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**SF- 33720 Tampere(FI)**(54) **Active noise cancellation system.**

(57) The invention relates to an active noise cancellation system for a motor vehicle, comprising means (1) for generating one or more electrical signals proportional to the noise in the target area, an electronic means (2) receiving these signals, such as an adaptive filter, for generating a cancellation noise signal, one or more sound sources (3) connected to said electronic means for generating cancellation noise in the target area, and one or more sensors (4) for detecting residual noise in the target area and transmitting it in an electrical form to the electronic means (2) to tune its operation. To enhance the operation of the system, an amplifier (5) has been disposed between the sound source or sources (3) of cancellation noise and the means (2) for generating a cancellation noise signal to control the gain of the cancellation noise signal in response to a signal (z) proportional to the rotation speed of the vehicle motor.

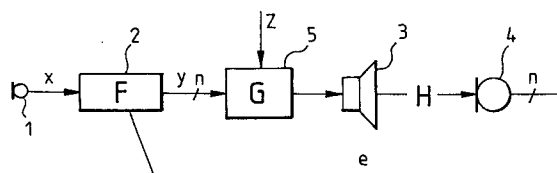


FIG. 3

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The present invention relates to an active noise cancellation system for a motor vehicle, comprising means for generating one or more electrical signals proportional to the noise in the target area, an electronic means receiving these signals, such as an adaptive filter, for generating a cancellation noise signal, one or more sound sources connected to said electronic means for generating cancellation noise in the target area, and one or more sensors for detecting residual noise in the target area and transmitting it in an electrical form to the electronic means to tune its operation.

Figure 1 in the accompanying drawings represents schematically the main principle of an active noise cancellation system, and Figure 2 shows a block diagram corresponding to this basic schematic drawing. A conventional system for active noise cancellation of the kind shown in Figure 1 comprises noise detection sensors 1 generating an electrical signal proportional to the noise present in the target area. These detection sensors can be either microphones, in which case the signal generated by them corresponds to the noise in the target area, or the detection sensors may also be of another type, in which case they generate for instance only a reference signal proportional to the rotation speed of the vehicle motor. Thus the signals generated by the detection sensors 1 need not correspond to the actual noise, but only be correlated with it. These detection sensor signals are conveyed to an electronic means 2 generating a noise cancellation signal, which most commonly is an adaptive filter. This adaptive filter calculates by means of a suitable algorithm, such as an LMS algorithm or a Fan-Vemuri algorithm, a signal which in amplitude corresponds to the produced noise signal but is of an opposite phase thereto. Such a cancellation noise signal is reproduced by cancellation noise sources, such as loudspeakers 3, to generate cancellation noise in the target area. Attenuation of the noise is achieved as a combined result of the actual noise and the cancellation noise of an opposite phase. In practice, noise can be cancelled by such an arrangement about 10 - 30 dB for instance at the motor noise frequency. In order that the means for generating the cancellation noise signal may be effectively controlled and adapted to the conditions in each case, the system further comprises residual noise sensors 4 which have been adapted to detect residual noise in the target area and control the means 2 for generating the cancellation noise in response to this.

Figure 2 shows a block diagram corresponding to the system of Figure 1. Therein the signal generated by the noise detection sensor 1 has been denoted by the reference character  $x$ , which signal is inputted in a means 2 for generating a cancellation noise signal, which generates a signal  $y$  that is

a function of the noise signal  $x$ . This signal  $y$  is then reproduced by a loudspeaker 3, in which situation the signal proceeds as a sound wave via a transmission route  $H$  to a sensor 4 for residual noise. This sensor 4 for residual noise, which may in practice be for instance a microphone, generates an electrical signal  $e$  which may be represented as a function  $H(y) + n$ , wherein  $n$  is noise in the microphone 4.

In practice, it has been found that the degree of cancellation achieved by the systems of Figures 1 and 2 is greatly dependent on the amplitude gain of  $H(y)$ . This gain dependence leads in practice to such a situation that a system of the kind described in Figure 2 is only stable with specific gains and even so that the gains that are available are greatly dependent on the frequency band in which one wishes the active noise cancellation to be the most effective.

