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(72) Inventors; and
(71) Applicants: **SKILLINGS, Steve** [US/US]; 250 Clover Hill Road, Whitinsville, MA 01588 (US). **KUOK, Meng, Ru** [SG/SG]; 12 Jalan Kilang Barat, #03-01, Singapore 159354 (SG).

(74) Agent: **LICHAUCO, Faustino**; Occhiuti & Rohlicek LLP, 321 Summer Street, Boston, MA 02210 (US).

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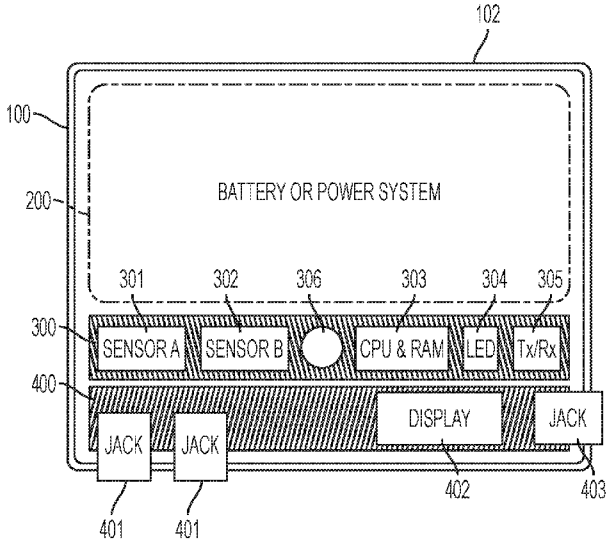

FIG. 1

(57) Abstract: A musical-instrument activity monitor having a sensor and a processor coupled to said sensor. The sensor detects a signal indicative of activity of the musical instrument.

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MUSICAL ACTIVITY MONITOR

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application No. 62/360,591 filed July 11, 2016, the contents of which are hereby incorporated by reference in its entirety.

FIELD OF INVENTION

This invention generally relates to devices for management of musical instruments, and in particular, to devices for monitoring activity of musical instruments.

BACKGROUND

Musicians at all skill levels seek to improve their abilities and to maintain their muscular dexterity and stamina. A known way of improving such abilities is to engage in regular practice sessions.

In addition, many musical instrument manufacturers warrant their products against manufacturer's defects. However, it can be difficult to distinguish between manufacturer's defects and customer misuse.

Retail musical instrument stores stock different instruments. In the course of shopping for an instrument, customers will try different instruments. A retail store does not have an effective way to determine which instruments are being tried out the most.

SUMMARY

In one aspect, the invention features a musical-instrument activity monitor having a sensor and a processor coupled to the sensor. The sensor is disposed to detect a signal indicative of activity of the musical instrument.

In some embodiments, the sensor is an environmental sensor. Other embodiments include those in which the sensor is an accelerometer, a temperature sensor, a humidity sensor, a

photo-sensor, a piezoelectric sensor, an EMI sensor, a gyroscopic sensor, a tuner, and a GPS unit.

The sensor, in some embodiments, attaches to an actuator of the musical instrument. Examples of actuators include a drumstick, a bow, a mallet, and a plectrum.

In other embodiments, the sensor attaches to the body of the musical instrument.

Sensors also include those that detect an acoustic signal produced by the musical instrument, those that are disposed in a microphone, in which case the musical instrument would be the singer's vocal cords, those that detect motion of the musical instrument, and those that record an acoustic signal produced by the musical instrument.

A variety of ways are available to attach the sensor, including a clamp, a suction device, a magnet, glue, a hook-and-loop fastener, or a screw.

The sensor can also be an internal sensor. These internal sensors sense something about the state of the activity monitor itself. Examples include a sensor that measures an available power level for the activity monitor, and a sensor that measures an internal temperature the activity monitor.

Some embodiments also have a communication interface for establishing communication between the activity monitor and an external device. Such an interface can establish wireless communication between the activity monitor and an external device. Alternatively, it can establish communication between the activity monitor and an external device over a wire.

Regardless of the nature of the link, whether it is wired or wireless, the communication interface can establish communication between the activity monitor and many other

devices. Examples of devices with which the activity monitor could communicate include a personal computer, a tuning actuator, a smart phone, and even a cloud-based platform. Information shared can include information representative of musical instrument activity.

Among the embodiments are those that also have a display for displaying information derived from a signal provided to the processor by the sensor.

In some embodiments, the musical-instrument activity monitor has a battery for providing power to the sensor and the processor. The battery can be either rechargeable or replaceable.

The processor is configured to determine one or more states of the instrument. For example, in some embodiments, the processor determines, from data provided by the sensor, that the instrument is at rest. In others, it determines, from data provided by the sensor, that the instrument is in motion. In yet others, it determines, from data provided by the sensor, that the instrument is being played.

The processor is also useful for identifying a potential source of damage to an instrument. For example, in some embodiments, the processor determines, from data provided by the sensor, that the instrument has sustained a shock in excess of a predetermined shock threshold, or that it has been stored in an environment having a humidity that is outside a desired range of humidity, or that it has been stored in an environment having a temperature that is outside a desired range of temperature.

In some embodiments, the processor is configured to calculate a tempo of the music based on a signal from the sensor.

Among the embodiments are those in which a casing encloses the musical-instrument activity monitor. A variety of casings are possible. Some casings are made of a material that is transparent to electromagnetic radiation having wavelengths in a GPS communication band. Others are made of a material that is transparent to electromagnetic radiation having wavelengths in a band designated for wireless networks. Yet others are configured such that, when the casing is vibrated by vibration of a first amplitude, the musical-instrument activity monitor is vibrated at a second amplitude that is less than the first amplitude. These would be shock-proof or essentially shock-proof casings. Casings can be made of a wide variety of materials including metal, plastic, wood, rubber, and combinations thereof.

Some casings protect against humidity. These are configured such that a value of relative humidity outside the casing is higher than a value of relative humidity inside the casing. Other casings are water-resistant or waterproof. In these embodiments, the casing is configured such that water outside the casing fails to penetrate the casing.

Among the embodiments that have a casing are those that also have a modular attachment configured to couple to a universal attachment that is common to plural musical instruments. In these embodiments, the casing is attachable to a first musical instrument by mating the modular attachment to a first universal attachment that is attached to the first musical instrument. It is then detachable from the first musical instrument and attachable to a second musical instrument by mating the modular attachment to a second universal attachment that is attached to the second musical instrument. In this embodiment, the second universal attachment is identical in structure to the first universal attachment.

