



(51) International Patent Classification:

H04R 3/04 (2006.01) *H04S 7/00* (2006.01)
H04R 5/04 (2006.01) *G06F 3/048* (2013.01)
H04R 29/00 (2006.01) *G06F 3/0484* (2013.01)

(21) International Application Number:

PCT/US2020/017896

(22) International Filing Date:

12 February 2020 (12.02.2020)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

16/274,068 12 February 2019 (12.02.2019) US

(71) Applicant: **SONOS, INC.** [US/US]; 614 Chapala Street, Santa Barbara, CA 93101 (US).(72) Inventors: **VAUTRIN, Jodi**; 614 Chapala Street, Santa Barbara, CA 93101 (US). **MCDEVITT, Jennifer**; 614 Chapala Street, Santa Barbara, CA 93101 (US). **VALENTE, Daniel**; 614 Chapala Street, Santa Barbara, CA 93101 (US).(74) Agent: **SUNG, Brian, K.**; KPPB LLP, 2190 S. Towne Centre Place, Suite 300, Anaheim, CA 92806 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: METHODS FOR CALIBRATING PASSIVE SPEAKERS WITH A GRAPHICAL USER INTERFACE

(57) Abstract: Systems and methods for detecting and configuring passive speakers within a playback system using a graphical user interface are disclosed. In one embodiment, a method of for detecting and configuration passive speakers in a playback system using a mobile device includes deriving speaker identification data concerning one or more passive speakers connected to an audio device in a playback system based upon at least an electrical signal sent to and returned from the one or more passive speakers, where the electrical signal is sent by the audio device including an audio stage comprising one or more amplifiers, and where the speaker identification data comprises information identifying a type of speaker, and displaying a graphical user interface screen on a mobile device based upon the identified type of speaker, where the displayed information and selectable options are dependent upon the identified type of speaker.

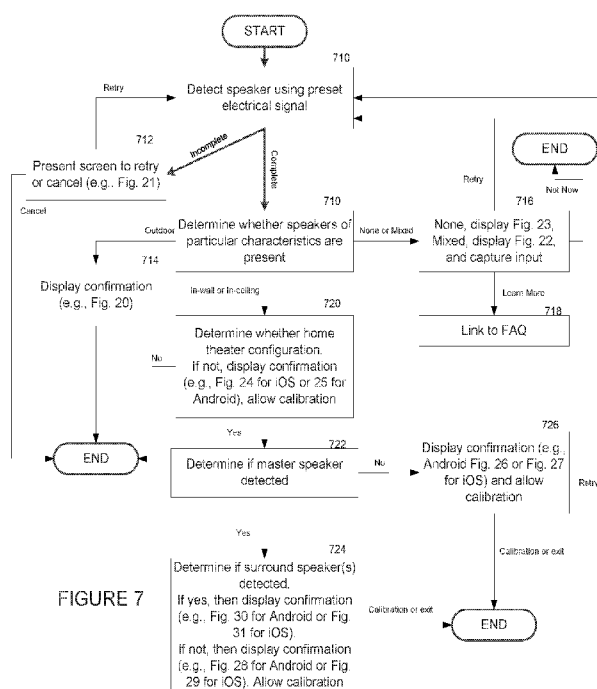


FIGURE 7

METHODS FOR CALIBRATING PASSIVE SPEAKERS WITH A GRAPHICAL USER INTERFACE

FIELD OF THE DISCLOSURE

[001] The present disclosure is related to consumer goods and, more particularly, to methods, systems, products, features, services, and other elements directed to media playback or some aspect thereof.

BACKGROUND

[002] Options for accessing and listening to digital audio in an out-loud setting were limited until in 2002, when SONOS, Inc. began development of a new type of playback system. Sonos then filed one of its first patent applications in 2003, entitled “Method for Synchronizing Audio Playback between Multiple Networked Devices,” and began offering its first media playback systems for sale in 2005. The Sonos Wireless Home Sound System enables people to experience music from many sources via one or more networked playback devices. Through a software control application installed on a controller (e.g., smartphone, tablet, computer, voice input device), one can play what she wants in any room having a networked playback device. Media content (e.g., songs, podcasts, video sound) can be streamed to playback devices such that each room with a playback device can play back corresponding different media content. In addition, rooms can be grouped together for synchronous playback of the same media content, and/or the same media content can be heard in all rooms synchronously.

SUMMARY OF THE INVENTION

[003] Systems and methods for detecting and configuring passive speakers within a playback system using a graphical user interface are disclosed.

BRIEF DESCRIPTION OF THE DRAWINGS

[004] Features, aspects, and advantages of the presently disclosed technology may be better understood with regard to the following description, appended claims, and accompanying drawings, as listed below. A person skilled in the relevant art will understand that the features shown in the drawings are for purposes of illustrations, and variations, including different and/or additional features and arrangements thereof, are possible.

[005] Figure 1A is a partial cutaway view of an environment having a media playback system configured in accordance with aspects of the disclosed technology.

[006] Figure 1B is a schematic diagram of the media playback system of Figure 1A and one or more networks.

[007] Figure 1C is a block diagram of a playback device in accordance with certain embodiments of the invention.

[008] Figure 1D is a block diagram of a playback device in accordance with certain embodiments of the invention.

[009] Figure 1E is a block diagram of a network microphone device in accordance with certain embodiments of the invention.

[0010] Figure 1F is a block diagram of a network microphone device in accordance with certain embodiments of the invention.

[0011] Figure 1G is a block diagram of a playback device in accordance with certain embodiments of the invention.

[0012] Figure 1H is a partial schematic diagram of a control device in accordance with certain embodiments of the invention.

[0013] Figures 1-I through 1L are schematic diagrams of corresponding media playback system zones in accordance with certain embodiments of the invention.

[0014] Figure 1M is a schematic diagram of media playback system areas in accordance with certain embodiments of the invention.

[0015] Figure 1N is a block diagram illustrating a playback device connected to a passive speaker in accordance with certain embodiments of the invention.

[0016] Figure 2A is a front isometric view of a playback device configured in accordance with certain embodiments of the invention.

[0017] Figure 2B is a front isometric view of the playback device of Figure 3A without a grille.

[0018] Figure 2C is an exploded view of the playback device of Figure 2A.

[0019] Figure 3A is a front view of a network microphone device configured in accordance with certain embodiments of the invention.

[0020] Figure 3B is a side isometric view of the network microphone device of Figure 3A.

[0021] Figure 3C is an exploded view of the network microphone device of Figures 3A and 3B.

[0022] Figure 3D is an enlarged view of a portion of Figure 3B.

[0023] Figure 3E is a block diagram of the network microphone device of Figures 3A-3D in accordance with certain embodiments of the invention.

[0024] Figure 3F is a schematic diagram of an example voice input.

[0025] Figures 4A-4D are schematic diagrams of a control device in various stages of operation in accordance with certain embodiments of the invention.

[0026] Figure 5 is front view of a control device in accordance with certain embodiments of the invention.

[0027] Figure 6 is a message flow diagram of a media playback system in accordance with certain embodiments of the invention.

[0028] Figure 7 is a flow chart illustrating a process for setting up speakers in a playback system using a graphical user interface of a mobile device in accordance with certain embodiments of the invention.

[0029] Figures 8-31 are example screens that may be shown as part of a graphical user interface for a speaker detection process on a mobile device in accordance with embodiments of the invention.

[0030] The drawings are for the purpose of illustrating example embodiments, but those of ordinary skill in the art will understand that the technology disclosed herein is not limited to the arrangements and/or instrumentality shown in the drawings.

DETAILED DESCRIPTION

I. Overview

[0031] Embodiments described herein relate to detection and configuration of passive speakers in a playback system and providing information during the configuration on a graphical user interface of a mobile device.

[0032] In some embodiments, for example, a method of for detecting and configuration passive speakers in a playback system using a mobile device includes deriving speaker identification data concerning one or more passive speakers connected to an audio device in a playback system based upon at least an electrical signal sent to and returned from the one or more passive speakers, where the speaker identification data comprises information identifying a type of speaker. A graphical

user interface on the mobile device can provide information concerning the one or more passive speakers during configuration.

[0033] When consumers purchase speakers to set up in a home audio system, they often attempt to install the speakers themselves or have a professional install the speakers. In several embodiments of the invention, one or more speakers become part of an integrated media playback system that recognizes the type and/or characteristics of the speakers to configure them for optimal subsequent audio playback. These can be semi-permanent fixture speakers, such as in-wall or in-ceiling speakers. Furthermore, the speakers can be set up for a particular role in an environment that is suitable for that type of speaker, e.g., outdoor speaker or a specific position in a home theater system. The speakers may be passive speakers that do not have an internal amplifier and are connected to channels of an external amplifier in the playback system. Processes for detecting and configuring speakers that may be utilized in accordance with embodiments of the invention include those disclosed in U.S. Patent Application Serial No. 16/115,525 entitled “Passive Speaker Authentication” (the ‘525 patent), the relevant disclosure of which is hereby incorporated by reference in its entirety. Calibration of speakers can include processes such as those described in U.S. Patent No. 9,706,323 entitled “Playback Device Calibration” (the ‘323 patent) and U.S. Patent Application Serial No. 16/115,524 entitled “Playback Device Calibration” (the ‘524 patent), the relevant disclosures of which are hereby incorporated by reference in their entireties.

[0034] In many embodiments of the invention, setting up speakers involves the use of a mobile device, such as a smartphone or tablet, which has a display screen with a graphical user interface. The display screen may be a touch screen. In several embodiments, the mobile device includes a microphone and/or one or more other playback devices in the playback system include a microphone that can be used in the setup process. The process of setting up the speakers can

incorporate capturing selections on the display screen made by a user, transmitting an audio signal to the one or more speakers, and/or receiving audio played back through the one or more speakers on the microphone of the mobile device and/or playback device(s). In some embodiments, the mobile device used for setup may also be a control device for directing playback of content as described further below.

[0035] While some examples described herein may refer to functions performed by given actors such as “users,” “listeners,” and/or other entities, it should be understood that this is for purposes of explanation only. The claims should not be interpreted to require action by any such example actor unless explicitly required by the language of the claims themselves.

[0036] In the Figures, identical reference numbers identify generally similar, and/or identical, elements. To facilitate the discussion of any particular element, the most significant digit or digits of a reference number refers to the Figure in which that element is first introduced. For example, element 110a is first introduced and discussed with reference to Figure 1A. Many of the details, dimensions, angles and other features shown in the Figures are merely illustrative of particular embodiments of the disclosed technology. Accordingly, other embodiments can have other details, dimensions, angles and features without departing from the spirit or scope of the disclosure. In addition, those of ordinary skill in the art will appreciate that further embodiments of the various disclosed technologies can be practiced without several of the details described below.

II. Suitable Operating Environment

[0037] Figure 1A is a partial cutaway view of a media playback system 100 distributed in an environment 101 (e.g., a house). The media playback system 100 comprises one or more playback devices 110 (identified individually as playback devices 110a-n), one or more network microphone

devices 120 (“NMDs”) (identified individually as NMDs 120a-c), and one or more control devices 130 (identified individually as control devices 130a and 130b).

[0038] As used herein the term “playback device” can generally refer to a network device configured to receive, process, and output data of a media playback system. For example, a playback device can be a network device that receives and processes audio content. In some embodiments, a playback device includes one or more transducers or speakers powered by one or more amplifiers. In other embodiments, however, a playback device includes one of (or neither of) the speaker and the amplifier. For instance, a playback device can comprise one or more amplifiers configured to drive one or more speakers external to the playback device via a corresponding wire or cable.

[0039] Moreover, as used herein the term “NMD” (i.e., a “network microphone device”) can generally refer to a network device that is configured for audio detection. In some embodiments, an NMD is a stand-alone device configured primarily for audio detection. In other embodiments, an NMD is incorporated into a playback device (or vice versa).

[0040] The term “control device” can generally refer to a network device configured to perform functions relevant to facilitating user access, control, and/or configuration of the media playback system 100.

[0041] Each of the playback devices 110 is configured to receive audio signals or data from one or more media sources (e.g., one or more remote servers, one or more local devices) and play back the received audio signals or data as sound. The one or more NMDs 120 are configured to receive spoken word commands, and the one or more control devices 130 are configured to receive user input. In response to the received spoken word commands and/or user input, the media playback system 100 can play back audio via one or more of the playback devices 110. In certain

embodiments, the playback devices 110 are configured to commence playback of media content in response to a trigger. For instance, one or more of the playback devices 110 can be configured to play back a morning playlist upon detection of an associated trigger condition (e.g., presence of a user in a kitchen, detection of a coffee machine operation). In some embodiments, for example, the media playback system 100 is configured to play back audio from a first playback device (e.g., the playback device 100a) in synchrony with a second playback device (e.g., the playback device 100b). Interactions between the playback devices 110, NMDs 120, and/or control devices 130 of the media playback system 100 configured in accordance with the various embodiments of the disclosure are described in greater detail below with respect to Figures 1B-6.

[0042] In the illustrated embodiment of Figure 1A, the environment 101 comprises a household having several rooms, spaces, and/or playback zones, including (clockwise from upper left) a master bathroom 101a, a master bedroom 101b, a second bedroom 101c, a family room or den 101d, an office 101e, a living room 101f, a dining room 101g, a kitchen 101h, and an outdoor patio 101i. While certain embodiments and examples are described below in the context of a home environment, the technologies described herein may be implemented in other types of environments. In some embodiments, for example, the media playback system 100 can be implemented in one or more commercial settings (e.g., a restaurant, mall, airport, hotel, a retail or other store), one or more vehicles (e.g., a sports utility vehicle, bus, car, a ship, a boat, an airplane), multiple environments (e.g., a combination of home and vehicle environments), and/or another suitable environment where multi-zone audio may be desirable.

[0043] The media playback system 100 can comprise one or more playback zones, some of which may correspond to the rooms in the environment 101. The media playback system 100 can be established with one or more playback zones, after which additional zones may be added, or

removed, to form, for example, the configuration shown in Figure 1A. Each zone may be given a name according to a different room or space such as the office 101e, master bathroom 101a, master bedroom 101b, the second bedroom 101c, kitchen 101h, dining room 101g, living room 101f, and/or the balcony 101i. In some aspects, a single playback zone may include multiple rooms or spaces. In certain aspects, a single room or space may include multiple playback zones.

[0044] In the illustrated embodiment of Figure 1A, the master bathroom 101a, the second bedroom 101c, the office 101e, the living room 101f, the dining room 101g, the kitchen 101h, and the outdoor patio 101i each include one playback device 110, and the master bedroom 101b and the den 101d include a plurality of playback devices 110. In the master bedroom 101b, the playback devices 110l and 110m may be configured, for example, to play back audio content in synchrony as individual ones of playback devices 110, as a bonded playback zone, as a consolidated playback device, and/or any combination thereof. Similarly, in the den 101d, the playback devices 110h-j can be configured, for instance, to play back audio content in synchrony as individual ones of playback devices 110, as one or more bonded playback devices, and/or as one or more consolidated playback devices. Additional details regarding bonded and consolidated playback devices are described below with respect to Figures 1B and 1E and 1I-1M.

[0045] In some aspects, one or more of the playback zones in the environment 101 may each be playing different audio content. For instance, a user may be grilling on the patio 101i and listening to hip hop music being played by the playback device 110c while another user is preparing food in the kitchen 101h and listening to classical music played by the playback device 110b. In another example, a playback zone may play the same audio content in synchrony with another playback zone. For instance, the user may be in the office 101e listening to the playback device 110f playing back the same hip hop music being played back by playback device 110c on the patio 101i. In

some aspects, the playback devices 110c and 110f play back the hip hop music in synchrony such that the user perceives that the audio content is being played seamlessly (or at least substantially seamlessly) while moving between different playback zones. Additional details regarding audio playback synchronization among playback devices and/or zones can be found, for example, in U.S. Patent No. 8,234,395 entitled, “System and method for synchronizing operations among a plurality of independently clocked digital data processing devices,” which is incorporated herein by reference in its entirety.

a. Suitable Media Playback System

[0046] Figure 1B is a schematic diagram of the media playback system 100 and at least one cloud network 102. For ease of illustration, certain devices of the media playback system 100 and the cloud network 102 are omitted from Figure 1B. One or more communication links 103 (referred to hereinafter as “the links 103”) communicatively couple the media playback system 100 and the cloud network 102.

[0047] The links 103 can comprise, for example, one or more wired networks, one or more wireless networks, one or more wide area networks (WAN), one or more local area networks (LAN), one or more personal area networks (PAN), one or more telecommunication networks (e.g., one or more Global System for Mobiles (GSM) networks, Code Division Multiple Access (CDMA) networks, Long-Term Evolution (LTE) networks, 5G communication network networks, and/or other suitable data transmission protocol networks), etc. In many embodiments, a cloud network 102 is configured to deliver media content (e.g., audio content, video content, photographs, social media content) to the media playback system 100 in response to a request transmitted from the media playback system 100 via the links 103. In some embodiments, a cloud network 102 is configured to receive data (e.g., voice input data) from the media playback system

100 and correspondingly transmit commands and/or media content to the media playback system 100.

[0048] The cloud network 102 comprises computing devices 106 (identified separately as a first computing device 106a, a second computing device 106b, and a third computing device 106c). The computing devices 106 can comprise individual computers or servers, such as, for example, a media streaming service server storing audio and/or other media content, a voice service server, a social media server, a media playback system control server, etc. In some embodiments, one or more of the computing devices 106 comprise modules of a single computer or server. In certain embodiments, one or more of the computing devices 106 comprise one or more modules, computers, and/or servers. Moreover, while the cloud network 102 is described above in the context of a single cloud network, in some embodiments the cloud network 102 comprises a plurality of cloud networks comprising communicatively coupled computing devices. Furthermore, while the cloud network 102 is shown in Figure 1B as having three of the computing devices 106, in some embodiments, the cloud network 102 comprises fewer (or more than) three computing devices 106.

[0049] The media playback system 100 is configured to receive media content from the networks 102 via the links 103. The received media content can comprise, for example, a Uniform Resource Identifier (URI) and/or a Uniform Resource Locator (URL). For instance, in some examples, the media playback system 100 can stream, download, or otherwise obtain data from a URI or a URL corresponding to the received media content. A network 104 communicatively couples the links 103 and at least a portion of the devices (e.g., one or more of the playback devices 110, NMDs 120, and/or control devices 130) of the media playback system 100. The network 104 can include, for example, a wireless network (e.g., a WiFi network, a Bluetooth, a Z-Wave network, a ZigBee,

and/or other suitable wireless communication protocol network) and/or a wired network (e.g., a network comprising Ethernet, Universal Serial Bus (USB), and/or another suitable wired communication). As those of ordinary skill in the art will appreciate, as used herein, “WiFi” can refer to several different communication protocols including, for example, Institute of Electrical and Electronics Engineers (IEEE) 802.11a, 802.11b, 802.11g, 802.11n, 802.11ac, 802.11ac, 802.11ad, 802.11af, 802.11ah, 802.11ai, 802.11aj, 802.11aq, 802.11ax, 802.11ay, 802.15, etc. transmitted at 2.4 Gigahertz (GHz), 5 GHz, and/or another suitable frequency.

[0050] In some embodiments, the network 104 comprises a dedicated communication network that the media playback system 100 uses to transmit messages between individual devices and/or to transmit media content to and from media content sources (e.g., one or more of the computing devices 106). In certain embodiments, the network 104 is configured to be accessible only to devices in the media playback system 100, thereby reducing interference and competition with other household devices. In other embodiments, however, the network 104 comprises an existing household communication network (e.g., a household WiFi network). In some embodiments, the links 103 and the network 104 comprise one or more of the same networks. In some aspects, for example, the links 103 and the network 104 comprise a telecommunication network (e.g., an LTE network, a 5G network). Moreover, in some embodiments, the media playback system 100 is implemented without the network 104, and devices comprising the media playback system 100 can communicate with each other, for example, via one or more direct connections, PANs, telecommunication networks, and/or other suitable communication links. The network 104 may be referred to herein as a “local communication network” to differentiate the network 104 from the cloud network 102 that couples the media playback system 100 to remote devices, such as cloud services.

[0051] In some embodiments, audio content sources may be regularly added or removed from the media playback system 100. In some embodiments, for example, the media playback system 100 performs an indexing of media items when one or more media content sources are updated, added to, and/or removed from the media playback system 100. The media playback system 100 can scan identifiable media items in some or all folders and/or directories accessible to the playback devices 110, and generate or update a media content database comprising metadata (e.g., title, artist, album, track length) and other associated information (e.g., URIs, URLs) for each identifiable media item found. In some embodiments, for example, the media content database is stored on one or more of the playback devices 110, network microphone devices 120, and/or control devices 130.

[0052] In the illustrated embodiment of Figure 1B, the playback devices 110l and 110m comprise a group 107a. The playback devices 110l and 110m can be positioned in different rooms in a household and be grouped together in the group 107a on a temporary or permanent basis based on user input received at the control device 130a and/or another control device 130 in the media playback system 100. When arranged in the group 107a, the playback devices 110l and 110m can be configured to play back the same or similar audio content in synchrony from one or more audio content sources. In certain embodiments, for example, the group 107a comprises a bonded zone in which the playback devices 110l and 110m comprise left audio and right audio channels, respectively, of multi-channel audio content, thereby producing or enhancing a stereo effect of the audio content. In some embodiments, the group 107a includes additional playback devices 110. In other embodiments, however, the media playback system 100 omits the group 107a and/or other grouped arrangements of the playback devices 110. Additional details regarding groups and other

arrangements of playback devices are described in further detail below with respect to Figures 1-I through IM.

[0053] The media playback system 100 includes the NMDs 120a and 120d, each comprising one or more microphones configured to receive voice utterances from a user. In the illustrated embodiment of Figure 1B, the NMD 120a is a standalone device and the NMD 120d is integrated into the playback device 110n. The NMD 120a, for example, is configured to receive voice input 121 from a user 123. In some embodiments, the NMD 120a transmits data associated with the received voice input 121 to a voice assistant service (VAS) configured to (i) process the received voice input data and (ii) facilitate one or more operations on behalf of the media playback system 100.

[0054] In some aspects, for example, the computing device 106c comprises one or more modules and/or servers of a VAS (e.g., a VAS operated by one or more of SONOS®, AMAZON®, GOOGLE®, APPLE®, MICROSOFT®). The computing device 106c can receive the voice input data from the NMD 120a via the network 104 and the links 103.

[0055] In response to receiving the voice input data, the computing device 106c processes the voice input data (i.e., “Play Hey Jude by The Beatles”), and determines that the processed voice input includes a command to play a song (e.g., “Hey Jude”). In some embodiments, after processing the voice input, the computing device 106c accordingly transmits commands to the media playback system 100 to play back “Hey Jude” by the Beatles from a suitable media service (e.g., via one or more of the computing devices 106) on one or more of the playback devices 110. In other embodiments, the computing device 106c may be configured to interface with media services on behalf of the media playback system 100. In such embodiments, after processing the voice input, instead of the computing device 106c transmitting commands to the media playback

system 100 causing the media playback system 100 to retrieve the requested media from a suitable media service, the computing device 106c itself causes a suitable media service to provide the requested media to the media playback system 100 in accordance with the user's voice utterance.

b. Suitable Playback Devices

[0056] Figure 1C is a block diagram of the playback device 110a comprising an input/output 111. The input/output 111 can include an analog I/O 111a (e.g., one or more wires, cables, and/or other suitable communication links configured to carry analog signals) and/or a digital I/O 111b (e.g., one or more wires, cables, or other suitable communication links configured to carry digital signals). In some embodiments, the analog I/O 111a is an audio line-in input connection comprising, for example, an auto-detecting 3.5mm audio line-in connection. In some embodiments, the digital I/O 111b comprises a Sony/Philips Digital Interface Format (S/PDIF) communication interface and/or cable and/or a Toshiba Link (TOSLINK) cable. In some embodiments, the digital I/O 111b comprises an High-Definition Multimedia Interface (HDMI) interface and/or cable. In some embodiments, the digital I/O 111b includes one or more wireless communication links comprising, for example, a radio frequency (RF), infrared, WiFi, Bluetooth, or another suitable communication protocol. In certain embodiments, the analog I/O 111a and the digital I/O 111b comprise interfaces (e.g., ports, plugs, jacks) configured to receive connectors of cables transmitting analog and digital signals, respectively, without necessarily including cables.

[0057] The playback device 110a, for example, can receive media content (e.g., audio content comprising music and/or other sounds) from a local audio source 105 via the input/output 111 (e.g., a cable, a wire, a PAN, a Bluetooth connection, an ad hoc wired or wireless communication network, and/or another suitable communication link). The local audio source 105 can comprise, for example, a mobile device (e.g., a smartphone, a tablet, a laptop computer) or another suitable

audio component (e.g., a television, a desktop computer, an amplifier, a phonograph, a Blu-ray player, a memory storing digital media files). In some aspects, the local audio source 105 includes local music libraries on a smartphone, a computer, a networked-attached storage (NAS), and/or another suitable device configured to store media files. In certain embodiments, one or more of the playback devices 110, NMDs 120, and/or control devices 130 comprise the local audio source 105. In other embodiments, however, the media playback system omits the local audio source 105 altogether. In some embodiments, the playback device 110a does not include an input/output 111 and receives all audio content via the network 104.

[0058] The playback device 110a further comprises electronics 112, a user interface 113 (e.g., one or more buttons, knobs, dials, touch-sensitive surfaces, displays, touchscreens), and one or more transducers 114 (referred to hereinafter as “the transducers 114”). The electronics 112 are configured to receive audio from an audio source (e.g., the local audio source 105) via the input/output 111 or one or more of the computing devices 106a-c via the network 104 (Figure 1B)), amplify the received audio, and output the amplified audio for playback via one or more of the transducers 114. In some embodiments, the playback device 110a optionally includes one or more microphones 115 (e.g., a single microphone, a plurality of microphones, a microphone array) (hereinafter referred to as “the microphones 115”). In certain embodiments, for example, the playback device 110a having one or more of the optional microphones 115 can operate as an NMD configured to receive voice input from a user and correspondingly perform one or more operations based on the received voice input.

[0059] In the illustrated embodiment of Figure 1C, the electronics 112 comprise one or more processors 112a (referred to hereinafter as “the processors 112a”), memory 112b, software components 112c, a network interface 112d, one or more audio processing components 112g

(referred to hereinafter as “the audio components 112g”), one or more audio amplifiers 112h (referred to hereinafter as “the amplifiers 112h”), and power 112i (e.g., one or more power supplies, power cables, power receptacles, batteries, induction coils, Power-over Ethernet (POE) interfaces, and/or other suitable sources of electric power). In some embodiments, the electronics 112 optionally include one or more other components 112j (e.g., one or more sensors, video displays, touchscreens, battery charging bases).

[0060] The processors 112a can comprise clock-driven computing component(s) configured to process data, and the memory 112b can comprise a computer-readable medium (e.g., a tangible, non-transitory computer-readable medium loaded with one or more of the software components 112c) configured to store instructions for performing various operations and/or functions. The processors 112a are configured to execute the instructions stored on the memory 112b to perform one or more of the operations. The operations can include, for example, causing the playback device 110a to retrieve audio data from an audio source (e.g., one or more of the computing devices 106a-c (Figure 1B)), and/or another one of the playback devices 110. In some embodiments, the operations further include causing the playback device 110a to send audio data to another one of the playback devices 110a and/or another device (e.g., one of the NMDs 120). Certain embodiments include operations causing the playback device 110a to pair with another of the one or more playback devices 110 to enable a multi-channel audio environment (e.g., a stereo pair, a bonded zone).

