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(54) CONSUMER ELECTRONIC DEVICE AND METHOD FOR OPERATING A CONSUMER ELECTRONIC DEVICE

(57) The present invention provides a consumer electronic device (100, 200, 300) comprising electric units (101, 201, 301), a sound generation device (102, 202, 302) with a membrane (103, 203, 303) that is excitable by a control signal (104, 204, 304), and an air duct (105, 205, 305, 315) that is arranged between the membrane (103, 203, 303) and at least one of the electric units (101, 201, 301) such that air (106, 206, 306, 316) is guided from the membrane (103, 203, 303) to the electric units (101, 201, 301). The present invention further provides a method for operating a consumer electronic device (100, 200, 300).

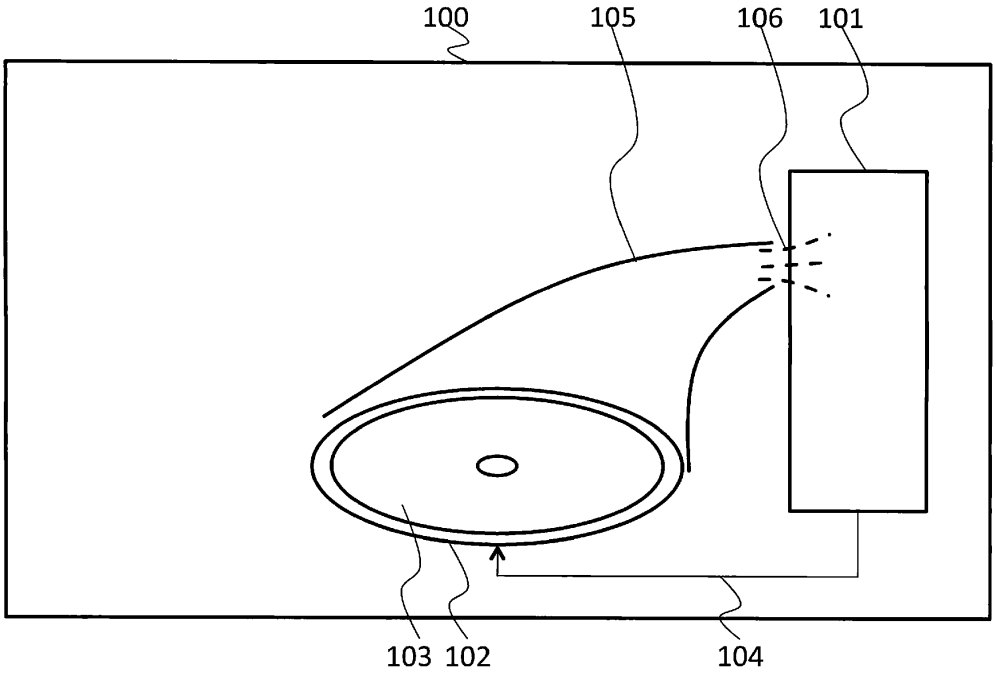

Fig. 1

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Description

TECHNICAL FIELD

[0001] The invention relates to a consumer electronic device and a method for operating a consumer electronic device.

BACKGROUND

[0002] Although applicable to any system that uses subwoofers, the present invention will be described in the following in conjunction with TV sets that comprise a subwoofer.

[0003] Modern consumer electronic devices comprise a plurality of electric or electronic units, like e.g. general processors, digital signal processors, amplifiers and the like. Each one of the units is provided with electric power in order to function. The power supply for these units as well as the units themselves will produce heat while they operate.

[0004] In consumer electronic devices the space in the housing is usually limited and the heat may therefore accumulate in the housing. For example, in modern TV sets, there may be heat problems as a result of a high power drain of the panel, mainboard components and the power supply.

[0005] Usually, cooler mechanics will be designed according to the worst case conditions that are expected for the respective device. For example passive coolers (metal, ceramic), or thermal gap fillers may be used. Active coolers such as fans may be used in some devices in which the noise produced by the fans is acceptable.

[0006] Accordingly, there is a need for an improved cooling of consumer electronic devices.

SUMMARY OF THE INVENTION

[0007] The present invention provides a consumer electronic device with the features of claim 1 and a method for operating a consumer electronic device with the features of claim 7.

[0008] Therefore it is provided:

> A consumer electronic device comprising electric units that may generate heat when operated, a sound generation device with a membrane that is excitable by a control signal, and an air duct, in particular in form of a horn, that may also be called horn, that is arranged between the membrane and at least one of the electric units such that air is guided from the membrane to the electric units.

