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- **Jasinski, Jukub Kamil**
Berlin (DE)
- **Rest, Maximilian**
Berlin (DE)
- **Takahashi, Tatsuya**
Berlin (DE)
- **Scaife, Iarla Brendan**
Berlin (DE)

(71) Applicant: **Korg Germany GmbH**
10997 Berlin (DE)

(74) Representative: **Putzke, Sascha**
Wolfenbütteler Straße 45
38124 Braunschweig (DE)

(72) Inventors:
• **Hartmann, Fionnbharr Lukas**
Berlin (DE)

(54) **METHOD FOR EXCITING A BODY TO VIBRATE, METHODS FOR PRODUCING A SOUND AND APPARATUS**

(57) The invention relates to a method for exciting a body to vibrate, the method comprising the steps: actuating the body to vibrate; detecting a movement of the

body during vibration of the body; outputting a signal representing the movement of the body; and controlling the vibration of the body on the basis of the signal.

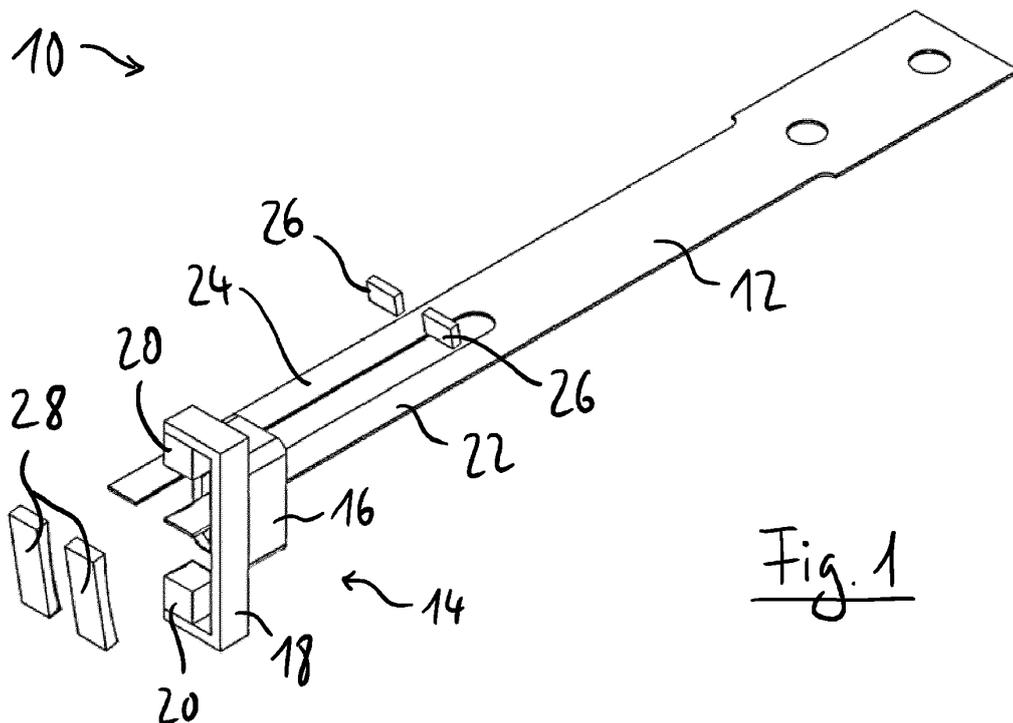


Fig. 1

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Description

[0001] The invention relates to a method for exciting a body to vibrate, methods for producing a sound and an apparatus.

[0002] Various technical applications require exciting a body to vibrate. For example, in electric musical instruments, such as electric pianos or electric guitars, there is typically a physical body resonating at a certain frequency upon actuation. The movement of the body is typically detected and a corresponding signal is output in order to produce a sound on the basis of the signal. Typically, the body is actuated by mechanical means. In the case of an electrical piano, for example, by means of a hammer. In the case of an electric guitar, for example, by means of a musician's fingers or a plectrum.

[0003] Another example of a technical application requiring excitation of a body to vibrate is the field of haptic feedback. A common realization of a haptic feedback unit is a vibration motor comprising a rotational motor equipped with an eccentric.

[0004] A drawback in the described applications is that the vibration behavior of the body will largely depend on its physical properties and may comprise undesired qualities, such as decay of vibration or vibration at undesired frequencies, modes and/or amplitude.

[0005] It is an object of the invention to improve methods for exciting a body to vibrate, such that the quality of vibration can be improved.

[0006] This object is achieved by a method for exciting a body to vibrate in accordance with claim 1. This method comprises the steps: actuating the body to vibrate; detecting a movement of the body during vibration of the body; outputting a signal representing the movement of the body; and controlling the vibration of the body on the basis of the signal.

[0007] This method provides for an advantageous control over the vibration behavior of the body and, thus, for a high degree of quality of vibration. The method essentially employs a feedback control by detecting the actual movement of the body and feeding back a signal representing this movement in order to control the vibration of the body. The solution is rather simple and yet provides for a wide range of vibration behaviors, which can be achieved through this control.

