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(54) Portable electrical apparatus comprising sound restitution means

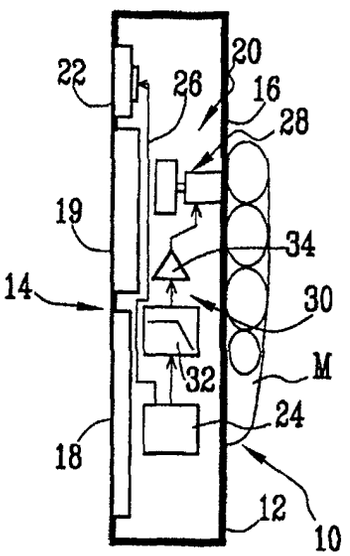
(57) The portable electrical apparatus (10) comprises:

- a chassis (12);
- an audio source (24) adapted for producing a control signal representative of a sound sequence; and
- sound restitution means (20) comprising a sound emission loudspeaker (22) linked to the said audio source (24) for the driving thereof as a function of the said control signal representative of a sound sequence.

The said sound restitution means (20) comprise a mechanical excitation source (28) coupled mechanically to the said chassis (12) and connected to the said audio source (24) for the driving thereof as a function of the said control signal representative of a sound sequence.

Application to a mobile telephone.

FIG.1



EP 1 221 825 A1

Description

[0001] The present invention relates to a portable electrical apparatus such as comprising;

- a chassis;
- an audio source adapted for producing a control signal representative of a sound sequence; and
- sound restitution means comprising a sound emission loudspeaker linked to said audio source for the driving thereof as function of said control signal representative of a sound sequence.

[0002] This portable electrical apparatus is for example a mobile telephone, a portable computer or an electronic diary.

[0003] Mobile telephones, as well as numerous other items of portable electrical apparatus, comprise sound restitution means allowing the generation of acoustic waves within the band of frequencies audible to man.

[0004] These sound restitution means comprise at least one loudspeaker having a diaphragm whose excitation allows the creation of sound waves in the ambient medium.

[0005] Owing to the generally restricted dimensions of portable electrical apparatus, the loudspeaker or loudspeakers used have a restricted diameter, which cannot exceed a few centimetres.

[0006] These loudspeakers do not allow reproduction of the low frequencies corresponding to low-pitched sounds. Specifically, the bottom cut-off frequency of a loudspeaker is related directly to its diameter. In particular, the signals lying within the infra-bass band corresponding to frequencies from 20 Hz to 300 Hz cannot be reproduced by a small-diameter loudspeaker.

[0007] At the present time, there is no known solution making it possible to reproduce, in free field, the low-pitched and infra-bass band in a mobile telephone or a portable computer equipped with a small-sized loudspeaker.

[0008] The impossibility of reproducing low-pitched sounds with such portable electrical apparatus is especially prejudicial to the sound quality obtained, in particular when listening to contemporary music where the low-pitched sounds are very prevalent.

[0009] The aim of the invention is to provide a solution to this problem by allowing the perception of infra-bass frequencies even with a small-sized portable electrical apparatus.

[0010] Accordingly, the subject of the invention is a portable electrical apparatus, of the aforesaid type, characterized in that said sound restitution means comprise a mechanical excitation source coupled mechanically to said chassis and connected to said audio source through a signal conditioning chain for the driving thereof as a function of said control signal representative of a sound sequence.

[0011] According to particular embodiments, the portable electrical apparatus comprises one or more of the following characteristics:

- said mechanical excitation source comprises a controlled force source linked to said audio source and a mobile assembly which can move with respect to said controlled force source, said controlled force source being adapted so as to act on said mobile assembly, said controlled force source and/or said mobile assembly being fixed to said chassis.
- said mechanical excitation source is adapted for a rectilinear movement of said mobile assembly.
- said mechanical excitation source forms a resonant system.
- said mechanical excitation source comprises a member for elastically returning said mobile assembly interposed between said controlled force source and said mobile assembly.
- the resonant frequency of said resonant system is substantially equal to 100 Hz.
- said mechanical excitation source comprises a damping member interposed between said controlled force source and said mobile assembly.
- said sound restitution means comprise means for slaving said controlled force source as a function of a parameter representative of the movement of said mobile assembly.
- said sound restitution means comprise a low-pass filter between said mechanical excitation source and said audio source.
- said sound restitution means comprise a double integrator between said mechanical excitation source and said audio source.
- it comprises means for securing said chassis to a resonant plate.
- said securing means comprise a suction cup fixed to said chassis and adapted so as to be applied against said resonant plate.
- said chassis exhibits an exterior face for gripping said portable electrical apparatus, and said mechanical excitation source is applied to said exterior gripping face; and
- it is an apparatus effecting at least one of the main functions specific to the apparatus group comprising:

    - a mobile telephone;
    - a portable computer;
    - a portable electronic calendar;
    - a portable television..