[0009] Further it is provided:

> A method for operating a consumer electronic device with electric units, the method comprising: exciting a membrane of a sound generation device with a control signal, and guiding air from the membrane to the electric units of the consumer electronic device, e.g. with an air duct that is arranged between the membrane and at least one of the electric units such that the air is guided accordingly.

[0010] The housings of modern TV sets are designed slimmer with every generation mainly for esthetic reasons. However, the slimmer a housing of an electronic device is, the more difficulties arise when heat must be transferred from the inside of the housing to the outside.

[0011] The present invention is based on the finding that sound generation devices, like speakers, comprise moving membranes and that in order to generate sound the membrane moves air according to the respective control or sound signal.

[0012] The present invention uses this fact and focuses the moving air with the help of the air duct onto the electric units of the consumer electronic device. An electric unit in this context may be any unit in the electronic consumer device that is powered by electric power. Such units will provide heat e.g. due to losses in the electronic elements of the respective unit.

[0013] By focusing the airflow of the sound generation device onto the electronic units, an air flow may actively be generated that actively cools the electric units.

[0014] Therefore, with the present invention no further active cooling elements are required in the consumer electronic device and passive cooling elements may be supported by the active airflow.

[0015] Further embodiments of the present invention are subject of the further subclaims and of the following description, referring to the drawings.

[0016] In an embodiment of the invention, the sound generation device may be a subwoofer.

[0017] Subwoofer speakers or drivers compared e.g. to mid-range drivers or tweeters comprise the biggest membrane and therefore produce the strongest airflow. Therefore, by using the subwoofer speaker of a consumer electronic device

as the source of air for cooling the electric units of the consumer electronic unit, the air flow to the electronic units may be maximized.

[0018] In another embodiment, the consumer electronic device may comprise a control unit configured to measure the temperature of the electric units and drive the sound generation device according to the measured temperature.

[0019] The control unit may e.g. be a DSP or digital signal processor of the consumer electronic device that generates the control signal for the sound generation device. The DSP may e.g. receive a digital sound data stream and may convert that sound data stream into an analogue signal that may then e.g. be provided to an amplifier. The amplifier may then drive the sound generation device with an amplified analogue signal. It is understood that the control unit may also comprise any other digital control unit, like e.g. a microcontroller, a general purpose processor or the like.

[0020] A control unit has the advantage that it can perform signal processing of e.g. sound data. The control unit may therefore adapt the driving signal not only according to a sound data stream but also according to the cooling requirements in the consumer electronic device.

[0021] The control unit may e.g. comprise a look-up table or a mapping function that maps a temperature of the electric units to a specific signal level that is needed to produce enough air flow for cooling the electric units.

[0022] In a further embodiment, the consumer electronic device may comprise a temperature sensor electronically coupled to the control unit and thermally coupled to at least one of the electric units.

[0023] The temperature sensor may be any type of temperature sensor that may be coupled to the control unit e.g. via an analogue or digital interface, e.g. a SPI interface, an 12C interface or the like. The temperature sensor can e.g. be arranged near, at or on the heat sources, i.e. the electric units, of the consumer electronic device. A single temperature sensor may be provided. It is however understood that more than one temperature sensor may also be provided to measure the temperatures of different electric units or heat sources.

[0024] In addition, the heat sensor may be provided as internal heat sensor of one of the heat sources, i.e. electric units. The temperature data from the heat sensor may e.g. be provided to the control unit e.g. via a digital data interface between the control unit and the respective electric unit.

[0025] In another embodiment, the control unit may be configured to adapt the gain of the control signal for the sound generation device based on the measured temperature.

[0026] The control unit may adapt the gain of the control signal by modifying the control signal, e.g. a sound data stream, in real time and increasing the signal levels of the control signal in the control unit. In addition or as an alternative, the control unit may also adapt the gain of the control signal by setting a gain factor of an amplifier in the consumer electronic device.

[0027] In an embodiment, the control unit may be configured to overlay the control signal with a low frequency signal based on the measured temperature.

[0028] The control signal may e.g. be a sound data stream that is provided together with a video that may be reproduced on the consumer electronic device, e.g. a TV set. The control signal may also be a sound data stream e.g. in an amplifier or a radio or the like. Especially for example in multimedia systems, like e.g. home cinema installations, the sound levels of the single speakers are adjusted to each other. Increasing the gain e.g. of the subwoofer signal may detune a fine tuned speaker setup.