[0061] The processors 112a can be further configured to perform operations causing the playback device 110a to synchronize playback of audio content with another of the one or more playback devices 110. As those of ordinary skill in the art will appreciate, during synchronous playback of audio content on a plurality of playback devices, a listener will preferably be unable

to perceive time-delay differences between playback of the audio content by the playback device 110a and the other one or more other playback devices 110. Additional details regarding audio playback synchronization among playback devices can be found, for example, in U.S. Patent No. 8,234,395, which was incorporated by reference above.

[0062] In some embodiments, the memory 112b is further configured to store data associated with the playback device 110a, such as one or more zones and/or zone groups of which the playback device 110a is a member, audio sources accessible to the playback device 110a, and/or a playback queue that the playback device 110a (and/or another of the one or more playback devices) can be associated with. The stored data can comprise one or more state variables that are periodically updated and used to describe a state of the playback device 110a. The memory 112b can also include data associated with a state of one or more of the other devices (e.g., the playback devices 110, NMDs 120, control devices 130) of the media playback system 100. In some aspects, for example, the state data is shared during predetermined intervals of time (e.g., every 5 seconds, every 10 seconds, every 60 seconds) among at least a portion of the devices of the media playback system 100, so that one or more of the devices have the most recent data associated with the media playback system 100.

[0063] The network interface 112d is configured to facilitate a transmission of data between the playback device 110a and one or more other devices on a data network such as, for example, the links 103 and/or the network 104 (Figure 1B). The network interface 112d is configured to transmit and receive data corresponding to media content (e.g., audio content, video content, text, photographs) and other signals (e.g., non-transitory signals) comprising digital packet data including an Internet Protocol (IP)-based source address and/or an IP-based destination address.

The network interface 112d can parse the digital packet data such that the electronics 112 properly receives and processes the data destined for the playback device 110a.

[0064] In the illustrated embodiment of Figure 1C, the network interface 112d comprises one or more wireless interfaces 112e (referred to hereinafter as “the wireless interface 112e”). The wireless interface 112e (e.g., a suitable interface comprising one or more antennae) can be configured to wirelessly communicate with one or more other devices (e.g., one or more of the other playback devices 110, NMDs 120, and/or control devices 130) that are communicatively coupled to the network 104 (Figure 1B) in accordance with a suitable wireless communication protocol (e.g., WiFi, Bluetooth, LTE). In some embodiments, the network interface 112d optionally includes a wired interface 112f (e.g., an interface or receptacle configured to receive a network cable such as an Ethernet, a USB-A, USB-C, and/or Thunderbolt cable) configured to communicate over a wired connection with other devices in accordance with a suitable wired communication protocol. In certain embodiments, the network interface 112d includes the wired interface 112f and excludes the wireless interface 112e. In some embodiments, the electronics 112 excludes the network interface 112d altogether and transmits and receives media content and/or other data via another communication path (e.g., the input/output 111).

[0065] The audio components 112g are configured to process and/or filter data comprising media content received by the electronics 112 (e.g., via the input/output 111 and/or the network interface 112d) to produce output audio signals. In some embodiments, the audio processing components 112g comprise, for example, one or more digital-to-analog converters (DAC), audio preprocessing components, audio enhancement components, a digital signal processors (DSPs), and/or other suitable audio processing components, modules, circuits, etc. In certain embodiments, one or more of the audio processing components 112g can comprise one or more subcomponents

of the processors 112a. In some embodiments, the electronics 112 omits the audio processing components 112g. In some aspects, for example, the processors 112a execute instructions stored on the memory 112b to perform audio processing operations to produce the output audio signals.

[0066] The amplifiers 112h are configured to receive and amplify the audio output signals produced by the audio processing components 112g and/or the processors 112a. The amplifiers 112h can comprise electronic devices and/or components configured to amplify audio signals to levels sufficient for driving one or more of the transducers 114. In some embodiments, for example, the amplifiers 112h include one or more switching or class-D power amplifiers. In other embodiments, however, the amplifiers include one or more other types of power amplifiers (e.g., linear gain power amplifiers, class-A amplifiers, class-B amplifiers, class-AB amplifiers, class-C amplifiers, class-D amplifiers, class-E amplifiers, class-F amplifiers, class-G and/or class H amplifiers, and/or another suitable type of power amplifier). In certain embodiments, the amplifiers 112h comprise a suitable combination of two or more of the foregoing types of power amplifiers. Moreover, in some embodiments, individual ones of the amplifiers 112h correspond to individual ones of the transducers 114. In other embodiments, however, the electronics 112 includes a single one of the amplifiers 112h configured to output amplified audio signals to a plurality of the transducers 114. In some other embodiments, the electronics 112 omits the amplifiers 112h.

[0067] The transducers 114 (e.g., one or more speakers and/or speaker drivers) receive the amplified audio signals from the amplifier 112h and render or output the amplified audio signals as sound (e.g., audible sound waves having a frequency between about 20 Hertz (Hz) and 20 kilohertz (kHz)). In some embodiments, the transducers 114 can comprise a single transducer. In other embodiments, however, the transducers 114 comprise a plurality of audio transducers. In some embodiments, the transducers 114 comprise more than one type of transducer. For example,

the transducers 114 can include one or more low frequency transducers (e.g., subwoofers, woofers), mid-range frequency transducers (e.g., mid-range transducers, mid-woofers), and one or more high frequency transducers (e.g., one or more tweeters). As used herein, “low frequency” can generally refer to audible frequencies below about 500 Hz, “mid-range frequency” can generally refer to audible frequencies between about 500 Hz and about 2 kHz, and “high frequency” can generally refer to audible frequencies above 2 kHz. In certain embodiments, however, one or more of the transducers 114 comprise transducers that do not adhere to the foregoing frequency ranges. For example, one of the transducers 114 may comprise a mid-woofer transducer configured to output sound at frequencies between about 200 Hz and about 5 kHz.

[0068] By way of illustration, SONOS, Inc. presently offers (or has offered) for sale certain playback devices including, for example, a “SONOS ONE,” “PLAY:1,” “PLAY:3,” “PLAY:5,” “PLAYBAR,” “PLAYBASE,” “CONNECT:AMP,” “CONNECT,” and “SUB.” Other suitable playback devices may additionally or alternatively be used to implement the playback devices of example embodiments disclosed herein. Additionally, one of ordinary skilled in the art will appreciate that a playback device is not limited to the examples described herein or to SONOS product offerings. In some embodiments, for example, one or more playback devices 110 comprises wired or wireless headphones (e.g., over-the-ear headphones, on-ear headphones, in-ear earphones). In other embodiments, one or more of the playback devices 110 comprise a docking station and/or an interface configured to interact with a docking station for personal mobile media playback devices. In certain embodiments, a playback device may be integral to another device or component such as a television, a lighting fixture, or some other device for indoor or outdoor use. In some embodiments, a playback device omits a user interface and/or one or more transducers.

For example, FIG. 1D is a block diagram of a playback device 110p comprising the input/output 111 and electronics 112 without the user interface 113 or transducers 114.

[0069] Figure 1E is a block diagram of a bonded playback device 110q comprising the playback device 110a (Figure 1C) sonically bonded with the playback device 110i (e.g., a subwoofer) (Figure 1A). In the illustrated embodiment, the playback devices 110a and 110i are separate ones of the playback devices 110 housed in separate enclosures. In some embodiments, however, the bonded playback device 110q comprises a single enclosure housing both the playback devices 110a and 110i. The bonded playback device 110q can be configured to process and reproduce sound differently than an unbonded playback device (e.g., the playback device 110a of Figure 1C) and/or paired or bonded playback devices (e.g., the playback devices 110l and 110m of Figure 1B). In some embodiments, for example, the playback device 110a is full-range playback device configured to render low frequency, mid-range frequency, and high frequency audio content, and the playback device 110i is a subwoofer configured to render low frequency audio content. In some aspects, the playback device 110a, when bonded with the first playback device, is configured to render only the mid-range and high frequency components of a particular audio content, while the playback device 110i renders the low frequency component of the particular audio content. In some embodiments, the bonded playback device 110q includes additional playback devices and/or another bonded playback device. Additional playback device embodiments are described in further detail below with respect to Figures 2A-3D.

c. Suitable Network Microphone Devices (NMDs)

[0070] Figure 1F is a block diagram of the NMD 120a (Figures 1A and 1B). The NMD 120a includes one or more voice processing components 124 (hereinafter “the voice components 124”) and several components described with respect to the playback device 110a (Figure 1C) including

the processors 112a, the memory 112b, and the microphones 115. The NMD 120a optionally comprises other components also included in the playback device 110a (Figure 1C), such as the user interface 113 and/or the transducers 114. In some embodiments, the NMD 120a is configured as a media playback device (e.g., one or more of the playback devices 110), and further includes, for example, one or more of the audio components 112g (Figure 1C), the amplifiers 114, and/or other playback device components. In certain embodiments, the NMD 120a comprises an Internet of Things (IoT) device such as, for example, a thermostat, alarm panel, fire and/or smoke detector, etc. In some embodiments, the NMD 120a comprises the microphones 115, the voice processing 124, and only a portion of the components of the electronics 112 described above with respect to Figure 1B. In some aspects, for example, the NMD 120a includes the processor 112a and the memory 112b (Figure 1B), while omitting one or more other components of the electronics 112. In some embodiments, the NMD 120a includes additional components (e.g., one or more sensors, cameras, thermometers, barometers, hygrometers).

[0071] In some embodiments, an NMD can be integrated into a playback device. Figure 1G is a block diagram of a playback device 110r comprising an NMD 120d. The playback device 110r can comprise many or all of the components of the playback device 110a and further include the microphones 115 and voice processing 124 (Figure 1F). The playback device 110r optionally includes an integrated control device 130c. The control device 130c can comprise, for example, a user interface (e.g., the user interface 113 of Figure 1B) configured to receive user input (e.g., touch input, voice input) without a separate control device. In other embodiments, however, the playback device 110r receives commands from another control device (e.g., the control device 130a of Figure 1B). Additional NMD embodiments are described in further detail below with respect to Figures 3A-3F.

[0072] Referring again to Figure 1F, the microphones 115 are configured to acquire, capture, and/or receive sound from an environment (e.g., the environment 101 of Figure 1A) and/or a room in which the NMD 120a is positioned. The received sound can include, for example, vocal utterances, audio played back by the NMD 120a and/or another playback device, background voices, ambient sounds, etc. The microphones 115 convert the received sound into electrical signals to produce microphone data. The voice processing 124 receives and analyzes the microphone data to determine whether a voice input is present in the microphone data. The voice input can comprise, for example, an activation word followed by an utterance including a user request. As those of ordinary skill in the art will appreciate, an activation word is a word or other audio cue signifying a user voice input. For instance, in querying the AMAZON® VAS, a user might speak the activation word "Alexa." Other examples include "Ok, Google" for invoking the GOOGLE® VAS and "Hey, Siri" for invoking the APPLE® VAS.

[0073] After detecting the activation word, voice processing 124 monitors the microphone data for an accompanying user request in the voice input. The user request may include, for example, a command to control a third-party device, such as a thermostat (e.g., NEST® thermostat), an illumination device (e.g., a PHILIPS HUE ® lighting device), or a media playback device (e.g., a Sonos® playback device). For example, a user might speak the activation word "Alexa" followed by the utterance "set the thermostat to 68 degrees" to set a temperature in a home (e.g., the environment 101 of Figure 1A). The user might speak the same activation word followed by the utterance "turn on the living room" to turn on illumination devices in a living room area of the home. The user may similarly speak an activation word followed by a request to play a particular song, an album, or a playlist of music on a playback device in the home. Additional description

regarding receiving and processing voice input data can be found in further detail below with respect to Figures 3A-3F.

d. Suitable Control Devices

[0074] Figure 1H is a partial schematic diagram of the control device 130a (Figures 1A and 1B). As used herein, the term “control device” can be used interchangeably with “controller” or “control system.” Among other features, the control device 130a is configured to receive user input related to the media playback system 100 and, in response, cause one or more devices in the media playback system 100 to perform an action(s) or operation(s) corresponding to the user input. In the illustrated embodiment, the control device 130a comprises a smartphone (e.g., an iPhone™, an Android phone) on which media playback system controller application software is installed. In some embodiments, the control device 130a comprises, for example, a tablet (e.g., an iPad™), a computer (e.g., a laptop computer, a desktop computer), and/or another suitable device (e.g., a television, an automobile audio head unit, an IoT device). In certain embodiments, the control device 130a comprises a dedicated controller for the media playback system 100. In other embodiments, as described above with respect to Figure 1G, the control device 130a is integrated into another device in the media playback system 100 (e.g., one more of the playback devices 110, NMDs 120, and/or other suitable devices configured to communicate over a network).

[0075] The control device 130a includes electronics 132, a user interface 133, one or more speakers 134, and one or more microphones 135. The electronics 132 comprise one or more processors 132a (referred to hereinafter as “the processors 132a”), a memory 132b, software components 132c, and a network interface 132d. The processor 132a can be configured to perform functions relevant to facilitating user access, control, and configuration of the media playback system 100. The memory 132b can comprise data storage that can be loaded with one or more of

the software components executable by the processor 302 to perform those functions. The software components 132c can comprise applications and/or other executable software configured to facilitate control of the media playback system 100. The memory 112b can be configured to store, for example, the software components 132c, media playback system controller application software, and/or other data associated with the media playback system 100 and the user.

[0076] The network interface 132d is configured to facilitate network communications between the control device 130a and one or more other devices in the media playback system 100, and/or one or more remote devices. In some embodiments, the network interface 132d is configured to operate according to one or more suitable communication industry standards (e.g., infrared, radio, wired standards including IEEE 802.3, wireless standards including IEEE 802.11a, 802.11b, 802.11g, 802.11n, 802.11ac, 802.15, 4G, LTE). The network interface 132d can be configured, for example, to transmit data to and/or receive data from the playback devices 110, the NMDs 120, other ones of the control devices 130, one of the computing devices 106 of Figure 1B, devices comprising one or more other media playback systems, etc. The transmitted and/or received data can include, for example, playback device control commands, state variables, playback zone and/or zone group configurations. For instance, based on user input received at the user interface 133, the network interface 132d can transmit a playback device control command (e.g., volume control, audio playback control, audio content selection) from the control device 304 to one or more of the playback devices 100. The network interface 132d can also transmit and/or receive configuration changes such as, for example, adding/removing one or more playback devices 100 to/from a zone, adding/removing one or more zones to/from a zone group, forming a bonded or consolidated player, separating one or more playback devices from a bonded or consolidated

player, among others. Additional description of zones and groups can be found below with respect to Figures 1-I through 1M.

[0077] The user interface 133 is configured to receive user input and can facilitate control of the media playback system 100. The user interface 133 includes media content art 133a (e.g., album art, lyrics, videos), a playback status indicator 133b (e.g., an elapsed and/or remaining time indicator), media content information region 133c, a playback control region 133d, and a zone indicator 133e. The media content information region 133c can include a display of relevant information (e.g., title, artist, album, genre, release year) about media content currently playing and/or media content in a queue or playlist. The playback control region 133d can include selectable (e.g., via touch input and/or via a cursor or another suitable selector) icons to cause one or more playback devices in a selected playback zone or zone group to perform playback actions such as, for example, play or pause, fast forward, rewind, skip to next, skip to previous, enter/exit shuffle mode, enter/exit repeat mode, enter/exit cross fade mode, etc. The playback control region 133d may also include selectable icons to modify equalization settings, playback volume, and/or other suitable playback actions. In the illustrated embodiment, the user interface 133 comprises a display presented on a touch screen interface of a smartphone (e.g., an iPhone™, an Android phone). In some embodiments, however, user interfaces of varying formats, styles, and interactive sequences may alternatively be implemented on one or more network devices to provide comparable control access to a media playback system.

[0078] The one or more speakers 134 (e.g., one or more transducers) can be configured to output sound to the user of the control device 130a. In some embodiments, the one or more speakers comprise individual transducers configured to correspondingly output low frequencies, mid-range frequencies, and/or high frequencies. In some aspects, for example, the control device 130a is

configured as a playback device (e.g., one of the playback devices 110). Similarly, in some embodiments the control device 130a is configured as an NMD (e.g., one of the NMDs 120), receiving voice commands and other sounds via the one or more microphones 135.

[0079] The one or more microphones 135 can comprise, for example, one or more condenser microphones, electret condenser microphones, dynamic microphones, and/or other suitable types of microphones or transducers. In some embodiments, two or more of the microphones 135 are arranged to capture location information of an audio source (e.g., voice, audible sound) and/or configured to facilitate filtering of background noise. Moreover, in certain embodiments, the control device 130a is configured to operate as playback device and an NMD. In other embodiments, however, the control device 130a omits the one or more speakers 134 and/or the one or more microphones 135. For instance, the control device 130a may comprise a device (e.g., a thermostat, an IoT device, a network device) comprising a portion of the electronics 132 and the user interface 133 (e.g., a touch screen) without any speakers or microphones. Additional control device embodiments are described in further detail below with respect to Figures 4A-4D and 5.

e. Suitable Playback Device Configurations

[0080] Figures 1-1 through 1M show example configurations of playback devices in zones and zone groups. Referring first to Figure 1M, in one example, a single playback device may belong to a zone. For example, the playback device 110g in the second bedroom 101c (FIG. 1A) may belong to Zone C. In some implementations described below, multiple playback devices may be “bonded” to form a “bonded pair” which together form a single zone. For example, the playback device 110l (e.g., a left playback device) can be bonded to the playback device 110l (e.g., a left playback device) to form Zone A. Bonded playback devices may have different playback responsibilities (e.g., channel responsibilities). In another implementation described below,

multiple playback devices may be merged to form a single zone. For example, the playback device 110h (e.g., a front playback device) may be merged with the playback device 110i (e.g., a subwoofer), and the playback devices 110j and 110k (e.g., left and right surround speakers, respectively) to form a single Zone D. In another example, the playback devices 110g and 110h can be merged to form a merged group or a zone group 108b. The merged playback devices 110g and 110h may not be specifically assigned different playback responsibilities. That is, the merged playback devices 110h and 110i may, aside from playing audio content in synchrony, each play audio content as they would if they were not merged.

[0081] Each zone in the media playback system 100 may be provided for control as a single user interface (UI) entity. For example, Zone A may be provided as a single entity named Master Bathroom. Zone B may be provided as a single entity named Master Bedroom. Zone C may be provided as a single entity named Second Bedroom.

[0082] Playback devices that are bonded may have different playback responsibilities, such as responsibilities for certain audio channels. For example, as shown in Figure 1-I, the playback devices 110l and 110m may be bonded so as to produce or enhance a stereo effect of audio content. In this example, the playback device 110l may be configured to play a left channel audio component, while the playback device 110k may be configured to play a right channel audio component. In some implementations, such stereo bonding may be referred to as “pairing.”

[0083] Additionally, bonded playback devices may have additional and/or different respective speaker drivers. As shown in Figure 1J, the playback device 110h named Front may be bonded with the playback device 110i named SUB. The Front device 110h can be configured to render a range of mid to high frequencies and the SUB device 110i can be configured render low frequencies. When unbonded, however, the Front device 110h can be configured render a full

range of frequencies. As another example, Figure 1K shows the Front and SUB devices 110h and 110i further bonded with Left and Right playback devices 110j and 110k, respectively. In some implementations, the Right and Left devices 110j and 110k can be configured to form surround or “satellite” channels of a home theater system. The bonded playback devices 110h, 110i, 110j, and 110k may form a single Zone D (FIG. 1M).

[0084] Playback devices that are merged may not have assigned playback responsibilities, and may each render the full range of audio content the respective playback device is capable of. Nevertheless, merged devices may be represented as a single UI entity (i.e., a zone, as discussed above). For instance, the playback devices 110a and 110n the master bathroom have the single UI entity of Zone A. In one embodiment, the playback devices 110a and 110n may each output the full range of audio content each respective playback devices 110a and 110n are capable of, in synchrony.

[0085] In some embodiments, an NMD is bonded or merged with another device so as to form a zone. For example, the NMD 120b may be bonded with the playback device 110e, which together form Zone F, named Living Room. In other embodiments, a stand-alone network microphone device may be in a zone by itself. In other embodiments, however, a stand-alone network microphone device may not be associated with a zone. Additional details regarding associating network microphone devices and playback devices as designated or default devices may be found, for example, in U.S. Patent Publication No. 2017/0242653 titled “Voice Control of a Media Playback System,” the relevant disclosure of which is hereby incorporated by reference herein in its entirety.

[0086] Zones of individual, bonded, and/or merged devices may be grouped to form a zone group. For example, referring to Figure 1M, Zone A may be grouped with Zone B to form a zone

group 108a that includes the two zones. Similarly, Zone G may be grouped with Zone H to form the zone group 108b. As another example, Zone A may be grouped with one or more other Zones C-I. The Zones A-I may be grouped and ungrouped in numerous ways. For example, three, four, five, or more (e.g., all) of the Zones A-I may be grouped. When grouped, the zones of individual and/or bonded playback devices may play back audio in synchrony with one another, as described in previously referenced U.S. Patent No. 8,234,395. Playback devices may be dynamically grouped and ungrouped to form new or different groups that synchronously play back audio content.

[0087] In various implementations, the zones in an environment may be the default name of a zone within the group or a combination of the names of the zones within a zone group. For example, Zone Group 108b can have be assigned a name such as “Dining + Kitchen”, as shown in Figure 1M. In some embodiments, a zone group may be given a unique name selected by a user.

[0088] Certain data may be stored in a memory of a playback device (e.g., the memory 112c of Figure 1C) as one or more state variables that are periodically updated and used to describe the state of a playback zone, the playback device(s), and/or a zone group associated therewith. The memory may also include the data associated with the state of the other devices of the media system, and shared from time to time among the devices so that one or more of the devices have the most recent data associated with the system.

[0089] In some embodiments, the memory may store instances of various variable types associated with the states. Variables instances may be stored with identifiers (e.g., tags) corresponding to type. For example, certain identifiers may be a first type “a1” to identify playback device(s) of a zone, a second type “b1” to identify playback device(s) that may be bonded in the zone, and a third type “c1” to identify a zone group to which the zone may belong. As a

related example, identifiers associated with the second bedroom 101c may indicate that the playback device is the only playback device of the Zone C and not in a zone group. Identifiers associated with the Den may indicate that the Den is not grouped with other zones but includes bonded playback devices 110h-110k. Identifiers associated with the Dining Room may indicate that the Dining Room is part of the Dining + Kitchen zone group 108b and that devices 110b and 110d are grouped (FIG. 1L). Identifiers associated with the Kitchen may indicate the same or similar information by virtue of the Kitchen being part of the Dining + Kitchen zone group 108b. Other example zone variables and identifiers are described below.

[0090] In yet another example, the media playback system 100 may store variables or identifiers representing other associations of zones and zone groups, such as identifiers associated with Areas, as shown in Figure 1M. An area may involve a cluster of zone groups and/or zones not within a zone group. For instance, Figure 1M shows an Upper Area 109a including Zones A-D, and a Lower Area 109b including Zones E-I. In one aspect, an Area may be used to invoke a cluster of zone groups and/or zones that share one or more zones and/or zone groups of another cluster. In another aspect, this differs from a zone group, which does not share a zone with another zone group. Further examples of techniques for implementing Areas may be found, for example, in U.S. Patent Publication No. 2018/0107446 filed August 21, 2017 and titled “Room Association Based on Name,” and U.S. Patent No. 8,483,853 filed September 11, 2007, and titled “Controlling and manipulating groupings in a multi-zone media system.” One playback device in a group can be identified as a group coordinator for the group, such as described in U.S. Patent Publication No. 2017/0192739 titled “Group Coordinator Selection.” The relevant disclosure of each of these applications is incorporated herein by reference in its entirety. In some embodiments, the media

playback system 100 may not implement Areas, in which case the system may not store variables associated with Areas.

[0091] In particular embodiments of the invention, one or more of the playback devices have an audio amplifier and output terminals for connection to or that are connected to input terminals of a passive speaker. Figure 1N is a block diagram of a playback device 140 configured to drive a passive speaker 142 external to the playback device 140. As shown, the playback device 140 includes amplifier(s) 141, as well as one or more output terminals 144 couplable to one or more input terminals 146 of the passive speaker.

[0092] The passive speaker 142 includes one or more transducers 150, such as one or more speaker drivers, configured to receive audio signals and output the received audio signals as sound. The passive speaker 148 further includes a passive speaker identification circuit 152 for communicating one or more characteristics of the passive speaker 148 to the playback device 140. Current sensor 154 and/or voltage sensor 156 connected to the amplifier(s) 141 of playback device 140 may be utilized to aid in determining characteristics of the passive speaker 148 and/or communicate with the passive speaker identification circuit 152. Additional details regarding techniques for identifying a passive speaker using a playback device are discussed in U.S. Patent Application Serial No. 16/115,525 entitled “Passive Speaker Authentication” (the ‘525 patent), incorporated by reference further above.

III. Example Systems and Devices

[0093] Figure 2A is a front isometric view of a playback device 210 configured in accordance with aspects of the disclosed technology. Figure 2B is a front isometric view of the playback device 210 without a grille 216e. Figure 2C is an exploded view of the playback device 210. Referring to Figures 2A-2C together, the playback device 210 comprises a housing 216 that includes an upper

portion 216a, a right or first side portion 216b, a lower portion 216c, a left or second side portion 216d, the grille 216e, and a rear portion 216f. A plurality of fasteners 216g (e.g., one or more screws, rivets, clips) attaches a frame 216h to the housing 216. A cavity 216j (Figure 2C) in the housing 216 is configured to receive the frame 216h and electronics 212. The frame 216h is configured to carry a plurality of transducers 214 (identified individually in Figure 2B as transducers 214a-f). The electronics 212 (e.g., the electronics 112 of Figure 1C) is configured to receive audio content from an audio source and send electrical signals corresponding to the audio content to the transducers 214 for playback.

[0094] The transducers 214 are configured to receive the electrical signals from the electronics 112, and further configured to convert the received electrical signals into audible sound during playback. For instance, the transducers 214a-c (e.g., tweeters) can be configured to output high frequency sound (e.g., sound waves having a frequency greater than about 2 kHz). The transducers 214d-f (e.g., mid-woofers, woofers, midrange speakers) can be configured output sound at frequencies lower than the transducers 214a-c (e.g., sound waves having a frequency lower than about 2 kHz). In some embodiments, the playback device 210 includes a number of transducers different than those illustrated in Figures 2A-2C. For example, as described in further detail below with respect to Figures 3A-3C, the playback device 210 can include fewer than six transducers (e.g., one, two, three). In other embodiments, however, the playback device 210 includes more than six transducers (e.g., nine, ten). Moreover, in some embodiments, all or a portion of the transducers 214 are configured to operate as a phased array to desirably adjust (e.g., narrow or widen) a radiation pattern of the transducers 214, thereby altering a user's perception of the sound emitted from the playback device 210.

[0095] In the illustrated embodiment of Figures 2A-2C, a filter 216i is axially aligned with the transducer 214b. The filter 216i can be configured to desirably attenuate a predetermined range of frequencies that the transducer 214b outputs to improve sound quality and a perceived sound stage output collectively by the transducers 214. In some embodiments, however, the playback device 210 omits the filter 216i. In other embodiments, the playback device 210 includes one or more additional filters aligned with the transducers 214b and/or at least another of the transducers 214.

