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[54] **SOUND MASKING METHOD AND SYSTEM**

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[51] **Int. Cl.** **H04m 1/19**

[58] **Field of Search** .... 179/1.5 M, 1.5 R, 1 P, 179/1 J, 1 SA, 1 CN; 340/15; 84/DIG. 26; 343/18 E

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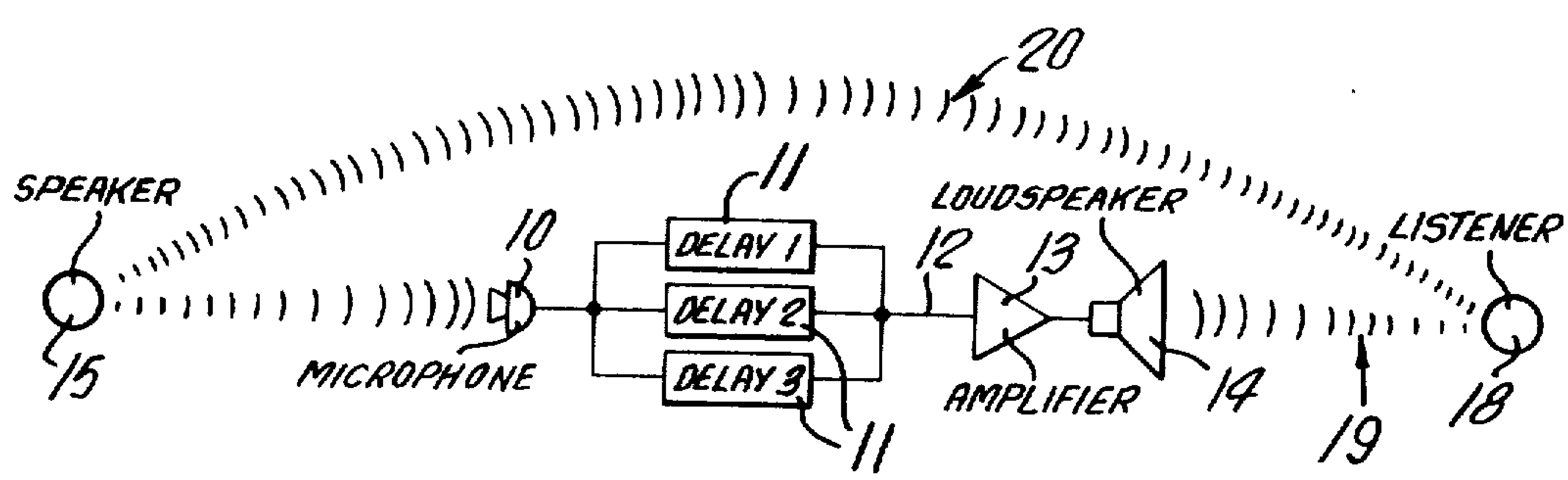
[57] **ABSTRACT**

A method and apparatus for masking sound comprising, receiving in an area an original sound signal which has to be masked. The original sound signal is then delayed to produce a time-delayed signal. The time-delayed signal is amplified and emitted outside the said area whereby the original sound signal will combine with the amplified time-delayed signal to produce a substantially unintelligible sound outside the said area.