[0008] In general, the body may be - in full or in part - any kind of body, such as a solid body, a liquid body and/or a gaseous body, such as air. In a preferable embodiment, the body is a solid and/or rigid body. It can for example be made of plastic, carbon, glass, wood and/or metal, such as aluminum or a ferromagnetic metal, such as steel, or a composite of at least two of the named materials.

[0009] Before feeding back the signal, which represents the movement of the body, for example a signal from a displacement sensor, various kinds of preprocessing steps can be performed on the signal. Some of those kinds are described as examples below.

[0010] In an embodiment, the body is vibrating in a resonating state and/or the body is excited such that it vibrates in a resonant state. The body may generally be a resonating body or resonator. Resonant vibration provides for a highly selective frequency behavior of the vibrating body, which is especially useful in sound production, for example. The vibration of the body may be solely controlled for amplitude, while the frequency is essentially maintained by the fact that the body is vibrating at its resonant frequency. Also, this allows for a rather small power input compared to the achievable amplitude.

[0011] According to a further embodiment, controlling the vibration of the body includes controlling an amplitude and/or a duration of the vibration of the body.

[0012] The vibration of the body may, for example, be simply maintained, e.g. for a predetermined duration. Alternatively or additionally, the vibration of the body may be controlled such that the body vibrates with a predetermined vibration decay curve, preferably one which is different from the "natural", i.e. uninfluenced, behavior. In fact, any kind of amplitude behavior can be realized, and especially in the context of musical instruments this provides for a broad realm of creativity.

[0013] Both actuating and/or controlling the vibration of the body can be performed by an actuator. The same actuator or different actuators can be used for initially actuating the body on the one hand and controlling the vibration of the body on the other hand.

[0014] As an actuator preferably a contactless actuator can be used. However, a contacting actuator, such as a hammer, may also be used and has its own advantages. In an electric piano, for example, a traditional piano hammer may be used in order to provide for a key feeling similar to a real piano. In both an electric piano and an electric guitar the initial sound when striking the vibrating body may be different than the frequency at its resonating state. This initial sound may be difficult to reproduce by a contactless actuator, which is why the combination of a contacting initial actuation and a contactless actuation for controlling the vibration over time may be particularly advantageous.

[0015] In general, the body may, for example, be initially excited by an electronically controlled actuator. As an alternative or additional possibility, the body may be initially excited by a mechanical device operated by a person, such as a musician. Such a mechanical device may be a key-hammer-mechanism, for example in an electric piano, a plectrum on an electric guitar or a bow on a string instrument. In another alternative or additional example, the body may additionally be excited directly by a person, for example by a finger or by blowing air onto the body.

[0016] Preferred working principles for an actuator include mechanical, magnetic, dielectric or piezoelectric actuation. Also, multiple actuators and/or a combination of the mentioned actuator types can be used. According to an advantageous example, the actuator can be a balanced armature driver.

[0017] The nature of this preferably contactless excitation scheme allows for kinetic energy to be injected into the vibrating body via a continuous, arbitrary signal, which is not typically possible in other systems, in particular in musical devices, based on resonating bodies, such as electric pianos, where the resonators are usually excited only by discrete, mechanical events, such as by striking a resonator with a hammer. One example of such an actuator is an electromagnetic driver which converts an arbitrary electrical control signal into motion in the body, for example using a balanced armature driver scheme.

[0018] In another embodiment, detecting the movement of the body comprises measuring a displacement of the body during vibration. A displacement sensor may be used for this purpose.

[0019] The movement of the body may, for example, be detected by means of a sensor. The sensor may preferably be a contactless sensor. The sensor may be an optical, magnetic, piezoelectric or dielectric sensor. Multiple sensors and/or a combination of the mentioned sensor types can be employed.

[0020] According to another embodiment, a signal representing the movement of the body may be processed by a frequency separator. The frequency separator may output at least a first frequency separator output signal. The vibration of the body may be controlled on the basis of the at least first frequency separator output signal. The frequency separator output signal represents movement of the body at the separated frequency or within the separated frequency range. The signal representing the movement of the body and being processed by the frequency separator may be the signal coming directly from the detection of the movement of the body, e.g. the signal output from a motion or displacement sensor. Alternatively, the signal may further be processed before being processed by the frequency separator.

[0021] According to an embodiment, controlling the vibration of the body includes receiving a signal representing the movement of the body, adapting the phase, amplitude and/or shape of the signal, outputting an adapted signal and controlling the vibration of the body on the basis of the adapted signal. The signal representing the movement of the body may be a signal coming directly from a movement or displacement sensor or another kind of signal representing the movement of the body, such as an output signal from a frequency separator. Manipulation of the signal as described improves the quality and degree to which the vibration of the body can be controlled.