Some embodiments feature a metronome. In these embodiments, the processor is configured to compare a signal from the sensor with a signal provided by the metronome to evaluate maintenance of correct tempo.

Embodiments further include those in which the processor is configured to determine a frequency response of the musical instrument to a stimulus and those in which it is configured to determine an impulse response of the musical instrument to a stimulus.

The device may also act as an actuator, in that it may change some aspect of the musical instrument, as desired by the musician, teacher, or manufacturer. For example, the device may send data to automated tuner motors, for a musical instrument with that capability on the musical instrument, so that a musician can have multiple tuning templates and styles, called "alternate tunings" that are hard to do quickly by hand.

In some embodiments, the device may work in concert with other devices connected to the musical instrument, such as an electronic magnetic pickup system for a guitar, a mechanical proximity sensor for a bass drum pedal, a vibration sensor for a cymbal, a microphone preamp, or another sensor system, and work with a plurality of device's data to share, store, process, compound, report, transmit and receive data to help the musician with their performance or practice, or to protect the musical instrument from damage, or a plurality of benefits for a musician.

Some musicians play in groups/bands, and the devices may work with other band members' devices to record group/band related data during a practice or live performance. The devices may share information device-to-device, through a smart phone or computer, or a "cloud" platform.

A device connected to a microphone, or microphone system, provides for a novel way to collect musician activity data via a microphone, humidity sensor, vibration sensors, accelerometers, and other sensors. High quality microphones are sensitive to saliva accidentally projected into the microphone capsule, and a sensor could give a musician, or club owner, data about the humidity level inside the microphone to ensure it gets cleaned and dried at appropriate intervals.

The device may be connected to a "cloud" platform that can provide advanced analytics of their data to do predictive analysis on replaceable components like strings, reeds, and drum heads. Drum heads and strings fail catastrophically by breaking without warning, rendering the musical instrument significantly impaired or unusable, forcing musicians to stop a performance, or to change strings and heads well before their duty cycle is complete, so as to avoid a catastrophic failure at an inopportune time. Since each musician has different techniques, it is impossible for manufacturers to predict a mean time before failure for their replaceable parts, but with a sensor, data collection and computer resources, a user can start to develop a usage profile for each of their musical instrument s and save money by not changing replaceable items ahead too soon in their duty cycle.

The device may also be connected to a recording system that captures audio and "tags" it with the appropriate metadata for the recording session including, but not limited to, which musical instrument is used in recording the song, a date stamp, geotagging, and a plurality of other useful data that is associated with the recording being made via the musical instrument.

Alerts and notifications can be set to automatically be sent to the device, to a smart phone or to a "cloud" platform from a plurality of systems, from within the device's own

system, from a smart phone or computer, or a "cloud" platform. The alerts may be design to alert a musician, parent, teacher, or other interested party, to different states, trends, recommendations, or artificial intelligence insights. Likewise, the user, or their parent, teacher, or interested party may be able to send notifications to the user's smart phone, computer or "cloud" platform account to alert, encourage or reward a user, or any plurality of notification types and methods that are useful for the user at the device, their smart phone, tablet, computer, smart television, social network, etc.

The device, when transmitting data to a musical instrument manufacturer's data systems, provides information about environmental history like humidity and temperature, and user induced events like drops or string breakage frequency that can help determine a product's recommended repair regiment, improve quality of the design of the product, and provide other innovative ways to improve musical instrument quality.

In some embodiments, various structures and shapes may be designed and configured to optimize, the performance of the sensors, the mounting location for data transmission, the attachment scheme, the musical instrument aesthetics, and other aspects, such that the device is performing at its best for each users' particular needs.

The data collected can be shared by the user on a social network for general and fan viewership, "gamification" applications where a user challenges a friend to a game such as "playing time per week." The musical instrument's identity and history may be stored for maintenance purposes and to improve resale value.

A device and system that allows a musician to monitor their activity level, track their musical instrument s usage, provide environmental data, alert/notify them of a plurality of

things has advantages for musicians, music teachers and more. By connecting the device to a musical instrument, or installing it in a musical instrument, or a musical instrument tool like a drum stick, the device enables a musician to retrieve and use data about their playing and progress. Connecting the device to other devices, smart phones, computers and/or a "cloud" platform, and backing up the data, analyzing the data and sharing the data to a social network, brings new types of collaboration, coaching and "competition" to musicians that can greatly enhance their time spent with their musical instrument, improving their skills, building their stamina, and increasing their understanding of their performance characteristics and musical instrument's general "health."

These and other aspects of the invention will be apparent from the following detailed description and the accompanying drawings, in which:

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 shows the components of a representative activity monitor;

FIG. 2 shows the activity monitor of FIG. 1 in communication with a digital information-processing device that is in communication with a cloud-based platform; and

FIGS. 3-5 shows the activity monitor of FIG. 1 connected to different kinds of musical instruments;

DETAILED DESCRIPTION OF EMBODIMENTS

FIG. 1 shows an activity monitor **100** that has a power section **200**, a control section **300**, and an I/O section **400**, all of which are integrated within a case **102**.

In some embodiments, the power section **200** converts AC into DC via a transformer. In other embodiments, an AC to DC transformer is outside the casing **102**, in which case the power section **200** processes DC power. In yet other embodiments, the

power section **200** has an internal battery, such as a rechargeable battery pack, or a replaceable battery like a "AA" or "coin cell" style, that supplies a suitable DC voltage for powering the activity monitor **100**.

The control section **300** includes an environmental sensor **301** and an internal sensor **302**. The use of a singular form "sensor" for referring to the environmental sensor **301** and the internal sensor **302** is for syntactic convenience and is not intended to mean that the sensor is limited to sensing only a single variable. For example, it is quite possible to refer to an apparatus that senses *n* variables to be a single sensor that measures *n* variables rather than *n* separate sensors each of which measures one of *n* variables.

An environmental sensor **301** senses one or more external variables. These are often indicative of the musical instrument's activity or its storage conditions. Examples of an environmental sensor **301** include any one or more sensors selected from a set that comprises a vibration sensor, an accelerometer, a temperature sensor, a humidity sensor, a photo-sensor, a gyroscope, and a GPS unit.

