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(54) **DEVICES, METHODS, AND GRAPHICAL USER INTERFACES FOR PROVIDING HAPTIC FEEDBACK**

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(21) Appl. No.: **19/085,900**

(22) Filed: **Mar. 20, 2025**

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G06F 3/0488	(2022.01)
G06F 3/04883	(2022.01)
H04M 1/72436	(2021.01)

(52) **U.S. Cl.**

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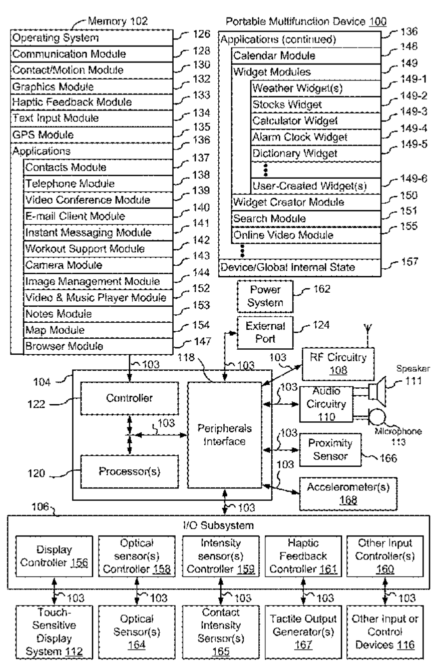
(57) **ABSTRACT**

An electronic device with a touch-sensitive surface, a display, and tactile output generator(s) displays a user interface including an adjustable control. The device detects a contact on the adjustable control, where movement of the contact away from the adjustable control changes an adjustment rate for adjusting the adjustable control based on movement of the contact. While continuously detecting the contact, the device detects a movement of the contact. In accordance with a determination that the movement moves more than a threshold amount away from the adjustable control, where the first threshold amount of movement triggers a transition from a first adjustment rate to a second adjustment rate, the device generates a tactile output when reaching the threshold amount and adjusts the adjustable control at the second adjustment rate. Otherwise, the device adjusts the adjustable control at the first adjustment rate without generating any tactile output.



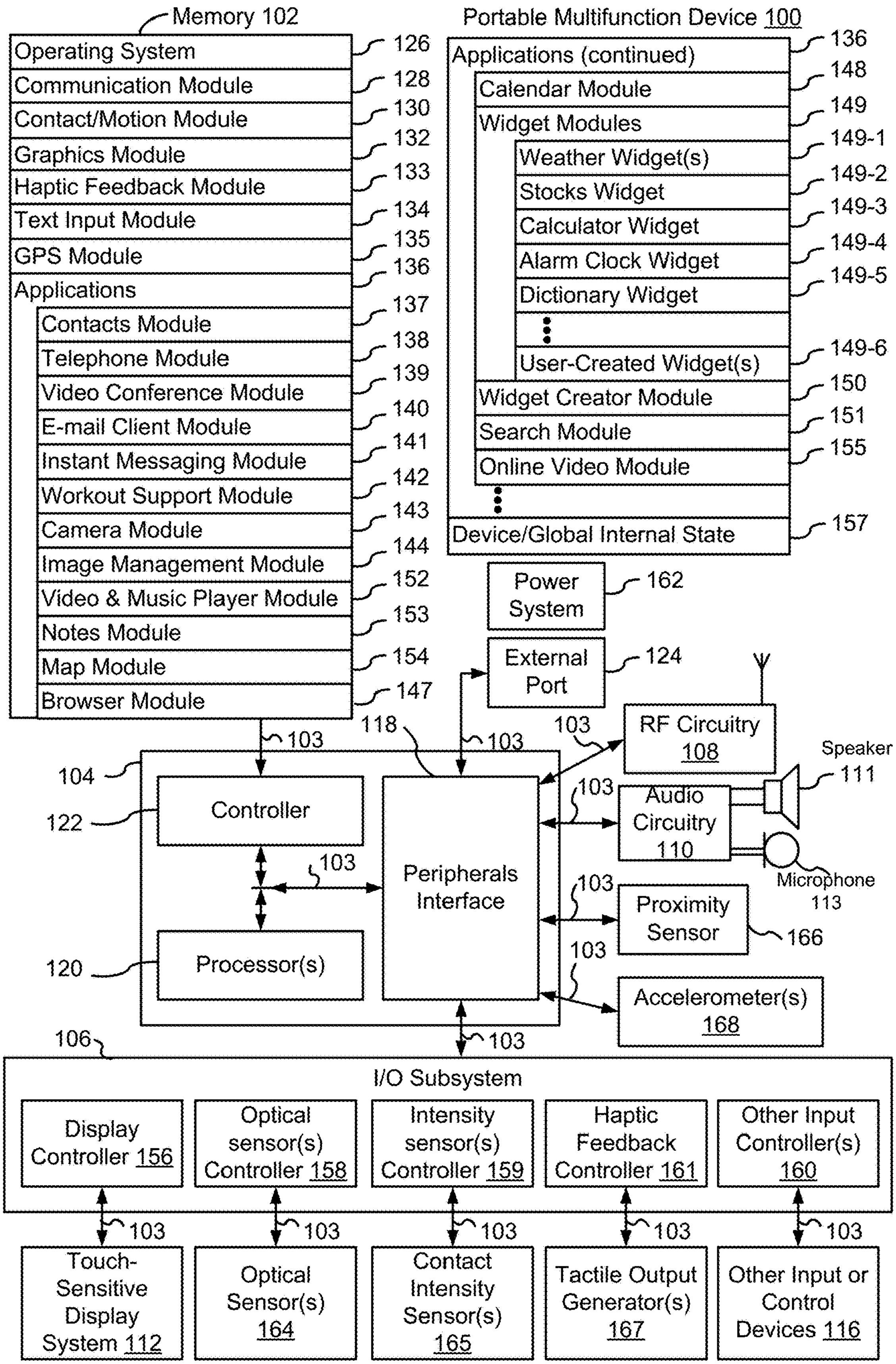

Memory 102
Operating System 126
Communication Module 128
Contact/Motion Module 130
Graphics Module 132
Haptic Feedback Module 133
Text Input Module 134
GPS Module 135
Applications 136
Contacts Module 137
Telephone Module 138
Video Conference Module 139
E-mail Client Module 140
Instant Messaging Module 141
Workout Support Module 142
Camera Module 143
Image Management Module 144
Video & Music Player Module 152
Notes Module 153
Map Module 154
Browser Module 147
Portable Multifunction Device 100
Applications (continued) 136
Calendar Module 148
Widget Modules 149
Weather Widget(s) 149-1
Stocks Widget 149-2
Calculator Widget 149-3
Alarm Clock Widget 149-4
Dictionary Widget 149-5
User-Created Widget(s) 149-6
Widget Creator Module 150
Search Module 151
Online Video Module 155
Device/Global Internal State 157
Power System 162
External Port 124
RF Circuitry 108
Speaker 111
Audio Circuitry 110
Microphone 113
Proximity Sensor 166
Accelerometer(s) 168
104
122
Controller
Processor(s)
120
Peripherals Interface
118
103
106
I/O Subsystem
Display Controller 156
Optical sensor(s) Controller 158
Intensity sensor(s) Controller 159
Haptic Feedback Controller 161
Other Input Controller(s) 160
Touch-Sensitive Display System 112
Optical Sensor(s) 164
Contact Intensity Sensor(s) 165
Tactile Output Generator(s) 167
Other Input or Control Devices 116

Figure 1A

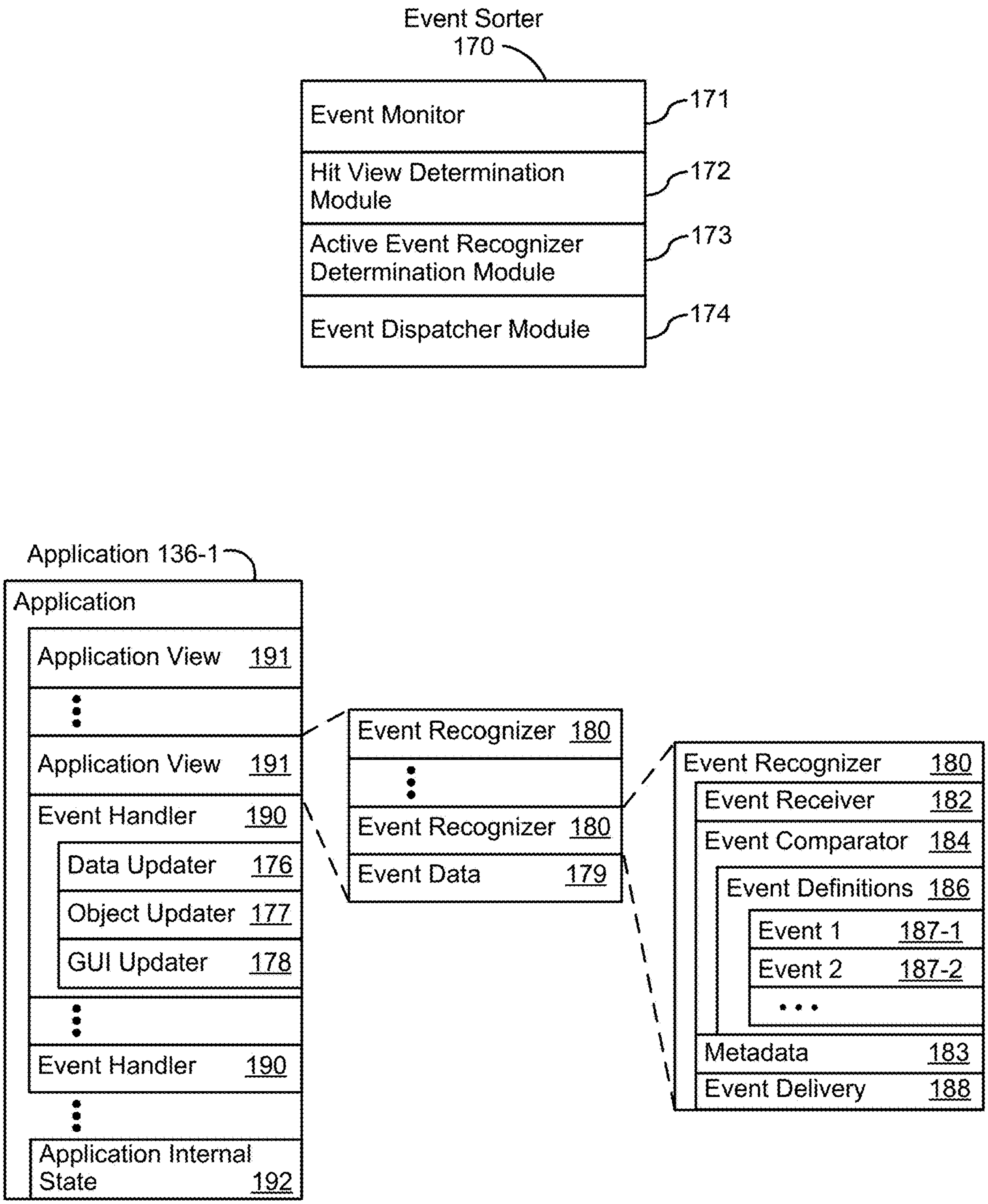

Event Sorter
170
Event Monitor
171
Hit View Determination Module
172
Active Event Recognizer Determination Module
173
Event Dispatcher Module
174
Application 136-1
Application
Application View 191
Application View 191
Event Handler 190
Data Updater 176
Object Updater 177
GUI Updater 178
Event Handler 190
Application Internal State 192
Event Recognizer 180
Event Recognizer 180
Event Data 179
Event Recognizer 180
Event Receiver 182
Event Comparator 184
Event Definitions 186
Event 1 187-1
Event 2 187-2
Metadata 183
Event Delivery 188

Figure 1B

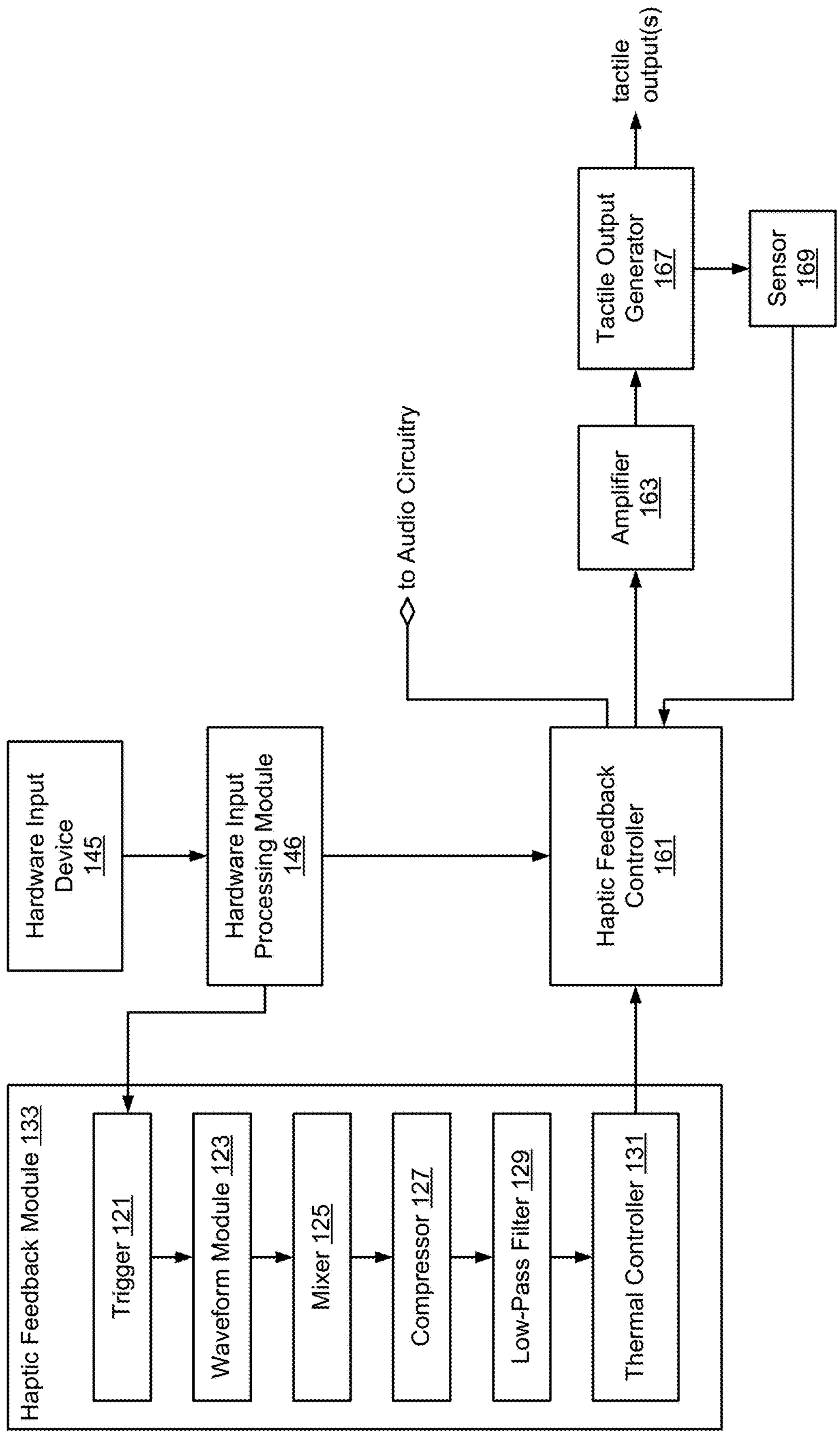

Haptic Feedback Module 133
Trigger 121
Waveform Module 123
Mixer 125
Compressor 127
Low-Pass Filter 129
Thermal Controller 131
Hardware Input Device 145
Hardware Input Processing Module 146
Haptic Feedback Controller 161
to Audio Circuitry
Amplifier 163
Tactile Output Generator 167
tactile output(s)
Sensor 169

Figure 1C

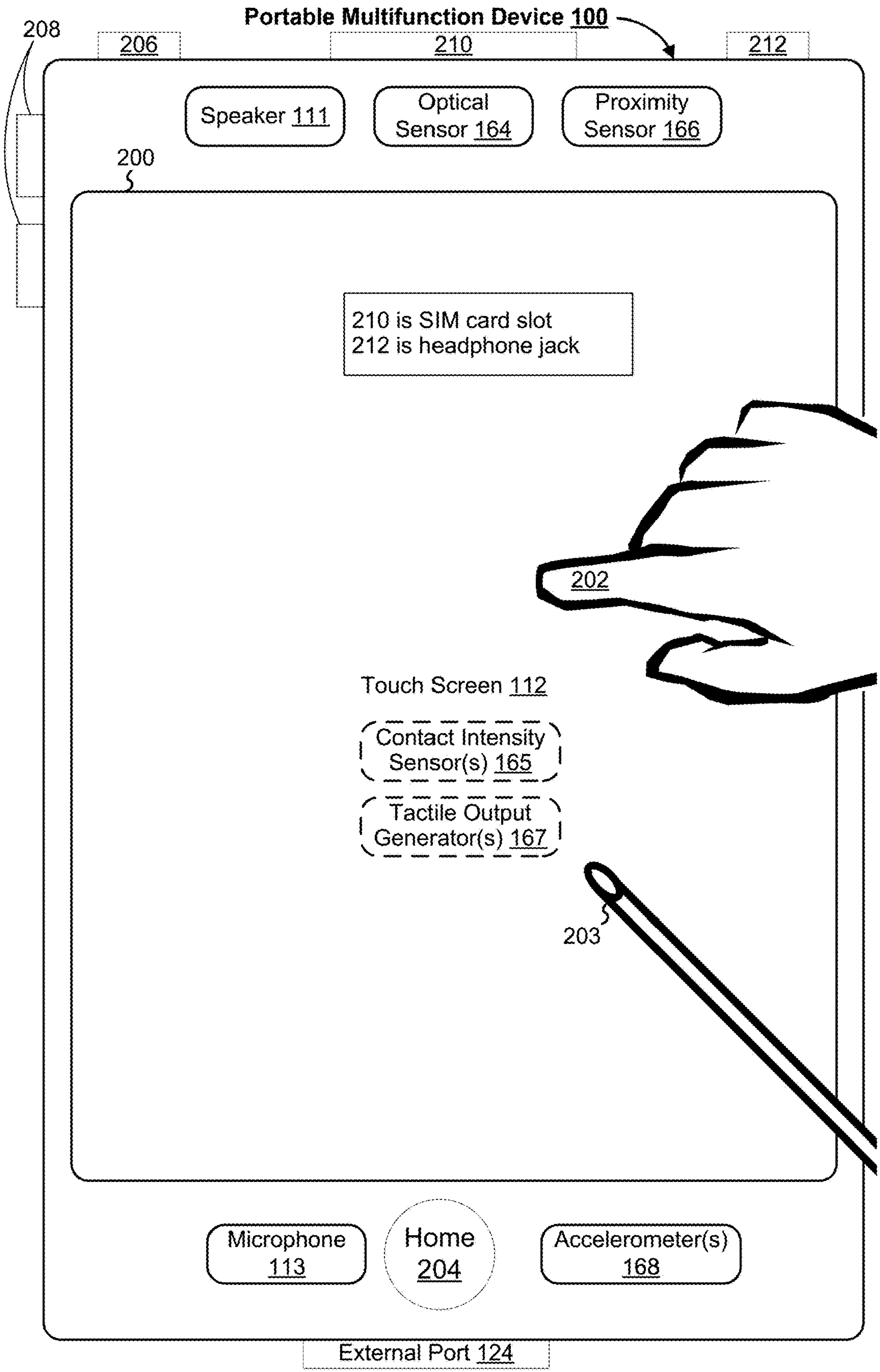

Portable Multifunction Device 100
208
206
210
212
Speaker 111
Optical Sensor 164
Proximity Sensor 166
200
210 is SIM card slot
212 is headphone jack
202
Touch Screen 112
Contact Intensity Sensor(s) 165
Tactile Output Generator(s) 167
203
Microphone 113
Home 204
Accelerometer(s) 168
External Port 124

Figure 2A

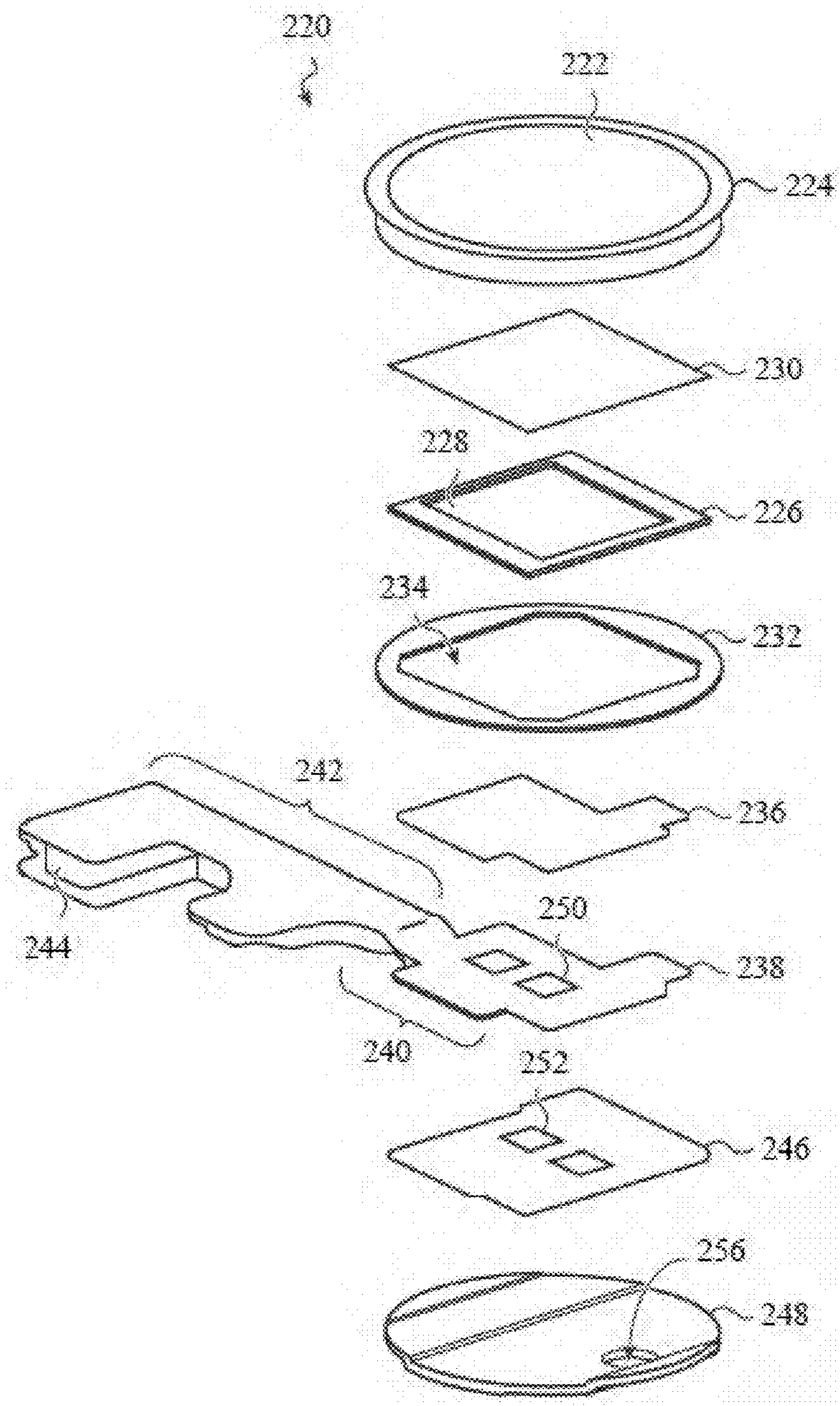

220
222
224
230
228
226
234
232
242
236
244
250
238
240
252
246
256
248

Figure 2B

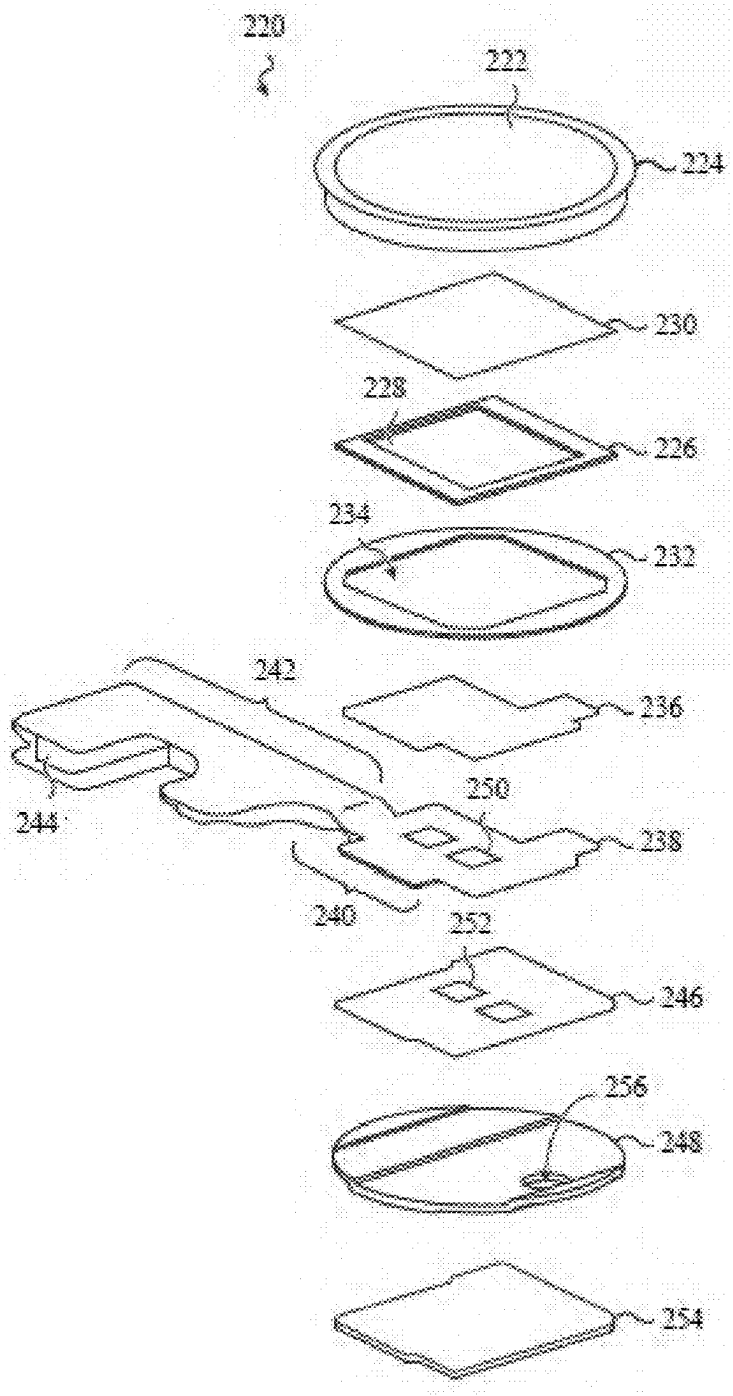
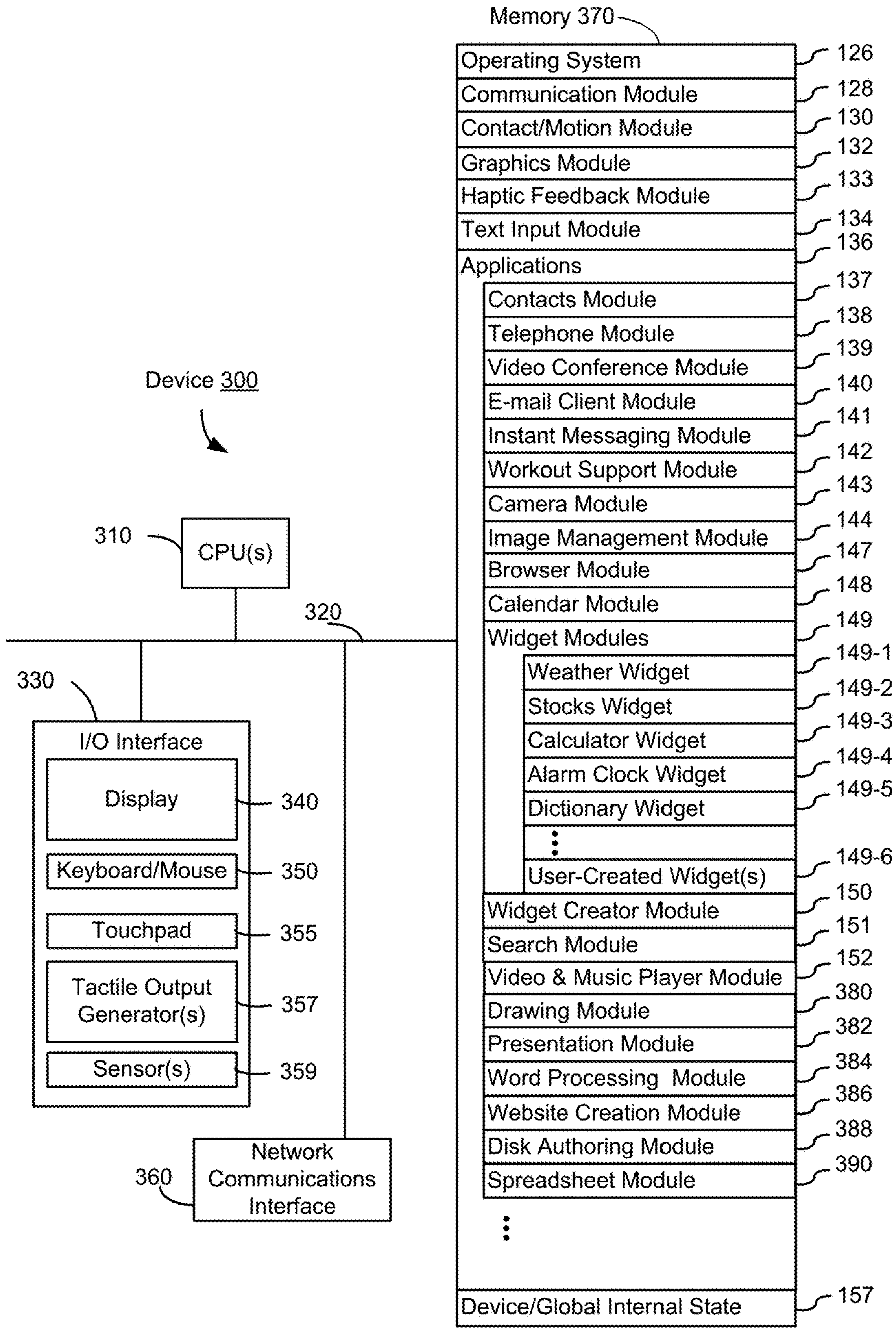
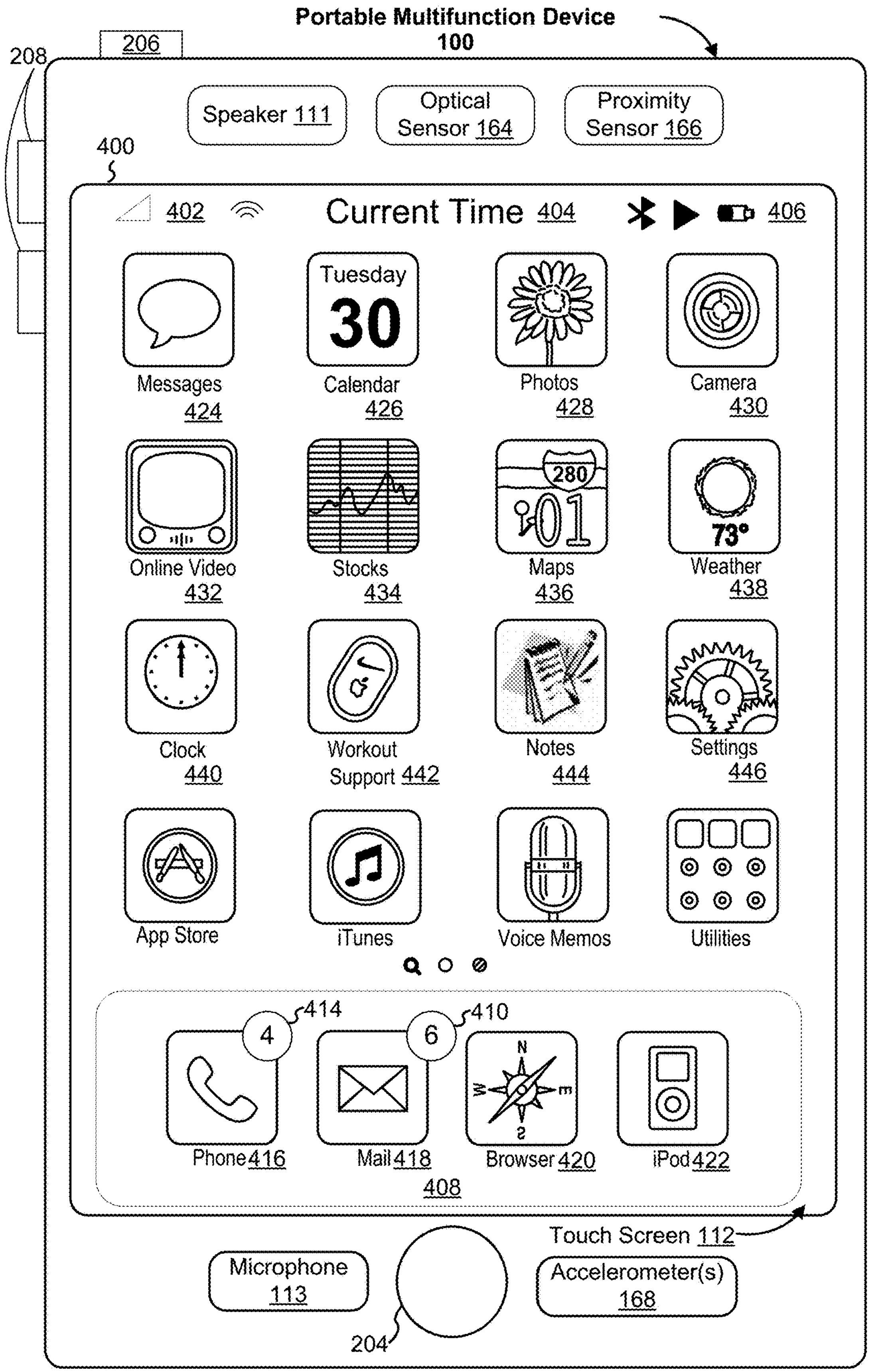

220
222
224
230
228
226
234
232
242
236
244
250
238
240
252
246
256
248
254

Figure 2C



Memory 370
Operating System
126
Communication Module
128
Contact/Motion Module
130
Graphics Module
132
Haptic Feedback Module
133
Text Input Module
134
Applications
136
Contacts Module
137
Telephone Module
138
Video Conference Module
139
E-mail Client Module
140
Instant Messaging Module
141
Workout Support Module
142
Camera Module
143
Image Management Module
144
Browser Module
147
Calendar Module
148
Widget Modules
149
Weather Widget
149-1
Stocks Widget
149-2
Calculator Widget
149-3
Alarm Clock Widget
149-4
Dictionary Widget
149-5
User-Created Widget(s)
149-6
Widget Creator Module
150
Search Module
151
Video & Music Player Module
152
Drawing Module
380
Presentation Module
382
Word Processing Module
384
Website Creation Module
386
Disk Authoring Module
388
Spreadsheet Module
390
Device/Global Internal State
157
Device 300
310
CPU(s)
320
330
I/O Interface
Display
340
Keyboard/Mouse
350
Touchpad
355
Tactile Output Generator(s)
357
Sensor(s)
359
360
Network Communications Interface

Figure 3



Portable Multifunction Device
100
206
208
Speaker 111
Optical Sensor 164
Proximity Sensor 166
400
402
Current Time 404
406
Tuesday
30
Messages 424
Calendar 426
Photos 428
Camera 430
280
73°
Online Video 432
Stocks 434
Maps 436
Weather 438
Clock 440
Workout Support 442
Notes 444
Settings 446
App Store
iTunes
Voice Memos
Utilities
414
410
4
6
N
Phone 416
Mail 418
Browser 420
iPod 422
408
Touch Screen 112
Microphone 113
Accelerometer(s) 168
204

Figure 4A

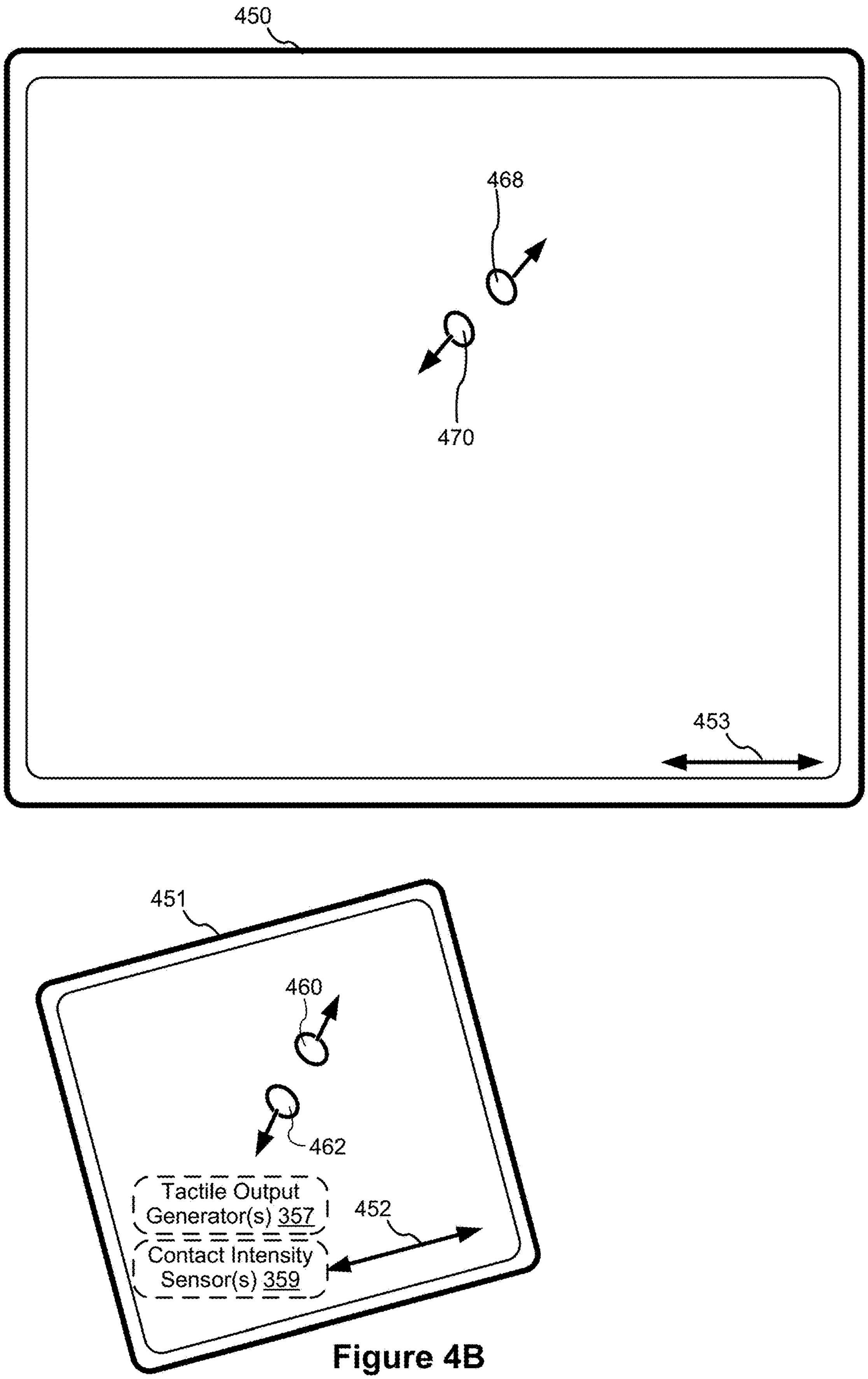

450
468
470
453
451
460
462
Tactile Output Generator(s) 357
452
Contact Intensity Sensor(s) 359