[0022] In another embodiment, controlling the vibration of the body includes controlling at least one mode, frequency and/or order of resonance specifically. This further improves vibration control. The vibration and/or the amplitude of a specific mode, frequency and/or order of resonance can for example be amplified or decreased. Different modes, frequencies and/or orders of resonance may be controlled differently, for example one may be

amplified or maintained and one may be decreased in amplitude.

[0023] As regards a mode controlled specifically, the different modes can generally relate to different parts of the body vibrating or to different directions of vibration. For example, when the body is an at least two-prong body, the at least two prongs can vibrate in a common mode, i.e. in parallel, and/or in differential mode, i.e. in an alternating manner. In a preferable embodiment, the vibration of the body includes controlling vibration in a common mode and in a differential mode separately and/or differently.

[0024] As regards an order of resonance controlled specifically, the term "order of resonance" refers to one resonant frequency of potentially multiple resonant frequencies of the body. Thus, a first order of resonance refers to a lowest resonant frequency, a second order of resonance refers to a second lowest resonant frequency, etc. The order may be the first, second or any higher order. Also, multiple orders may be controlled. An order may be separated by means of a frequency separator.

[0025] According to an embodiment, the method comprises shifting the resonant frequency or frequencies of the body. This further improves control over the vibration. In musical instruments, this provides for an even broader potential of creativity.

[0026] In an embodiment, the body comprises a ferromagnetic material, wherein a static magnetic field is applied to the body. This field changes the mechanical behavior of the body and, thus, its vibration behavior and most notably its resonant frequencies. Thus, applying a static magnetic field to a ferromagnetic body is a simple and easily controllable way to change the resonant frequencies of the body. This further improves control over the vibration behavior. The static magnetic field can be applied, for example, by means of a permanent magnet and/or an electromagnet. The static field may also be applied by means of a coil of a balanced armature driver.

[0027] According to an embodiment, the resonant frequency or frequencies are shifted by applying and/or changing a mechanical load on the body. Also, any kind of actuator can be used to change the vibration properties of the body, such as changing its elasticity and/or applying or changing a pre-load-condition.

[0028] According to a further embodiment, the body is an at least two-prong resonating body and/or is fork-shaped. Such a shape allows for a simple and precise design and choice of resonant frequencies of the body. This improves design flexibility. In particular, it allows for more degrees of freedom when designing resonant frequencies of the body.

[0029] The movement of the prongs of the body may be detected by dedicated sensors for each prong. It is possible to actuate and/or control only one prong or both or all prongs individually.

[0030] A resonating body with a two-prong shape and/or a shape of a fork, in particular a tuning fork shape, may be specifically designed to resonate in such a way

that the prongs share a common set of in-phase frequencies of oscillation and that a second set of frequencies is present in the differential motion of the two prongs. Once the motions of the prongs have been detected and converted to electrical signals independently, the common mode and differential mode frequencies can be isolated by adding and subtracting the detected signals from each prong's pickup for further processing.

[0031] In other advantageous examples, the body may be a string or a reed.

[0032] The invention further relates to a method for producing a sound, in particular in a musical instrument, the method comprising exciting a body to vibrate in accordance with a method described above.

[0033] The sound may be produced on the basis of the signal representing the movement of the body and/or on the basis of a frequency separator output signal. The same sensor or sensors can be used for sound production and controlling the vibration of the body, which is particularly advantageous regarding control quality and costs.

[0034] The signal representing the movement of the body may be further processed before producing the sound. For example, the signal may be amplified. Alternatively or additionally, the signal may be processed by an effects unit.

[0035] The sound may, for example, be output by a loudspeaker. The signal and/or the sound may be recorded by means of a recording device. Also, the sound may be amplified and/or further processed with other more complex sound shaping and/or reproducing circuitry.

[0036] The invention further relates to a method for producing a sound in a musical instrument, the method comprising the steps: actuating a body to vibrate by means of a contactless actuator, preferably an electromagnetic actuator; detecting a movement of the body during vibration of the body; outputting a signal representing the movement of the body; and producing a sound on the basis of the signal. This method may comprise exciting the body to vibrate in accordance with a method described above and/or producing a sound in accordance with a method described above. The method allows for kinetic energy to be injected into the vibrating or resonating body via a continuous, arbitrary signal, which is not typically possible in other musical devices based on vibrating or resonating bodies. The possibility to inject arbitrary signals allows for a wide range of possible sounds to be produced and thus provides for a large degree of creativity.

[0037] The invention further relates to an apparatus, in particular a musical instrument, comprising: a body configured to vibrate upon actuation, an actuator for actuating the body to vibrate, preferably a contactless actuator; a sensor for detecting a movement of the body during vibration of the body, wherein the sensor is configured to output a signal representing the movement of the body. The apparatus may preferably be configured to execute a method as described above.

[0038] The apparatus may preferably include a feedback control for controlling the vibration of the body on the basis of the signal.