An environmental sensor **301** that senses vibrations is useful since vibrations, particularly those that are within the range of the musical instrument, are indicative of a musician's playing time. Depending on their amplitude or frequency distribution, certain vibrations may be indicative of a shock associated with dropping the musical instrument.

An environmental sensor **301** that senses acceleration is useful since acceleration is indicative of musical activity. For example, an accelerometer on a bow, drumstick, a plectrum, or a trombone slide would certainly provide information on a musician's total playing time. Certain acceleration profiles

may also be indicative of a shock associated with dropping the musical instrument.

An environmental sensor **301** that measures temperature and humidity is also useful since such information is indicative of conditions under which the musical instrument has been stored. This is particularly important for acoustic instruments that are made of wood, including guitars, violins and the like, and woodwinds.

An environmental sensor **301** that senses light, such as a photo-sensor, is also useful because an extended period of darkness is indicative of time during which the musical instrument has not been in use.

An environmental sensor **301**, such as a gyroscope, that senses attitude also provides information regarding playing time as well as information on the musician's posture, which may be useful in correcting certain bad habits and posture. For example, many wind instruments are best held in a particular orientation to maximize available lung volume.

An environmental sensor **301** can also include a GPS unit. This type of environmental sensor **301** is especially useful for detecting a musical instrument's perambulations in case it is lost or stolen.

Other examples of environmental sensors **301** include piezoelectric sensors and EMI sensors.

In some embodiments, the environmental sensor **310** is one that is sensitive to audio signals. In such cases, the environmental sensor **310** may also be one that records the audio signals so that signal processing algorithms may be applied to them. Or, the environmental sensor **310** can act as a tuner and provide information on whether the instrument is in tune and remains in tune, and if not, the rate of change of pitch of the

instrument. This information on stability of pitch may be useful in diagnosing difficulties with the instrument.

An internal sensor **302** monitors internal variables. An example of an internal sensor **302** is a battery-level sensor. Another example of an internal sensor **302** is a temperature sensor that measures how warm the activity monitor **100** is. These internal sensors **302** are in communication with an on-board CPU **303** and provide useful feedback for assisting use by the CPU **303** in controlling the activity monitor **100**.

In some embodiments, the CPU **303** connects to a display **304**. In these embodiments, the CPU **303** provides information from the environmental sensor **301** and the internal sensor **302** to the user via the display **304**. Examples of a suitable display **304** include LED displays and LCD displays. Examples of such information include pitch, which enables the activity monitor **100** to act as a pitch tuner. Other information includes activity time and recording state.

In some embodiments, the CPU **303** connects to a transceiver **305** for exchanging data with another digital information-processing device **500**, as shown in FIG. 2. Examples of a digital information-processing device **500** include a smart phone **501**, computer **503**, a tablet **502**, or a network device.

In some embodiments, the digital information-processing device **500** controls operation of the activity monitor **100**. Communication between the digital information-processing device **500** and the activity monitor **100** can be established by a wired connection **701** or a wireless connection **700**.

Since there may be times when a digital information-processing device **500** is neither available nor convenient, it is useful to integrate, into the control section **300**, user-operable control elements **306**. Examples of such user-operable

control elements **306** include knobs, buttons, and a touch-screen interface.

In other embodiments, the transceiver **305** functions as an actuator. For example, certain musical instruments have motorized tuning heads. In such cases, the CPU **303** could use the transceiver **305** to instruct the tuning heads to rotate based on some user desired state. For example, if an environmental sensor **301** detects a pitch that is flat, the CPU **303** may use the transceiver **305** to send an instruction to a motorized tuning head to sharpen the pitch.

The I/O section includes one or more input jacks **401, 403.** The control section **300** controls the input jacks **401, 403** to permit different input options. Examples of different input options include receiving power from an external power supply or another activity monitor **100**, or causing data transmission via a wire using an input jack **401, 403.**

Once the data is transferred to a digital information-processing device **500** it can be manipulated locally within the digital information-processing device **500.** Alternatively, it can be further transmitted to a cloud-based platform **600,** either via a wireless connection **700** or a wired connection **701.** The cloud-based platform **600** can then be used for backing up data, for carrying out additional computations, and for any other data processing.

In some embodiments, the activity monitor **100** bypasses the digital information-processing device **500** and communicates directly with the cloud-based platform **600.** This connection can be established via a wireless connection **700** or a wired connection **701** with a network router or other communication device connected to the activity monitor **100.**

In some embodiments, the activity monitor **100** may act as its own network router and connect directly to the cloud-based

platform **600**. This connection can be established via a wireless connection **700** or a wired connection **701**.

As described in further detail below, once data is stored on either the cloud-based platform **600** or the digital information-processing device **500**, the user can carry out numerous data-processing tasks based on that data.

Software backups of states and function preferences can be saved to either the digital information-processing device **500** or to the cloud-based platform **600** for recall and reloading on any activity monitor **100**. The settings stored on the digital information-processing device **500** and/or the cloud-based platform **600** can be transmitted to a plurality of activity monitors **100**, to one or more digital information-processing devices **500**, and to a social network to be made available for sharing with other users and collaborators, such as other musicians, band members, teachers, coaches, professors, and instrument manufacturers.

In some embodiments, the digital information-processing device **500** or the cloud-based platform **600** can be used as a vehicle for providing updates to the software on the activity monitor **100**. These updates can provide bug fixes or add new features.

The activity monitor **100** thus provides the user with useful feedback, either directly via its own display **304** or via the display of a digital information-processing device **500**. Thus, feedback information includes information about status of the activity monitor **100** itself.

For instance, in those embodiments in which the power section **200** relies on a battery, the user can set a particular battery minimum level. When the battery discharges to this level, the activity monitor **100** alerts the user via the display of the digital information-processing device **500**.

Additionally, the cloud-based platform **600** can analyze data over time and make recommendations to the user via a display of a digital information-processing device **500** or via the device's feedback systems **304, 402.** Examples include recommendations pertaining to sharing player time, technique feedback, and other performance analytics.

The activity monitor **100** thus permits a musician to create data that can be used immediately, or at a later date to help musicians improve, enjoy, or log their playing. Likewise, the activity monitor **100** permits a musical instrument to collect usage data, data concerning its condition, and other information that is helpful in ascertaining the overall condition of the musical instrument.