11 Claims, 3 Drawing Figures



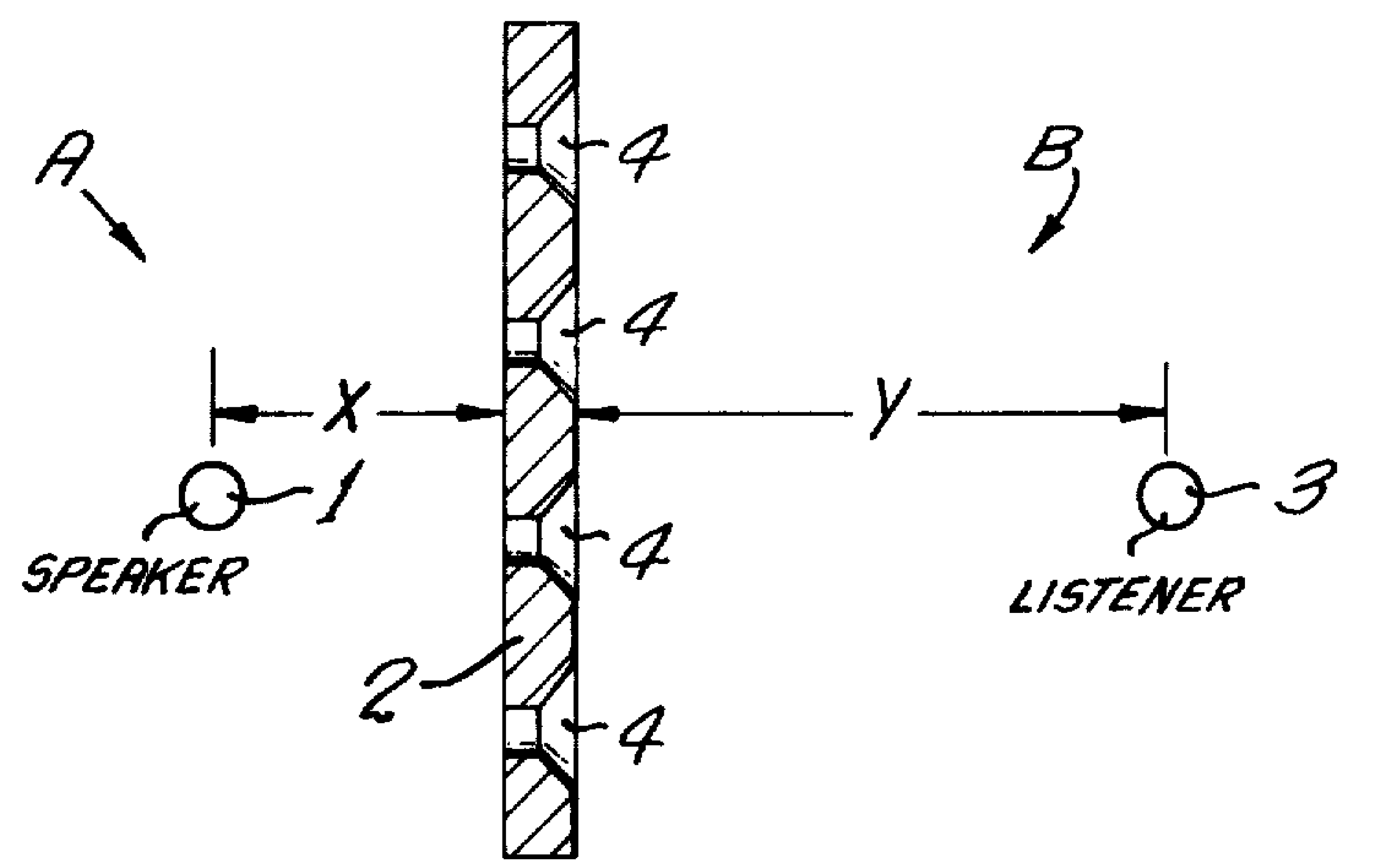


FIG. 1

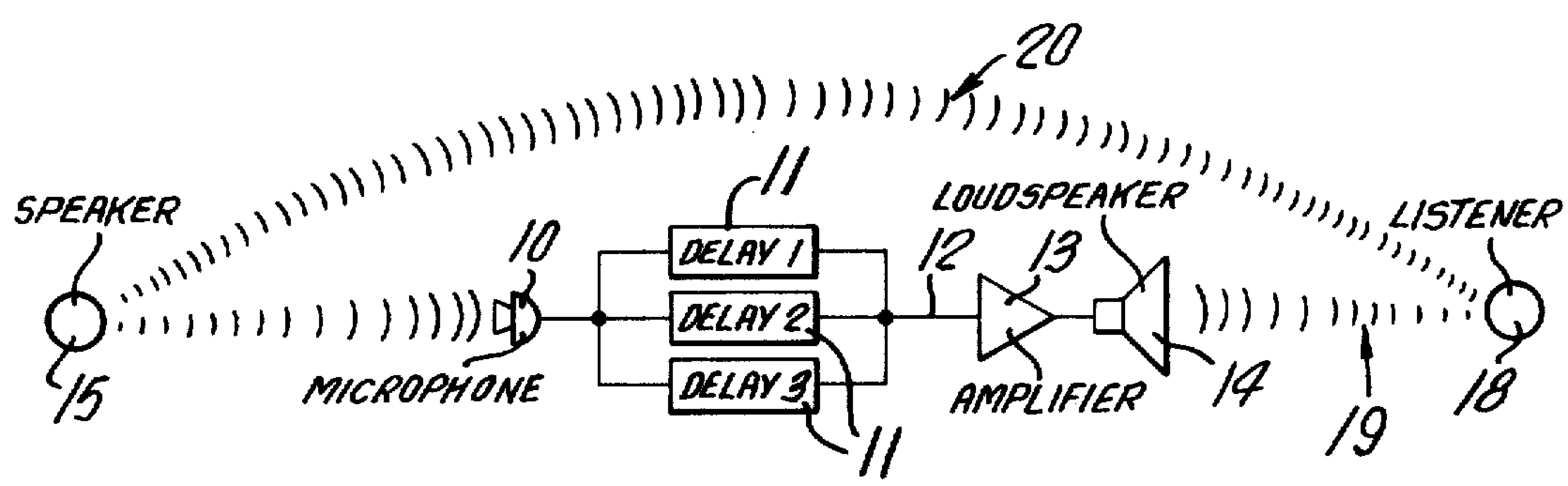


FIG. 2

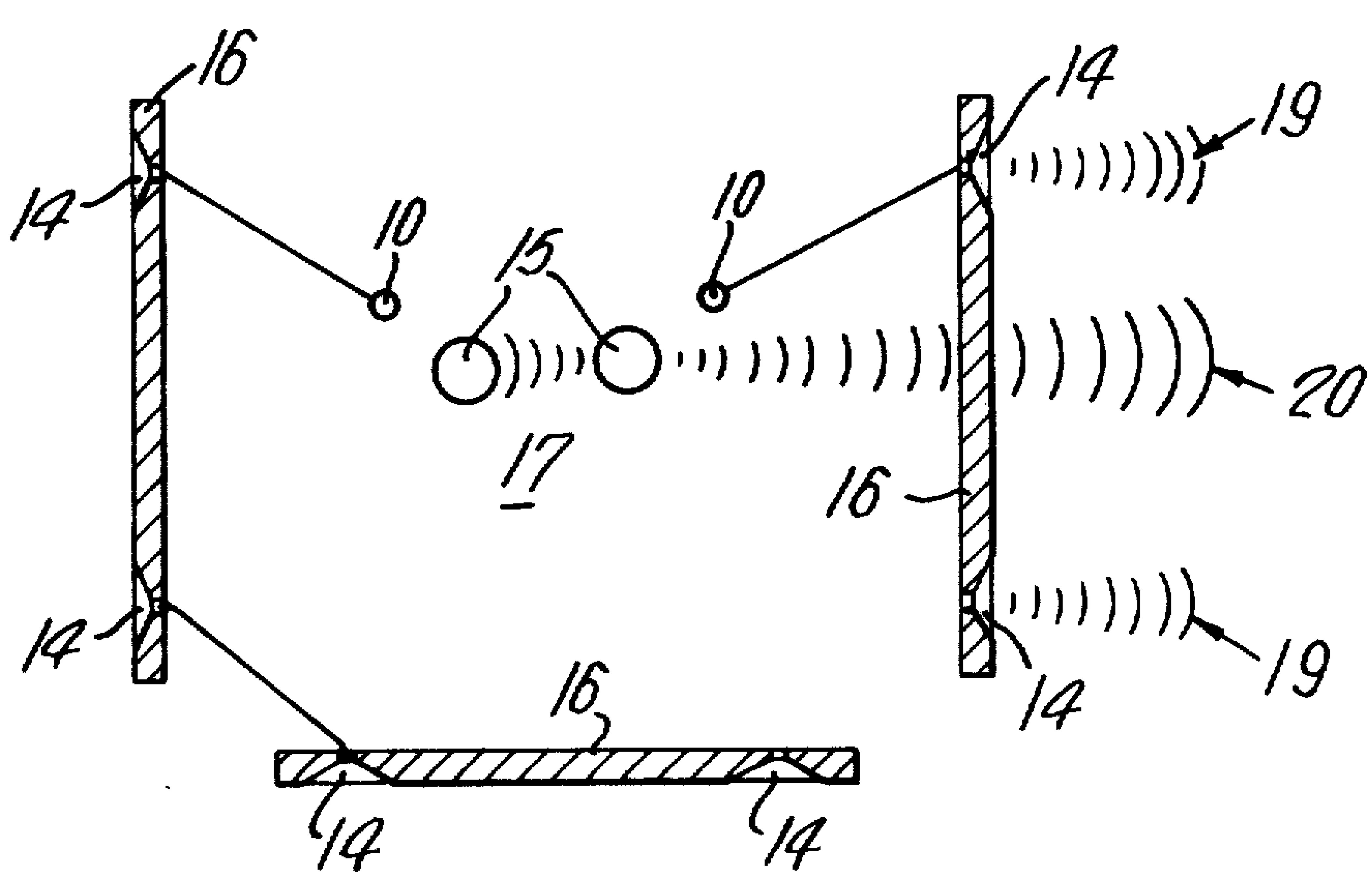


FIG. 3

SOUND MASKING METHOD AND SYSTEM

BACKGROUND OF THE INVENTION

a. Field of the Invention

This invention relates to a sound masking method and system in which the original sound is used to mask itself.

The present invention is particularly useful in masking conversation or voice signals in open landscape offices and other areas where people congregate and where speech privacy is desirable.

b. Description of the Prior Art

The open construction of landscape offices creates problems of speech privacy and of office equipment noise. In order to attenuate conversation and equipment noise in as short a distance as possible, it has been the practice to apply sound absorption materials to the walls and ceilings in such offices and to provide sound screens between working areas. Ideally, the sound is attenuated at a rate of 6 dBA every time the distance from the source is doubled, and this condition is approached in large offices when excellent sound-absorbing materials are used.

In addition to sound absorption, voice masking means are installed in the ceiling to create a background noise so that conversation cannot be understood beyond a distance of about 12 to 15 feet from the person who is speaking. The voice masking system may be electronic (in which case loudspeakers are installed in the ceiling) or it may simply be the rush of escaping air from a vent. Electronic voice masking systems are very versatile because the noise which they generate can be adjusted to give any desired frequency spectrum and octave band level. Masking noise is presently being generated by noise generators based upon well known noise criteria standards for masking the average human voice. With such a masking noise, it is found that a conversation level of 42 dBA is rendered unintelligible if the masking noise level is raised to about 43 dBA. But even these optimum voice masking methods suffer from a number of limitations.

