Feb. 24, 1942. G. HOLST ET AL 2,273,866

STEREOPHONIC SOUND RECORDING AND REPRODUCTION

Filed Sept. 27, 1938

Fig. 1.

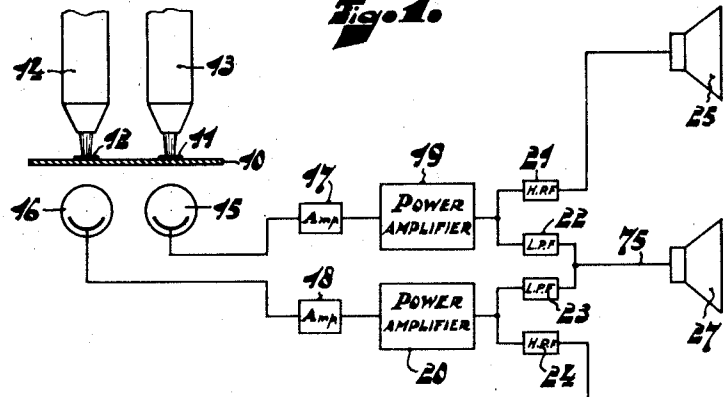



Fig. 2.

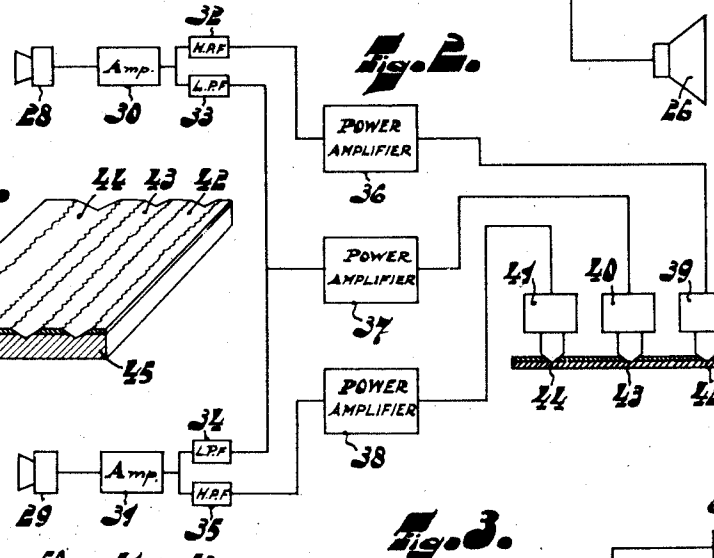


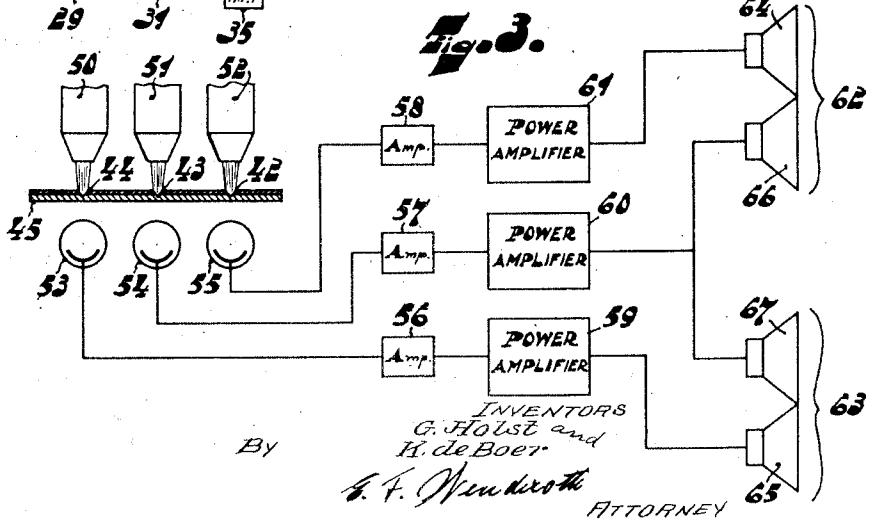

Fig. 4.