The activity monitor **100** creates activity data in different ways based on the kind of musical instrument it is intended to monitor. In general, there are three classes of musical instruments, shown in FIGS. 3-5.

FIG. 3 shows a first class in which the musical instrument is an essentially unitary body that produces a vibration representative of music. In some cases, the body of the musical instrument provides amplification. Examples include the acoustic guitar **801**, the acoustic piano **804**, and the saxophone **805.** In other cases, the amplification is electrical. Examples include the electric guitar **802** and the electric bass **803.** In other cases, the sound itself is idiophonic but indicative of at least the rhythmic component of music. This is the case with the drum set **806.**

In the foregoing types of instruments, it is useful for the processor **303** to analyze various spectral properties of a detected acoustic signal, such as frequency response of the instrument to a particular note or a particular chord, or its impulse response. These can be used to provide early warnings

of an incipient defect. For example, a wooden body that is beginning to split can sometimes alter the spectrum of a waveform in a subtle way that is not immediately perceptible.

In all the foregoing cases, there is an easily accessible analog signal that is representative of music. In these cases, the activity monitor **100** is mounted directly on the musical instrument. The mounting can be achieved by using a clamp, tape, glue, micro-suction, or hook-and-loop fasteners.

A second class of musical instruments, shown in FIG. 4, does not have an easily accessed analog signal representative of music. These musical instruments make music by creating or modifying electrical signals. Examples shown in FIG. 4 include an amplifier **826**, and an electric piano **828**. Also among these musical instruments are those, like the microphone **827**, that convert acoustic information to electronic information for amplification or signal processing.

For this second class of musical instruments, the activity monitor **100** generates activity data based on the electronic signals generated by the musical instrument, vibration data, musical-instrument motion data, and combinations thereof.

For example, some electronic keyboards **828** or electronic drum kits do not make musically useful acoustic sound when played or struck. Nevertheless, the motion of the keys and the striking of a drum pad provide information indicative of playing time and overall activity level

Many electronic musical instruments also produce musically useful frequency signals that are ultimately turned into sound. Many such musical instruments have a built-in output that is normally connected to an amplifier or recording device. The musical-instrument activity monitor **100** receives such electronic signals using a cable connected to such an output. This provides another source of activity data.

A similar signal is available from a microphone **827**, which captures air vibrations and converts them to electronic signals. These electronic signals may be useful for the activity monitor **100**. Mounting the activity monitor **100** inside the microphone, on the external casing **102**, or integrating it within a cable thus creates a way to capture activity data for musical instruments for which the actual source of vibrations is difficult to access. This is the case for a vocalist, as well as for certain kinds of musical instruments, such as a steel drum.

A third class of musical instruments is similar to the first class but with the addition of an easily accessible actuator. Examples of such musical instruments, as shown in FIG. 5, include a violin **851** and its bow **852**, a drum **806** and its drumstick **853**, and a guitar with its guitar pick.

For example, a violin **851** may have an activity monitor **100** mounted upon or within it to collecting a first set of activity data. Meanwhile, the bow **852** has its own sensor **100a** mounted thereof for collecting a second set of activity data. The first and second sets provide insight into how each of the components is being used by the musician, or their overall condition, such as the hair of the bow, or the humidity of the wood that the violin is made of.

In the case of a drum kit **806**, independent but connected sensors **100b**, **100c**, **100d**, **100e** couple to different components of the drum kit **806**. For example, a first sensor **100b** couples to a cymbal, a second and third sensors **100c**, **100d** couple to different tom-toms, a fifth sensor 100e couples to a bass drum, and a sixth sensor 100f couples to a drumstick. Activity data sets collected from the drums of the drum kit **806** and the drum sticks **853** can provide a variety of useful individual and group data sets.

For example, using such data, one might learn that a drum stick **853** hits a second drum more frequently than it hits a first drum. From this, one can then infer that that the first drum's wear is lower than that of the second drum. This information is useful for scheduling maintenance.

By collecting and analyzing data across a plurality of sensors, a drummer can review performance data, like tempo repeatability and accuracy. To facilitate accuracy in maintaining tempo, it is useful for the activity monitor 100 to have a metronome that keeps time. Using this metronome and data provided by the sensor, the processor is able to identify a fundamental frequency of what is being played and determine an extent to which the drummer, or any other musician for that matter, is maintaining a correct tempo.

By collecting and analyzing the combined data from all of the sensors of an entire band, and combining that with each band member's musical instrument, for example guitar, bass, drums and vocals, useful group data can be collected and analyzed while the band plays together, whether in performance or during a practice session.

Sensors can be mounted on a musical instrument in a variety of ways, including using mechanical fasteners like screws, tapes, clamps, micro-suction, magnets, tape, glue, or hook-and-loop fasteners.

Embodiments also include those in which the casing **102** is any one or more of waterproof, sweat proof, durable, and light.

In some embodiments, the casing **102** has a modular attachment **103** that engages a universal attachment. Each musical instrument in a set of instruments is coupled to a universal attachment. As a result, the casing **102** can be attached and detached from each of those musical instruments.

The casing **102** can be made of plastic, wood, rubber, or any of a variety of materials either alone or in combination.

The materials that comprise the casing **102** are selected for any of a variety of reasons, including aesthetic appeal and reduced weight. In some embodiments, the materials from which the casing **102** is made are selected for their transparency to radio waves. This promotes wireless communications, and in the case of embodiments that include a GPS receiver, the ability to receive a GPS signal.

In some embodiments, the casing **102** is configured to protect internal components from excessive motion, vibration, and humidity. In other embodiments, the casing **102** is configured to optimize performance for a sensor or sensor group.

It is to be understood that the foregoing description is intended to illustrate and not to limit the scope of the invention, which is defined by the scope of the appended claims. Other embodiments are within the scope of the following claims.

CLAIMS

1. An apparatus comprising a musical-instrument activity monitor, said musical-instrument activity monitor comprising a sensor and a processor coupled to said sensor, said sensor being disposed to detect a signal indicative of activity of said musical instrument.