Thus a problem is encountered with tuning the control system so as to operate effectively in different frequency bands without presenting problems in the operation of the system. This is achieved with the system of the invention, which is characterized in that an amplifier has been disposed between the sound source or sources of cancellation noise and the means for generating a cancellation noise signal to control the gain of the cancellation noise signal in response to a signal proportional to the rotation speed of the vehicle motor. Thus the stability problem has now been solved by varying the gain of the cancellation noise signal in dependence on the frequency and specifically in dependence on the rotation speed of the vehicle motor. Preferably the gain of the cancellation noise signal is increased when the rotation speed of the motor decreases. Even though the amplitude of the noise prevailing in the vehicle actually decreases when the rotation speed of the motor decreases simultaneously as the frequency of the noise decreases, yet in that case the gain must be increased on account of the practical limitations presented by the smallness of the interior of the vehicle and the properties of the sound sources available. Conventional loudspeakers reproduce low frequencies rather poorly, and the dimensions of the reproduction space also have a significant effect of restricting the possibility of reproduction of low frequencies.

In the following, the system of the invention will be described in more detail with reference to the enclosed drawing, wherein

Figure 1 shows schematically the principle of construction of an active sound cancellation system,

Figure 2 shows a block diagram corresponding to the system of Figure 1, and

Figure 3 shows a block diagram of the sound cancellation system of the invention.

Figure 3 represents a block diagram of the sound cancellation system of the invention, wherein an additional amplifier 5 has been disposed between the sound source of cancellation noise 3 and the means 2 for generating the cancellation noise signal, said additional amplifier being controlled as a function of the signal z. In accordance with the invention, this signal z is proportional to the rotation speed of the vehicle motor. Preferably the gain of the signal y generated by the amplifier 5 is an inverse function of the frequency of this signal z. Thus, as the frequency of the signal z increases the gain of the amplifier 5 is reduced, and respectively as the frequency of the signal z decreases, i.e. the rotation speed of the vehicle motor decreases, the gain is boosted. Increasing the gain at low frequencies is necessary in order for the loudspeaker 3 to be able to reproduce also these frequencies with a sufficient amplitude.

When an amplifier 5 providing a gain inversely correlated with the frequency of the principal source of noise for the cancellation of which the system is intended is incorporated into the system, problems related to the instability of the control system are avoided and the level of noise cancellation can be substantially enhanced. In order for optimum operation to be achieved in each use application, the gain of the amplifier 5 and specifically its variation as a function of the frequency of signal z must be adapted to the practical conditions prevailing in each case. However, the essential feature is that the gain of the amplifier 5 is controlled in dependence on the rotation speed of the vehicle motor.

## Claims

1. An active noise cancellation system for a motor vehicle, comprising means (1) for generating one or more electrical signals proportional to the noise in the target area, an electronic means (2) receiving these signals, such as an adaptive filter, for generating a cancellation noise signal, one or more sound sources (3) connected to said electronic means for generating cancellation noise in the target area, and one or more sensors (4) for detecting residual noise in the target area and transmitting it in an electrical form to the electronic means (2) to tune its operation, **characterized** in that an amplifier (5) has been disposed between the sound source or sources (3) of cancellation noise and the means (2) for generating a cancellation noise signal to control the gain of the cancellation noise signal in response to a signal (z) proportional to the

rotation speed of the vehicle motor.

2. A system as claimed in claim 1, **characterized** in that the gain of the amplifier (5) is inversely proportional to the frequency of the signal (z) controlling it.