[0012] The invention will be better understood on reading the following description, given merely by way of example and whilst referring to the drawings, in which:

- Figure 1 is a diagrammatic side view in longitudinal section of a mobile telephone according to the invention;

- Figure 2 is a diagrammatic view in longitudinal section of a mechanical excitation source incorporated into the mobile telephone of Figure 1; and
- Figure 3 is a diagrammatic side view in longitudinal section of a variant of the mobile telephone of Figure 1, this telephone being represented lying on a mounting.

[0013] Represented in Figure 1 is a mobile telephone 10 comprising a housing 12 having a front face 14 and a rear face 16. The rear face 16 of the mobile telephone constitutes an essentially continuous solid wall. As known per se, a keypad 18 and a screen 19 are present on the front face 14 of the telephone.

[0014] Furthermore, the telephone comprises sound restitution means 20. These means comprise a diaphragm loudspeaker 22 which is disposed inside the housing 12 in line with an orifice for the passage of sound waves, cut through the front face 14 of the telephone. The loudspeaker 22 is of restricted size and does not allow restitution of frequencies below 300 Hz.

[0015] The loudspeaker 22 is linked to an audio source 24 adapted so as to produce a control signal representative of a sound sequence.

[0016] The audio source 24 consists for example of the reception means of the mobile telephone. These means are of any suitable type and will not be described in detail in the subsequent description.

[0017] The output of the audio source 24 is linked directly by a conductor 26 to the loudspeaker 22 for the driving thereof on the basis of the control signal produced.

[0018] Furthermore and according to the invention, the sound restitution means 20 of the mobile telephone comprise a driven mechanical excitation source 28. This source 28 is mechanically coupled to the chassis of the telephone, that is to say to the structure bearing the mobile telephone. In the embodiment envisaged, the chassis of the telephone consists of the housing 12.

[0019] More precisely, the mechanical excitation source 28 is mechanically coupled to a rear face 16 of the mobile telephone so as to allow transmission of mechanical waves from the excitation source 28 to the rear face 16, in order to engender mechanical vibrations of this face.

[0020] The mechanical excitation source 28 is linked to the audio source 24 through a signal conditioning chain 30. The chain 30 comprises, firstly, at the output of the audio source 24, a low-pass filter 32 whose cut-off frequency is substantially equal to 300 Hz.

[0021] An amplifier 34 is linked at the output of the low-pass filter 32, the output of the amplifier 34 being connected directly to the mechanical excitation source 28.

[0022] Advantageously, the mechanical excitation source 28 forms a resonant system. An example of such a source is represented in Figure 2.

[0023] The source 28 comprises a controlled force source 36 linked at the output of the signal conditioning chain 30. The mechanical excitation source 28 furthermore comprises a mobile assembly 38 which can move in translation relative to the controlled force source 36 under the action of the latter.

[0024] One of the controlled force source 36 and mobile assembly 38 is rigidly fixed to the rear face 16 of the housing. In the embodiment illustrated, the controlled force source 36 is fixed to the rear face 16 of the housing and the mobile assembly 38 is therefore movable with respect to the rear face 16 of the housing.

[0025] The controlled force source 36 comprises an electromagnet 40 accommodated in a casing 42. The casing 42 comprises means for fixing to the rear face 16 of the housing, the mechanical excitation source 28 being mounted inside the housing. A coil 44 of the electromagnet is mounted fixedly inside the casing 42. The mobile assembly 38 comprises a magnetic bar 46 which is slidably movable along the axis of the coil 44. The magnetic bar 46 passes through a wall of the casing 42.

[0026] The mobile assembly 38 furthermore comprises a mobile mass 48 fixed to that end of the magnetic bar 46 projecting from the casing 42.

[0027] The mechanical excitation source 28 is disposed in the mobile telephone 10 in such a way that the movement of the mobile assembly 38 occurs along a direction substantially perpendicular to the principal plane of the rear face 16.

[0028] A damping element 49 formed for example by a block of foam is interposed between the controlled force source 36 and the mobile assembly 38. In the embodiment, the damping element is disposed around the magnetic bar 46 between the casing 42 and the mass 48.