Fig. 3.




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## STEREOPHONIC SOUND RECORDING AND REPRODUCTION

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9 Claims. (Cl. 179—100.4)

The present invention relates to a method and apparatus for the stereophonic recording and reproduction of sound and to a sound record for use in such reproduction.

The term "stereophonic reproduction" of sound as used herein and in the claims is to be understood to mean that type of reproduction in which the sound is reproduced by a plurality of reproducing devices in such a manner that a space effect is obtained, i. e. so that it is possible to locate a sound source in space even in the artificial reproduction. Thus the term stereophonic reproduction includes not only the well-known reverberation effect, but also the directional effect which allows one upon hearing a sound to localize its source and/or ascertain the movement thereof.

In sound recording it is well known to use for the above purpose, a plurality of spacially-separated receiving devices whose vibrations are transmitted through separate channels which are subsequently reproduced separately by means of spacially-separated reproducing devices. It is also well known to divide the frequency range of the sound vibrations to be recorded and reproduced, into a plurality of frequency ranges to avoid distortion. However, when combining this measure with stereophonic recording and reproduction, the apparatus becomes very complicated. More particularly, if the frequency range is divided into $n$-parts and there is stereophonic transmission in $m$-channels, it will be necessary to use $n$ times $m$ transmitting and reproducing devices.

The object of our invention is to overcome the above difficulties and to simplify such methods of recording and reproduction as well as the apparatus used.

A further object of our invention is to provide a new type of sound record for use in such types of reproduction.

We have found that the sound vibrations in the lowest frequency range are not essential for the stereophonic effect. More particularly these sound vibrations have a low frequency and large wave length, and thus have only a very slight directional effect and are not essential for locating the sound source.

In accordance with the invention, we supply the sound vibrations in the higher frequency range of each recording device, to separate channels, and supply the vibrations in the lower frequency range of these devices to a single channel. The higher frequency ranges, are reproduced by reproducing devices which are separated both acoustically and spacially, whereas the vibrations of the lowest frequency range are reproduced by a common reproducing device.

The term "channel" as used herein and in the claims is to be understood to include both a recording of the sound vibrations such as a sound track on a carrier, and a path in which the electrical current variations corresponding to the sound vibrations can flow, for instance, a carrier wave or a transmission line.

In one form of the invention in which the vibrations are recorded, we record the high-frequency ranges in separate sound tracks on a carrier and separately reproduce these tracks with spacially-separated reproducing devices, whereas we record the lowest frequency range in a common sound track and reproduce this latter track by a common reproducing device.

The upper limit of the lowest frequency range, which is consequently common to all recording and reproducing devices, generally lies between 200 and 300 vibrations per second. Below these frequencies the sound waves have substantially no directional effect.

In order that the invention can be more clearly understood and readily carried into effect, we shall describe the same in more detail with reference to the accompanying drawing in which:

Figure 1 is a schematic diagram of a stereophonic reproducing system embodying the invention,

Fig. 2 is a schematic diagram of a stereophonic recording system embodying the invention,

Fig. 3 is a schematic diagram of a stereophonic reproducing system for reproducing the record made in system of Fig. 2, and

Fig. 4 is a perspective view on an enlarged scale of a stereophonic sound record according to the invention.

In the reproducing system shown in Figure 1 a sound carrier 10 provided with two stereophonically-recorded sound tracks 11 and 12 is reproduced by two similar reproducing devices, one including an objective 13 and a photo-electric cell 15 and the other including an objective 14 and a photo-electric cell 16. The tracks 11 and 12 are produced in the usual manner by the use of receivers which are spaced apart, and each track includes all the frequencies recorded.

The electric current variations produced by photo-electric cell 15 are amplified by a preliminary amplifier 17 and a power amplifier 19, and the high frequency variations pass through a high pass filter 21 to a reproducing device 25 and the lower frequencies pass through a low pass filter

22 to a reproducing device 27. Similarly the current variations produced by photo-electric cell 16 are amplified by a preliminary amplifier 18 and a power amplifier 20, and the high frequency variations pass through a high pass filter 24 to a reproducing device 26 which is spaced from reproducing device 25, whereas the low frequency variations pass through a low pass filter 23 to the reproducing device 27.