[0096] Figures 3A and 3B are front and right isometric side views, respectively, of an NMD 320 configured in accordance with embodiments of the disclosed technology. Figure 3C is an exploded view of the NMD 320. Figure 3D is an enlarged view of a portion of Figure 3B including a user interface 313 of the NMD 320. Referring first to Figures 3A-3C, the NMD 320 includes a housing 316 comprising an upper portion 316a, a lower portion 316b and an intermediate portion 316c (e.g., a grille). A plurality of ports, holes or apertures 316d in the upper portion 316a allow sound to pass through to one or more microphones 315 (Figure 3C) positioned within the housing 316. The one or more microphones 316 are configured to received sound via the apertures 316d and produce electrical signals based on the received sound. In the illustrated embodiment, a frame 316e (Figure 3C) of the housing 316 surrounds cavities 316f and 316g configured to house, respectively, a first transducer 314a (e.g., a tweeter) and a second transducer 314b (e.g., a mid-woofer, a midrange speaker, a woofer). In other embodiments, however, the NMD 320 includes a single transducer, or more than two (e.g., two, five, six) transducers. In certain embodiments, the NMD 320 omits the transducers 314a and 314b altogether.

[0097] Electronics 312 (Figure 3C) includes components configured to drive the transducers 314a and 314b, and further configured to analyze audio data corresponding to the electrical signals produced by the one or more microphones 315. In some embodiments, for example, the electronics

312 comprises many or all of the components of the electronics 112 described above with respect to Figure 1C. In certain embodiments, the electronics 312 includes components described above with respect to Figure 1F such as, for example, the one or more processors 112a, the memory 112b, the software components 112c, the network interface 112d, etc. In some embodiments, the electronics 312 includes additional suitable components (e.g., proximity or other sensors).

[0098] Referring to Figure 3D, the user interface 313 includes a plurality of control surfaces (e.g., buttons, knobs, capacitive surfaces) including a first control surface 313a (e.g., a previous control), a second control surface 313b (e.g., a next control), and a third control surface 313c (e.g., a play and/or pause control). A fourth control surface 313d is configured to receive touch input corresponding to activation and deactivation of the one or microphones 315. A first indicator 313e (e.g., one or more light emitting diodes (LEDs) or another suitable illuminator) can be configured to illuminate only when the one or more microphones 315 are activated. A second indicator 313f (e.g., one or more LEDs) can be configured to remain solid during normal operation and to blink or otherwise change from solid to indicate a detection of voice activity. In some embodiments, the user interface 313 includes additional or fewer control surfaces and illuminators. In one embodiment, for example, the user interface 313 includes the first indicator 313e, omitting the second indicator 313f. Moreover, in certain embodiments, the NMD 320 comprises a playback device and a control device, and the user interface 313 comprises the user interface of the control device .

[0099] Referring to Figures 3A-3D together, the NMD 320 is configured to receive voice commands from one or more adjacent users via the one or more microphones 315. As described above with respect to Figure 1B, the one or more microphones 315 can acquire, capture, or record sound in a vicinity (e.g., a region within 10m or less of the NMD 320) and transmit electrical

signals corresponding to the recorded sound to the electronics 312. The electronics 312 can process the electrical signals and can analyze the resulting audio data to determine a presence of one or more voice commands (e.g., one or more activation words). In some embodiments, for example, after detection of one or more suitable voice commands, the NMD 320 is configured to transmit a portion of the recorded audio data to another device and/or a remote server (e.g., one or more of the computing devices 106 of Figure 1B) for further analysis. The remote server can analyze the audio data, determine an appropriate action based on the voice command, and transmit a message to the NMD 320 to perform the appropriate action. For instance, a user may speak “Sonos, play Michael Jackson.” The NMD 320 can, via the one or more microphones 315, record the user’s voice utterance, determine the presence of a voice command, and transmit the audio data having the voice command to a remote server (e.g., one or more of the remote computing devices 106 of Figure 1B, one or more servers of a VAS and/or another suitable service). The remote server can analyze the audio data and determine an action corresponding to the command. The remote server can then transmit a command to the NMD 320 to perform the determined action (e.g., play back audio content related to Michael Jackson). The NMD 320 can receive the command and play back the audio content related to Michael Jackson from a media content source. As described above with respect to Figure 1B, suitable content sources can include a device or storage communicatively coupled to the NMD 320 via a LAN (e.g., the network 104 of Figure 1B), a remote server (e.g., one or more of the remote computing devices 106 of Figure 1B), etc. In certain embodiments, however, the NMD 320 determines and/or performs one or more actions corresponding to the one or more voice commands without intervention or involvement of an external device, computer, or server.

[00100] Figure 3E is a functional block diagram showing additional features of the NMD 320 in accordance with aspects of the disclosure. The NMD 320 includes components configured to facilitate voice command capture including voice activity detector component(s) 312k, beam former components 312l, acoustic echo cancellation (AEC) and/or self-sound suppression components 312m, activation word detector components 312n, and voice/speech conversion components 312o (e.g., voice-to-text and text-to-voice). In the illustrated embodiment of Figure 3E, the foregoing components 312k-312o are shown as separate components. In some embodiments, however, one or more of the components 312k-312o are subcomponents of the processors 112a.

[00101] The beamforming and self-sound suppression components 312l and 312m are configured to detect an audio signal and determine aspects of voice input represented in the detected audio signal, such as the direction, amplitude, frequency spectrum, etc. The voice activity detector activity components 312k are operably coupled with the beamforming and AEC components 312l and 312m and are configured to determine a direction and/or directions from which voice activity is likely to have occurred in the detected audio signal. Potential speech directions can be identified by monitoring metrics which distinguish speech from other sounds. Such metrics can include, for example, energy within the speech band relative to background noise and entropy within the speech band, which is measure of spectral structure. As those of ordinary skill in the art will appreciate, speech typically has a lower entropy than most common background noise. The activation word detector components 312n are configured to monitor and analyze received audio to determine if any activation words (e.g., wake words) are present in the received audio. The activation word detector components 312n may analyze the received audio using an activation word detection algorithm. If the activation word detector 312n detects an activation word, the

NMD 320 may process voice input contained in the received audio. Example activation word detection algorithms accept audio as input and provide an indication of whether an activation word is present in the audio. Many first- and third-party activation word detection algorithms are known and commercially available. For instance, operators of a voice service may make their algorithm available for use in third-party devices. Alternatively, an algorithm may be trained to detect certain activation words. In some embodiments, the activation word detector 312n runs multiple activation word detection algorithms on the received audio simultaneously (or substantially simultaneously). As noted above, different voice services (e.g. AMAZON's ALEXA®, APPLE's SIRI®, or MICROSOFT's CORTANA®) can each use a different activation word for invoking their respective voice service. To support multiple services, the activation word detector 312n may run the received audio through the activation word detection algorithm for each supported voice service in parallel.

[00102] The speech/text conversion components 312o may facilitate processing by converting speech in the voice input to text. In some embodiments, the electronics 312 can include voice recognition software that is trained to a particular user or a particular set of users associated with a household. Such voice recognition software may implement voice-processing algorithms that are tuned to specific voice profile(s). Tuning to specific voice profiles may require less computationally intensive algorithms than traditional voice activity services, which typically sample from a broad base of users and diverse requests that are not targeted to media playback systems.

[00103] Figure 3F is a schematic diagram of an example voice input 328 captured by the NMD 320 in accordance with aspects of the disclosure. The voice input 328 can include a activation word portion 328a and a voice utterance portion 328b. In some embodiments, the activation word

557a can be a known activation word, such as “Alexa,” which is associated with AMAZON's ALEXA®. In other embodiments, however, the voice input 328 may not include a activation word. In some embodiments, a network microphone device may output an audible and/or visible response upon detection of the activation word portion 328a. In addition or alternately, an NMB may output an audible and/or visible response after processing a voice input and/or a series of voice inputs.

[00104] The voice utterance portion 328b may include, for example, one or more spoken commands (identified individually as a first command 328c and a second command 328e) and one or more spoken keywords (identified individually as a first keyword 328d and a second keyword 328f). In one example, the first command 328c can be a command to play music, such as a specific song, album, playlist, etc. In this example, the keywords may be one or words identifying one or more zones in which the music is to be played, such as the Living Room and the Dining Room shown in Figure 1A. In some examples, the voice utterance portion 328b can include other information, such as detected pauses (e.g., periods of non-speech) between words spoken by a user, as shown in Figure 3F. The pauses may demarcate the locations of separate commands, keywords, or other information spoke by the user within the voice utterance portion 328b.

[00105] In some embodiments, the media playback system 100 is configured to temporarily reduce the volume of audio content that it is playing while detecting the activation word portion 557a. The media playback system 100 may restore the volume after processing the voice input 328, as shown in Figure 3F. Such a process can be referred to as ducking, examples of which are disclosed in U.S. Patent Publication No. 2017/0242653 titled “Voice Control of a Media Playback System,” the relevant disclosure of which is hereby incorporated by reference herein in its entirety.

[00106] Figures 4A-4D are schematic diagrams of a control device 430 (e.g., the control device 130a of Figure 1H, a smartphone, a tablet, a dedicated control device, an IoT device, and/or another suitable device) showing corresponding user interface displays in various states of operation. A first user interface display 431a (Figure 4A) includes a display name 433a (i.e., “Rooms”). A selected group region 433b displays audio content information (e.g., artist name, track name, album art) of audio content played back in the selected group and/or zone. Group regions 433c and 433d display corresponding group and/or zone name, and audio content information audio content played back or next in a playback queue of the respective group or zone. An audio content region 433e includes information related to audio content in the selected group and/or zone (i.e., the group and/or zone indicated in the selected group region 433b). A lower display region 433f is configured to receive touch input to display one or more other user interface displays. For example, if a user selects “Browse” in the lower display region 433f, the control device 430 can be configured to output a second user interface display 431b (Figure 4B) comprising a plurality of music services 433g (e.g., Spotify, Radio by Tunein, Apple Music, Pandora, Amazon, TV, local music, line-in) through which the user can browse and from which the user can select media content for play back via one or more playback devices (e.g., one of the playback devices 110 of Figure 1A). Alternatively, if the user selects “My Sonos” in the lower display region 433f, the control device 430 can be configured to output a third user interface display 431c (Figure 4C). A first media content region 433h can include graphical representations (e.g., album art) corresponding to individual albums, stations, or playlists. A second media content region 433i can include graphical representations (e.g., album art) corresponding to individual songs, tracks, or other media content. If the user selections a graphical representation 433j (Figure 4C), the control device 430 can be configured to begin play back of audio content corresponding to the graphical representation 433j

and output a fourth user interface display 431d. Fourth user interface display 431d includes an enlarged version of the graphical representation 433j, media content information 433k (e.g., track name, artist, album), transport controls 433m (e.g., play, previous, next, pause, volume), and indication 433n of the currently selected group and/or zone name.

[00107] Figure 5 is a schematic diagram of a control device 530 (e.g., a laptop computer, a desktop computer). The control device 530 includes transducers 534, a microphone 535, and a camera 536. A user interface 531 includes a transport control region 533a, a playback status region 533b, a playback zone region 533c, a playback queue region 533d, and a media content source region 533e. The transport control region comprises one or more controls for controlling media playback including, for example, volume, previous, play/pause, next, repeat, shuffle, track position, crossfade, equalization, etc. The audio content source region 533e includes a listing of one or more media content sources from which a user can select media items for play back and/or adding to a playback queue.

[00108] The playback zone region 533b can include representations of playback zones within the media playback system 100 (Figures 1A and 1B). In some embodiments, the graphical representations of playback zones may be selectable to bring up additional selectable icons to manage or configure the playback zones in the media playback system, such as a creation of bonded zones, creation of zone groups, separation of zone groups, renaming of zone groups, etc. In the illustrated embodiment, a “group” icon is provided within each of the graphical representations of playback zones. The “group” icon provided within a graphical representation of a particular zone may be selectable to bring up options to select one or more other zones in the media playback system to be grouped with the particular zone. Once grouped, playback devices in the zones that have been grouped with the particular zone can be configured to play audio content

in synchrony with the playback device(s) in the particular zone. Analogously, a “group” icon may be provided within a graphical representation of a zone group. In the illustrated embodiment, the “group” icon may be selectable to bring up options to deselect one or more zones in the zone group to be removed from the zone group. In some embodiments, the control device 530 includes other interactions and implementations for grouping and ungrouping zones via the user interface 531. In certain embodiments, the representations of playback zones in the playback zone region 533b can be dynamically updated as playback zone or zone group configurations are modified.

[00109] The playback status region 533c includes graphical representations of audio content that is presently being played, previously played, or scheduled to play next in the selected playback zone or zone group. The selected playback zone or zone group may be visually distinguished on the user interface, such as within the playback zone region 533b and/or the playback queue region 533d. The graphical representations may include track title, artist name, album name, album year, track length, and other relevant information that may be useful for the user to know when controlling the media playback system 100 via the user interface 531.

[00110] The playback queue region 533d includes graphical representations of audio content in a playback queue associated with the selected playback zone or zone group. In some embodiments, each playback zone or zone group may be associated with a playback queue containing information corresponding to zero or more audio items for playback by the playback zone or zone group. For instance, each audio item in the playback queue may comprise a uniform resource identifier (URI), a uniform resource locator (URL) or some other identifier that may be used by a playback device in the playback zone or zone group to find and/or retrieve the audio item from a local audio content source or a networked audio content source, possibly for playback by the playback device. In some embodiments, for example, a playlist can be added to a playback queue, in which information

corresponding to each audio item in the playlist may be added to the playback queue. In some embodiments, audio items in a playback queue may be saved as a playlist. In certain embodiments, a playback queue may be empty, or populated but “not in use” when the playback zone or zone group is playing continuously streaming audio content, such as Internet radio that may continue to play until otherwise stopped, rather than discrete audio items that have playback durations. In some embodiments, a playback queue can include Internet radio and/or other streaming audio content items and be “in use” when the playback zone or zone group is playing those items.

[00111] When playback zones or zone groups are “grouped” or “ungrouped,” playback queues associated with the affected playback zones or zone groups may be cleared or re-associated. For example, if a first playback zone including a first playback queue is grouped with a second playback zone including a second playback queue, the established zone group may have an associated playback queue that is initially empty, that contains audio items from the first playback queue (such as if the second playback zone was added to the first playback zone), that contains audio items from the second playback queue (such as if the first playback zone was added to the second playback zone), or a combination of audio items from both the first and second playback queues. Subsequently, if the established zone group is ungrouped, the resulting first playback zone may be re-associated with the previous first playback queue, or be associated with a new playback queue that is empty or contains audio items from the playback queue associated with the established zone group before the established zone group was ungrouped. Similarly, the resulting second playback zone may be re-associated with the previous second playback queue, or be associated with a new playback queue that is empty, or contains audio items from the playback queue associated with the established zone group before the established zone group was ungrouped.

[00112] Figure 6 is a message flow diagram illustrating data exchanges between devices of the media playback system 100 (Figures 1A-1M).

[00113] At step 650a, the media playback system 100 receives an indication of selected media content (e.g., one or more songs, albums, playlists, podcasts, videos, stations) via the control device 130a. The selected media content can comprise, for example, media items stored locally on or more devices (e.g., the audio source 105 of Figure 1C) connected to the media playback system and/or media items stored on one or more media service servers (one or more of the remote computing devices 106 of Figure 1B). In response to receiving the indication of the selected media content, the control device 130a transmits a message 651a to the playback device 110a (Figures 1A-1C) to add the selected media content to a playback queue on the playback device 110a.

[00114] At step 650b, the playback device 110a receives the message 651a and adds the selected media content to the playback queue for play back.

[00115] At step 650c, the control device 130a receives input corresponding to a command to play back the selected media content. In response to receiving the input corresponding to the command to play back the selected media content, the control device 130a transmits a message 651b to the playback device 110a causing the playback device 110a to play back the selected media content. In response to receiving the message 651b, the playback device 110a transmits a message 651c to the computing device 106a requesting the selected media content. The computing device 106a, in response to receiving the message 651c, transmits a message 651d comprising data (e.g., audio data, video data, a URL, a URI) corresponding to the requested media content.

[00116] At step 650d, the playback device 110a receives the message 651d with the data corresponding to the requested media content and plays back the associated media content.

[00117] At step 650e, the playback device 110a optionally causes one or more other devices to play back the selected media content. In one example, the playback device 110a is one of a bonded zone of two or more players (Figure 1M). The playback device 110a can receive the selected media content and transmit all or a portion of the media content to other devices in the bonded zone. In another example, the playback device 110a is a coordinator of a group and is configured to transmit and receive timing information from one or more other devices in the group. The other one or more devices in the group can receive the selected media content from the computing device 106a, and begin playback of the selected media content in response to a message from the playback device 110a such that all of the devices in the group play back the selected media content in synchrony.

IV. Setup and Calibration of Speakers using a Mobile Device

[00118] Playback systems in accordance with certain embodiments of the invention incorporate passive speakers that may be one of a variety of types, for example, in-wall, in-ceiling, or outdoor speakers. In-ceiling speakers can be considered a type of in-wall speaker. Additional types can include passive speakers that are not meant for permanent installation, such as bookshelf and floor-standing speakers. A passive speaker may be associated with a manufacturer and/or model number. Such information may be stored as speaker identification data that can be retrieved or derived by activating a speaker identification circuit in the speaker. In several embodiments, the speaker identification circuit can be communicated with through the terminals of the speaker. Techniques for determining speaker identification data for and from a passive speaker that may be utilized in accordance with embodiments of the invention are disclosed in U.S. Patent Application Serial No. 16/115,525 entitled “Passive Speaker Authentication” (the ‘525 patent), the relevant disclosure of which is incorporated by reference further above. Passive speaker detection and configuration may

be facilitated with the user of a mobile device and/or a playback device. A user can utilize a mobile device that performs a process to set up a passive speaker in a playback system in accordance with embodiments of the invention, where the mobile device presents a graphical user interface (e.g., on a display screen) to show relevant information and capture input.

[00119] The mobile device may execute any of a variety of operating systems (e.g., iOS or Android) and certain aspects and/or options in the process may depend on capabilities of the operating system. Some calibration processes may be limited to one or more operating systems, upon an assumption that certain components of devices are relatively consistent in certain operating systems while they are not in other operation systems. For example, Apple devices generally run iOS and have microphones with similar level of fidelity, characteristics, and frequency response. Calibration of speakers using audio captured from such microphones can perform more consistently since the characteristics are better known.

[00120] In the following discussions, a playback device may be an all-in-one device that includes speakers, amplifiers, etc., within the same enclosure, such as the playback device 210 shown in Figure 2A, or an audio device connected to one or more passive speakers, as will be generally discussed below. The audio device may include an audio amplifier, network interface, one or more processors, etc., similar to that of the playback device 210, absent transducers/speakers to output audio.

[00121] A process for configuring a passive speaker for an audio device to which it is connected using a mobile device with a graphical user interface is illustrated in Figure 7. Some aspects may be performed by a mobile device having a graphical user interface, while other aspects may be performed by a playback device connected to the passive speaker. Figures 14-19 illustrate initial screens that may be shown on a graphical user interface on a mobile device that can be advanced

through by selections on the screen (e.g., selecting Settings, Room Settings, Room Name (e.g., a room of the house), Detect, Continue).

[00122] The process 700 includes detecting (710) a passive speaker type using a preset electrical signal (e.g., identification signal). An amplifier of an audio device connected to the passive speaker(s) may include a current sensor and/or a voltage sensor that can determine various characteristics of the passive speaker. The measured current and/or voltage can be used to determine a modulated input impedance of the passive speaker, which may be produced by a speaker identification circuit electrically connected to the terminals of the passive speaker. The modulated input impedance can communicate speaker identification data or information indicative of speaker identification data (e.g., an identifier to look up the information in a database) to the amplifier of the audio device, which may in turn pass the data to the mobile device. The speaker identification data can include information such as, but not limited to, the manufacturer, a model or model number, a serial number, peak voltage or current limits, a frequency response, i.e. impedance at one or more frequencies, and/or thermal response of the speaker. Additional information can include a speaker type (e.g., in-wall, in-ceiling, outdoor, etc.), whether the passive speaker is designed for home theater use, and/or whether the passive speaker is designed to be part of a master playback device/group coordinator (e.g., meant for front channels in a home theater setup), or part of a slave playback device/group member (e.g., meant for surround channels in the home theater setup). The additional information can be stored in association with the other information, or can be derived from one or more pieces of information (e.g., model or model number).

[00123] Some of the additional information may be stored on the audio device to which the passive speaker is connected and provided by the audio device to the mobile device during setup.

For instance, if the audio device has previously been configured to be part of a home theater configuration and has stored thereon corresponding state information, the passive speakers connected to the audio device may accordingly be used for outputting home theater audio. In another instance, the audio device to which the passive speaker is connected may have an active connection to a home theater audio source, such as via an active HDMI or optical interface. Such a connection may further indicate that the passive speakers connected to the audio device may be used for outputting home theater audio. The aforementioned speaker information can also be used for configuration steps as will be discussed further below. Techniques for this detection can include, but are not limited to, those described in the '525 patent incorporated by reference further above. After detection, the playback device can resume the previous volume level (before detection) and any content that was previously playing.

[00124] If detection fails for any of a variety of reasons, the user interface can display (712) an error message such as the screen shown in Fig. 21. The screen can allow the user to indicate to retry (e.g., "Try again") or exit the process (e.g., "Cancel"). Selecting retry restarts detection and selecting exit can return the user to a previous screen. User input is captured on the mobile device and the process proceeds according to the selection, as with many of the subsequent selection screens described below.

[00125] If the passive speaker(s) is detected to be an outdoor speaker, the process can proceed to display (714) a confirmation message such as that shown in Fig. 20 indicating that the outdoor speaker is configured and enhancements have been enabled for audio signals reproduced through the outdoor speaker. In some embodiments, additional calibration may be not be permitted for passive speakers identified as outdoor speakers. In such a case, a button such as one labeled "Done" presents the option to exit the process. In some other embodiments, additional calibration may be

permitted despite the passive speakers being identified as outdoor speakers. For instance, some users may wish to use outdoor passive speakers indoors. In such a case, options to initiate calibration such as that shown in Figure 24 may be displayed.

[00126] If the detection results in passive speakers of mixed type that are not compatible, the process can proceed to display (716) an information screen such as that shown in Fig. 22 indicating the status and that may include buttons to retry (“Try again”), exit (“Not now”), or see additional information (“Learn more”). Requesting more information can hyperlink (718) to informational pages such as an FAQ (frequently asked questions) page. Similarly, when no compatible passive speakers are found, an information screen such as that shown in Fig. 23 can be displayed indicating as such and with options to retry, exit, or provide additional information.

[00127] The process may determine that the passive speakers are indoor in-wall or in-ceiling speakers, in which case the process determines (720) whether the passive speakers are meant for a home theater configuration. In one example, a home theater configuration can be indicated, for example, by information in the speaker identification data or other means as described. If it is not a home theater configuration, a confirmation screen such as that shown in Fig. 24 can be shown that indicates that the passive speakers have been detected and configured with audio enhancements. If calibration of the passive speakers (in connection with the playback device to which it is connected) is permitted (e.g., the mobile device is an iOS device), the screen may present buttons for calibration (e.g., “Tune with Trueplay”) or to skip (e.g., “Not now”). If calibration is not permitted (e.g., the mobile device is an Android device), the screen may show a confirmation message such as “Audio enhancements designed for these speakers have been unlocked” and a button to continue (e.g., “Done”) as illustrated in Fig. 25.

[00128] If the process determines (722) that the passive speakers are meant for a home theater configuration, it proceeds to determine if the audio device connected to the passive speaker is configured as a master playback device/group coordinator of the home theater configuration or if another playback device within the playback system is configured as the master playback device/group coordinator of the home theater configuration. In many embodiments, the master playback device/group coordinator in a home theater configuration is one that is configured to output front channels of home theater audio. If the audio device connected to the passive speaker is not configured as the master playback device/group coordinator of the home theater configuration, the process can display a message confirming that the passive speaker(s) have been identified as surround speaker(s) and/or that an appropriate audio calibration has been loaded. If further calibration is not permitted (e.g., the mobile device is an Android device), the screen may show a confirmation message and a button to continue (e.g., “Done”) or to start the detection process over (e.g., “Detect again”) such as the screen shown in Fig. 26. If further calibration of the speakers is permitted (e.g., the mobile device is an iOS device), the screen may present buttons for calibration (“Tune with Trueplay”), to skip (“Not now”), or to start the detection process over (“Detect again”) such as the screen shown in Fig. 27.

[00129] If the process determines that the audio device connected to the passive speakers is configured as the master playback device/group coordinator of the home theater configuration, the process then proceeds to determine (724) if surround speakers are present in the playback system. The determination of whether surround speakers are present may involve determining if an additional audio device (with additional passive speakers connected) are also configured for the home theater configuration along with the audio device and passive speakers currently being setup. If surround speakers are not present, a confirmation message may display confirming detection of

front speakers, such as that shown in Fig. 28. When further calibration is permitted, a screen may appear such as shown in Fig. 29 that presents buttons for calibration (“Tune with Trueplay”), to skip (“Not now”), or to start the detection process over (“Detect again”).

[00130] If surround speakers are present and the audio device connected to the passive speakers is configured as the master playback device/group coordinator, the screen may display (726) a confirmation message confirming that both front and surround speakers are detected. One such confirmation screen is shown in Fig. 30. If further calibration of the speakers is permitted (e.g., the mobile device is an iOS device), the screen may present buttons for calibration (“Tune with Trueplay”) or to skip (“Not now”) as shown in Fig. 31.

[00131] Calibration at this point, or at other points mentioned further above, may utilize any of a variety of techniques, such as but not limited to, those described in the ‘323 and ‘524 patents incorporated by reference further above. For example, speaker calibration can include adjusting a frequency curve of the speaker output to match that of a target frequency curve. The target frequency curve represents an equalization that results in the output of the speaker having a desired audio playback quality. The target frequency curves may be set by a manufacturer or system integrator. Calibration can be performed using a microphone capturing audio played back through the passive speaker in the environment and applying EQ settings and/or other effects. Figures 8-10 illustrate screens that may be shown during a process of calibrating speakers in accordance with an embodiment of the invention, while Figures 11-13 illustrate screens that may be shown during a subsequent calibration after detecting that a first calibration has been done. These sequences may be shown as user input is selected through selecting buttons in the graphical user interface and may be shown before or after the speaker detection process discussed above, depending on what selections were made in the interface.

[00132] While a specific process is discussed above with respect to Fig. 7, one skilled in the art will recognize that any of a variety of processes may be utilized to detect and configure in accordance with embodiments of the invention. Figures that show example graphical user interface screens are discussed and illustrated in connection with the process above. These figures are shown as examples of particular embodiments for the types of information conveyed and user interface elements allowing user input. One skilled in the art will appreciate that variations to the text, layout, and appearance may be appropriate as to a particular application in accordance with embodiments of the invention.

V. Conclusion

[00133] The above discussions relating to playback devices, controller devices, playback zone configurations, and media content sources provide only some examples of operating environments within which functions and methods described below may be implemented. Other operating environments and configurations of media playback systems, playback devices, and network devices not explicitly described herein may also be applicable and suitable for implementation of the functions and methods.

[00134] The description above discloses, among other things, various example systems, methods, apparatus, and articles of manufacture including, among other components, firmware and/or software executed on hardware. It is understood that such examples are merely illustrative and should not be considered as limiting. For example, it is contemplated that any or all of the firmware, hardware, and/or software aspects or components can be embodied exclusively in hardware, exclusively in software, exclusively in firmware, or in any combination of hardware, software, and/or firmware. Accordingly, the examples provided are not the only ways) to implement such systems, methods, apparatus, and/or articles of manufacture.

[00135] Additionally, references herein to “embodiment” means that a particular feature, structure, or characteristic described in connection with the embodiment can be included in at least one example embodiment of an invention. The appearances of this phrase in various places in the specification are not necessarily all referring to the same embodiment, nor are separate or alternative embodiments mutually exclusive of other embodiments. As such, the embodiments described herein, explicitly and implicitly understood by one skilled in the art, can be combined with other embodiments.