[0029] Furthermore, an elastic return member, such as a spiral spring 50, provides for the link between the casing 42 and the mobile assembly 38 formed of the magnetic bar 46 and of the mobile mass 38.

[0030] The mechanical excitation source 28 illustrated in Figure 2 forms a resonant system. The resonant oscillatory frequency is equal to k/m where k is the stiffness of the spring 50 and m is the mass of the mobile assembly 38. The mass m is substantially equal to the mass of the mobile mass 48.

[0031] For a resonant system of this kind, the quality factor at resonance is dependent on the mobile assembly 38, on the spring 50 and on the damping element 49.

[0032] A damping element 49 producing weak damping allows considerable generation of vibrations, the spectrum of which is, however, very closely spaced. A damping element 49 producing high damping makes it possible to stretch the spectrum of vibrations but reduces the amplitude of the vibrations.

[0033] Advantageously, the mobile assembly 38 and the spring 50 are chosen so that the resonant frequency of the mechanical excitation source 28 is substantially equal to 100 Hz.

[0034] The damping element 49 is chosen so as to

produce damping such that an attenuation of for example 20 dB is obtained at the frequency of 200 Hz.

[0035] The mobile assembly 38, the controlled force source 36, the damper 49 and the spring 50 are dimensioned so that the amplitude of the oscillations of the mobile assembly 38 is a maximum in the frequency range from 20 Hz to 300 Hz for example.

[0036] As a variant, the spring 50 and/or the damping element 49 are dispensed with.

[0037] The controlled force source 36 employed in the mechanical excitation source 28 is advantageously slaved by regulating means known per se. The slaving parameter is preferably a parameter representative of the movement of the mobile assembly 38. This parameter is for example the speed of the mobile assembly, its position, or its acceleration.

[0038] When the mobile telephone 10 is operating, the audio source 24 produces a control signal representative of a sound sequence. The control signal is applied, on the one hand, to the loudspeaker 22 and, on the other hand, to the input of the signal conditioning chain 30.

[0039] The control signal provided by the audio source 24 emanates for example from a data file received by the mobile telephone 10, this file being for example in the MP3, ATTRAC3 or WAV format.

[0040] The control signal engenders the excitation of the diaphragm of the loudspeaker 22 and the production of sound waves.

[0041] Simultaneously, the same control signal is filtered by the low-pass filter 32 and is then amplified by the amplifier 34. The signal thus conditioned then excites the electromagnet 40, which provides for a corresponding movement of the mobile assembly 38.

[0042] The movements of the mobile assembly 38 relative to the casing 42, itself secured to the housing 12, engender on the housing, and in particular its rear face 16, a force which is proportional to the derivative of the control signal. This force is in fact directly proportional to the acceleration and to the mass of the mobile assembly 38, according to the fundamental law of dynamics.

[0043] When the user is holding the housing 12 of the mobile telephone in his hand, denoted H in Figure 1, with the rear face 16 of the housing applied against the palm of his hand, the force produced by the mechanical excitation source 28 is applied directly to the hand of the user. The latter then perceives the vibration produced by the mechanical excitation source 28. This mechanical vibration reproduces the frequencies of the infra-bass band of the sound sequence.

[0044] It is found, in general, that the low-pitched sounds whose frequency lies within the infra-bass band are perceived as much by the body surface of the human being as by his/her eardrums. Thus, the mechanical loading applied to the palm of the hand allows the user of the mobile telephone to feel a vibration in the infra-bass band, this vibration being perceived as a component of the sound signal whose highest frequencies are restored by the loudspeaker 22.

[0045] As a variant, in the mechanical excitation source 28, the mobile assembly 38, the spring 50 and the damping element 49 are formed by one and the same member, this member consisting for example of a rubber-clad elastic reed. The elastic reed then fulfils the function of the mobile mass and also of the elastic return member, the rubber itself providing for the damping function.

[0046] Represented in Figure 3 is a variant embodiment of the mobile telephone of Figure 1.

[0047] In this embodiment, elements identical or similar to those of the embodiment of Figure 1 are designated by the same reference numbers.

[0048] According to this variant embodiment, the signal conditioning chain 30 comprises, between the low-pass filter 32 and the amplifier 34, a double integrator 60 making it possible to perform two successive integrations of the control signal with respect to time.

[0049] Moreover, a suction cup 62 is fixed mechanically to the rear face 16 of the mobile telephone. This suction cup comprises an elastic cap 63 whose suction surface points away from the rear face 16. Advantageously, this suction cup 62 is fixed in line with the mechanical excitation source 28.