[0039] The apparatus may preferably comprise a sound production unit configured to produce a sound on the basis of the signal.

[0040] Any embodiment and/or feature described herein with regard to a method or apparatus of the invention may be employed to improve another method or apparatus of the invention described herein.

[0041] In the following, further examples are described with reference to the attached drawings:

Fig. 1 shows a system of hardware components for exciting a body to vibrate.

Fig. 2 shows a vibrating body with a contactless actuator.

Fig. 3 depicts a pickup scheme for detecting the movement of a vibrating body.

Fig. 4 depicts a vibrating body vibrating at different modes and at different frequencies.

[0042] In fig. 1, a system 10 includes a resonator or body 12, which is designed in this embodiment with a two-prong shape and essentially with a fork shape. Similar to a tuning fork, the resonating frequencies of the body may be precisely designed and controlled due to its shape.

[0043] The system 10 further includes a contactless actuator 14, which is best visible in fig. 2. The actuator 14 of this embodiment comprises a coil 16, a yoke 18 and magnets 20 attached to the yoke at opposite ends thereof. The actuator 14 essentially operates according to the working principle of a balanced armature driver.

[0044] The body 12 comprises two prongs 22 and 24. In this embodiment, the actuator 14 acts on only one of the prongs, i.e. on prong 22. In other embodiments, both or all prongs may be actuated individually by dedicated actuators or together by one actuator. Prong 22 extends through coil 16 and between the magnets 20.

[0045] Fig. 1 further shows hardware elements of an optical pickup system of the system 10. For each prong 22 and 24 there is an LED 26 and a light sensor 28. The function of the optical pickup system is depicted in more detail in fig. 3. The LED 26 emits light in the direction to the optical sensor 28. The optical pickup system 26, 28 and the prong 22 or 24 are arranged such that a displacement of the prong 22 or 24 from its neutral (middle) position changes how the light from the LED 26 reaches the optical sensor 28.

[0046] The optical sensor 28 may comprise an array of detectors arranged along its length. In this case, the degree of displacement, i.e. the amplitude, may be derived from the information, which detectors receive light and which ones essentially do not. In another example,

the sensor 28 may measure light intensity and the measured intensity provides information on the displacement. Other pickup systems, such as non-optical systems, may also be used. The pickup system for prong 24 is the same as the one for prong 22 in this embodiment, but a different setup is possible.

[0047] Fig. 4 depicts different modes of vibration and different orders of resonance of a vibrating body 12. Figs. 4a and 4b show common modes, i.e. the prongs 22 and 24 oscillate synchronously. Figs. 4c and 4d show differential modes, i.e. the prongs 22 and 24 oscillate alternately. Figs. 4a and 4c depict vibration at a first order of resonance, while figs. 4b and 4d depict vibration at a second order of resonance. One or all of the modes and/or orders depicted here may be controlled separately. One might be dampened and/or one might be amplified or maintained, for example.

[0048] Fig. 5 shows an exemplary control scheme 30 that may be employed to control the vibration of the body 12 described above or another kind of body. The control scheme 30 includes a body 12, an actuator 14 and a sensor 28. The vibration of the body 12 is controlled on the basis of a signal representing the movement of the body 12 by means of a feedback loop. The feedback loop of this embodiment includes further processing steps of the signal originating from the sensor 28 and will be described in more detail below. The individual processing steps are generally not necessary, but individually improve control of the vibration of the body 12.

[0049] The control scheme 30 comprises a frequency separator 32, which receives a signal representing the movement of the body 12, in this case the signal 33 directly coming from the sensor 28. The frequency separator 32 outputs multiple frequency separator output signals, in this case three frequency separator output signals 34.1, 34.2 and 34.3. Each frequency separator output signal 34 represents the movement of the body 12 at a certain frequency or frequency range.

[0050] Each frequency separator output signal 34 is fed into an amplitude control block 36. The amplitude control blocks 36.2 and 36.3 may be configured like amplitude control block 36.1, which will be described in more detail below.

[0051] The control scheme 30 includes an envelope detector 38, which is in this embodiment a part of the amplitude control block 36. The envelope detector 38 detects an envelope of a signal representing a movement of the body 12, in this case the frequency separator output signal 34.1. The output signal of the envelope detector is fed as a negative into an adder 40 together with a control signal 42 from a control signal unit 44. There may be dedicated control signals 42 and/or control signal units 44 for multiple or each amplitude control blocks 36.

[0052] The frequency separator output signal 34 is also fed into a phase adjustment unit 46. The output signal of the phase adjustment unit is fed into a gain adjustment unit 48. The output signal of the gain adjustment unit is fed into a shape adjustment unit 50.

[0053] The output signal of the shape adjustment unit 50 is fed into a multiplier 52 together with an output signal of the adder 40. An output signal of the multiplier 52 represents an output signal 54.1 of the amplitude control block 36.1. The output signals 54 from the amplitude control blocks 36 are fed into an adder 56. The output signal of the adder 56 is fed into the actuator 14 and, thus, represents an actuator input signal 58. Thus, a feedback loop is established.