2. The apparatus of claim **1**, wherein said sensor comprises an environmental sensor.

3. The apparatus of claim **1**, wherein said sensor comprises an accelerometer.

4. The apparatus of claim **1**, wherein said sensor comprises a temperature sensor.

5. The apparatus of claim **1**, wherein said sensor comprises a humidity sensor.

6. The apparatus of claim **1**, wherein said sensor comprises a light sensor.

7. The apparatus of claim **1**, wherein said sensor comprises a piezoelectric sensor.

8. The apparatus of claim **1**, wherein said sensor comprises an EMI sensor.

9. The apparatus of claim **1**, wherein said sensor comprises a gyroscopic sensor.

10. The apparatus of claim **1**, wherein said sensor comprises a GPS unit.

11. The apparatus of claim **1**, wherein said sensor is configured for attachment to an actuator of said musical instrument.

12. The apparatus of claim **11**, wherein said actuator comprises a drumstick.

13. The apparatus of claim **11**, wherein said actuator comprises a bow.

14. The apparatus of claim **11**, wherein said actuator comprises a mallet.

15. The apparatus of claim **11**, wherein said actuator comprises a plectrum.

16. The apparatus of claim **1**, wherein said sensor is configured for attachment to a body of said musical instrument.

17. The apparatus of claim **1**, wherein said sensor is configured to detect an acoustic signal produced by said musical instrument.

18. The apparatus of claim **1**, wherein said sensor is disposed in a microphone and said musical instrument is a pair of vocal cords.

19. The apparatus of claim **1**, wherein said sensor is configured to detect motion of said musical instrument.

20. The apparatus of claim **1**, wherein said sensor is configured to record an acoustic signal produced by said musical instrument.

21. The apparatus of claim **1**, further comprising a clamp for mounting said sensor to said musical instrument.

22. The apparatus of claim **1**, further comprising a suction device for mounting said sensor to said musical instrument.

23. The apparatus of claim **1**, further comprising a magnet for mounting said sensor to said musical instrument.

24. The apparatus of claim 1, further comprising glue for causing said sensor to adhere to said musical instrument.

25. The apparatus of claim 1, further comprising tape for taping said sensor to said musical instrument.

26. The apparatus of claim 1, further comprising a hook-and-loop fastener for fastening said sensor to said musical instrument.

27. The apparatus of claim 1, further comprising a screw for fastening said sensor to said musical instrument.

28. The apparatus of claim 1, wherein said sensor is configured to measure an available power level for said activity monitor.

29. The apparatus of claim 1, wherein said sensor is configured to measure an internal temperature said activity monitor.

30. The apparatus of claim 1, further comprising a communication interface for establishing communication between said activity monitor and an external device.

31. The apparatus of claim 1, further comprising a communication interface for establishing wireless communication between said activity monitor and an external device.

32. The apparatus of claim 1, further comprising a communication interface for establishing communication between said activity monitor and an external device over a wire.

33. The apparatus of claim 1, further comprising a communication interface configured to establish

communication between said activity monitor and a personal computer.

34. The apparatus of claim 1, further comprising a communication interface configured to establish communication between said activity monitor and a tuning actuator.

35. The apparatus of claim 1, further comprising a communication interface configured to establish communication between said activity monitor and a smart phone.

36. The apparatus of claim 1, further comprising a communication interface configured to establish communication between said activity monitor and a cloud-based platform.

37. The apparatus of claim 1, further comprising a display for displaying information derived from a signal provided to said processor by said sensor.

38. The apparatus of claim 1, wherein said musical-instrument activity monitor further comprises a battery for providing power to said sensor and said processor.

39. The apparatus of claim 38, wherein said battery is rechargeable.

40. The apparatus of claim 38, wherein said battery is replaceable.

41. The apparatus of claim 1, wherein said processor is configured to determine, from data provided by said sensor, that said instrument is at rest.

42. The apparatus of claim **1**, wherein said processor is configured to determine, from data provided by said sensor, that said instrument is in motion.

43. The apparatus of claim **1**, wherein said processor is configured to determine, from data provided by said sensor, that said instrument is being played.

44. The apparatus of claim **1**, wherein said processor is configured to determine, from data provided by said sensor, that said instrument has sustained a shock in excess of a predetermined shock threshold.

45. The apparatus of claim **1**, wherein said processor is configured to determine, from data provided by said sensor, that said instrument is in an environment having a humidity that is outside a desired range of humidity.

46. The apparatus of claim **1**, wherein said processor is configured to determine, from data provided by said sensor, that said instrument is in an environment having a temperature that is outside a desired range of temperature.

47. The apparatus of claim **1**, wherein said processor is configured to calculate a tempo of said music based on a signal from said sensor.

48. The apparatus of claim **1**, further comprising a casing that encloses said musical-instrument activity monitor.

49. The apparatus of claim **48**, wherein said casing is made of a material that is transparent to electromagnetic radiation having wavelengths in a GPS communication band.

50. The apparatus of claim **48**, wherein said casing is made of a material that is transparent to electromagnetic radiation having wavelengths in a band designated for wireless networks.

51. The apparatus of claim **48**, wherein said casing is configured such that, when said casing is vibrated by vibration of a first amplitude, said musical-instrument activity monitor is vibrated at a second amplitude that is less than said first amplitude.

52. The apparatus of claim **48**, wherein said casing comprises plastic.

53. The apparatus of claim **48**, wherein said casing comprises wood.

54. The apparatus of claim **48**, wherein said casing comprises rubber.

55. The apparatus of claim **48**, wherein said casing is configured such that a value of relative humidity outside said casing is higher than a value of relative humidity inside said casing.

56. The apparatus of claim **48**, wherein said casing is configured such that water outside said casing fails to penetrate said casing.

57. The apparatus of claim **48**, wherein said casing comprises a modular attachment configured to couple to a universal attachment that is common to plural musical instruments, wherein said casing is attachable to a first musical instrument by mating said modular attachment to a first universal attachment that is attached to said first musical instrument, wherein said casing is detachable from said first musical instrument, wherein said casing is attachable to a second musical instrument by mating said modular attachment to a second universal attachment that is attached to said second musical instrument, and wherein said second universal attachment is identical in structure to said first universal attachment.