[00136] The specification is presented largely in terms of illustrative environments, systems, procedures, steps, logic blocks, processing, and other symbolic representations that directly or indirectly resemble the operations of data processing devices coupled to networks. These process descriptions and representations are typically used by those skilled in the art to most effectively convey the substance of their work to others skilled in the art. Numerous specific details are set forth to provide a thorough understanding of the present disclosure. However, it is understood to those skilled in the art that certain embodiments of the present disclosure can be practiced without certain, specific details. In other instances, well known methods, procedures, components, and circuitry have not been described in detail to avoid unnecessarily obscuring aspects of the embodiments. Accordingly, the scope of the present disclosure is defined by the appended claims rather than the foregoing description of embodiments.

[00137] When any of the appended claims are read to cover a purely software and/or firmware implementation, at least one of the elements in at least one example is hereby expressly defined to include a tangible, non-transitory medium such as a memory, DVD, CD, Blu-ray, and so on, storing the software and/or firmware.

CLAIMS

What is claimed is:

1. A method for detecting and configuring passive speakers in a playback system using a mobile device, the method comprising:

deriving speaker identification data concerning one or more passive speakers connected to an audio device in a playback system based upon at least an electrical signal sent to and returned from the one or more passive speakers,

wherein the electrical signal is sent by the audio device, the audio device including an audio stage comprising one or more amplifiers, and

wherein the speaker identification data comprises information identifying a type of speaker;

based on speaker identification data, identifying a type of speaker of the one or more passive speakers;

based on the identified type of speaker, displaying, by a mobile device, information and selectable options dependent upon the identified type of speaker.

2. The method of claim 1, wherein displaying information and selectable options includes displaying an option for a user to initiate a calibration process only when it is determined that the identified type of speaker is suitable for the calibration process.

3. The method of claim 1 or 2, further comprising determining, based on the speaker identification data, whether the one or more passive speakers are configured for a home theater configuration; and

when the identified type of speaker is a type of speaker configured for use in a home theater arrangement, determining whether the audio device is configured as a master playback device, and

when the audio device is not configured as a master playback device, displaying a confirmation screen on the mobile device indicating:

that the one or more speakers are configured as surround speakers with audio enhancements applied.

4. The method of claim 3, further comprising, when the audio device is configured as a master playback device, determining whether the playback system includes surround speakers; and if the playback system includes surround speakers, displaying a confirmation screen on the mobile device indicating the one or more passive speakers are configured as front speakers and surround speakers with audio enhancements applied, and

if the playback system does not include surround speakers, displaying a confirmation screen on the mobile device indicating the one or more passive speakers are configured as front speakers with audio enhancements applied.

5. The method of one of claims 3 and 4, further comprising displaying the option for a user to begin the calibration process is displayed on the confirmation screen.

6. The method of claim 1, wherein, when the identified type of speaker is an outdoor speaker, displaying a completion screen on a display of the mobile device.

7. The method of any preceding claim, wherein deriving speaker identification data concerning one or more speakers in a playback system based upon at least an electrical signal sent to and returned from the one or more speakers comprises:

activating a passive speaker identification circuit in the one or more speakers by the playback device using the electrical signal;

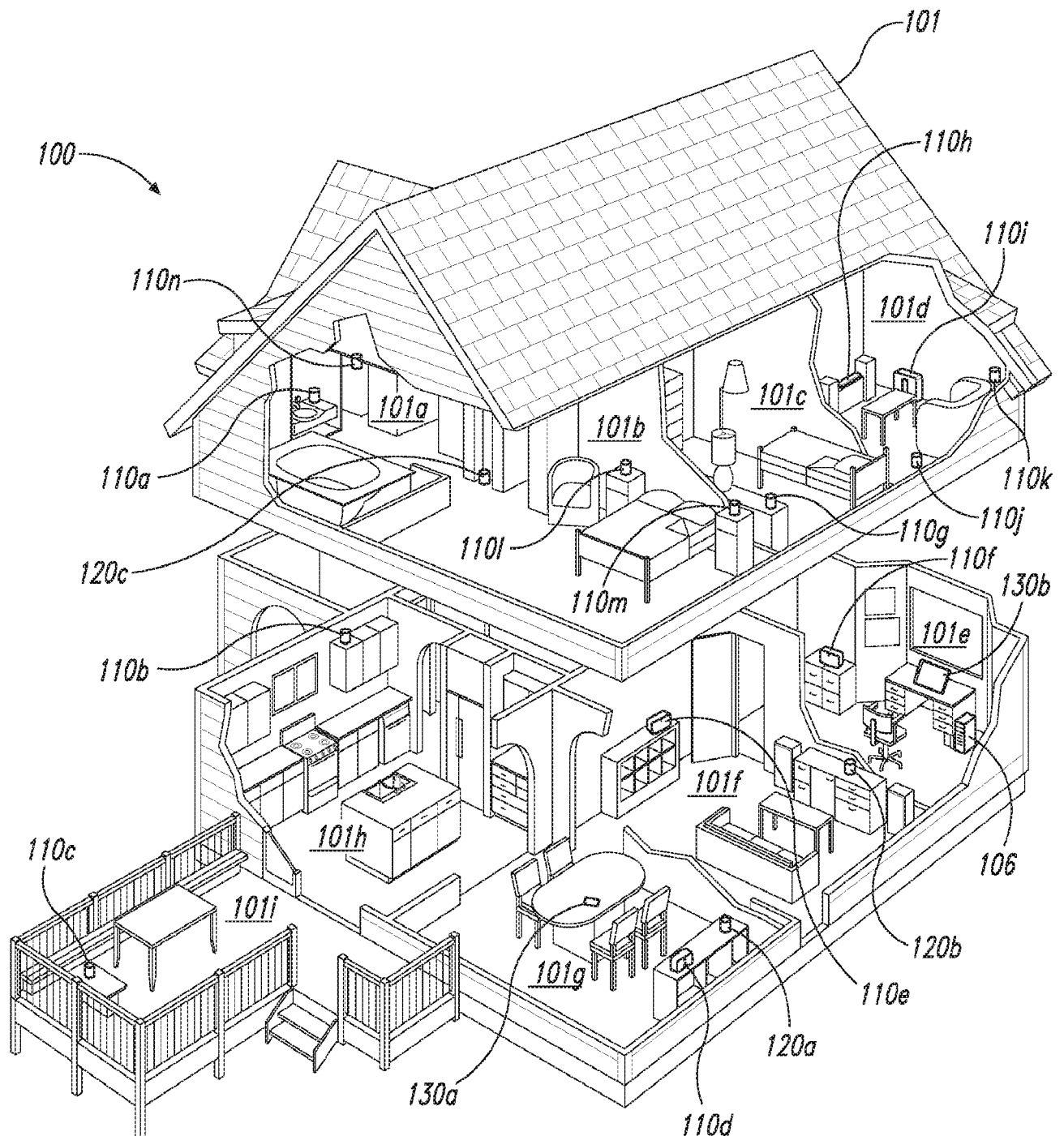
measuring an electrical current of the electrical signal by the playback device;

determining, based on the measured electrical current, an impedance modulation of the passive speaker; and

determining the information identifying a type of speaker based on the determined impedance modulation of the speaker.

8. The method of any preceding claim, wherein:
the speaker identification data is stored in a speaker identification database and
deriving speaker identification data comprises receiving information from a speaker identification circuit in the one or more passive speakers and using the received information to retrieve speaker identification data from the speaker identification database.
9. The method of any preceding claim, further comprising, when it is determined, based on the speaker identification data, that none of the one or more passive speakers is compatible with configuration process for the playback system, displaying an error screen indicating that no compatible speaker was detected.
10. The method of any preceding claim, further comprising, when the speaker identification data indicates that one or more of the passive speakers are not a same type of speaker, displaying an error screen indicating that mixed types of speakers were detected.
11. The method of any preceding claim, further comprising playing back an audio signal with equalizer curve applied that is based upon information from the derived speaker identification data.
12. The method of any preceding claim, wherein determining whether the playback system is in a home theater configuration comprises:
retrieving a model number of the one or more passive speakers; and
determining whether the model number is assigned to a home theater category of products.
13. The method of one of claims 2 and 4, further comprising:
determining a particular operating system being run by the mobile device and
displaying the option for the user to performing a calibration process on the one or more passive speakers when the calibration process is configured for the particular operating system.

14. The method of one of claims 2, 4, and 13, wherein the calibration process comprises:
playing a preset calibration audio signal from the one or more passive speakers; and
adjusting a frequency curve of the speaker output to match that of a target frequency curve.
15. The method of one of claims 2 to 14, wherein a master playback device is a playback device that is configured to output audio for front channels in surround sound decoded audio.
16. The method of any preceding claim, wherein the speaker identification data is received by the mobile device from the audio device.
17. A computing device comprising:
one or more processors; and
a tangible, non-transitory computer-readable medium having stored thereon instructions executable by the one or more processors to perform a method according to any preceding claim.
18. Tangible, non-transitory computer-readable medium having stored thereon instructions executable by one or more processors of a computing device to cause the computing device to perform a method according to one of claims 1 to 16.

*Fig. 1A*

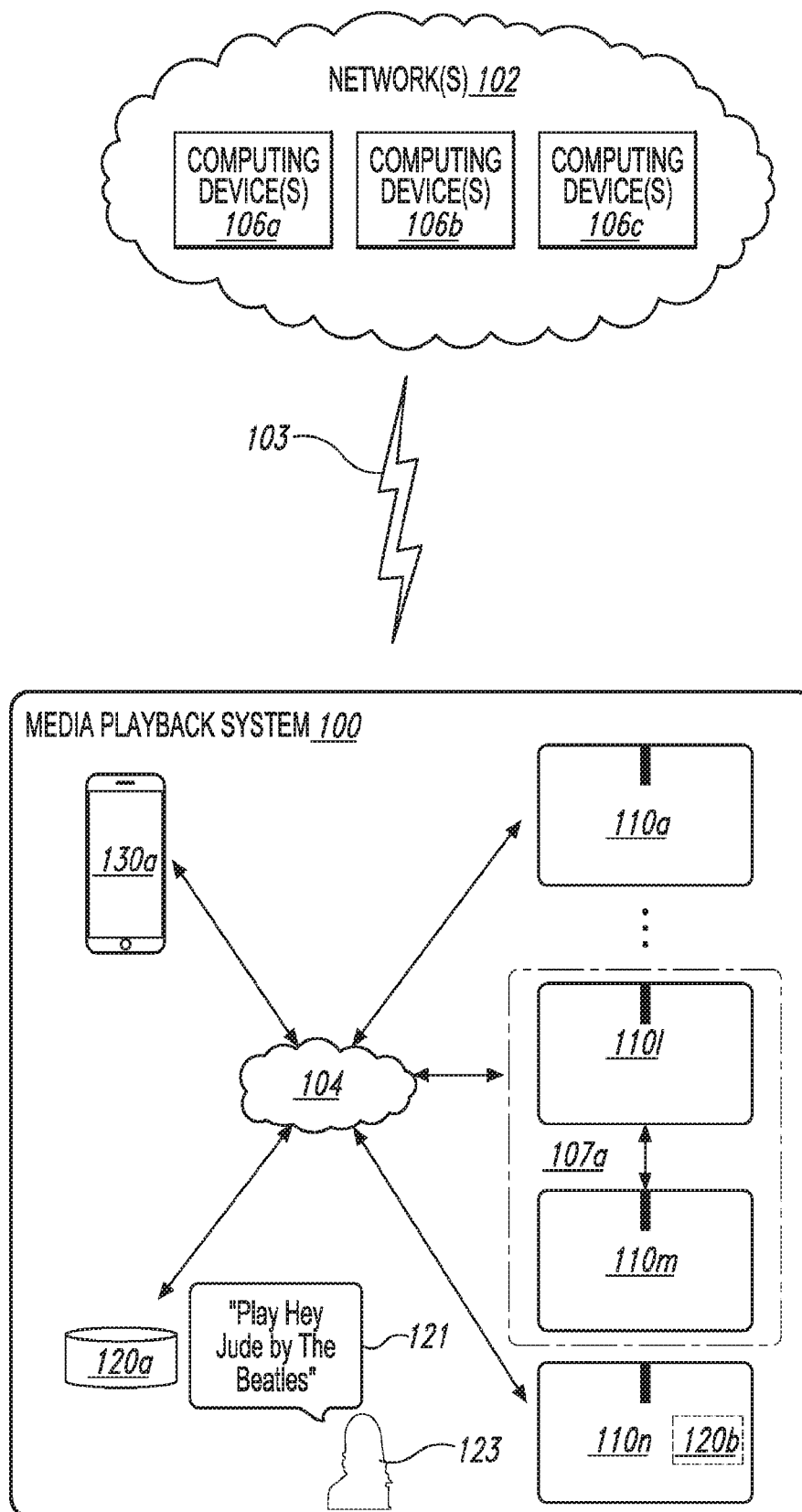
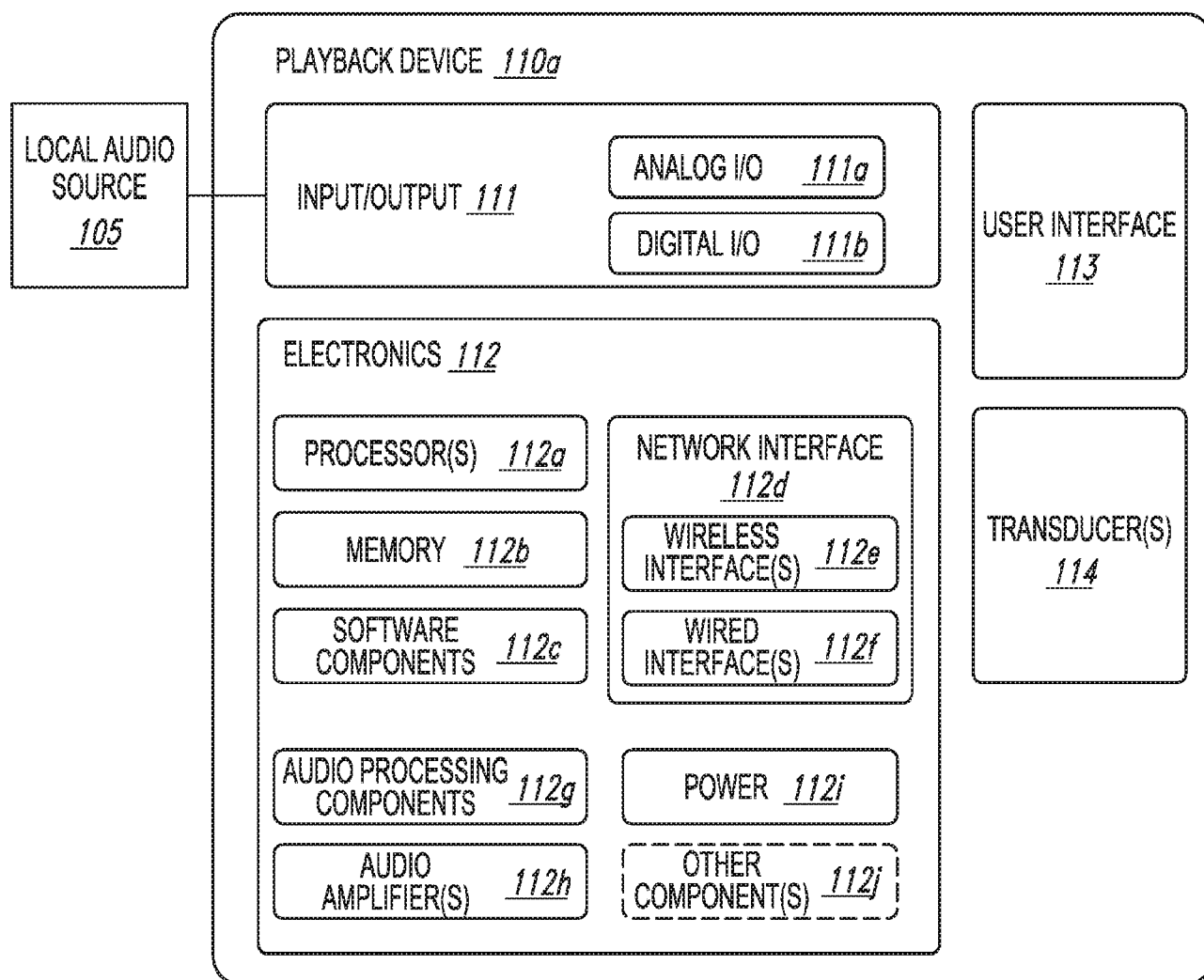
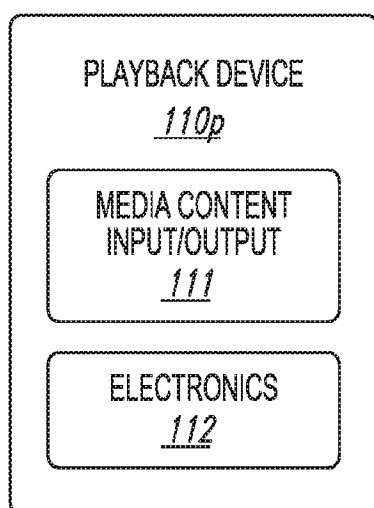
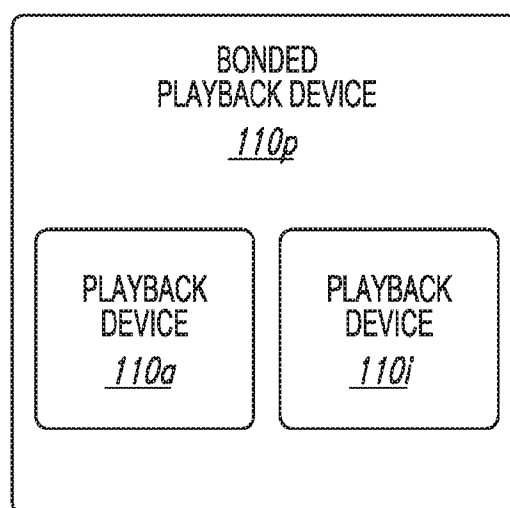