[0054] The control scheme 30 further includes an excitation impulse unit 60 outputting an excitation impulse signal, which is fed into a pulse forming unit 62. The output signal of the pulse forming unit 62 is fed into the adder 56. Thereby, the actuator 14 may additionally be used to initiate vibration of the body 12 and not only for maintaining and/or controlling the vibration of the body 12.

[0055] Furthermore, the control scheme 30 comprises an auxiliary input unit 64, an output signal of which is fed into the adder 56. The auxiliary input unit 64 may preferably output and/or inject a broadband signal. Spectral properties of the vibrating body 12 may filter the spectrum of the broadband input signal. This auxiliary input 64 may be used to implement filter banks, delay effects and/or reverb effects. Also, music may be input through the auxiliary input unit 64.

[0056] The actuator 14 may comprise additional circuitry, such as a driver, e.g. a current and/or voltage driver. The sensor 28 may comprise additional circuitry, such as an amplifier, e.g. a high impedance and/or low noise amplifier. In general, an actual implementation of the control scheme 30 may comprise additional circuitry of various sorts and the depiction of the scheme is only of a schematical nature illustrating selected elements.

[0057] Once the body 12 is excited, the amplitude of the body's oscillation at its resonant frequencies can be controlled over time using the scheme 30 presented here in the diagram of fig. 3. In this scheme, each frequency signal 34, which has been extracted electronically from the sensed pick-up signals, undergoes phase, amplitude and shape adaptation. The signal is then subject to amplitude modulation by an error signal 65, e.g. for controlling the feedback gain, before being injected into the input of the actuator 14, in order to keep the resonator excited at its resonant frequency. The error signal can be generated by subtracting a detected envelope of signal 34 from the level desired by the user, which may be - but is not necessarily - conveyed to the system using an envelope generator, as is common in synthesizer systems.

[0058] In the scheme presented here, a physical body 12 is excited into a resonating state by injecting kinetic energy into the body 12 using an actuator 14. The injection of kinetic energy can be achieved for example through mechanical, magnetic, dielectric or piezoelectric means. It is also possible to initially and/or additionally actuate the body 12 manually.

[0059] The resulting complex movement of the resonating body 12 is sensed and converted into an electrical signal. Sensory elements, such as sensor 28, can com-

prise - but are not limited to - optical, magnetic, piezoelectric and dielectric elements. A frequency separator 32 can be added to gain control over a defined number of distinct frequencies. The resulting signals are processed and fed back into the actuator 14 in order to keep the resonator 12 in motion, potentially indefinitely, after exciting it.

[0060] The same signals can also be used to make the distinct resonances of the physical body audible, i.e. to produce a sound. A loud speaker 66 may be used, e.g. together with an amplifier (not shown), to produce a sound on the basis of a signal representing the movement of the body 12, for example on the basis of sensor output signal 33 or (not shown) on the basis of a frequency separator output signal 34 or any other signal of the scheme.

[0061] Subsequent to the envelope detector 38 and/or prior to the adder 40, further processing steps and/or units may be implemented, such as amplitude, phase and/or shape modification as described with reference to units 46, 48, 50.

[0062] Finally, it will be clear that similar to the auxiliary input unit 64, further inputs, especially inputs to the adder 56, are possible to implement. Also, there may be multiple auxiliary input units 64 with different purposes and/or output signals.

List of References

[0063]

10	system
12	body
14	actuator
16	coil
18	yoke
20	magnet
22	prong
24	prong
26	LED
28	light sensor
30	control scheme
32	frequency separator
33	sensor output signal
34	frequency separator output signal
36	amplitude control block
38	envelope detector
40	adder
42	control signal
44	control signal unit
46	phase adjustment unit
48	gain adjustment unit
50	shape adjustment unit
52	multiplier
54	amplitude control block output signal
56	adder
58	actuator input signal
60	excitation impulse unit
62	pulse forming unit