1. To be effective, the noise level throughout the office must be approximately 45 dBA and sustained noise above this level is found to be objectionable.
2. Normal conversation level in a well-designed landscape office drops to a level of about 45 dBA at a distance of 12 to 15 feet from the speaker. This means that if the voice masking noise level is adjusted to 45 dBA, conversation cannot be understood beyond 12 to 15 feet from the speaker. But the conversation can be understood within this 12 to 15 foot radius.
3. Even when enclosed by sound absorbing screens a speaker often has the feeling that his conversation may be overheard, which may be correct in view of (2) above.
4. The voice masking noise is always present and, although the occupants may not notice it after a few minutes in the area, there is a general feeling of relief when the background noise is removed.
5. If a person speaks louder than normal his voice will carry considerably beyond the acceptable 15 foot limit.

The intelligibility of speech depends upon (a) the language which is spoken, (b) the frequency spectrum of the speaker's voice and (c) the loudness of the voice. Actual tests show that two speakers who talk simultaneously can individually be understood by concentrating on one of the two voices. However, this ability to distinguish between two simultaneous conversations is severely diminished if the conversations are produced by the same speaker. Actual tests have shown that three or more simultaneous conversations generated by the same speaker produce a voice signal which is almost unintelligible. The same number of simultaneous conversations by individuals which have different frequency spectra can in general be distinguished from one another and understood. It is upon this phenomenon that this invention is based.