Figure 4B

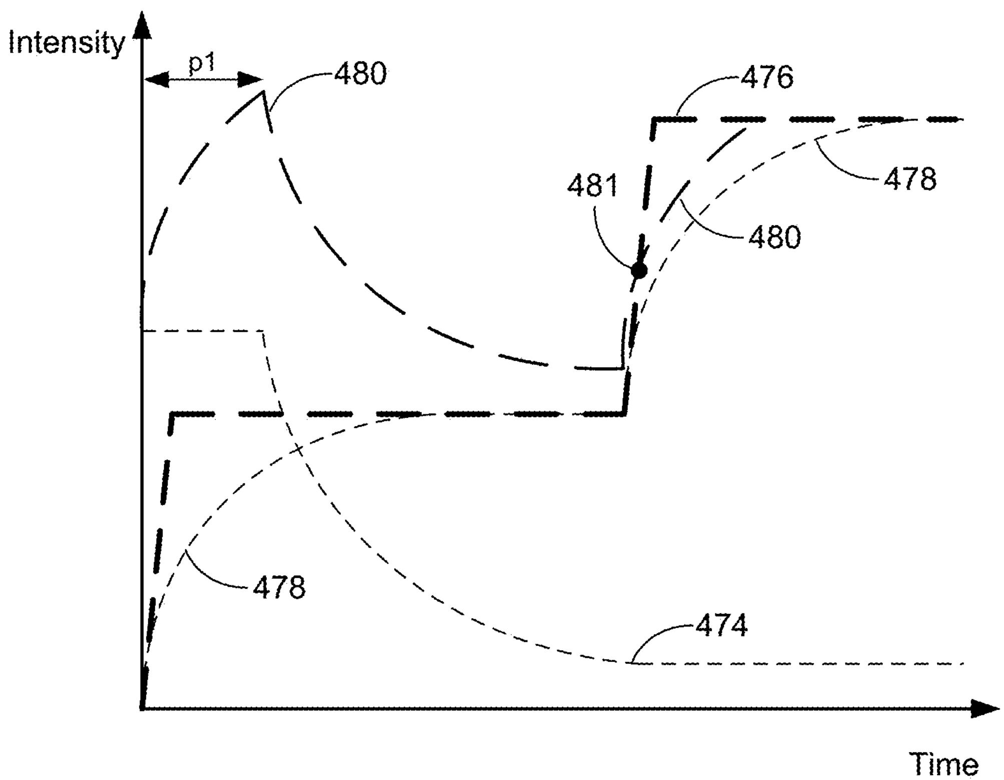


Figure 4C

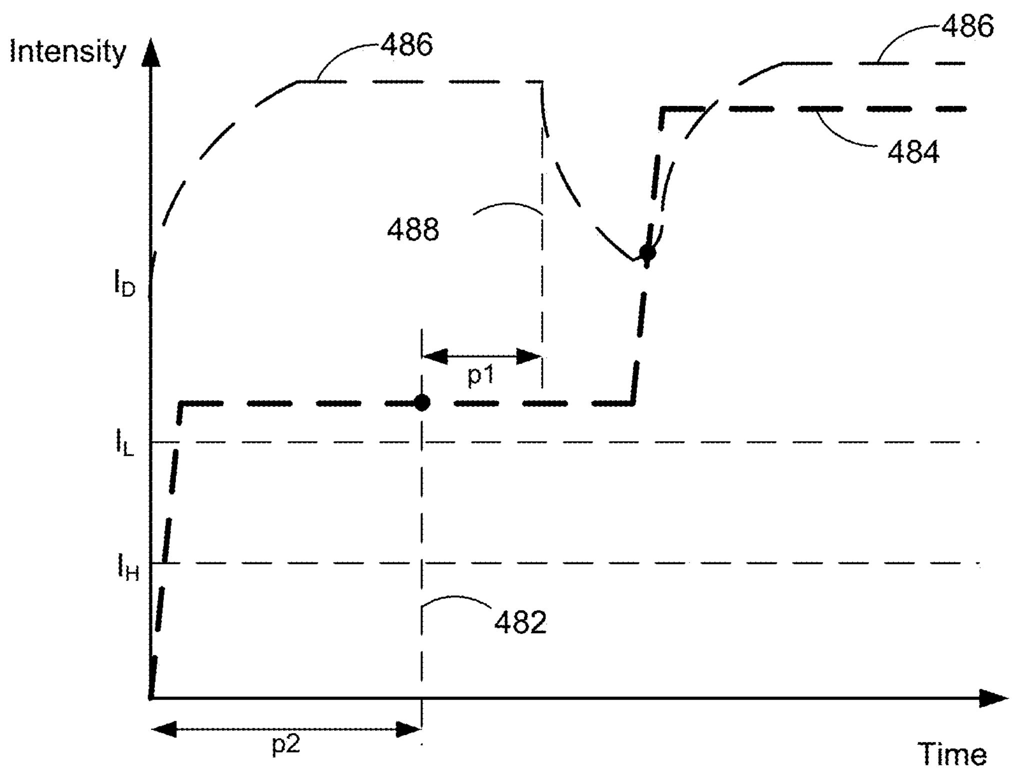


Figure 4D

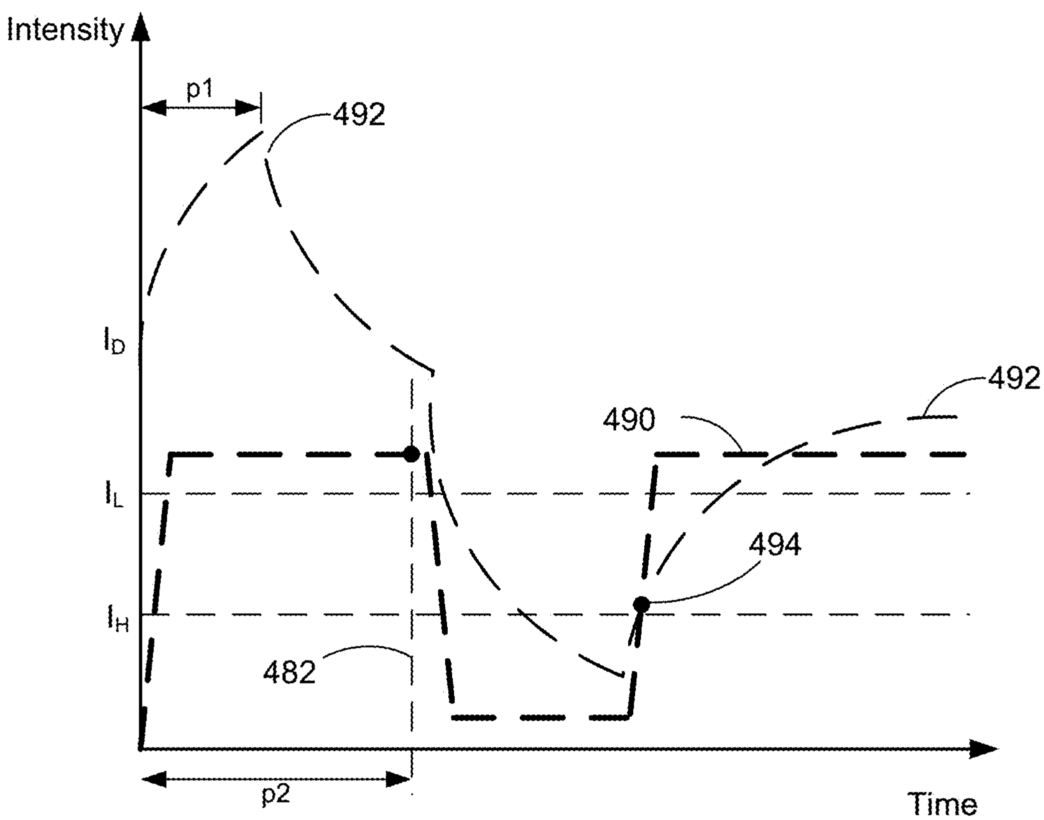
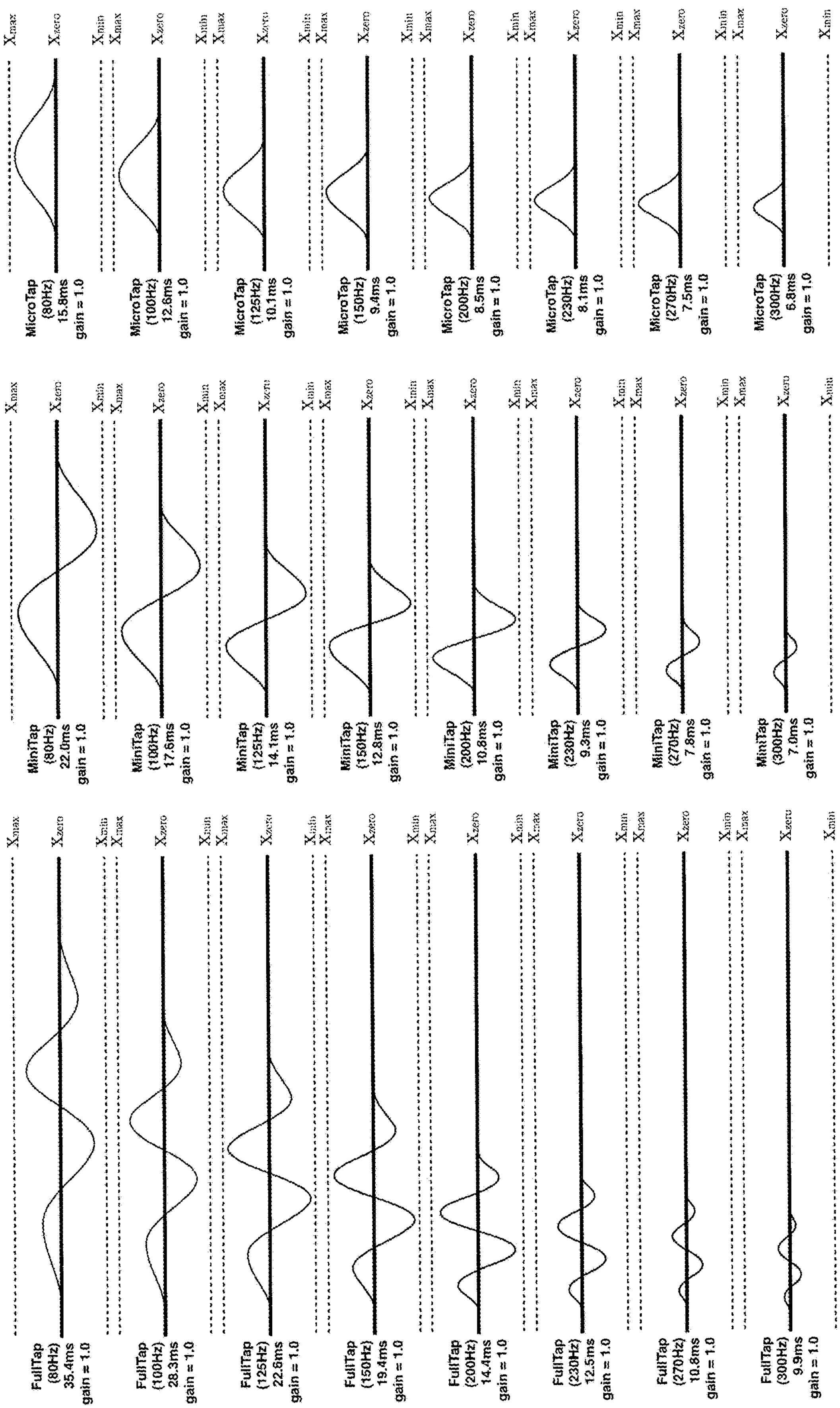


Figure 4E



MicroTap (80Hz) 15.8ms gain = 1.0
MicroTap (100Hz) 12.6ms gain = 1.0
MicroTap (125Hz) 10.1ms gain = 1.0
MicroTap (150Hz) 9.4ms gain = 1.0
MicroTap (200Hz) 8.5ms gain = 1.0
MicroTap (230Hz) 8.1ms gain = 1.0
MicroTap (270Hz) 7.5ms gain = 1.0
MicroTap (300Hz) 6.8ms gain = 1.0
MiniTap (80Hz) 22.0ms gain = 1.0
MiniTap (100Hz) 17.6ms gain = 1.0
MiniTap (125Hz) 14.1ms gain = 1.0
MiniTap (150Hz) 12.8ms gain = 1.0
MiniTap (200Hz) 10.8ms gain = 1.0
MiniTap (230Hz) 9.3ms gain = 1.0
MiniTap (270Hz) 7.8ms gain = 1.0
MiniTap (300Hz) 7.0ms gain = 1.0
FullTap (80Hz) 35.4ms gain = 1.0
FullTap (100Hz) 28.3ms gain = 1.0
FullTap (125Hz) 22.6ms gain = 1.0
FullTap (150Hz) 19.4ms gain = 1.0
FullTap (200Hz) 14.4ms gain = 1.0
FullTap (230Hz) 12.5ms gain = 1.0
FullTap (270Hz) 10.8ms gain = 1.0
FullTap (300Hz) 9.9ms gain = 1.0
X_{max}
X_{zero}
X_{min}

Figure 4F

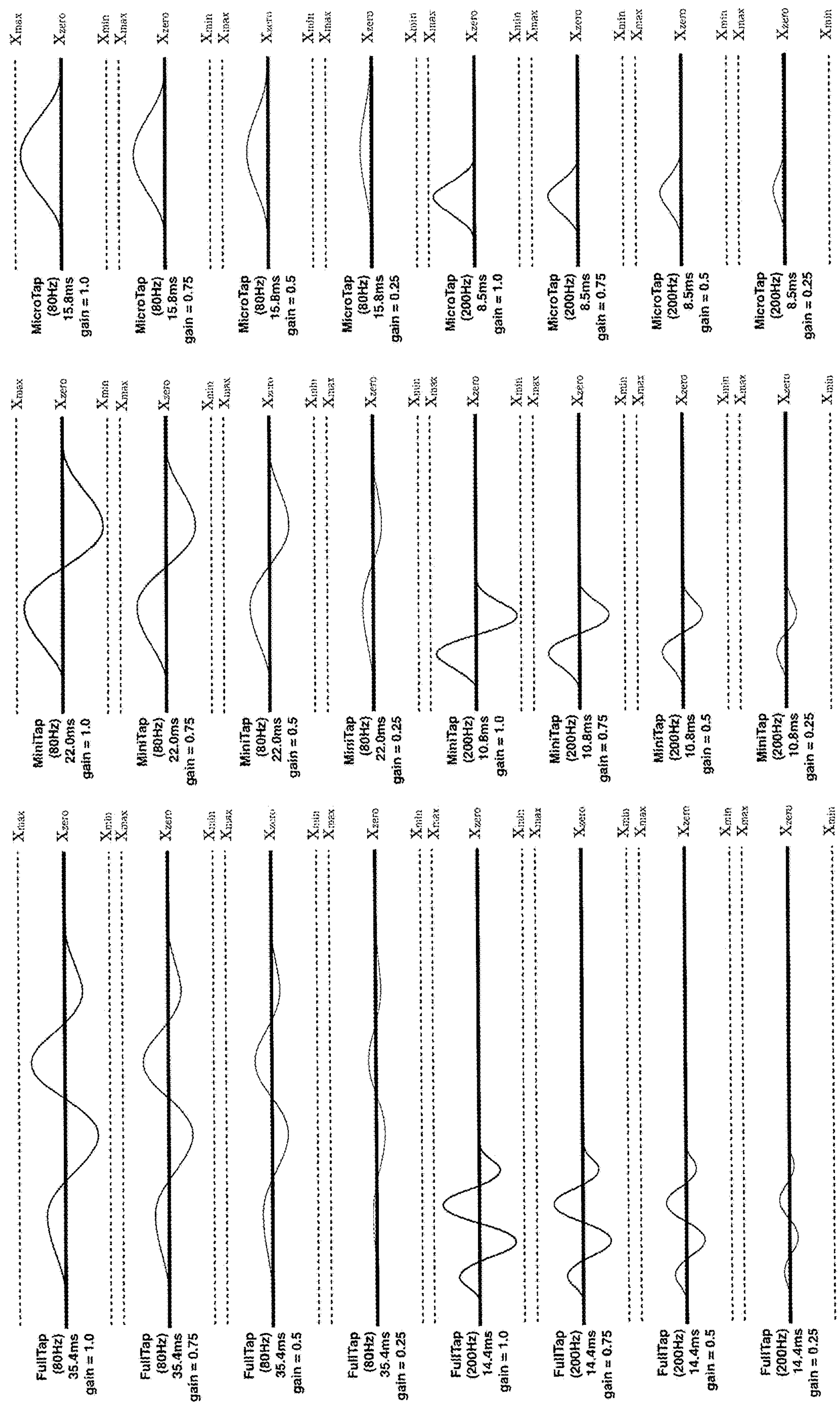

FullTap (80Hz) 35.4ms gain = 1.0
FullTap (80Hz) 35.4ms gain = 0.75
FullTap (80Hz) 35.4ms gain = 0.5
FullTap (80Hz) 35.4ms gain = 0.25
FullTap (200Hz) 14.4ms gain = 1.0
FullTap (200Hz) 14.4ms gain = 0.75
FullTap (200Hz) 14.4ms gain = 0.5
FullTap (200Hz) 14.4ms gain = 0.25
MiniTap (80Hz) 22.0ms gain = 1.0
MiniTap (80Hz) 22.0ms gain = 0.75
MiniTap (80Hz) 22.0ms gain = 0.5
MiniTap (80Hz) 22.0ms gain = 0.25
MiniTap (200Hz) 10.8ms gain = 1.0
MiniTap (200Hz) 10.8ms gain = 0.75
MiniTap (200Hz) 10.8ms gain = 0.5
MiniTap (200Hz) 10.8ms gain = 0.25
MicroTap (80Hz) 15.8ms gain = 1.0
MicroTap (80Hz) 15.8ms gain = 0.75
MicroTap (80Hz) 15.8ms gain = 0.5
MicroTap (80Hz) 15.8ms gain = 0.25
MicroTap (200Hz) 8.5ms gain = 1.0
MicroTap (200Hz) 8.5ms gain = 0.75
MicroTap (200Hz) 8.5ms gain = 0.5
MicroTap (200Hz) 8.5ms gain = 0.25
X_{max}
X_{zero}
X_{min}

Figure 4G

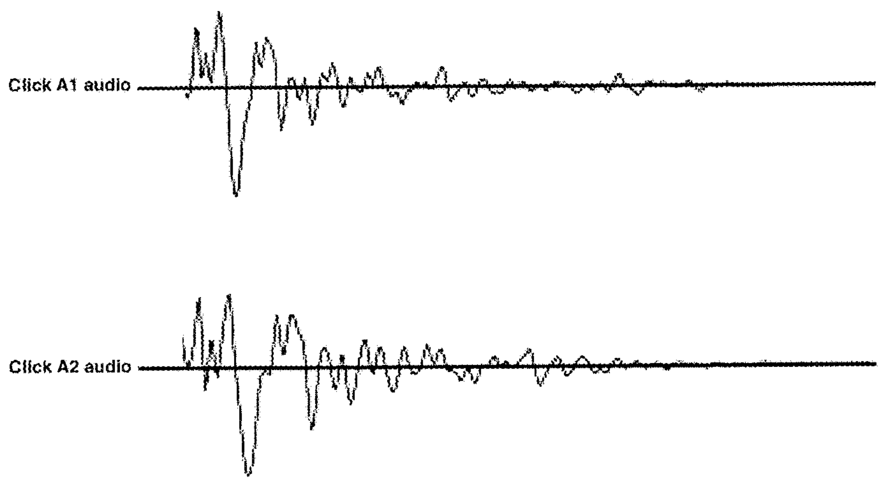


Figure 4H

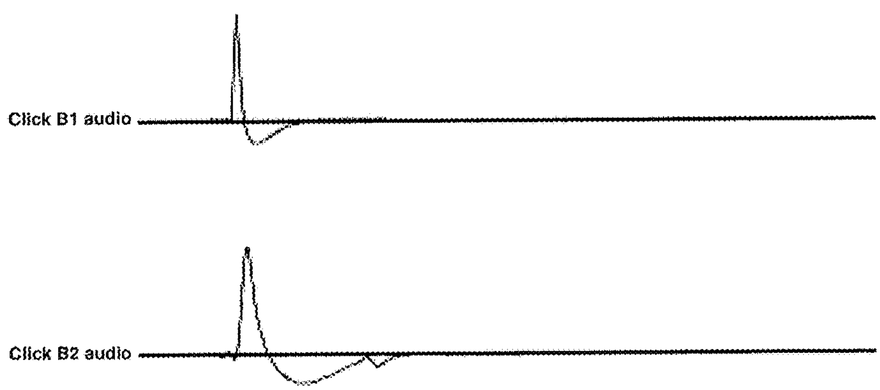


Figure 4I

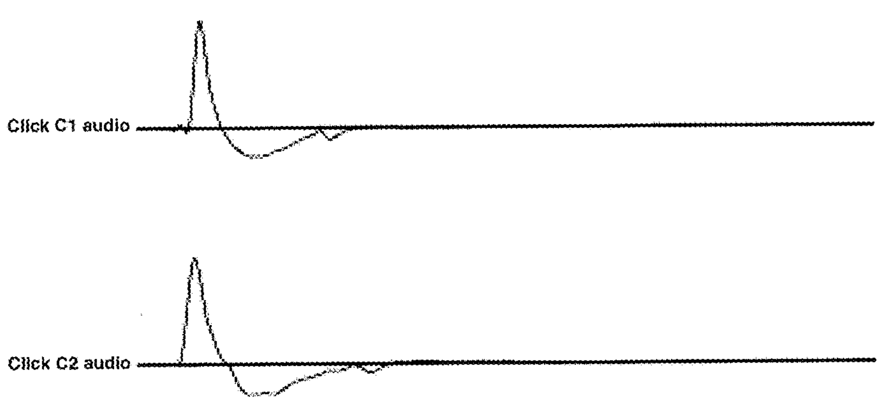


Figure 4J

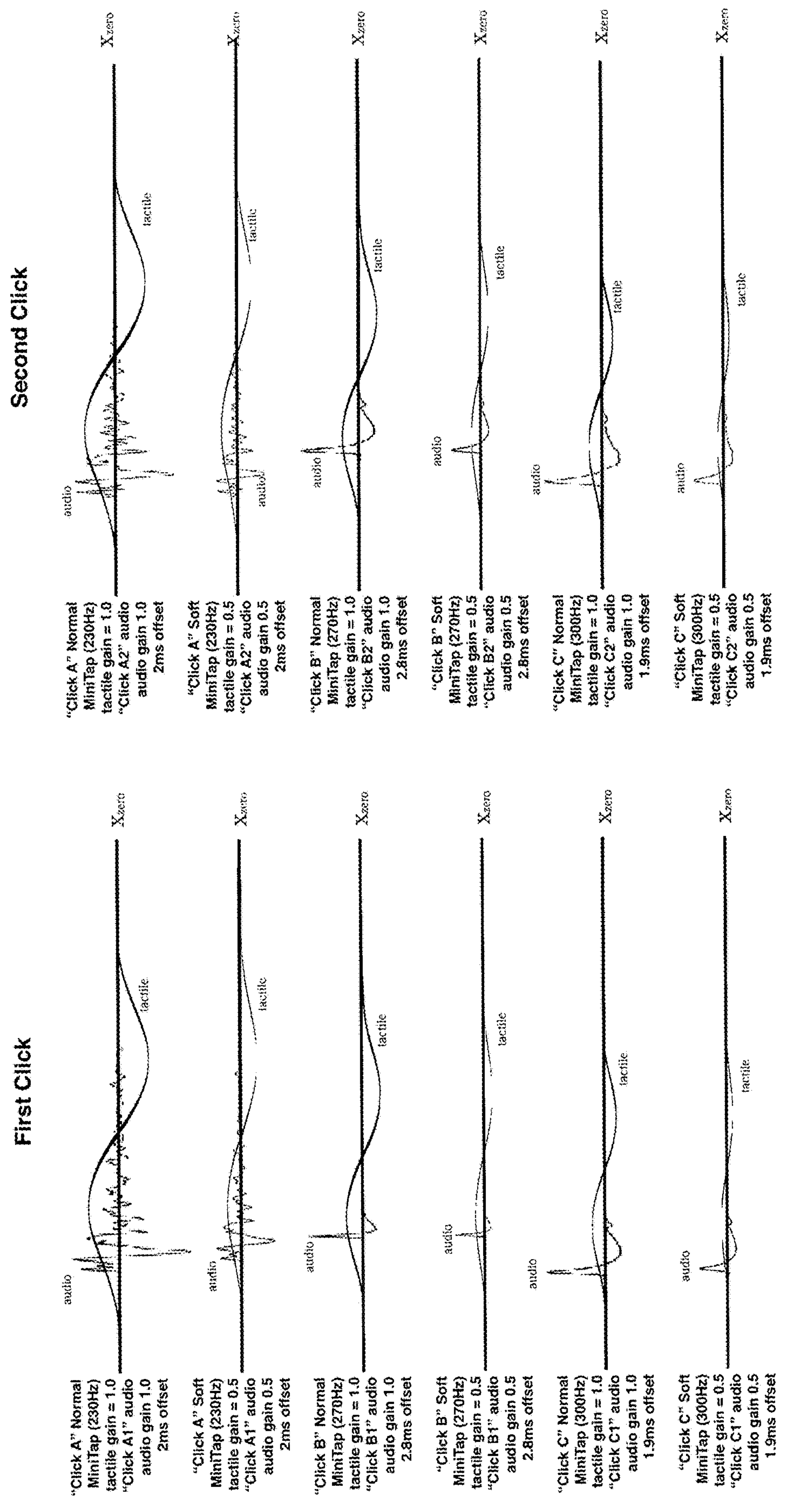

First Click
"Click A" Normal
MiniTap (230Hz)
tactile gain = 1.0
"Click A1" audio
audio gain 1.0
2ms offset
"Click A" Soft
MiniTap (230Hz)
tactile gain = 0.5
"Click A1" audio
audio gain 0.5
2ms offset
"Click B" Normal
MiniTap (270Hz)
tactile gain = 1.0
"Click B1" audio
audio gain 1.0
2.8ms offset
"Click B" Soft
MiniTap (270Hz)
tactile gain = 0.5
"Click B1" audio
audio gain 0.5
2.8ms offset
"Click C" Normal
MiniTap (300Hz)
tactile gain = 1.0
"Click C1" audio
audio gain 1.0
1.9ms offset
"Click C" Soft
MiniTap (300Hz)
tactile gain = 0.5
"Click C1" audio
audio gain 0.5
1.9ms offset
Second Click
"Click A" Normal
MiniTap (230Hz)
tactile gain = 1.0
"Click A2" audio
audio gain 1.0
2ms offset
"Click A" Soft
MiniTap (230Hz)
tactile gain = 0.5
"Click A2" audio
audio gain 0.5
2ms offset
"Click B" Normal
MiniTap (270Hz)
tactile gain = 1.0
"Click B2" audio
audio gain 1.0
2.8ms offset
"Click B" Soft
MiniTap (270Hz)
tactile gain = 0.5
"Click B2" audio
audio gain 0.5
2.8ms offset
"Click C" Normal
MiniTap (300Hz)
tactile gain = 1.0
"Click C2" audio
audio gain 1.0
1.9ms offset
"Click C" Soft
MiniTap (300Hz)
tactile gain = 0.5
"Click C2" audio
audio gain 0.5
1.9ms offset
audio
tactile
Xzero

Figure 4K

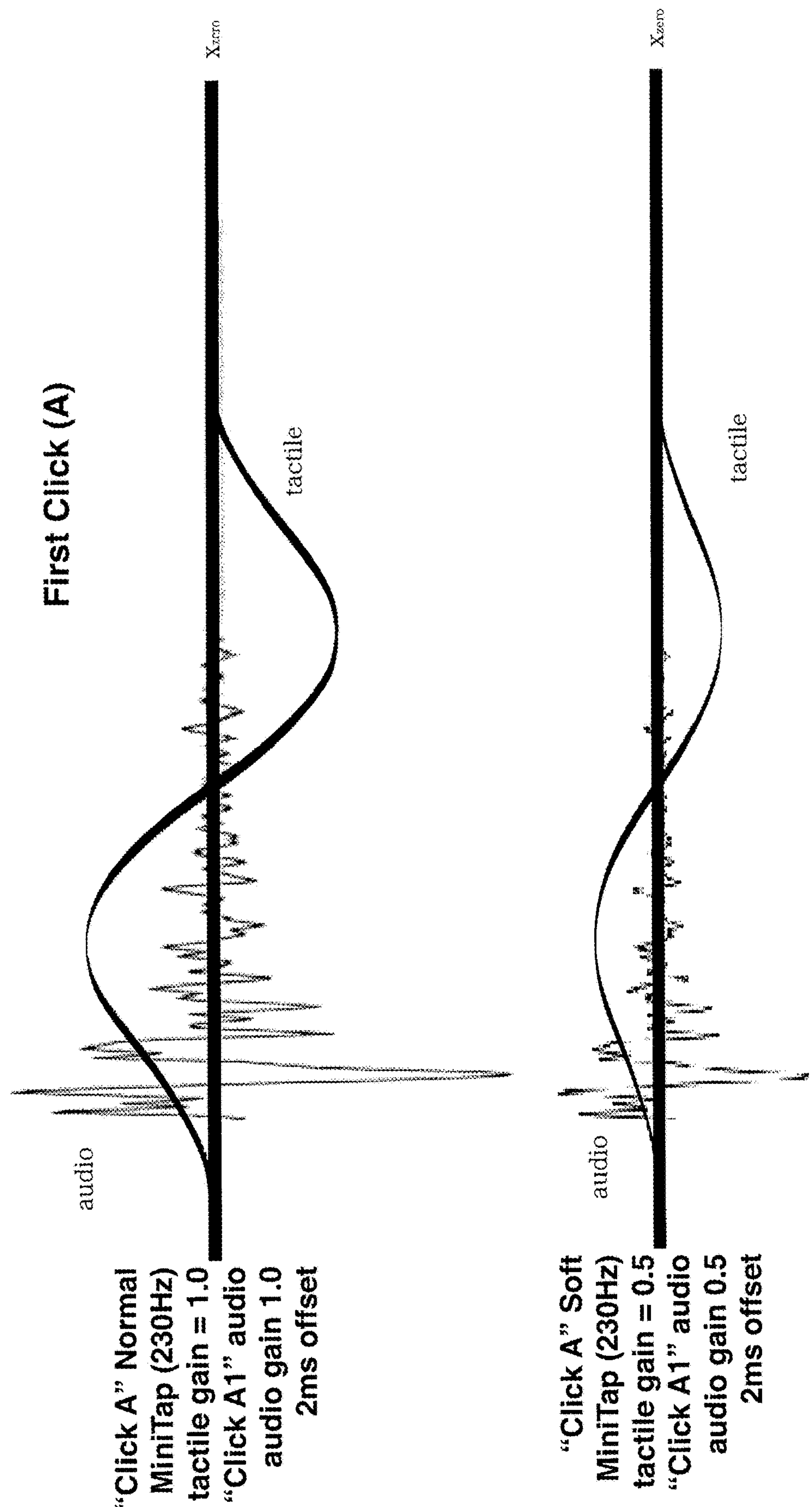

First Click (A)
“Click A” Normal
MiniTap (230Hz)
tactile gain = 1.0
“Click A1” audio
audio gain 1.0
2ms offset
audio
tactile
Xzero
“Click A” Soft
MiniTap (230Hz)
tactile gain = 0.5
“Click A1” audio
audio gain 0.5
2ms offset
audio
tactile
Xzero

Figure 4L

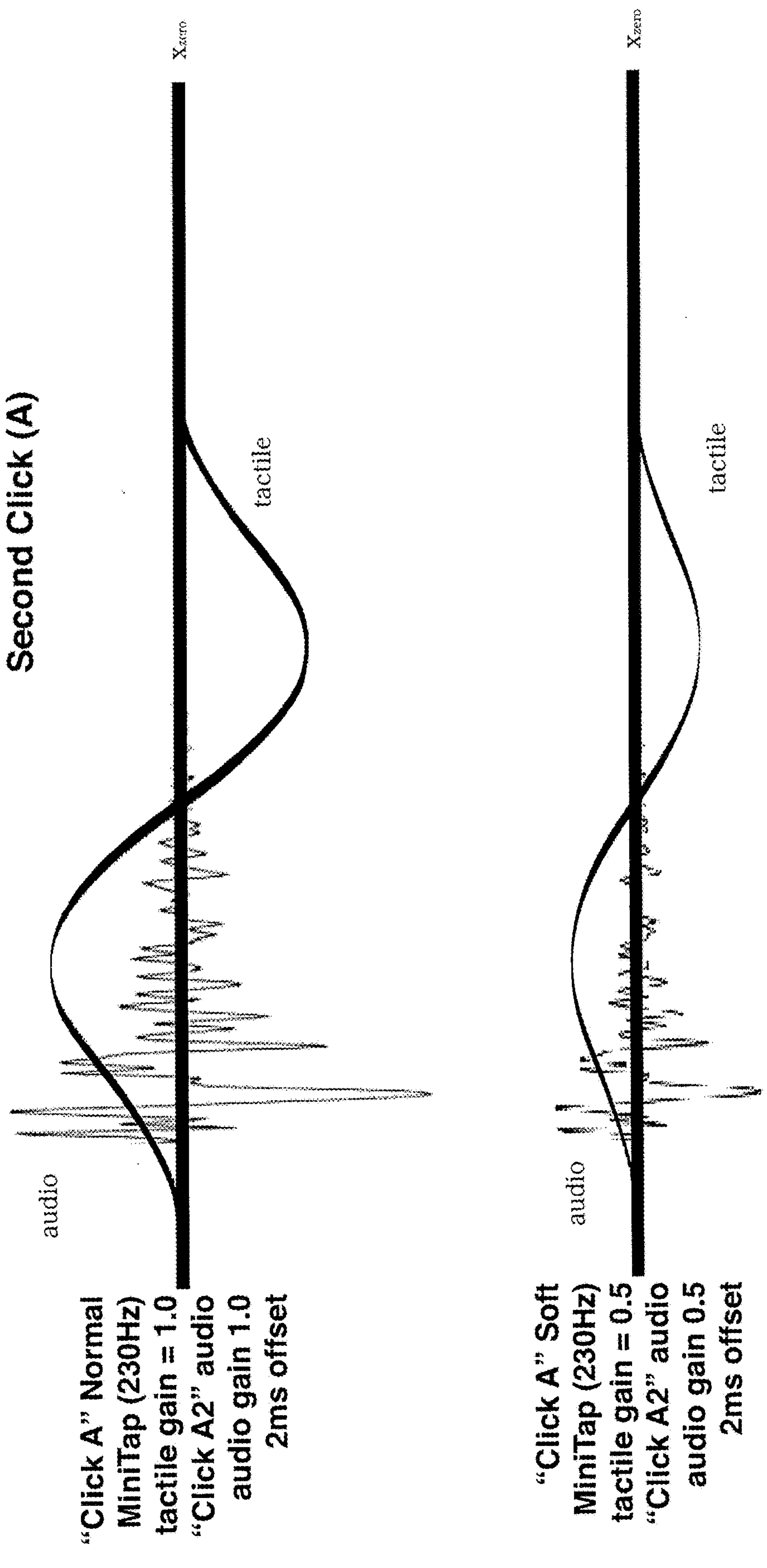

Second Click (A)
X_{zero}
audio
tactile
"Click A" Normal
MiniTap (230Hz)
tactile gain = 1.0
"Click A2" audio
audio gain 1.0
2ms offset
X_{zero}
audio
tactile
"Click A" Soft
MiniTap (230Hz)
tactile gain = 0.5
"Click A2" audio
audio gain 0.5
2ms offset

Figure 4M

First Click (B)

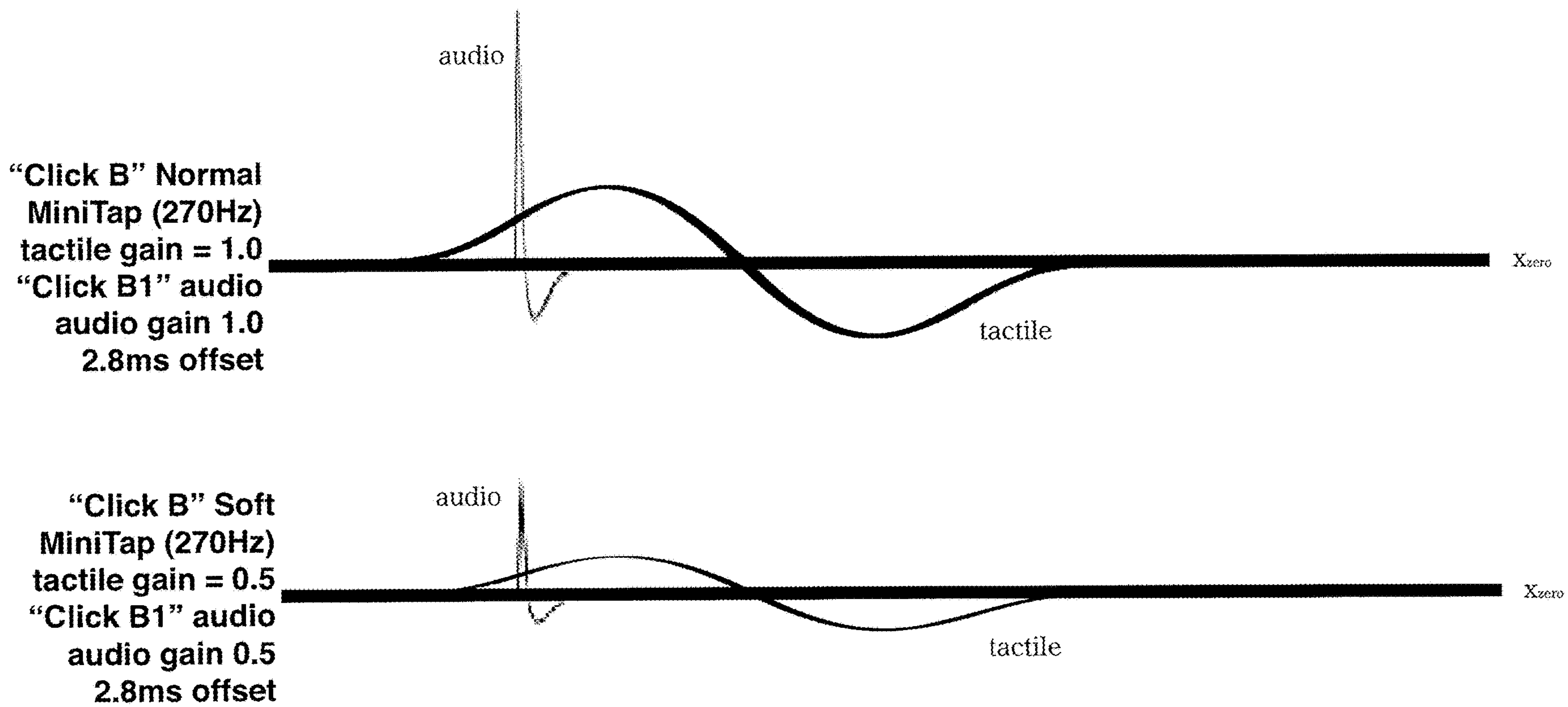


Figure 4N

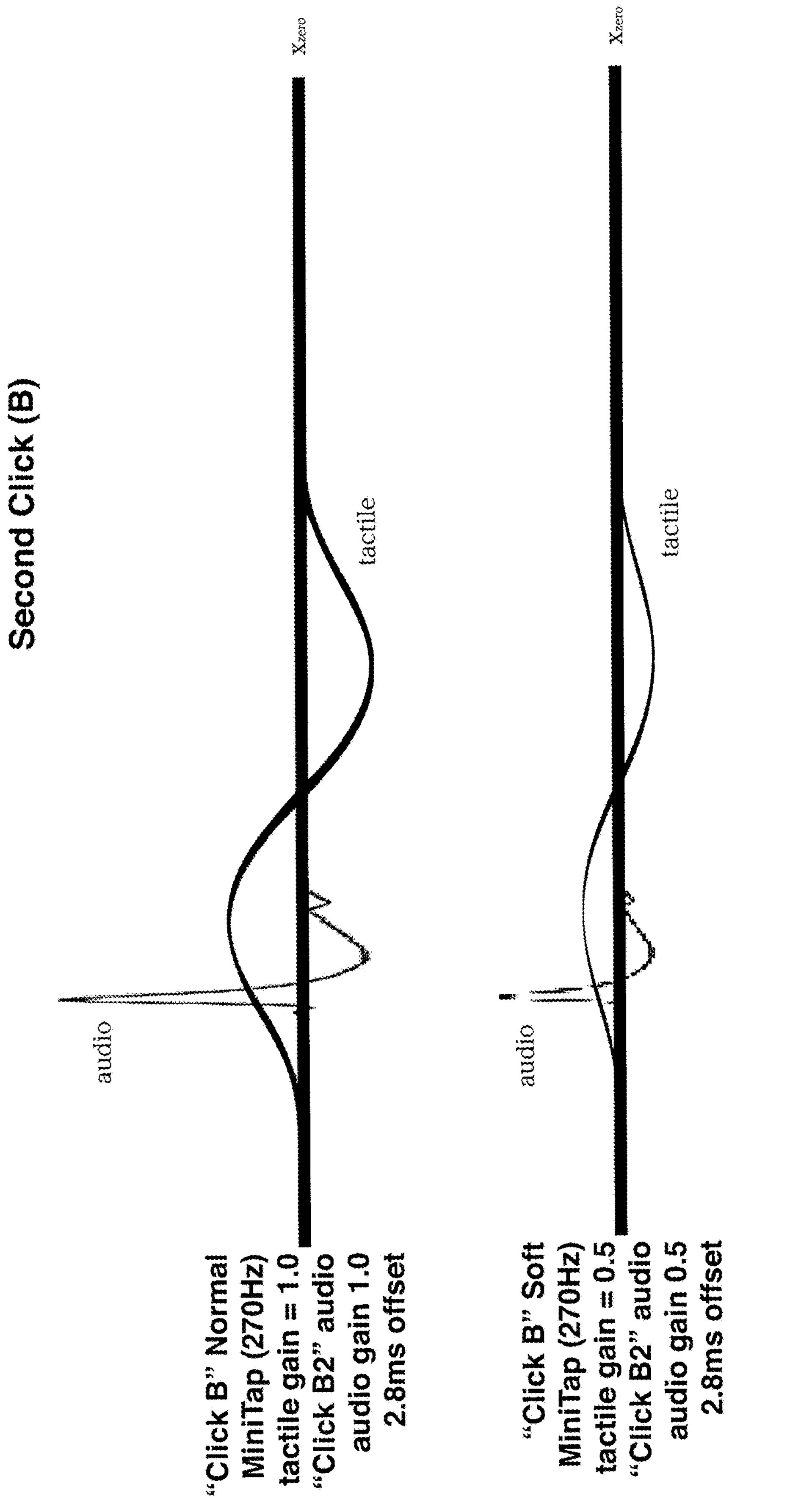

Second Click (B)
"Click B" Normal
MiniTap (270Hz)
tactile gain = 1.0
"Click B2" audio
audio gain 1.0
2.8ms offset
audio
tactile
X_{zero}
"Click B" Soft
MiniTap (270Hz)
tactile gain = 0.5
"Click B2" audio
audio gain 0.5
2.8ms offset
audio
tactile
X_{zero}