[0029] In addition, subwoofer signals with a frequency of less than 20Hz are not audible by the human ear. Therefore, a low frequency signal may be used to produce an airflow without influencing the hearing experience of the users.

[0030] In a further embodiment, the low frequency signal may comprise a frequency between 0,5 Hz and 25 Hz, especially between 2 Hz and 15 Hz, especially between 5 Hz and 10 Hz.

[0031] Low frequencies may not be perceived by the human ear anymore and at the same time generate a constant airflow when applied to a subwoofer membrane. Therefore such low frequencies may be used to produce the air flow for cooling electric units in the consumer electronic device without deteriorating the hearing experience of the users. Such a low frequency signal may e.g. also be generated during quiet sections of the audio or sound data stream without producing audible fragments or vibrations.

[0032] In another embodiment, the consumer electronic device may comprise a plurality of air ducts that are each arranged between the sound generation device and different electric units of the consumer electronic device.

[0033] The multiple air ducts may be permanently open and supply air from the sound generation device to the different electric units. However, a valve-like element may also be provided. Such a valve-like may selectively open or close different air ducts.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] For a more complete understanding of the present invention and advantages thereof, reference is now made to the following description taken in conjunction with the accompanying drawings. The invention is explained in more detail below using exemplary embodiments which are specified in the schematic figures of the drawings, in which:

Fig. 1 shows a block diagram of an embodiment of a consumer electronic device according to the present invention;

Fig. 2 shows a block diagram of another embodiment of a consumer electronic device according to the present invention;

Fig. 3 shows a block diagram of another embodiment of a consumer electronic device according to the present invention;

Fig. 4 shows a flow diagram of an embodiment of a method according to the present invention; and

Fig. 5 shows a flow diagram of an embodiment of a method according to the present invention.

[0035] In the figures like reference signs denote like elements unless stated otherwise.

DETAILED DESCRIPTION OF THE DRAWINGS

[0036] Fig. 1 shows a block diagram of consumer electronic device 100. The consumer electronic device 100 comprises an electric unit 101 and a sound generation device 102. The electric unit 101 may e.g. be a motherboard of the consumer electronic device 100. Such a motherboard may comprise a plurality of further electric or electronic devices. While operating, the electric unit 101 will consume electric power and produce heat that must be absorbed or conveyed out of the consumer electronic device 100. The sound generation device 102 comprises a membrane 103 or diaphragm 103 that moves when the sound generation device 102 is excited by a control signal 104. The movement of the membrane 103 will also move air 106.

[0037] In addition, the consumer electronic device 100 comprises an air duct 105, also called channel or horn. The air duct 105 is arranged between the sound generation device 102 and the electric unit 101 and guides the air that is moved by the membrane 103 in the direction of the electric unit 101.

[0038] The sound generation device 102 may e.g. be a subwoofer of the consumer electronic device 100 and the air duct 105 may be the reflex port of the sound generation device 102. Such a reflex port enables the sound from the rear side of the membrane 103 to increase the efficiency of the system at low frequencies as compared to a typical closed box loudspeaker.

[0039] The arrangement presented here for the consumer electronic device 100 therefore allows actively cooling the electric unit 101 while the consumer electronic device 100 is in use with the air flow produced by the sound generation device 102. No further or additional active cooling elements will be necessary. It is understood that any known passive cooling element, like e.g. heat sinks or the like may be combined with the present invention. Further, it is understood, that the consumer electronic device 100 may also comprise more than one sound generation device 102 and more than one electric unit 101. The consumer electronic device 100 may also comprise sound generation devices 102 that are not used to provide an active airflow, such sound generation devices 102 may e.g. be mid-range speakers or tweeters that accompany a subwoofer 102.

[0040] The consumer electronic device 100 may be any type of device, like e.g. a TV set, a Wi-Fi speaker, an internet radio or the like.

[0041] Fig. 2 shows a consumer electronic device 200 that is based on the consumer electronic device 100. Therefore the consumer electronic device 200 also comprises an electric unit 201, a sound generation device 202 with a membrane 203 and an air duct 205.

[0042] In the consumer electronic device 200 the electric unit 201 is a motherboard 201 that comprises further electric devices 213, 214 together with a control unit 207 and an amplifier 208. The electric device 213 further comprises a dedicated temperature sensor 211.

[0043] The control unit 207 receives information 209, 210 about the temperatures of the electric devices 213, 214. For the electric device 213 the control unit 207 receives this information 210 via the temperature sensor 211. The temperature sensor 211 may e.g. be coupled to the control unit 207 via an analogue interface or via a digital interface, like e.g. a SPI-intertace, or an I2C-interface.