In essence, the invention uses the speaker's voice to mask itself.

SUMMARY OF INVENTION

According to a broad aspect, the present invention provides a method and apparatus for masking sound comprising, receiving in an area an original sound signal which has to be masked. The original sound signal is then delayed to produce a time-delayed signal. The time-delayed signal is amplified and emitted outside the said area whereby the original sound signal will combine with the amplified time-delayed signal to produce a substantially unintelligible sound outside the said area.

According to a further aspect, the invention provides a method of masking conversation by

i. Detecting the original voice signal or conversation, S^o; o
ii. Delaying the detected signal S_o by a fixed time interval t_1 to give a new signal S_1;
iii. Delaying the detected signal S_o by a fixed time interval t_2 to give a new signal S_2;
iv. Delaying the detected signal S_o by a fixed time interval t_3 to give a new signal S_3;
v. Combining and amplifying S_1, S_2, S_3 so as to obtain a composite signal $(S_1 + S_2 + S_3)$ to produce the effect of three identical conversations;
vi. Driving one or more loudspeakers with the composite signal $(S_1 + S_2 + S_3)$ to produce the effect of three identical conversations displaced in time. (Note: orally, with a proper selection of t_1, t_2, t_3, this sound is practically unintelligible);
vii. The composite sound emitted by the loudspeakers is adjusted to a level so that it masks the original speaker's voice in such a way as to render it orally unintelligible to a listener

According to a further broad aspect, the present invention provides a voice-masking system whereby an original voice signal in one area is used to generate a multiple time-delayed composite sound in a second area so as to render the original voice signal unintelligible in said second area.

