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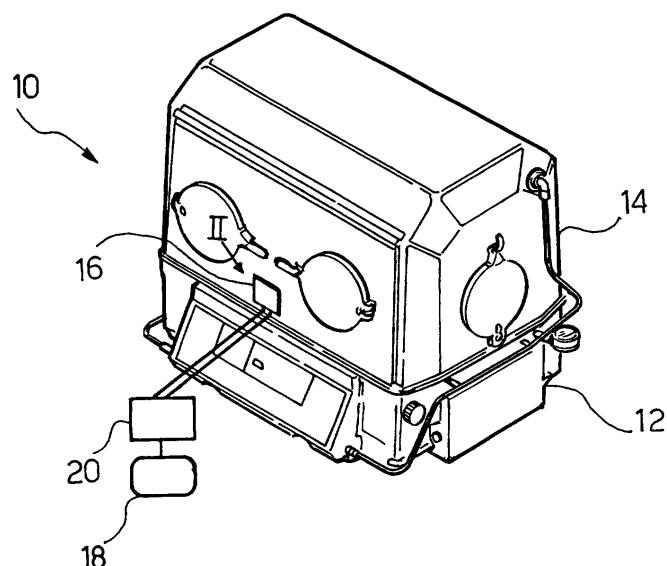
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(54) **Apparatus for controlling the climate in an environment intended to accomodate a new-born child**

(57) The apparatus comprises a base structure and a wall, in the form of a shell for example, which in combination with the base structure delimits a space in which, in operation, controlled environmental conditions

are maintained. The apparatus comprises at least one electrically controlled actuator (16) capable of producing mechanical vibrations of the wall (14) to generate acoustic waves in the aforesaid space.

FIG. 1



Description

[0001] The present invention relates to an apparatus for climatic control in an environment designed to house a newborn child, comprising at least one wall which, associated with a base structure, delimits a space in which, in operation, controlled environmental conditions are maintained.

[0002] The present invention is applicable both to an incubator for newborn children, comprising a shell resting on a base structure, and to what is known as a neonatal isolation unit, comprising a supporting plate acting as a crib, with a heating radiator placed above it and one or more folding walls which can be used to protect the newborn child from air currents.

[0003] Research in the sector of medical apparatus has led to the production of increasingly sophisticated incubators for assistance to newborn children, especially premature ones, these incubators providing a micro-climate within which the newborn child can carry out its physiological activities with the minimum expenditure of energy. Up to the present time, the attention of manufacturers has been focused on the problems of providing controlled temperature and humidity conditions, sufficient air exchange, isolation from the external environment, convenience of observation from the outside and ease of access.

[0004] However, recent experiments conducted by the applicants have demonstrated that the acoustic environment inside incubators is very unsatisfactory, especially in respect of the quality of the sounds which are perceived by the newborn child (noises caused by the fan and air flow). Paediatric and neonatal research has demonstrated that, in neonatal treatment, the relationship between the acoustic environment and the central nervous system is of fundamental importance for the development and learning of the newborn child. Particular attention must therefore be paid to preterm newborn children who are all too frequently placed in an environment very different from the mother's womb.

[0005] However, generating a more favourable acoustic environment within an incubator is a rather complicated process. This is because the reproduction of acoustic signals in an incubator by means of conventional electromagnetic reproduction equipment is incompatible with the requirements of internal sterility, maintainability of the apparatus and general electromagnetic compatibility. More precisely, the use of conventional sound reproduction equipment in an incubator appears impracticable because this equipment would produce a change in the aerodynamic path within the incubator, and would create problems for the maintenance of the conditions specified by the regulations, particularly with respect to the conditions of temperature, humidity, internal asepsis, mechanical strength and portability. Moreover, electromagnetic sound reproduction equipment creates a variable magnetic field which is propagated in the vicinity of the equipment. This mag-

netic field could cause interference with the electrical and electronic control devices of the incubator, as well as disturbances to the newborn child and obstacles to its proper development.

[0006] The object of the present invention is to provide a sound reproduction device for incubators or for neonatal isolation units which is not affected by the aforesaid problems.

