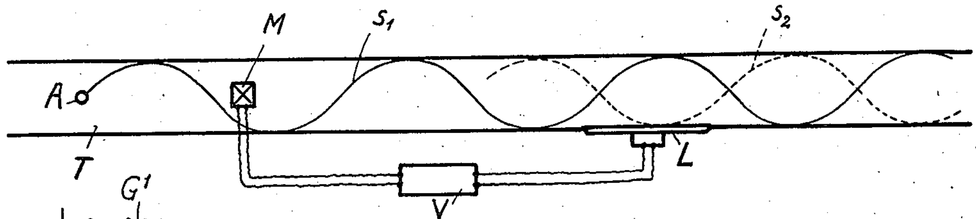
June 9, 1936. P. LUEG 2,043,416

PROCESS OF SILENCING SOUND OSCILLATIONS

Filed March 8, 1934

Fig. 1



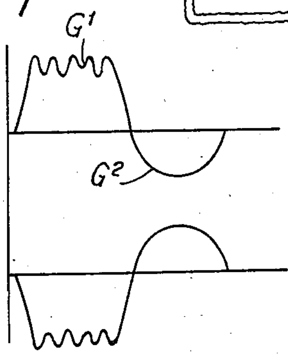


Fig. 3

Fig. 2

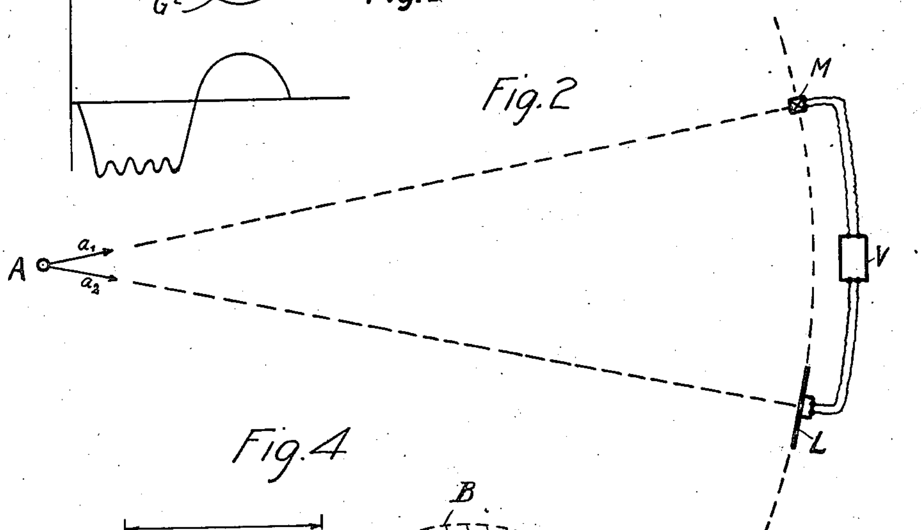
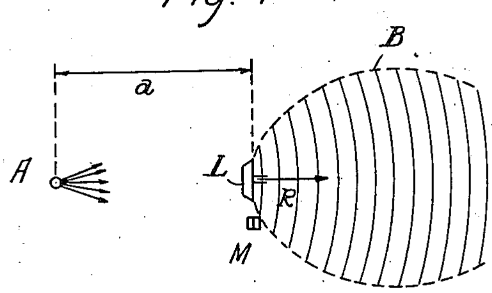


Fig. 4



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PROCESS OF SILENCING SOUND OSCILLATIONS

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4 Claims. (Cl. 179—1)

In the known processes of silencing sound oscillations the silencing is effected by subjecting these oscillations to a displacement of phases, but in these processes only the source of the oscillations is used to cause the displacement of phases, so that the superposition of phases takes place in a purely mechanical manner.

The present invention does away with these drawbacks and relates to a process of silencing sound oscillations especially of a disturbing nature, which can be employed independently of the source of oscillation. According to the present invention the sound oscillations, which are to be silenced are taken in by a receiver and reproduced by a reproducing apparatus in the form of sounds having an opposite phase. The means of carrying out said processes consist preferably of electrical apparatus and the reception is effected by a microphone, by which the acoustic oscillations are transformed into electric ones. The microphone is connected over an amplifier with a reproducing apparatus (loudspeaker). The phase opposition can be effected by several means. In case for instance of only one single tune moving in one well defined direction (in a pipe for instance) the phase opposition can be effected in a very simple manner by adjusting the distance between the microphone and the producing apparatus. In this case the microphone is preferably placed between the sound source and the reproducing apparatus causing the sound oscillations to meet first the microphone and then the reproducing apparatus. Consequently two different kinds of oscillations are present in the reproducing apparatus, the one representing the sound oscillation of the tune, moving with normal sound velocity, the other representing a wave advanced with respect to the first wave by electrical means between the microphone and the reproducing apparatus and reproduced by the reproducing apparatus. The phase opposition can be effected by suitably adjusting the distance between the microphone and the reproducing apparatus.

In order to silence acoustic vibrations of any shape within a certain range, the microphone and loudspeaker are suitably placed close to each other in such a way that the oscillations coming from a certain point will meet the microphone and the loudspeaker at the same time. The reflected picture of these oscillations which do not have the usual sine form is made in an electric way by changing the poles of the loudspeaker for instance, or by installing a transformer connected with the electric apparatus. In this way a silencing of the noise is effected within the range of the reproducer. Preferably one side of the loudspeaker diaphragm is used for it, whereas the other side is silenced.

It is to be understood of course that in the same way several receiving and reproducing apparatus can be used working either in a single way or in connection with each other.