[0044] The electric device 214 in contrast to the electric device 213 comprises an integrated temperature sensor and provides the information 209 to the control unit 207 via an interface (not explicitly shown) of the control unit 207 with the electric device 214. The interface between the control unit 207 and the electric device 214 may e.g. be any type of interface that couples the control unit 207 to the electric device 214. Such an interface may e.g. be a SPI-interface, an I2C-interface or any type of serial or parallel data interface.

[0045] The control unit 207 will under normal conditions generate the control signal 204 that is used to drive the sound generation device 202. The control signal 204 will be amplified by amplifier 208 and then be provided to the sound generation device 202. Under normal conditions refers to no increased cooling performance being needed for cooling

the electric unit 201, or especially the electric devices 213, 214.

[0046] However, under conditions of increased cooling of the electric unit 201, and especially the electric devices 213, 214, the control unit 207 may alter or modify the control signal 204 or adapt the gain 212 of the control signal 204 in the amplifier 208.

[0047] A simple method to increase the airflow produced by the membrane 203 of the sound generation device 202 is to increase the excitation of the membrane 203. This may be achieved by increasing the signal levels of the control signal 204. The amplifier 208 may therefore be configured by the control unit 207 with an increased gain 212. Increasing the gain of the amplifier for the control signal 204 will also increase the audible level of the sound produced by the membrane 203, e.g. the bass part of an audio stream.

[0048] Therefore, in addition or as an alternative to modifying the gain 212, the control unit 207 may also modify the control signal 204 by adding or overlaying a low frequency signal to the control signal 204. Such a low frequency signal may e.g. be a sine signal with a frequency of less than 25 Hz. Such a low frequency or lower frequencies cannot be heard by the human ear and may therefore be used to produce an airflow for cooling the electric unit 201, and especially the electric devices 213, 214, without modifying the sound that is heard by humans.

[0049] It is understood, that even if shown as separate units, the electric devices 213, 214, the control unit 207 and the amplifier 208 may also be integrated into a single IC or may be distributed over various carrier boards.

[0050] Fig. 3 shows a block diagram of a consumer electronic device 300 that is based on the consumer electronic device 200. Therefore the consumer electronic device 300 also comprises an electric unit 301 with electric devices 313, 314, a sound generation device 302 with a membrane 303, an air duct 305, a control unit 307 and an amplifier 308.

[0051] The consumer electronic device 300 further comprises a power supply unit 318 that provides electric power to the electric unit 301, and especially the electric devices 313, 314, the control unit 207 and the amplifier 208.

[0052] Since the power supply unit 318 and the electric unit 301 are separately arranged in the consumer electronic device 300, they both may need separate cooling.

[0053] In order to cool the power supply unit 318 and the electric unit 301, the consumer electronic device 300 comprises a second air duct 315 that provides air 316 to the power supply unit 318.

[0054] As an option the consumer electronic device 300 may also comprise a flap 317 that is controllable to guide the air from the membrane 303 into the air duct 305 or the air duct 315. This allows guiding the full airflow to either one of the heat sources, e.g. in an alternating manner. The flap 317 may e.g. be controlled by the control unit 307.

[0055] For sake of clarity in the following description of the method based Figs. 4 and 5 the reference signs used above in the description of apparatus based Figs. 1 - 3 will be maintained.

[0056] Fig. 4 shows a flow diagram of a method for operating a consumer electronic device 100, 200, 300 with electric units 101, 201, 301.

[0057] The method comprises exciting S1 a membrane 103, 203, 303 of a sound generation device 102, 202, 302 of the consumer electronic device 100, 200, 300 with a control signal 104, 204, 304. The membrane 103, 203, 303 may e.g. be the membrane 103, 203, 303 of a subwoofer of the consumer electronic device 100, 200, 300.

[0058] To cool the electric units 101, 201, 301 air 106, 206, 306, 316 is guided S2 from the membrane 103, 203, 303 to the electric units 101, 201, 301 of the consumer electronic device 100, 200, 300.

[0059] Fig. 5 shows a flow diagram of a method that is based on the method of Fig. 4 and comprises further steps S3, S4 and/or S5.

[0060] The step S3 comprises measuring the temperature 209, 210, 309, 310 of the electric units 101, 201, 301. Exciting S1 the sound generation device 102, 202, 302 will then be performed according to the measured temperature 209, 210, 309, 310.

[0061] Further, prior to exciting S3, the method may comprise at least one of steps S4 and S5. Step S4 comprises adapting the gain 212, 312 of the control signal 104, 204, 304 for the sound generation device 102, 202, 302 based on the measured temperature 209, 210, 309, 310.