Figure 4O

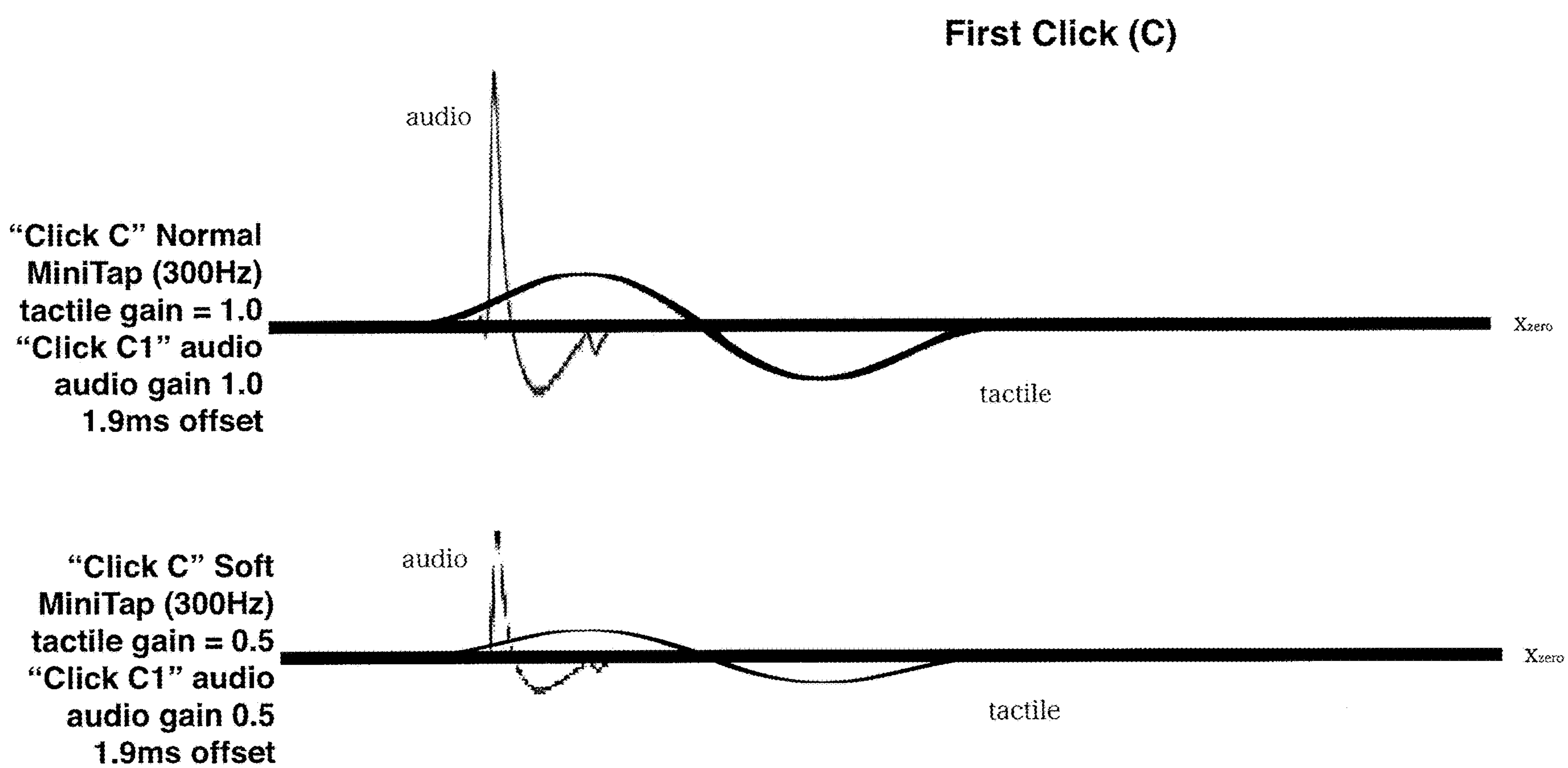

First Click (C)
audio
“Click C” Normal
MiniTap (300Hz)
tactile gain = 1.0
“Click C1” audio
audio gain 1.0
1.9ms offset
X_{zero}
tactile
audio
“Click C” Soft
MiniTap (300Hz)
tactile gain = 0.5
“Click C1” audio
audio gain 0.5
1.9ms offset
X_{zero}
tactile

Figure 4P

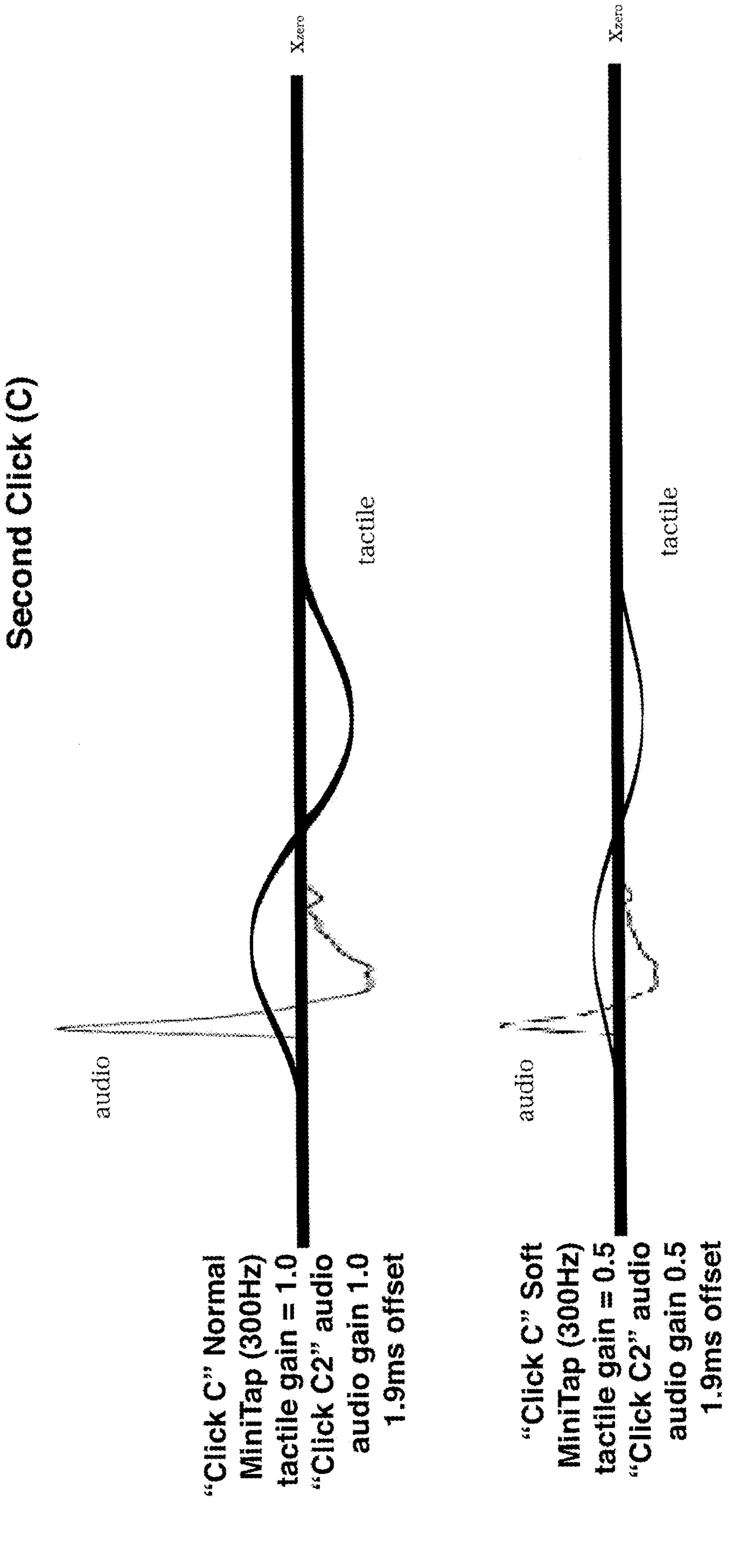

Second Click (C)
X_{zero}
tactile
audio
"Click C" Normal
MiniTap (300Hz)
tactile gain = 1.0
"Click C2" audio
audio gain 1.0
1.9ms offset
X_{zero}
tactile
audio
"Click C" Soft
MiniTap (300Hz)
tactile gain = 0.5
"Click C2" audio
audio gain 0.5
1.9ms offset

Figure 4Q

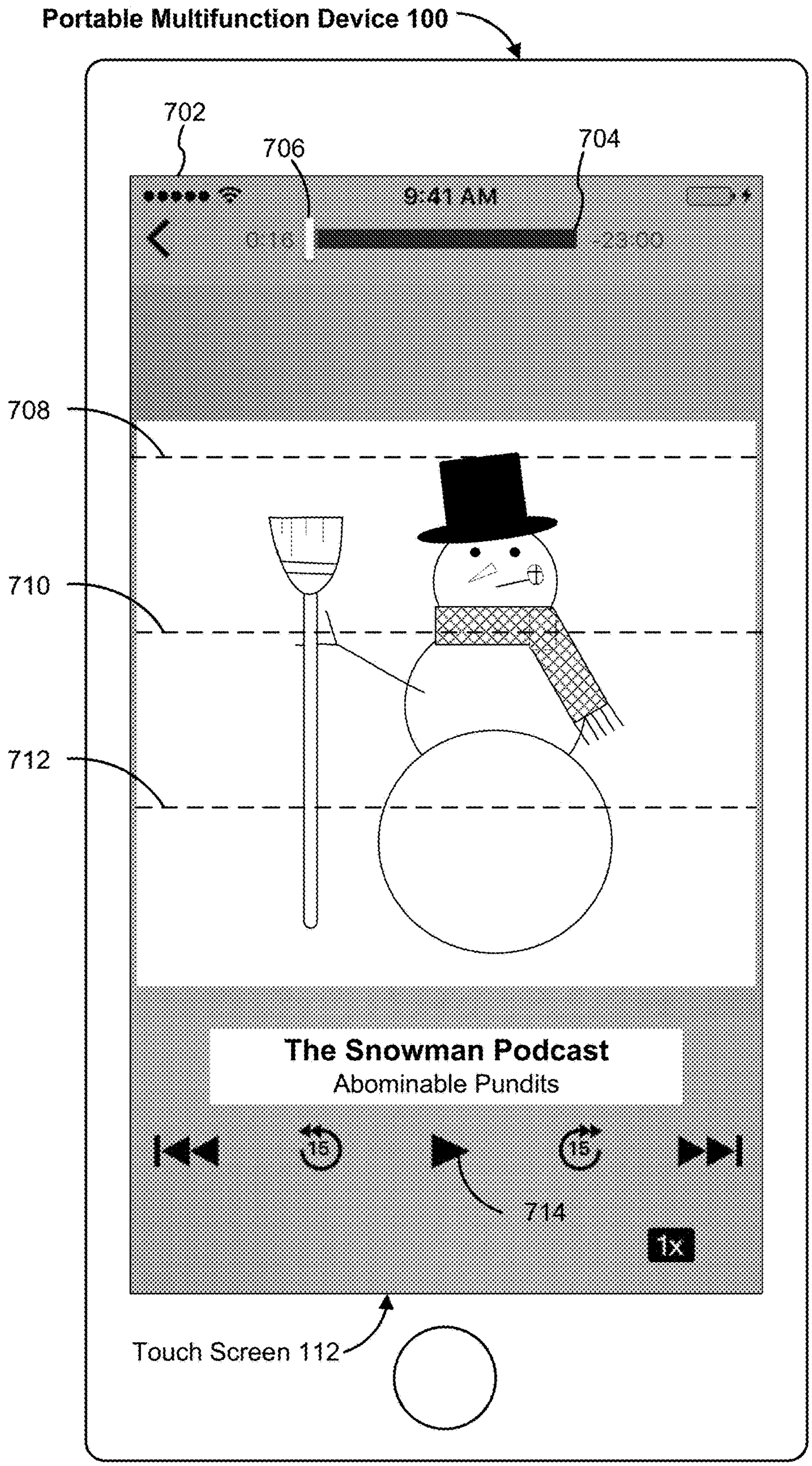

Portable Multifunction Device 100
702
706
704
9:41 AM
0:16
-23:00
708
710
712
The Snowman Podcast
Abominable Pundits
15
15
714
1x
Touch Screen 112

Figure 5A

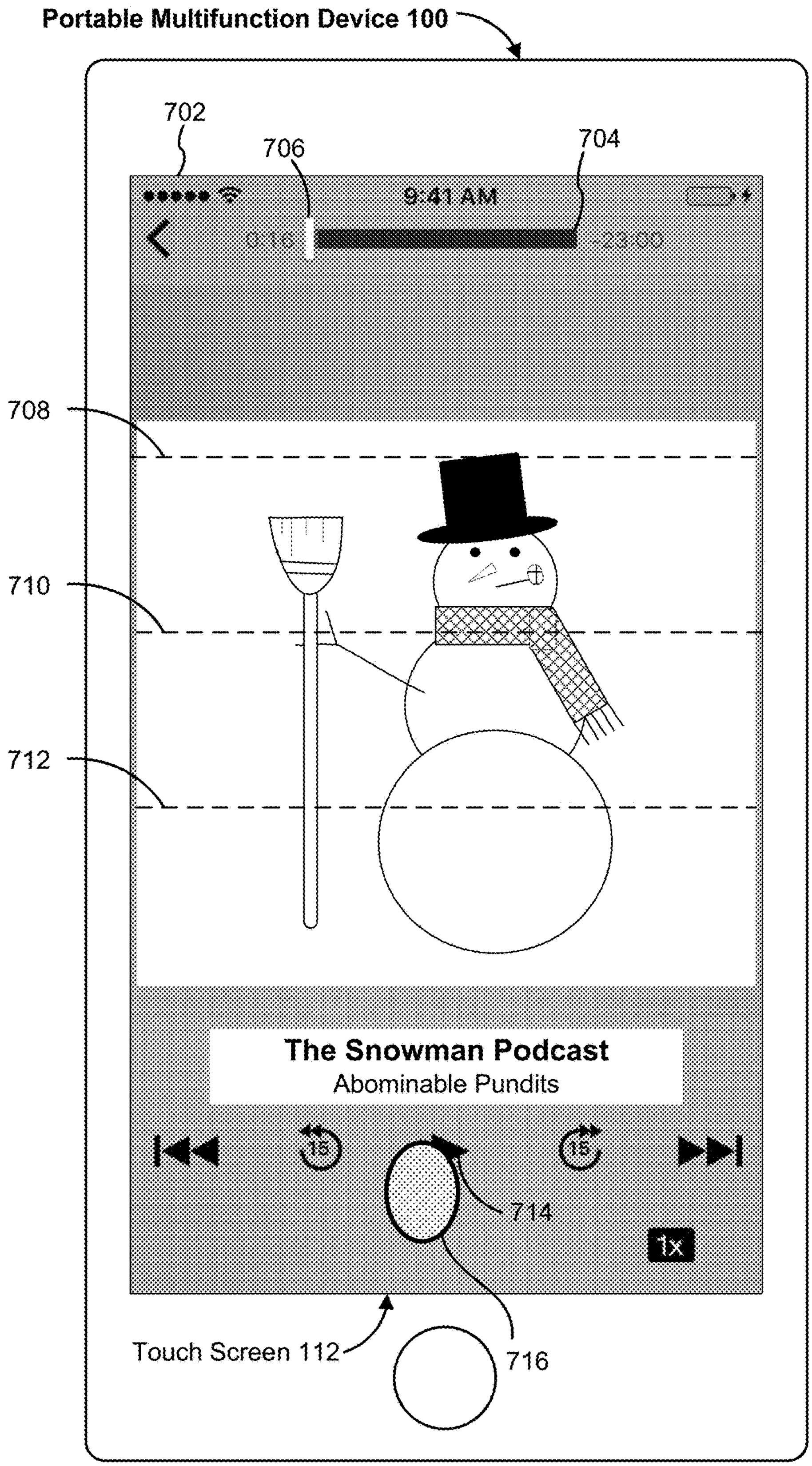

Portable Multifunction Device 100
702
706
704
9:41 AM
0:16
-23:00
708
710
712
The Snowman Podcast
Abominable Pundits
15
15
714
1x
Touch Screen 112
716

Figure 5B

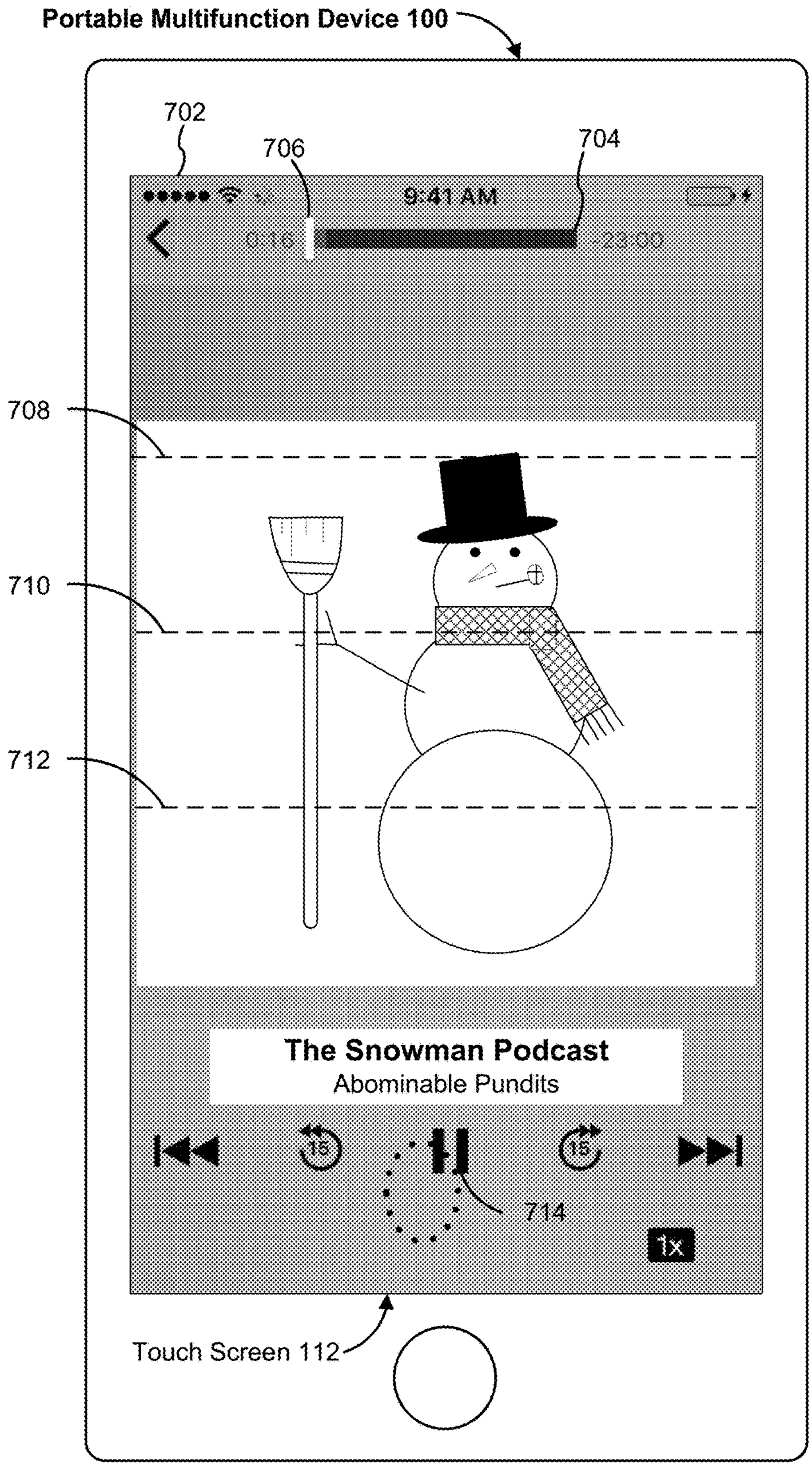

Portable Multifunction Device 100
702
706
704
9:41 AM
0:16
-23:00
708
710
712
The Snowman Podcast
Abominable Pundits
15
15
714
1x
Touch Screen 112

Figure 5C

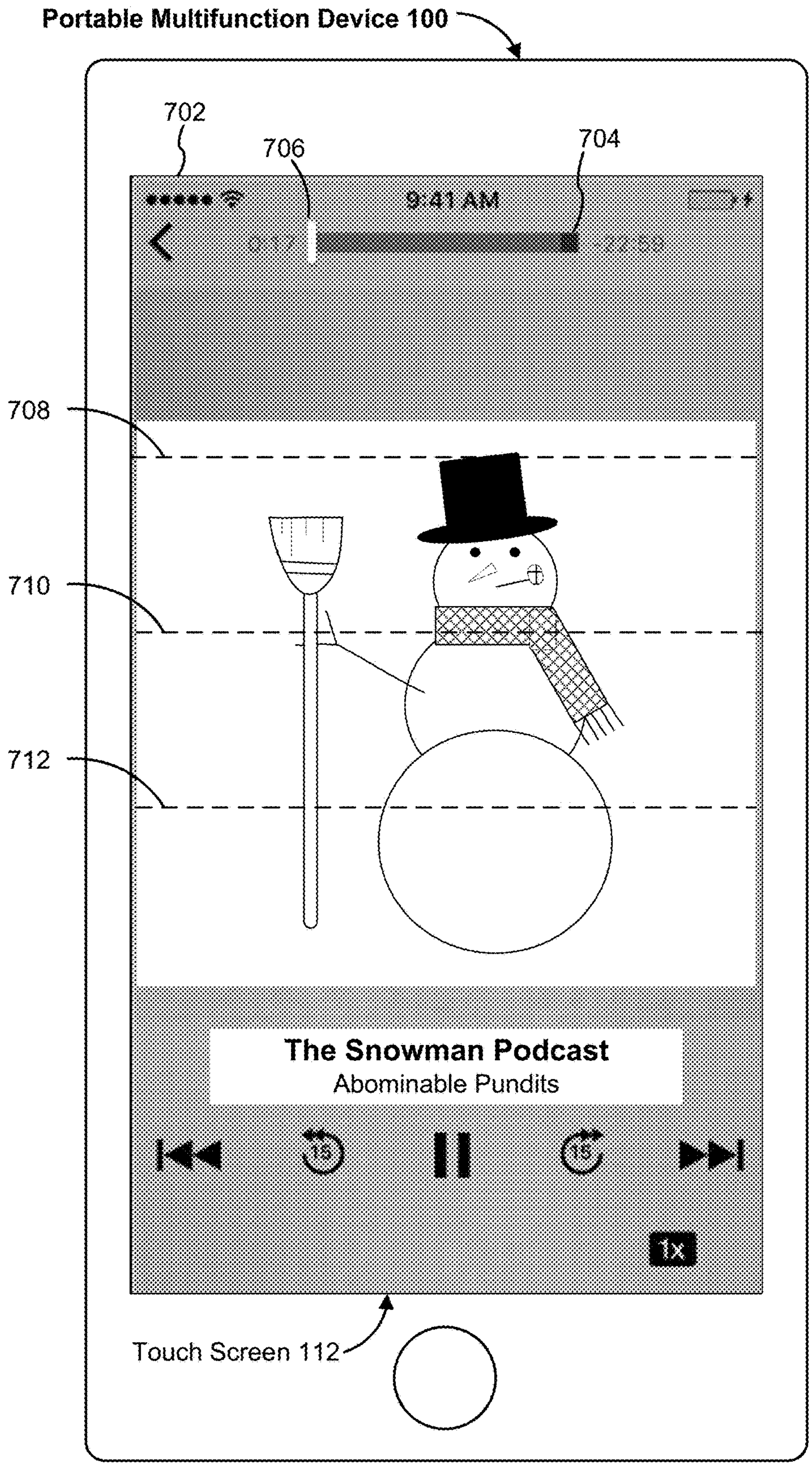

Portable Multifunction Device 100
702
706
704
9:41 AM
708
710
712
The Snowman Podcast
Abominable Pundits
1x
Touch Screen 112

Figure 5D

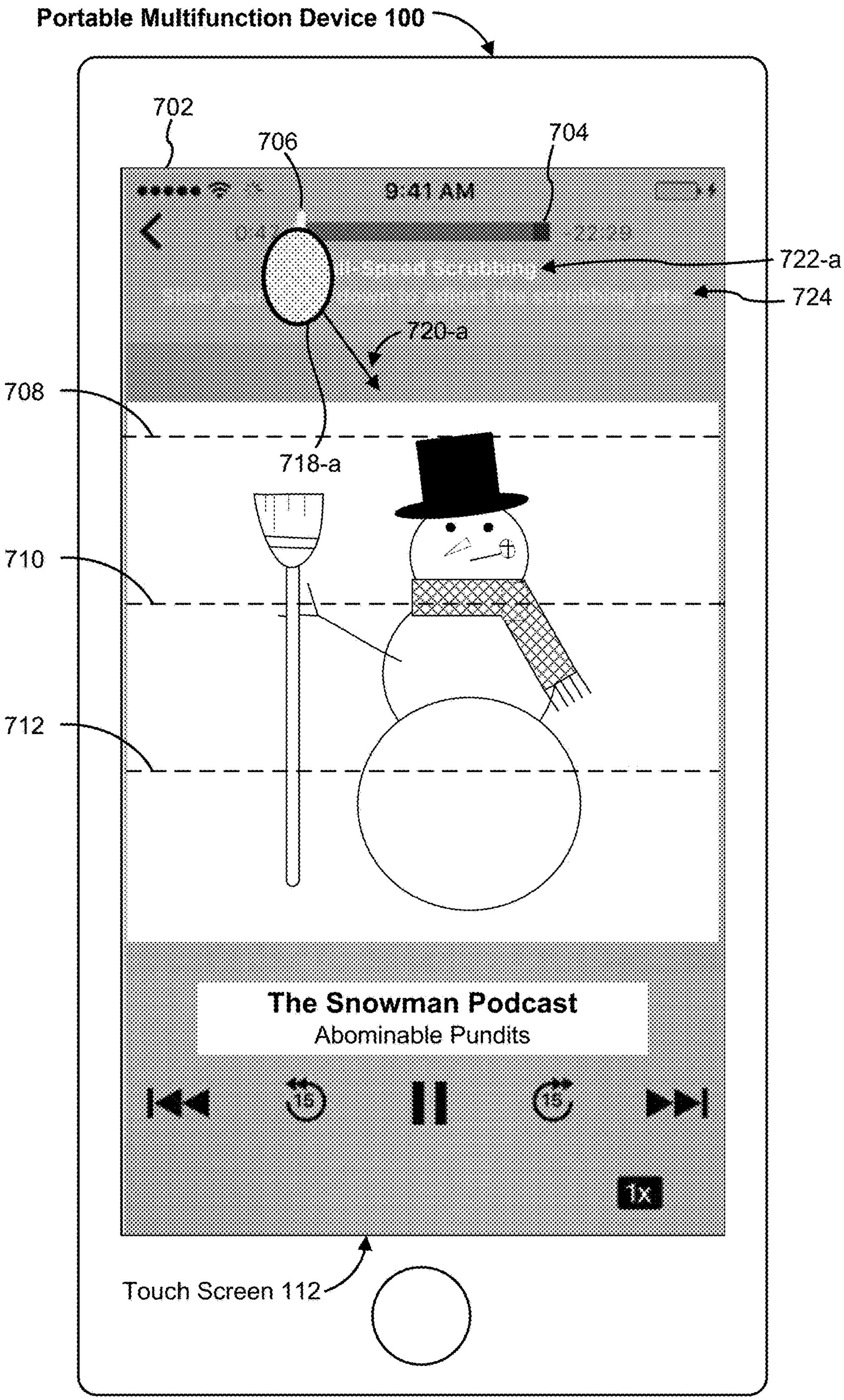

Portable Multifunction Device 100
702
706
704
9:41 AM
22:29
722-a
724
720-a
708
718-a
710
712
The Snowman Podcast
Abominable Pundits
15
15
1x
Touch Screen 112

Figure 5E

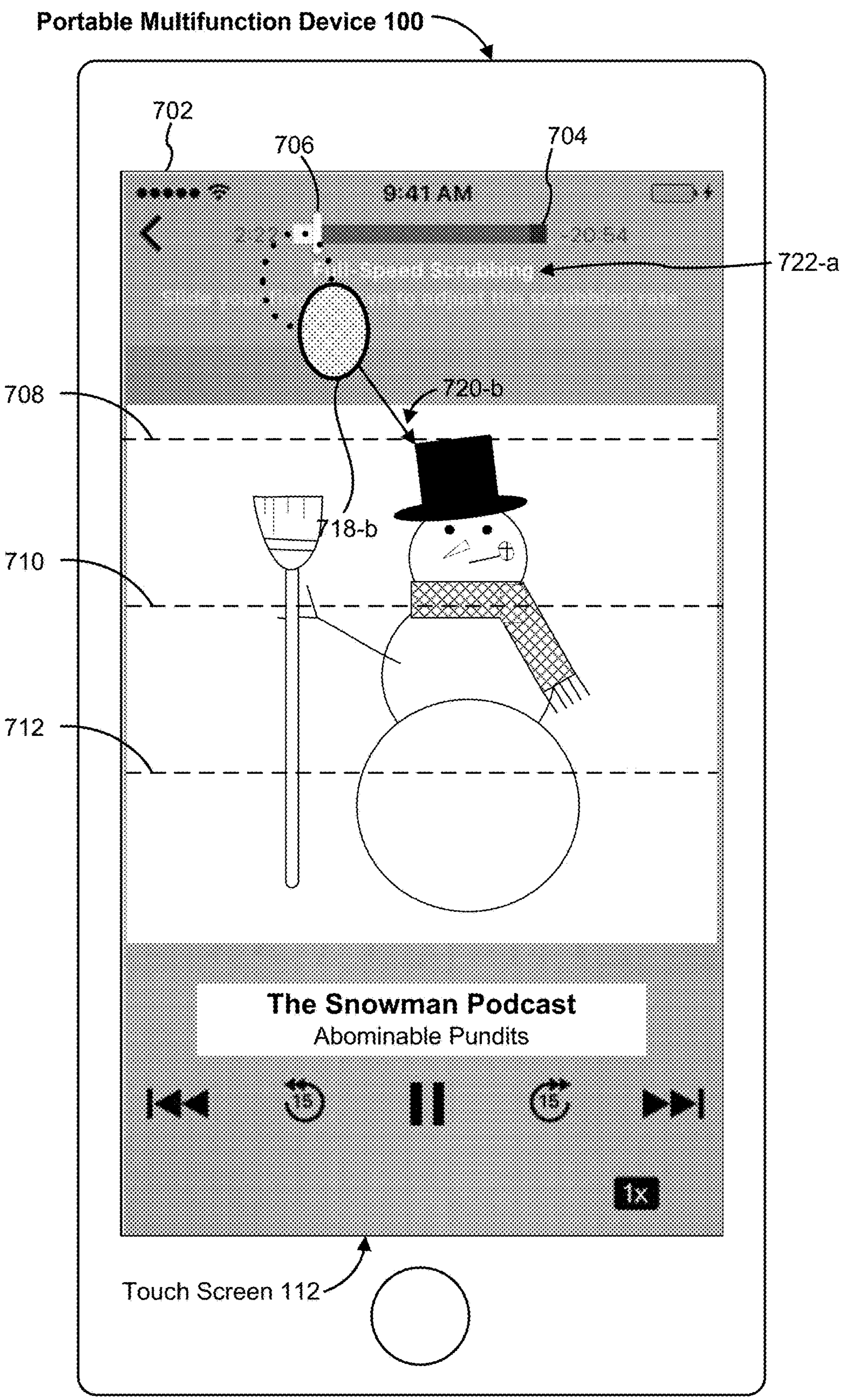

Portable Multifunction Device 100
702
706
704
9:41 AM
722-a
708
720-b
718-b
710
712
The Snowman Podcast
Abominable Pundits
15
15
1x
Touch Screen 112

Figure 5F

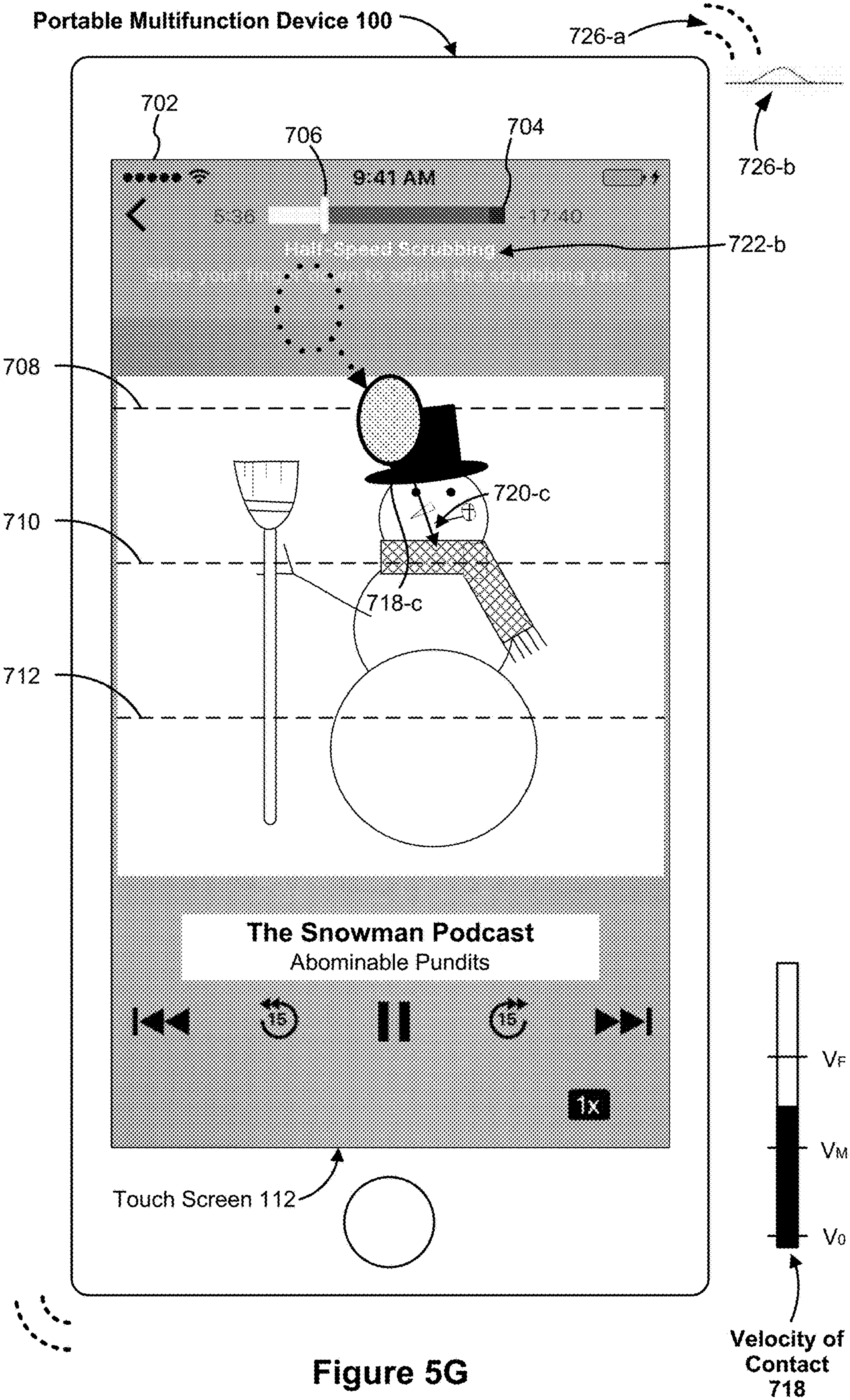

Portable Multifunction Device 100
726-a
726-b
702
706
704
9:41 AM
5:36
-17:40
Half-Speed Scrubbing
722-b
708
710
712
720-c
718-c
The Snowman Podcast
Abominable Pundits
15
15
1x
Touch Screen 112
VF
VM
V0
Velocity of Contact 718

Figure 5G

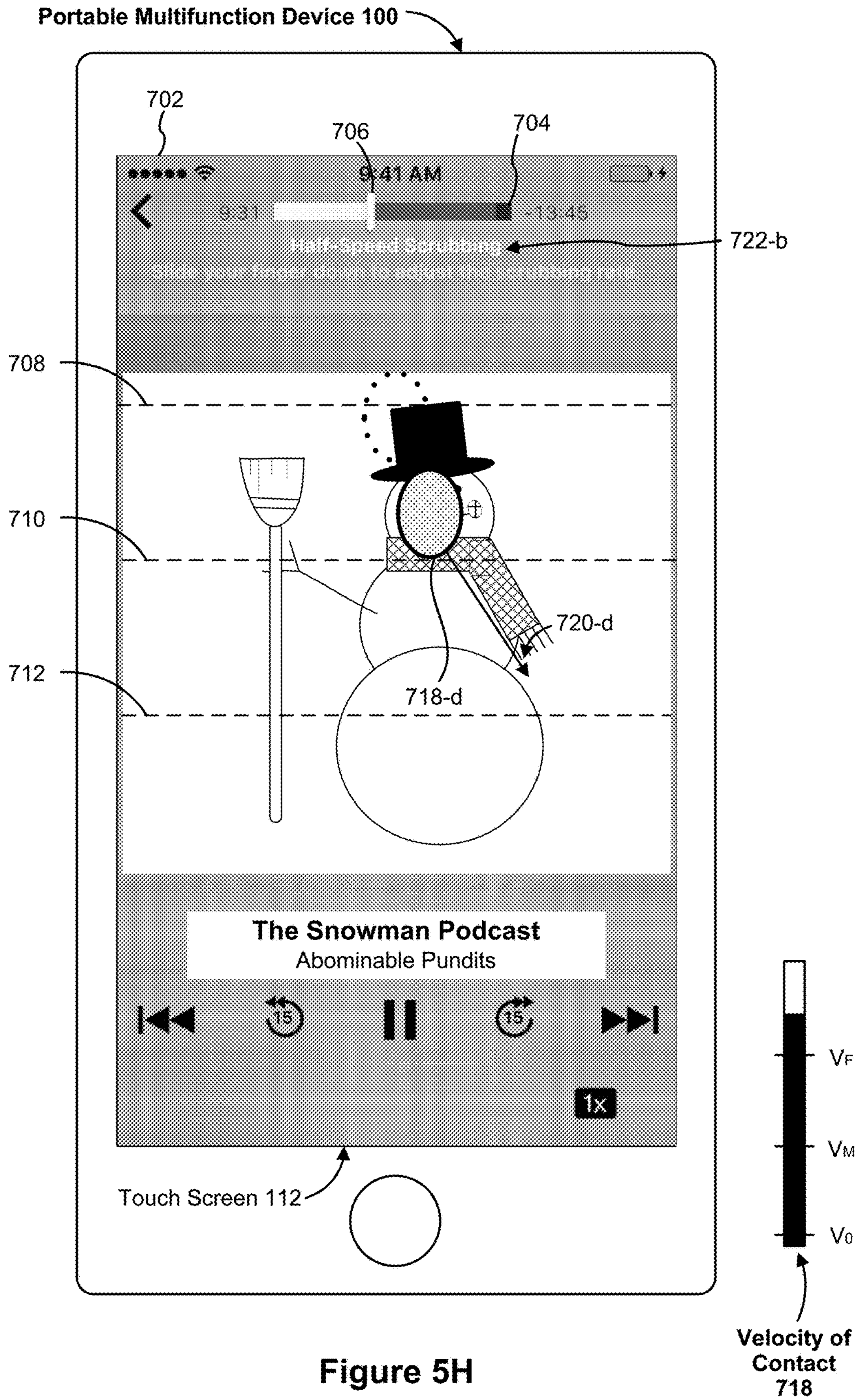

Portable Multifunction Device 100
702
706
704
9:41 AM
722-b
708
710
712
720-d
718-d
The Snowman Podcast
Abominable Pundits
15
15
1x
Touch Screen 112
VF
VM
V0
Velocity of Contact 718