[0007] According to the present invention, this object is achieved by an apparatus having the characteristics forming the subject of the claims.

[0008] The idea on which the present invention is based consists in the production of an acoustic field by means of suitable mechanical vibrations of a wall produced by an electrically operated actuator driven by an electronic control system. The actuator which generates the vibrations of the wall is preferably of the piezoelectric type.

[0009] The system according to the present invention can be used to achieve a considerable improvement in the acoustic comfort within an incubator or a neonatal isolation unit by creating a diffused acoustic field which reproduces sounds which are pleasant or familiar to the newborn child. The sound reproduction device according to the present invention can be added to existing incubators without the need for substantial structural modifications and does not affect the conditions of sterility, thermal equilibrium or electrical and electromagnetic compatibility of the apparatus.

[0010] The present invention will now be described with reference to the attached drawings, provided purely by way of non-limiting example, in which:

- Figure 1 is a schematic perspective view of an incubator provided with a sound reproduction device according to the present invention,
- Figure 2 is a schematic view showing in greater detail the component indicated by the arrow II in Figure 1, and
- Figure 3 is a diagram which shows the spectral distribution of intrauterine sounds which can be reproduced within an incubator by means of the device according to the invention.

[0011] The following text describes the application of the present invention to an incubator, but it is to be understood that what is stated with reference to incubators can also be applied to an equal extent to neonatal isolation units.

[0012] With reference to the drawings, the number 10 indicates an incubator comprising, in a known way, a base structure 12 and a transparent shell 14, generally consisting of plastic material such as polycarbonate, polymethyl methacrylate, or other transparent plastic material. The shell 14 delimits, together with the base 12, an isolated space in which known devices in use maintain controlled temperature and humidity conditions.

[0013] The incubator 10 is provided with a sound reproduction device comprising at least one electrically operated actuator 16 capable of producing mechanical vibrations of the shell 14 which generate an acoustic field in the space circumscribed by the shell 14. In the following text, reference will be made to a structure comprising only one actuator 16, but it is to be understood that the same considerations are applicable to an equal extent in a case in which the sound reproduction device comprises a plurality of actuators connected together in series or in parallel.

[0014] The actuator 16 is rigidly connected to the shell 14. Preferably, it is applied to the outer surface of the shell by gluing, for example, or by any other mechanical fixing system. The application of the actuator 16 to the outside of the shell 14 enables the conditions of sterility of the incubator to be kept the same as those of a similar incubator without the sound reproduction device. The actuator 16 could also be positioned in a different way, provided that it is capable of transmitting mechanical vibrations to the shell 14. For example, the actuator 16 could be incorporated in the plastic material forming one of the walls of the shell 14. The major advantage of the solution according to the invention is that the sound is generated directly by the shell 14. Consequently, a particularly uniform diffused sound field is produced inside the shell. The actuator 16 is simply an electromechanical transducer capable of converting an electrical drive signal into mechanical vibrations.

[0015] The electrical drive signal of the actuator 16 is provided by an electronic drive unit comprising a sound reproduction device 18 consisting, for example, of a CD or magnetic tape player, and an amplifier and equalizer unit 20.

[0016] The actuator 16 which produces the vibrations of the shell 14 preferably consists of a piezoelectric transducer whose general structure is shown schematically in Figure 2. With reference to this figure, the actuator 16 comprises a body of piezoelectric ceramic 22 in the form of a plate, on the two opposite faces of which are deposited two metallic layers 24 (only one of which is visible in the figure) connected to corresponding electrical conductors 26. The piezoelectric actuator 16 converts the electrical signal from the conductors 26 into deformations directed along the axis 28 and into shear deformations directed orthogonally to the axis. The actuator 16 is rigidly connected to the shell 14 and is arranged in such a way that the axis 28 runs orthogonally with respect to the surface of the shell to which the actuator is applied. The axial deformations of the actuator 16 therefore produce mechanical vibrations of the shell 14 with the same frequency, which generate sound waves with the same frequency as the electrical signal sent to the actuator 16.

