Nov. 4, 1952 H. A. BROOS 2,616,970

DEVICE FOR THE TRANSMISSION BY ELECTRICAL MEANS OF OSCILLATIONS OF ACOUSTIC FREQUENCY

Filed Dec. 22, 1948

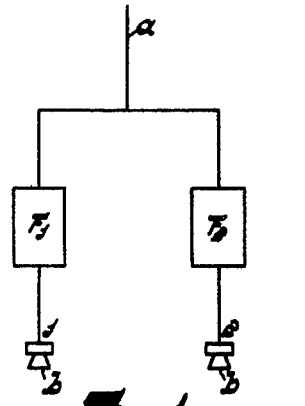

Fig. 1

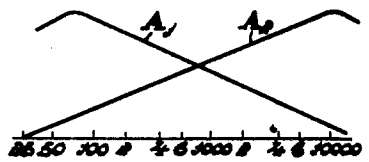

Fig. 2

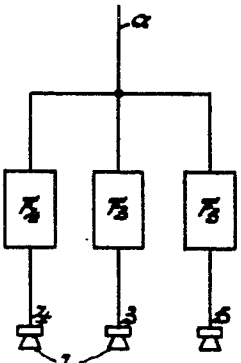

Fig. 3

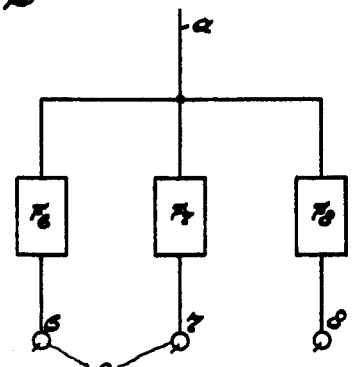

Fig. 5

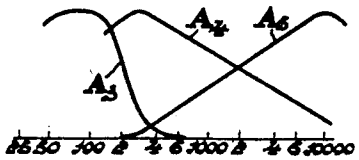

Fig. 4

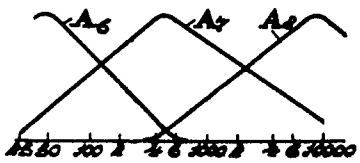

Fig. 6

INVENTOR.

HENRICUS ADRIANUS BROOS

BY Fred M. Vogel

AGENT

Patented Nov. 4, 1952 2,616,970

# UNITED STATES PATENT OFFICE

2,616,970

## DEVICE FOR THE TRANSMISSION BY ELECTRICAL MEANS OF OSCILLATIONS OF ACOUSTIC FREQUENCY

Henricus Adrianus Broos, Eindhoven, Netherlands, assignor to Hartford National Bank and Trust Company, Hartford, Conn., as trustee

Application December 22, 1948, Serial No. 66,814
In the Netherlands February 11, 1948

4 Claims. (Cl. 179—1)

1

This invention relates to devices for the transmission by electrical means of oscillations of acoustic frequency, the electrical oscillations representing the first-mentioned oscillations being set up in a frequency-dependent manner, with the use of filters across at least two channels, each comprising only one filter, by applying a voltage, if desired adjustable, such that for obtaining a spatial impression during reproduction, if desired via recording of the sound on a support, the strength of reproduction increases in one channel and decreases in the other channel upon changing from a frequency or group of frequencies to an adjacent frequency or group of frequencies.

The term "spatial impression" is to be understood to mean the impression as if the sound originates from one or more sound sources exhibiting spatial extensiveness.

A certain extent of spatial impression is already obtained with a known device in which electrical oscillations of acoustic frequency, coming from one channel are divided with the use of some filters which partly overlap over an equal number of reproducing channels. The spatial impression obtained when the loudspeakers are arranged in a row with some spacing and ranged according to increasing or decreasing ranges of frequencies is such that the lowest tones are heard coming from the outer loudspeaker at one side and the highest tones from the outer loudspeaker at the other side, the intermediate loudspeaker reproducing the intermediate ranges of frequencies. Since the transmission characteristic curves of the filters for two adjacent ranges of frequencies partly overlap, the frequencies of the overlapping region are reproduced by two loudspeakers, but not in the same strength ratio for each frequency. The image of the spatial position of such a frequency is thus located between the two loudspeakers and spatially varies in position for each frequency of the overlapping region.

The imperfection of this device resides in the fact that during the reproduction of those frequencies which are not located in the overlapping portion of the transmission characteristic curve of two adjacent filters, but which are passed by only one filter, all these frequencies are reproduced at the same spatial area, namely that of the loudspeaker associated with the filter concerned. With chromatic increase of frequencies a reproduction is thus obtained in which the sound image is at rest at the outer loudspeaker, then rapidly moves to a subsequent loudspeaker,

2

again stops there during a certain time, etc. Consequently, such a device does not allow of a reproduction in which, according to frequency, the sound image of a frequency continuously varies in position over that portion of the reproduced range of frequencies which contributes to the spatial impression.