The high pass filters 21 and 24 allow the passage of only oscillations above about 200 to 300 cycles per sec. and preferably about 250 whereas the low pass filters 22 and 23 allow the passage of only oscillations whose frequencies lie below this value.

Thus, with a system such as shown in Fig. 1, the stereophonic sound record, as regards the high-frequency range, is separately supplied to the spacially-separated reproducing devices 25 and 26, whereas all the low frequency oscillations of both tracks 11 and 12 are supplied to the single reproducing device 27.

In the drawing each of the reproducing devices 25, 26, and 27 consist of only a single loudspeaker. However, it should be well understood that for each of these devices it is possible to substitute a plurality of loudspeakers which are connected in parallel acoustically. For instance reproducing device 27 may be replaced by a plurality of loudspeakers which are electrically interconnected to the feed conductor 75, or some of the speakers may be supplied directly from filter 22 and others supplied directly from filter 23. However, with the method according to the invention, one reproducing device, i. e. a loudspeaker or a plurality thereof connected acoustically, can be dispensed with. If in accordance with the prior art each frequency range were reproduced in a separate manner acoustically, it would be necessary to use two of the reproducing devices 27.

In the recording system illustrated in Fig. 2, the sound to be recorded is picked up by two spacially-separated sound receiving devices 28 and 29 which together effect the stereophonic recording. As shown each device consists of a single microphone, but each may comprise a plurality of electrically-connected microphones which are connected in parallel acoustically.

The electrical current variations produced by device 28 are amplified in a preliminary amplifier 30, whereupon the high frequency variations pass through a high pass filter 32, are amplified by a power amplifier 36, and applied to a recording device 39. The low frequency variations leaving amplifier 30 pass through a low pass filter 33, are amplified by a power amplifier 37, and transmitted to a recording device 40. In a similar manner, the current variations produced by device 29 are amplified by a preliminary amplifier 31, filtered by low pass filter 34 and high pass filter 35, the high frequencies being amplified by a power amplifier 38 and transmitted to a third recording device 41, and the low frequencies being amplified by amplifier 37 and passing to recording device 40.

The recording may be effected in any of the well known manner, but as indicated it is effected mechanically by the method described in the U. S. Patent #1,919,116 to James A. Miller. In this case each of the recording devices 39, 40 and 41 is provided with a cutting tool having a V shaped cutting edge which cuts a track in a carrier 45. As shown more clearly in Figure 4 the carrier 45 comprises a cutting layer 76 of transparent material and a thin covering layer 77 of opaque material, the tracks 42, 43 and 44 being produced by removing portions of layer 77.

The filters 32 and 35 pass only frequencies above above 250 cycles per sec. so that the two sound tracks 42 and 44 are stereophonic records of the high frequency range. However, the variations of the low frequency range are passed by the low pass filters 33 and 34, which have a cut-off at about 250 cycles per sec., and after being amplified by the common amplifier 37, are recorded by the single recording device 40. Thus, it is seen that the apparatus is considerably simplified because only a single power amplifier 37 and recording device 40 are used for the low frequency range.

As shown in Fig. 4 the resulting sound carrier has only a single track 43 for the low frequencies, and two stereophonic tracks 42 and 44 for the high frequencies. In some cases, for instance for stereophonic transmission of sound in large rooms, it may be desirable to use a purality of recording groups. For instance, it may be desirable to use six tracks in the high range and two tracks in the low range. In any case, however, the invention makes it possible to reduce the number of tracks and thus to simplify the recording apparatus.

In the reproducing system of Fig. 3, the sound tracks 42, 43 and 44 of the carrier 45 are optically scanned by three objectives 52, 51 and 50 respectively to produce current variations by means of photo-electric cells 55, 54 and 53 respectively.