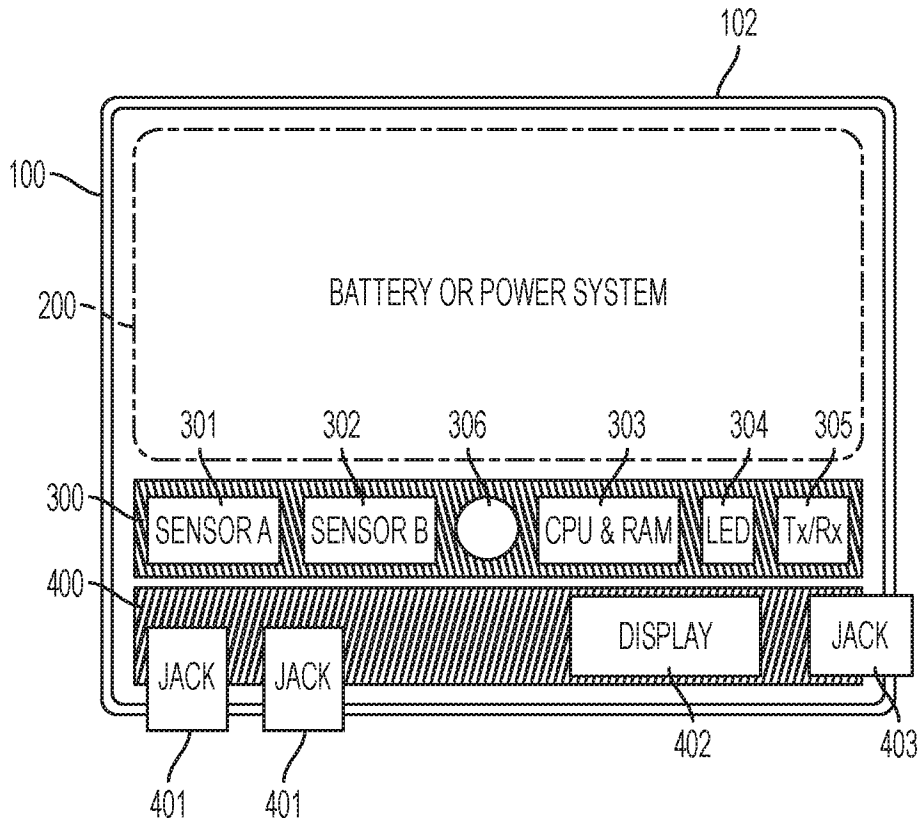
58. The apparatus of claim 1, further comprising a metronome, wherein said processor is configured to compare a signal from said sensor with a signal provided by said metronome to evaluate maintenance of correct tempo.

59. The apparatus of claim 1, wherein said processor is configured to determine a frequency response of said musical instrument to a stimulus.

60. The apparatus of claim 1, wherein said processor is configured to determine an impulse response of said musical instrument to a stimulus.

61. The apparatus of claim 1, further comprising a communication interface, wherein said processor is configured to use said communication interface to share information representative of musical instrument activity on via said communication interface.

62. The apparatus of claim 1, wherein said environmental sensor comprises a tuner.


102
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200
BATTERY OR POWER SYSTEM
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302
306
303
304
305
300
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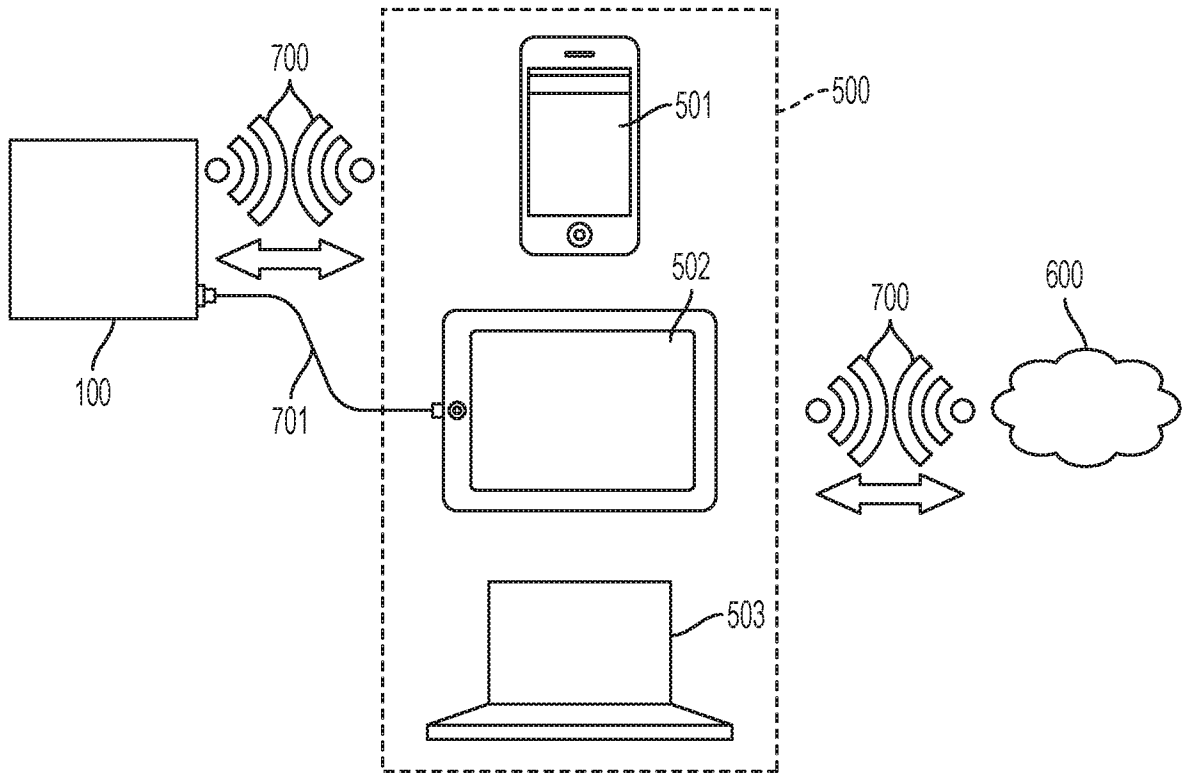
SENSOR B
CPU & RAM
LED
Tx/Rx
400
JACK
JACK
DISPLAY
JACK
401
401
402
403