Figure 5H

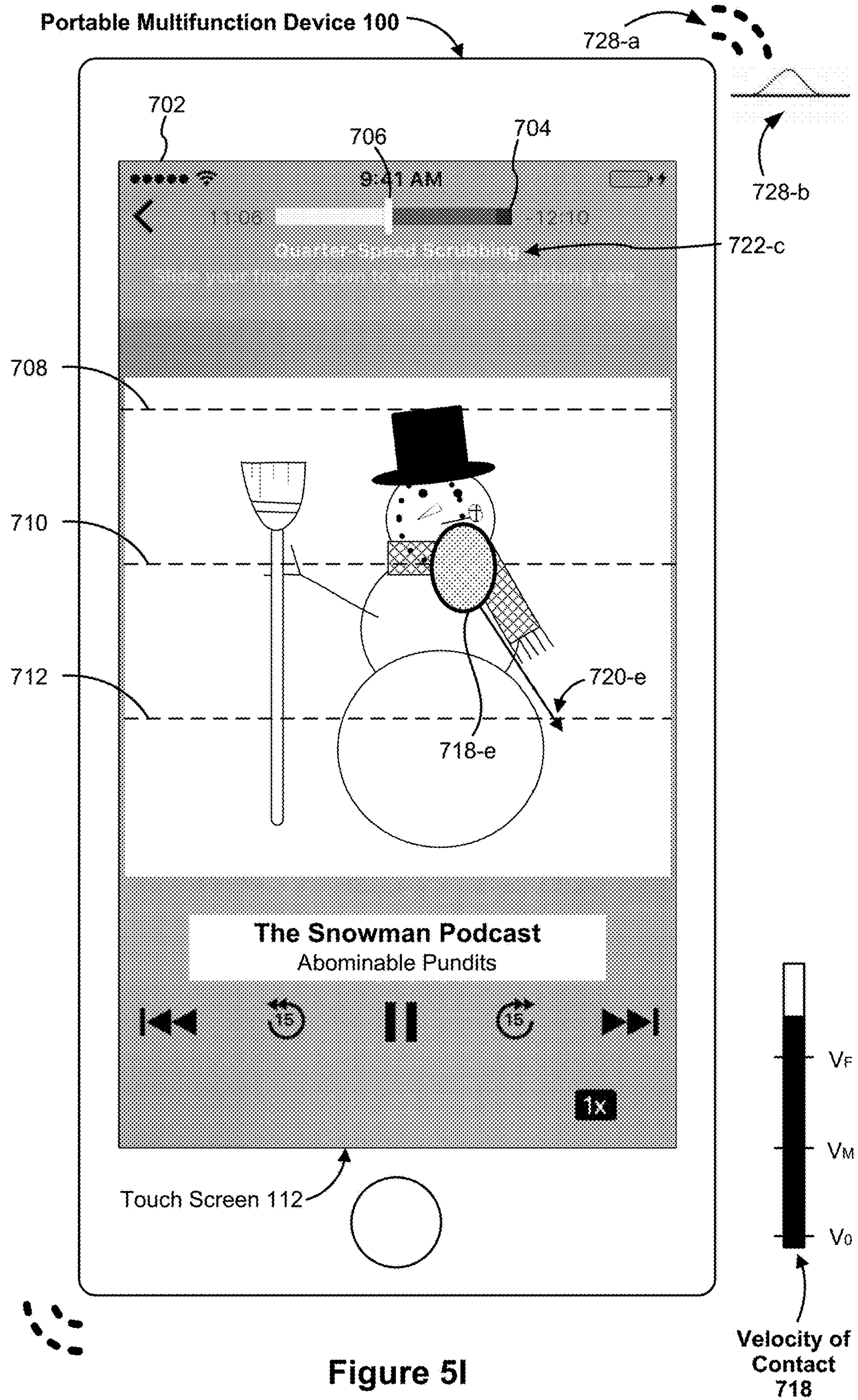

Portable Multifunction Device 100
728-a
728-b
702
706
704
9:41 AM
11:06
-12:10
Quarter Speed Scrubbing
722-c
708
710
712
720-e
718-e
The Snowman Podcast
Abominable Pundits
15
15
1x
Touch Screen 112
V_F
V_M
V_0
Velocity of Contact 718

Figure 5I

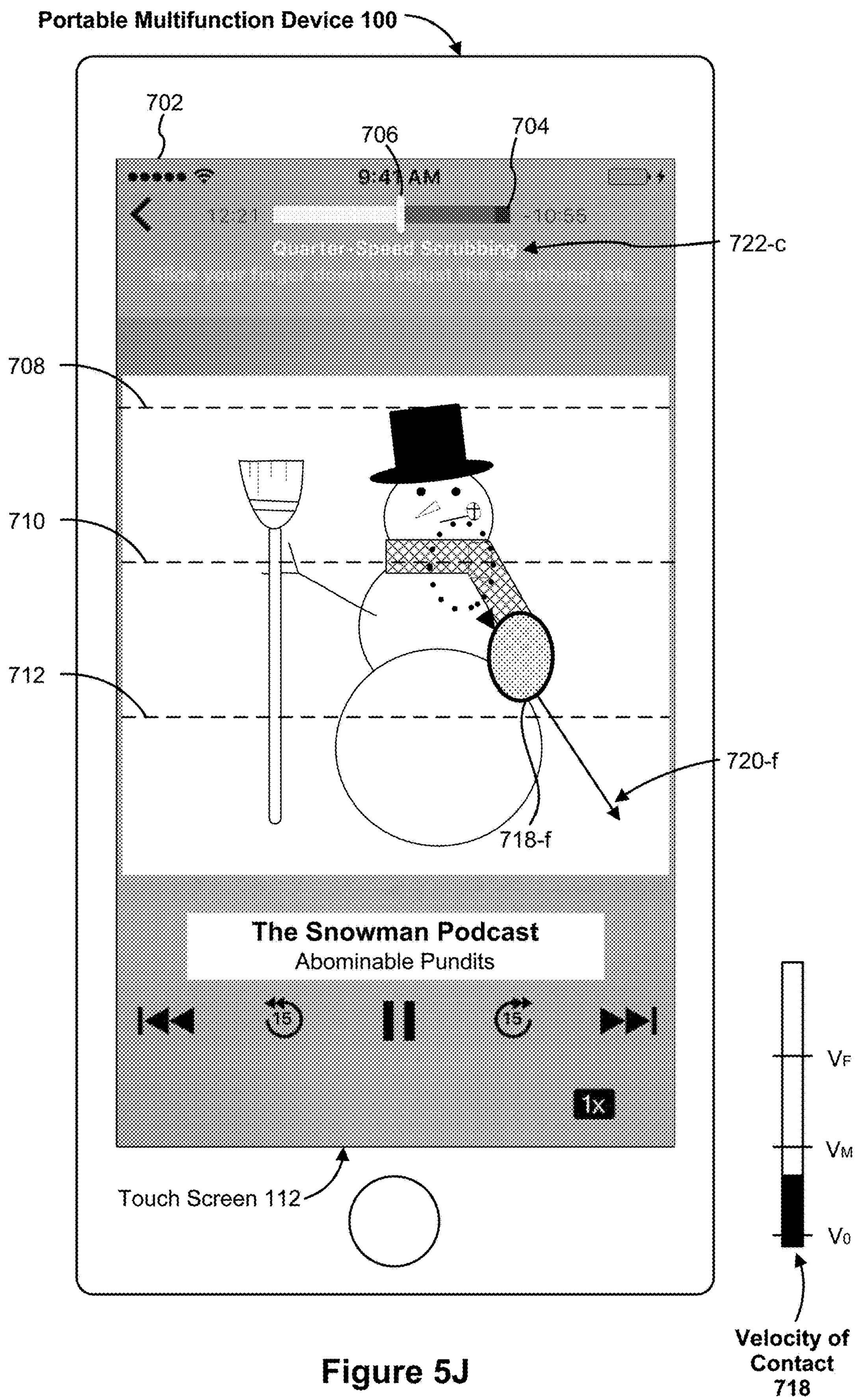

Portable Multifunction Device 100
702
706
704
9:41 AM
722-c
708
710
712
720-f
718-f
The Snowman Podcast
Abominable Pundits
1x
Touch Screen 112
V_F
V_M
V_0
Velocity of Contact 718

Figure 5J

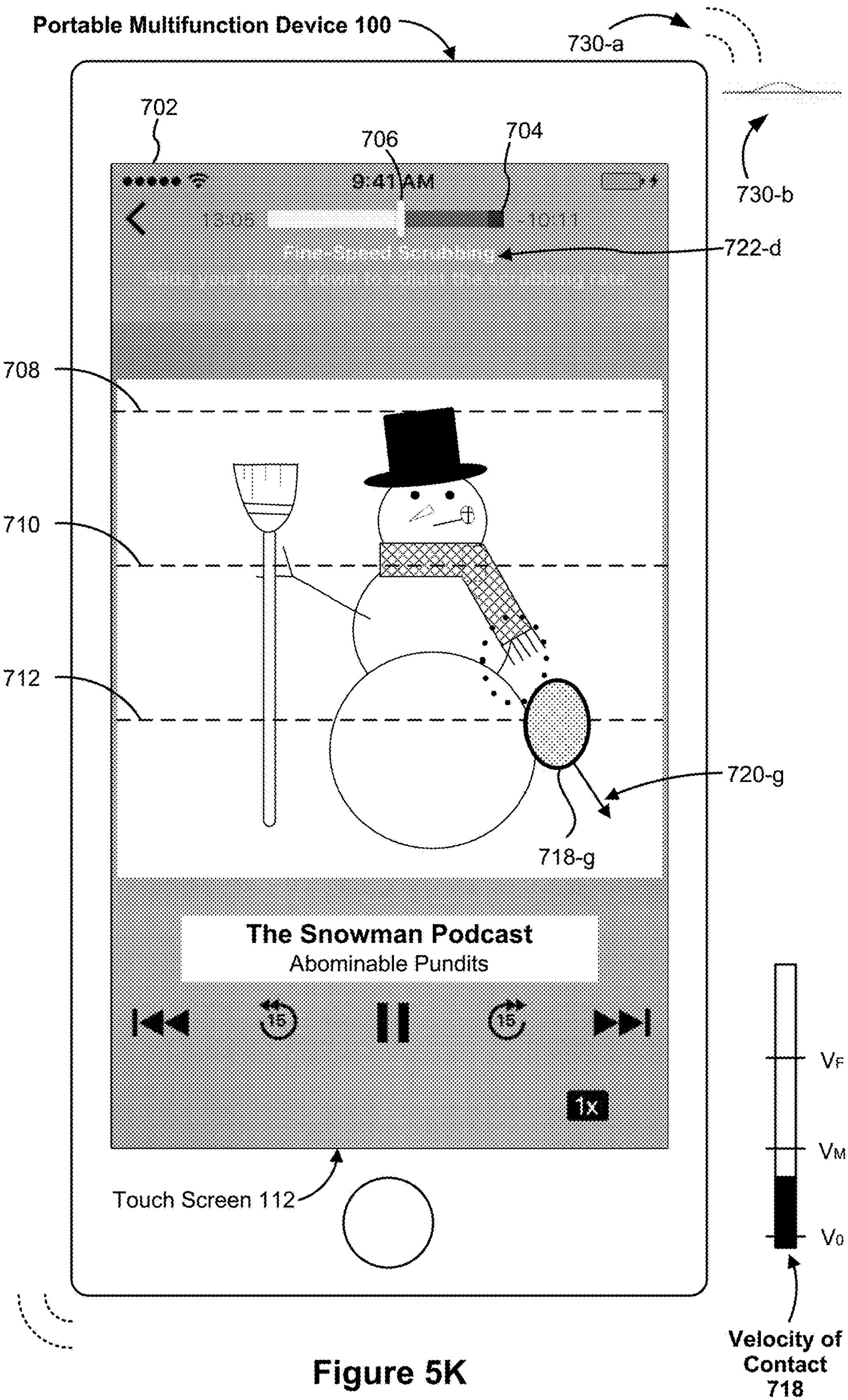
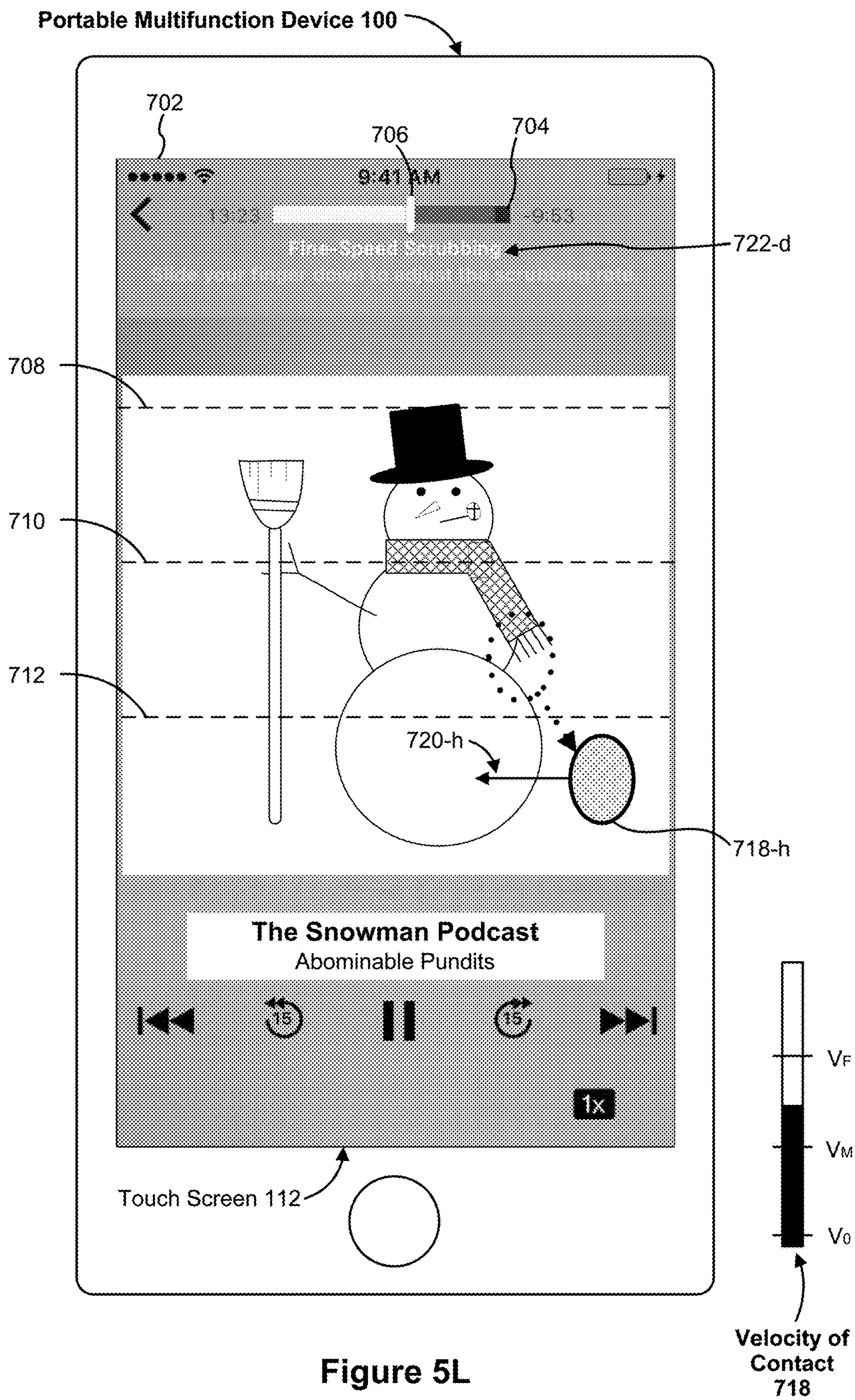
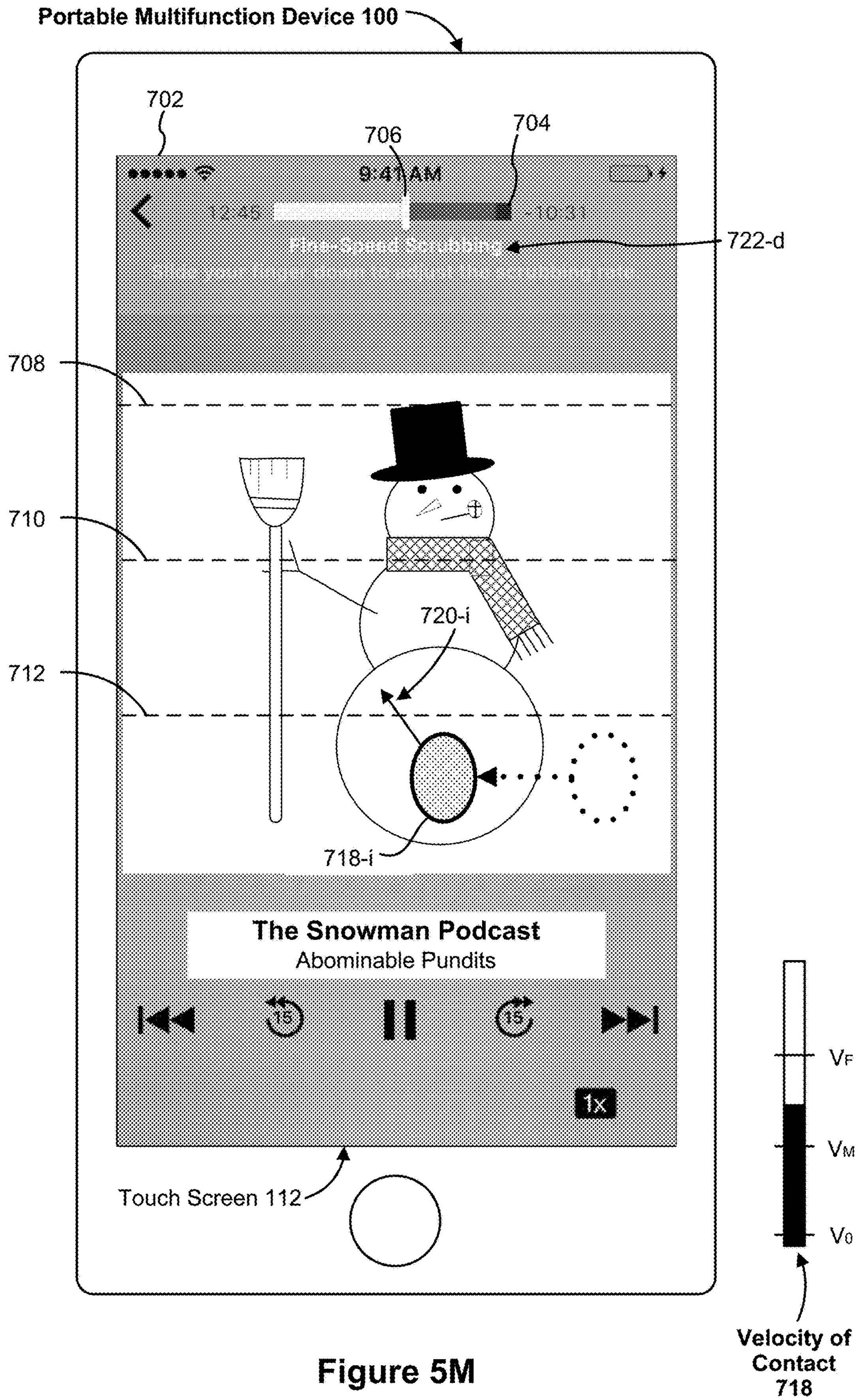

Portable Multifunction Device 100
730-a
730-b
702
706
704
9:41 AM
13:06
-10:11
Fine-Speed Scrubbing
722-d
708
710
712
720-g
718-g
The Snowman Podcast
Abominable Pundits
15
15
1x
Touch Screen 112
V_F
V_M
V_0
Velocity of Contact 718

Figure 5K



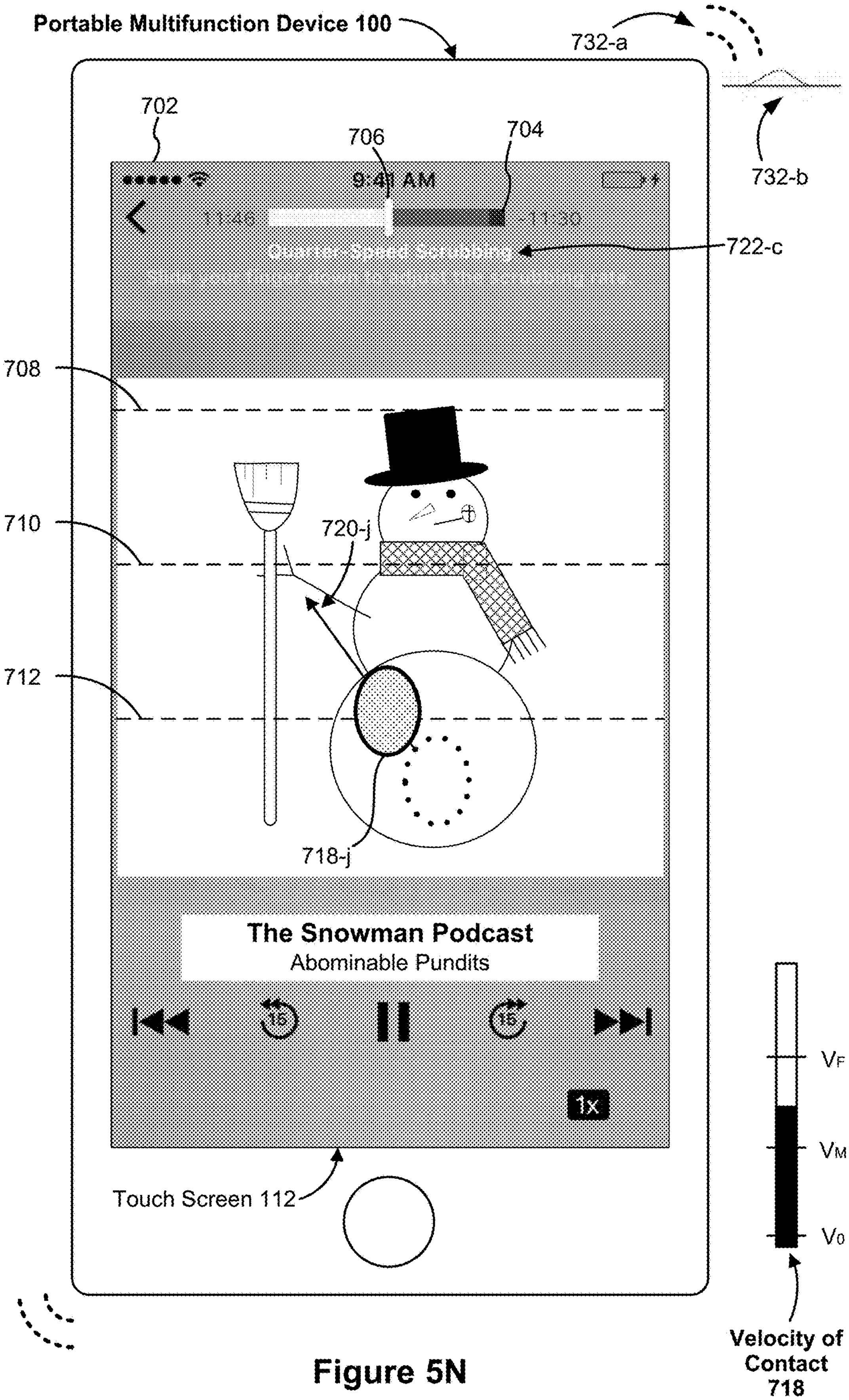
Portable Multifunction Device 100
702
706
704
9:41 AM
722-d
708
710
712
720-h
718-h
The Snowman Podcast
Abominable Pundits
15
15
1x
Touch Screen 112
V_F
V_M
V_0
Velocity of Contact 718

Figure 5L



Portable Multifunction Device 100
702
706
704
9:41 AM
12:45
-10:31
Fine-Speed Scrubbing
722-d
708
710
712
720-i
718-i
The Snowman Podcast
Abominable Pundits
15
15
1x
Touch Screen 112
V_F
V_M
V_0
Velocity of Contact 718

Figure 5M



Portable Multifunction Device 100
732-a
732-b
702
706
704
9:41 AM
722-c
Quarter Speed Scrubbing
708
710
712
720-j
718-j
The Snowman Podcast
Abominable Pundits
15
15
1x
Touch Screen 112
VF
VM
V0
Velocity of Contact 718

Figure 5N

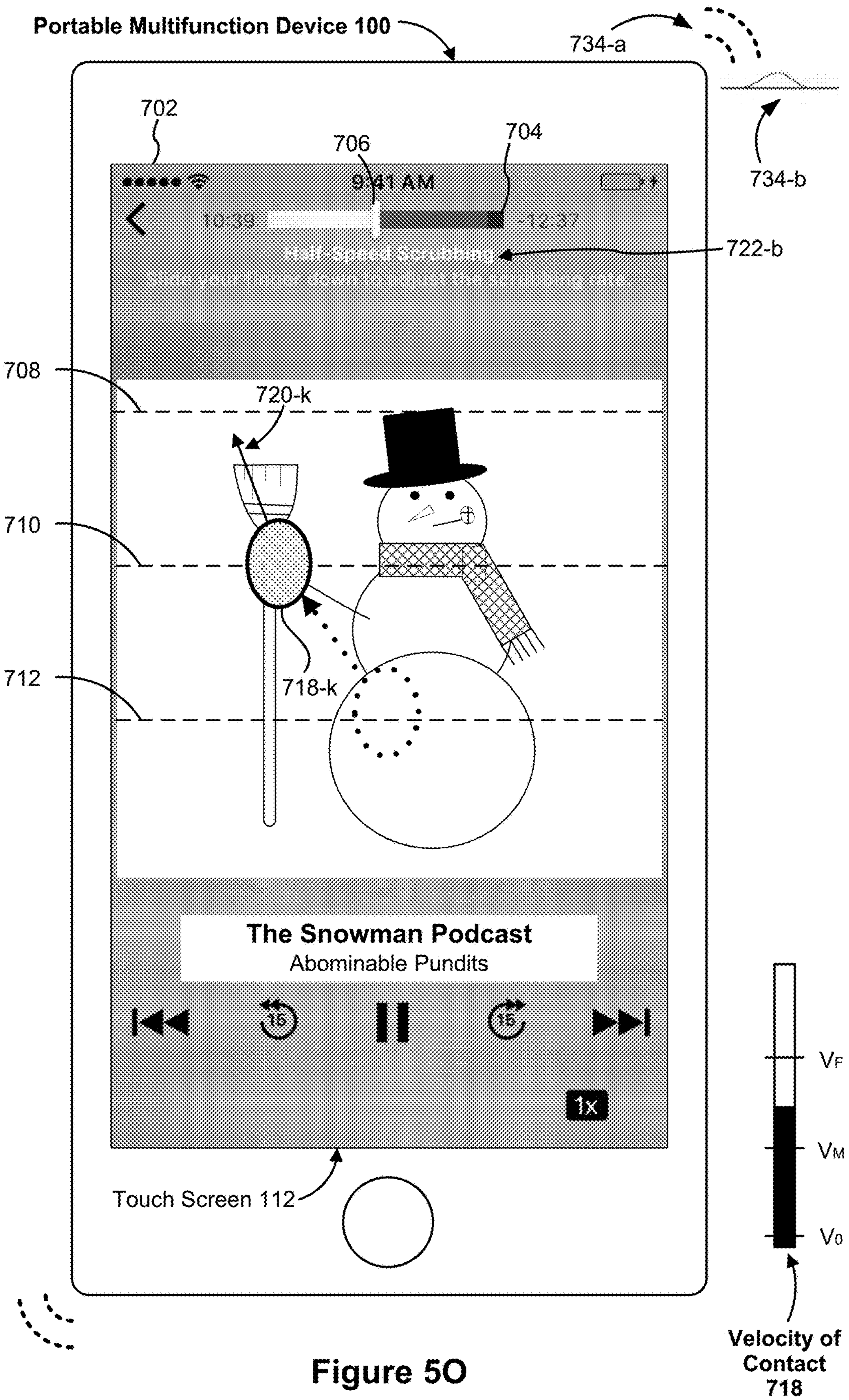
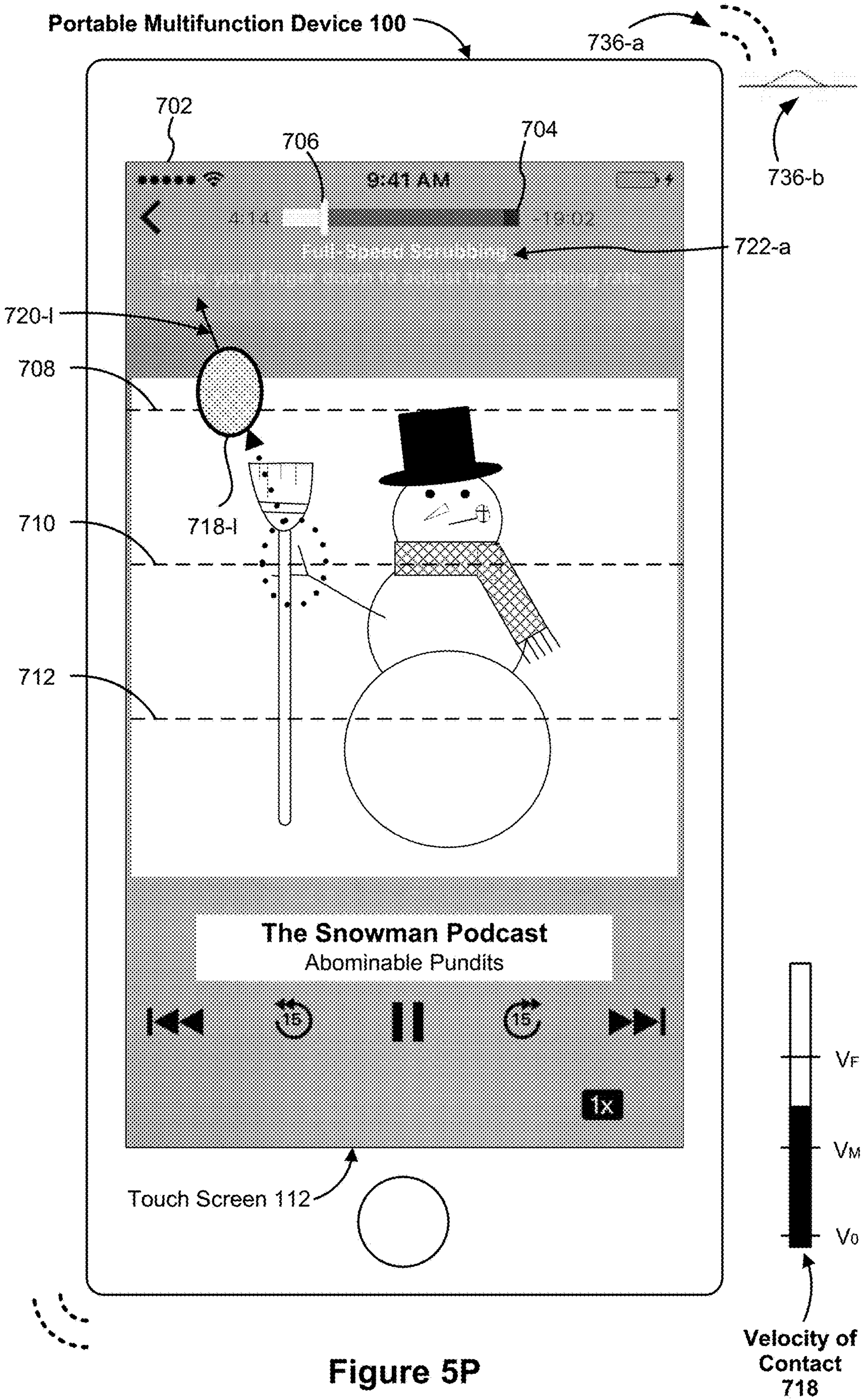

Portable Multifunction Device 100
734-a
734-b
702
706
704
9:41 AM
10:39
-12:37
Half-Speed Scrubbing
722-b
708
720-k
710
718-k
712
The Snowman Podcast
Abominable Pundits
1x
Touch Screen 112
V_F
V_M
V_0
Velocity of Contact 718

Figure 5O



Portable Multifunction Device 100
736-a
736-b
702
706
704
9:41 AM
4:14
-19:02
Full-Speed Scrubbing
722-a
720-l
708
718-l
710
712
The Snowman Podcast
Abominable Pundits
15
15
1x
Touch Screen 112
V_F
V_M
V_0
Velocity of Contact 718

Figure 5P

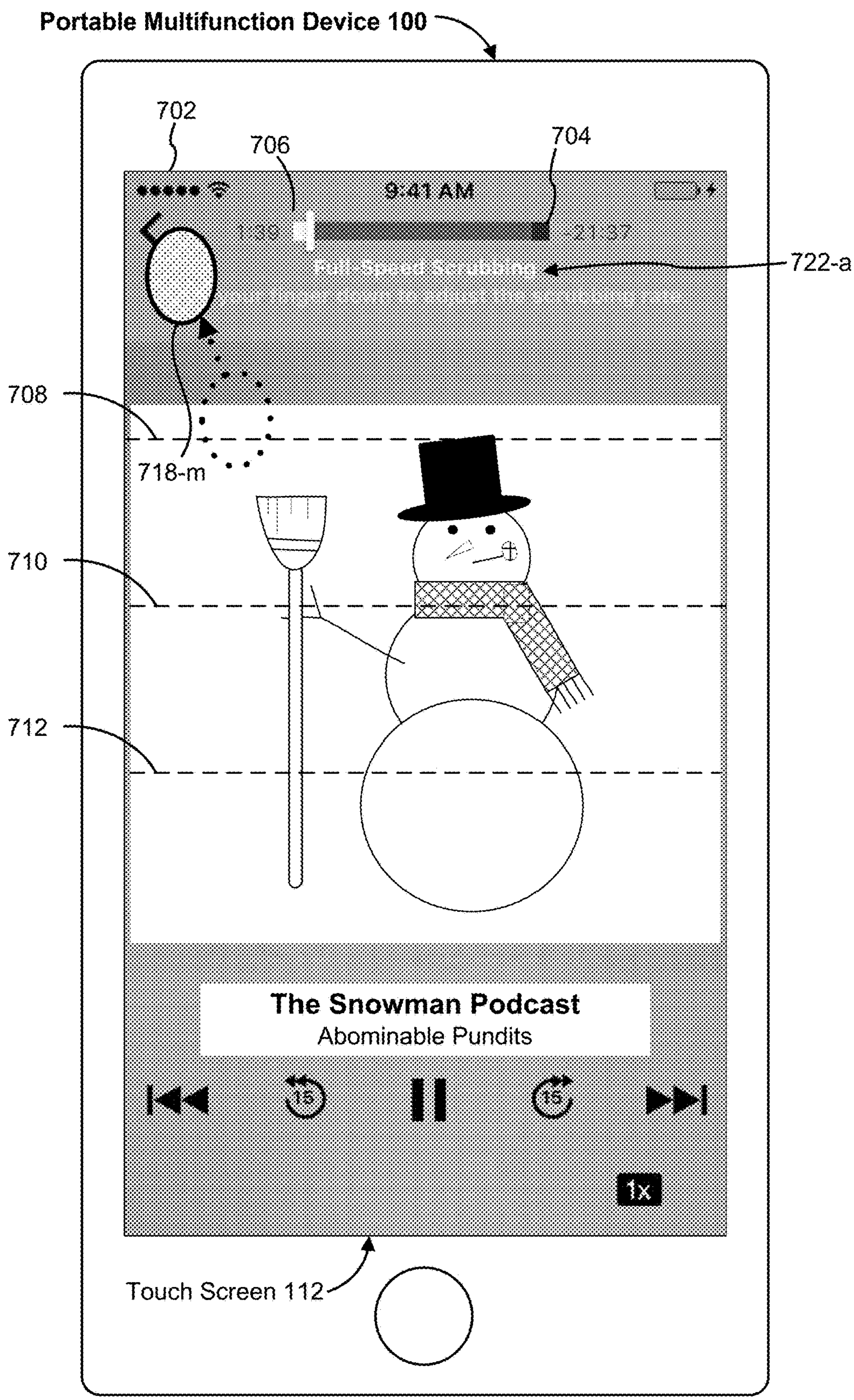

Portable Multifunction Device 100
702
706
704
9:41 AM
1:39
-21:37
Full-Speed Scrubbing
722-a
708
718-m
710
712
The Snowman Podcast
Abominable Pundits
15
15
1x
Touch Screen 112

Figure 5Q

2400

2402
Display a user interface including an adjustable control.

2404
Detect a contact on a touch-sensitive surface at a location that corresponds to the adjustable control on the display, where movement of the contact that corresponds to movement away from the adjustable control changes an adjustment rate for adjusting the adjustable control based on movement of the contact.

A

2406
While continuously detecting the contact on the touch-sensitive surface:

2406-a
detect a first movement of the contact across the touch-sensitive surface; and

2406-b
in response to detecting the first movement of the contact:

2406-c
in accordance with a determination that the first movement of the contact corresponds to more than a first threshold amount of movement of a focus selector away from the adjustable control, where the first threshold amount of movement triggers a transition from a first adjustment rate to a second adjustment rate:

2406-d
generate a first tactile output, via the one or more tactile output devices, when the focus selector has reached the first threshold amount of movement; and

2406-e
adjust the adjustable control at the second adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the first threshold amount; and

B

Figure 6A

2406

B

2406-f

in accordance with a determination that the first movement of the contact corresponds to less than the first threshold amount of movement of the focus selector away from the adjustable control, adjust the adjustable control at the first adjustment rate in accordance with movement of the contact without generating the first tactile output.

C

2408

While continuously detecting the contact on the touch-sensitive surface:

2408-a

detect a second movement of the contact across the touch-sensitive surface; and

2408-b

in response to detecting the second movement of the contact:

2408-c

in accordance with a determination that the second movement of the contact corresponds to more than a second threshold amount of movement of the focus selector away from the adjustable control, where the second threshold amount of movement triggers a transition from the second adjustment rate to a third adjustment rate:

2408-d

generate a second tactile output, via the one or more tactile output devices, when the focus selector has reached the second threshold amount of movement; and

2408-e

adjust the adjustable control at the third adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the second threshold amount; and

2408-f

in accordance with a determination that the second movement of the contact corresponds to less than the second threshold amount of movement of the focus selector away from the adjustable control, adjust the adjustable control at the second adjustment rate in accordance with movement of the contact without generating the second tactile output.

D

Figure 6B

D

2410
While continuously detecting the contact on the touch-sensitive surface:

2410-a
detect a third movement of the contact across the touch-sensitive surface; and

2410-b
in response to detecting the third movement of the contact:

2410-c
in accordance with a determination that the third movement of the contact corresponds to more than a third threshold amount of movement of the focus selector away from the adjustable control, where the third threshold amount of movement triggers a transition from the third adjustment rate to a fourth adjustment rate:

2410-d
generate a third tactile output, via the one or more tactile output devices, when the focus selector has reached the third threshold amount of movement; and

2410-e
adjust the adjustable control at the fourth adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the third threshold amount; and

2410-f
in accordance with a determination that the third movement of the contact corresponds to less than the third threshold amount of movement of the focus selector away from the adjustable control, adjust the adjustable control at the third adjustment rate in accordance with movement of the contact without generating the third tactile output.