64	auxiliary input unit
65	error signal
66	loud speaker

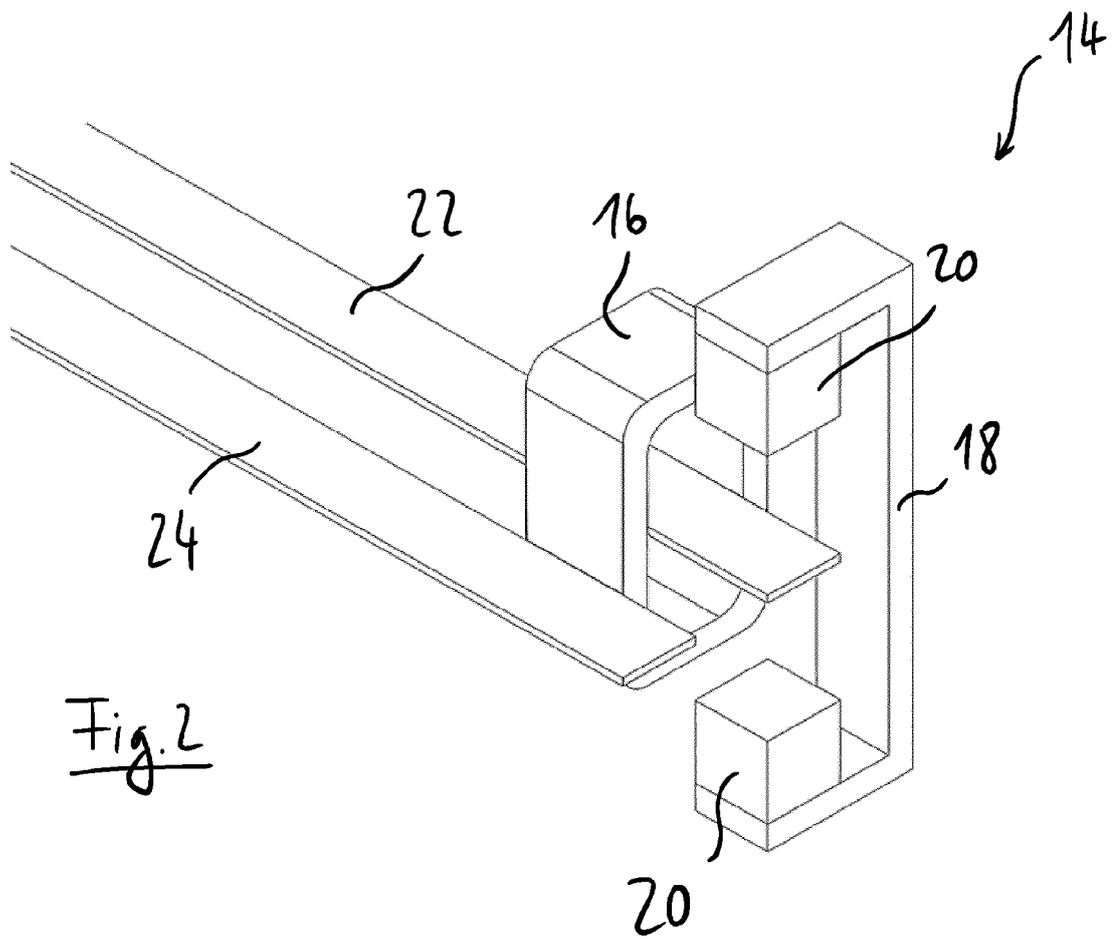
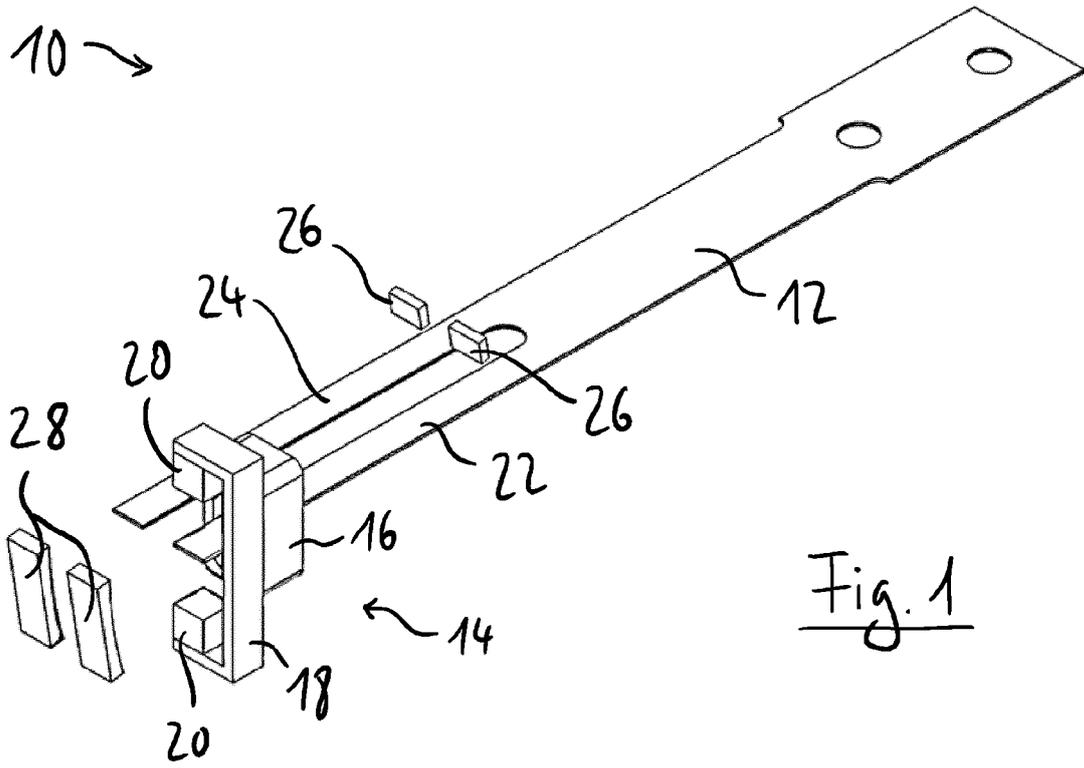
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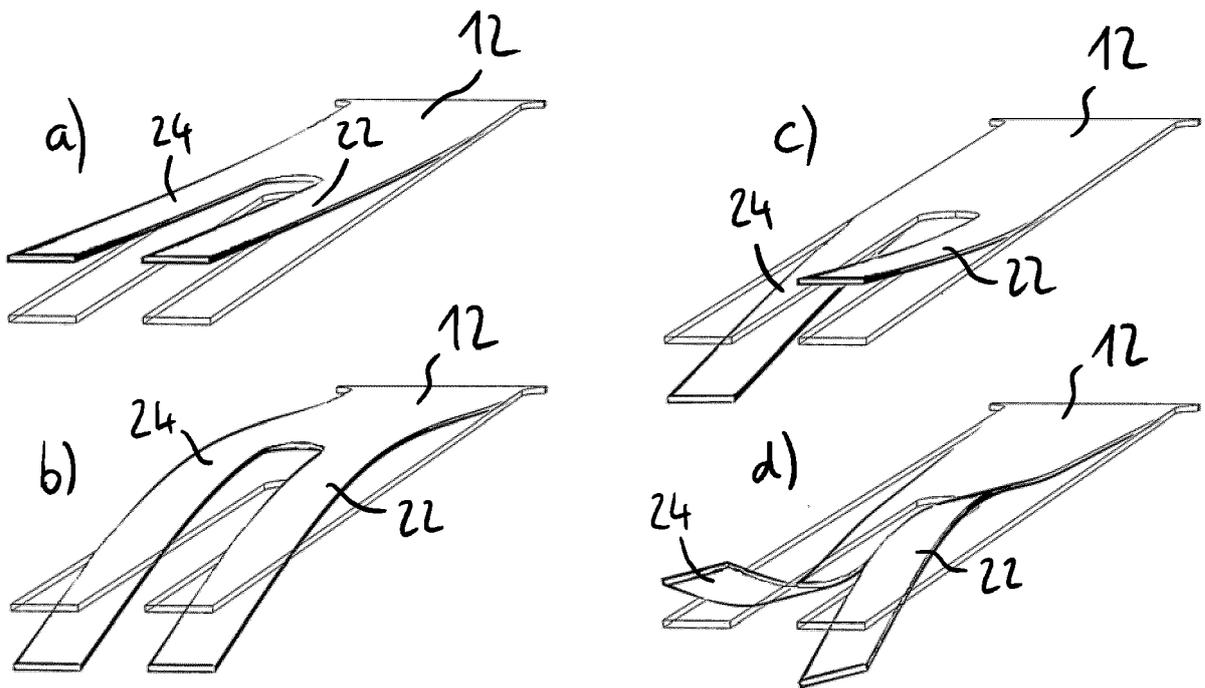
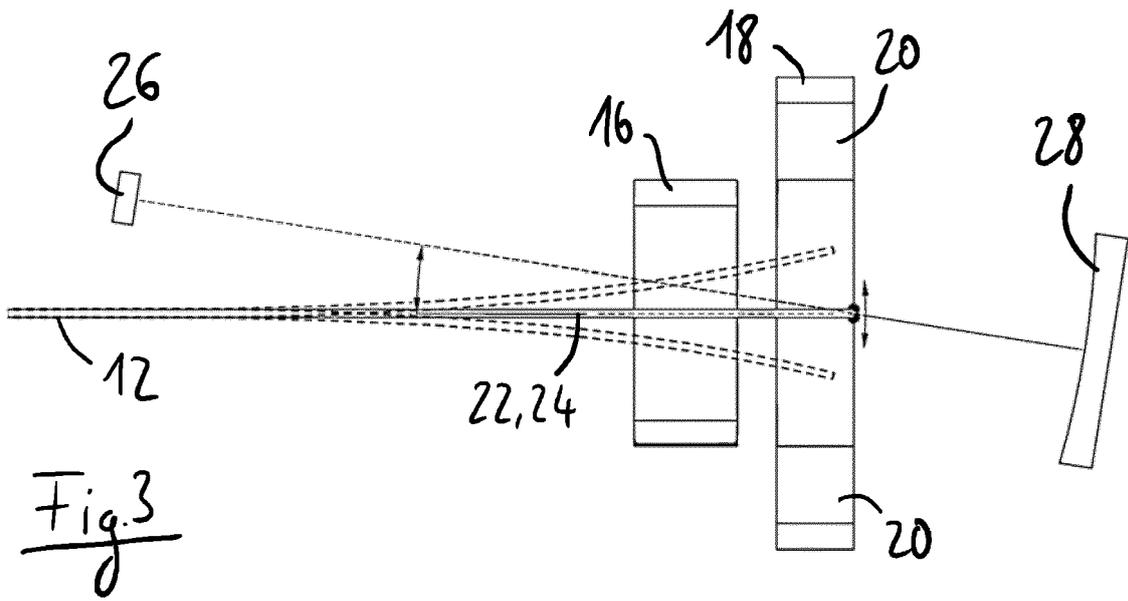
Claims