[0050] The suction cup 62 makes it possible to fix the mobile telephone against the surface of an elastically deformable plate 64 by suction. This plate consists for example of the top of a desk or any other mounting of large dimensions.

[0051] For the operation thereof, the mobile telephone rests with its rear face 16 extending substantially parallel to the mounting 64. In this position, a damping pad 66 is advantageously interposed between the housing 12 of the mobile telephone and the mounting 64 so as to avoid any rigid contact between the housing and the mounting.

[0052] When the mobile telephone is operating, the control signal representative of the sound sequence, which control signal is provided by the audio source 24, provides for the simultaneous driving of the loudspeaker 22 and of the mechanical excitation source 28.

[0053] During the movement of the mobile assembly 38, the force applied to the rear face 16 of the telephone is transmitted by the suction cup 62 to the mounting 64. Under the action of this force, the mounting 64 is caused to vibrate, so producing an acoustic wave. The mounting 64 then acts as a diaphragm on the ambient air.

[0054] In this embodiment, the control signal is integrated twice with respect to time before being applied to the mechanical excitation source 28.

[0055] The deformation of the mounting 64 is proportional to the force applied by the mechanical excitation source 28. The acoustic wave created by the deformation of the mounting 64 is proportional to the rate of deformation thereof. The acoustic wave created is therefore the second derivative with respect to time of the electrical signal applied to the acoustic excitation

source.

[0056] Since the electrical signal applied to the mechanical excitation source 28 is the double integral with respect to time of the control signal provided by the audio source 24 after filtering, the acoustic wave produced by the vibration of the mounting 64 is proportional to the control signal produced by the audio source 24.

[0057] The double integrator 60 makes it possible to obtain an optimal frequency response. Nevertheless, this double integrator imposes considerable travel of the mobile assembly 38 in the mechanical excitation source 28. In order to avoid too strong a loading of the mechanical excitation source 28, the double integrator 60 can be dispensed with. Dispensing therewith leads to a frequency response rising by 12 dB per octave for example.

[0058] The presence of the pad 66 between the housing 12 of the mobile telephone and the mounting 64 makes it possible to avoid the detachment of the mobile telephone and hence the existence of impact noise.

[0059] Likewise, the presence of the suction cup 62 avoids such detachment when the total mass of the mobile telephone is insufficient.

[0060] The suction cup can be replaced with any other means of securing the mechanical excitation source 28 to the mounting 24. These means may consist, for example, of a screw, a hook, a fastening tab or an adhesive means.

[0061] In the embodiment illustrated, the suction cup is disposed in line with the mechanical excitation source. However, if the chassis consisting, in the example considered, of the rear face of the mobile telephone is very rigid, the suction cup can be disposed some distance from the mechanical excitation source. Such a disposition then makes it possible to amplify the force applied to the mounting 64 by a lever arm effect. The chassis of the telephone then constitutes a lever articulated at the point of contact of the telephone on the mounting, the mechanical excitation source 28 applying a force to the lever at a first point, which force is retransmitted to the mounting 64 by the suction cup at a second point distant from the point of articulation.

[0062] It is clear that any type of portable electrical apparatus, besides the portable telephone described previously, can implement the invention such as a portable computer, a portable electronic calendar, a portable television as well as an apparatus effecting at least one of the main functions specific to the here-above mentioned apparatus.

Claims

1. Portable electrical apparatus (10), comprising:

- a chassis (12);
- an audio source (24) adapted for producing a control signal representative of a sound sequence; and
- sound restitution means (20) comprising a sound emission loudspeaker (22) linked to said audio source (24) for the driving thereof as a function of said control signal representative of a sound sequence,

characterized in that said sound restitution means (20) comprise a mechanical excitation source (28) coupled mechanically to said chassis (12) and connected to said audio source (24) through a signal conditioning chain for the driving thereof as a function of said control signal representative of a sound sequence.

2. Portable electrical apparatus (10) according to Claim 1, **characterized in that** said mechanical excitation source (28) forms a resonant system and **in that** the resonant frequency of said resonant system is substantially equal to 100 Hz.

3. Portable electrical apparatus (10) according to any of the preceding claims, **characterized in that** said mechanical excitation source (28) comprises a controlled force source (36) linked to said audio source (24) and a mobile assembly (38) which can move with respect to said controlled force source (36), said controlled force source (36) being adapted so as to act on said mobile assembly (38), said controlled force source (36) and/or said mobile assembly (38) being fixed to said chassis (12) and **in that** said mechanical excitation source (28) comprises a damping member (49) interposed between said controlled force source (36) and said mobile assembly (38).