E

Figure 6C

E

2412
While continuously detecting the contact on the touch-sensitive surface:

2412-a
detect a fourth movement of the contact across the touch-sensitive surface; and

2412-b
in response to detecting the fourth movement of the contact:

2412-c
in accordance with a determination that the fourth movement of the contact corresponds to more than a fourth threshold amount of movement of the focus selector toward the adjustable control, where the fourth threshold amount of movement triggers a transition from the second adjustment rate to the first adjustment rate:

2412-d
generate a fourth tactile output, via the one or more tactile output devices, when the focus selector has reached the fourth threshold amount of movement; and

2412-e
adjust the adjustable control at the first adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the fourth threshold amount; and

2412-f
in accordance with a determination that the fourth movement of the contact corresponds to less than the fourth threshold amount of movement of the focus selector toward the adjustable control, adjust the adjustable control at the second adjustment rate in accordance with movement of the contact without generating the fourth tactile output.

2404

A

2414
Adjusting the adjustable control at a respective adjustment rate in accordance with movement of the contact includes adjusting the adjustable control by an amount that is proportional to the movement of the contact in a respective direction with a proportionality constant that corresponds to the respective adjustment rate.

Figure 6D

2406

C

2416
In accordance with a determination that the first movement of the contact corresponds to more than the first threshold amount of movement of the focus selector away from the adjustable control, switch from displaying a visual indication of the first adjustment rate to displaying a visual indication of the second adjustment rate; and

2416-a
in accordance with a determination that the first movement of the contact does not correspond to more than the first threshold amount of movement of the focus selector away from the adjustable control, maintain display of the visual indication of the first adjustment rate.

2418
Generating the first tactile output, via the one or more tactile output devices, when the focus selector has reached the first threshold amount of movement includes:

2418-a
determining a movement metric that corresponds to movement of the contact when the focus selector reaches the first threshold amount of movement; and

2418-b
generating the first tactile output in accordance with a tactile output pattern that is adjusted in accordance with the movement metric.

2420
When the first threshold amount of movement is reached, an amplitude of the tactile output pattern is adjusted in accordance with a movement speed of the focus selector when the threshold amount of movement is reached.

Figure 6E

2406

C

2422
The adjustable control includes a movable indicator that is configured to move along a linear path in accordance with the movement of the focus selector; and

2422-a
movement of the focus selector in a direction perpendicular to the linear path is required to move the focus selector from a first region in the user interface that corresponds to the first adjustment rate to a second region in the user interface that corresponds to the second adjustment rate.

2424
The adjustable control includes a rotatable indicator that is configured to rotate around an axis in accordance with the movement of the focus selector; and

2424-a
movement of the focus selector in a radial direction away from axis is required to move the focus selector from a first region in the user interface that corresponds to the first adjustment rate to a second region in the user interface that corresponds to the second adjustment rate.

2426
In accordance with a determination that the first movement of the contact corresponds to more than the first threshold amount of movement of the focus selector away from the adjustable control, where the first threshold amount of movement triggers a transition from the first adjustment rate to the second adjustment rate, adjust the control at the first adjustment rate in accordance with movement of the contact that is detected before the focus selector has moved more than the first threshold amount.

Figure 6F

2406

C

2428

In accordance with a determination that the first movement of the contact corresponds to more than a second threshold amount of movement of the focus selector away from the adjustable control, where the second threshold amount of movement triggers a transition from the second adjustment rate to a third adjustment rate:

2428-a

generate a second tactile output, via the one or more tactile output devices, when the focus selector has reached the second threshold amount of movement; and

2428-b

adjust the adjustable control at a third adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the second threshold amount.

2430

In accordance with a determination that the first movement of the contact corresponds to more than a third threshold amount of movement of the focus selector away from the adjustable control, where the third threshold amount of movement triggers a transition from a third adjustment rate to a fourth adjustment rate:

2430-a

generate a third tactile output, via the one or more tactile output devices, when the focus selector has reached the third threshold amount of movement; and

2430-b

adjust the adjustable control at a fourth adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the third threshold amount.

Figure 6G

DEVICES, METHODS, AND GRAPHICAL USER INTERFACES FOR PROVIDING HAPTIC FEEDBACK

RELATED APPLICATIONS

[0001] This is a continuation of U.S. application Ser. No. 18/677,665, filed May 29, 2024, which is a continuation of U.S. application Ser. No. 17/751,519, filed May 23, 2022, which is a continuation of U.S. application Ser. No. 16/157,891, filed Oct. 11, 2018, now U.S. Pat. No. 11,379,041, which is a continuation of U.S. application Ser. No. 15/273,650, filed Sep. 22, 2016, now U.S. Pat. No. 10,156,903, which is a continuation of U.S. application Ser. No. 15/272,380, filed Sep. 21, 2016, now U.S. Pat. No. 9,996,157, which claims priority to U.S. Provisional Application Ser. No. 62/384,170, filed Sep. 6, 2016, entitled "Devices, Methods, and Graphical User Interfaces for Providing Haptic Feedback," and priority to U.S. Provisional Application Ser. No. 62/349,115, filed Jun. 12, 2016, entitled "Devices, Methods, and Graphical User Interfaces for Providing Haptic Feedback," all of which are incorporated by reference herein in their entirety.

TECHNICAL FIELD

[0002] This relates generally to electronic devices with touch-sensitive surfaces, including but not limited to electronic devices with touch-sensitive surfaces that generate tactile outputs to provide haptic feedback to a user.

BACKGROUND

[0003] The use of touch-sensitive surfaces as input devices for computers and other electronic computing devices has increased significantly in recent years. Example touch-sensitive surfaces include touchpads and touch-screen displays. Such surfaces are widely used to manipulate user interfaces and objects therein on a display. Example user interface objects include digital images, video, text, icons, and control elements such as buttons and other graphics.

[0004] Haptic feedback, typically in combination with visual and/or audio feedback, is often used in an attempt to make manipulation of user interfaces and user interface objects more efficient and intuitive for a user, thereby improving the operability of electronic devices. But conventional methods of providing haptic feedback are not as helpful as they could be.

SUMMARY

[0005] Accordingly, there is a need for electronic devices with improved methods and interfaces for providing haptic feedback. Such methods and interfaces optionally complement or replace conventional methods for providing haptic feedback. Such methods and interfaces reduce the number, extent, and/or nature of the inputs from a user by helping the user to understand the connection between provided inputs and device responses to the inputs, thereby creating a more efficient human-machine interface.

[0006] The above deficiencies and other problems associated with user interfaces for electronic devices with touch-sensitive surfaces are reduced or eliminated by the disclosed devices. In some embodiments, the device is a desktop computer. In some embodiments, the device is portable (e.g., a notebook computer, tablet computer, or handheld device). In some embodiments, the device is a personal electronic device (e.g., a wearable electronic device, such as a watch). In some embodiments, the device has a touchpad. In some embodiments, the device has a touch-sensitive display (also known as a "touch screen" or "touch-screen display"). In some embodiments, the device has a graphical user interface (GUI), one or more processors, memory and one or more modules, programs or sets of instructions stored in the memory for performing multiple functions. In some embodiments, the user interacts with the GUI primarily through stylus and/or finger contacts and gestures on the touch-sensitive surface. In some embodiments, the functions optionally include image editing, drawing, presenting, word processing, spreadsheet making, game playing, telephoning, video conferencing, e-mailing, instant messaging, workout support, digital photographing, digital videoing, web browsing, digital music playing, note taking, and/or digital video playing. Executable instructions for performing these functions are, optionally, included in a non-transitory computer readable storage medium or other computer program product configured for execution by one or more processors.

[0007] There is a need for electronic devices with more methods and interfaces for providing haptic feedback indicating crossing of a threshold for triggering or canceling an operation. Such methods and interfaces may complement or replace conventional methods for indicating crossing of a threshold for triggering or canceling an operation. Such methods and interfaces reduce the number, extent, and/or the nature of the inputs from a user and produce a more efficient human-machine interface.

[0008] In accordance with some embodiments, a method is performed at an electronic device with a touch-sensitive surface, a display, and one or more tactile output generators for generating tactile outputs. The method includes displaying a user interface on the display, where the user interface includes an adjustable control; detecting a contact on the touch-sensitive surface at a location that corresponds to the adjustable control on the display, where movement of the contact that corresponds to movement away from the adjustable control changes an adjustment rate for adjusting the adjustable control based on movement of the contact; while continuously detecting the contact on the touch-sensitive surface: detecting a first movement of the contact across the touch-sensitive surface. The method further includes: in response to detecting the first movement of the contact: in accordance with a determination that the first movement of the contact corresponds to more than a first threshold amount of movement of a focus selector away from the adjustable control, where the first threshold amount of movement triggers a transition from a first adjustment rate to a second adjustment rate: generating a first tactile output, via the one or more tactile output devices, when the focus selector has reached the first threshold amount of movement; and adjusting the adjustable control at the second adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the first threshold amount; and in accordance with a determination that the first movement of the contact corresponds to less than the first threshold amount of movement of the focus selector away from the adjustable control, adjusting the adjustable control at the first adjustment rate in accordance with movement of the contact without generating the first tactile output.

[0009] Thus, electronic devices with displays and touch-sensitive surfaces are provided with methods and interfaces for providing haptic feedback, thereby increasing the effectiveness, efficiency, and user satisfaction with such devices. Such methods and interfaces may complement or replace conventional methods for providing haptic feedback.

[0010] In accordance with some embodiments, an electronic device includes a display, a touch-sensitive surface, optionally one or more sensors to detect intensities of contacts with the touch-sensitive surface, one or more processors, memory, and one or more programs; the one or more programs are stored in the memory and configured to be executed by the one or more processors and the one or more programs include instructions for performing or causing performance of the operations of any of the methods described herein. In accordance with some embodiments, a computer readable storage medium has stored therein instructions which when executed by an electronic device with a display, a touch-sensitive surface, and optionally one or more sensors to detect intensities of contacts with the touch-sensitive surface, cause the device to perform or cause performance of the operations of any of the methods described herein. In accordance with some embodiments, a graphical user interface on an electronic device with a display, a touch-sensitive surface, optionally one or more sensors to detect intensities of contacts with the touch-sensitive surface, a memory, and one or more processors to execute one or more programs stored in the memory includes one or more of the elements displayed in any of the methods described herein, which are updated in response to inputs, as described in any of the methods described herein. In accordance with some embodiments, an electronic device includes: a display, a touch-sensitive surface, and optionally one or more sensors to detect intensities of contacts with the touch-sensitive surface; and means for performing or causing performance of the operations of any of the methods described herein. In accordance with some embodiments, an information processing apparatus, for use in an electronic device with a display and a touch-sensitive surface, and optionally one or more sensors to detect intensities of contacts with the touch-sensitive surface, includes means for performing or causing performance of the operations of any of the methods described herein.

[0011] Thus, electronic devices with displays, touch-sensitive surfaces, optionally one or more sensors to detect intensities of contacts with the touch-sensitive surface, one or more tactile output generators, optionally one or more device orientation sensors, and optionally an audio system, are provided with improved methods and interfaces for providing haptic feedback to a user, thereby increasing the effectiveness, efficiency, and user satisfaction with such devices. Such methods and interfaces may complement or replace conventional methods for providing haptic feedback to a user.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] For a better understanding of the various described embodiments, reference should be made to the Description of Embodiments below, in conjunction with the following drawings in which like reference numerals refer to corresponding parts throughout the figures.

[0013] FIG. **1**A is a block diagram illustrating a portable multifunction device with a touch-sensitive display in accordance with some embodiments.

[0014] FIG. **1**B is a block diagram illustrating example components for event handling in accordance with some embodiments.

[0015] FIG. **1**C is a block diagram illustrating a tactile output module in accordance with some embodiments.

[0016] FIG. **2**A illustrates a portable multifunction device having a touch screen in accordance with some embodiments.

[0017] FIGS. **2**B-**2**C show exploded views of a force-sensitive input device in accordance with some embodiments.

[0018] FIG. **3** is a block diagram of an example multifunction device with a display and a touch-sensitive surface in accordance with some embodiments.

[0019] FIG. **4**A illustrates an example user interface for a menu of applications on a portable multifunction device in accordance with some embodiments.

[0020] FIG. **4**B illustrates an example user interface for a multifunction device with a touch-sensitive surface that is separate from the display in accordance with some embodiments.

[0021] FIGS. **4**C-**4**E illustrate examples of dynamic intensity thresholds in accordance with some embodiments.

[0022] FIGS. **4**F-**4**G illustrate a set of sample tactile output patterns in accordance with some embodiments.

[0023] FIGS. **4**H-**4**J illustrate example haptic audio output patterns versus time that are used in conjunction with tactile outputs to simulate button clicks in accordance with some embodiments.

[0024] FIG. **4**K illustrates example combinations of tactile output patterns and haptic audio output patterns versus time in accordance with some embodiments.

[0025] FIGS. **4**L-**4**Q enlarge the combinations shown in FIG. **4**K for clarity.

[0026] FIGS. **5**A-**5**Q illustrate exemplary user interfaces for providing haptic feedback during variable rate scrubbing in accordance with some embodiments.

[0027] FIGS. **6**A-**6**G are flow diagrams of a process for providing haptic feedback during variable rate scrubbing in accordance with some embodiments.

DESCRIPTION OF EMBODIMENTS

[0028] Many electronic devices provide feedback as input is detected at a graphical user interface to provide an indication of the effects the input has on device operations. Methods described herein provide haptic feedback, often in conjunction with visual and/or audio feedback, to help a user understand the effects of detected inputs on device operations and to provide information to a user about the state of a device.

[0029] The methods, devices, and GUIs described herein use haptic feedback to improve user interface interactions in multiple ways. For example, they make it easier to: indicate hidden thresholds; perform scrubbing, such as index bar scrubbing and variable rate scrubbing; enhance rubber band effects; drag and drop objects; indicate device orientation; and scroll movable user interface components that represent selectable options.

Example Devices

[0030] Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings. In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the various described embodiments. However, it will be apparent to one of ordinary skill in the art that the various described embodiments may be practiced without these specific details. In other instances, well-known methods, procedures, components, circuits, and networks have not been described in detail so as not to unnecessarily obscure aspects of the embodiments.

[0031] It will also be understood that, although the terms first, second, etc. are, in some instances, used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first contact could be termed a second contact, and, similarly, a second contact could be termed a first contact, without departing from the scope of the various described embodiments. The first contact and the second contact are both contacts, but they are not the same contact, unless the context clearly indicates otherwise.

[0032] The terminology used in the description of the various described embodiments herein is for the purpose of describing particular embodiments only and is not intended to be limiting. As used in the description of the various described embodiments and the appended claims, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will also be understood that the term "and/or" as used herein refers to and encompasses any and all possible combinations of one or more of the associated listed items. It will be further understood that the terms "includes," "including," "comprises," and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0033] As used herein, the term "if" is, optionally, construed to mean "when" or "upon" or "in response to determining" or "in response to detecting," depending on the context. Similarly, the phrase "if it is determined" or "if [a stated condition or event] is detected" is, optionally, construed to mean "upon determining" or "in response to determining" or "upon detecting [the stated condition or event]" or "in response to detecting [the stated condition or event]," depending on the context.

[0034] Embodiments of electronic devices, user interfaces for such devices, and associated processes for using such devices are described. In some embodiments, the device is a portable communications device, such as a mobile telephone, that also contains other functions, such as PDA and/or music player functions. Example embodiments of portable multifunction devices include, without limitation, the iPhone®, iPod Touch®, and iPad® devices from Apple Inc. of Cupertino, California. Other portable electronic devices, such as laptops or tablet computers with touch-sensitive surfaces (e.g., touch-screen displays and/or touchpads), are, optionally, used. It should also be understood that, in some embodiments, the device is not a portable communications device, but is a desktop computer with a touch-sensitive surface (e.g., a touch-screen display and/or a touchpad).

[0035] In the discussion that follows, an electronic device that includes a display and a touch-sensitive surface is described. It should be understood, however, that the electronic device optionally includes one or more other physical user-interface devices, such as a physical keyboard, a mouse and/or a joystick.

[0036] The device typically supports a variety of applications, such as one or more of the following: a note taking application, a drawing application, a presentation application, a word processing application, a website creation application, a disk authoring application, a spreadsheet application, a gaming application, a telephone application, a video conferencing application, an e-mail application, an instant messaging application, a workout support application, a photo management application, a digital camera application, a digital video camera application, a web browsing application, a digital music player application, and/or a digital video player application.

[0037] The various applications that are executed on the device optionally use at least one common physical user-interface device, such as the touch-sensitive surface. One or more functions of the touch-sensitive surface as well as corresponding information displayed on the device are, optionally, adjusted and/or varied from one application to the next and/or within a respective application. In this way, a common physical architecture (such as the touch-sensitive surface) of the device optionally supports the variety of applications with user interfaces that are intuitive and transparent to the user.

[0038] Attention is now directed toward embodiments of portable devices with touch-sensitive displays. FIG. **1**A is a block diagram illustrating portable multifunction device **100** with touch-sensitive display system **112** in accordance with some embodiments. Touch-sensitive display system **112** is sometimes called a "touch screen" for convenience, and is sometimes simply called a touch-sensitive display. Device **100** includes memory **102** (which optionally includes one or more computer readable storage mediums), memory controller **122**, one or more processing units (CPUs) **120**, peripherals interface **118**, RF circuitry **108**, audio circuitry **110**, speaker **111**, microphone **113**, input/output (I/O) subsystem **106**, other input or control devices **116**, and external port **124**. Device **100** optionally includes one or more optical sensors **164**. Device **100** optionally includes one or more intensity sensors **165** for detecting intensities of contacts on device **100** (e.g., a touch-sensitive surface such as touch-sensitive display system **112** of device **100**). Device **100** includes one or more tactile output generators **167** for generating tactile outputs on device **100** (e.g., generating tactile outputs on a touch-sensitive surface such as touch-sensitive display system **112** of device **100** or touchpad **355** of device **300**). These components optionally communicate over one or more communication buses or signal lines **103**.

[0039] As used in the specification and claims, the term "tactile output" refers to physical displacement of a device relative to a previous position of the device, physical displacement of a component (e.g., a touch-sensitive surface) of a device relative to another component (e.g., housing) of the device, or displacement of the component relative to a center of mass of the device that will be detected by a user with the user's sense of touch. For example, in situations where the device or the component of the device is in contact with a surface of a user that is sensitive to touch (e.g., a finger, palm, or other part of a user's hand), the tactile output generated by the physical displacement will be interpreted by the user as a tactile sensation corresponding to a perceived change in physical characteristics of the device or the component of the device. For example, movement of a touch-sensitive surface (e.g., a touch-sensitive display or trackpad) is, optionally, interpreted by the user as a "down click" or "up click" of a physical actuator button. In some cases, a user will feel a tactile sensation such as an "down click" or "up click" even when there is no movement of a physical actuator button associated with the touch-sensitive surface that is physically pressed (e.g., displaced) by the user's movements. As another example, movement of the touch-sensitive surface is, optionally, interpreted or sensed by the user as "roughness" of the touch-sensitive surface, even when there is no change in smoothness of the touch-sensitive surface. While such interpretations of touch by a user will be subject to the individualized sensory perceptions of the user, there are many sensory perceptions of touch that are common to a large majority of users. Thus, when a tactile output is described as corresponding to a particular sensory perception of a user (e.g., an "up click," a "down click," "roughness"), unless otherwise stated, the generated tactile output corresponds to physical displacement of the device or a component thereof that will generate the described sensory perception for a typical (or average) user. Using tactile outputs to provide haptic feedback to a user enhances the operability of the device and makes the user-device interface more efficient (e.g., by helping the user to provide proper inputs and reducing user mistakes when operating/interacting with the device) which, additionally, reduces power usage and improves battery life of the device by enabling the user to use the device more quickly and efficiently.

[0040] In some embodiments, a tactile output pattern specifies characteristics of a tactile output, such as the amplitude of the tactile output, the shape of a movement waveform of the tactile output, the frequency of the tactile output, and/or the duration of the tactile output.

[0041] When tactile outputs with different tactile output patterns are generated by a device (e.g., via one or more tactile output generators that move a moveable mass to generate tactile outputs), the tactile outputs may invoke different haptic sensations in a user holding or touching the device. While the sensation of the user is based on the user's perception of the tactile output, most users will be able to identify changes in waveform, frequency, and amplitude of tactile outputs generated by the device. Thus, the waveform, frequency and amplitude can be adjusted to indicate to the user that different operations have been performed. As such, tactile outputs with tactile output patterns that are designed, selected, and/or engineered to simulate characteristics (e.g., size, material, weight, stiffness, smoothness, etc.); behaviors (e.g., oscillation, displacement, acceleration, rotation, expansion, etc.); and/or interactions (e.g., collision, adhesion, repulsion, attraction, friction, etc.) of objects in a given environment (e.g., a user interface that includes graphical features and objects, a simulated physical environment with virtual boundaries and virtual objects, a real physical environment with physical boundaries and physical objects, and/or a combination of any of the above) will, in some circumstances, provide helpful feedback to users that reduces input errors and increases the efficiency of the user's operation of the device. Additionally, tactile outputs are, optionally, generated to correspond to feedback that is unrelated to a simulated physical characteristic, such as an input threshold or a selection of an object. Such tactile outputs will, in some circumstances, provide helpful feedback to users that reduces input errors and increases the efficiency of the user's operation of the device.

[0042] In some embodiments, a tactile output with a suitable tactile output pattern serves as a cue for the occurrence of an event of interest in a user interface or behind the scenes in a device. Examples of the events of interest include activation of an affordance (e.g., a real or virtual button, or toggle switch) provided on the device or in a user interface, success or failure of a requested operation, reaching or crossing a boundary in a user interface, entry into a new state, switching of input focus between objects, activation of a new mode, reaching or crossing an input threshold, detection or recognition of a type of input or gesture, etc. In some embodiments, tactile outputs are provided to serve as a warning or an alert for an impending event or outcome that would occur unless a redirection or interruption input is timely detected. Tactile outputs are also used in other contexts to enrich the user experience, improve the accessibility of the device to users with visual or motor difficulties or other accessibility needs, and/or improve efficiency and functionality of the user interface and/or the device. Tactile outputs are optionally accompanied with audio outputs and/or visible user interface changes, which further enhance a user's experience when the user interacts with a user interface and/or the device, and facilitate better conveyance of information regarding the state of the user interface and/or the device, and which reduce input errors and increase the efficiency of the user's operation of the device.

[0043] FIG. **4**F provides a set of sample tactile output patterns that may be used, either individually or in combination, either as is or through one or more transformations (e.g., modulation, amplification, truncation, etc.), to create suitable haptic feedback in various scenarios and for various purposes, such as those mentioned above and those described with respect to the user interfaces and methods discussed herein. This example of a palette of tactile outputs shows how a set of three waveforms and eight frequencies can be used to produce an array of tactile output patterns. In addition to the tactile output patterns shown in this figure, each of these tactile output patterns is optionally adjusted in amplitude by changing a gain value for the tactile output pattern, as shown, for example for FullTap 80 Hz, FullTap 200 Hz, MiniTap 80 Hz, MiniTap 200 Hz, MicroTap 80 Hz, and MicroTap 200 Hz in FIG. **4**G, which are each shown with variants having a gain of 1.0, 0.75, 0.5, and 0.25. As shown in FIG. **4**G, changing the gain of a tactile output pattern changes the amplitude of the pattern without changing the frequency of the pattern or changing the shape of the waveform. In some embodiments, changing the frequency of a tactile output pattern also results in a lower amplitude as some tactile output generators are limited by how much force can be applied to the moveable mass and thus higher frequency movements of the mass are constrained to lower amplitudes to ensure that the acceleration needed to create the waveform does not require force outside of an operational force range of the tactile output generator (e.g., the peak amplitudes of the FullTap at 230 Hz, 270 Hz, and 300 Hz are lower than the amplitudes of the FullTap at 80 Hz, 100 Hz, 125 Hz, and 200 Hz).

[0044] In FIG. **4**F**1**, each column shows tactile output patterns that have a particular waveform. The waveform of a tactile output pattern represents the pattern of physical displacements relative to a neutral position (e.g., x_{zero}) versus time that a moveable mass goes through to generate a tactile output with that tactile output pattern. For example, a first set of tactile output patterns shown in the left column in FIG. **4F1** (e.g., tactile output patterns of a "FullTap") each have a waveform that includes an oscillation with two complete cycles (e.g., an oscillation that starts and ends in a neutral position and crosses the neutral position three times). A second set of tactile output patterns shown in the middle column in FIG. **4F1** (e.g., tactile output patterns of a "MiniTap") each have a waveform that includes an oscillation that includes one complete cycle (e.g., an oscillation that starts and ends in a neutral position and crosses the neutral position one time). A third set of tactile output patterns shown in the right column in FIG. **4F1** (e.g., tactile output patterns of a "MicroTap") each have a waveform that includes an oscillation that include one half of a complete cycle (e.g., an oscillation that starts and ends in a neutral position and does not cross the neutral position). The waveform of a tactile output pattern also includes a start buffer and an end buffer that represent the gradual speeding up and slowing down of the moveable mass at the start and at the end of the tactile output. The example waveforms shown in FIG. **4F1**-**4F4** and **4G1**-**4G4** include x_{min} and x_{max} values which represent the maximum and minimum extent of movement of the moveable mass. For larger electronic devices with larger moveable masses, there may be larger or smaller minimum and maximum extents of movement of the mass. The example shown in FIGS. **4F1**-**4F4** and **4G1**-**4G4** describes movement of a mass in 1 dimension, however similar principles would also apply to movement of a moveable mass in two or three dimensions.

[0045] As shown in FIG. **4F1**, each tactile output pattern also has a corresponding characteristic frequency that affects the "pitch" of a haptic sensation that is felt by a user from a tactile output with that characteristic frequency. For a continuous tactile output, the characteristic frequency represents the number of cycles that are completed within a given period of time (e.g., cycles per second) by the moveable mass of the tactile output generator. For a discrete tactile output, a discrete output signal (e.g., with 0.5, 1, or 2 cycles) is generated, and the characteristic frequency value specifies how fast the moveable mass needs to move to generate a tactile output with that characteristic frequency. As shown in FIG. **4F1**, for each type of tactile output (e.g., as defined by a respective waveform, such as FullTap, MiniTap, or MicroTap), a higher frequency value corresponds to faster movement(s) by the moveable mass, and hence, in general, a shorter time to complete the tactile output (e.g., including the time to complete the required number of cycle(s) for the discrete tactile output, plus a start and an end buffer time). For example, a FullTap with a characteristic frequency of 80 Hz takes longer to complete than FullTap with a characteristic frequency of 100 Hz (e.g., 35.4 ms vs. 28.3 ms in FIG. **4F1**). In addition, for a given frequency, a tactile output with more cycles in its waveform at a respective frequency takes longer to complete than a tactile output with fewer cycles its waveform at the same respective frequency. For example, a FullTap at 150 Hz takes longer to complete than a MiniTap at 150 Hz (e.g., 19.4 ms vs. 12.8 ms), and a MiniTap at 150 Hz takes longer to complete than a MicroTap at 150 Hz (e.g., 12.8 ms vs. 9.4 ms). However, for tactile output patterns with different frequencies this rule may not apply (e.g., tactile outputs with more cycles but a higher frequency may take a shorter amount of time to complete than tactile outputs with fewer cycles but a lower frequency, and vice versa). For example, at 300 Hz, a FullTap takes as long as a MiniTap (e.g., 9.9 ms).

[0046] As shown in FIG. **4F1**, a tactile output pattern also has a characteristic amplitude that affects the amount of energy that is contained in a tactile signal, or a "strength" of a haptic sensation that may be felt by a user through a tactile output with that characteristic amplitude. In some embodiments, the characteristic amplitude of a tactile output pattern refers to an absolute or normalized value that represents the maximum displacement of the moveable mass from a neutral position when generating the tactile output. In some embodiments, the characteristic amplitude of a tactile output pattern is adjustable, e.g., by a fixed or dynamically determined gain factor (e.g., a value between 0 and 1), in accordance with various conditions (e.g., customized based on user interface contexts and behaviors) and/or preconfigured metrics (e.g., input-based metrics, and/or user-interface-based metrics). In some embodiments, an input-based metric (e.g., an intensity-change metric or an input-speed metric) measures a characteristic of an input (e.g., a rate of change of a characteristic intensity of a contact in a press input or a rate of movement of the contact across a touch-sensitive surface) during the input that triggers generation of a tactile output. In some embodiments, a user-interface-based metric (e.g., a speed-across-boundary metric) measures a characteristic of a user interface element (e.g., a speed of movement of the element across a hidden or visible boundary in a user interface) during the user interface change that triggers generation of the tactile output. In some embodiments, the characteristic amplitude of a tactile output pattern may be modulated by an "envelope" and the peaks of adjacent cycles may have different amplitudes, where one of the waveforms shown above is further modified by multiplication by an envelope parameter that changes over time (e.g., from 0 to 1) to gradually adjust amplitude of portions of the tactile output over time as the tactile output is being generated.

[0047] Although specific frequencies, amplitudes, and waveforms are represented in the sample tactile output patterns in FIG. **4F1** for illustrative purposes, tactile output patterns with other frequencies, amplitudes, and waveforms may be used for similar purposes. For example, waveforms that have between 0.5 to 4 cycles can be used. Other frequencies in the range of 60 Hz-400 Hz may be used as well. Table 1 provides examples of particular haptic feedback behaviors, configurations, and examples of their use.

TABLE 1

Behavior Configuration	Feedback Configuration	Examples
	User Interface Haptics	
Retarget Default	MicroTap High (270 Hz) Gain: 0.4 Minimum Interval: 0.05	Drag calendar event across day boundary Retarget in force press quick action menu Sliding over origin point in a scrubber Reaching 0 degrees when cropping/straightening Rearranging a list when items snap together Swiping across multiple keyboards in a keyboard selection menu (e.g.,

TABLE 1-continued

Behavior Configuration	Feedback Configuration	Examples
		a vertical menu) after a long press on a keyboard selection icon; or Swiping across multiple alternate characters in an accent keyboard (e.g., a horizontal menu) after a long press on a character key
Retarget Strong	MicroTap High (270 Hz) Gain: 0.5 Minimum Interval: 0.05	Retarget in A-Z scrubber
Retarget Picker	MicroTap High (270 Hz) Gain: 0.4 Minimum Interval: 0.05	Spinning a wheel in the wheels of time user interface
Impact Default	MicroTap Medium (150 Hz) Gain max: 0.8 Gain min: 0.0	Changing scrubbing speed when adjusting a slider Creating a new calendar event by tapping and holding Activating a toggle switch (changing the switch from on to off or off to on) Reaching a predefined orientation on a compass (e.g., every 45 degrees from North) Reaching a level state (e.g., 0 degrees tilt in any axis for 0.5 seconds) Dropping a pin in a map Sending or receiving a message with an emphasis animation (e.g., "slam" effect) Sending or receiving an acknowledgment of a message Snapping a ruler to different orientations (e.g., every 45 degrees) Crossing over a suggested photo while scrubbing through a burst of photos Crossing over a detent in a scrubber (e.g., text size, haptic strength, display brightness, display color temperature) Transaction failure notification (ApplePay Failure)
Impact Light	MicroTap Medium (150 Hz) Gain max: 0.6 Gain min: 0.0	Picking up an existing item (e.g., a calendar event, a favorite in web browser) Moving a time selector over a minor division of time (e.g., 15 min) in sleep alarm
Impact Strong	MicroTap Medium (150 Hz) Gain max: 1.0 Gain min: 0.0	Moving a time selector over a major division of time (e.g., 1 hour) in sleep alarm
Edge Scrubber	MicroTap Medium (150 Hz) Gain max: 0.6 Gain min: 0.3	Dragging a brightness scrubber to an edge of the scrubber Dragging a volume scrubber to an edge of the scrubber
Edge Zoom	MicroTap High (270 Hz) Gain: 0.6	Reaching maximum zoom level when zooming into a photo Re-centering a map
Drag Default	MicroTap High (270 Hz) Gain Pickup: 1.0 Gain Drop: 0.6	Pickup and drop an event in calendar

TABLE 1-continued

Behavior Configuration	Feedback Configuration	Examples
Drag Snapping	MicroTap High (270 Hz) Gain Pickup: 1.0 Gain Drop: 0.6 Gain Snap: 1.0	Rearrange lists in weather, contacts, music, etc.
States Swipe Action	Swipe in: MiniTap High (270 Hz) Gain: 1.0	Swipe to delete a mail message or conversation Swipe to mark a mail message as read/unread in mail
	Swipe out: MicroTap High (270 Hz) Gain: 0.55	Swipe to delete a table row (e.g., a document in a document creation/viewing application, a note in a notes application, a location in a weather application, a podcast in a podcast application, a song in a playlist in a music application, a voice memo in a voice recording application Swipe to delete a message while displaying a pressure-triggered preview Swipe to mark a message as read/unread while displaying a pressure-triggered preview Swipe to delete a news article Swipe to favorite/love a news article
Button Default	MicroTap High (270 Hz) Gain: 0.9	Reply to message/conversation Adding a bookmark in an electronic book reader application Activating a virtual assistant Starting to record a voice memo Stopping recording a voice memo
Button Destructive	MiniTap Low (100 Hz) Feedback Intensity: 0.8	Delete message/conversation
Event Success	FullTap Medium (200 Hz) Gain: 0.7 MiniTap High (270 Hz) Gain: 1.0	Confirmation that a payment has been made Alert that authentication is needed to make a payment (e.g., biometric authentication or passcode authentication) Adding a payment account to an electronic wallet application Pairing success for Bluetooth pairing
Event Error	MiniTap High (270 Hz) Gain: 0.85 Gain: 0.75 FullTap Medium (200 Hz) Gain: 0.65 FullTap Low (150 Hz) Gain: 0.75	Failure to process a payment transaction Failure to authenticate a fingerprint detected on a fingerprint sensor Incorrect passcode/password entered in a passcode/password entry UI
Event Warning	FullTap High (300 Hz) Gain: 0.9 FullTap Custom (270 Hz) Gain: 0.9	Shake to undo
	Force Press	
States Preview	MicroTap Custom (200 Hz) Gain: 1.0	Peek/Preview (e.g., peek at a mail message)

TABLE 1-continued

Behavior Configuration	Feedback Configuration	Examples
States Preview	FullTap Custom (150 Hz) Gain: 1.0	Pop/Commit (e.g., pop into full mail message)
States Preview	MicroTap Custom (200 Hz) Gain: 1.0	Unavailable (e.g., press hard on an app icon that doesn't have any associated quick actions)
	System Haptics	
Device Locked	MicroTap Medium (150 Hz) Gain: 1.0 MiniTap Medium (150 Hz) Gain: 1.0	Press power button once to lock device
Vibe on Attach	Vibe at 150 Hz that gradually increases or decreases in amplitude over time	Attach device to power source
Ringtones & Alerts	Custom tactile output using one or more of: Vibe 150 Hz MicroTap 150 Hz MiniTap 150 Hz FullTap 150 Hz	Receive phone call or text message
Alert before Mute	3x FullTap (150 Hz)	Mute the device
	Solid-State Home Button	
1 ("Tick")	MiniTap 230 Hz Gain: 1.0	Press home button with click option 1 selected
2 ("Tak")	MiniTap 270 Hz Gain: 1.0	Press home button with click option 2 selected
3 ("Tock")	MiniTap 300 Hz Gain: 1.0	Press home button with click option 3 selected
	Special Effects	
Full screen moments	Custom wide band tactile outputs	Full screen messages moments (e.g., fireworks, lightening, etc.) in Messages
Digital Touch	Custom tactile outputs	Taps and heartbeats in Messages

[0048] The examples shown above in Table 1 are intended to illustrate a range of circumstances in which tactile outputs can be generated for different inputs and events. Table 1 should not be taken as a requirement that a device respond to each of the listed inputs or events with the indicated tactile output. Rather, Table 1 is intended to illustrate how tactile outputs vary and/or are similar for different inputs and/or events (e.g., based on the tactile output pattern, frequency, gain, etc.). For example, Table 1 shows how an "event success" tactile output varies from an "event failure" tactile output and how a retarget tactile output differs from an impact tactile output.

[0049] FIGS. **4**H-**4**J illustrate example haptic audio output patterns versus time that are used in conjunction with tactile outputs to simulate button clicks in accordance with some embodiments.

[0050] FIG. **4**K illustrates example combinations of tactile output patterns and haptic audio output patterns versus time in accordance with some embodiments. FIGS. **4**L-**4**Q enlarge the combinations shown in FIG. **4**K for clarity.

[0051] In FIG. **4**H, the top haptic audio pattern "Click A1 audio" is audio output that is played conjunction with "Click A" Normal MiniTap (230 Hz) to simulate a first down-click in a "normal" first click, as shown in FIG. **4**K (first row in the First Click column) and the upper portion of FIG. **4**L, where the rate of change of intensity of a contact at a control activation threshold is above a threshold rate of change (e.g., the contact is making a "normal" hard/fast press). In this example, "Click A1 audio" is offset from the start of the "Click A" Normal MiniTap (230 Hz) tactile output by 2 ms. In some cases, the same "Click A1 audio" and "Click A" Normal MiniTap (230 Hz) are played to simulate the first up-click that follows the first down-click. In some cases, the gain of the "Click A1 audio" and/or "Click A" Normal MiniTap (230 Hz) are reduced (e.g., by 50%) in the up-click relative to the preceding down-click.

[0052] The top haptic audio pattern "Click A1 audio" is also played in conjunction with "Click A" Soft MiniTap (230 Hz) to simulate a first down-click in a "soft" first click, as shown in FIG. **4**K (second row in the First Click column) and the lower portion of FIG. **4**L, where the rate of change of intensity of a contact at a control activation threshold is below a threshold rate of change (e.g., the contact is making a "soft" and/or slow press). To simulate a "soft" down-click, the gain of the "Click A1 audio" and "Click A" Soft MiniTap (230 Hz) are reduced (e.g., by 50%) in the "soft" down-click relative to the "normal" down-click. In this example, "Click A1 audio" is offset from the start of the "Click A" Soft MiniTap (230 Hz) tactile output by 2 ms. In some cases, the same "Click A1 audio" and "Click A" Soft MiniTap (230 Hz) are played to simulate the first up-click that follows the first down-click. In some cases, the gain of the "Click A1 audio" and/or "Click A" Soft MiniTap (230 Hz) are reduced (e.g., by 50%) in the up-click relative to the preceding down-click.

[0053] In FIG. **4**H, the bottom haptic audio pattern "Click A2 audio" is audio output that is played conjunction with "Click A" Normal MiniTap (230 Hz) to simulate a second down-click in a "normal" second click that follows the first click within a predetermined period of time (e.g., as the second click in a double click input), as shown in FIG. **4**K (first row in the Second Click column) and the upper portion of FIG. **4**M, where the rate of change of intensity of a contact at a control activation threshold is above a threshold rate of change (e.g., the contact in the second click is making a "normal" hard/fast press). In this example, "Click A2 audio" is offset from the start of the "Click A" Normal MiniTap (230 Hz) tactile output by 2 ms. In some cases, the same "Click A2 audio" and "Click A" Normal MiniTap (230 Hz) are played to simulate the second up-click that follows the second down-click. In some cases, the gain of the "Click A2 audio" and/or "Click A" Normal MiniTap (230 Hz) are reduced (e.g., by 50%) in the second up-click relative to the preceding second down-click.

[0054] The bottom haptic audio pattern "Click A2 audio" is also played in conjunction with "Click A" Soft MiniTap (230 Hz) to simulate a second down-click in a "soft" second click that follows the first click within a predetermined period of time (e.g., as the second click in a double click input), as shown in FIG. **4**K (second row in the Second Click column) and the lower portion of FIG. **4**M, where the rate of change of intensity of a contact at a control activation threshold is below a threshold rate of change (e.g., the contact is making a "soft" and/or slow press). To simulate a "soft" down-click, the gain of the "Click A2 audio" and "Click A" Soft MiniTap (230 Hz) are reduced (e.g., by 50%) in the "soft" down-click relative to the "normal" down-click. In this example, "Click A2 audio" is offset from the start of the "Click A" Soft MiniTap (230 Hz) tactile output by 2 ms. In some cases, the same "Click A2 audio" and "Click A" Soft MiniTap (230 Hz) are played to simulate the second up-click that follows the second down-click. In some cases, the gain of the "Click A2 audio" and/or "Click A" Soft MiniTap (230 Hz) are reduced (e.g., by 50%) in the second up-click relative to the preceding second down-click.

[0055] In FIG. **4**I, the top haptic audio pattern "Click B1 audio" is audio output that is played conjunction with "Click B" Normal MiniTap (270 Hz) to simulate a first down-click in a "normal" first click, as shown in FIG. **4**K (third row in the First Click column) and the upper portion of FIG. **4**N, where the rate of change of intensity of a contact at a control activation threshold is above a threshold rate of change (e.g., the contact is making a "normal" hard/fast press). In this example, "Click B1 audio" is offset from the start of the "Click B" Normal MiniTap (270 Hz) tactile output by 2.8 ms. In some cases, the same "Click B1 audio" and "Click B" Normal MiniTap (270 Hz) are played to simulate the first up-click that follows the first down-click. In some cases, the gain of the "Click B1 audio" and/or "Click B" Normal MiniTap (270 Hz) are reduced (e.g., by 50%) in the up-click relative to the preceding down-click.