- Method for exciting a body (12) to vibrate, the method comprising the steps:
 - actuating the body (12) to vibrate, detecting a movement of the body (12) during vibration of the body (12), outputting a signal (33, 34, 54) representing the movement of the body (12), and controlling the vibration of the body (12) on the basis of the signal (33, 34, 54).
- Method according to claim 1, wherein the body (12) is vibrating in a resonating state.
- Method according to one of the preceding claims, wherein controlling the vibration of the body (12) includes controlling an amplitude and/or a duration of the vibration of the body (12).
- Method according to one of the preceding claims, wherein controlling the vibration of the body (12) comprises maintaining the vibration of the body (12).
- Method according to one of the preceding claims, wherein actuating and/or controlling the vibration of the body (12) is performed by an actuator (14), preferably a contactless actuator and/or a mechanical, magnetic, dielectric or piezoelectric actuator.
- Method according to one of the preceding claims, wherein the movement of the body (12) is detected by means of a sensor (28), preferably a contactless sensor and/or an optical, magnetic, piezoelectric or dielectric sensor.
- Method according to one of the preceding claims, wherein a signal (33) representing the movement of the body (12) is processed by a frequency separator (32), which outputs at least a first frequency separator output signal (34), wherein the vibration of the body (12) is controlled on the basis of the at least first frequency separator output signal (34).
- Method according to one of the preceding claims, wherein controlling the vibration of the body (12) includes receiving a signal (34) representing the movement of the body (12), adapting the phase, amplitude and/or shape of the signal, outputting an adapted signal (54) and