[0017] For the application of the present invention to a neonatal isolation unit, the actuator 16 could be applied to one of the lateral walls of the structure, which generally consist of polycarbonate or material similar to

that of the shell of an incubator.

[0018] The sound reproduction device according to the present invention has been developed in order to provide better acoustic comfort within the incubator. It can be used to transmit music, speech or, in general, sounds which are familiar or pleasant to the newborn child. In particular, but not exclusively, the device according to the present invention has been developed with the aim of reproducing endogenous intrauterine sounds within the incubator, according to the process described in detail in Italian patent application No. T096A000825 filed by G. Brero, G. Dealessandri, M. Vivalda and S. Gervasio.

[0019] Figure 3 shows the spectral distribution of endogenous intrauterine sounds, in other words the sounds which are heard by the foetus during pregnancy. These sounds have a particular spectral distribution. In Figure 3 it can be seen that the frequency band of intrauterine sounds lies between the threshold of audibility and 400 Hz. The spectrum has an upper cutoff frequency at about 63 Hz, beyond which the sounds are progressively attenuated by the tissues and by the amniotic fluid, this process being characterized by a decay of approximately 5 dB for every third of an octave. Additionally, the maternal heartbeat corresponds to the very low frequencies, in other words those in the band from 40 to 80 Hz.

[0020] The reproduction of music, of speech and particularly of intrauterine sounds within an incubator cannot be achieved by directly connecting the output of a conventional stereo system to the piezoelectric actuator 16. This is because, owing to the transfer function of the actuator-shell-cavity system, the reproduced sound would be of low fidelity and almost entirely lacking in the low frequencies. This would have a serious effect, particularly on the primary objective of the device, in other words the reproduction of the intrauterine sounds which, as has been stated, have a marked spectral concentration in the low frequencies. It is therefore necessary for the amplifier-equalizer unit 20 which drives the actuator 16 to modify the input signal received from the acoustic reproducer 18 (CD or magnetic tape player) in such a way as to compensate the problems of the transducer operation and to provide the desired high acoustic fidelity, perception of the low frequencies and intelligibility. The amplifier contained in the unit 20 is therefore designed specifically to drive a capacitive load and to supply a sufficient power at the low frequencies. The equalizer is programmed in such a way as to make the acoustic spectrum uniform within the shell 14 by emphasizing the cardiac frequency band.

[0021] The reproduction of any external signal within the incubator requires a low noise level of the apparatus responsible for the normal operation of the incubator. Existing lower-noise incubators do not exceed the sound pressure level of 46-47 dB(A) measured in the centre of the shell 14 in normal operating conditions. A particularly critical source of noise from the point of view

of sound insulation is the fan used to circulate the air within the incubator. This is a source of noise with distinct tonal characteristics, since the noise emission frequency is related to the rotation speed of the motor and to the number of blades of the fan. Conventional sound insulation systems are difficult to apply in the specific case of the fan and have little practical effect.

[0022] The sound reproduction device according to the present invention can also be used for the purpose of improving the sound insulation of the incubator by using the known principle of active cancellation of the signal, which consists essentially in the generation of an acoustic signal in phase opposition to the noise component which is to be attenuated.

that it comprises an electronic control unit programmed to provide active sound insulation of the said isolated space by generating acoustic signals in phase opposition to the noises which are to be attenuated.

Claims

1. Apparatus for climatic control in an environment designed to house a newborn child, comprising at least one wall (14) which, associated with a base structure (12), delimits a space in which, in operation, controlled environmental conditions are maintained, characterized in that it comprises at least one electrically controlled actuator (16) applied to the aforesaid wall (14), the said actuator (16) being capable of producing mechanical vibrations of the wall (14) to generate acoustic waves in the aforesaid space.
2. Apparatus according to Claim 1, characterized in that the aforesaid actuator (16) is rigidly connected to the aforesaid wall (14).
3. Apparatus according to Claim 2, characterized in that the aforesaid wall (14) comprises at least one portion of plastic material in which the said actuator (16) is incorporated.
4. Apparatus according to Claim 1, characterized in that the aforesaid actuator (16) comprises a piezoelectric element (22) capable of producing mechanical vibrations of the wall (14) correlated with an electrical exciting signal.
5. Apparatus according to Claim 1, characterized in that it comprises an electronic drive device (20) capable of receiving an electrical input signal and of producing an electrical signal for driving the said actuator (16), the said drive device (20) being designed to vary the drive signal with respect to the input signal in such a way as to compensate for the alterations which an ordinary input signal undergoes as a result of the transfer function of the sound reproduction system comprising the actuator (16), the shell (14) and the isolated space.
6. Apparatus according to Claim 1, characterized in