[0056] The top haptic audio pattern "Click B1 audio" is also played in conjunction with "Click B" Soft MiniTap (270 Hz) to simulate a first down-click in a "soft" first click, as shown in FIG. **4**K (fourth row in the First Click column) and the lower portion of FIG. **4**N, where the rate of change of intensity of a contact at a control activation threshold is below a threshold rate of change (e.g., the contact is making a "soft" and/or slow press). To simulate a "soft" down-click, the gain of the "Click B1 audio" and "Click B" Soft MiniTap (270 Hz) are reduced (e.g., by 50%) in the "soft" down-click relative to the "normal" down-click. In this example, "Click B1 audio" is offset from the start of the "Click B" Soft MiniTap (270 Hz) tactile output by 2.8 ms. In some cases, the same "Click B1 audio" and "Click B" Soft MiniTap (270 Hz) are played to simulate the first up-click that follows the first down-click. In some cases, the gain of the "Click B1 audio" and/or "Click B" Soft MiniTap (230 Hz) are reduced (e.g., by 50%) in the up-click relative to the preceding down-click.

[0057] In FIG. **4**I, the bottom haptic audio pattern "Click B2 audio" is audio output that is played conjunction with "Click B" Normal MiniTap (270 Hz) to simulate a second down-click in a "normal" second click that follows the first click within a predetermined period of time (e.g., as the second click in a double click input), as shown in FIG. **4**K (third row in the Second Click column) and the upper portion of FIG. **4**O, where the rate of change of intensity of a contact at a control activation threshold is above a threshold rate of change (e.g., the contact in the second click is making a "normal" hard/fast press). In this example, "Click B2 audio" is offset from the start of the "Click B" Normal MiniTap (270 Hz) tactile output by 2.8 ms. In some cases, the same "Click B2 audio" and "Click B" Normal MiniTap (230 Hz) are played to simulate the second up-click that follows the second down-click. In some cases, the gain of the "Click B2 audio" and/or "Click B" Normal MiniTap (270 Hz) are reduced (e.g., by 50%) in the second up-click relative to the preceding second down-click.

[0058] The bottom haptic audio pattern "Click B2 audio" is also played in conjunction with "Click B" Soft MiniTap (270 Hz) to simulate a second down-click in a "soft" second click that follows the first click within a predetermined period of time (e.g., as the second click in a double click input), as shown in FIG. **4**K (fourth row in the Second Click column) and the lower portion of FIG. **4**O, where the rate of change of intensity of a contact at a control activation threshold is below a threshold rate of change (e.g., the contact is making a "soft" and/or slow press). To simulate a "soft" down-click, the gain of the "Click B2 audio" and "Click B" Soft MiniTap (270 Hz) are reduced (e.g., by 50%) in the "soft" down-click relative to the "normal" down-click. In this example, "Click B2 audio" is offset from the start of the "Click B" Soft MiniTap (270 Hz) tactile output by 2.8 ms. In some cases, the same "Click B2 audio" and "Click B" Soft MiniTap (270 Hz) are played to simulate the second up-click that follows the second down-click. In some cases, the gain of the "Click B2 audio" and/or "Click B" Soft MiniTap (270 Hz) are reduced (e.g., by 50%) in the second up-click relative to the preceding second down-click.

[0059] In FIG. **4**J, the top haptic audio pattern "Click C1 audio" is audio output that is played conjunction with "Click C" Normal MiniTap (300 Hz) to simulate a first down-click in a "normal" first click, as shown in FIG. **4**K (fifth row in the First Click column) and the upper portion of FIG. **4**P, where the rate of change of intensity of a contact at a control activation threshold is above a threshold rate of change (e.g., the contact is making a "normal" hard/fast press). In this example, "Click C1 audio" is offset from the start of the "Click C" Normal MiniTap (300 Hz) tactile output by 1.9 ms. In some cases, the same "Click C1 audio" and "Click C" Normal MiniTap (300 Hz) are played to simulate the first up-click that follows the first down-click. In some cases, the gain of the "Click C1 audio" and/or "Click C" Normal MiniTap (300 Hz) are reduced (e.g., by 50%) in the up-click relative to the preceding down-click.

[0060] The top haptic audio pattern "Click C1 audio" is also played in conjunction with "Click C" Soft MiniTap (300 Hz) to simulate a first down-click in a "soft" first click, as shown in FIG. **4**K (sixth row in the First Click column) and the lower portion of FIG. **4**P, where the rate of change of intensity of a contact at a control activation threshold is below a threshold rate of change (e.g., the contact is making a "soft" and/or slow press). To simulate a "soft" down-click, the gain of the "Click C1 audio" and "Click C" Soft MiniTap (300 Hz) are reduced (e.g., by 50%) in the "soft" down-click relative to the "normal" down-click. In this example, "Click C1 audio" is offset from the start of the "Click C" Soft MiniTap (300 Hz) tactile output by 1.9 ms. In some cases, the same "Click C1 audio" and "Click C" Soft MiniTap (270 Hz) are played to simulate the first up-click that follows the first down-click. In some cases, the gain of the "Click C1 audio" and/or "Click C" Soft MiniTap (300 Hz) are reduced (e.g., by 50%) in the up-click relative to the preceding down-click.

[0061] In FIG. **4**J, the bottom haptic audio pattern "Click C2 audio" is audio output that is played conjunction with "Click C" Normal MiniTap (300 Hz) to simulate a second down-click in a "normal" second click that follows the first click within a predetermined period of time (e.g., as the second click in a double click input), as shown in FIG. **4**K (fifth row in the Second Click column) and the upper portion of FIG. **4**Q, where the rate of change of intensity of a contact at a control activation threshold is above a threshold rate of change (e.g., the contact in the second click is making a "normal" hard/fast press). In this example, "Click C2 audio" is offset from the start of the "Click C" Normal MiniTap (300 Hz) tactile output by 1.9 ms. In some cases, the same "Click C2 audio" and "Click C" Normal MiniTap (300 Hz) are played to simulate the second up-click that follows the second down-click. In some cases, the gain of the "Click C2 audio" and/or "Click C" Normal MiniTap (300 Hz) are reduced (e.g., by 50%) in the second up-click relative to the preceding second down-click.

[0062] The bottom haptic audio pattern "Click C2 audio" is also played in conjunction with "Click C" Soft MiniTap (300 Hz) to simulate a second down-click in a "soft" second click that follows the first click within a predetermined period of time (e.g., as the second click in a double click input), as shown in FIG. **4**K (sixth row in the Second Click column) and the lower portion of FIG. **4**Q, where the rate of change of intensity of a contact at a control activation threshold is below a threshold rate of change (e.g., the contact is making a "soft" and/or slow press). To simulate a "soft" down-click, the gain of the "Click C2 audio" and "Click C" Soft MiniTap (300 Hz) are reduced (e.g., by 50%) in the "soft" down-click relative to the "normal" down-click. In this example, "Click C2 audio" is offset from the start of the "Click C" Soft MiniTap (300 Hz) tactile output by 1.9 ms. In some cases, the same "Click C2 audio" and "Click C" Soft MiniTap (300 Hz) are played to simulate the second up-click that follows the second down-click. In some cases, the gain of the "Click C2 audio" and/or "Click C" Soft MiniTap (300 Hz) are reduced (e.g., by 50%) in the second up-click relative to the preceding second down-click.

[0063] It should be appreciated that device **100** is only one example of a portable multifunction device, and that device **100** optionally has more or fewer components than shown, optionally combines two or more components, or optionally has a different configuration or arrangement of the components. The various components shown in FIG. **1**A are implemented in hardware, software, firmware, or a combination thereof, including one or more signal processing and/or application specific integrated circuits.

[0064] Memory **102** optionally includes high-speed random access memory and optionally also includes non-volatile memory, such as one or more magnetic disk storage devices, flash memory devices, or other non-volatile solid-state memory devices. Access to memory **102** by other components of device **100**, such as CPU(s) **120** and the peripherals interface **118**, is, optionally, controlled by memory controller **122**.

[0065] Peripherals interface **118** can be used to couple input and output peripherals of the device to CPU(s) **120** and memory **102**. The one or more processors **120** run or execute various software programs and/or sets of instructions stored in memory **102** to perform various functions for device **100** and to process data.

[0066] In some embodiments, peripherals interface **118**, CPU(s) **120**, and memory controller **122** are, optionally, implemented on a single chip, such as chip **104**. In some other embodiments, they are, optionally, implemented on separate chips.

[0067] RF (radio frequency) circuitry **108** receives and sends RF signals, also called electromagnetic signals. RF circuitry **108** converts electrical signals to/from electromagnetic signals and communicates with communications networks and other communications devices via the electromagnetic signals. RF circuitry **108** optionally includes well-known circuitry for performing these functions, including but not limited to an antenna system, an RF transceiver, one or more amplifiers, a tuner, one or more oscillators, a digital signal processor, a CODEC chipset, a subscriber identity module (SIM) card, memory, and so forth. RF circuitry **108** optionally communicates with networks, such as the Internet, also referred to as the World Wide Web (WWW), an intranet and/or a wireless network, such as a cellular telephone network, a wireless local area network (LAN) and/or a metropolitan area network (MAN), and other devices by wireless communication. The wireless communication optionally uses any of a plurality of communications standards, protocols and technologies, including but not limited to Global System for Mobile Communications (GSM), Enhanced Data GSM Environment (EDGE), high-speed downlink packet access (HSDPA), high-speed uplink packet access (HSUPA), Evolution, Data-Only (EV-DO), HSPA, HSPA+, Dual-Cell HSPA (DC-HSPDA), long term evolution (LTE), near field communication (NFC), wideband code division multiple access (W-CDMA), code division multiple access (CDMA), time division multiple access (TDMA), Bluetooth, Wireless Fidelity (Wi-Fi) (e.g., IEEE 802.11a, IEEE 802.11ac, IEEE 802.11ax, IEEE 802.11b, IEEE 802.11g and/or IEEE 802.1In), voice over Internet Protocol (VoIP), Wi-MAX, a protocol for e-mail (e.g., Internet message access protocol (IMAP) and/or post office protocol (POP)), instant messaging (e.g., extensible messaging and presence protocol (XMPP), Session Initiation Protocol for Instant Messaging and Presence Leveraging Extensions (SIMPLE), Instant Messaging and Presence Service (IMPS)), and/or Short Message Service (SMS), or any other suitable communication protocol, including communication protocols not yet developed as of the filing date of this document.

[0068] Audio circuitry **110**, speaker **111**, and microphone **113** provide an audio interface between a user and device **100**. Audio circuitry **110** receives audio data from peripherals interface **118**, converts the audio data to an electrical signal, and transmits the electrical signal to speaker **111**. Speaker **111** converts the electrical signal to human-audible sound waves. Audio circuitry **110** also receives electrical signals converted by microphone **113** from sound waves. Audio circuitry **110** converts the electrical signal to audio data and transmits the audio data to peripherals interface **118** for processing. Audio data is, optionally, retrieved from and/or transmitted to memory **102** and/or RF circuitry **108** by peripherals interface **118**. In some embodiments, audio circuitry **110** also includes a headset jack (e.g., **212**, FIG. **2**A). The headset jack provides an interface between audio circuitry **110** and removable audio input/output peripherals, such as output-only headphones or a headset with both output (e.g., a headphone for one or both ears) and input (e.g., a microphone).

[0069] I/O subsystem **106** couples input/output peripherals on device **100**, such as touch-sensitive display system

112 and other input or control devices **116**, with peripherals interface **118**. I/O subsystem **106** optionally includes display controller **156**, optical sensor controller **158**, intensity sensor controller **159**, haptic feedback controller **161**, and one or more input controllers **160** for other input or control devices. The one or more input controllers **160** receive/send electrical signals from/to other input or control devices **116**. The other input or control devices **116** optionally include physical buttons (e.g., push buttons, rocker buttons, etc.), dials, slider switches, joysticks, click wheels, and so forth. In some alternate embodiments, input controller(s) **160** are, optionally, coupled with any (or none) of the following: a keyboard, infrared port, USB port, stylus, and/or a pointer device such as a mouse. The one or more buttons (e.g., **208**, FIG. **2**A) optionally include an up/down button for volume control of speaker **111** and/or microphone **113**. The one or more buttons optionally include a push button (e.g., **206**, FIG. **2**A).

[0070] Touch-sensitive display system **112** provides an input interface and an output interface between the device and a user. Display controller **156** receives and/or sends electrical signals from/to touch-sensitive display system **112**. Touch-sensitive display system **112** displays visual output to the user. The visual output optionally includes graphics, text, icons, video, and any combination thereof (collectively termed "graphics"). In some embodiments, some or all of the visual output corresponds to user interface objects. As used herein, the term "affordance" refers to a user-interactive graphical user interface object (e.g., a graphical user interface object that is configured to respond to inputs directed toward the graphical user interface object). Examples of user-interactive graphical user interface objects include, without limitation, a button, slider, icon, selectable menu item, switch, hyperlink, or other user interface control.

[0071] Touch-sensitive display system **112** has a touch-sensitive surface, sensor or set of sensors that accepts input from the user based on haptic and/or tactile contact. Touch-sensitive display system **112** and display controller **156** (along with any associated modules and/or sets of instructions in memory **102**) detect contact (and any movement or breaking of the contact) on touch-sensitive display system **112** and converts the detected contact into interaction with user-interface objects (e.g., one or more soft keys, icons, web pages or images) that are displayed on touch-sensitive display system **112**. In an example embodiment, a point of contact between touch-sensitive display system **112** and the user corresponds to a finger of the user or a stylus.

[0072] Touch-sensitive display system **112** optionally uses LCD (liquid crystal display) technology, LPD (light emitting polymer display) technology, or LED (light emitting diode) technology, although other display technologies are used in other embodiments. Touch-sensitive display system **112** and display controller **156** optionally detect contact and any movement or breaking thereof using any of a plurality of touch sensing technologies now known or later developed, including but not limited to capacitive, resistive, infrared, and surface acoustic wave technologies, as well as other proximity sensor arrays or other elements for determining one or more points of contact with touch-sensitive display system **112**. In an example embodiment, projected mutual capacitance sensing technology is used, such as that found in the iPhone®, iPod Touch®, and iPad® from Apple Inc. of Cupertino, California.

[0073] Touch-sensitive display system **112** optionally has a video resolution in excess of 100 dpi. In some embodiments, the touch screen video resolution is in excess of 400 dpi (e.g., 500 dpi, 800 dpi, or greater). The user optionally makes contact with touch-sensitive display system **112** using any suitable object or appendage, such as a stylus, a finger, and so forth. In some embodiments, the user interface is designed to work with finger-based contacts and gestures, which can be less precise than stylus-based input due to the larger area of contact of a finger on the touch screen. In some embodiments, the device translates the rough finger-based input into a precise pointer/cursor position or command for performing the actions desired by the user.

[0074] In some embodiments, in addition to the touch screen, device **100** optionally includes a touchpad (not shown) for activating or deactivating particular functions. In some embodiments, the touchpad is a touch-sensitive area of the device that, unlike the touch screen, does not display visual output. The touchpad is, optionally, a touch-sensitive surface that is separate from touch-sensitive display system **112** or an extension of the touch-sensitive surface formed by the touch screen.

[0075] Device **100** also includes power system **162** for powering the various components. Power system **162** optionally includes a power management system, one or more power sources (e.g., battery, alternating current (AC)), a recharging system, a power failure detection circuit, a power converter or inverter, a power status indicator (e.g., a light-emitting diode (LED)) and any other components associated with the generation, management and distribution of power in portable devices.

[0076] Device **100** optionally also includes one or more optical sensors **164**. FIG. **1**A shows an optical sensor coupled with optical sensor controller **158** in I/O subsystem **106**. Optical sensor(s) **164** optionally include charge-coupled device (CCD) or complementary metal-oxide semiconductor (CMOS) phototransistors. Optical sensor(s) **164** receive light from the environment, projected through one or more lens, and converts the light to data representing an image. In conjunction with imaging module **143** (also called a camera module), optical sensor(s) **164** optionally capture still images and/or video. In some embodiments, an optical sensor is located on the back of device **100**, opposite touch-sensitive display system **112** on the front of the device, so that the touch screen is enabled for use as a viewfinder for still and/or video image acquisition. In some embodiments, another optical sensor is located on the front of the device so that the user's image is obtained (e.g., for selfies, for videoconferencing while the user views the other video conference participants on the touch screen, etc.).

[0077] Device **100** optionally also includes one or more contact intensity sensors **165**. FIG. **1**A shows a contact intensity sensor coupled with intensity sensor controller **159** in I/O subsystem **106**. Contact intensity sensor(s) **165** optionally include one or more piezoresistive strain gauges, capacitive force sensors, electric force sensors, piezoelectric force sensors, optical force sensors, capacitive touch-sensitive surfaces, or other intensity sensors (e.g., sensors used to measure the force (or pressure) of a contact on a touch-sensitive surface). Contact intensity sensor(s) **165** receive contact intensity information (e.g., pressure information or a proxy for pressure information) from the environment. In some embodiments, at least one contact intensity sensor is collocated with, or proximate to, a touch-sensitive surface (e.g., touch-sensitive display system **112**). In some embodiments, at least one contact intensity sensor is located on the back of device **100**, opposite touch-screen display system **112** which is located on the front of device **100**.

[0078] Device **100** optionally also includes one or more proximity sensors **166**. FIG. **1**A shows proximity sensor **166** coupled with peripherals interface **118**. Alternately, proximity sensor **166** is coupled with input controller **160** in I/O subsystem **106**. In some embodiments, the proximity sensor turns off and disables touch-sensitive display system **112** when the multifunction device is placed near the user's ear (e.g., when the user is making a phone call).

[0079] Device **100** optionally also includes one or more tactile output generators **167**. FIG. **1**A shows a tactile output generator coupled with haptic feedback controller **161** in I/O subsystem **106**. Tactile output generator(s) **167** optionally include one or more electroacoustic devices such as speakers or other audio components and/or electromechanical devices that convert energy into linear motion such as a motor, solenoid, electroactive polymer, piezoelectric actuator, electrostatic actuator, or other tactile output generating component (e.g., a component that converts electrical signals into tactile outputs on the device). Tactile output generator(s) **167** receive tactile feedback generation instructions from haptic feedback module **133** and generates tactile outputs on device **100** that are capable of being sensed by a user of device **100**. In some embodiments, at least one tactile output generator is collocated with, or proximate to, a touch-sensitive surface (e.g., touch-sensitive display system **112**) and, optionally, generates a tactile output by moving the touch-sensitive surface vertically (e.g., in/out of a surface of device **100**) or laterally (e.g., back and forth in the same plane as a surface of device **100**). In some embodiments, at least one tactile output generator sensor is located on the back of device **100**, opposite touch-sensitive display system **112**, which is located on the front of device **100**.

[0080] Device **100** optionally also includes one or more accelerometers **168**. FIG. **1**A shows accelerometer **168** coupled with peripherals interface **118**. Alternately, accelerometer **168** is, optionally, coupled with an input controller **160** in I/O subsystem **106**. In some embodiments, information is displayed on the touch-screen display in a portrait view or a landscape view based on an analysis of data received from the one or more accelerometers. Device **100** optionally includes, in addition to accelerometer(s) **168**, a magnetometer (not shown) and a GPS (or GLONASS or other global navigation system) receiver (not shown) for obtaining information concerning the location and orientation (e.g., portrait or landscape) of device **100**.

[0081] In some embodiments, the software components stored in memory **102** include operating system **126**, communication module (or set of instructions) **128**, contact/motion module (or set of instructions) **130**, graphics module (or set of instructions) **132**, haptic feedback module (or set of instructions) **133**, text input module (or set of instructions) **134**, Global Positioning System (GPS) module (or set of instructions) **135**, and applications (or sets of instructions) **136**. Furthermore, in some embodiments, memory **102** stores device/global internal state **157**, as shown in FIGS. **1**A and **3**. Device/global internal state **157** includes one or more of: active application state, indicating which applications, if any, are currently active; display state, indicating what applications, views or other information occupy various regions of touch-sensitive display system **112**; sensor state, including information obtained from the device's various sensors and other input or control devices **116**; and location and/or positional information concerning the device's location and/or attitude.

[0082] Operating system **126** (e.g., iOS, Darwin, RTXC, LINUX, UNIX, OS X, WINDOWS, or an embedded operating system such as VxWorks) includes various software components and/or drivers for controlling and managing general system tasks (e.g., memory management, storage device control, power management, etc.) and facilitates communication between various hardware and software components.

[0083] Communication module **128** facilitates communication with other devices over one or more external ports **124** and also includes various software components for handling data received by RF circuitry **108** and/or external port **124**. External port **124** (e.g., Universal Serial Bus (USB), FIREWIRE, etc.) is adapted for coupling directly to other devices or indirectly over a network (e.g., the Internet, wireless LAN, etc.). In some embodiments, the external port is a multi-pin (e.g., 30-pin) connector that is the same as, or similar to and/or compatible with the 30-pin connector used in some iPhone®, iPod Touch®, and iPad® devices from Apple Inc. of Cupertino, California. In some embodiments, the external port is a Lightning connector that is the same as, or similar to and/or compatible with the Lightning connector used in some iPhone®, iPod Touch®, and iPad® devices from Apple Inc. of Cupertino, California.

[0084] Contact/motion module **130** optionally detects contact with touch-sensitive display system **112** (in conjunction with display controller **156**) and other touch-sensitive devices (e.g., a touchpad or physical click wheel). Contact/motion module **130** includes various software components for performing various operations related to detection of contact (e.g., by a finger or by a stylus), such as determining if contact has occurred (e.g., detecting a finger-down event), determining an intensity of the contact (e.g., the force or pressure of the contact or a substitute for the force or pressure of the contact), determining if there is movement of the contact and tracking the movement across the touch-sensitive surface (e.g., detecting one or more finger-dragging events), and determining if the contact has ceased (e.g., detecting a finger-up event or a break in contact). Contact/motion module **130** receives contact data from the touch-sensitive surface. Determining movement of the point of contact, which is represented by a series of contact data, optionally includes determining speed (magnitude), velocity (magnitude and direction), and/or an acceleration (a change in magnitude and/or direction) of the point of contact. These operations are, optionally, applied to single contacts (e.g., one finger contacts or stylus contacts) or to multiple simultaneous contacts (e.g., "multitouch"/multiple finger contacts). In some embodiments, contact/motion module **130** and display controller **156** detect contact on a touchpad.

[0085] Contact/motion module **130** optionally detects a gesture input by a user. Different gestures on the touch-sensitive surface have different contact patterns (e.g., different motions, timings, and/or intensities of detected contacts). Thus, a gesture is, optionally, detected by detecting a particular contact pattern. For example, detecting a finger tap gesture includes detecting a finger-down event followed by detecting a finger-up (lift off) event at the same position (or substantially the same position) as the finger-down event (e.g., at the position of an icon). As another example, detecting a finger swipe gesture on the touch-sensitive surface includes detecting a finger-down event followed by detecting one or more finger-dragging events, and subsequently followed by detecting a finger-up (lift off) event. Similarly, tap, swipe, drag, and other gestures are optionally detected for a stylus by detecting a particular contact pattern for the stylus.

[0086] In some embodiments, detecting a finger tap gesture depends on the length of time between detecting the finger-down event and the finger-up event, but is independent of the intensity of the finger contact between detecting the finger-down event and the finger-up event. In some embodiments, a tap gesture is detected in accordance with a determination that the length of time between the finger-down event and the finger-up event is less than a predetermined value (e.g., less than 0.1, 0.2, 0.3, 0.4 or 0.5 seconds), independent of whether the intensity of the finger contact during the tap meets a given intensity threshold (greater than a nominal contact-detection intensity threshold), such as a light press or deep press intensity threshold. Thus, a finger tap gesture can satisfy particular input criteria that do not require that the characteristic intensity of a contact satisfy a given intensity threshold in order for the particular input criteria to be met. For clarity, the finger contact in a tap gesture typically needs to satisfy a nominal contact-detection intensity threshold, below which the contact is not detected, in order for the finger-down event to be detected. A similar analysis applies to detecting a tap gesture by a stylus or other contact. In cases where the device is capable of detecting a finger or stylus contact hovering over a touch sensitive surface, the nominal contact-detection intensity threshold optionally does not correspond to physical contact between the finger or stylus and the touch sensitive surface.

[0087] The same concepts apply in an analogous manner to other types of gestures. For example, a swipe gesture, a pinch gesture, a depinch gesture, and/or a long press gesture are optionally detected based on the satisfaction of criteria that are either independent of intensities of contacts included in the gesture, or do not require that contact(s) that perform the gesture reach intensity thresholds in order to be recognized. For example, a swipe gesture is detected based on an amount of movement of one or more contacts; a pinch gesture is detected based on movement of two or more contacts towards each other; a depinch gesture is detected based on movement of two or more contacts away from each other; and a long press gesture is detected based on a duration of the contact on the touch-sensitive surface with less than a threshold amount of movement. As such, the statement that particular gesture recognition criteria do not require that the intensity of the contact(s) meet a respective intensity threshold in order for the particular gesture recognition criteria to be met means that the particular gesture recognition criteria are capable of being satisfied if the contact(s) in the gesture do not reach the respective intensity threshold, and are also capable of being satisfied in circumstances where one or more of the contacts in the gesture do reach or exceed the respective intensity threshold. In some embodiments, a tap gesture is detected based on a determination that the finger-down and finger-up event are detected within a predefined time period, without regard to whether the contact is above or below the respective intensity threshold during the predefined time period, and a swipe gesture is detected based on a determination that the contact movement is greater than a predefined magnitude, even if the contact is above the respective intensity threshold at the end of the contact movement. Even in implementations where detection of a gesture is influenced by the intensities of contacts performing the gesture (e.g., the device detects a long press more quickly when the intensity of the contact is above an intensity threshold or delays detection of a tap input when the intensity of the contact is higher), the detection of those gestures does not require that the contacts reach a particular intensity threshold so long as the criteria for recognizing the gesture can be met in circumstances where the contact does not reach the particular intensity threshold (e.g., even if the amount of time that it takes to recognize the gesture changes).

[0088] Contact intensity thresholds, duration thresholds, and movement thresholds are, in some circumstances, combined in a variety of different combinations in order to create heuristics for distinguishing two or more different gestures directed to the same input element or region so that multiple different interactions with the same input element are enabled to provide a richer set of user interactions and responses. The statement that a particular set of gesture recognition criteria do not require that the intensity of the contact(s) meet a respective intensity threshold in order for the particular gesture recognition criteria to be met does not preclude the concurrent evaluation of other intensity-dependent gesture recognition criteria to identify other gestures that do have criteria that is met when a gesture includes a contact with an intensity above the respective intensity threshold. For example, in some circumstances, first gesture recognition criteria for a first gesture—which do not require that the intensity of the contact(s) meet a respective intensity threshold in order for the first gesture recognition criteria to be met—are in competition with second gesture recognition criteria for a second gesture—which are dependent on the contact(s) reaching the respective intensity threshold. In such competitions, the gesture is, optionally, not recognized as meeting the first gesture recognition criteria for the first gesture if the second gesture recognition criteria for the second gesture are met first. For example, if a contact reaches the respective intensity threshold before the contact moves by a predefined amount of movement, a deep press gesture is detected rather than a swipe gesture. Conversely, if the contact moves by the predefined amount of movement before the contact reaches the respective intensity threshold, a swipe gesture is detected rather than a deep press gesture. Even in such circumstances, the first gesture recognition criteria for the first gesture still do not require that the intensity of the contact(s) meet a respective intensity threshold in order for the first gesture recognition criteria to be met because if the contact stayed below the respective intensity threshold until an end of the gesture (e.g., a swipe gesture with a contact that does not increase to an intensity above the respective intensity threshold), the gesture would have been recognized by the first gesture recognition criteria as a swipe gesture. As such, particular gesture recognition criteria that do not require that the intensity of the contact(s) meet a respective intensity threshold in order for the particular gesture recognition criteria to be met will (A) in some circumstances ignore the intensity of the contact with respect to the intensity threshold (e.g. for a tap gesture) and/or (B) in some circumstances still be dependent on the intensity of the contact with respect to the intensity threshold in the sense that the particular gesture recognition criteria (e.g., for a long press gesture) will fail if a competing set of intensity-dependent gesture recognition criteria (e.g., for a deep press gesture) recognize an input as corresponding to an intensity-dependent gesture before the particular gesture recognition criteria recognize a gesture corresponding to the input (e.g., for a long press gesture that is competing with a deep press gesture for recognition).

[0089] Graphics module **132** includes various known software components for rendering and displaying graphics on touch-sensitive display system **112** or other display, including components for changing the visual impact (e.g., brightness, transparency, saturation, contrast or other visual property) of graphics that are displayed. As used herein, the term "graphics" includes any object that can be displayed to a user, including without limitation text, web pages, icons (such as user-interface objects including soft keys), digital images, videos, animations and the like.

[0090] In some embodiments, graphics module **132** stores data representing graphics to be used. Each graphic is, optionally, assigned a corresponding code. Graphics module **132** receives, from applications etc., one or more codes specifying graphics to be displayed along with, if necessary, coordinate data and other graphic property data, and then generates screen image data to output to display controller **156**.

[0091] Haptic feedback module **133** includes various software components for generating instructions used by tactile output generator(s) **167** to produce tactile outputs at one or more locations on device **100** in response to user interactions with device **100**.

[0092] Text input module **134**, which is, optionally, a component of graphics module **132**, provides soft keyboards for entering text in various applications (e.g., contacts module **137**, e-mail client module **140**, IM module **141**, browser module **147**, and any other application that needs text input).

[0093] GPS module **135** determines the location of the device and provides this information for use in various applications (e.g., to telephone module **138** for use in location-based dialing, to camera module **143** as picture/video metadata, and to applications that provide location-based services such as weather widgets, local yellow page widgets, and map/navigation widgets).

[0094] Applications **136** optionally include the following modules (or sets of instructions), or a subset or superset thereof:

- **[0095]** contacts module **137** (sometimes called an address book or contact list);
- **[0096]** telephone module **138**;
- **[0097]** video conferencing module **139**;
- **[0098]** e-mail client module **140**;
- **[0099]** instant messaging (IM) module **141**;
- **[0100]** workout support module **142**;
- **[0101]** camera module **143** for still and/or video images;
- **[0102]** image management module **144**;
- **[0103]** browser module **147**;
- **[0104]** calendar module **148**;
- **[0105]** widget modules **149**, which optionally include one or more of: weather widget **149-1**, stocks widget **149-2**, calculator widget **149-3**, alarm clock widget **149-4**, dictionary widget **149-5**, and other widgets obtained by the user, as well as user-created widgets **149-6**;
- **[0106]** widget creator module **150** for making user-created widgets **149-6**;
- **[0107]** search module **151**;
- **[0108]** video and music player module **152**, which is, optionally, made up of a video player module and a music player module;
- **[0109]** notes module **153**;
- **[0110]** map module **154**; and/or
- **[0111]** online video module **155**.

[0112] Examples of other applications **136** that are, optionally, stored in memory **102** include other word processing applications, other image editing applications, drawing applications, presentation applications, JAVA-enabled applications, encryption, digital rights management, voice recognition, and voice replication.

[0113] In conjunction with touch-sensitive display system **112**, display controller **156**, contact module **130**, graphics module **132**, and text input module **134**, contacts module **137** includes executable instructions to manage an address book or contact list (e.g., stored in application internal state **192** of contacts module **137** in memory **102** or memory **370**), including: adding name(s) to the address book; deleting name(s) from the address book; associating telephone number(s), e-mail address(es), physical address(es) or other information with a name; associating an image with a name; categorizing and sorting names; providing telephone numbers and/or e-mail addresses to initiate and/or facilitate communications by telephone module **138**, video conference module **139**, e-mail client module **140**, or IM module **141**; and so forth.

[0114] In conjunction with RF circuitry **108**, audio circuitry **110**, speaker **111**, microphone **113**, touch-sensitive display system **112**, display controller **156**, contact module **130**, graphics module **132**, and text input module **134**, telephone module **138** includes executable instructions to enter a sequence of characters corresponding to a telephone number, access one or more telephone numbers in address book **137**, modify a telephone number that has been entered, dial a respective telephone number, conduct a conversation and disconnect or hang up when the conversation is completed. As noted above, the wireless communication optionally uses any of a plurality of communications standards, protocols and technologies.

[0115] In conjunction with RF circuitry **108**, audio circuitry **110**, speaker **111**, microphone **113**, touch-sensitive display system **112**, display controller **156**, optical sensor(s) **164**, optical sensor controller **158**, contact module **130**, graphics module **132**, text input module **134**, contact list **137**, and telephone module **138**, videoconferencing module **139** includes executable instructions to initiate, conduct, and terminate a video conference between a user and one or more other participants in accordance with user instructions.

[0116] In conjunction with RF circuitry **108**, touch-sensitive display system **112**, display controller **156**, contact module **130**, graphics module **132**, and text input module **134**, e-mail client module **140** includes executable instructions to create, send, receive, and manage e-mail in response to user instructions. In conjunction with image management module **144**, e-mail client module **140** makes it very easy to create and send e-mails with still or video images taken with camera module **143**.

[0117] In conjunction with RF circuitry **108**, touch-sensitive display system **112**, display controller **156**, contact module **130**, graphics module **132**, and text input module **134**, the instant messaging module **141** includes executable instructions to enter a sequence of characters corresponding to an instant message, to modify previously entered characters, to transmit a respective instant message (for example, using a Short Message Service (SMS) or Multimedia Message Service (MMS) protocol for telephony-based instant messages or using XMPP, SIMPLE, Apple Push Notification Service (APNs) or IMPS for Internet-based instant messages), to receive instant messages, and to view received instant messages. In some embodiments, transmitted and/or received instant messages optionally include graphics, photos, audio files, video files and/or other attachments as are supported in a MMS and/or an Enhanced Messaging Service (EMS). As used herein, "instant messaging" refers to both telephony-based messages (e.g., messages sent using SMS or MMS) and Internet-based messages (e.g., messages sent using XMPP, SIMPLE, APNs, or IMPS).

[0118] In conjunction with RF circuitry **108**, touch-sensitive display system **112**, display controller **156**, contact module **130**, graphics module **132**, text input module **134**, GPS module **135**, map module **154**, and music player module **146**, workout support module **142** includes executable instructions to create workouts (e.g., with time, distance, and/or calorie burning goals); communicate with workout sensors (in sports devices and smart watches); receive workout sensor data; calibrate sensors used to monitor a workout; select and play music for a workout; and display, store and transmit workout data.

[0119] In conjunction with touch-sensitive display system **112**, display controller **156**, optical sensor(s) **164**, optical sensor controller **158**, contact module **130**, graphics module **132**, and image management module **144**, camera module **143** includes executable instructions to capture still images or video (including a video stream) and store them into memory **102**, modify characteristics of a still image or video, and/or delete a still image or video from memory **102**.

[0120] In conjunction with touch-sensitive display system **112**, display controller **156**, contact module **130**, graphics module **132**, text input module **134**, and camera module **143**, image management module **144** includes executable instructions to arrange, modify (e.g., edit), or otherwise manipulate, label, delete, present (e.g., in a digital slide show or album), and store still and/or video images.

[0121] In conjunction with RF circuitry **108**, touch-sensitive display system **112**, display system controller **156**, contact module **130**, graphics module **132**, and text input module **134**, browser module **147** includes executable instructions to browse the Internet in accordance with user instructions, including searching, linking to, receiving, and displaying web pages or portions thereof, as well as attachments and other files linked to web pages.

[0122] In conjunction with RF circuitry **108**, touch-sensitive display system **112**, display system controller **156**, contact module **130**, graphics module **132**, text input module **134**, e-mail client module **140**, and browser module **147**, calendar module **148** includes executable instructions to create, display, modify, and store calendars and data associated with calendars (e.g., calendar entries, to do lists, etc.) in accordance with user instructions.

[0123] In conjunction with RF circuitry **108**, touch-sensitive display system **112**, display system controller **156**, contact module **130**, graphics module **132**, text input module **134**, and browser module **147**, widget modules **149** are mini-applications that are, optionally, downloaded and used by a user (e.g., weather widget **149-1**, stocks widget **149-2**, calculator widget **149-3**, alarm clock widget **149-4**, and dictionary widget **149-5**) or created by the user (e.g., user-created widget **149-6**). In some embodiments, a widget includes an HTML (Hypertext Markup Language) file, a CSS (Cascading Style Sheets) file, and a JavaScript file. In some embodiments, a widget includes an XML (Extensible Markup Language) file and a JavaScript file (e.g., Yahoo!Widgets).

[0124] In conjunction with RF circuitry **108**, touch-sensitive display system **112**, display system controller **156**, contact module **130**, graphics module **132**, text input module **134**, and browser module **147**, the widget creator module **150** includes executable instructions to create widgets (e.g., turning a user-specified portion of a web page into a widget).

[0125] In conjunction with touch-sensitive display system **112**, display system controller **156**, contact module **130**, graphics module **132**, and text input module **134**, search module **151** includes executable instructions to search for text, music, sound, image, video, and/or other files in memory **102** that match one or more search criteria (e.g., one or more user-specified search terms) in accordance with user instructions.

[0126] In conjunction with touch-sensitive display system **112**, display system controller **156**, contact module **130**, graphics module **132**, audio circuitry **110**, speaker **111**, RF circuitry **108**, and browser module **147**, video and music player module **152** includes executable instructions that allow the user to download and play back recorded music and other sound files stored in one or more file formats, such as MP3 or AAC files, and executable instructions to display, present or otherwise play back videos (e.g., on touch-sensitive display system **112**, or on an external display connected wirelessly or via external port **124**). In some embodiments, device **100** optionally includes the functionality of an MP3 player, such as an iPod (trademark of Apple Inc.).

[0127] In conjunction with touch-sensitive display system **112**, display controller **156**, contact module **130**, graphics module **132**, and text input module **134**, notes module **153** includes executable instructions to create and manage notes, to do lists, and the like in accordance with user instructions.

[0128] In conjunction with RF circuitry **108**, touch-sensitive display system **112**, display system controller **156**, contact module **130**, graphics module **132**, text input module **134**, GPS module **135**, and browser module **147**, map module **154** includes executable instructions to receive, display, modify, and store maps and data associated with maps (e.g., driving directions; data on stores and other points of interest at or near a particular location; and other location-based data) in accordance with user instructions.

[0129] In conjunction with touch-sensitive display system **112**, display system controller **156**, contact module **130**, graphics module **132**, audio circuitry **110**, speaker **111**, RF circuitry **108**, text input module **134**, e-mail client module **140**, and browser module **147**, online video module **155** includes executable instructions that allow the user to access, browse, receive (e.g., by streaming and/or download), play back (e.g., on the touch screen **112**, or on an external display connected wirelessly or via external port **124**), send an e-mail with a link to a particular online video, and otherwise manage online videos in one or more file formats, such as H.264. In some embodiments, instant messaging module **141**, rather than e-mail client module **140**, is used to send a link to a particular online video.

[0130] Each of the above identified modules and applications correspond to a set of executable instructions for performing one or more functions described above and the methods described in this application (e.g., the computer-implemented methods and other information processing methods described herein). These modules (i.e., sets of instructions) need not be implemented as separate software programs, procedures or modules, and thus various subsets of these modules are, optionally, combined or otherwise re-arranged in various embodiments. In some embodiments, memory **102** optionally stores a subset of the modules and data structures identified above. Furthermore, memory **102** optionally stores additional modules and data structures not described above.

[0131] In some embodiments, device **100** is a device where operation of a predefined set of functions on the device is performed exclusively through a touch screen and/or a touchpad. By using a touch screen and/or a touchpad as the primary input control device for operation of device **100**, the number of physical input control devices (such as push buttons, dials, and the like) on device **100** is, optionally, reduced.

[0132] The predefined set of functions that are performed exclusively through a touch screen and/or a touchpad optionally include navigation between user interfaces. In some embodiments, the touchpad, when touched by the user, navigates device **100** to a main, home, or root menu from any user interface that is displayed on device **100**. In such embodiments, a "menu button" is implemented using a touchpad. In some other embodiments, the menu button is a physical push button or other physical input control device instead of a touchpad.

[0133] FIG. **1**B is a block diagram illustrating example components for event handling in accordance with some embodiments. In some embodiments, memory **102** (in FIGS. **1**A) or **370** (FIG. **3**) includes event sorter **170** (e.g., in operating system **126**) and a respective application **136-1** (e.g., any of the aforementioned applications **136**, **137-155**, **380-390**).