Fig. 1B

*Fig. 1C**Fig. 1D**Fig. 1E*

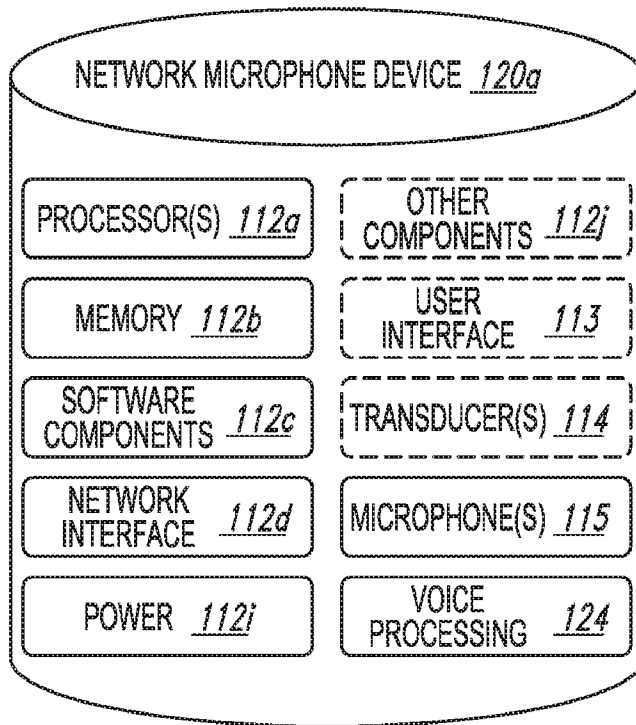


Fig. 1F

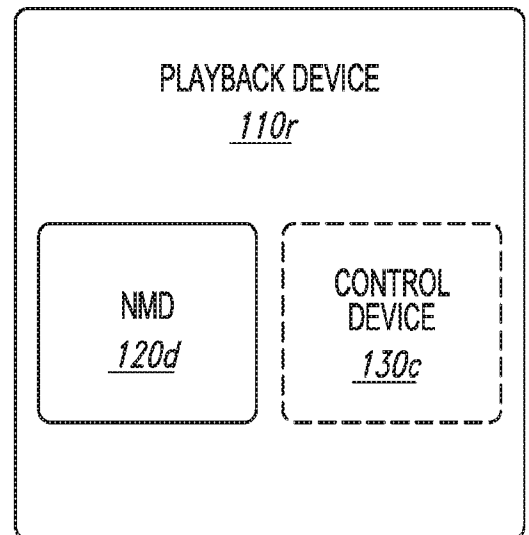


Fig. 1G

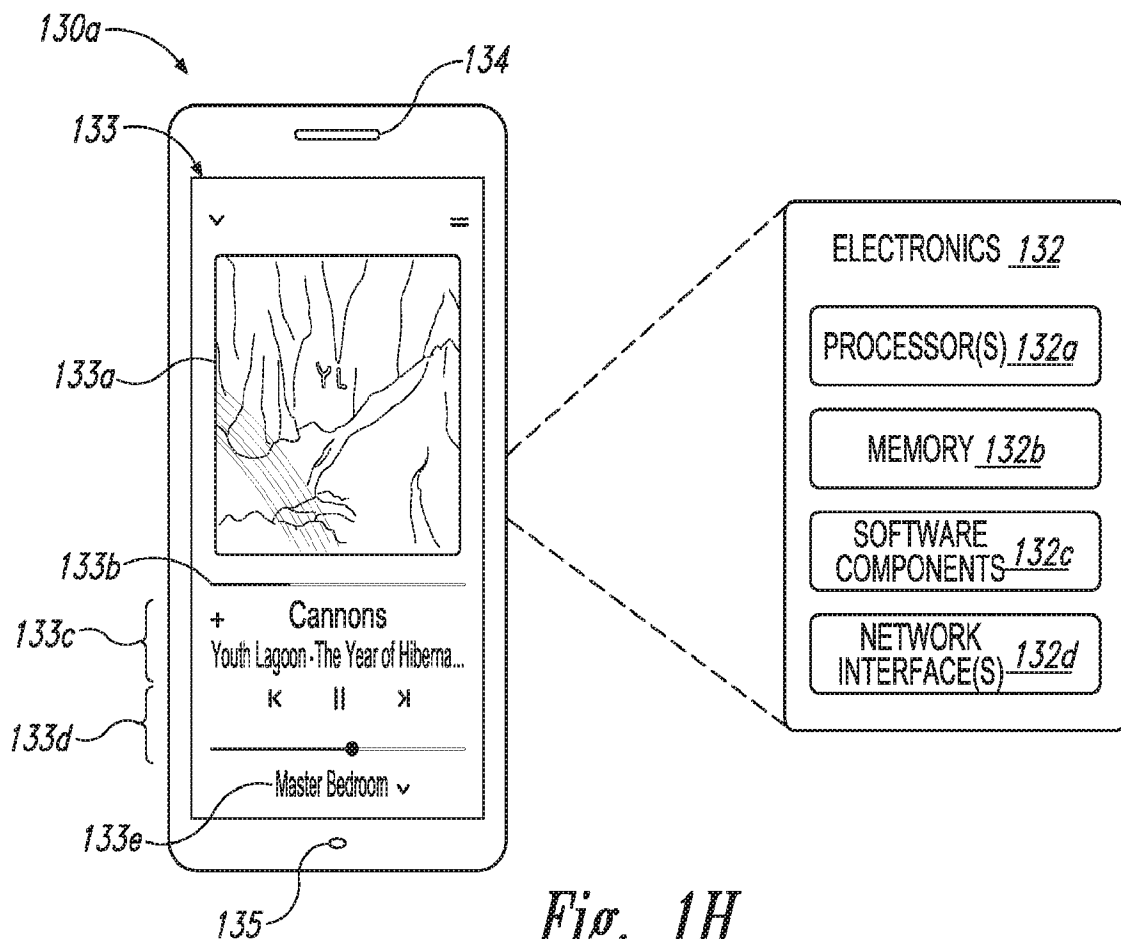


Fig. 1H

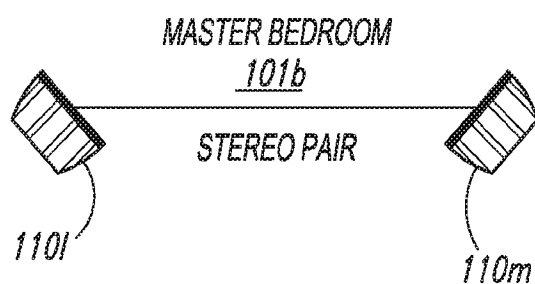


Fig. 1I

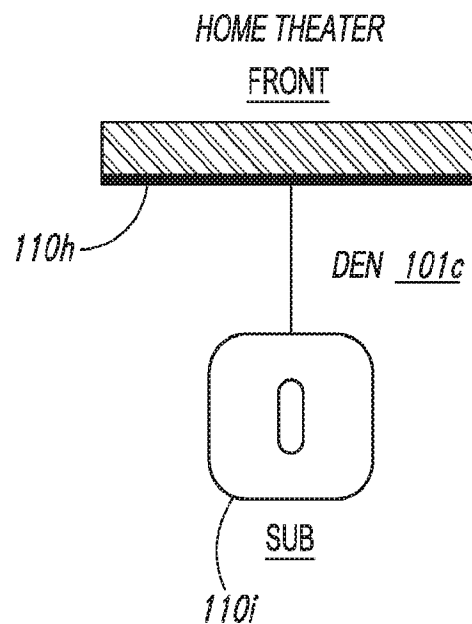


Fig. 1J

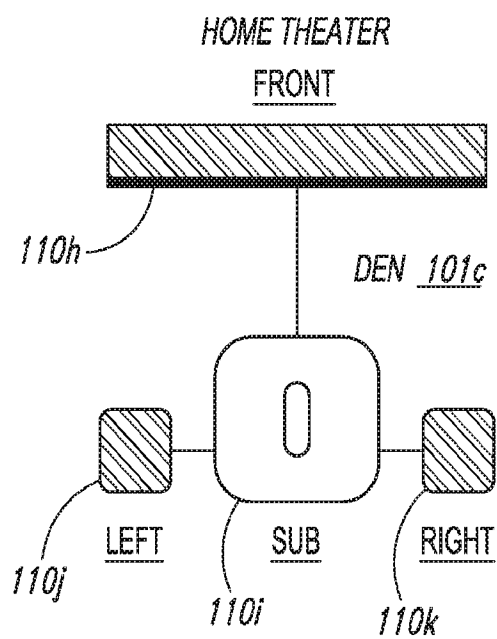


Fig. 1K

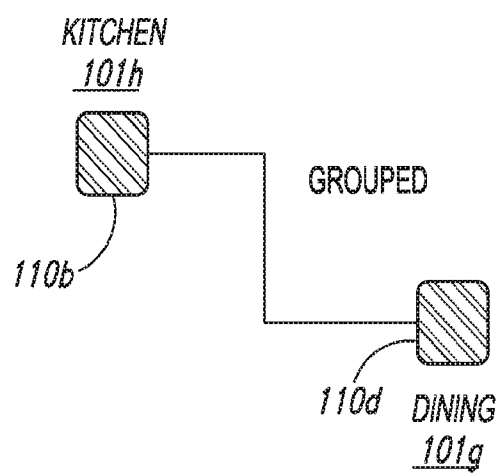


Fig. 1L

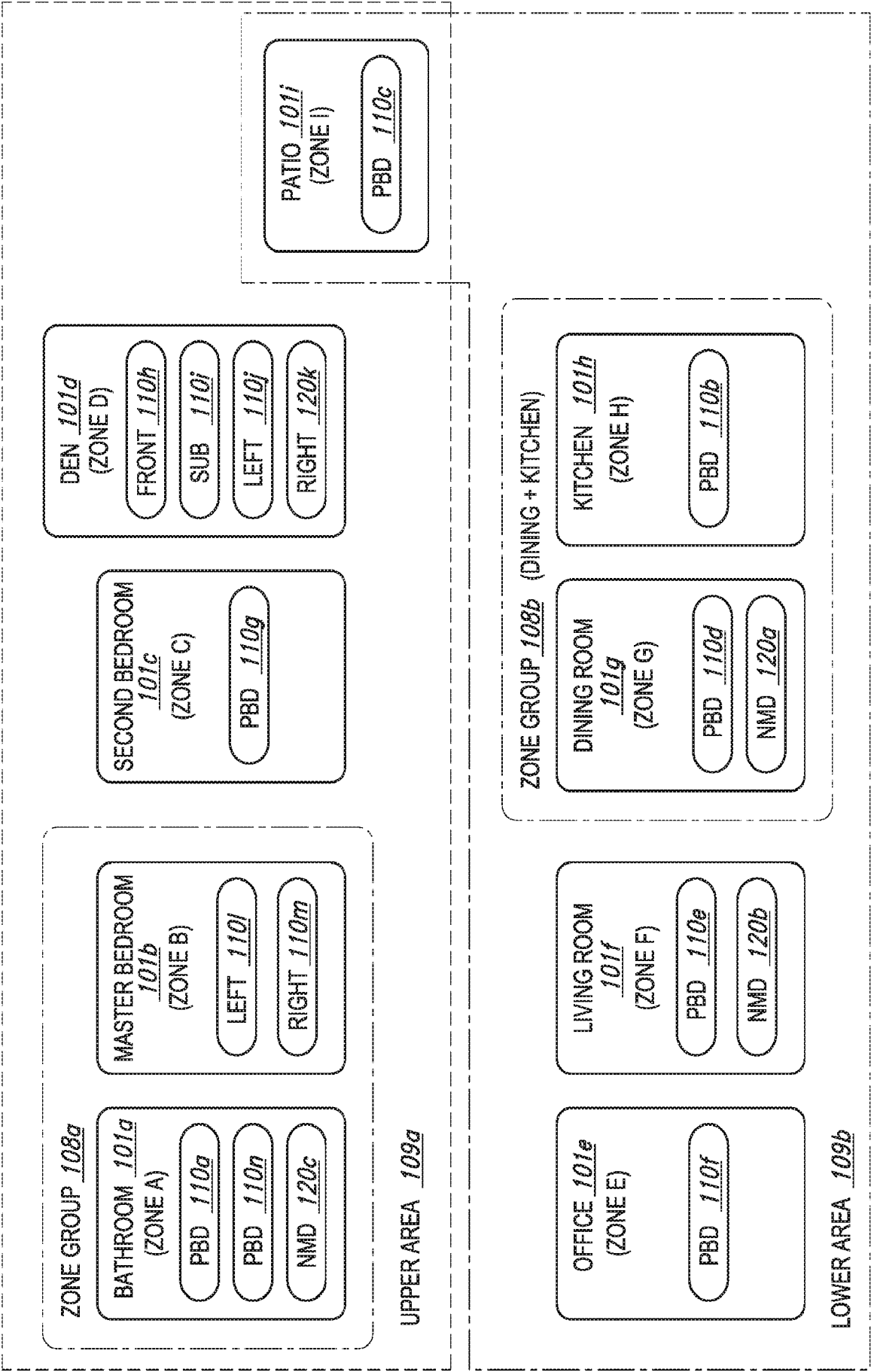


Fig. 1M

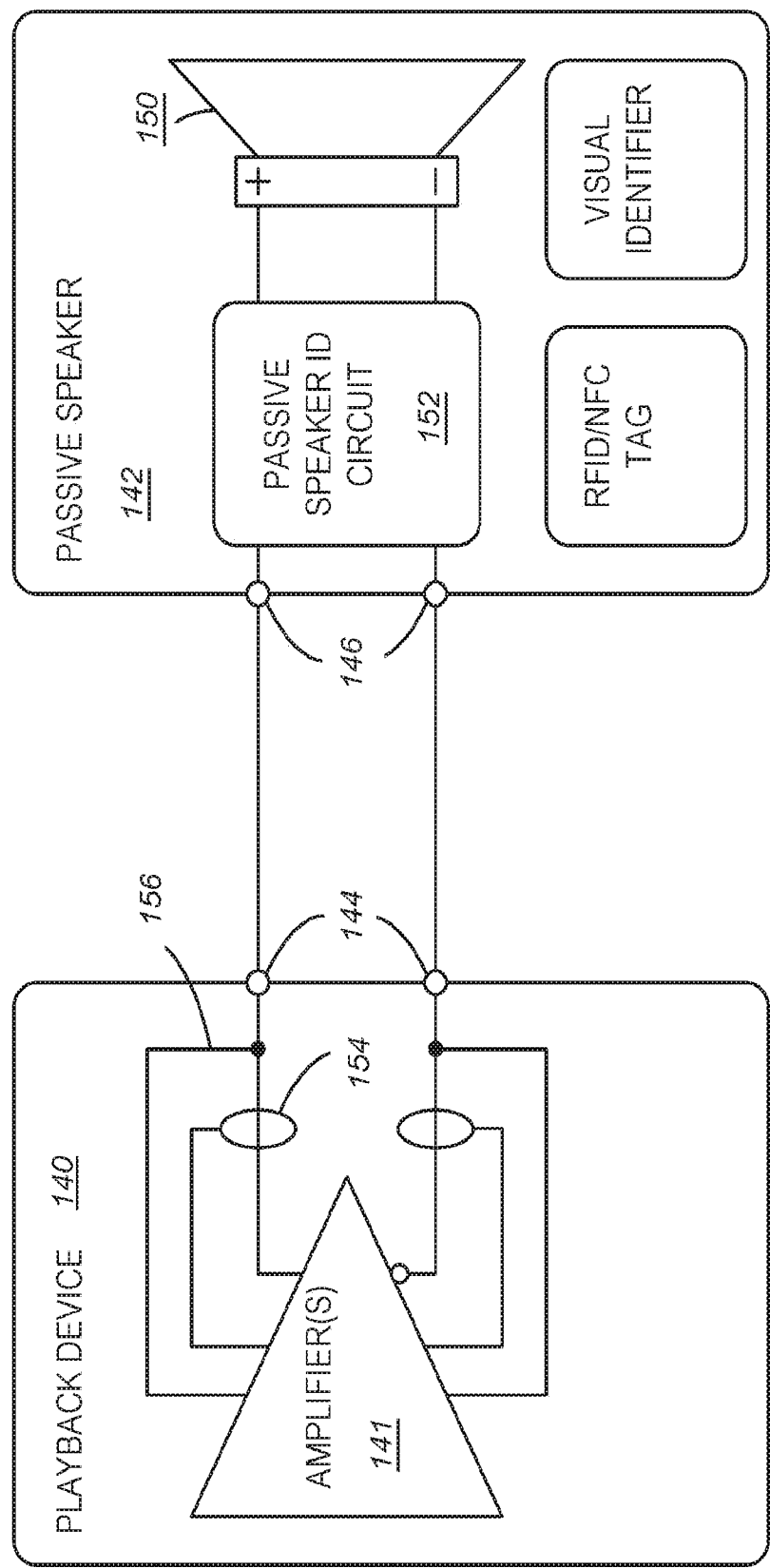


Figure 1N

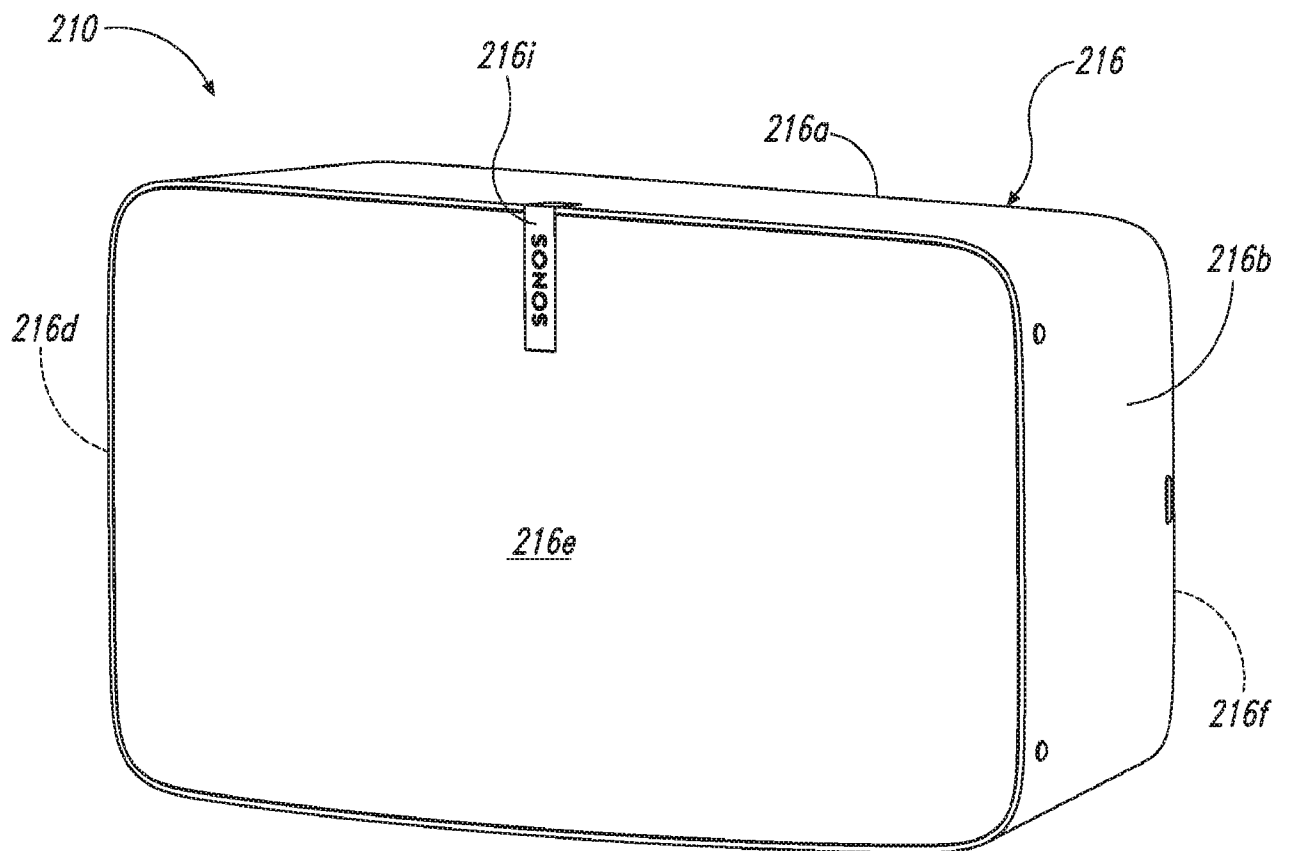


Fig. 2A

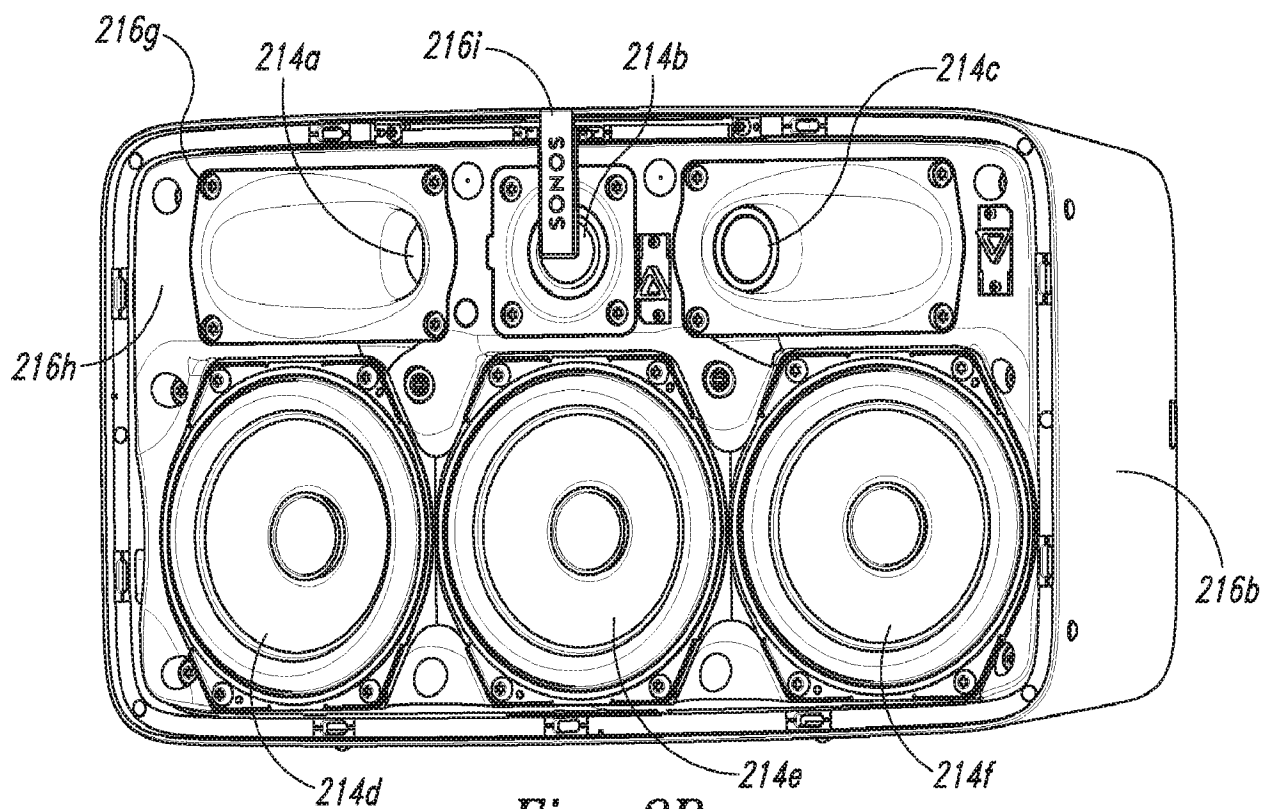


Fig. 2B

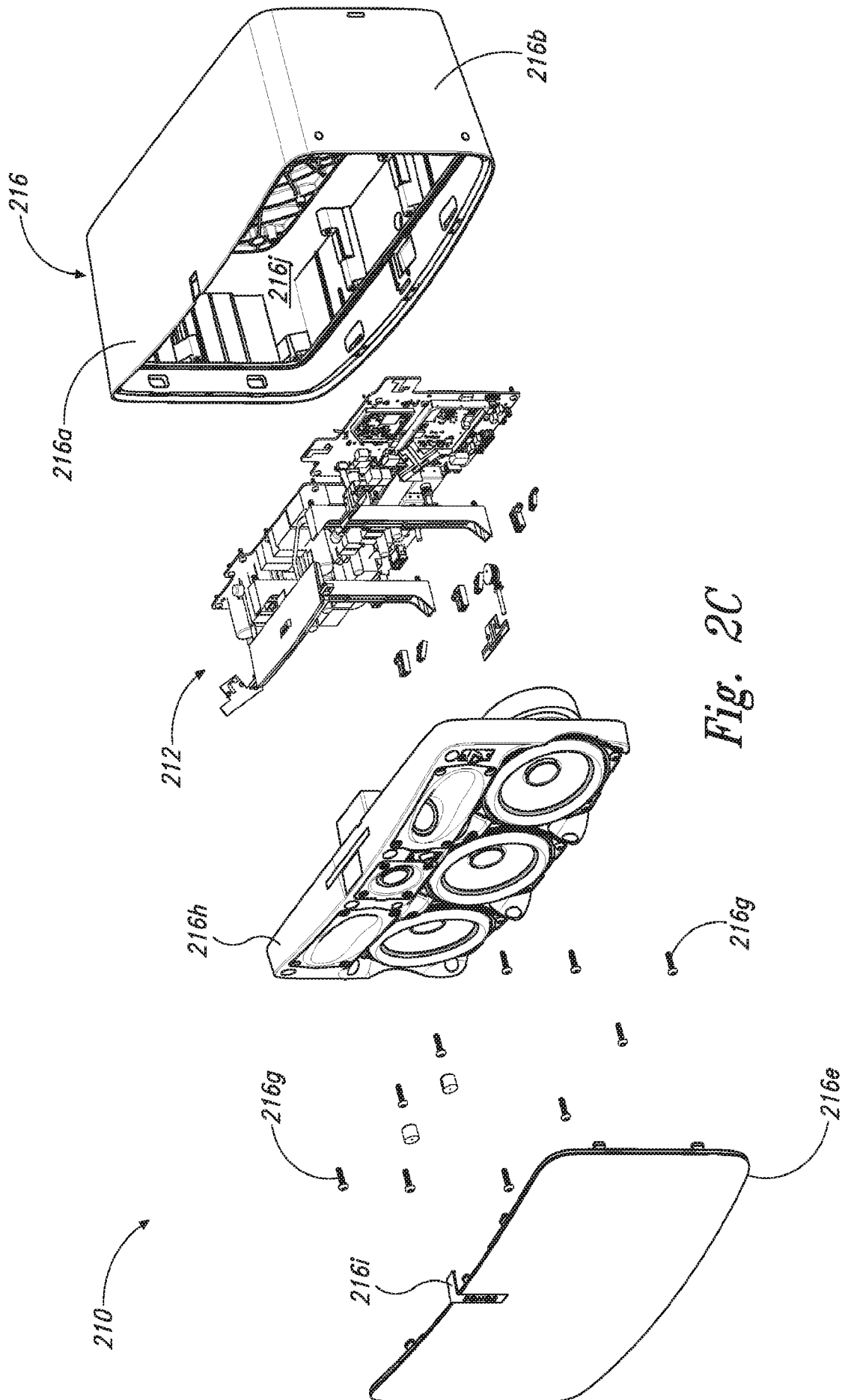
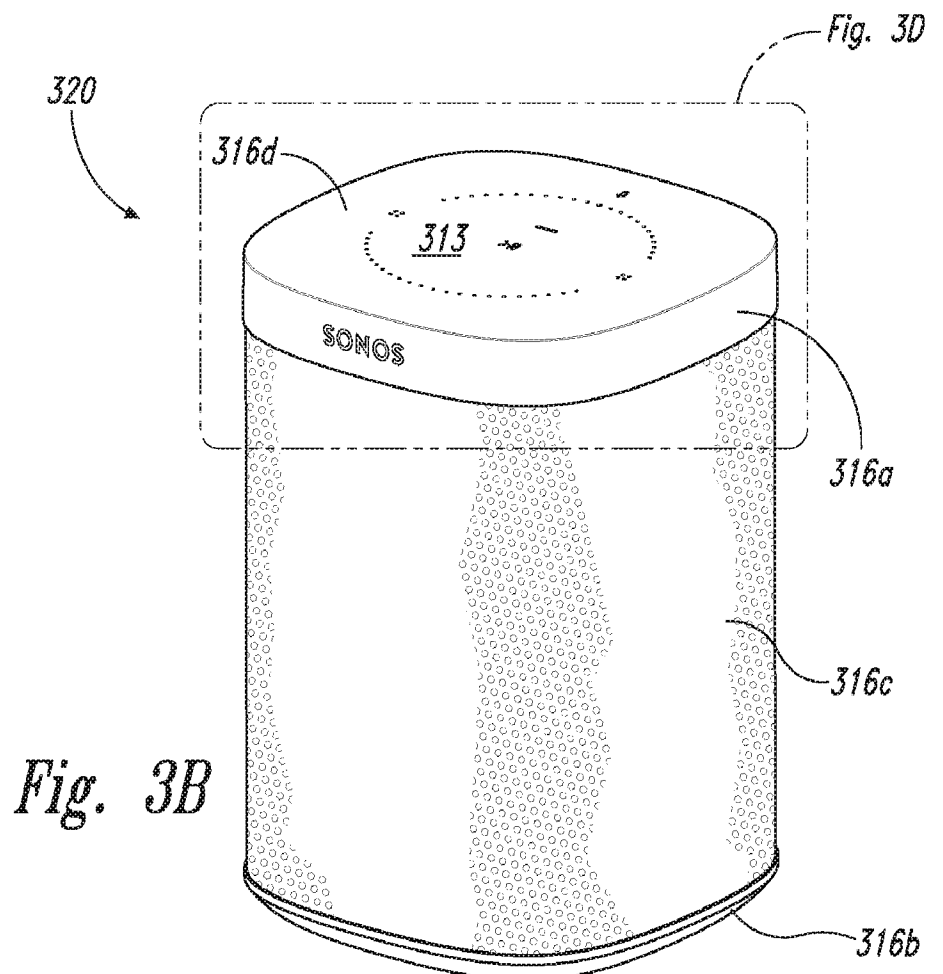
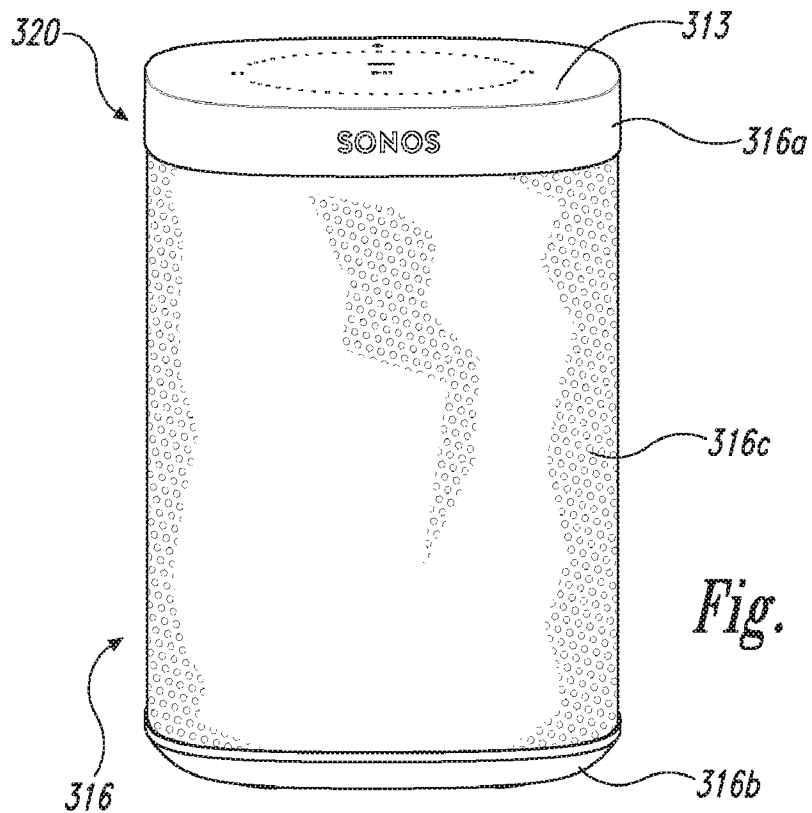


Fig. 2C



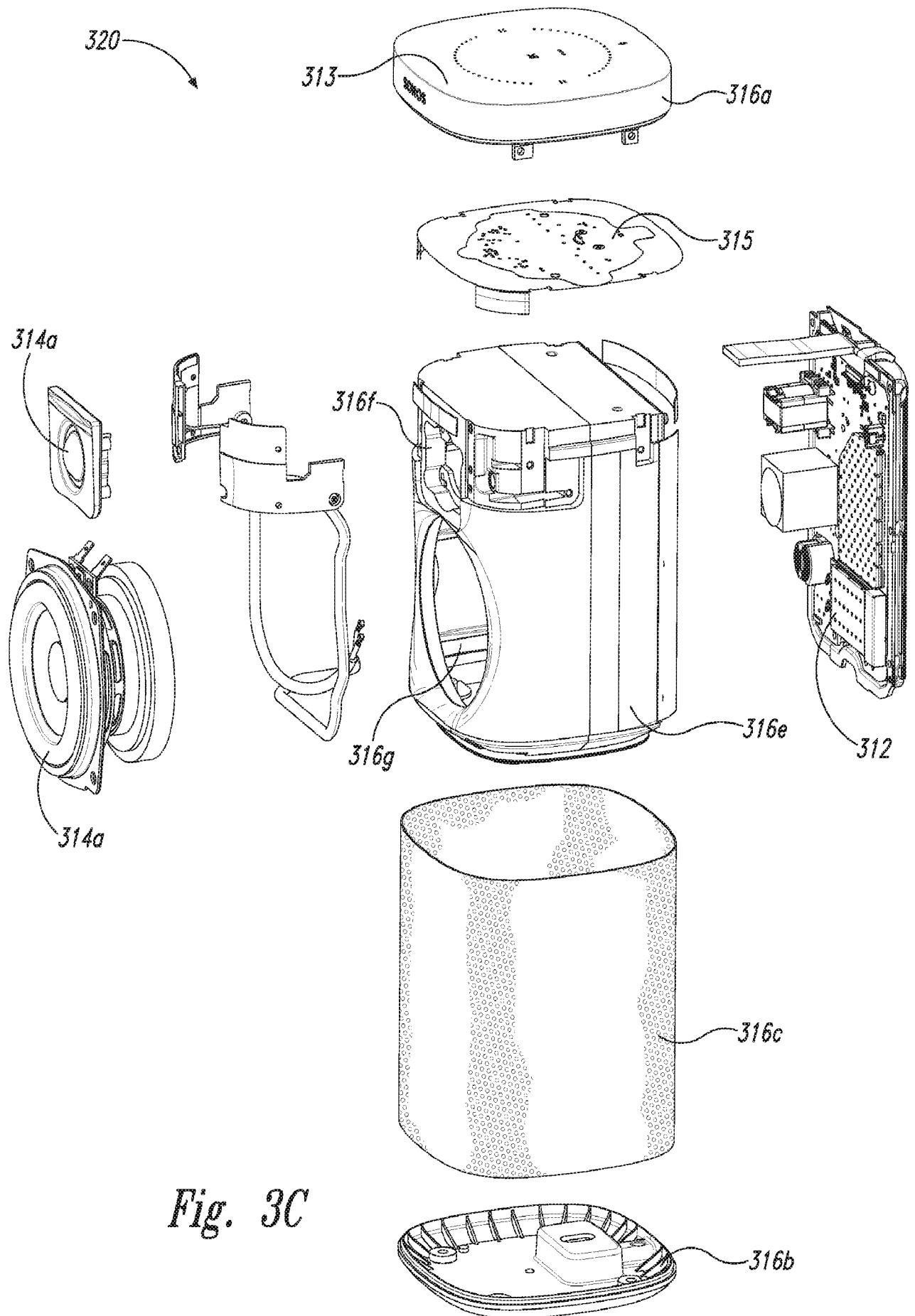
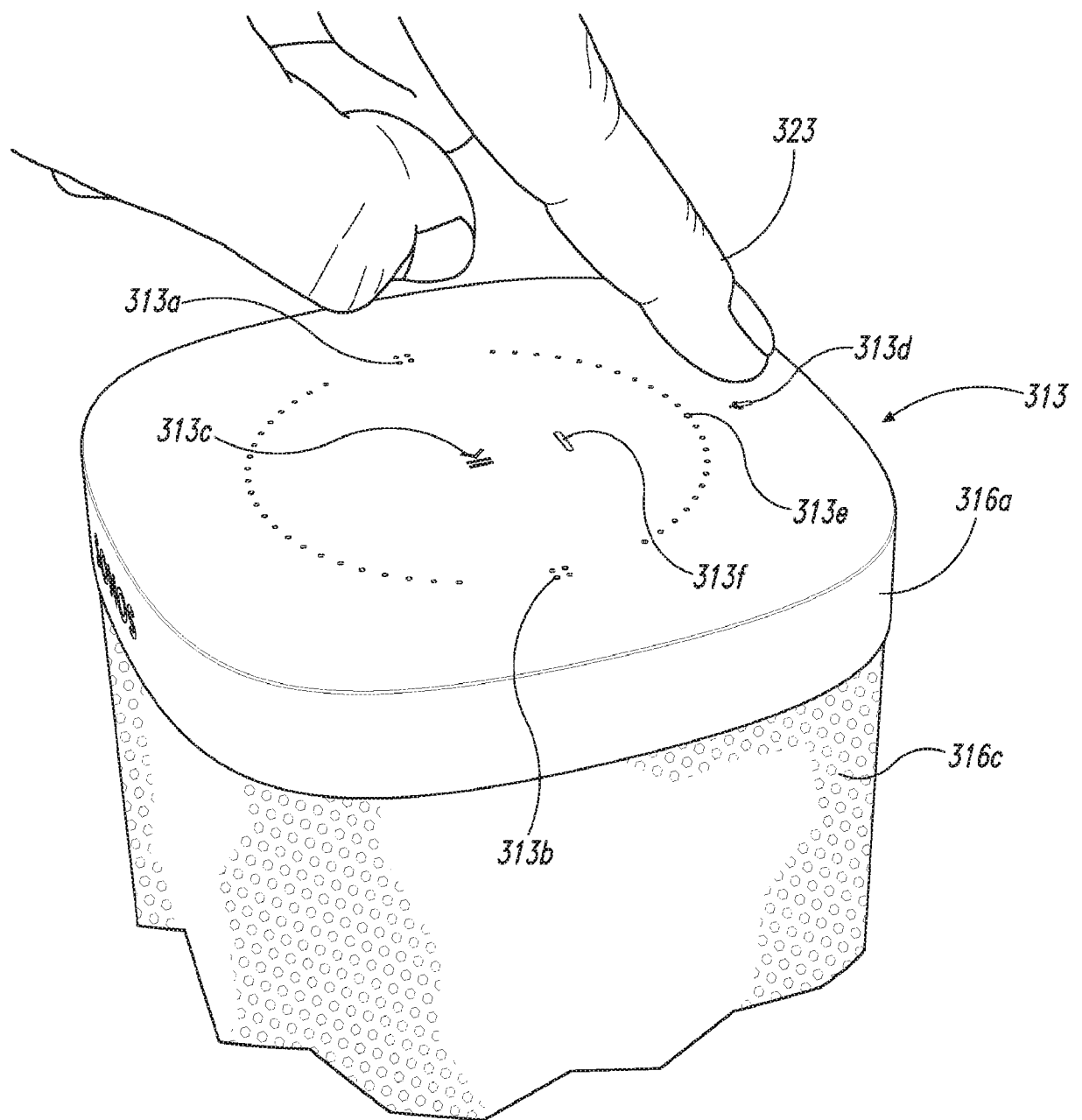