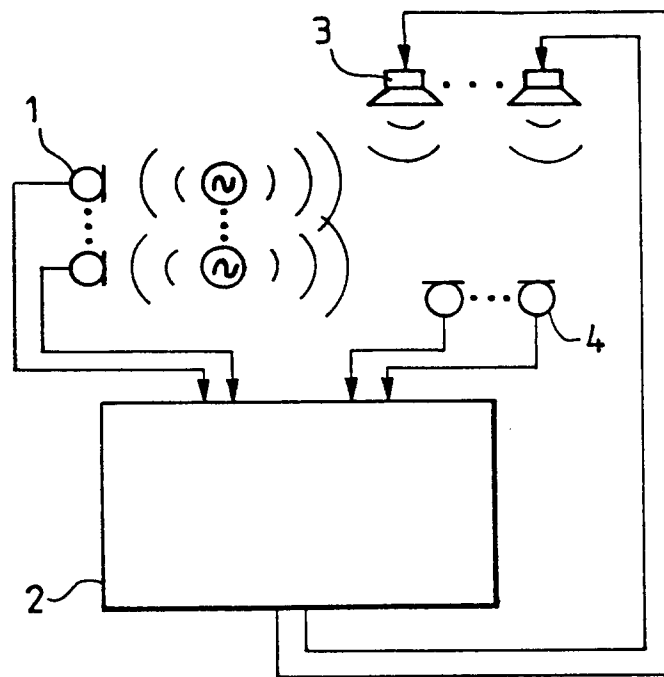


FIG. 1

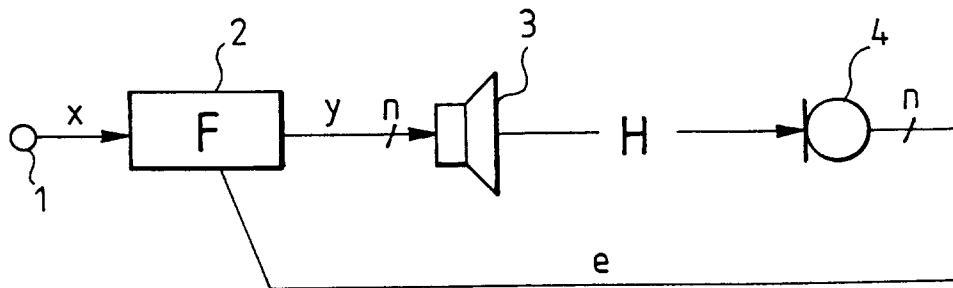


FIG. 2

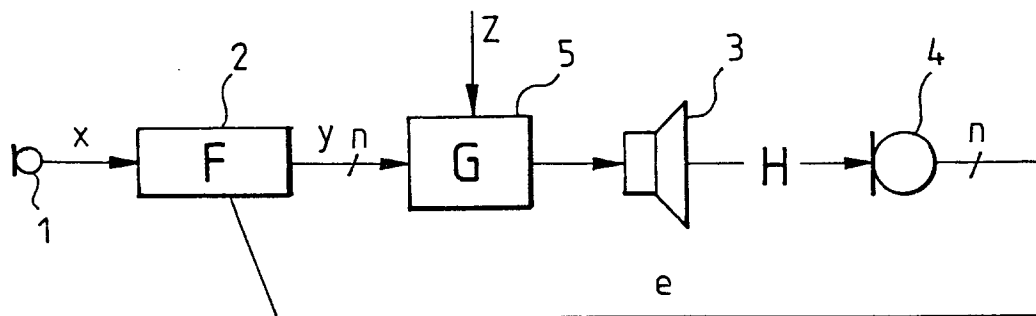


FIG. 3



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## EUROPEAN SEARCH REPORT

Application Number

EP 92 11 8416

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	FR-A-2 531 023 (AUTOMOBILES PEUGEOT AND AUTOMOBILES CITROEN) * Abstract; page 1, line 33 - page 2, line 10; page 5, lines 12-23; claims 1,3 *	1	G 10 K 11/16
A	--- MACHINE DESIGN, vol. 59, no. 29, 10th December 1987, page 70, Cleveland, Ohio, US; ANONYMOUSLY: "Low-frequency noise gets waved back" * Whole document *	1	
A	--- EP-A-0 098 594 (NISSAN MOTOR CO., LTD) -----		
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H 04 M G 10 K B 60 R
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 28-01-1993	Examiner DE HEERING P
<b>CATEGORY OF CITED DOCUMENTS</b> X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... & : member of the same patent family, corresponding document			