[0134] Event sorter **170** receives event information and determines the application **136-1** and application view **191** of application **136-1** to which to deliver the event information. Event sorter **170** includes event monitor **171** and event dispatcher module **174**. In some embodiments, application **136-1** includes application internal state **192**, which indicates the current application view(s) displayed on touch-sensitive display system **112** when the application is active or executing. In some embodiments, device/global internal state **157** is used by event sorter **170** to determine which application(s) is (are) currently active, and application internal state **192** is used by event sorter **170** to determine application views **191** to which to deliver event information.

[0135] In some embodiments, application internal state **192** includes additional information, such as one or more of: resume information to be used when application **136-1** resumes execution, user interface state information that indicates information being displayed or that is ready for display by application **136-1**, a state queue for enabling the user to go back to a prior state or view of application **136-1**, and a redo/undo queue of previous actions taken by the user.

[0136] Event monitor **171** receives event information from peripherals interface **118**. Event information includes information about a sub-event (e.g., a user touch on touch-sensitive display system **112**, as part of a multi-touch gesture). Peripherals interface **118** transmits information it receives from I/O subsystem **106** or a sensor, such as proximity sensor **166**, accelerometer(s) **168**, and/or microphone **113** (through audio circuitry **110**). Information that peripherals interface **118** receives from I/O subsystem **106** includes information from touch-sensitive display system **112** or a touch-sensitive surface.

[0137] In some embodiments, event monitor **171** sends requests to the peripherals interface **118** at predetermined intervals. In response, peripherals interface **118** transmits event information. In other embodiments, peripheral interface **118** transmits event information only when there is a significant event (e.g., receiving an input above a predetermined noise threshold and/or for more than a predetermined duration).

[0138] In some embodiments, event sorter **170** also includes a hit view determination module **172** and/or an active event recognizer determination module **173**.

[0139] Hit view determination module **172** provides software procedures for determining where a sub-event has taken place within one or more views, when touch-sensitive display system **112** displays more than one view. Views are made up of controls and other elements that a user can see on the display.

[0140] Another aspect of the user interface associated with an application is a set of views, sometimes herein called application views or user interface windows, in which information is displayed and touch-based gestures occur. The application views (of a respective application) in which a touch is detected optionally correspond to programmatic levels within a programmatic or view hierarchy of the application. For example, the lowest level view in which a touch is detected is, optionally, called the hit view, and the set of events that are recognized as proper inputs are, optionally, determined based, at least in part, on the hit view of the initial touch that begins a touch-based gesture.

[0141] Hit view determination module **172** receives information related to sub-events of a touch-based gesture. When an application has multiple views organized in a hierarchy, hit view determination module **172** identifies a hit view as the lowest view in the hierarchy which should handle the sub-event. In most circumstances, the hit view is the lowest level view in which an initiating sub-event occurs (i.e., the first sub-event in the sequence of sub-events that form an event or potential event). Once the hit view is identified by the hit view determination module, the hit view typically receives all sub-events related to the same touch or input source for which it was identified as the hit view.

[0142] Active event recognizer determination module **173** determines which view or views within a view hierarchy should receive a particular sequence of sub-events. In some embodiments, active event recognizer determination module **173** determines that only the hit view should receive a particular sequence of sub-events. In other embodiments, active event recognizer determination module **173** determines that all views that include the physical location of a sub-event are actively involved views, and therefore determines that all actively involved views should receive a particular sequence of sub-events. In other embodiments, even if touch sub-events were entirely confined to the area associated with one particular view, views higher in the hierarchy would still remain as actively involved views.

[0143] Event dispatcher module **174** dispatches the event information to an event recognizer (e.g., event recognizer **180**). In embodiments including active event recognizer determination module **173**, event dispatcher module **174**

delivers the event information to an event recognizer determined by active event recognizer determination module **173**. In some embodiments, event dispatcher module **174** stores in an event queue the event information, which is retrieved by a respective event receiver module **182**.

[0144] In some embodiments, operating system **126** includes event sorter **170**. Alternatively, application **136-1** includes event sorter **170**. In yet other embodiments, event sorter **170** is a stand-alone module, or a part of another module stored in memory **102**, such as contact/motion module **130**.

[0145] In some embodiments, application **136-1** includes a plurality of event handlers **190** and one or more application views **191**, each of which includes instructions for handling touch events that occur within a respective view of the application's user interface. Each application view **191** of the application **136-1** includes one or more event recognizers **180**. Typically, a respective application view **191** includes a plurality of event recognizers **180**. In other embodiments, one or more of event recognizers **180** are part of a separate module, such as a user interface kit (not shown) or a higher level object from which application **136-1** inherits methods and other properties. In some embodiments, a respective event handler **190** includes one or more of: data updater **176**, object updater **177**, GUI updater **178**, and/or event data **179** received from event sorter **170**. Event handler **190** optionally utilizes or calls data updater **176**, object updater **177** or GUI updater **178** to update the application internal state **192**. Alternatively, one or more of the application views **191** includes one or more respective event handlers **190**. Also, in some embodiments, one or more of data updater **176**, object updater **177**, and GUI updater **178** are included in a respective application view **191**.

[0146] A respective event recognizer **180** receives event information (e.g., event data **179**) from event sorter **170**, and identifies an event from the event information. Event recognizer **180** includes event receiver **182** and event comparator **184**. In some embodiments, event recognizer **180** also includes at least a subset of: metadata **183**, and event delivery instructions **188** (which optionally include sub-event delivery instructions).

[0147] Event receiver **182** receives event information from event sorter **170**. The event information includes information about a sub-event, for example, a touch or a touch movement. Depending on the sub-event, the event information also includes additional information, such as location of the sub-event. When the sub-event concerns motion of a touch, the event information optionally also includes speed and direction of the sub-event. In some embodiments, events include rotation of the device from one orientation to another (e.g., from a portrait orientation to a landscape orientation, or vice versa), and the event information includes corresponding information about the current orientation (also called device attitude) of the device.

[0148] Event comparator **184** compares the event information to predefined event or sub-event definitions and, based on the comparison, determines an event or sub-event, or determines or updates the state of an event or sub-event. In some embodiments, event comparator **184** includes event definitions **186**. Event definitions **186** contain definitions of events (e.g., predefined sequences of sub-events), for example, event **1** (**187-1**), event **2** (**187-2**), and others. In some embodiments, sub-events in an event **187** include, for example, touch begin, touch end, touch movement, touch cancellation, and multiple touching. In one example, the definition for event **1** (**187-1**) is a double tap on a displayed object. The double tap, for example, comprises a first touch (touch begin) on the displayed object for a predetermined phase, a first lift-off (touch end) for a predetermined phase, a second touch (touch begin) on the displayed object for a predetermined phase, and a second lift-off (touch end) for a predetermined phase. In another example, the definition for event **2** (**187-2**) is a dragging on a displayed object. The dragging, for example, comprises a touch (or contact) on the displayed object for a predetermined phase, a movement of the touch across touch-sensitive display system **112**, and lift-off of the touch (touch end). In some embodiments, the event also includes information for one or more associated event handlers **190**.

[0149] In some embodiments, event definition **187** includes a definition of an event for a respective user-interface object. In some embodiments, event comparator **184** performs a hit test to determine which user-interface object is associated with a sub-event. For example, in an application view in which three user-interface objects are displayed on touch-sensitive display system **112**, when a touch is detected on touch-sensitive display system **112**, event comparator **184** performs a hit test to determine which of the three user-interface objects is associated with the touch (sub-event). If each displayed object is associated with a respective event handler **190**, the event comparator uses the result of the hit test to determine which event handler **190** should be activated. For example, event comparator **184** selects an event handler associated with the sub-event and the object triggering the hit test.

[0150] In some embodiments, the definition for a respective event **187** also includes delayed actions that delay delivery of the event information until after it has been determined whether the sequence of sub-events does or does not correspond to the event recognizer's event type.

[0151] When a respective event recognizer **180** determines that the series of sub-events do not match any of the events in event definitions **186**, the respective event recognizer **180** enters an event impossible, event failed, or event ended state, after which it disregards subsequent sub-events of the touch-based gesture. In this situation, other event recognizers, if any, that remain active for the hit view continue to track and process sub-events of an ongoing touch-based gesture.

[0152] In some embodiments, a respective event recognizer **180** includes metadata **183** with configurable properties, flags, and/or lists that indicate how the event delivery system should perform sub-event delivery to actively involved event recognizers. In some embodiments, metadata **183** includes configurable properties, flags, and/or lists that indicate how event recognizers interact, or are enabled to interact, with one another. In some embodiments, metadata **183** includes configurable properties, flags, and/or lists that indicate whether sub-events are delivered to varying levels in the view or programmatic hierarchy.

[0153] In some embodiments, a respective event recognizer **180** activates event handler **190** associated with an event when one or more particular sub-events of an event are recognized. In some embodiments, a respective event recognizer **180** delivers event information associated with the event to event handler **190**. Activating an event handler **190** is distinct from sending (and deferred sending) sub-events to a respective hit view. In some embodiments, event recognizer **180** throws a flag associated with the recognized event, and event handler **190** associated with the flag catches the flag and performs a predefined process.

[0154] In some embodiments, event delivery instructions **188** include sub-event delivery instructions that deliver event information about a sub-event without activating an event handler. Instead, the sub-event delivery instructions deliver event information to event handlers associated with the series of sub-events or to actively involved views. Event handlers associated with the series of sub-events or with actively involved views receive the event information and perform a predetermined process.

[0155] In some embodiments, data updater **176** creates and updates data used in application **136-1**. For example, data updater **176** updates the telephone number used in contacts module **137**, or stores a video file used in video player module **145**. In some embodiments, object updater **177** creates and updates objects used in application **136-1**. For example, object updater **177** creates a new user-interface object or updates the position of a user-interface object. GUI updater **178** updates the GUI. For example, GUI updater **178** prepares display information and sends it to graphics module **132** for display on a touch-sensitive display.

[0156] In some embodiments, event handler(s) **190** includes or has access to data updater **176**, object updater **177**, and GUI updater **178**. In some embodiments, data updater **176**, object updater **177**, and GUI updater **178** are included in a single module of a respective application **136-1** or application view **191**. In other embodiments, they are included in two or more software modules.

[0157] It shall be understood that the foregoing discussion regarding event handling of user touches on touch-sensitive displays also applies to other forms of user inputs to operate multifunction devices **100** with input-devices, not all of which are initiated on touch screens. For example, mouse movement and mouse button presses, optionally coordinated with single or multiple keyboard presses or holds; contact movements such as taps, drags, scrolls, etc., on touch-pads; pen stylus inputs; movement of the device; oral instructions; detected eye movements; biometric inputs; and/or any combination thereof are optionally utilized as inputs corresponding to sub-events which define an event to be recognized.

[0158] FIG. **1**C is a block diagram illustrating a tactile output module in accordance with some embodiments. In some embodiments, I/O subsystem **106** (e.g., haptic feedback controller **161** (FIG. **1**A) and/or other input controller(s) **160** (FIG. **1**A)) includes at least some of the example components shown in FIG. **1**C. In some embodiments, peripherals interface **118** includes at least some of the example components shown in FIG. **1**C.

[0159] In some embodiments, the tactile output module includes haptic feedback module **133**. In some embodiments, haptic feedback module **133** aggregates and combines tactile outputs for user interface feedback from software applications on the electronic device (e.g., feedback that is responsive to user inputs that correspond to displayed user interfaces and alerts and other notifications that indicate the performance of operations or occurrence of events in user interfaces of the electronic device). Haptic feedback module **133** includes one or more of: waveform module **123** (for providing waveforms used for generating tactile outputs), mixer **125** (for mixing waveforms, such as waveforms in different channels), compressor **127** (for reducing or compressing a dynamic range of the waveforms), low-pass filter **129** (for filtering out high frequency signal components in the waveforms), and thermal controller **131** (for adjusting the waveforms in accordance with thermal conditions). In some embodiments, haptic feedback module **133** is included in haptic feedback controller **161** (FIG. **1**A). In some embodiments, a separate unit of haptic feedback module **133** (or a separate implementation of haptic feedback module **133**) is also included in an audio controller (e.g., audio circuitry **110**, FIG. **1**A) and used for generating audio signals. In some embodiments, a single haptic feedback module **133** is used for generating audio signals and generating waveforms for tactile outputs.

[0160] In some embodiments, haptic feedback module **133** also includes trigger module **121** (e.g., a software application, operating system, or other software module that determines a tactile output is to be generated and initiates the process for generating the corresponding tactile output). In some embodiments, trigger module **121** generates trigger signals for initiating generation of waveforms (e.g., by waveform module **123**). For example, trigger module **121** generates trigger signals based on preset timing criteria. In some embodiments, trigger module **121** receives trigger signals from outside haptic feedback module **133** (e.g., in some embodiments, haptic feedback module **133** receives trigger signals from hardware input processing module **146** located outside haptic feedback module **133**) and relays the trigger signals to other components within haptic feedback module **133** (e.g., waveform module **123**) or software applications that trigger operations (e.g., with trigger module **121**) based on activation of the hardware input device (e.g., a home button). In some embodiments, trigger module **121** also receives tactile feedback generation instructions (e.g., from haptic feedback module **133**, FIGS. **1**A and **3**). In some embodiments, trigger module **121** generates trigger signals in response to haptic feedback module **133** (or trigger module **121** in haptic feedback module **133**) receiving tactile feedback instructions (e.g., from haptic feedback module **133**, FIGS. **1**A and **3**).

[0161] Waveform module **123** receives trigger signals (e.g., from trigger module **121**) as an input, and in response to receiving trigger signals, provides waveforms for generation of one or more tactile outputs (e.g., waveforms selected from a predefined set of waveforms designated for use by waveform module **123**, such as the waveforms described in greater detail below with reference to FIGS. **4**F-**4**G).

[0162] Mixer **125** receives waveforms (e.g., from waveform module **123**) as an input, and mixes together the waveforms. For example, when mixer **125** receives two or more waveforms (e.g., a first waveform in a first channel and a second waveform that at least partially overlaps with the first waveform in a second channel) mixer **125** outputs a combined waveform that corresponds to a sum of the two or more waveforms. In some embodiments, mixer **125** also modifies one or more waveforms of the two or more waveforms to emphasize particular waveform(s) over the rest of the two or more waveforms (e.g., by increasing a scale of the particular waveform(s) and/or decreasing a scale of the rest of the waveforms). In some circumstances, mixer **125** selects one or more waveforms to remove from the combined waveform (e.g., the waveform from the oldest source is dropped when there are waveforms from more than three sources that have been requested to be output concurrently by tactile output generator **167**)

[0163] Compressor **127** receives waveforms (e.g., a combined waveform from mixer **125**) as an input, and modifies the waveforms. In some embodiments, compressor **127** reduces the waveforms (e.g., in accordance with physical specifications of tactile output generators **167** (FIG. **1**A) or **357** (FIG. **3**)) so that tactile outputs corresponding to the waveforms are reduced. In some embodiments, compressor **127** limits the waveforms, such as by enforcing a predefined maximum amplitude for the waveforms. For example, compressor **127** reduces amplitudes of portions of waveforms that exceed a predefined amplitude threshold while maintaining amplitudes of portions of waveforms that do not exceed the predefined amplitude threshold. In some embodiments, compressor **127** reduces a dynamic range of the waveforms. In some embodiments, compressor **127** dynamically reduces the dynamic range of the waveforms so that the combined waveforms remain within performance specifications of the tactile output generator **167** (e.g., force and/or moveable mass displacement limits).

[0164] Low-pass filter **129** receives waveforms (e.g., compressed waveforms from compressor **127**) as an input, and filters (e.g., smooths) the waveforms (e.g., removes or reduces high frequency signal components in the waveforms). For example, in some instances, compressor **127** includes, in compressed waveforms, extraneous signals (e.g., high frequency signal components) that interfere with the generation of tactile outputs and/or exceed performance specifications of tactile output generator **167** when the tactile outputs are generated in accordance with the compressed waveforms. Low-pass filter **129** reduces or removes such extraneous signals in the waveforms.

[0165] Thermal controller **131** receives waveforms (e.g., filtered waveforms from low-pass filter **129**) as an input, and adjusts the waveforms in accordance with thermal conditions of device **100** (e.g., based on internal temperatures detected within device **100**, such as the temperature of haptic feedback controller **161**, and/or external temperatures detected by device **100**). For example, in some cases, the output of haptic feedback controller **161** varies depending on the temperature (e.g. haptic feedback controller **161**, in response to receiving same waveforms, generates a first tactile output when haptic feedback controller **161** is at a first temperature and generates a second tactile output when haptic feedback controller **161** is at a second temperature that is distinct from the first temperature). For example, the magnitude (or the amplitude) of the tactile outputs may vary depending on the temperature. To reduce the effect of the temperature variations, the waveforms are modified (e.g., an amplitude of the waveforms is increased or decreased based on the temperature).

[0166] In some embodiments, haptic feedback module **133** (e.g., trigger module **121**) is coupled to hardware input processing module **146**. In some embodiments, other input controller(s) **160** in FIG. **1**A includes hardware input processing module **146**. In some embodiments, hardware input processing module **146** receives inputs from hardware input device **145** (e.g., other input or control devices **116** in FIG. **1**A, such as a home button). In some embodiments, hardware input device **145** is any input device described herein, such as touch-sensitive display system **112** (FIG. **1**A), keyboard/mouse **350** (FIG. **3**), touchpad **355** (FIG. **3**), one of other input or control devices **116** (FIG. **1**A), or an intensity-sensitive home button (e.g., as shown in FIG. **2**B or a home button with a mechanical actuator as illustrated in FIG. **2**C). In some embodiments, hardware input device **145** consists of an intensity-sensitive home button (e.g., as shown in FIG. **2**B or a home button with a mechanical actuator as illustrated in FIG. **2**C), and not touch-sensitive display system **112** (FIG. **1**A), keyboard/mouse **350** (FIG. **3**), or touchpad **355** (FIG. **3**). In some embodiments, in response to inputs from hardware input device **145**, hardware input processing module **146** provides one or more trigger signals to haptic feedback module **133** to indicate that a user input satisfying predefined input criteria, such as an input corresponding to a "click" of a home button (e.g., a "down click" or an "up click"), has been detected. In some embodiments, haptic feedback module **133** provides waveforms that correspond to the "click" of a home button in response to the input corresponding to the "click" of a home button, simulating a haptic feedback of pressing a physical home button.

[0167] In some embodiments, the tactile output module includes haptic feedback controller **161** (e.g., haptic feedback controller **161** in FIG. **1**A), which controls the generation of tactile outputs. In some embodiments, haptic feedback controller **161** is coupled to a plurality of tactile output generators, and selects one or more tactile output generators of the plurality of tactile output generators and sends waveforms to the selected one or more tactile output generators for generating tactile outputs. In some embodiments, haptic feedback controller **161** coordinates tactile output requests that correspond to activation of hardware input device **145** and tactile output requests that correspond to software events (e.g., tactile output requests from haptic feedback module **133**) and modifies one or more waveforms of the two or more waveforms to emphasize particular waveform(s) over the rest of the two or more waveforms (e.g., by increasing a scale of the particular waveform(s) and/or decreasing a scale of the rest of the waveforms, such as to prioritize tactile outputs that correspond to activations of hardware input device **145** over tactile outputs that correspond to software events).

[0168] In some embodiments, as shown in FIG. **1**C, an output of haptic feedback controller **161** is coupled to audio circuitry of device **100** (e.g., audio circuitry **110**, FIG. **1**A), and provides audio signals to audio circuitry of device **100**. In some embodiments, haptic feedback controller **161** provides both waveforms used for generating tactile outputs and audio signals used for providing audio outputs in conjunction with generation of the tactile outputs. In some embodiments, haptic feedback controller **161** modifies audio signals and/or waveforms (used for generating tactile outputs) so that the audio outputs and the tactile outputs are synchronized (e.g., by delaying the audio signals and/or waveforms). In some embodiments, haptic feedback controller **161** includes a digital-to-analog converter used for converting digital waveforms into analog signals, which are received by amplifier **163** and/or tactile output generator **167**.

[0169] In some embodiments, the tactile output module includes amplifier **163**. In some embodiments, amplifier **163** receives waveforms (e.g., from haptic feedback controller **161**) and amplifies the waveforms prior to sending the amplified waveforms to tactile output generator **167** (e.g., any of tactile output generators **167** (FIG. **1**A) or **357** (FIG. **3**)). For example, amplifier **163** amplifies the received waveforms to signal levels that are in accordance with physical specifications of tactile output generator **167** (e.g., to a voltage and/or a current required by tactile output generator **167** for generating tactile outputs so that the signals sent to tactile output generator **167** produce tactile outputs that correspond to the waveforms received from haptic feedback controller **161**) and sends the amplified waveforms to tactile output generator **167**. In response, tactile output generator **167** generates tactile outputs (e.g., by shifting a moveable mass back and forth in one or more dimensions relative to a neutral position of the moveable mass).

[0170] In some embodiments, the tactile output module includes sensor **169**, which is coupled to tactile output generator **167**. Sensor **169** detects states or state changes (e.g., mechanical position, physical displacement, and/or movement) of tactile output generator **167** or one or more components of tactile output generator **167** (e.g., one or more moving parts, such as a membrane, used to generate tactile outputs). In some embodiments, sensor **169** is a magnetic field sensor (e.g., a Hall Effect sensor) or other displacement and/or movement sensor. In some embodiments, sensor **169** provides information (e.g., a position, a displacement, and/or a movement of one or more parts in tactile output generator **167**) to haptic feedback controller **161** and, in accordance with the information provided by sensor **169** about the state of tactile output generator **167**, haptic feedback controller **161** adjusts the waveforms output from haptic feedback controller **161** (e.g., waveforms sent to tactile output generator **167**, optionally via amplifier **163**).

[0171] FIG. **2**A illustrates a portable multifunction device **100** having a touch screen (e.g., touch-sensitive display system **112**, FIG. **1**A) in accordance with some embodiments. The touch screen optionally displays one or more graphics within user interface (UI) **200**. In this embodiment, as well as others described below, a user is enabled to select one or more of the graphics by making a gesture on the graphics, for example, with one or more fingers **202** (not drawn to scale in the figure) or one or more styluses **203** (not drawn to scale in the figure). In some embodiments, selection of one or more graphics occurs when the user breaks contact with the one or more graphics. In some embodiments, the gesture optionally includes one or more taps, one or more swipes (from left to right, right to left, upward and/or downward) and/or a rolling of a finger (from right to left, left to right, upward and/or downward) that has made contact with device **100**. In some implementations or circumstances, inadvertent contact with a graphic does not select the graphic. For example, a swipe gesture that sweeps over an application icon optionally does not select the corresponding application when the gesture corresponding to selection is a tap.

[0172] Device **100** optionally also includes one or more physical buttons, such as "home" or menu button **204**. As described previously, menu button **204** is, optionally, used to navigate to any application **136** in a set of applications that are, optionally executed on device **100**. Alternatively, in some embodiments, the menu button is implemented as a soft key in a GUI displayed on the touch-screen display.

[0173] In some embodiments, device **100** includes the touch-screen display, menu button **204**, push button **206** for powering the device on/off and locking the device, volume adjustment button(s) **208**, Subscriber Identity Module (SIM) card slot **210**, head set jack **212**, and docking/charging external port **124**. Push button **206** is, optionally, used to turn the power on/off on the device by depressing the button and holding the button in the depressed state for a predefined time interval; to lock the device by depressing the button and releasing the button before the predefined time interval has elapsed; and/or to unlock the device or initiate an unlock process. In some embodiments, device **100** also accepts verbal input for activation or deactivation of some functions through microphone **113**. Device **100** also, optionally, includes one or more contact intensity sensors **165** for detecting intensities of contacts on touch-sensitive display system **112** and/or one or more tactile output generators **167** for generating tactile outputs for a user of device **100**.

[0174] FIGS. **2**B-**2**C show exploded views of a first input device suitable for use in the electronic devices shown in FIGS. **1**A, **2**A, **3**, and/or **4**A (e.g., as home button **204**). FIG. **2**B shows an example of an intensity-sensitive home button with capacitive sensors used to determine a range of intensity values that correspond to force applied to the intensity-sensitive home button. FIG. **2**C shows an example of a home button with a mechanical switch element. With reference to FIG. **2**B, the input device stack **220** includes a cover element **222** and a trim **224**. In the illustrated embodiment, the trim **224** completely surrounds the sides of the cover element **222** and the perimeter of the top surface of the cover element **222**. Other embodiments are not limited to this configuration. For example, in one embodiment the sides and/or top surface of the cover element **222** can be partially surrounded by the trim **224**. Alternatively, the trim **224** can be omitted in other embodiments.

[0175] Both the cover element **222** and the trim **224** can be formed with any suitable opaque, transparent, and/or translucent material. For example, the cover element **222** can be made of glass, plastic, or sapphire and the trim **224** may be made of a metal or plastic. In some embodiments, one or more additional layers (not shown) can be positioned below the cover element **222**. For example, an opaque ink layer can be disposed below the cover element **222** when the cover element **222** is made of a transparent material. The opaque ink layer can conceal the other components in the input device stack **220** so that the other components are not visible through the transparent cover element **222**.

[0176] A first circuit layer **226** can be disposed below the cover element **222**. Any suitable circuit layer may be used. For example, the first circuit layer **226** may be a circuit board or a flexible circuit. The first circuit layer **226** can include one or more circuits, signal lines, and/or integrated circuits. In one embodiment, the first circuit layer **226** includes a biometric sensor **228**. Any suitable type of biometric sensor can be used. For example, in one embodiment the biometric sensor is a capacitive fingerprint sensor that captures at least one fingerprint when a user's finger (or fingers) approaches and/or contacts the cover element **222**.

[0177] The first circuit layer **226** may be attached to the bottom surface of the cover element **222** with an adhesive layer **230**. Any suitable adhesive can be used for the adhesive layer. For example, a pressure sensitive adhesive layer may be used as the adhesive layer **230**.

[0178] A compliant layer **232** is disposed below the first circuit layer **226**. In one embodiment, the compliant layer **232** includes an opening **234** formed in the compliant layer **232**. The opening **234** exposes the top surface of the first circuit layer **226** and/or the biometric sensor **228** when the device stack **220** is assembled. In the illustrated embodiment, the compliant layer **232** is positioned around an interior perimeter of the trim **224** and/or around a peripheral edge of the cover element **222**. Although depicted in a circular shape, the compliant layer **232** can have any given shape and/or dimensions, such as a square or oval. The compliant layer **232** is shown as a continuous compliant layer in FIGS. **2**B and **2**C, but other embodiments are not limited to this configuration. In some embodiments, multiple discrete compliant layers may be used in the device stack **220**. Additionally, in some embodiments, the compliant layer **232** does not include the opening **234** and the compliant layer **232** extends across at least a portion of the input device stack **220**. For example, the compliant layer **232** may extend across the bottom surface of the cover element **222**, the bottom surface of the first circuit layer **226**, or a portion of the bottom surface of the cover element **222** (e.g., around the peripheral edge of the cover element) and the bottom surface of the first circuit layer **226**.

[0179] A second circuit layer **238** is positioned below the first circuit layer **226**. A flexible circuit and a circuit board are examples of a circuit layer that can be used in the second circuit layer **238**. In some embodiments, the second circuit layer **238** can include a first circuit section **240** and a second circuit section **242**. The first and second circuit sections **240**, **242** can be electrically connected one another other.

[0180] The first circuit section **240** can include a first set of one or more intensity sensor components that are included in an intensity sensor. In some embodiments, the first circuit section **240** can be electrically connected to the first circuit layer **226**. For example, when the first circuit layer **226** includes a biometric sensor **228**, the biometric sensor **228** may be electrically connected to the first circuit section **240** of the second circuit layer **238**.

[0181] The second circuit section **242** can include additional circuitry, such as signal lines, circuit components, integrated circuits, and the like. In one embodiment, the second circuit section **242** may include a board-to-board connector **244** to electrically connect the second circuit layer **238** to other circuitry in the electronic device. For example, the second circuit layer **238** can be operably connected to a processing device using the board-to-board connector **244**. Additionally, or alternatively, the second circuit layer **238** may be operably connected to circuitry that transmits signals (e.g., sense signals) received from the intensity sensor component(s) in the first circuit section **240** to a processing device. Additionally, or alternatively, the second circuit layer **238** may be operably connected to circuitry that provides signals (e.g., drive signals, a reference signal) to the one or more intensity sensor components in the first circuit section **240**.

[0182] In some embodiments, the first circuit section **240** of the second circuit layer **238** may be attached to the bottom surface of the first circuit layer **226** using an adhesive layer **236**. In a non-limiting example, a die attach film may be used to attach the first circuit section **240** to the bottom surface of the first circuit layer **226**.

[0183] A third circuit layer **246** is disposed below the first circuit section **240** of the second circuit layer **238**. The third circuit layer **246** may include a second set of one or more intensity sensor components that are included in an intensity sensor. The third circuit layer **246** is supported by and/or attached to a support element **248**. In one embodiment, the support element **248** is attached to the trim **224** to produce an enclosure for the other components in the device stack **220**. The support element **248** may be attached to the trim **224** using any suitable attachment mechanism.

[0184] The first set of one or more intensity sensor components in the first circuit section **240** and the second set of one or more intensity sensor components in the third circuit layer **246** together form an intensity sensor. The intensity sensor can use any suitable intensity sensing technology. Example sensing technologies include, but are not limited to, capacitive, piezoelectric, piezoresistive, ultrasonic, and magnetic.

[0185] In the examples shown in FIGS. **2**B and **2**C, the intensity sensor is a capacitive force sensor. With a capacitive force sensor, the first set of one or more intensity sensor components can include a first set of one or more electrodes **250** and the second set of one or more force sensor components a second set of one or more electrodes **252**. Although shown in a square shape in FIGS. **2**B and **2**C each electrode in the first and second sets of one or more electrodes **250**, **252** can have any given shape (e.g., rectangles, circles). Additionally, the one or more electrodes in the first and second sets **250**, **252** may be arranged in any given pattern (e.g., one or more rows and one or more columns).

[0186] FIGS. **2**B and **2**C show two electrodes in the first and second sets of one or more electrodes **250**, **252**. However, other embodiments are not limited to this configuration. The first and second sets of one or more electrodes **250**, **252** may each be a single electrode or multiple discrete electrodes. For example, if the first set of one or more electrodes is a single electrode, the second set of one or more electrodes comprises multiple discrete electrodes. In some embodiments, the second set of one or more electrodes can be a single electrode and the first set includes multiple discrete electrodes. Alternatively, both the first and second sets of one or more electrodes may each include multiple discrete electrodes.

[0187] Each electrode in the first set of one or more electrodes **250** is aligned in at least one direction (e.g., vertically) with a respective electrode in the second set of one or more electrodes **252** to produce one or more capacitors. When a force input is applied to the cover element **222** (e.g., the input surface of the input device), at least one electrode in the first set **250** moves closer to a respective electrode in the second set **252**, which varies the capacitance of the capacitor(s). A capacitance signal sensed from each capacitor represents a capacitance measurement of that capacitor. A processing device (not shown) is configured to receive the capacitance signal(s) and correlate the capacitance signal(s) to an amount of intensity applied to the cover element **222**. In some embodiments the force sensor can replace a switch element and different intensity thresholds can be used to determine activation events.

[0188] In some embodiments, such as the embodiment shown in FIG. **2**C, a switch element **254** can be positioned below the support element **248**. The switch element **254** registers a user input when a force input applied to the cover element **222** exceeds a given amount of force (e.g., a force threshold associated with closing the distance between the first circuit section **240** and the third circuit layer **246**). Any suitable switch element can be used. For example, the switch element **254** may be a dome switch that collapses when the force input applied to the cover element **222** exceeds the force threshold. When collapsed, the dome switch completes a circuit that is detected by a processing device and recognized as a user input (e.g., a selection of an icon, function, or application). In one embodiment, the dome switch is arranged such that the apex of the collapsible dome is proximate to the bottom surface of the support plate **248**. In another embodiment, the base of the collapsible dome can be proximate to the bottom surface of the support plate **248**.

[0189] FIG. **3** is a block diagram of an example multifunction device with a display and a touch-sensitive surface in accordance with some embodiments. Device **300** need not be portable. In some embodiments, device **300** is a laptop computer, a desktop computer, a tablet computer, a multimedia player device, a navigation device, an educational device (such as a child's learning toy), a gaming system, or a control device (e.g., a home or industrial controller). Device **300** typically includes one or more processing units (CPU's) **310**, one or more network or other communications interfaces **360**, memory **370**, and one or more communication buses **320** for interconnecting these components. Communication buses **320** optionally include circuitry (sometimes called a chipset) that interconnects and controls communications between system components. Device **300** includes input/output (I/O) interface **330** comprising display **340**, which is typically a touch-screen display. I/O interface **330** also optionally includes a keyboard and/or mouse (or other pointing device) **350** and touchpad **355**, tactile output generator **357** for generating tactile outputs on device **300** (e.g., similar to tactile output generator(s) **167** described above with reference to FIG. **1**A), sensors **359** (e.g., optical, acceleration, proximity, touch-sensitive, and/or contact intensity sensors similar to contact intensity sensor(s) **165** described above with reference to FIG. **1**A). Memory **370** includes high-speed random access memory, such as DRAM, SRAM, DDR RAM or other random access solid state memory devices; and optionally includes non-volatile memory, such as one or more magnetic disk storage devices, optical disk storage devices, flash memory devices, or other non-volatile solid state storage devices. Memory **370** optionally includes one or more storage devices remotely located from CPU(s) **310**. In some embodiments, memory **370** stores programs, modules, and data structures analogous to the programs, modules, and data structures stored in memory **102** of portable multifunction device **100** (FIG. **1**A), or a subset thereof. Furthermore, memory **370** optionally stores additional programs, modules, and data structures not present in memory **102** of portable multifunction device **100**. For example, memory **370** of device **300** optionally stores drawing module **380**, presentation module **382**, word processing module **384**, website creation module **386**, disk authoring module **388**, and/or spreadsheet module **390**, while memory **102** of portable multifunction device **100** (FIG. **1**A) optionally does not store these modules.

[0190] Each of the above identified elements in FIG. **3** are, optionally, stored in one or more of the previously mentioned memory devices. Each of the above identified modules corresponds to a set of instructions for performing a function described above. The above identified modules or programs (i.e., sets of instructions) need not be implemented as separate software programs, procedures or modules, and thus various subsets of these modules are, optionally, combined or otherwise re-arranged in various embodiments. In some embodiments, memory **370** optionally stores a subset of the modules and data structures identified above. Furthermore, memory **370** optionally stores additional modules and data structures not described above.

[0191] Attention is now directed towards embodiments of user interfaces ("UI") that are, optionally, implemented on portable multifunction device **100**.

[0192] FIG. **4**A illustrates an example user interface for a menu of applications on portable multifunction device **100** in accordance with some embodiments. Similar user interfaces are, optionally, implemented on device **300**. In some embodiments, user interface **400** includes the following elements, or a subset or superset thereof:

- **[0193]** Signal strength indicator(s) **402** for wireless communication(s), such as cellular and Wi-Fi signals;
- **[0194]** Time **404**;
- **[0195]** Bluetooth indicator **405**;
- **[0196]** Battery status indicator **406**;
- **[0197]** Tray **408** with icons for frequently used applications, such as:
  - **[0198]** Icon **416** for telephone module **138**, labeled "Phone," which optionally includes an indicator **414** of the number of missed calls or voicemail messages;
  - **[0199]** Icon **418** for e-mail client module **140**, labeled "Mail," which optionally includes an indicator **410** of the number of unread e-mails;
  - **[0200]** Icon **420** for browser module **147**, labeled "Browser;" and
  - **[0201]** Icon **422** for video and music player module **152**, also referred to as iPod (trademark of Apple Inc.) module **152**, labeled "iPod;" and
- **[0202]** Icons for other applications, such as:
  - **[0203]** Icon **424** for IM module **141**, labeled "Messages;"
  - **[0204]** Icon **426** for calendar module **148**, labeled "Calendar;"
  - **[0205]** Icon **428** for image management module **144**, labeled "Photos;"
  - **[0206]** Icon **430** for camera module **143**, labeled "Camera;"
  - **[0207]** Icon **432** for online video module **155**, labeled "Online Video;"
  - **[0208]** Icon **434** for stocks widget **149-2**, labeled "Stocks;"
  - **[0209]** Icon **436** for map module **154**, labeled "Maps;"
  - **[0210]** Icon **438** for weather widget **149-1**, labeled "Weather;"
  - **[0211]** Icon **440** for alarm clock widget **149-4**, labeled "Clock;"
  - **[0212]** Icon **442** for workout support module **142**, labeled "Workout Support;"
  - **[0213]** Icon **444** for notes module **153**, labeled "Notes;" and
  - **[0214]** Icon **446** for a settings application or module, which provides access to settings for device **100** and its various applications **136**.

[0215] It should be noted that the icon labels illustrated in FIG. **4**A are merely examples. For example, in some embodiments, icon **422** for video and music player module **152** is labeled "Music" or "Music Player." Other labels are, optionally, used for various application icons. In some embodiments, a label for a respective application icon includes a name of an application corresponding to the respective application icon. In some embodiments, a label for a particular application icon is distinct from a name of an application corresponding to the particular application icon.

[0216] FIG. **4**B illustrates an example user interface on a device (e.g., device **300**, FIG. **3**) with a touch-sensitive surface **451** (e.g., a tablet or touchpad **355**, FIG. **3**) that is separate from the display **450**. Device **300** also, optionally, includes one or more contact intensity sensors (e.g., one or more of sensors **357**) for detecting intensities of contacts on touch-sensitive surface **451** and/or one or more tactile output generators **359** for generating tactile outputs for a user of device **300**.

[0217] Although many of the examples that follow will be given with reference to inputs on touch screen display **112** (where the touch sensitive surface and the display are combined), in some embodiments, the device detects inputs on a touch-sensitive surface that is separate from the display, as shown in FIG. **4**B. In some embodiments, the touch-sensitive surface (e.g., **451** in FIG. **4**B) has a primary axis (e.g., **452** in FIG. **4**B) that corresponds to a primary axis (e.g., **453** in FIG. **4**B) on the display (e.g., **450**). In accordance with these embodiments, the device detects contacts (e.g., **460** and **462** in FIG. **4**B) with the touch-sensitive surface **451** at locations that correspond to respective locations on the display (e.g., in FIG. **4**B, contact **460** corresponds to **468** and contact **462** corresponds to **470**). In this way, user inputs (e.g., contacts **460** and **462**, and movements thereof) detected by the device on the touch-sensitive surface (e.g., **451** in FIG. **4**B) are used by the device to manipulate the user interface on the display (e.g., **450** in FIG. **4**B) of the multifunction device when the touch-sensitive surface is separate from the display. It should be understood that similar methods are, optionally, used for other user interfaces described herein.

[0218] Additionally, while the following examples are given primarily with reference to finger inputs (e.g., finger contacts, finger tap gestures, finger swipe gestures, etc.), it should be understood that, in some embodiments, one or more of the finger inputs are replaced with input from another input device (e.g., a mouse based input or a stylus input). For example, a swipe gesture is, optionally, replaced with a mouse click (e.g., instead of a contact) followed by movement of the cursor along the path of the swipe (e.g., instead of movement of the contact). As another example, a tap gesture is, optionally, replaced with a mouse click while the cursor is located over the location of the tap gesture (e.g., instead of detection of the contact followed by ceasing to detect the contact). Similarly, when multiple user inputs are simultaneously detected, it should be understood that multiple computer mice are, optionally, used simultaneously, or a mouse and finger contacts are, optionally, used simultaneously.

[0219] As used herein, the term "focus selector" is an input element that indicates a current part of a user interface with which a user is interacting. In some implementations that include a cursor or other location marker, the cursor acts as a "focus selector," so that when an input (e.g., a press input) is detected on a touch-sensitive surface (e.g., touchpad **355** in FIG. **3** or touch-sensitive surface **451** in FIG. **4**B) while the cursor is over a particular user interface element (e.g., a button, window, slider or other user interface element), the particular user interface element is adjusted in accordance with the detected input. In some implementations that include a touch-screen display (e.g., touch-sensitive display system **112** in FIG. **1**A or the touch screen in FIG. **4**A) that enables direct interaction with user interface elements on the touch-screen display, a detected contact on the touch-screen acts as a "focus selector," so that when an input (e.g., a press input by the contact) is detected on the touch-screen display at a location of a particular user interface element (e.g., a button, window, slider or other user interface element), the particular user interface element is adjusted in accordance with the detected input. In some implementations, focus is moved from one region of a user interface to another region of the user interface without corresponding movement of a cursor or movement of a contact on a touch-screen display (e.g., by using a tab key or arrow keys to move focus from one button to another button); in these implementations, the focus selector moves in accordance with movement of focus between different regions of the user interface. Without regard to the specific form taken by the focus selector, the focus selector is generally the user interface element (or contact on a touch-screen display) that is controlled by the user so as to communicate the user's intended interaction with the user interface (e.g., by indicating, to the device, the element of the user interface with which the user is intending to interact). For example, the location of a focus selector (e.g., a cursor, a contact, or a selection box) over a respective button while a press input is detected on the touch-sensitive surface (e.g., a touchpad or touch screen) will indicate that the user is intending to activate the respective button (as opposed to other user interface elements shown on a display of the device).