Fig. 3C

*Fig. 3D*

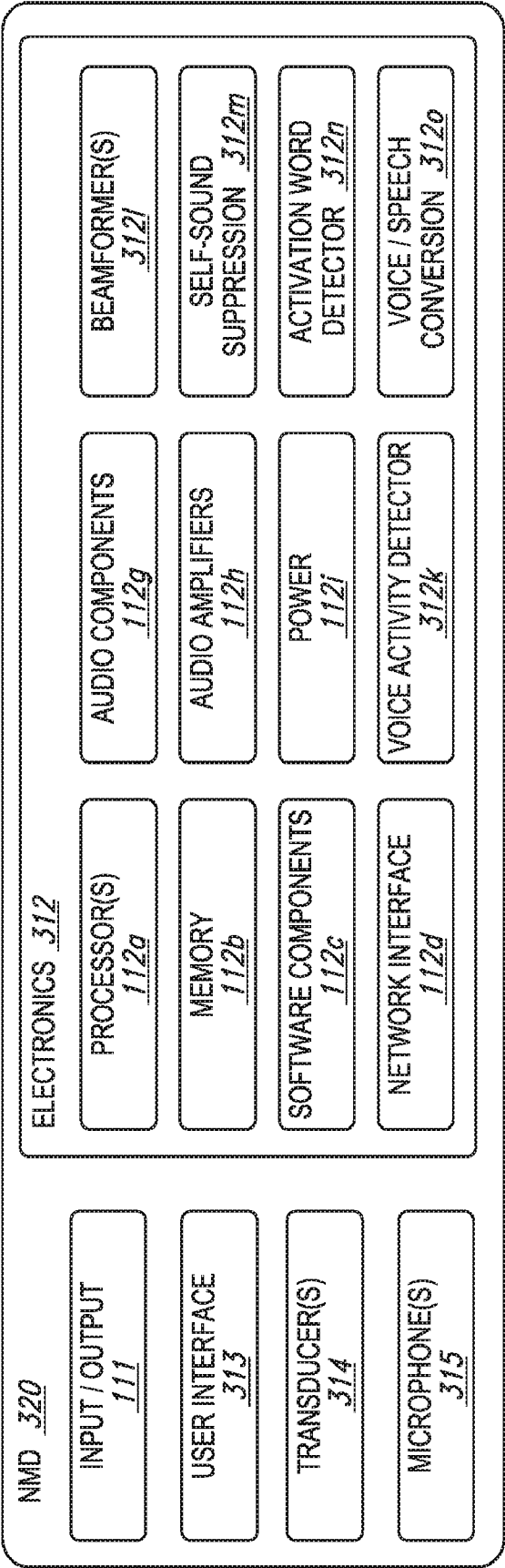


Fig. 3E

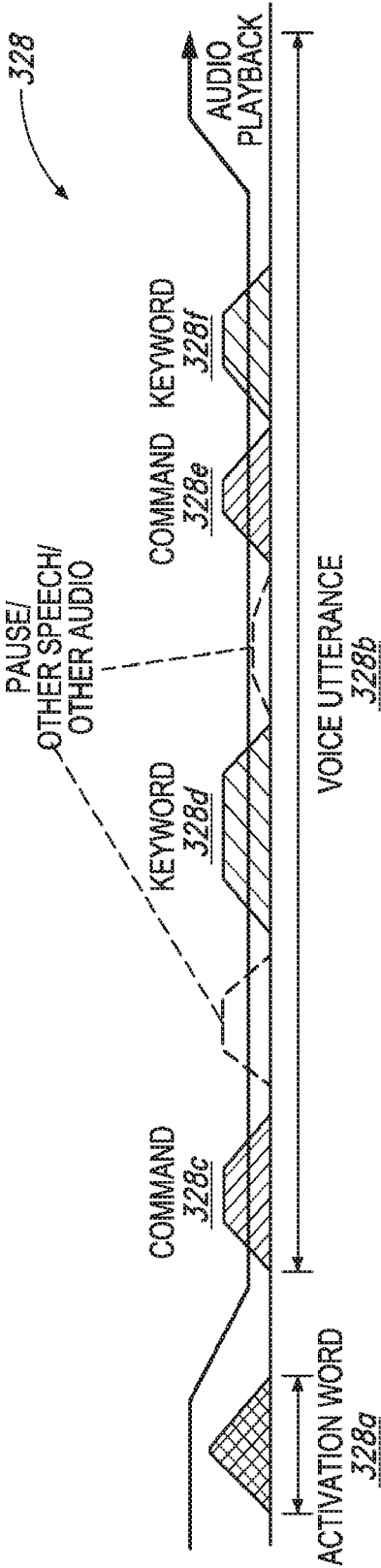
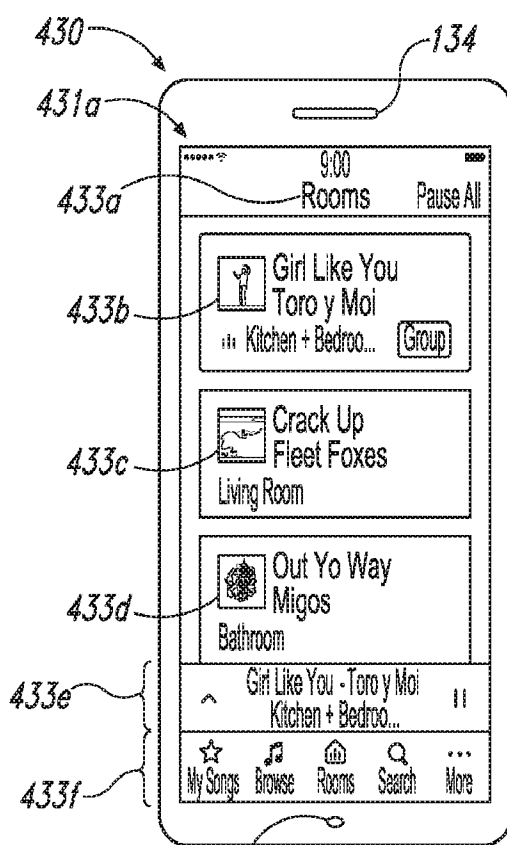
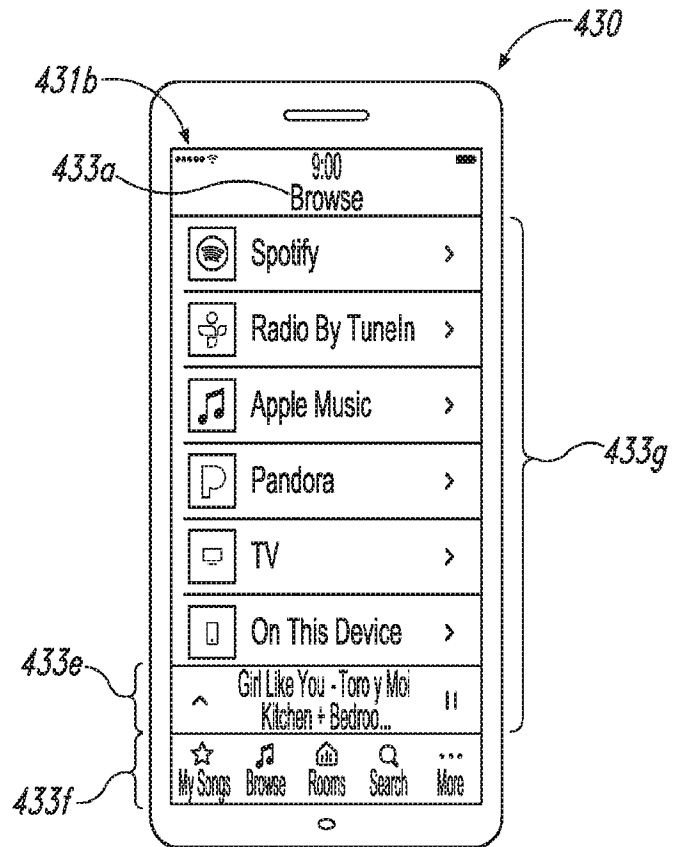
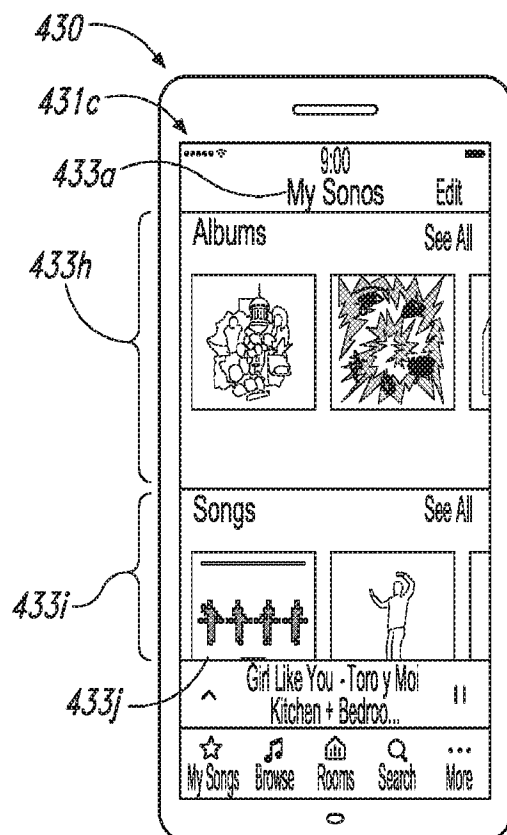
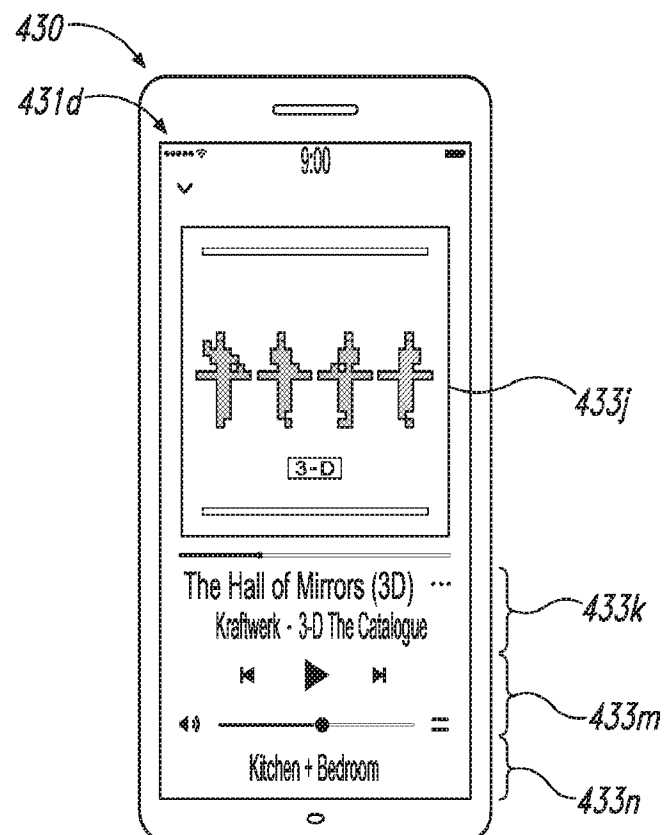