- controlling the vibration of the body (12) on the basis of the adapted signal (54).
9. Method according to one of the preceding claims, wherein controlling the vibration of the body (12) includes controlling at least one mode, frequency and/or order of resonance specifically, in particular wherein a common mode and/or a differential mode are controlled specifically.
10. Method according to one of the preceding claims, wherein the body (12) is an at least two-prong body and/or is fork-shaped and/or wherein the body (12) is a resonating body.
11. Method for producing a sound, in particular in a musical instrument, the method comprising exciting a body to vibrate in accordance with the method of one of the preceding claims.
12. Method according to claim 11,
- wherein the sound is produced on the basis of the signal (33, 34, 54) representing the movement of the body (12) and/or on the basis of a frequency separator output signal (34) and/or wherein the signal (33, 34, 54) is further processed and/or amplified before producing the sound.
13. Method according to one of claims 11 and 12,
- wherein the sound is output by a loudspeaker (66) and/or wherein the signal and/or the sound is recorded by means of a recording device.
14. Method for producing a sound in a musical instrument, the method comprising the steps:
- actuating a body (12) to vibrate by means of a contactless actuator (14), preferably an electromagnetic actuator,
- detecting a movement of the body (12) during vibration of the body (12),
- outputting a signal (33, 34, 54) representing the movement of the body (54);
- producing a sound on the basis of the signal (33, 34, 54).
15. Apparatus, in particular a musical instrument, comprising:
- a body (12) configured to vibrate upon actuation, an actuator (14) for actuating the body (12) to vibrate, preferably a contactless actuator,

a sensor (28) for detecting a movement of the body (12) during vibration of the body (12), wherein the sensor (28) is configured to output a signal (33) representing the movement of the body (12), and preferably a feedback control (30) for controlling the vibration of the body (12) on the basis of the signal (33), and/or preferably a sound production unit (66) configured to produce a sound on the basis of the signal (33).







EUROPEAN SEARCH REPORT

Application Number

EP 23 15 2006

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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2018/013491 A1 (DARTMOUTH COLLEGE [US]) 18 January 2018 (2018-01-18) * abstract; figures 1-11 * * paragraph [0011] - paragraph [0025] * * paragraph [0091] - paragraph [0119] * -----	1-15	INV. G10H3/14 G10H3/20 G10H3/22 G10H3/26
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X	FR 2 775 823 A1 (HERVE CHRISTOPHE [FR]) 3 September 1999 (1999-09-03) * abstract; figures 8-9 * * page 5, line 6 - page 8, line 5 * -----	1, 14, 15	TECHNICAL FIELDS SEARCHED (IPC) G10H

The present search report has been drawn up for all claims

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Place of search Munich	Date of completion of the search 16 June 2023	Examiner Lecointe, Michael
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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

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EPO FORM 1503 03.82 (P04C01)

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

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5 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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