FIG. 1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701
503

FIG. 2

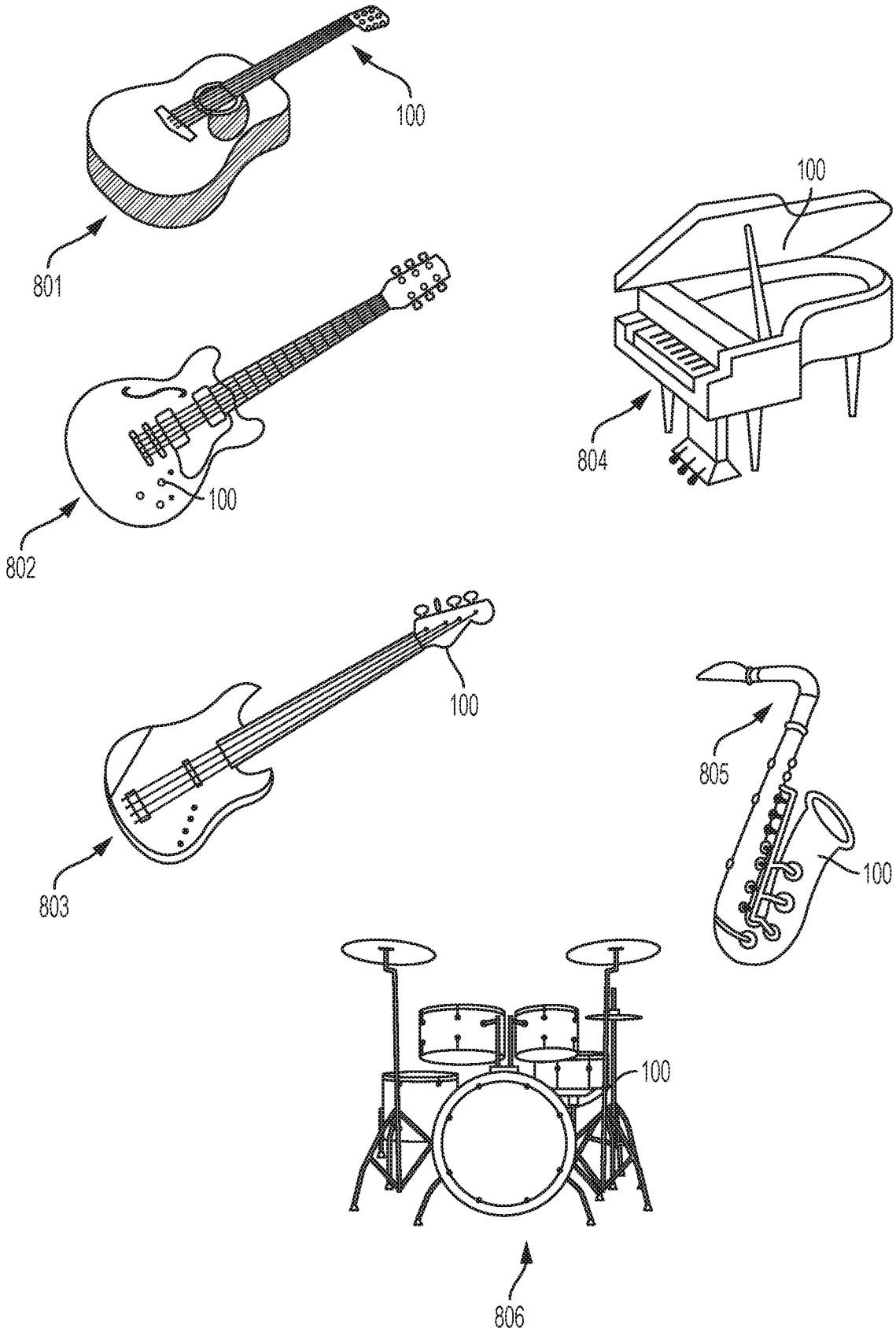
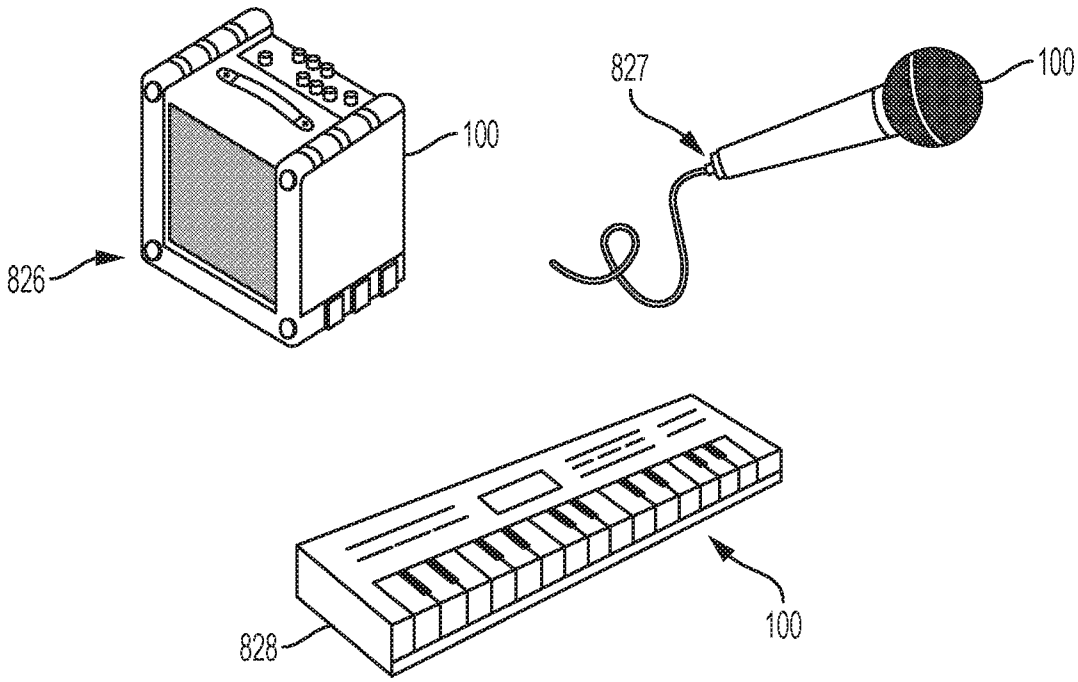