In the device according to the invention this disadvantage is obviated in that the filters exhibit frequency characteristic curves such that the whole or substantially the whole range of frequencies to be reproduced by at least one of the channels, at least in so far as it contributes to the spatial impression, is also reproduced by one or more of the other channels to an extent which contributes to the effect.

The term "extent which contributes to the effect" is to be understood to mean that a determined minimum difference in ratio between the sound strengths of two frequencies or groups of frequencies to be positioned side by side in the sound image is required in each of at least two channels, viz. a difference in ratio such that the sound images produced of the two frequencies or groups of frequencies occupy preceptibly different positions in space. As mentioned before, this may be ensured with the device according to the invention by causing the strength of reproduction to increase in at least one of the channels and to decrease in at least one of the other channels upon change in frequency.

As a rule, the aim will be to ensure that the ratio between the sum of the strengths of reproduction of a determined frequency in the various channels and that of the other frequencies is equal to the ratio between the strengths of the oscillations of the corresponding frequencies upon generation. Preferably, for example for two channels, use is thus made of filters such that upon change from one frequency or group of frequencies to an adjacent frequency or group of frequencies, the strength of reproduction in one channel increases to the same extent as it decreases in the other channel.

Furthermore, if each frequency has an individual position or the groups are of equal size, the distance between these frequencies or groups will be chosen to be equal, so that the filters for each channel are required to be such that in the case of two channels and with logarithmic increase of frequency the voltage transmitted by one filter increases to such extent that the sound strength reproduced by the associated channel exhibits a substantially linear increase and, for the other filter, decreases to such extent that the

sound strength reproduced by the other channel exhibits a substantially linear decrease.

In a reproducing device comprising three loudspeakers for example the outer loudspeaker, which may be positioned with some spacing, may each comprise a filter such that their sound strength increases and decreases in substantially linear proportion with the logarithm of frequency in a range of, for example, from 500 to 1200 c./sec. The central loudspeaker in this case reproduces the frequencies below 500 c./sec., which frequencies, as is well known, do not contribute to the spatial impression.

The device according to the invention permits inter alia of reproducing with a spatial impression electrical oscillations which are not transmitted stereophonically by microphones and which originate, for example, from a piano and, if desired, have been recorded afterwards in the form of a sound track. The sound image thereof may be such as to convey the impression as if it displaces in space, dependently on frequency, in a similar manner as heard by the player of the instrument himself.

It will be evident that the same effect is obtained if an electric musical instrument is used as a source of oscillations of acoustic frequency. Since stereophonic reproduction of electric musical instruments is not possible, a device according to the invention enables the sound image of such instruments nevertheless to produce a spatial impression. The device according to the invention permits of obtaining a spatial impression more particularly of a source of oscillations of acoustic frequency which exhibits a spatial extensiveness, which is small with respect to the spatial impression of the sound image thereof. Thus it is possible, for example, that a musical box, all the acoustic oscillations of which seem to originate from the same place, provides a sound image such that the different tones are heard at different places, hence in such manner that, for example, all tones are heard side by side, in which event the total width of the sound image may be equal to the distance between the loudspeakers of the reproducing channels.

The invention will now be explained more fully by reference to the accompanying drawing showing diagrammatically by way of example, some embodiments thereof.

Fig. 1 shows a device in which each of two channels comprises a filter such that a strength of reproduction as shown in Fig. 2 is obtained for each channel.

Fig. 3 shows a device for three channels. The reproduction characteristic curve of this device is shown in Fig. 4. Figs 5 and 6 are variants of Figs. 3 and 4.

In Fig. 1 reference numeral 1 designates a channel for the transmission of electrical oscillation of acoustic frequency. The oscillations are supplied to two channels 1 and 2, each comprising a filter $F_1$, $F_2$, respectively. The filters are dependent on frequency in such manner that the strength of the sound to be reproduced by loudspeakers *b* is dependent on frequency in a manner as represented in Fig. 2 by the curve $A_1$ for channel 1 and by the curve $A_2$ for channel 2. A determined frequency will thus be reproduced by the loudspeaker of channel 1 and by that of channel 2. The position occupied by this frequency in the sound image will thus be located, according to the ratio between the strengths of reproduction of the two channels, between the loudspeakers of the channels, the distance between the two loudspeakers being equal to the total width of the sound image of the whole of the range of frequencies.



The electrical oscillations of the single channel *a* may originate either from a microphone or from a record. As an alternative, they may be supplied by other generating members such, for example, as electric musical instruments.

Fig. 3 shows the image of a three-channel system for the reproduction of sound. Here the electrical oscillations of the single channel *a* are supplied to the three channels 3, 4, 5, which comsupplied to the three channels 3, 4, 5, which comprise the frequency-dependent filters $F_3$, $F_4$, $F_5$ respectively. As may be seen from Fig. 4, which shows the reproduction curves of the three channels of Fig. 3, the loudspeaker *b* of channel 3 only reproduces the low frequencies. The higher frequencies are transmitted with different strengths by the two channels 5 and 5 and the sound image is thus reproduced dependently on frequency between the loudspeakers of the said channels.

