se-

lected frequency components to the said high frequency band, and transmitting the bands so added.

3. In a distortion compensating network, an audio input circuit designed and arranged to receive a predetermined frequency range, at least one set of high-pass and low-pass sections, an output section, wave distorting means associated with said high-pass section, and means for transferring a component of the distorted current having frequencies below the lower cut-off of the high-pass section into the output section.

4. In a distortion compensating network, an audio input circuit, so designed and arranged to receive a predetermined frequency range, at least one set of high-pass and low-pass sections, an output section, wave distorting means associated with said low-pass section, and means for transferring a component of the distorted current having frequencies above the upper cut-off of the low-pass section into the output section, and means for transmitting variations in current in the output section.

5. In an audio frequency translation device, means for collecting a band of frequencies, means for selecting from said band substantially those frequencies which are preferentially transmitted and separating therefrom substantially the other collected frequencies at least, means for distorting the latter frequencies to ones substantially within the first noted band, means for imposing the distorted frequencies on said first band, and means for producing sound from the composite frequencies.

6. In an audio frequency translation device, means for collecting a band of frequencies, means for selecting portions of said band, means for distorting said selected portions, means for recombining said selected and distorted portions with components of the original band of frequencies, means for selecting from the resulting composite frequencies, at least a portion thereof, and means for producing sound from said portion.

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