FIG. 3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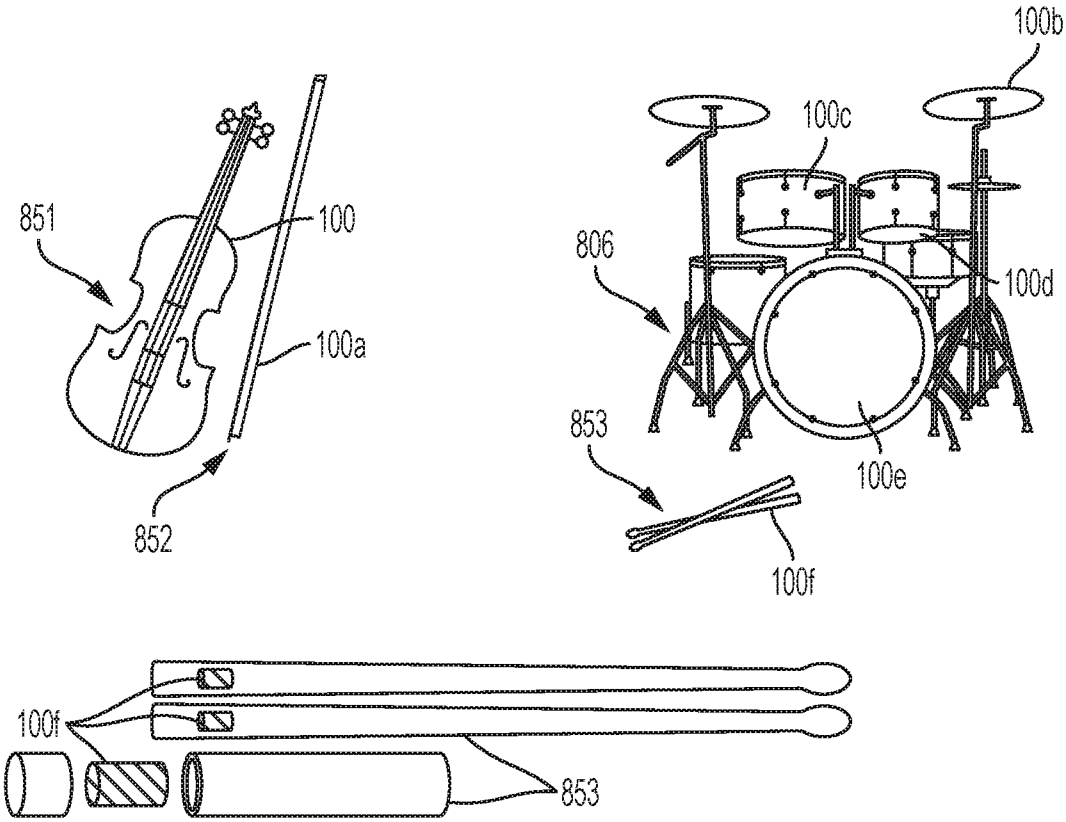
828
100

FIG. 4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852
100b
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806
100d
853
100e
100f
100f
853

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/041507

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A63B 69/36; G06F 3/00; G06F 3/01; G09B 15/04; G10H 1/055; H01H 13/785 (2017.01)

CPC - A63B 69/3608; A63B 2220/10; A63B 2220/24; A63B 2220/34; A63B 2220/805; A63B 2220/833; A63B 2220/836; G06F 3/011; G09B 15/04; G10H 1/0556; H01H 13/785; H01H 2201/036 (2017.08)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2015/085092 A1 (BEAN) 11 June 2015 (11.06.2015), entire document	1-5, 16, 19, 20, 28, 30, 31, 33-36, 38, 41-43, 48, 61
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Y		6-15, 17, 18, 21-27, 29, 32, 37, 39, 40, 44-47, 49-60, 62
Y	US 2015/0122109 A1 (HSU) 07 May 2015 (07.05.2015), entire document	6, 7, 11-15, 21, 23, 27, 32, 51-54, 62
Y	US 2016/0140945 A1 (PARSEK LAB S.R.L.) 19 May 2016 (19.05.2016), entire document	8
Y	US 2008/0173162 A1 (WILLIAMS) 24 July 2008 (24.07.2008), entire document	9, 40
Y	US 2016/0042726 A1 (BEST CASE SCENARIO, LLC) 11 February 2016 (11.02.2016), entire document	10, 29, 37, 44-46
Y	US 2009/0320672 A1 (RASKER) 31 December 2009 (31.12.2009), entire document	12, 14, 39
Y	GROSSHAUSER et al. "Finger Position and Pressure Sensing Techniques for String and Keyboard Instruments." In: NIME. 30 May 2013 (30.05.2013) Retrieved from <https://www.researchgate.net/profile/Tobias_Grosshauser/publication/281595743_Finger_position_and_pressure_sensing_techniques_for_string_and_keyboard_instruments/links/55f2ef2708ae1d9803923979.pdf>, entire document	15, 24

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
04 September 2017	21 SEP 2017
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Authorized officer Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/041507

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2005/0051022 A1 (HODDER et al) 10 March 2005 (10.03.2005), entire document	17
Y	US 2014/0210309 A1 (FUJIFILM CORPORATION) 31 July 2014 (31.07.2014), entire document	18, 25
Y	US 2015/0082970 A1 (CHEKARDZHIKOV) 26 March 2015 (26.03.2015), entire document	22
Y	US 2005/0126375 A1 (HOSLER) 16 June 2005 (16.06.2005), entire document	26
Y	US 2015/0143977 A1 (CLEVX, LLC) 28 May 2015 (28.05.2015), entire document	47, 58
Y	WO 2015/025152 A1 (ARM IP LIMITED) 26 February 2015 (26.02.2015), entire document	49, 50
Y	US 2004/0170444 A1 (YAMADA) 02 September 2004 (02.09.2004), entire document	55
Y	US 2014/0131236 A1 (KUSHNER) 15 May 2014 (15.05.2014), entire document	56
Y	US 2014/0033893 A1 (VILLARAN-VALDIVIA) 06 February 2014 (06.02.2014), entire document	57
Y	EP 0 764 003 B1 (UNIVERSITY OF WASHINGTON) 17 October 2001 (17.10.2001), entire document	59, 60
A	US 4,649,784 A (FULKS et al) 17 March 1987 (17.03.1987), entire document	1-62
A	US 6,148,280 A (KRAMER) 14 November 2000 (14.11.2000), entire document	1-62
A	US 2004/0074379 A1 (LUDWIG) 22 April 2004 (22.04.2004), entire document	1-62
A	US 6,162,981 A (NEWCOMER et al) 19 December 2000 (19.12.2000), entire document	1-62