The reproducing is effected by two spacially-separated reproducing devices 62 and 63. Device 62 comprises a high-frequency loudspeaker 64 and a low-frequency loudspeaker 66, and device 63 comprises a high-frequency loudspeaker 65 and a low-frequency loudspeaker 67. The current variations produced by cell 55 are amplified by a preliminary amplifier 58 and a power amplifier 61, and supplied to speaker 64, and similarly the current variations produced by cell 53 are amplified by a preliminary amplifier 56 and a power amplifier 59 and supplied to speaker 65. The low-frequency current variations produced by cell 54 are amplified by a preliminary amplifier 57 and a power amplifier 60, and the amplified current variations are supplied to both the speakers 66 and 67.

Instead of reproducing the low frequency range by means of the speakers 66 and 67, which are acoustically combined with the high-frequency speakers, it is of course possible to use a separate reproducing device for this purpose, as shown in Figure 1. In this case it is possible to use for the low frequencies a single speaker or a plurality of speakers which are separated acoustically from the high-frequency speakers.

Although Figures 2 and 3 illustrate recording and reproduction in which the sound is recorded in a carrier and then reproduced, it should be understood that our invention is not limited thereto. The invention also extends to a completely electrical system in which the vibrations are transmitted completely by electric transmission, i. e. by wire or carrier wave, from the recording point to the reproducing point. Furthermore, it is possible to divide the high frequencies into a plurality of bands and reproduce these by additional speakers.

While we have described the invention in connection with specific examples and applications, we do not wish to be limited thereto but desire the appended claims to be construed as broadly as is permissible in view of the prior art.

That we claim is:

1. A method of sterophonically recording sound vibrations by means of a plurality of recording devices, comprising the steps of dividing the vibrations into a plurality of frequency ranges, transmitting in separate channels the vibrations in the higher frequency ranges of each recording device, and transmitting in a single channel the vibrations in the lowest frequency range of said devices.

2. A method of stereophonically recording sound vibrations by means of a plurality of recording devices comprising the steps of dividing the vibrations into a plurality of frequency ranges including a low frequency range whose upper limit lies between about 200 to 300 cycles per sec., transmitting in separate channels the vibrations in the higher frequency ranges of each recording device, and transmitting in a single channel the vibrations in the low frequency range.

3. A method of stereophonically reproducing sound vibrations by means of separate reproducing devices, comprising the steps of separating the vibrations into a plurality of frequency ranges, transmitting the vibrations of the higher frequency ranges to a plurality of said devices which are separated acoustically and spacially, and transmitting the vibrations of the lowest frequency to only one of said reproducing devices.

4. A method of stereophonically reproducing sound vibrations by means of a plurality of separate reproducing devices, comprising the steps of transmitting the vibrations by separate channels, separating the vibrations of each channel into a plurality of frequency ranges including a low frequency range having an upper limit between 200 to 300 cycles per sec., transmitting the vibrations of the high frequency range to a plurality of said devices which are separated spacially and acoustically, and transmitting the vibrations of the low-frequency range to only one of said reproducing devices.

5. A method of stereophonically recording sound vibrations on a carrier comprising the steps of separating the vibrations into a plurality of frequency ranges including a low frequency range, recording the vibrations of the low frequency range in a single sound track, and recording the remaining vibrations in a plurality of sound tracks.

6. A method of reproducing sound vibrations from a stereophonic sound record having a plurality of sound tracks, comprising the steps of scanning the sound tracks, separating the current variations produced by the scanning into a plurality of frequency ranges including a low frequency range, transmitting the low-frequency variations to a single reproducing device, and transmitting the remaining frequencies to a plurality of acoustically-separated reproducing devices.

7. A stereophonic sound record comprising a carrier provided with a plurality of high-frequency sound tracks and low-frequency sound tracks, the number of the low-frequency sound tracks being substantially less than the number of high-frequency sound tracks.

8. A stereophonic sound record comprising a carrier provided with a plurality of high-frequency sound tracks and a single low-frequency sound track.

9. A sterephonic sound recording system comprising a plurality of sound receiving devices, filtering means for separating the current variations of each device into a low-frequency range and a high-frequency range, means to apply the high-frequency variations produced by each device to individual recording devices, and means to apply the low-frequency variations produced by all the devices to a single recording device.

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