Sometimes it will be necessary not to silence all the noise oscillations but only a part of them. This will be the case when for instance disagreeable secondary (stray) noises (see further below) for instance in theaters, concert halls, etc. have to be avoided. In the same way is this the case in offices in which the disagreeable noise of the type writing machines has to be silenced. This can be effected in a very simple way in accordance with the invention by taking in well defined frequencies of the sound oscillations, by displacing the phases and reproducing same thereupon.

In the specification only the outstanding features of the process are stated and the means of the process may be modified by a more refined working out of the problem. The electric reception and the transforming of the acoustic oscillations have the advantage of an extraordinarily exact reproduction, so that a much more exact and more sudden silencing of the oscillations can be obtained than by the mechanical process. The process on the whole can be employed in solid as well as in liquid and in gaseous sound carriers.

The invention will appear more clearly from the following detailed description when taken in connection with the accompanying drawing showing by way of example preferred embodiments of the inventive idea.

In the drawing:—

Figure 1 illustrates diagrammatically means of silencing a single linear sound wave.

Figure 2 illustrates diagrammatically a plurality of sound waves and means for silencing or damping the same.

Figure 3 is a diagram illustrating the sound waves.

Figure 4 illustrates diagrammatically means for silencing spatial sound waves.

Figure 1 illustrates a simple device by means of which a single predetermined tone which comes from a predetermined direction is silenced or damped within a pipe T. This sound or tone is actually a sine-like sound wave and is to be silenced or damped by a sound wave having an opposite phase. This sound of opposite phase is produced simply by adjusting the distance between the microphone M, which is built into the pipe T and the sound reproducing device or loudspeaker L. The microphone is situated between the source of the sounds and the loudspeaker. Therefore, the sound waves s^1 arriving from the point A first strike the microphone and then the loudspeaker. The sound wave received by the microphone is transmitted electrically with the assistance of the amplifier E to the loudspeaker. Naturally this electrically transmitted sound wave is advanced in relation to the sound wave s^1, which moves with a normal velocity of sound.

The extent of this advancement of the electrically transmitted sound wave can be conveniently adjusted by adjusting the distance between the microphone and the loudspeaker. It is easily possible to determine and regulate the distance between the microphone and the loudspeaker in such manner that the sound wave s^2 which is electrically reproduced by the loudspeaker has an opposite phase from the original natural sound wave s^1. Therefore, due to this creation of a sound wave having an opposite phase, the two sound waves will silence each other or dampen each other.

Figure 2 shows a sound source A which, for instance, is situated in open space, so that it emits sound waves traveling in all directions. In that case the microphone M and the loudspeaker L are both placed at the same distance from the source A and are electrically interconnected by means of an amplifier V. Sound waves a_1 and a_2 produced by the source A strike the microphone M and the loudspeaker L, respectively. The sound wave a_1 striking the microphone M is reproduced by the loudspeaker L in an opposite phase. This changing of the phase may be accomplished by several well known methods, for instance, by changing the poles of the loudspeaker L, or by providing a transformer (not shown) between the loudspeaker L and the microphone M. The sound waves produced by the sound source A are silenced around the loudspeaker L by sound waves having an opposite phase produced by the loudspeaker L.

The sound waves which do not have a sine-like form, i. e., noises, may be represented by the irregular curve G^1, G^2, which is shown in Figure 3. Naturally an exact phase opposition cannot be produced by shifting a sound wave of this type by 180°, since the two halves of the curve are entirely different one from the other. In that case the phase opposition is produced by the following means. In my present invention, I employ the principle that an ordinary oscillating membrane of a loudspeaker provided with flat surfaces of the type employed in the usual surface loudspeaker, creates thickenings and thinnings of the air when a sound is reproduced. In the example illustrated in Figure 4, the noise emerging from the point A reaches the microphone M situated at a distance a from the point A. The microphone M transmits this noise electrically to the loudspeaker in such manner that an opposite wave is produced, such as shown in Figure 3. This means that each time when a thickening of the air meets the microphone the loudspeaker answers by a corresponding thinning of the air and vice versa.

Due to this arrangement, phase opposition is produced within the space B, mainly in the direction of the arrow R.

What I claim is:

1. In combination, means receiving sound oscillations travelling in the air and means reproducing sound oscillations within the field of action of the first-mentioned sound oscillations and causing them to travel substantially in the same direction as that of the first-mentioned sound oscillations, the second-mentioned sound oscillations having an opposite phase in relation to the first-mentioned sound oscillations, whereby the received sound oscillations are silenced within the range of the reproduced sound oscillations.

2. A process of silencing sound oscillations comprising receiving a sound wave travelling through the air, causing said sound wave to produce electrical oscillations, and transforming said electrical oscillations into a sound wave having an opposite phase to the received sound wave and travelling through the air substantially in the direction of the received sound wave, whereby the received sound wave is silenced within the range of the second-mentioned sound wave.

3. In combination, a microphone for receiving a sound wave travelling through the air in substantially one direction, an amplifier electrically connected with said microphone, and means electrically connected with said amplifier for transforming electrical oscillations caused by said sound wave into another sound wave traveling through the air substantially in the same direction as the received sound wave, the distance between said microphone and said means being adjustable to cause a mutual elimination of the two sound waves within the field of action of the received sound wave.

4. In combination with a source of sound waves travelling through the air; a microphone adapted to receive sound waves emitted by said source and situated at a certain distance from said source, and a loudspeaker electrically connected with said microphone and situated at the same distance from said source, said loudspeaker producing sound waves having an opposite phase to the received sound waves and travelling through the air substantially in the same direction as the received sound waves, whereby the received sound waves are eliminated within the field of action of the sound waves produced by the loudspeaker.

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