[0062] Step S5 comprises overlaying the control signal 104, 204, 304 with a low frequency signal based on the measured temperature 209, 210, 309, 310. The low frequency signal may e.g. comprise a frequency between 0,5 Hz and 25 Hz, especially between 2 Hz and 15 Hz, or between 5 Hz and 10 Hz.

[0063] Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that a variety of alternate and/or equivalent implementations exist. It should be appreciated that the exemplary embodiment or exemplary embodiments are only examples, and are not intended to limit the scope, applicability, or configuration in any way. Rather, the foregoing summary and detailed description will provide those skilled in the art with a convenient road map for implementing at least one exemplary embodiment, it being understood that various changes may be made in the function and arrangement of elements described in an exemplary embodiment without departing from the scope as set forth in the appended claims and their legal equivalents. Generally, this application is intended to cover any adaptations or variations of the specific embodiments discussed herein.

[0064] Thus, the present invention provides a consumer electronic device 100, 200, 300 comprising electric units 101, 201, 301, a sound generation device 102, 202, 302 with a membrane 103, 203, 303 that is excitable by a control signal

104, 204, 304, and an air duct 105, 205, 305, 315 that is arranged between the membrane 103, 203, 303 and at least one of the electric units 101, 201, 301 such that air 106, 206, 306, 316 is guided from the membrane 103, 203, 303 to the electric units 101, 201, 301. The present invention further provides a corresponding method for operating a consumer electronic device 100, 200, 300.

List of reference signs

[0065]

100, 200, 300	consumer electronic device
101, 201, 301	electric unit
102, 202, 302	sound generation device
103, 203, 303	membrane
104, 204, 304	control signal
105, 205, 305, 315	air duct
106, 206, 306, 316	air
207, 307	control unit
208, 308	amplifier
209, 210, 309, 310	temperature
211, 311	temperature sensor
212, 312	gain
213, 214, 313, 314	electric device
317	flap
318	power supply
S1 - S5	method steps

Claims

1. Consumer electronic device (100, 200, 300) comprising:

   electric units (101, 201, 301),
   a sound generation device (102, 202, 302) with a membrane (103, 203, 303) that is excitable by a control signal (104, 204, 304),
   an air duct (105, 205, 305, 315) that is arranged between the membrane (103, 203, 303) and at least one of the electric units (101, 201, 301) such that air (106, 206, 306, 316) is guided from the membrane (103, 203, 303) to the electric units (101, 201, 301).

2. Consumer electronic device (100, 200, 300) according to claim 1, wherein the sound generation device (102, 202, 302) is a subwoofer.

3. Consumer electronic device (100, 200, 300) according to any one of the preceding claims, comprising a control unit (207, 307) configured to measure the temperature (209, 210, 309, 310) of the electric units (101, 201, 301) and drive the sound generation device (102, 202, 302) according to the measured temperature (209, 210, 309, 310).

4. Consumer electronic device (100, 200, 300) according to claim 3, comprising a temperature sensor electronically coupled to the control unit (207, 307) and thermally coupled to at least one of the electric units (101, 201, 301).

5. Consumer electronic device (100, 200, 300) according to claim 3, wherein the control unit (207, 307) is configured to adapt the gain (212, 312) of the control signal (104, 204, 304) for the sound generation device (102, 202, 302) based on the measured temperature (209, 210, 309, 310).

6. Consumer electronic device (100, 200, 300) according to claim 3, wherein the control unit (207, 307) is configured to overlay the control signal (104, 204, 304) with a low frequency signal based on the measured temperature (209, 210, 309, 310).

7. Consumer electronic device (100, 200, 300) according to claim 6, wherein low frequency signal comprises a frequency between 0,5 Hz and 25 Hz, especially between 2 Hz and 15 Hz, more especially between 5 Hz and 10 Hz.

8. Method for operating a consumer electronic device (100, 200, 300) with electric units (101, 201, 301), the method comprising:

exciting (S1) a membrane (103, 203, 303) of a sound generation device (102, 202, 302) with a control signal (104, 204, 304),
guiding (S2) air (106, 206, 306, 316) from the membrane (103, 203, 303) to the electric units (101, 201, 301) of the consumer electronic device (100, 200, 300).