Fig. 3F

*Fig. 4A**Fig. 4B**Fig. 4C**Fig. 4D*

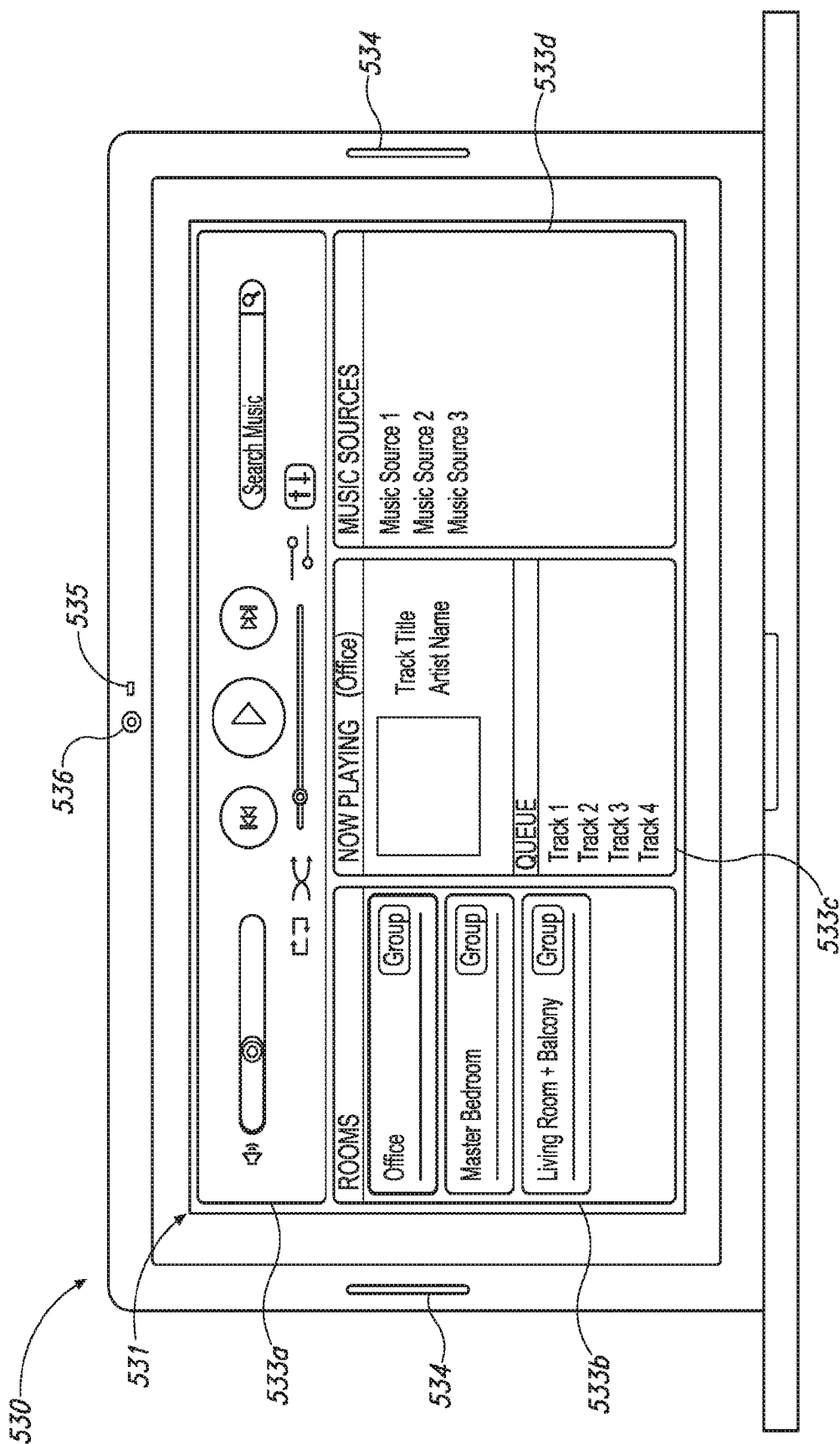


Fig. 5

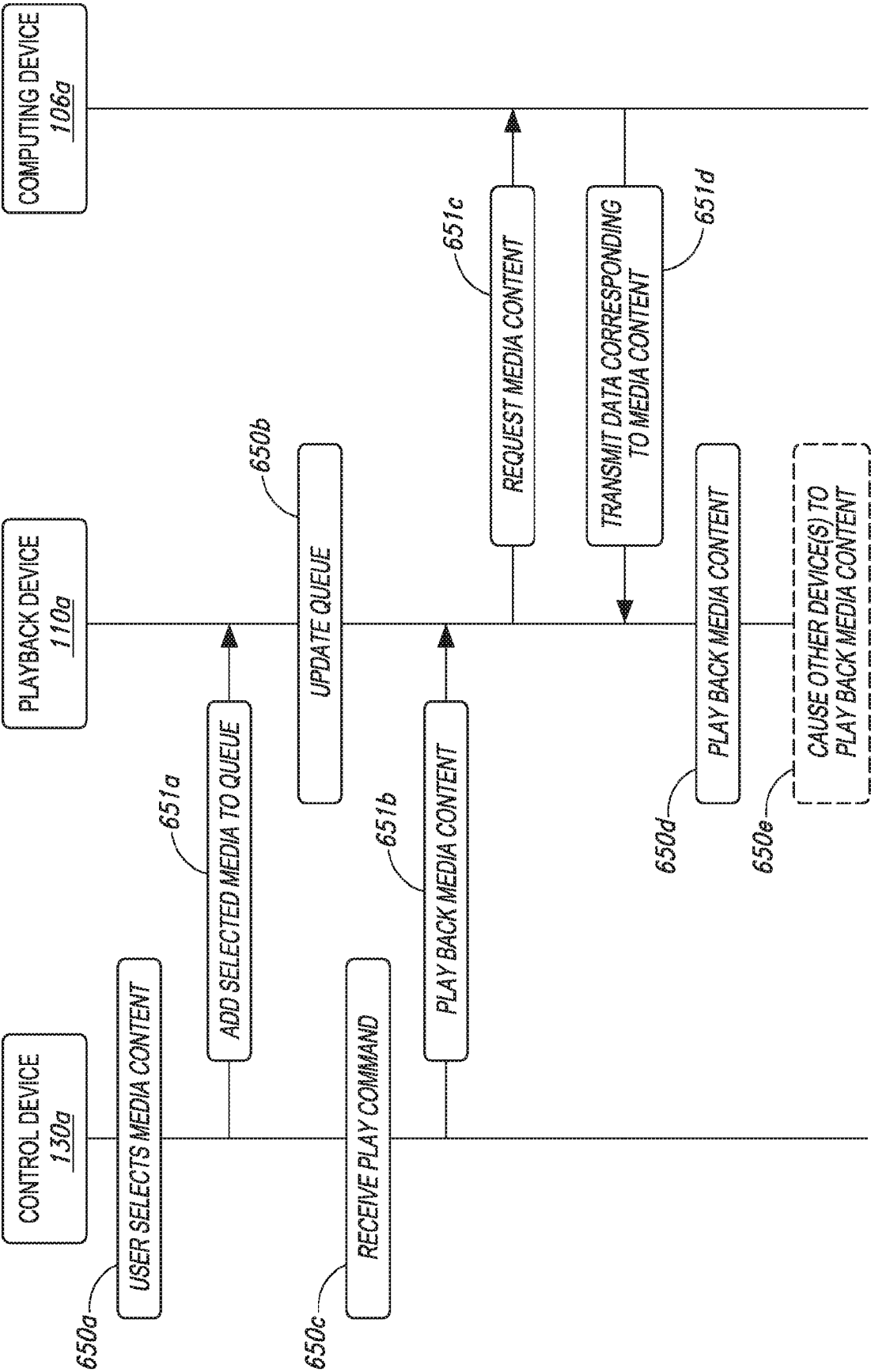


Fig. 6

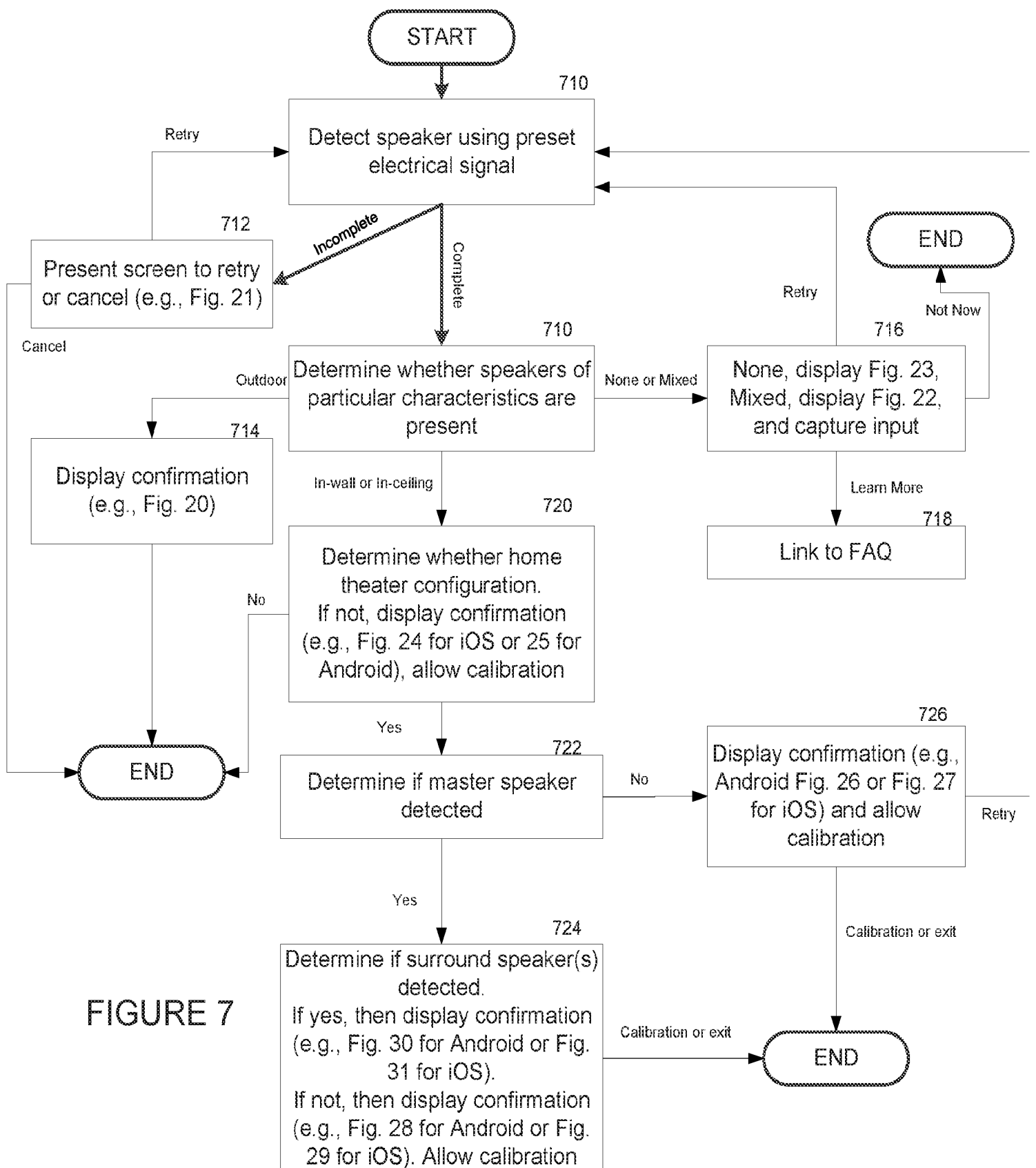


FIGURE 7

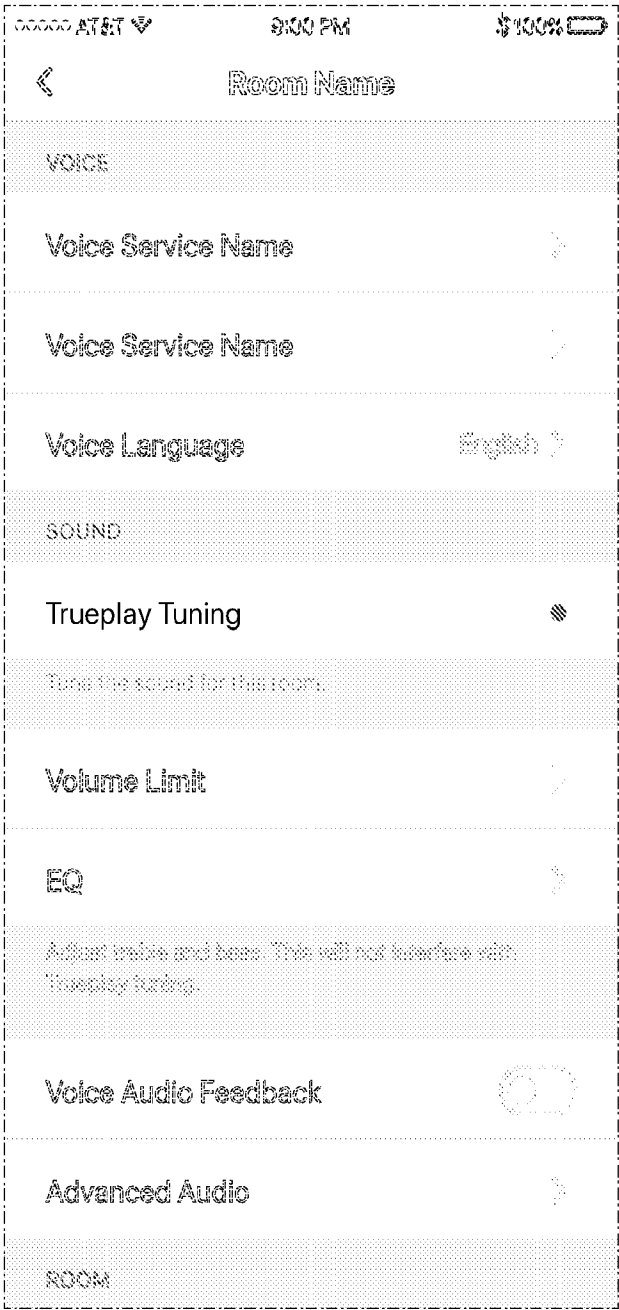


FIG. 8

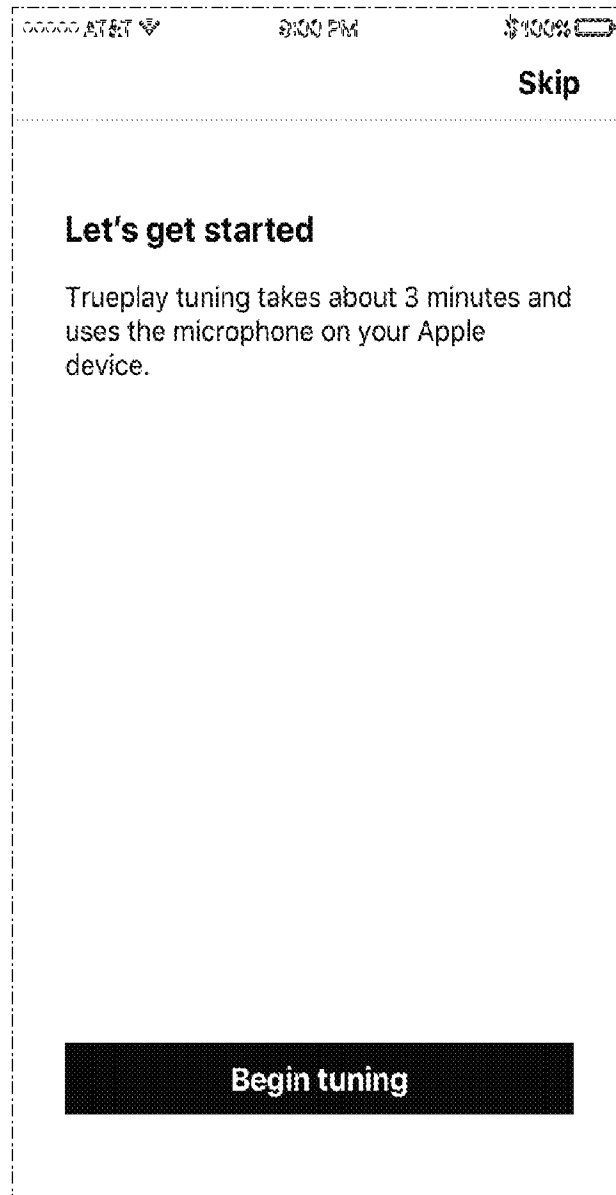


FIG. 9

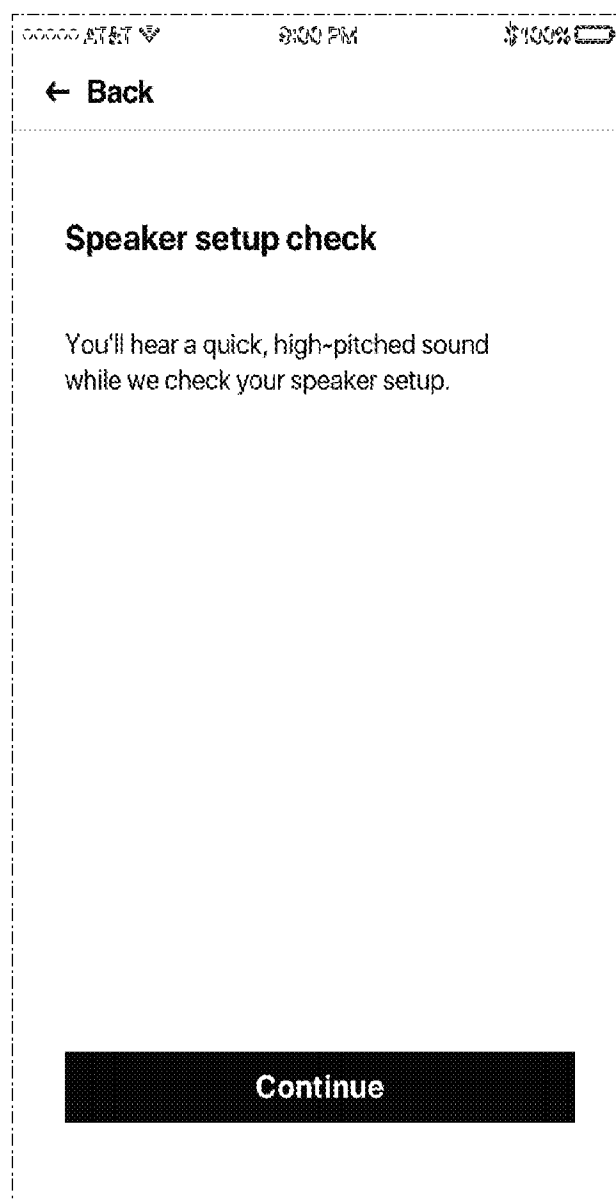


FIG. 10

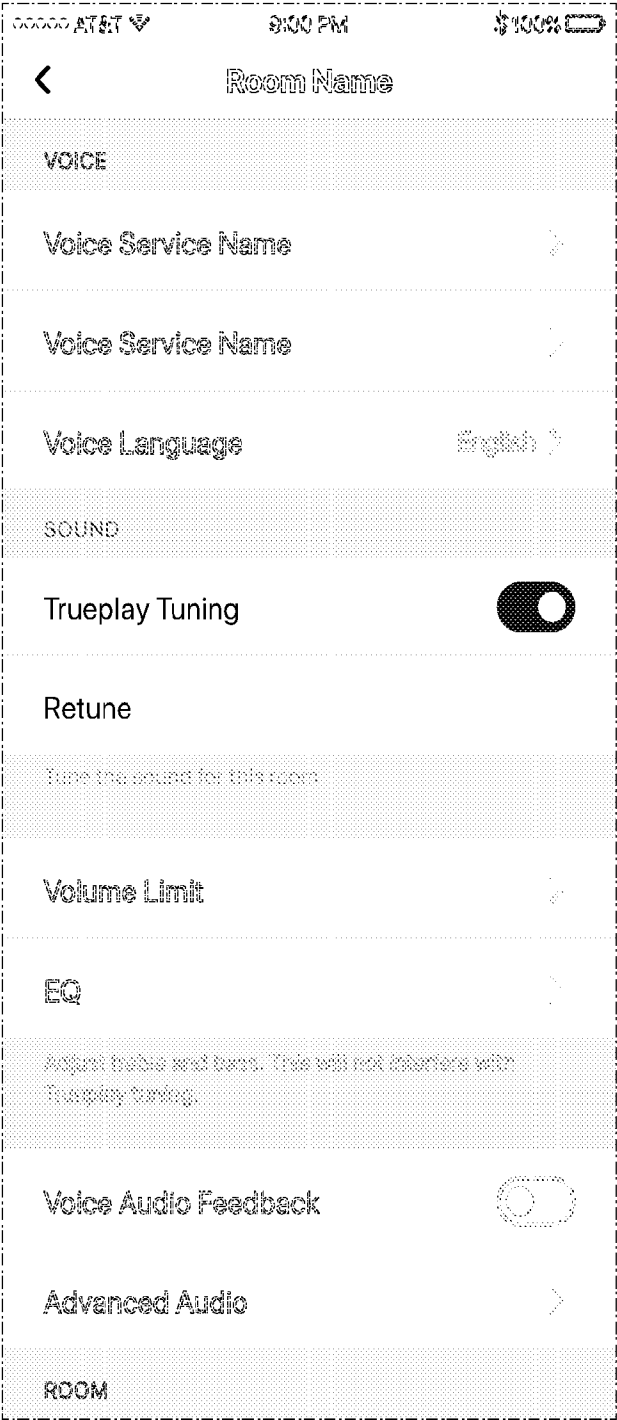


FIG. 11

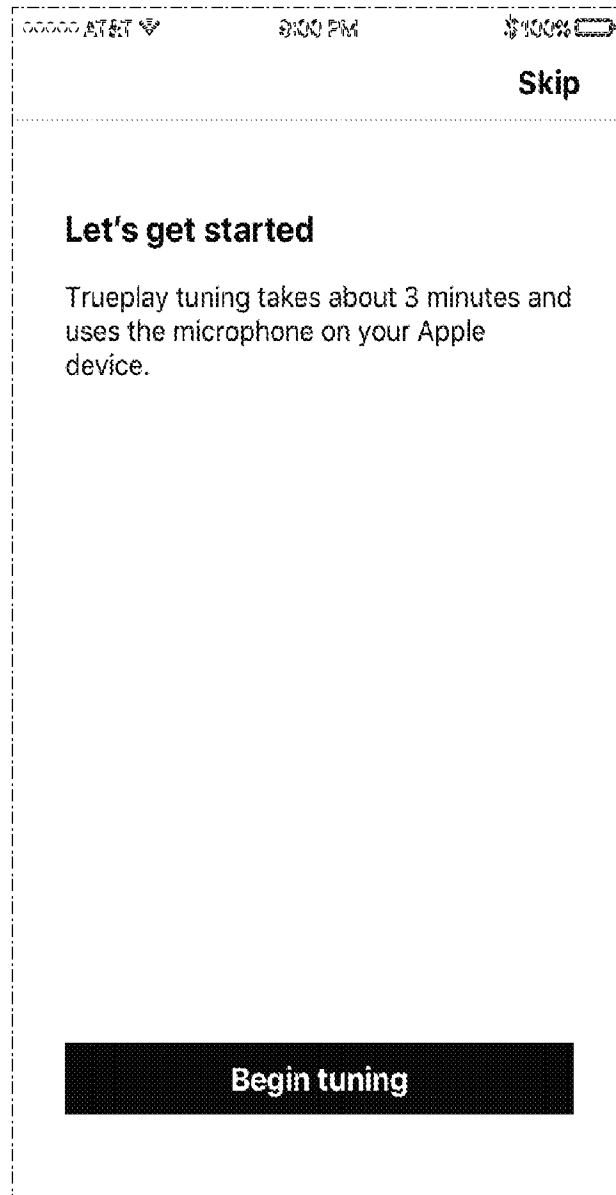


FIG. 12

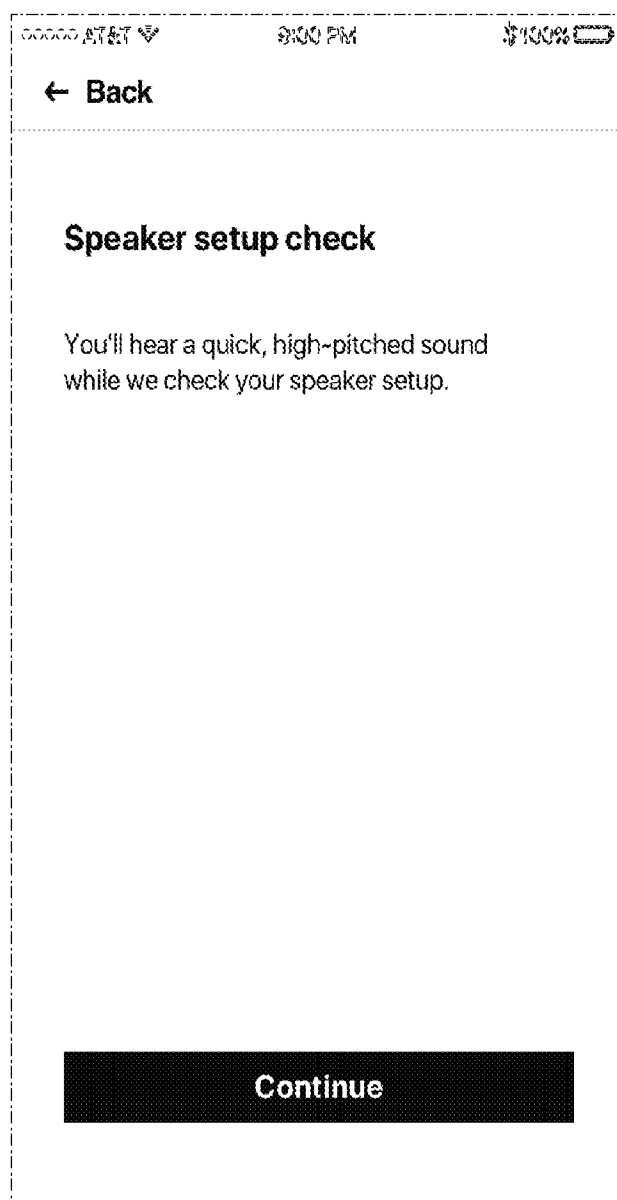


FIG. 13

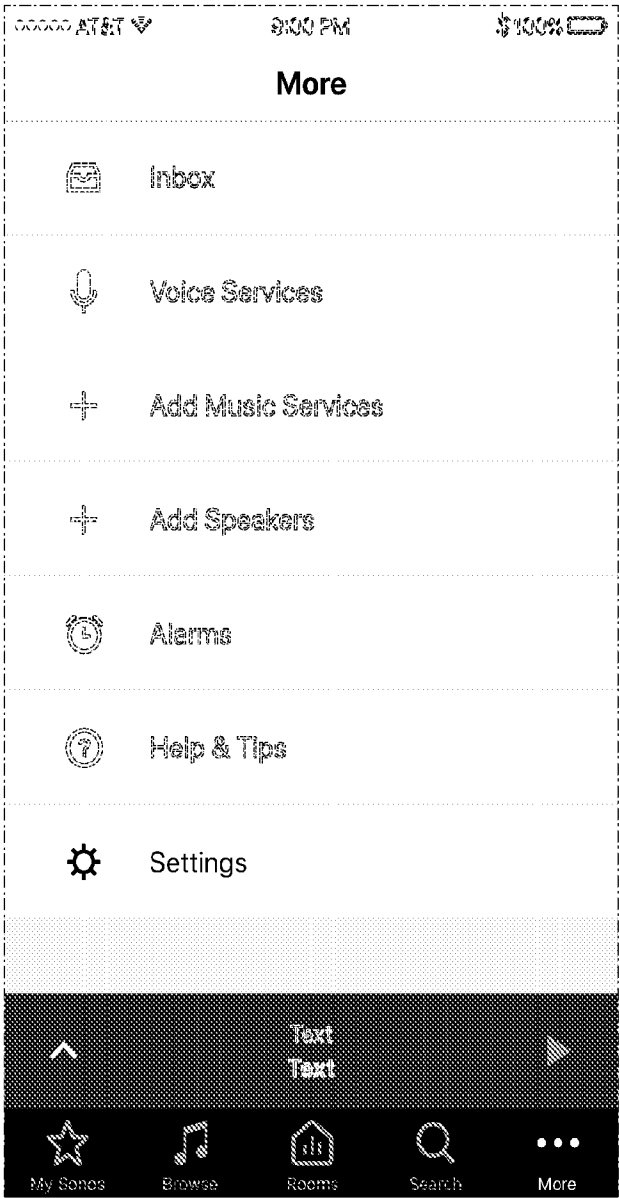


FIG. 14

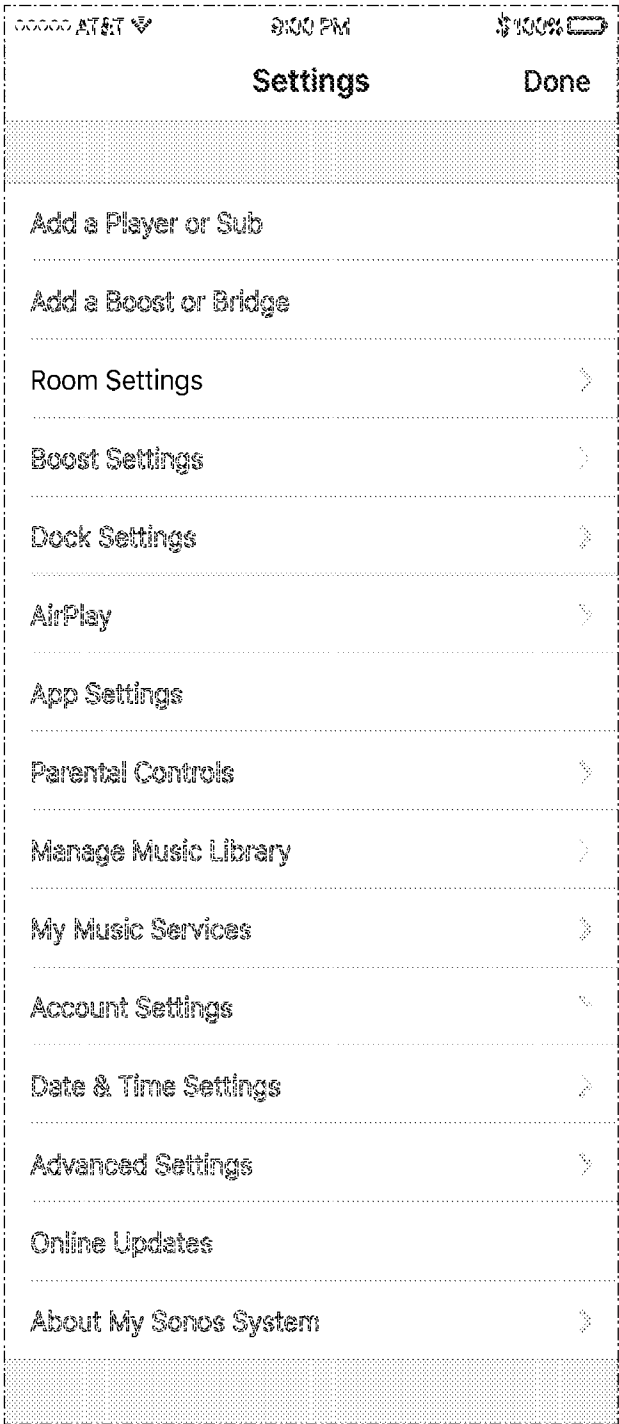


FIG. 15

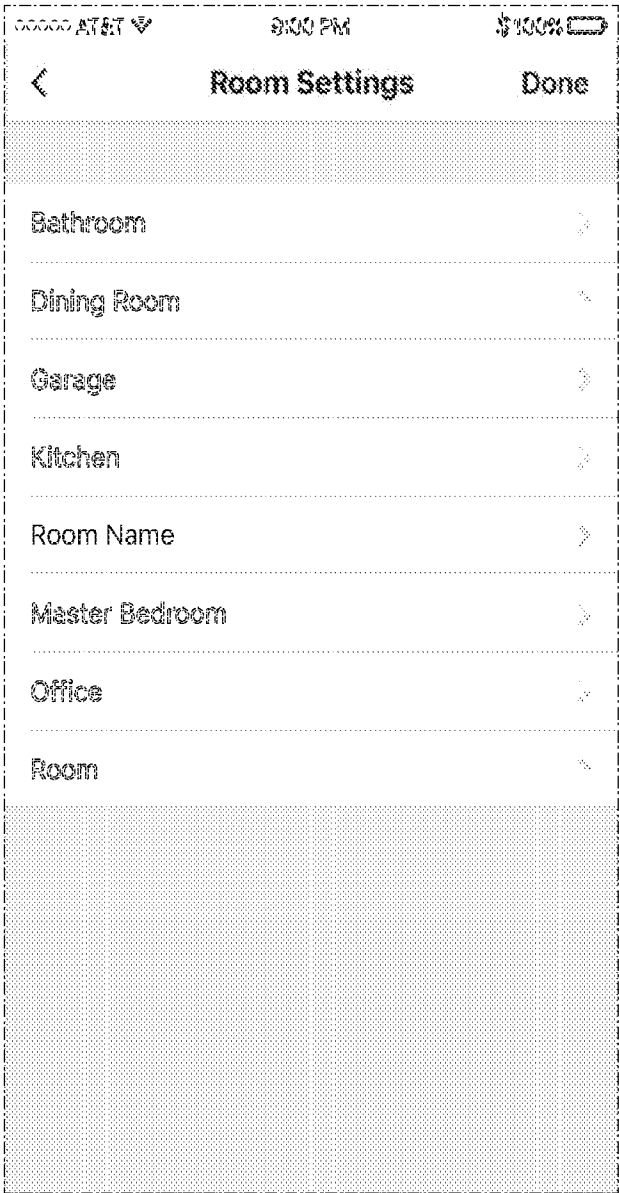


FIG. 16

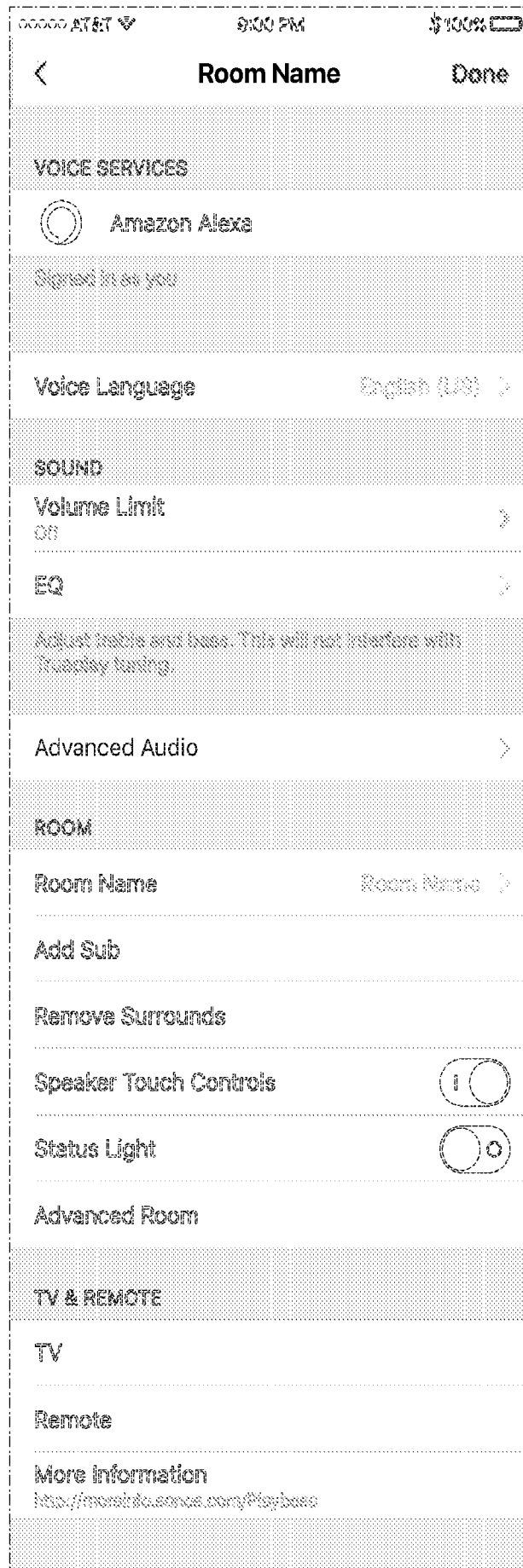


FIG. 17

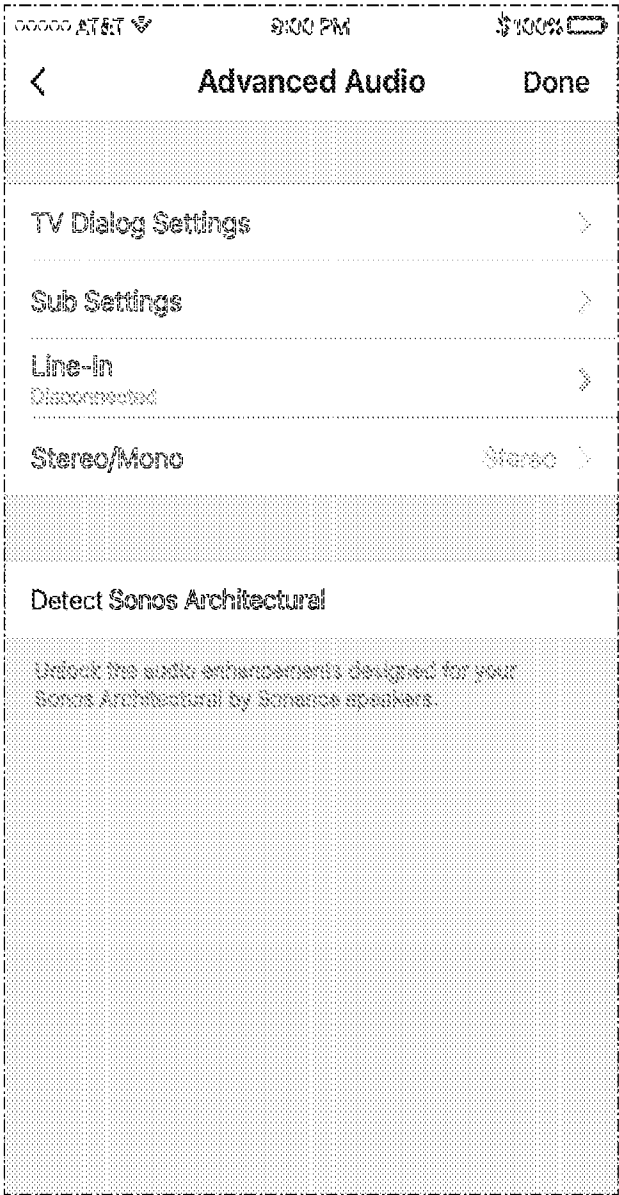


FIG. 18

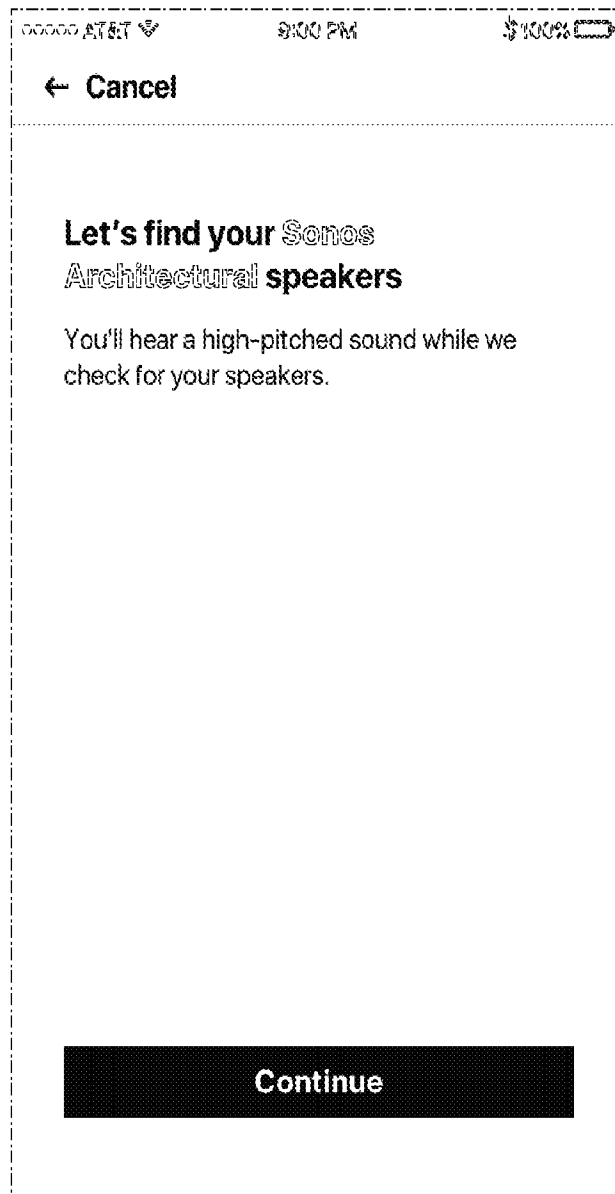


FIG. 19

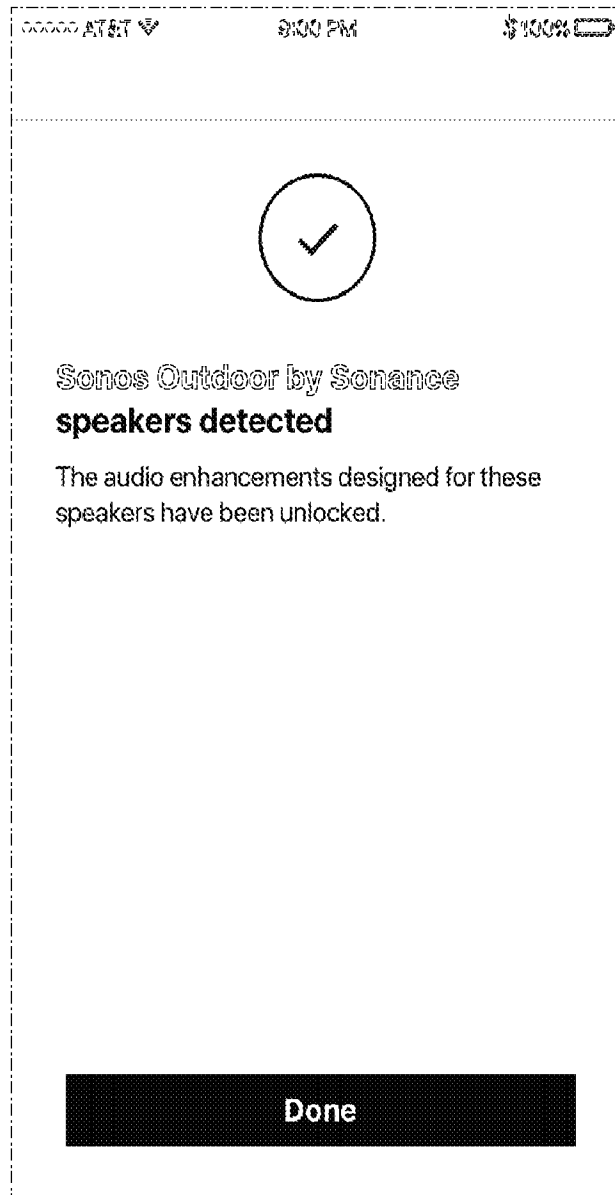


FIG. 20

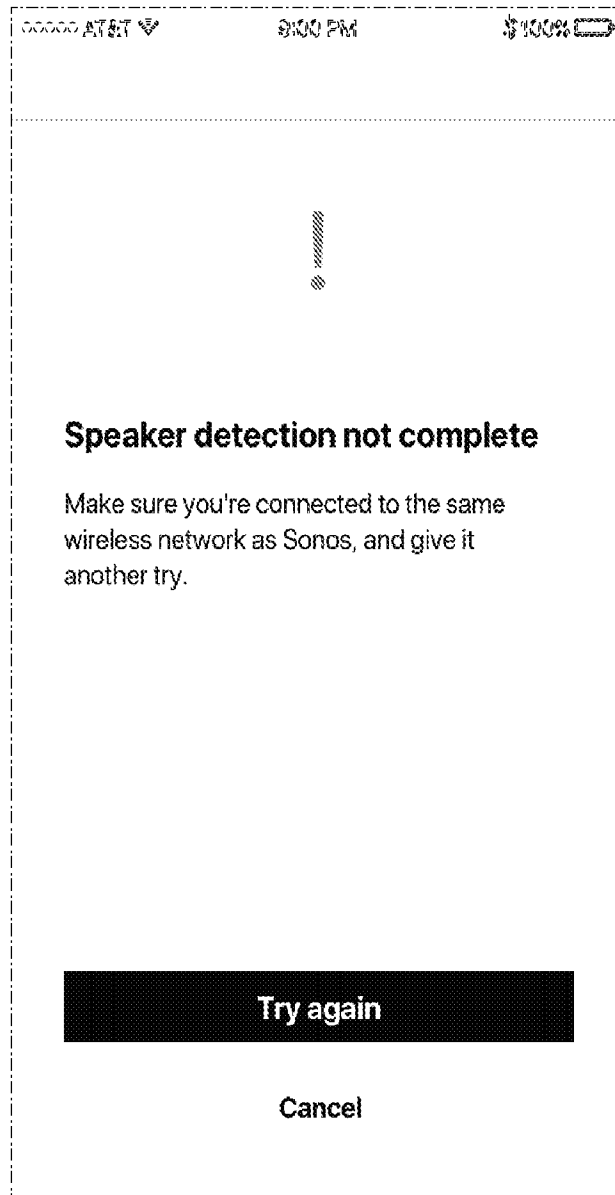


FIG. 21

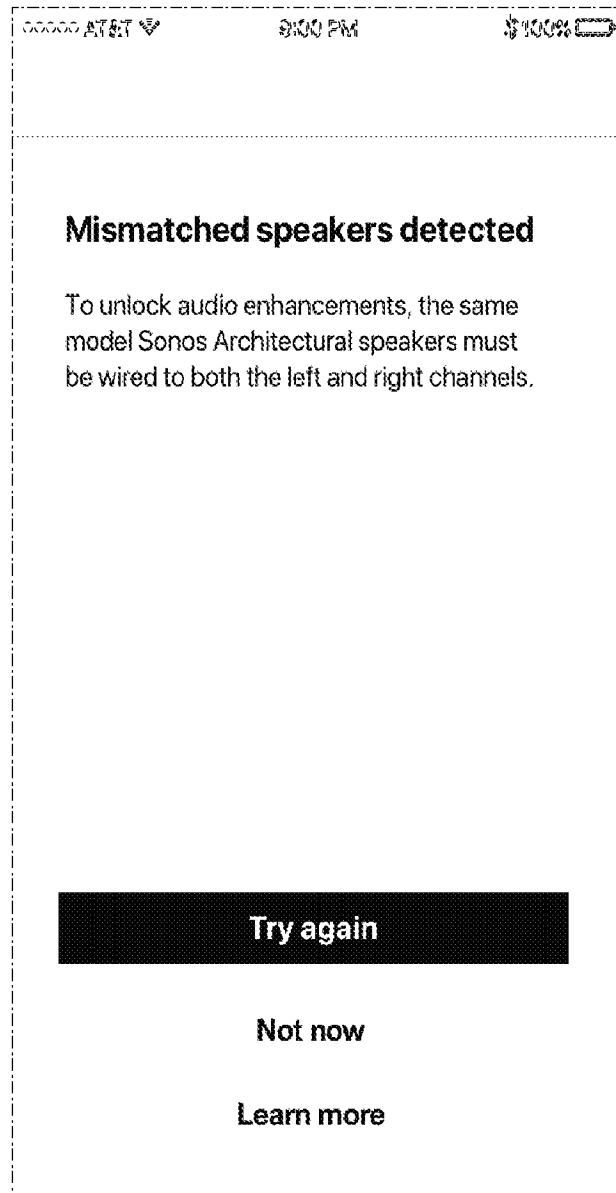


FIG. 22

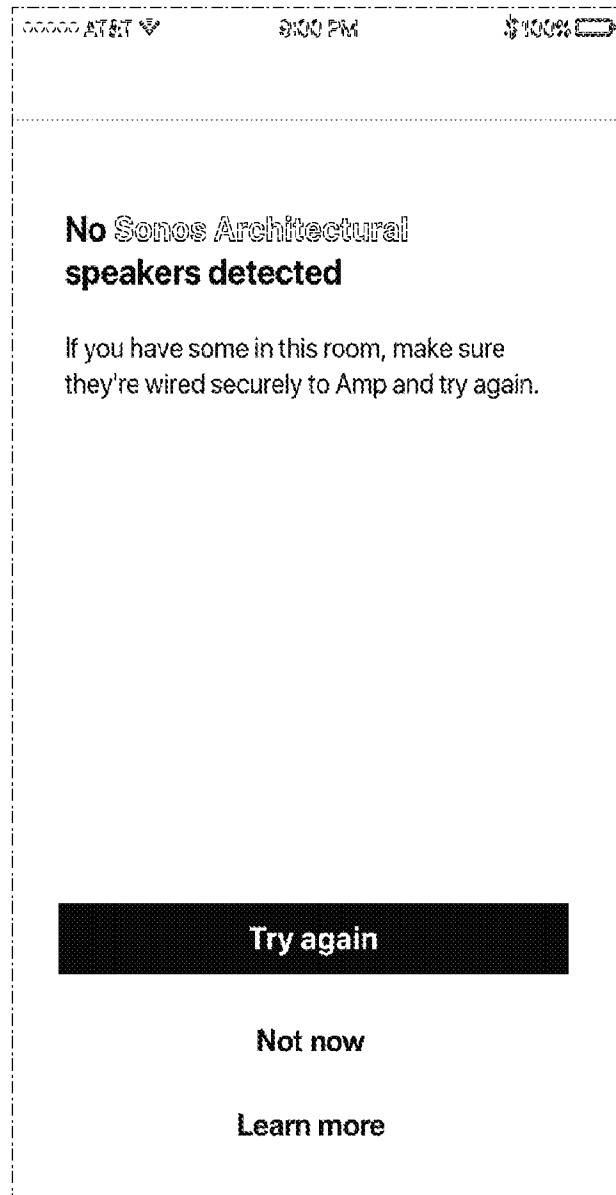


FIG. 23

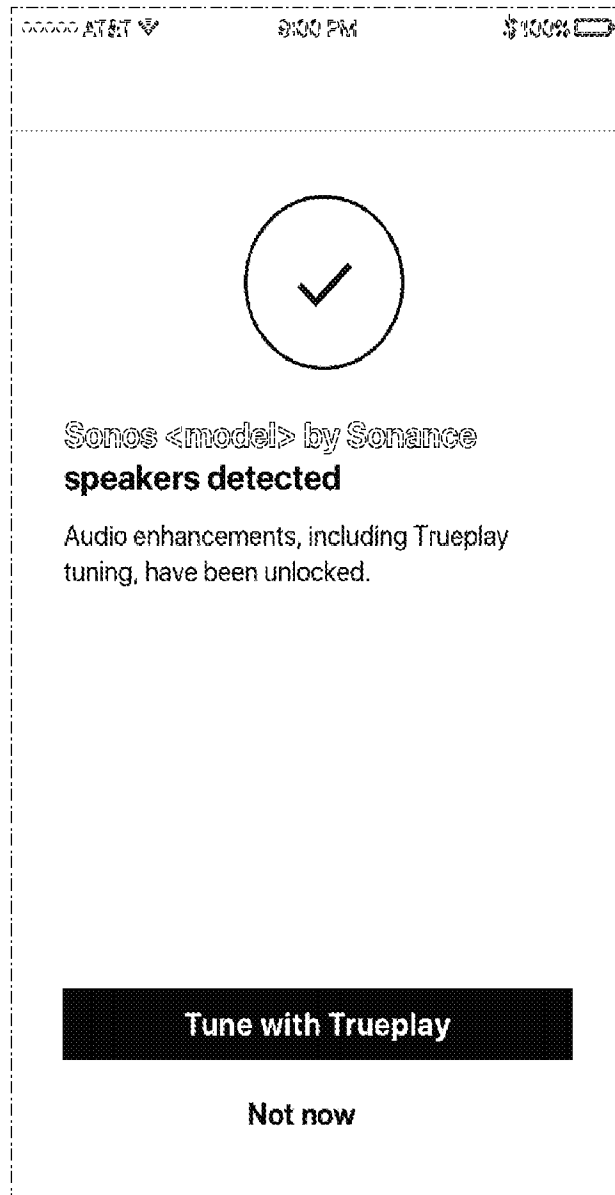


FIG. 24

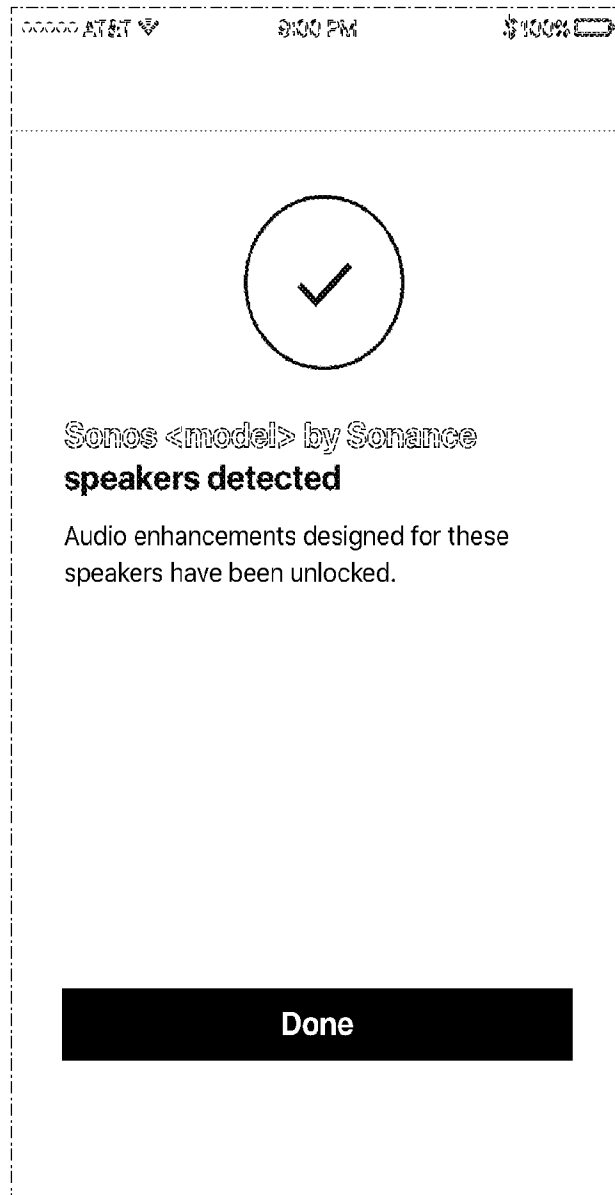


FIG. 25

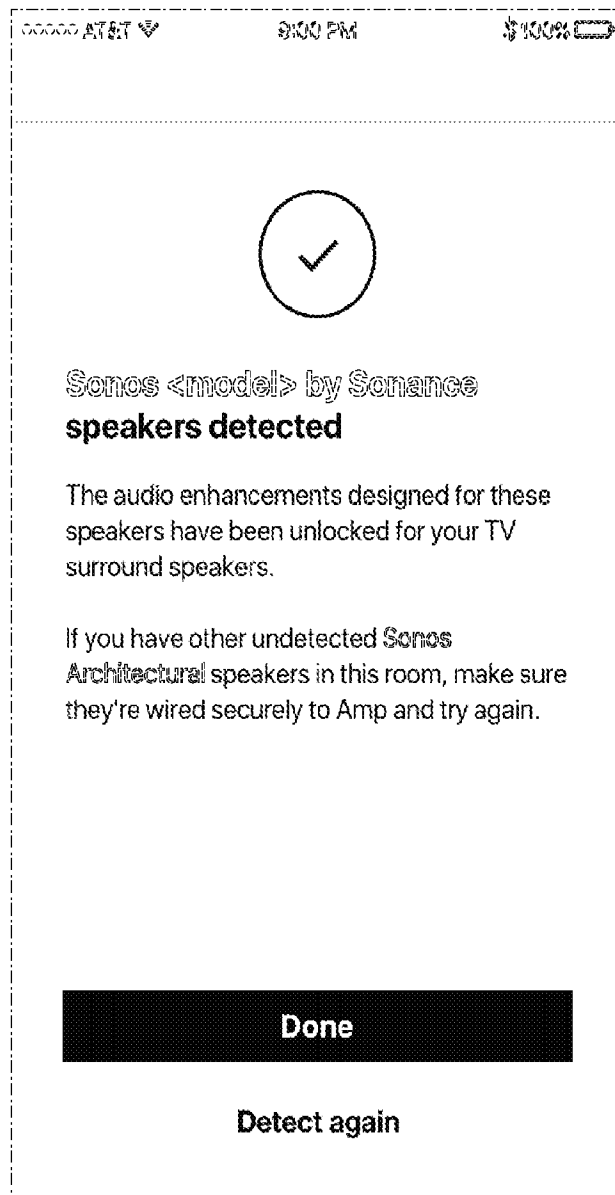


FIG. 26

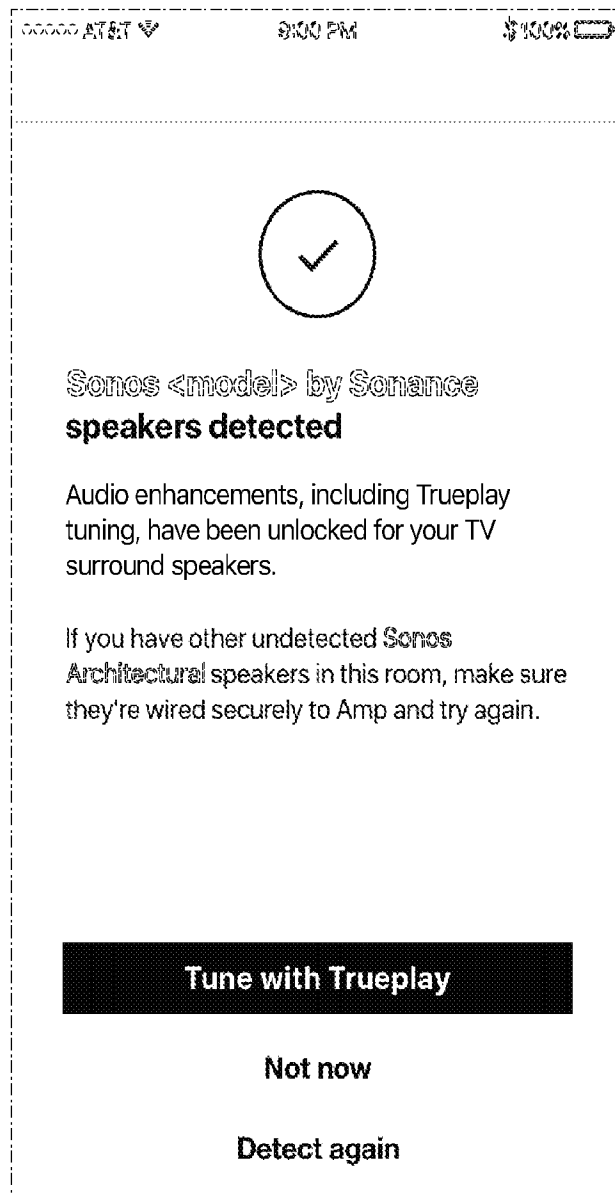


FIG. 27

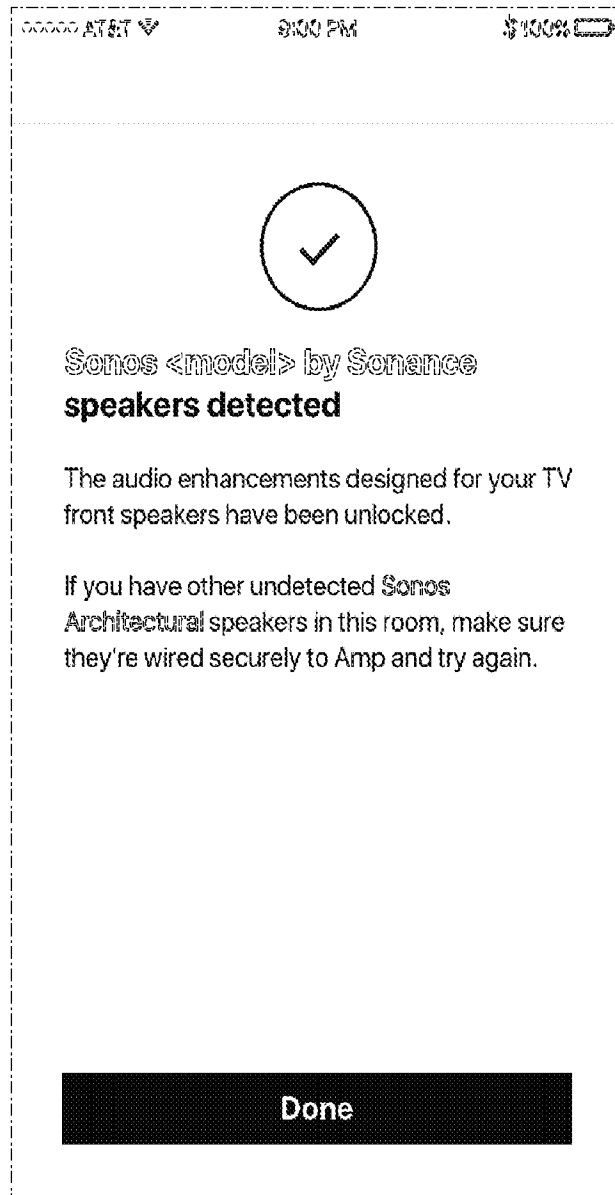


FIG. 28

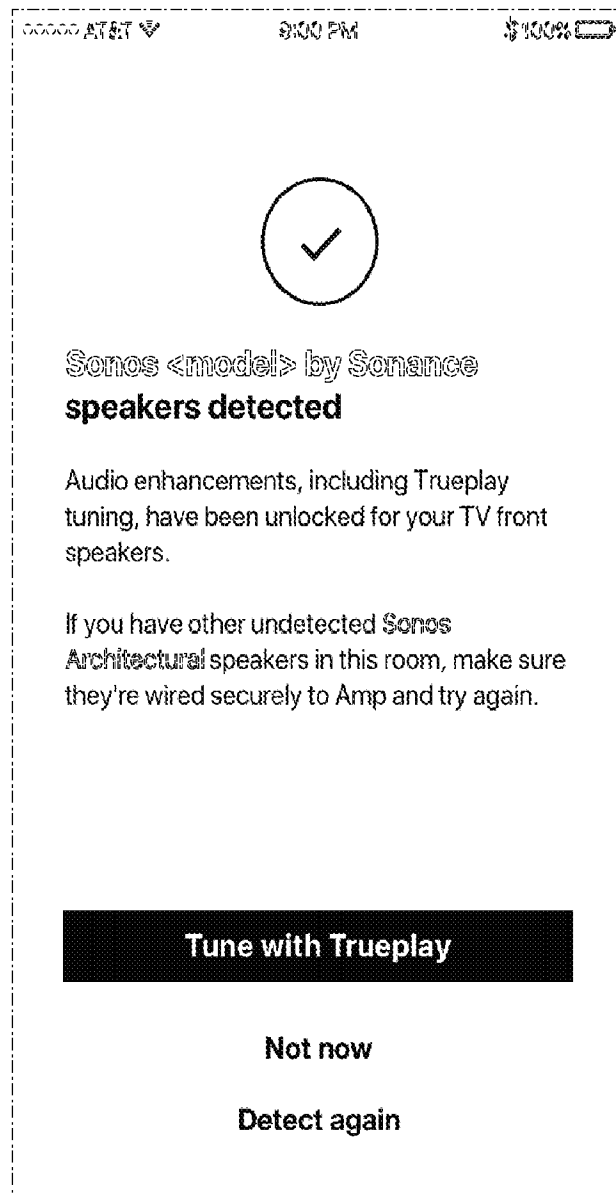


FIG. 29



FIG. 30

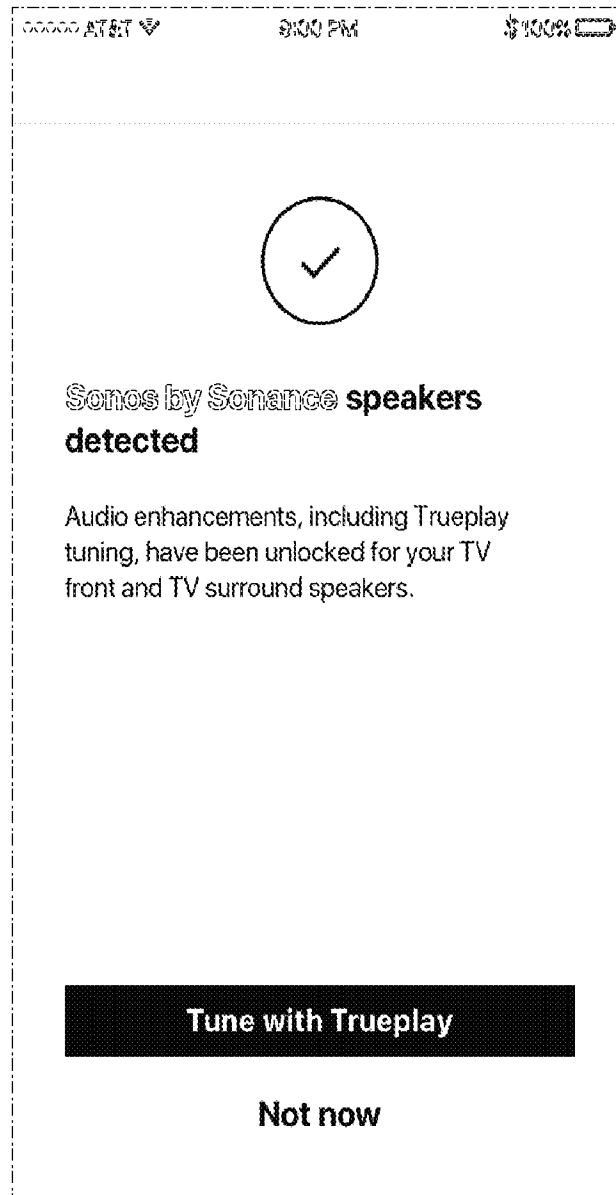


FIG. 31

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2020/017896

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04R3/04 H04R5/04 H04R29/00 H04S7/00 G06F3/048
G06F3/0484

ADD.

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)

H04R H04S G06F

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 9 247 365 B1 (ELLIS SHAWN [US] ET AL) 26 January 2016 (2016-01-26)	1,3,4, 7-11, 16-18