FIG. 1

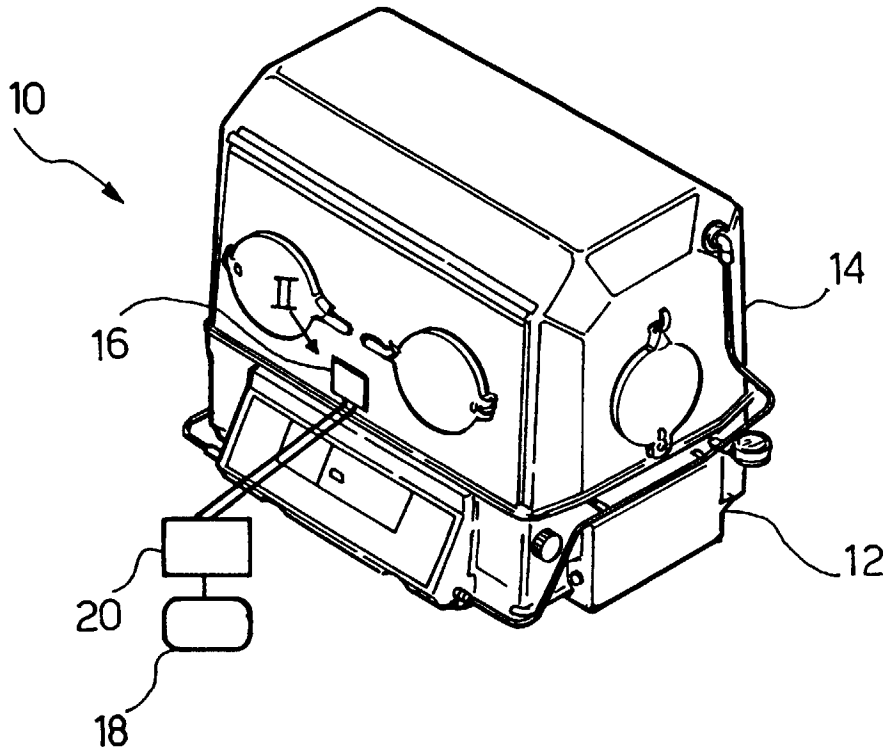


FIG. 2

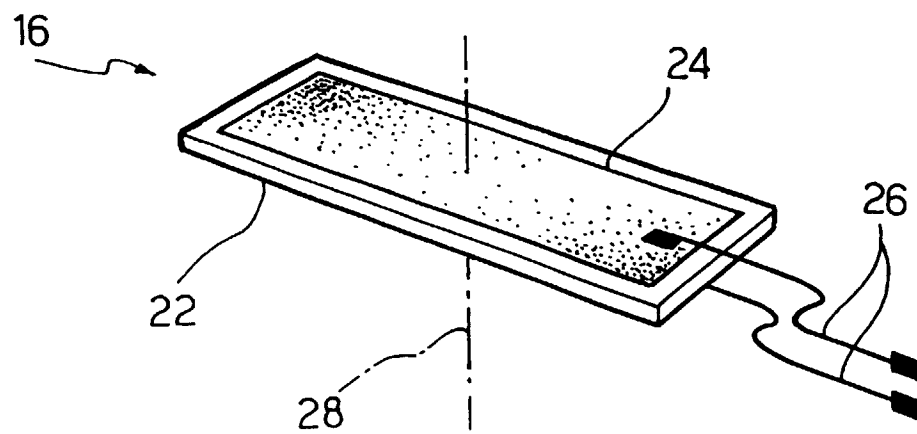
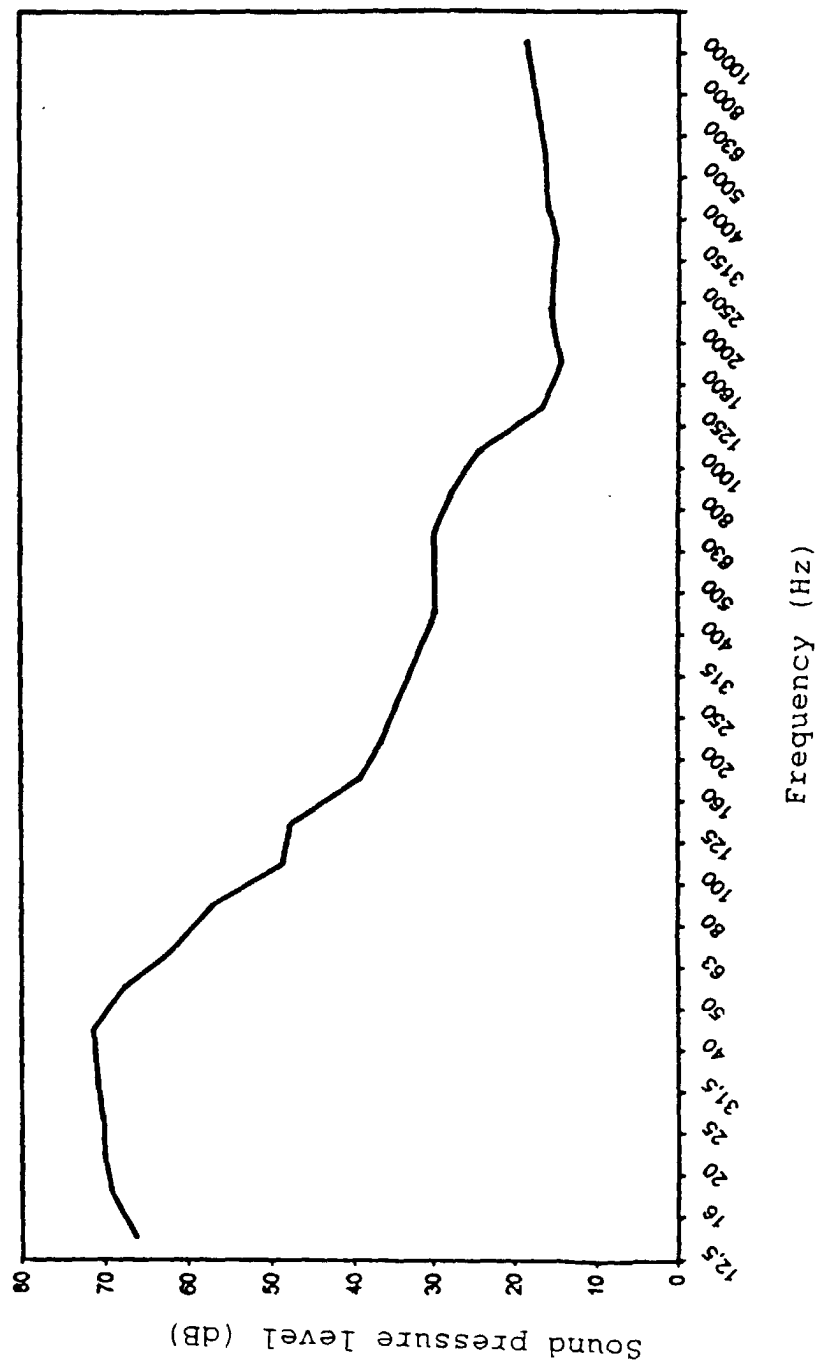


FIG. 3





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 83 0214

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION
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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED
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Place of search		Date of completion of the search	Examiner
THE HAGUE		16 September 1999	Baert, F
CATEGORY OF CITED DOCUMENTS 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			

EPO FORM 1503 03/82 (P4/C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 99 83 0214

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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