9. Method according to claim 8, wherein when exciting (S1), the membrane (103, 203, 303) of a subwoofer is excited.

10. Method according to any one of the preceding claims 7 and 8, comprising measuring (S3) the temperature (209, 210, 309, 310) of the electric units (101, 201, 301) and driving the sound generation device (102, 202, 302) according to the measured temperature (209, 210, 309, 310).

11. Method according to claim 10, comprising adapting (S4) the gain (212, 312) of the control signal (104, 204, 304) for the sound generation device (102, 202, 302) based on the measured temperature (209, 210, 309, 310).

12. Method according to claim 10, comprising overlaying (S5) the control signal (104, 204, 304) with a low frequency signal based on the measured temperature (209, 210, 309, 310).

13. Method according to claim 12, wherein low frequency signal comprises a frequency between 0,5 Hz and 25 Hz, especially between 2 Hz and 15 Hz, especially between 5 Hz and 10 Hz.

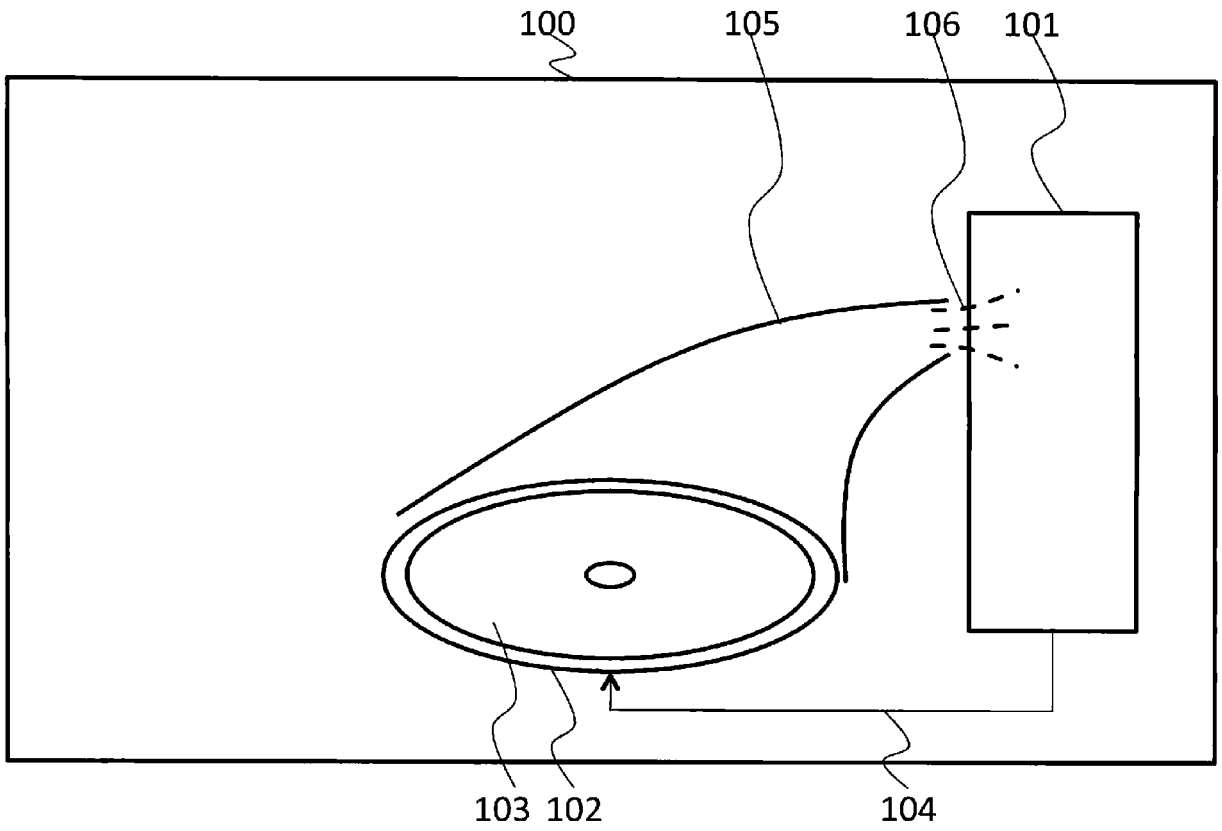

Fig. 1

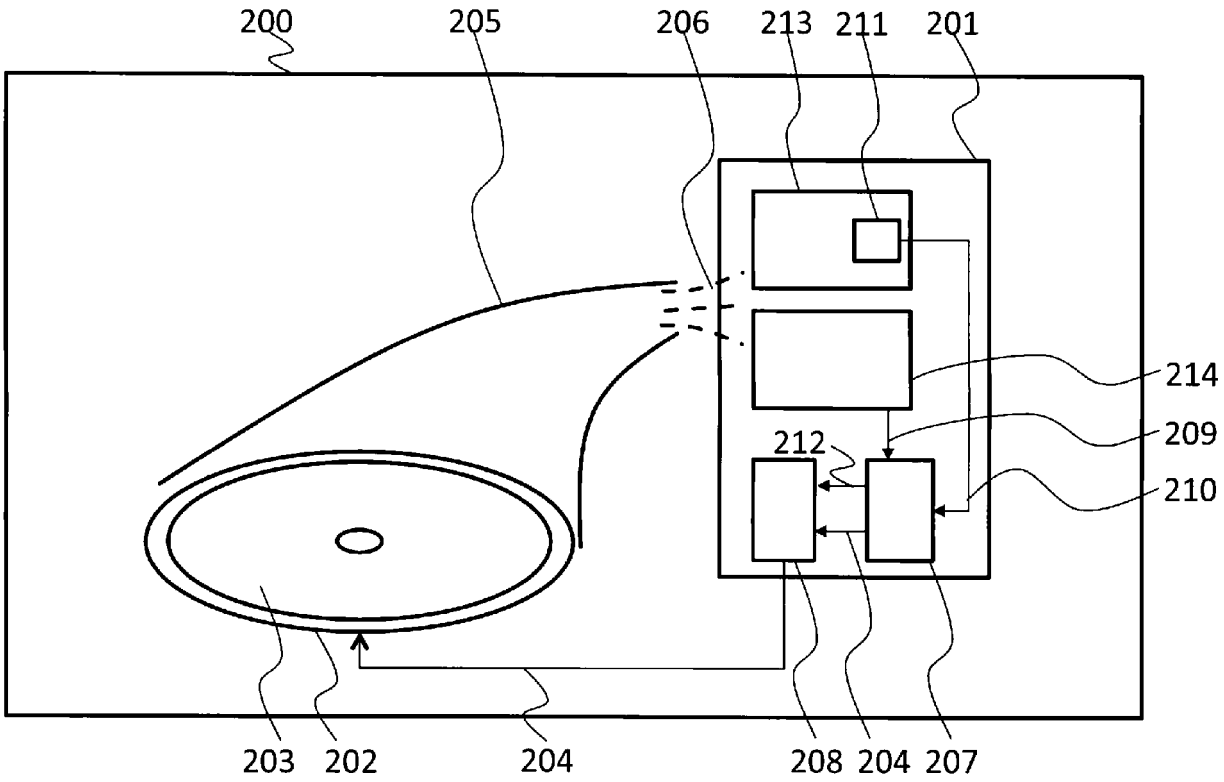

Fig. 2

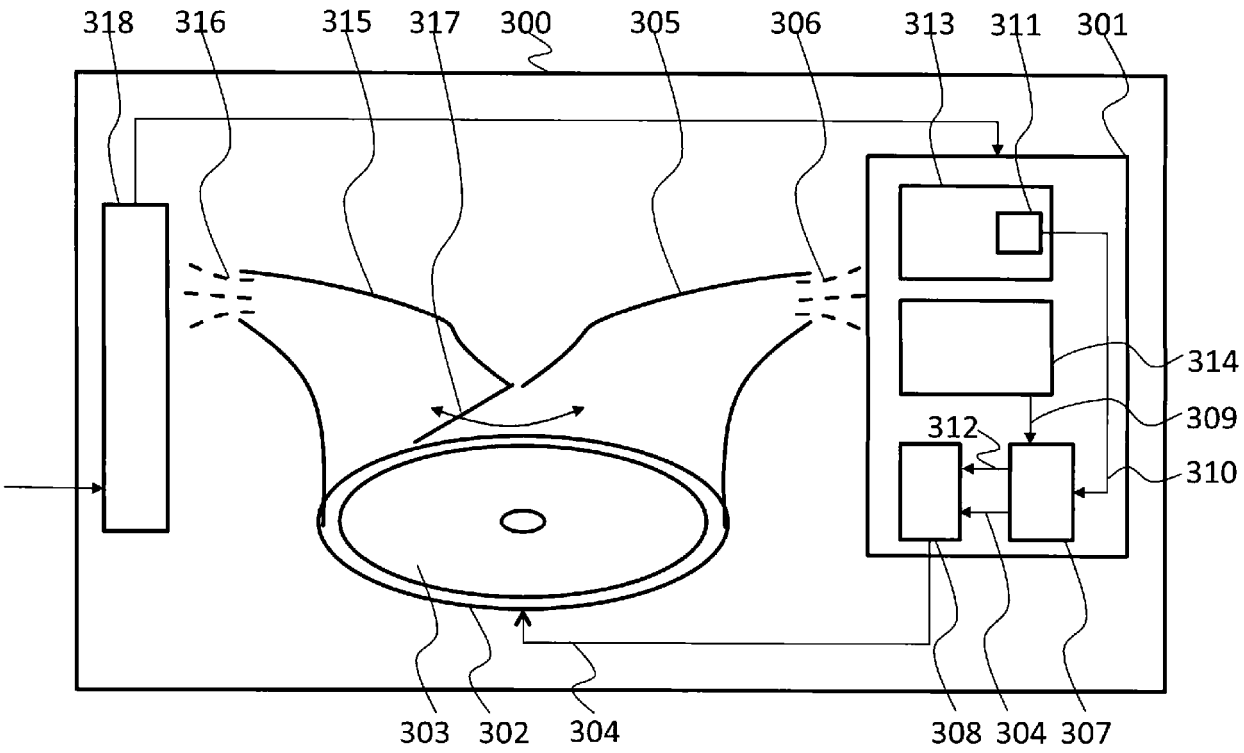
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Fig. 3