Y	column 3, line 1 - column 8, line 43; claims 1-10; figures 2,3	2,5,6, 12-15
Y	----- WO 2007/016465 A2 (KLIPSCH L L C [US]; NACKVI FAWAD [US]; ZENOR JON DOUGLAS [US]) 8 February 2007 (2007-02-08) page 11, line 9 - page 16, line 27; claim 62 ----- -/-	2,5,6, 13-15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"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

18 May 2020

Date of mailing of the international search report

29/05/2020

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Borowski, Michael

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2020/017896

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Genelec: "Operating Manual Genelec Loudspeaker Manager GLM(TM) 2.0 System Table of Contents", 7 November 2014 (2014-11-07), XP055610697, Retrieved from the Internet: URL:https://www.genelec.com/sites/default/files/media/Studio%20monitors/Software/GLM%202.0/glm_2.0_system_operating_manual_0.pdf [retrieved on 2019-08-02]	12
A	the whole document	1-11, 13-18
A	----- US 2007/201705 A1 (DOROGUSKER JESSE L [US] ET AL) 30 August 2007 (2007-08-30) the whole document -----	1-18

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2020/017896

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 9247365	B1	26-01-2016	NONE
WO 2007016465	A2	08-02-2007	NONE
US 2007201705	A1	30-08-2007	AU 2007220888 A1 07-09-2007
		BR PI0708320 A2 24-05-2011	
		CA 2643438 A1 07-09-2007	
		CN 101422055 A 29-04-2009	
		CN 102186135 A 14-09-2011	
		EP 1989921 A2 12-11-2008	
		EP 2205008 A1 07-07-2010	
		GB 2449198 A 12-11-2008	
		HK 1146345 A1 09-08-2013	
		JP 4917108 B2 18-04-2012	
		JP 2009528576 A 06-08-2009	
		KR 20080113381 A 30-12-2008	
		US 2007201705 A1 30-08-2007	
		US 2012070017 A1 22-03-2012	
		WO 2007100989 A2 07-09-2007	