4. Portable electrical apparatus (10) according to any of the preceding claims, **characterized in that** said mechanical excitation source (28) comprises a controlled force source (36) linked to said audio source (24) and a mobile assembly (38) which can move with respect to said controlled force source (36), said controlled force source (36) being adapted so as to act on said mobile assembly (38), said controlled force source (36) and/or said mobile assembly (38) being fixed to said chassis (12) and **in that** said sound restitution means (20) comprise means for slaving said controlled force source (36) as a function of a parameter representative of the movement of said mobile assembly (38).

5. Portable electrical apparatus (10) according to any of the preceding claims, **characterized in that** said sound restitution means (20) comprise a low-pass filter (32) between said mechanical excitation source (28) and said audio source (24).

6. Portable electrical apparatus (10) according to any

of the preceding claims, **characterized in that** said sound restitution means (20) comprise a double integrator (60) between said mechanical excitation source (28) and said audio source (24).

7. Portable electrical apparatus (10) according to any of the preceding claims, **characterized in that** it comprises means (62) for securing said chassis (12) to a resonant plate (64).

8. Portable electrical apparatus (10) according to Claim 7, **characterized in that** said securing means comprise a suction cup (62) fixed to said chassis (12) and adapted so as to be applied against said resonant plate (64).

9. Portable electrical apparatus (10) according to any of the preceding claims, **characterized in that** said chassis (12) exhibits an exterior face (16) for gripping said portable electrical apparatus, and **in that** said mechanical excitation source (28) is applied to said exterior gripping face (16).

10. Portable electrical apparatus according to any of the preceding claims, **characterized in that** it is an apparatus effecting at least one of the main functions specific to the apparatus group comprising:

- a mobile telephone (10);
- a portable computer;
- a portable electronic calendar;
- a portable television.

FIG.1

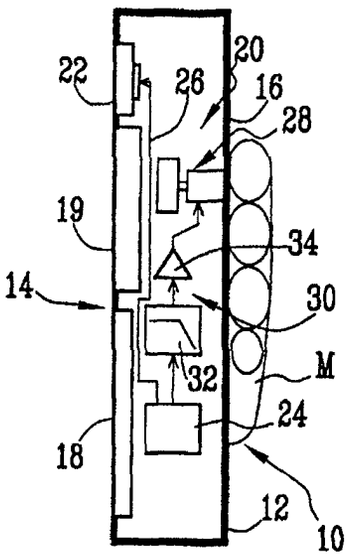
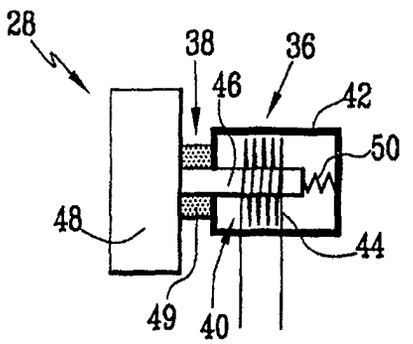


FIG.2



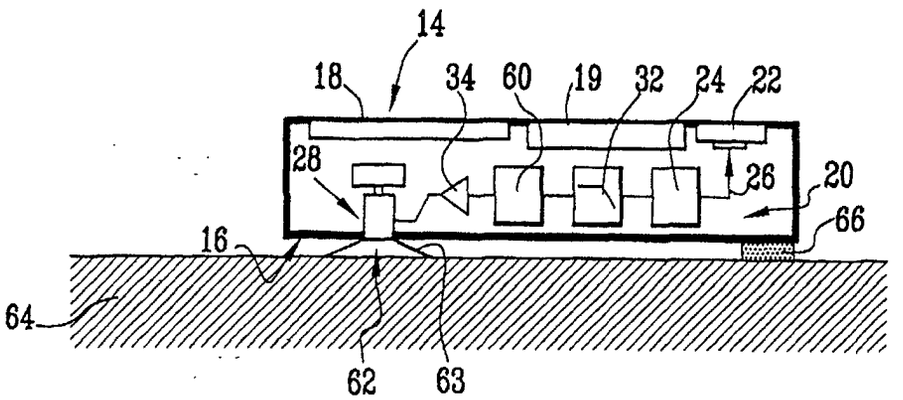


FIG.3

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EUROPEAN SEARCH REPORT

Application Number
EP 02 29 0025

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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TECHNICAL FIELDS SEARCHED (Int.Cl.7)

H04R
H04M
G01V
H01Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17 April 2002	Zanti, P

CATEGORY OF CITED DOCUMENTS

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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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17-04-2002

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82