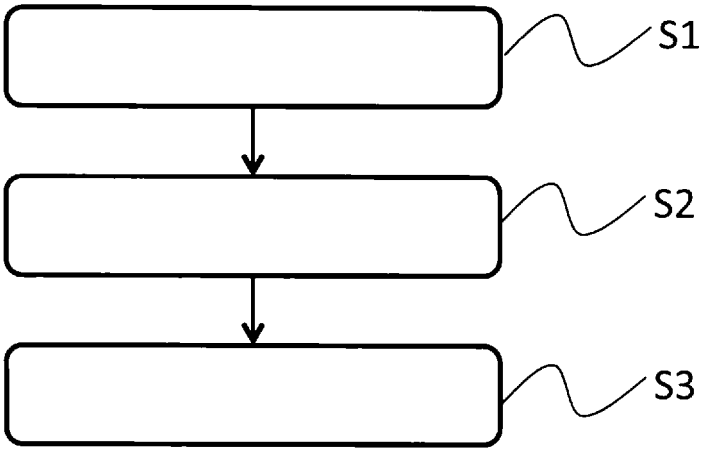

Fig. 4

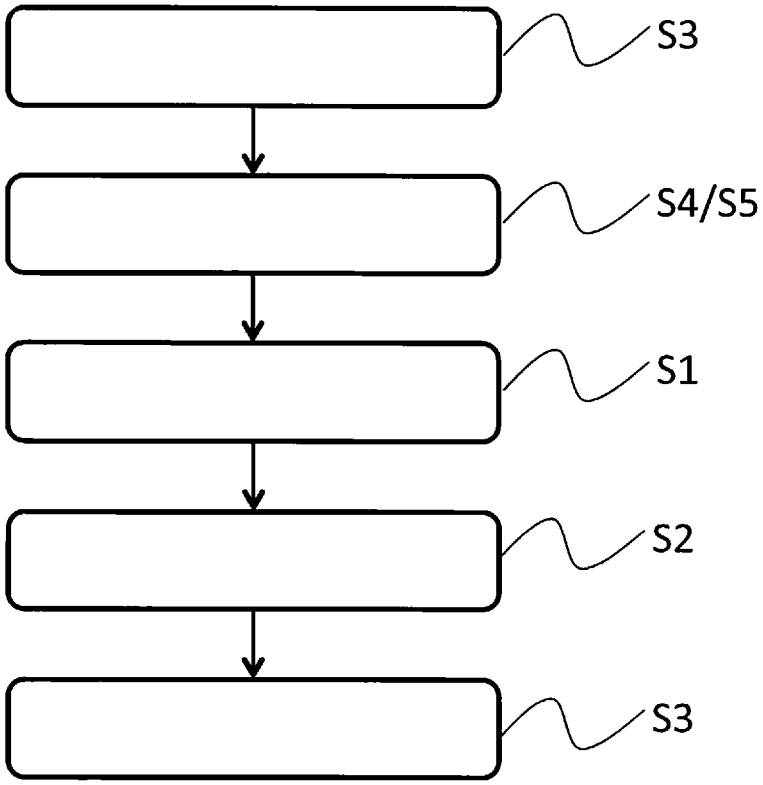

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 17 16 2988

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	27 July 2017	Lörch, Dominik

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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