BRIEF DESCRIPTION OF DRAWINGS

The invention will now be described with reference to the accompanying drawings in which

FIG. 1 is a schematic illustration of an experiment relating to the present invention,

FIG. 2 is a schematic illustration of the system of the present invention, and

FIG. 3 is a plan view of the specific adaption of the system of the present invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Tests were carried out using the concepts of this invention and FIG. 1 is representative of the experiments which were made. In this figure areas A and B are a plan view of part of a larger landscaped office suitably equipped with sound-absorbing material. Speaker **1** was located a distance X, 5 feet in front of and facing sound screen **2**, while listener **3** was located a distance Y, 10 feet behind the screen. When speaker **1** talked at normal voice level, the average sound level recorded at the listener's position was about 42 dBA. In the absence of background noise the articulation was 100% intelligible to the listener.

A series of loudspeakers 4 distributed over the width of the screen and facing area B and located 4 feet from the floor were then driven by a composite signal derived from the original speaker's voice. The composite signal consisted of three identical conversations displaced from each other in time by about 0.2 seconds. It was discovered that the noise level of the composite signal had to be raised only to 38 dBA at the listener's position in order that the original voice signal of 42 dBA be rendered unintelligible. When the same loudspeakers were driven by an electronic noise generator having a standard noise criteria frequency spectrum, a noise level of 43 dBA was needed to mask the original voice signal of 42 dBA. From a voice-masking standpoint the composite signal is, therefore, more efficient than the standard electronic noise generator.

Except for an occasional word, the composite sound from the loudspeakers was quite unintelligible, even when a listener came to within a few inches of the loudspeakers.

With the composite sound adjusted to a level of 38 dBA at the listener's position, it was found that there was even greater loss of intelligibility as the listener approached the loudspeakers and the speaker. This is because the composite sound level increases more rapidly than the original speaker's voice level owing to the relative proximity of the loudspeakers compared to the speaker.

Varying the loudness of the speaker's voice produced corresponding changes in the composite sound level and it was found that when intelligibility was lost at one level, it was substantially lost for all levels.

Referring now more particularly to FIG. 2 there is shown the conversation masking system comprising a microphone **10** connected to the input of three delay means **11** whose outputs are connected to the input **12** of amplifier **13**. The amplified composite masking signal at the output of amplifier **13** is connected to one or more loudspeakers **14**. The amplifier **13** is provided with a variable gain control (not shown) to adjust the level of the composite masking signal to produce the desired masking effect.

Microphone **10** picks up voice signals emanating from speaker **15** and delay means **11** retard the original voice signal by intervals t, $2t$ and $3t$ respectively where t may have any value between 0.1 and 0.3 seconds. The composite delayed sound **19** from the loudspeaker is adjusted to a suitable level so as to mask the original speaker's voice **20**.

As illustrated in FIG. **2**, the original signal is delayed three times so that the sound **19** from the loudspeakers **14** will be unintelligible. If desired, more than three delays may be used, but the further reduction in intelligibility is not significant.

To a listener **18**, the system of FIG. 2 creates the effect of four simultaneous conversations, the composite voice signal **19** and the original voice signal **20**, all out of phase and, consequently, unintelligible.

The short delay of 0.1 to 0.3 seconds referred to above will enable a listener to catch the first syllables of a conversation but the delayed signals quickly mask the subsequent portions of the speaker's voice. This very slight intelligibility is not a serious disadvantage because a syllable caught here and there is not enough to attract attention nor it is sufficient for comprehension.

As shown in FIG. **3**, in practice, one or more loudspeakers emitting the composite delayed signals **19** are located around area **17** where the speaker **15** is sitting and directed away from the speaker towards the other areas of the landscaped office. The sound level of loudspeakers **14** is adjusted so that it will mask the conversation **20** coming from speaker **15** for a listener who is, say, 5 feet away from the sound screen and outside area **17**. In this way the range of intelligibility is greatly reduced and, in an appropriate sound absorbing environment, may be limited to working area **17** bounded by the acoustic screens **16**.