Fig. 5 shows a device which is a variant of Fig. 3. As before, three reproduction channels for obtaining a spatial impression in the reproduction space are shown between the two outer loudspeakers each channel comprising a filter. The channels 6, 7, 8, comprise filters $F_6$, $F_7$, $F_8$ respectively such that the sound upon being reproduced through the same number of channels via a record produced by members *c* in the form of three tracks, has a strength which is dependent on frequency, as indicated in Fig 6 by $A_6$ for the channel 6 and by $A_7$ and $A_8$ for the channels 7 and 8. Here the low tones are also divided over two channels so that each tone occupies its own position. Consequently, upon change from a very low frequency to a higher frequency, the strength of reproduction of the frequencies reproduced by the channels 6 and 7 will in this device increase in channel 7 and decrease in channel 6.

It is evident that the invention is not limited to the curves of Figs. 2, 4 and 6. Other curves may alternatively be used to ensure a certain desired spatial impression.

Since the electrical oscillations from channel *a* provided a sound image having a width equal to the distance between the loudspeakers of the outer channels, the device may be used with advantage with instruments exhibiting a spatial extensiveness which is small with respect to the spatial impression of the sound image thereof, such, for example, as a musical box.

What I claim is:

1. Electrical apparatus for reproducing, with simulated spacial perspective, audio oscillations having a given frequency range obtained from a sound source and transmitted through a single channel, said apparatus comprising a plurality of transmission subchannels, a like plurality of reproducers disposed in spaced relation, each reproducer being coupled to said single channel through a respective subchannel, and a filter network in each subchannel preceding the associated reproducer, one of said networks having a frequency-response characteristic at which the resultant amplitude of oscillations applied to the associated reproducer decreases as a function of frequency throughout a predetermined portion of said frequency range, another of said networks having a frequency-response characteristic at which the resultant amplitude of oscillations applied to the associated reproducer increases as a

function of frequency throughout said predetermined portion of said frequency range.

2. Electrical apparatus for reproducing, with simulated spacial perspective, audio oscillations having a given frequency range obtained from a sound source and transmitted through a single channel, said apparatus comprising first and second transmission subchannels, first and second reproducers disposed in spaced relation and coupled to said single channel through said first and second subchannels respectively, and first and second filter networks inserted in said first and second subchannels respectively, said first network having a frequency-response characteristic at which the amplitude of oscillations applied to said first reproducer increases in accordance with frequency through said given range, said second network having a frequency-response characteristic at which the amplitude of oscillations applied to said second reproducer decreases in accordance with frequency throughout said given range.

3. Electrical apparatus for reproducing, with simulated spacial perspective, audio oscillations having a given frequency range obtained from a sound source and transmitted through a single channel, said apparatus comprising first, second and third transmission subchannels, first, second and third reproducers disposed in spaced relation and coupled to said single channel through said first, second and third subchannels respectively, and first, second and third filter networks inserted in said first, second and third subchannels respectively, said first network having a frequency-response characteristic at which solely the oscillations within the low-frequency band of said range are applied with substantially undisturbed amplitude to said first reproducer, said second network having a frequency-response characteristic at which the amplitude of oscillations within the remaining high-frequency band in said range applied to said second reproducer decreases in accordance with frequency, said third network having a frequency-response characteristic at which the amplitude of oscillations within said high-frequency band applied to said third reproducer increases in accordance with frequency.



4. Electrical apparatus for reproducing, with simulated spacial perspective, audio oscillations having a given frequency range obtained from a sound source and transmitted through a single channel, said apparatus comprising first, second and third transmission subchannels, first, second and third reproducers disposed in spaced relation and coupled to said single channel through said first, second and third subchannels respectively, and first, second and third filter networks inserted in said first, second and third subchannels respectively, said first network having a frequency-response characteristic at which the amplitude of oscillations applied to said first reproducer within the low-frequency band of said given range decreases in accordance with frequency, said second network having a frequency-response characteristic at which the amplitude of oscillations applied to said second reproducer increases in accordance with frequency within said low-frequency band and decreases in accordance with frequency within the remaining high-frequency band of said given range, said third network having a frequency-response characteristic at which the amplitude of oscillations applied to said third reproducer increases in accordance with frequency within said high-frequency band.

HENRICUS ADRIANUS BROOS.

## REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

| Number | Name | Date |
|---|---|---|
| 1,674,683 | Hahnemann | June 26, 1928 |
| 2,093,540 | Blumlein | Sept. 21, 1937 |
| 2,098,372 | Blumlein | Nov. 9, 1937 |
| 2,261,628 | Lovell | Nov. 4, 1941 |
| 2,352,696 | De Boer et al. | June 4, 1944 |