Typically, one or more microphones **10** are conveniently placed within the working area **17** and loudspeakers **14** are mounted on the acoustic screens **16**. The screens serve the dual purpose of attenuating the original conversation **20** coming from the speaker and of obstructing the entry into area **17** of the composite sound **19** from the loudspeakers.

The invention described above offers the following advantages:

a. The composite masking noise is only emitted when the person is talking and in the absence of speech there is no background noise.
b. The effective range of intelligibility is greatly reduced compared with ordinary masking systems. In effect, in ordinary systems, conversation can be understood within a radius of 15 feet from the speaker whereas with this new masking system the range is reduced to the working area surrounded by the loudspeakers. Preferably, although not exclusively, the loudspeakers are secured in a wall surface, such as acoustic screens as described hereinabove.
c. Office workers who have high pitched or low pitched voices will be masked to the same extent because the masking is done by the voice itself. In conventional systems, the masking frequencies are a weighted average of all voice frequencies which can never mask efficiently the specific frequency spectrum of a particular individual.
d. If a person tends to speak loud, the masking noise increases in proportion thereby maintaining privacy. Conversely, a person who speaks softly will generate a soft masking noise creating minimum local disturbance. Owing to the composite signal emitted by the loudspeaker it is impossible to understand what is being said even when someone is relatively close to said loudspeaker.
e. Because the sound from a working area is quite unintelligible, there is less tendency for occupants outside the area to listen to what is being said. They are not disturbed to the same extent as they are in a conventional masking system.
f. A masking noise level substantially lower than normal can render a conversation unintelligible.

Although the preferred embodiment disclosed herein relates to a method and system for masking voice signals it is within the ambit of the invention to mask other audible intelligible signals, such as morse code.

I claim:

1. A method of masking sound comprising the steps of

i. receiving in an area an original sound signal which has to be masked,

ii. delaying said original sound signal two or more times wherein to produce a time delayed substantially unintelligible signal having two or more delayed original signal components each one following the other at specific time intervals,

iii. amplifying said time-delayed unintelligible signal, and

iv. emitting said amplified time-delayed unintelligible signal outside said area whereby said original sound signal will combine in free space with said amplified time-delayed signal to produce a substantially unintelligible sound outside said area.

2. A method as claimed in claim 1 wherein said original sound signal is a voice signal.

3. A method as claimed in claim 2, wherein said voice signal is delayed two or more times at intervals of 0.1 to 0.3 seconds approximately.

4. A method as claimed in claim 2 wherein step (iv) includes emitting said amplified time-delayed signal at a desired masking level at one or more locations outside of said area, said time-delayed signal having substantially the same frequency components and loudness as said original signal.

5. A method as claimed in claim 2 wherein there is further comprised the additional step of damping said original signal and said delayed signal in the region between receiving means and sound emitting means.

6. A sound masking system comprising receiver means sound signal receiving an original sound signal from an area, two or more time delay means connected to said receiver means and each receiving said original voice signal, each said time delay means having a different time delay and having a common output to produce a time-delayed substantially unintelligible signal having two or more time-delayed original signal components each one delayed from another at specific time intervals, an amplifier connected to said common output of said time delay means for amplifying said time-delayed signal, and one or more loudspeakers connected to said amplifier to emit said amplified time-delayed substantially unintelligible signal outside said area whereby said original sound will combine in free space with said amplifier time-delayed signal to produce a substantially unintelligible sound outside said area.

7. A sound masking system as claimed in claim 6 wherein said original signal is a voice signal and wherein said delay means are delay circuits.

8. A sound masking system as claimed in claim 7 wherein said original voice signal is delayed two or more times at specific time intervals of 0.1 to 0.3 seconds approximately.

9. A sound masking system as claimed in claim 7 wherein said emitted time-delayed signal has substantially the same frequency components and is adjustable to produce a loudness level substantially the same as said original voice signal.

10. A sound masking system as claimed in claim 7 wherein said receiver means comprises one or more microphones mounted in one or more locations within said area, said one or more loudspeakers being mounted on one or more acoustic screens to emit said unintelligible sound outwardly of said screens and said area.

11. A sound masking system as claimed in claim 7 wherein said time-delayed signal emitted by said loudspeakers is substantially 4 dBA below the level of said original voice signal.

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