[0220] As used in the specification and claims, the term "intensity" of a contact on a touch-sensitive surface is the force or pressure (force per unit area) of a contact (e.g., a finger contact or a stylus contact) on the touch-sensitive surface, or to a substitute (proxy) for the force or pressure of a contact on the touch-sensitive surface. The intensity of a contact has a range of values that includes at least four distinct values and more typically includes hundreds of distinct values (e.g., at least 256). Intensity of a contact is, optionally, determined (or measured) using various approaches and various sensors or combinations of sensors. For example, one or more force sensors underneath or adjacent to the touch-sensitive surface are, optionally, used to measure force at various points on the touch-sensitive surface. In some implementations, force measurements from multiple force sensors are combined (e.g., a weighted average or a sum) to determine an estimated force of a contact. Similarly, a pressure-sensitive tip of a stylus is, optionally, used to determine a pressure of the stylus on the touch-sensitive surface. Alternatively, the size of the contact area detected on the touch-sensitive surface and/or changes thereto, the capacitance of the touch-sensitive surface proximate to the contact and/or changes thereto, and/or the resistance of the touch-sensitive surface proximate to the contact and/or changes thereto are, optionally, used as a substitute for the force or pressure of the contact on the touch-sensitive surface. In some implementations, the substitute measurements for contact force or pressure are used directly to determine whether an intensity threshold has been exceeded (e.g., the intensity threshold is described in units corresponding to the substitute measurements). In some implementations, the substitute measurements for contact force or pressure are converted to an estimated force or pressure and the estimated force or pressure is used to determine whether an intensity threshold has been exceeded (e.g., the intensity threshold is a pressure threshold measured in units of pressure). Using the intensity of a contact as an attribute of a user input allows for user access to additional device functionality that may otherwise not be readily accessible by the user on a reduced-size device with limited real estate for displaying affordances (e.g., on a touch-sensitive display) and/or receiving user input (e.g., via a touch-sensitive display, a touch-sensitive surface, or a physical/mechanical control such as a knob or a button).

[0221] In some embodiments, contact/motion module **130** uses a set of one or more intensity thresholds to determine whether an operation has been performed by a user (e.g., to determine whether a user has "clicked" on an icon). In some embodiments, at least a subset of the intensity thresholds are determined in accordance with software parameters (e.g., the intensity thresholds are not determined by the activation thresholds of particular physical actuators and can be adjusted without changing the physical hardware of device **100**). For example, a mouse "click" threshold of a trackpad or touch-screen display can be set to any of a large range of predefined thresholds values without changing the trackpad or touch-screen display hardware. Additionally, in some implementations a user of the device is provided with software settings for adjusting one or more of the set of intensity thresholds (e.g., by adjusting individual intensity thresholds and/or by adjusting a plurality of intensity thresholds at once with a system-level click "intensity" parameter).

[0222] As used in the specification and claims, the term "characteristic intensity" of a contact is a characteristic of the contact based on one or more intensities of the contact. In some embodiments, the characteristic intensity is based on multiple intensity samples. The characteristic intensity is, optionally, based on a predefined number of intensity samples, or a set of intensity samples collected during a predetermined time period (e.g., 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10 seconds) relative to a predefined event (e.g., after detecting the contact, prior to detecting liftoff of the contact, before or after detecting a start of movement of the contact, prior to detecting an end of the contact, before or after detecting an increase in intensity of the contact, and/or before or after detecting a decrease in intensity of the contact). A characteristic intensity of a contact is, optionally based on one or more of: a maximum value of the intensities of the contact, a mean value of the intensities of the contact, an average value of the intensities of the contact, a top 10 percentile value of the intensities of the contact, a value at the half maximum of the intensities of the contact, a value at the 90 percent maximum of the intensities of the contact, a value produced by low-pass filtering the intensity of the contact over a predefined period or starting at a predefined time, or the like. In some embodiments, the duration of the contact is used in determining the characteristic intensity (e.g., when the characteristic intensity is an average of the intensity of the contact over time). In some embodiments, the characteristic intensity is compared to a set of one or more intensity thresholds to determine whether an operation has been performed by a user. For example, the set of one or more intensity thresholds may include a first intensity threshold and a second intensity threshold. In this example, a contact with a characteristic intensity that does not exceed the first threshold results in a first operation, a contact with a characteristic intensity that exceeds the first intensity threshold and does not exceed the second intensity threshold results in a second operation, and a contact with a characteristic intensity that exceeds the second intensity threshold results in a third operation. In some embodiments, a comparison between the characteristic intensity and one or more intensity thresholds is used to determine whether or not to perform one or more operations (e.g., whether to perform a respective option or forgo performing the respective operation) rather than being used to determine whether to perform a first operation or a second operation.

[0223] In some embodiments, a portion of a gesture is identified for purposes of determining a characteristic intensity. For example, a touch-sensitive surface may receive a continuous swipe contact transitioning from a start location and reaching an end location (e.g., a drag gesture), at which point the intensity of the contact increases. In this example, the characteristic intensity of the contact at the end location may be based on only a portion of the continuous swipe contact, and not the entire swipe contact (e.g., only the portion of the swipe contact at the end location). In some embodiments, a smoothing algorithm may be applied to the intensities of the swipe contact prior to determining the characteristic intensity of the contact. For example, the smoothing algorithm optionally includes one or more of: an unweighted sliding-average smoothing algorithm, a triangular smoothing algorithm, a median filter smoothing algorithm, and/or an exponential smoothing algorithm. In some circumstances, these smoothing algorithms eliminate narrow spikes or dips in the intensities of the swipe contact for purposes of determining a characteristic intensity.

[0224] The user interface figures described herein optionally include various intensity diagrams that show the current intensity of the contact on the touch-sensitive surface relative to one or more intensity thresholds (e.g., a contact detection intensity threshold IT_0, a light press intensity threshold IT_L, a deep press intensity threshold IT_D (e.g., that is at least initially higher than I_L), and/or one or more other intensity thresholds (e.g., an intensity threshold I_H that is lower than I_L)). This intensity diagram is typically not part of the displayed user interface, but is provided to aid in the interpretation of the figures. In some embodiments, the light press intensity threshold corresponds to an intensity at which the device will perform operations typically associated with clicking a button of a physical mouse or a trackpad. In some embodiments, the deep press intensity threshold corresponds to an intensity at which the device will perform operations that are different from operations typically associated with clicking a button of a physical mouse or a trackpad. In some embodiments, when a contact is detected with a characteristic intensity below the light press intensity threshold (e.g., and above a nominal contact-detection intensity threshold IT_0 below which the contact is no longer detected), the device will move a focus selector in accordance with movement of the contact on the touch-sensitive surface without performing an operation associated with the light press intensity threshold or the deep press intensity threshold. Generally, unless otherwise stated, these intensity thresholds are consistent between different sets of user interface figures.

[0225] In some embodiments, the response of the device to inputs detected by the device depends on criteria based on the contact intensity during the input. For example, for some "light press" inputs, the intensity of a contact exceeding a first intensity threshold during the input triggers a first response. In some embodiments, the response of the device to inputs detected by the device depends on criteria that include both the contact intensity during the input and time-based criteria. For example, for some "deep press" inputs, the intensity of a contact exceeding a second intensity threshold during the input, greater than the first intensity threshold for a light press, triggers a second response only if a delay time has elapsed between meeting the first intensity threshold and meeting the second intensity threshold. This delay time is typically less than 200 ms in duration (e.g., 40, 100, or 120 ms, depending on the magnitude of the second intensity threshold, with the delay time increasing as the second intensity threshold increases). This delay time helps to avoid accidental recognition of deep press inputs. As another example, for some "deep press" inputs, there is a reduced-sensitivity time period that occurs after the time at which the first intensity threshold is met. During the reduced-sensitivity time period, the second intensity threshold is increased. This temporary increase in the second intensity threshold also helps to avoid accidental deep press inputs. For other deep press inputs, the response to detection of a deep press input does not depend on time-based criteria.

[0226] In some embodiments, one or more of the input intensity thresholds and/or the corresponding outputs vary based on one or more factors, such as user settings, contact motion, input timing, application running, rate at which the intensity is applied, number of concurrent inputs, user history, environmental factors (e.g., ambient noise), focus selector position, and the like. Example factors are described in U.S. patent application Ser. Nos. 14/399,606 and 14/624,296, which are incorporated by reference herein in their entireties.

[0227] For example, FIG. **4**C illustrates a dynamic intensity threshold **480** that changes over time based in part on the intensity of touch input **476** over time. Dynamic intensity threshold **480** is a sum of two components, first component **474** that decays over time after a predefined delay time p1 from when touch input **476** is initially detected, and second component **478** that trails the intensity of touch input **476** over time. The initial high intensity threshold of first component **474** reduces accidental triggering of a "deep press" response, while still allowing an immediate "deep press" response if touch input **476** provides sufficient intensity. Second component **478** reduces unintentional triggering of a "deep press" response by gradual intensity fluctuations of in a touch input. In some embodiments, when touch input **476** satisfies dynamic intensity threshold **480** (e.g., at point **481** in FIG. **4**C), the "deep press" response is triggered.

[0228] FIG. **4**D illustrates another dynamic intensity threshold **486** (e.g., intensity threshold I_D). FIG. **4**D also illustrates two other intensity thresholds: a first intensity threshold I_H and a second intensity threshold I_L. In FIG. **4**D, although touch input **484** satisfies the first intensity threshold I_H and the second intensity threshold I_L prior to time p2, no response is provided until delay time p2 has elapsed at time **482**. Also in FIG. **4**D, dynamic intensity threshold **486** decays over time, with the decay starting at time **488** after a predefined delay time p1 has elapsed from time **482** (when the response associated with the second intensity threshold I_L was triggered). This type of dynamic intensity threshold reduces accidental triggering of a response associated with the dynamic intensity threshold I_D immediately after, or concurrently with, triggering a response associated with a lower intensity threshold, such as the first intensity threshold I_H or the second intensity threshold I_L.

[0229] FIG. **4**E illustrate yet another dynamic intensity threshold **492** (e.g., intensity threshold I_D). In FIG. **4**E, a response associated with the intensity threshold I_L is triggered after the delay time p2 has elapsed from when touch input **490** is initially detected. Concurrently, dynamic intensity threshold **492** decays after the predefined delay time p1 has elapsed from when touch input **490** is initially detected. So a decrease in intensity of touch input **490** after triggering the response associated with the intensity threshold I_L, followed by an increase in the intensity of touch input **490**, without releasing touch input **490**, can trigger a response associated with the intensity threshold I_D (e.g., at time **494**) even when the intensity of touch input **490** is below another intensity threshold, for example, the intensity threshold IL.

[0230] An increase of characteristic intensity of the contact from an intensity below the light press intensity threshold IT_L to an intensity between the light press intensity threshold IT_L and the deep press intensity threshold IT_D is sometimes referred to as a "light press" input. An increase of characteristic intensity of the contact from an intensity below the deep press intensity threshold IT_D to an intensity above the deep press intensity threshold IT_D is sometimes referred to as a "deep press" input. An increase of characteristic intensity of the contact from an intensity below the contact-detection intensity threshold IT_0 to an intensity between the contact-detection intensity threshold IT_0 and the light press intensity threshold IT_L is sometimes referred to as detecting the contact on the touch-surface. A decrease of characteristic intensity of the contact from an intensity above the contact-detection intensity threshold IT_0 to an intensity below the contact-detection intensity threshold IT_0 is sometimes referred to as detecting liftoff of the contact from the touch-surface. In some embodiments IT_0 is zero. In some embodiments, IT_0 is greater than zero. In some illustrations a shaded circle or oval is used to represent intensity of a contact on the touch-sensitive surface. In some illustrations, a circle or oval without shading is used represent a respective contact on the touch-sensitive surface without specifying the intensity of the respective contact.

[0231] In some embodiments, described herein, one or more operations are performed in response to detecting a gesture that includes a respective press input or in response to detecting the respective press input performed with a respective contact (or a plurality of contacts), where the respective press input is detected based at least in part on detecting an increase in intensity of the contact (or plurality of contacts) above a press-input intensity threshold. In some embodiments, the respective operation is performed in response to detecting the increase in intensity of the respective contact above the press-input intensity threshold (e.g., the respective operation is performed on a "down stroke" of the respective press input). In some embodiments, the press input includes an increase in intensity of the respective contact above the press-input intensity threshold and a subsequent decrease in intensity of the contact below the press-input intensity threshold, and the respective operation is performed in response to detecting the subsequent decrease in intensity of the respective contact below the press-input threshold (e.g., the respective operation is performed on an "up stroke" of the respective press input).

[0232] In some embodiments, the device employs intensity hysteresis to avoid accidental inputs sometimes termed "jitter," where the device defines or selects a hysteresis intensity threshold with a predefined relationship to the press-input intensity threshold (e.g., the hysteresis intensity threshold is X intensity units lower than the press-input intensity threshold or the hysteresis intensity threshold is 75%, 90%, or some reasonable proportion of the press-input intensity threshold). Thus, in some embodiments, the press input includes an increase in intensity of the respective contact above the press-input intensity threshold and a subsequent decrease in intensity of the contact below the hysteresis intensity threshold that corresponds to the press-input intensity threshold, and the respective operation is performed in response to detecting the subsequent decrease in intensity of the respective contact below the hysteresis intensity threshold (e.g., the respective operation is performed on an "up stroke" of the respective press input). Similarly, in some embodiments, the press input is detected only when the device detects an increase in intensity of the contact from an intensity at or below the hysteresis intensity threshold to an intensity at or above the press-input intensity threshold and, optionally, a subsequent decrease in intensity of the contact to an intensity at or below the hysteresis intensity, and the respective operation is performed in response to detecting the press input (e.g., the increase in intensity of the contact or the decrease in intensity of the contact, depending on the circumstances).

[0233] For ease of explanation, the description of operations performed in response to a press input associated with a press-input intensity threshold or in response to a gesture including the press input are, optionally, triggered in response to detecting: an increase in intensity of a contact above the press-input intensity threshold, an increase in intensity of a contact from an intensity below the hysteresis intensity threshold to an intensity above the press-input intensity threshold, a decrease in intensity of the contact below the press-input intensity threshold, or a decrease in intensity of the contact below the hysteresis intensity threshold corresponding to the press-input intensity threshold. Additionally, in examples where an operation is described as being performed in response to detecting a decrease in intensity of a contact below the press-input intensity threshold, the operation is, optionally, performed in response to detecting a decrease in intensity of the contact below a hysteresis intensity threshold corresponding to, and lower than, the press-input intensity threshold. As described above, in some embodiments, the triggering of these responses also depends on time-based criteria being met (e.g., a delay time has elapsed between a first intensity threshold being met and a second intensity threshold being met).

User Interfaces and Associated Processes

[0234] Attention is now directed towards embodiments of user interfaces ("UI") and associated processes that may be implemented on an electronic device, such as portable multifunction device **100** or device **300**, with a display, a touch-sensitive surface, one or more tactile output generators for generating tactile outputs, and (optionally) one or more sensors to detect intensities of contacts with the touch-sensitive surface.

[0235] These user interfaces and associated processes provide new, improved ways to use haptic feedback to:

- **[0236]** indicate hidden thresholds;
- **[0237]** perform scrubbing, such as index bar scrubbing, variable rate scrubbing, and slider scrubbing;
- **[0238]** enhance rubber band effects;
- **[0239]** drag and drop objects;
- **[0240]** indicate device orientation; and
- **[0241]** scroll movable user interface components that represent selectable options.

[0242] FIGS. **5**A-**5**Q illustrate example user interfaces for providing tactile outputs during variable rate scrubbing in accordance with some embodiments. The user interfaces in these figures are used to illustrate the processes described below, including the processes in FIGS. **6**A-**6**G. For convenience of explanation, some of the embodiments will be discussed with reference to operations performed on a device with a touch-sensitive display system **112**. In such embodiments, the focus selector is, optionally: a respective finger or stylus contact, a representative point corresponding to a finger or stylus contact (e.g., a centroid of a respective contact or a point associated with a respective contact), or a centroid of two or more contacts detected on the touch-sensitive display system **112**. However, analogous operations are, optionally, performed on a device with a display **450** and a separate touch-sensitive surface **451** in response to detecting the contacts on the touch-sensitive surface **451** while displaying the user interfaces shown in the figures on the display **450**, along with a focus selector.

[0243] FIGS. **5**A-**5**D illustrate initiating playing of content in a content player at a regular playback speed.

[0244] FIG. **5**A displays a user interface **702** for a media content player that includes: a slider control **704**; an adjustable progress indicator **706** in the slider control that indicates a current position in the content being played on the device; and other media content player controls, such as a play/pause icon **714**.

[0245] In FIG. **5**B, the device detects an input on the play/pause icon **714**, such as a tap gesture by contact **716**, which initiates playback of the content at a regular playback speed, as shown in FIGS. **5**C-**5**D.

[0246] FIGS. **5**E-**5**K illustrate movement **720** of contact **718** (e.g., in a drag gesture) from the progress indicator **706**, away from the slider control **704**, and across boundaries **708**, **710**, and **712**. In some embodiments, boundaries **708**, **710**, and **712** are visually marked in user interface **702**. In some embodiments, boundaries **708**, **710**, and **712** are invisible boundaries. In some embodiments, each boundary is optionally displayed briefly when it is crossed by a contact. In some embodiments, the boundaries separate areas that correspond to different scrubbing rates for adjusting the position of the progress indicator **706** in slider control **704**. In some embodiments, while contact **718** (which started on progress indicator **706**) is above boundary **708**, the position of the progress indicator **706** in the slider control **704** moves by the same amount as the horizontal component of movement of contact **718** on the display, parallel to the slider control (so-called "full-speed scrubbing"). While contact **718** is between boundary **708** and boundary **710**, the position of the progress indicator **706** in the slider control **704** moves by an amount that is just a fraction (e.g., ½ or equivalently 50%) of the horizontal component of movement of contact **718** on the display, parallel to the slider control (so-called "half-speed scrubbing"). While contact **718** is between boundary **710** and boundary **712**, the position of the progress indicator **706** in the slider control **704** moves by an amount that is an even smaller fraction (e.g., ¼ or equivalently 25%) of the horizontal component of movement of contact **718** on the display, parallel to the slider control (so-called "quarter-speed scrubbing"). While contact **718** is below boundary **712**, the position of the progress indicator **706** in the slider control **704** moves by an amount that is a still smaller fraction (e.g., ⅛ or equivalently 12.5%) of the horizontal component of movement of contact **718** on the display, parallel to the slider control (so-called "fine-speed scrubbing"). The fractional scrubbing rates used here (50%, 25%, and 12.5%) are just examples. Different scrubbing rates that progressively decrease as the vertical distance between the contact and the slider control increases could also be used.

[0247] The device provides tactile outputs (e.g., a MicroTap medium (150 Hz), Gain max: 0.8, Gain min: 0.0) to help a user adjust the scrubbing rate and quickly and precisely adjust the position of the progress indicator **706**. In some embodiments, tactile outputs are triggered when the contact **718** crosses each of boundaries **708**, **710**, and **712**. For example, tactile output **726** (FIG. **5**G) is produced when contact **718** crosses boundary **708**; tactile output **728** (FIG. **5**I) is produced when contact **718** crosses boundary **710**; and tactile output **730** (FIG. **5**K) is produced when the contact **718** crosses boundary **712**. These tactile outputs provide feedback to the user that the scrubbing rate is changing, which helps the user to select and use the desired scrubbing rate (e.g., initially using full-speed scrubbing to move the progress indicator quickly and then using slower scrubbing speeds to more precisely adjust the position of the progress indicator).

[0248] In some embodiments, crossing boundaries **708**, **710**, and **712** also triggers concurrent changes in visual feedback to the user. For example, the displayed text "Full-Speed Scrubbing" (e.g., as shown by scrubbing speed indicator **722**-*a* in FIGS. **5**E-**5**F) is changed to "Half-Speed Scrubbing" (e.g., as shown by scrubbing speed indicator **722**-*b* in FIG. **5**G) when the contact **718** crosses boundary **708**; the displayed text "Half-Speed Scrubbing" (e.g., as shown by scrubbing speed indicator **722**-*b* in FIGS. **5**G-**5**H) is changed to "Quarter-Speed Scrubbing" (e.g., as shown by scrubbing speed indicator **722**-*c* in FIG. **5**I) when the contact **718** crosses boundary **710**; and the displayed text "Quarter-Speed Scrubbing" (e.g., as shown by scrubbing speed indicator **722**-*c* in FIGS. **5**I-**5**J) is changed to "Fine-Speed Scrubbing" (e.g., as shown by scrubbing speed indicator **722**-*a* in FIG. **5**K) when the contact **718** crosses boundary **712**. Providing concurrent visual feedback enhances the overall feedback to the user that the scrubbing rate is changing, which helps the user to select and use the desired scrubbing rate.

[0249] FIGS. **5**L-**5**Q illustrate movement **720** of the contact **718** (e.g., in a continuation of the drag gesture in FIGS. **5**E-**5**K) back towards the slider control **704**, first across boundary **712**, then across boundary **710**, and then across boundary **708**. In some embodiments, the device provides tactile outputs when the contact **718** crosses each of boundaries **712**, **710**, and **708**, and concurrently adjusts the scrubbing rate (e.g., from fine-speed scrubbing to quarter-speed scrubbing, to half-speed scrubbing, and then to full-speed scrubbing).

[0250] In some embodiments, the characteristics of a given tactile output depend on the characteristics of the movement of the contact **718**. In some embodiments, the device determines the velocity of the contact **718** at the time that a given boundary (or other threshold) is crossed. In some embodiments, the tactile output pattern is adjusted in accordance with the velocity of the contact when the boundary is crossed. In some embodiments, a gain factor applied to the amplitude of the tactile output pattern increases as the velocity of the contact at the boundary increases. For example, in FIG. **5**G, the velocity of movement **720**-*c* of the contact **718**-*c* at boundary **708** is between a medium speed threshold V_M and a fast speed threshold V_F and a medium gain is applied in tactile output **726** (e.g., MicroTap (150 Hz), Gain: 0.5). The same tactile output pattern occurs in FIGS. **5**N (e.g., for tactile output **732**), **50** (e.g., for tactile output **734**), and **5**P (e.g., for tactile output **736**) because the velocity of movement **720** of the contact **718** at the boundary crossings in these figures is between V_M and V_F. In contrast, in FIG. **5**I, the velocity of movement **720**-*e* of the contact **718**-*e* at boundary **710** is above the fast speed threshold V_F and a large gain is applied in tactile output **728** (e.g., MicroTap (150 Hz), Gain: 0.8). Conversely, in FIG. **5**K, the velocity of movement **720**-*g* of the contact **718**-*g* at boundary **712** is between the medium speed threshold V_M and a low speed threshold V_0 and a small gain is applied in tactile output **730** (e.g., MicroTap (150 Hz), Gain: 0.3). This increase in gain/amplitude with velocity increases feedback to the user, which the user might otherwise miss because of the rapid contact movement. In some embodiments, the gain factor increases with the total velocity of the contact at the boundary (or other threshold). In some embodiments, the gain factor increases with the vertical component of the velocity of the contact at the boundary (or other threshold).

[0251] FIGS. **6**A-**6**G are flow diagrams illustrating a method **2400** of providing haptic feedback during variable rate scrubbing in accordance with some embodiments. The method **2400** is performed at an electronic device (e.g., device **300**, FIG. **3**, or portable multifunction device **100**, FIG. **1**A) with a display, a touch-sensitive surface, one or more tactile output generators for generating tactile outputs, and optionally one or more sensors to detect intensities of contacts with the touch-sensitive surface. In some embodiments, the display is a touch-screen display and the touch-sensitive surface is on or integrated with the display. In some embodiments, the display is separate from the touch-sensitive surface. Some operations in method **2400** are, optionally, combined and/or the order of some operations is, optionally, changed.

[0252] As described below, the method **2400** relates to providing haptic feedback when a boundary between zones associated with two different adjustment rates of an adjustable control is crossed by a focus selector in accordance with movement of a contact across a touch-sensitive surface. Haptic feedback indicating the crossing of the boundary between such zones is advantageous over conventional visual feedback without haptic feedback because it is easier to notice and less distracting than some types of visual feedback. Additionally, tactile feedback provides valuable information to the user for touch screen user interfaces where the user's finger is obscuring corresponding visual feedback. Additionally, with haptic feedback, the boundary between adjacent zones need not be visually marked in the control user interface, and the changes in the user interface that correspond to the crossing of the boundary may be made more subtle and less intrusive to avoid visually cluttering the user interface and/or unnecessarily distracting the user from a task at hand. With haptic feedback, the user does not need to be as visually focused on the user interface while providing an input (e.g., a swipe gesture). Providing this improved nonvisual feedback enhances the operability of the device (e.g., by non-visually alerting the user that an adjustment rate has changed during an input) and makes the user-device interface more efficient (e.g., by helping the user to provide proper inputs and reducing user mistakes when operating/interacting with the device).

[0253] The device displays (**2402**) a user interface on the display, where the user interface includes an adjustable control (e.g., slider control **704** with adjustable progress indicator **706**, FIG. **5**A). In some embodiments, the adjustable control is a progress indicator with a scrubbing thumb or icon. In some embodiments, the adjustable control is an indication of progress along a predefine path that is configured to move along the predefined path in the user interface. In some embodiments, the adjustable control is a position indicator or progress icon that is configured to move back and forth along a linear slider control (e.g., an audio/video scrubber) in accordance with a drag input by a contact. In some embodiments, the adjustable control is a rotatable dial that is configured to rotate back and forth around an axis in accordance with a drag input by a contact or a rotation input by two contacts.

[0254] The device then detects (**2404**) a contact (or two concurrent contacts) on the touch-sensitive surface at a location that corresponds to the adjustable control on the display (e.g., contact **718**-*a*, FIG. **5**E), where movement of the contact that corresponds to movement away from the adjustable control changes an adjustment rate for adjusting the adjustable control based on movement of the contact (e.g., detecting touch-down of a contact while a focus selector is located on the progress indicator, or detecting touch-down of a contact on a touch-screen display at a location that corresponds to the progress indicator).

[0255] While continuously detecting (**2406**) the contact on the touch-sensitive surface (e.g., the drag input or rotation input is provided by a continuous contact moving across the touch-sensitive surface, after the progress indicator has been selected by the focus selector upon initial detection of the contact), the device detects (**2406**-*a*) a first movement of the contact across the touch-sensitive surface (e.g., a diagonal movement, or a vertical movement followed by a horizontal movement, or a horizontal movement followed by a vertical movement, or a series of zigzag movement that causes both horizontal displacements and vertical displacements of the focus selector, a rotational movement that includes both a radial component away from an axis and a rotational component around the axis, etc.). In response (**2406**-*b*) to detecting the first movement of the contact: in accordance with a determination that the first movement of the contact corresponds to more than a first threshold amount of movement of a focus selector away from the adjustable control (**2406**-*c*) (e.g., movement **720**-*c* of contact **718**-*c*, FIG. **5**G), where the first threshold amount of movement triggers a transition from a first adjustment rate to a second adjustment rate (e.g., from full-speed to half-speed scrubbing rate): the device generates (**2406**-*d*) a first tactile output **726**, FIG. **5**G (e.g., a MicroTap medium (150 Hz), Gain max: 0.8, Gain min: 0.0), via the one or more tactile output devices, when the focus selector has reached the first threshold amount of movement, and adjusts (**2406**-*e*) the adjustable control at the second adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the first threshold amount (e.g., movement **720**-*d* of contact **718**-*d*, FIG. **5**H); and in accordance with a determination that the first movement of the contact corresponds to less than the first threshold amount of movement of the focus selector away from the adjustable control (e.g., movement **720**-*a* of contact **718**-*a*, FIG. **5**E and movement **720**-*b* of contact **718**-*b*, FIG. **5**F), the device adjusts (**2406**-*f*) the adjustable control at the first adjustment rate in accordance with movement of the contact without generating the first tactile output.

[0256] In some embodiments, while continuously detecting (**2408**) the contact on the touch-sensitive surface, the device detects (**2408**-*a*) a second movement of the contact across the touch-sensitive surface (e.g., a diagonal movement, or a vertical movement followed by a horizontal movement, or a horizontal movement followed by a vertical movement, or a series of zigzag movement that causes both horizontal displacements and vertical displacements of the focus selector, a radial movement followed by a rotational movement, a spiral movement around a center of rotation, etc.). In response (**2408**-*b*) to detecting the second movement of the contact: in accordance with a determination that the second movement of the contact corresponds to more than a second threshold amount of movement of the focus selector away from the adjustable control (e.g., movement **720**-*e* of contact **718**-*e*, FIG. **5**I) (e.g., the second threshold amount of movement corresponds to a second threshold distance or a second threshold position away from the adjustable control in the vertical direction) (**2408**-*c*), where the second threshold amount of movement triggers a transition from the second adjustment rate to a third adjustment rate (e.g., from half-speed to quarter-speed scrubbing rate): the device generates (**2408**-*d*) a second tactile output **728**, FIG. **5**I (e.g., a MicroTap medium (150 Hz), Gain max: 0.8, Gain min: 0.0), via the one or more tactile output devices, when the focus selector has reached the second threshold amount of movement, and adjusts (**2408**-*e*) the adjustable control at the third adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the second threshold amount (e.g., movement **720**-*f* of contact **718**-*f*, FIG. **5**J); and in accordance with a determination that the second movement of the contact corresponds to less than the second threshold amount of movement of the focus selector away from the adjustable control (e.g., movement **720**-*d* of contact **718**-*d*, FIG. **5**H), the device adjusts (**2408**-*f*) the adjustable control at the second adjustment rate in accordance with movement of the contact without generating the second tactile output.

[0257] In some embodiments, while continuously detecting (**2410**) the contact on the touch-sensitive surface: the device detects (**2410**-*a*) a third movement of the contact across the touch-sensitive surface (e.g., a diagonal movement, or a vertical movement followed by a horizontal movement, or a horizontal movement followed by a vertical movement, or a series of zigzag movement that causes both horizontal displacements and vertical displacements of the focus selector, a radial movement followed by a rotational movement, a spiral movement around a center of rotation, etc.). In response (**2410**-*b*) to detecting the third movement of the contact: in accordance with a determination that the third movement of the contact corresponds to more than a third threshold amount of movement of the focus selector away from the adjustable control (e.g., movement **720**-*g* of contact **718**-*g*, FIG. **5**K) (e.g., the third threshold amount of movement corresponds to a third threshold distance or a third threshold position away from the adjustable control in the vertical direction) (**2410**-*c*), where the third threshold amount of movement triggers a transition from the third adjustment rate to a fourth adjustment rate (e.g., from quarter-speed to fine scrubbing speed): the device generates (**2410**-*d*) a third tactile output **730**, FIG. **5**K (e.g., a Micro-

Tap medium (150 Hz), Gain max: 0.8, Gain min: 0.0), via the one or more tactile output devices, when the focus selector has reached the third threshold amount of movement, and adjusts (**2410**-*e*) the adjustable control at the fourth adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the third threshold amount (e.g., movement **720**-*h* of contact **718**-*h*, FIG. **5**L); and in accordance with a determination that the third movement of the contact corresponds to less than the third threshold amount of movement of the focus selector away from the adjustable control (e.g., movement **720**-*f* of contact **718**-*f*, FIG. **5**J), the device adjusts (**2410**-*f*) the adjustable control at the third adjustment rate in accordance with movement of the contact without generating the third tactile output.

[0258] In some embodiments, while continuously detecting (**2412**) the contact on the touch-sensitive surface, the device detects (**2412**-*a*) a fourth movement of the contact across the touch-sensitive surface (e.g., a diagonal movement, or a vertical movement followed by a horizontal movement, or a horizontal movement followed by a vertical movement, or a series of zigzag movement that causes both horizontal displacements and vertical displacements of the focus selector, a radial movement followed by a rotational movement, a spiral movement around a center of rotation, etc.). In response (**2412**-*b*) to detecting the fourth movement of the contact: in accordance with a determination that the fourth movement of the contact corresponds to more than a fourth threshold amount of movement of the focus selector toward the adjustable control (e.g., movement **720-1** of contact **718-1**, FIG. **5**P) (e.g., the fourth threshold amount of movement corresponds to a fourth threshold distance or a fourth threshold position away from the adjustable control in the vertical direction) (**2412**-*c*), where the fourth threshold amount of movement triggers a transition from the second adjustment rate to the first adjustment rate (e.g., from half-speed to full-speed): the device generates (**2412**-*d*) a fourth tactile output **736**, FIG. **5**P (e.g., a MicroTap medium (150 Hz), Gain max: 0.8, Gain min: 0.0), via the one or more tactile output devices, when the focus selector has reached the fourth threshold amount of movement, and adjusts (**2412**-*e*) the adjustable control at the first adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the fourth threshold amount (e.g., movement **720** of contact **718**-*m*, FIG. **5**Q); and in accordance with a determination that the fourth movement of the contact corresponds to less than the fourth threshold amount of movement of the focus selector toward the adjustable control, the device adjusts (**2412**-*f*) the adjustable control at the second adjustment rate in accordance with movement of the contact without generating the fourth tactile output. In some embodiments, a corresponding tactile output is generated when a threshold position between regions corresponding to other adjustment rates is crossed by the contact as well.

[0259] In some embodiments, adjusting the adjustable control at a respective adjustment rate in accordance with movement of the contact includes (**2414**) adjusting the adjustable control by an amount (e.g., a linear amount or an angular amount) that is proportional to the movement of the contact in a respective direction (e.g., movement along the linear progress bar, or movement in a direction around a rotational axis) with a proportionality constant (e.g., 1, 0.5, 0.25, etc.) that corresponds to the respective adjustment rate (e.g., the full-speed adjustment rate, the half-speed adjustment rate, the quarter-speed adjustment rate, etc.).

[0260] In some embodiments, while continuously detecting the contact on the touch-sensitive surface: in response to detecting the first movement of the contact: in accordance with a determination that the first movement of the contact corresponds to more than the first threshold amount of movement of the focus selector away from the adjustable control, the device switches (**2416**) from displaying a visual indication of the first adjustment rate (e.g., the text "full-speed scrubbing," **722**-*a* in FIG. **5**F) to displaying a visual indication of the second adjustment rate (e.g., the text "half-speed scrubbing," **722**-*b* in FIG. **5**G); and in accordance with a determination that the first movement of the contact does not correspond to more than the first threshold amount of movement of the focus selector away from the adjustable control, the device maintains (**2416**-*b*) display of the visual indication of the first adjustment rate (e.g., the text "full-speed scrubbing").

[0261] In some embodiments, generating the first tactile output (**2418**), via the one or more tactile output devices, when the focus selector has reached the first threshold amount of movement includes determining (**2418**-*a*) a movement metric that corresponds to movement of the contact when the focus selector reaches the first threshold amount of movement (e.g., a movement speed of the contact when the first threshold amount of movement is reached, such as the velocity **718** of movement **720**-*c* of contact **718**-*c* in FIG. **5**G), and generating (**2418**-*b*) the first tactile output **726** in accordance with a tactile output pattern that is adjusted in accordance with the movement metric (e.g., a faster movement speed corresponds to a higher gain factor that is applied to the amplitude of the tactile output pattern).

[0262] In some embodiments, when the first threshold amount of movement is reached, an amplitude of the tactile output pattern is adjusted (**2420**) in accordance with a movement speed of the focus selector when the threshold amount of movement is reached. In some embodiments, when the first threshold amount of movement is movement in a respective direction relative to (e.g., perpendicular to) the linear scrubber, the movement speed is based on the speed of the focus selector in the respective direction.

[0263] In some embodiments, the adjustable control includes (**2422**) a movable indicator that is configured to move along a linear path in accordance with the movement of the focus selector, and movement (**2422**-*a*) of the focus selector (e.g., a contact) in a direction perpendicular to the linear path is required to move the focus selector from a first region in the user interface that corresponds to the first adjustment rate to a second region in the user interface that corresponds to the second adjustment rate. In some embodiments, the linear control includes a linear slider with a moveable indicator icon/knob (e.g., slider control **704** with adjustable progress indicator **706**, FIG. **5**A). In some embodiments, the linear control includes a media progress indicator that indicates current playback location of a media file. In some embodiments, the linear control includes a content browsing indicator that indicates the location of currently displayed page within multi-page content (e.g., an electronic book).

[0264] In some embodiments, the adjustable control includes (**2424**) a rotatable indicator that is configured to rotate around an axis in accordance with the movement of the focus selector, and movement (**2424**-*a*) of the focus selector (e.g., a contact) in a radial direction away from axis is required to move the focus selector from a first region in the user interface that corresponds to the first adjustment rate to a second region in the user interface that corresponds to the second adjustment rate. In some embodiments, the adjustable control includes a rotatable dial with a marker that corresponds to the start position. The dial is rotated by a movement of the focus selector that is around the axis. Movement of the focus selector in the radial direction corresponds to movement that changes the adjustment rate.

[0265] In some embodiments, in response to detecting the first movement of the contact, in accordance with a determination that the first movement of the contact corresponds to more than the first threshold amount of movement of the focus selector away from the adjustable control, where the first threshold amount of movement triggers a transition from the first adjustment rate to the second adjustment rate, the device adjusts (**2426**) the control at the first adjustment rate in accordance with movement of the contact that is detected before the focus selector has moved more than the first threshold amount (e.g., movement **720**-*a* of contact **718**-*a* in FIG. **5**E and movement **720**-*b* of contact **718**-*b* in FIG. **5**F).

[0266] In some embodiments, in response to detecting the first movement of the contact: in accordance with a determination that the first movement of the contact corresponds to more than a second threshold amount of movement of the focus selector away from the adjustable control (**2428**) (e.g., movement **720**-*e* of contact **718**-*e* in FIG. **5**I), where the second threshold amount of movement triggers a transition from the second adjustment rate to a third adjustment rate (e.g., from half-speed to quarter-speed scrubbing rate): the device generates (**2428**-*a*) a second tactile output **728**, FIG. **5**I (e.g., a MicroTap medium (150 Hz), Gain max: 0.8, Gain min: 0.0), via the one or more tactile output devices, when the focus selector has reached the second threshold amount of movement, and (e.g., in addition to or instead of generating the first tactile output) adjusts (**2428**-*b*) the adjustable control at a third adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the second threshold amount (e.g., movement **720**-*f* of contact **718**-*f* in FIG. **5**J. In some embodiments, the adjustable control is adjusted at the first adjustment rate in accordance with movement of the contact that is detected before the focus selector has moved more than the first threshold amount. In some embodiments, the adjustable control is adjusted at the second adjustment rate in accordance with movement of the contact that is detected before the focus selector has moved more than the second threshold amount (but has moved more than the first threshold amount).

[0267] In some embodiments, in response to detecting the first movement of the contact: in accordance with a determination that the first movement of the contact corresponds to more than a third threshold amount of movement of the focus selector away from the adjustable control (**2430**) (e.g., movement **720**-*g* of contact **718**-*g* in FIG. **5**K), where the third threshold amount of movement triggers a transition from a third adjustment rate to a fourth adjustment rate (e.g., from quarter-speed to a fine-speed scrubbing rate): the device generates (**2430**-*a*) a third tactile output **730**, FIG. **5**K (e.g., a MicroTap medium (150 Hz), Gain max: 0.8, Gain min: 0.0), via the one or more tactile output devices, when the focus selector has reached the third threshold amount of movement, and (e.g., in addition to or instead of generating the first tactile output and/or the second tactile output) adjusts (**2430**-*b*) the adjustable control at a fourth adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the third threshold amount (e.g., movement **720**-*h* of contact **718**-*h* in FIG. **5**L). In some embodiments, the adjustable control is adjusted at the first adjustment rate in accordance with movement of the contact that is detected before the focus selector has moved more than the first threshold amount. In some embodiments, the adjustable control is adjusted at the second adjustment rate in accordance with movement of the contact that is detected before the focus selector has moved more than the second threshold amount (but has moved more than the first threshold amount). In some embodiments, the adjustable control is adjusted at the third adjustment rate in accordance with movement of the contact that is detected before the focus selector has moved more than the third threshold amount (but has moved more than the second threshold amount).

[0268] It should be understood that the particular order in which the operations in FIGS. **6**A-**6**G have been described is merely exemplary and is not intended to indicate that the described order is the only order in which the operations could be performed. One of ordinary skill in the art would recognize various ways to reorder the operations described herein. Additionally, it should be noted that details of other processes described herein with respect to other methods described herein are also applicable in an analogous manner to method **2400** described above with respect to FIGS. **6**A-**6**G. For example, the contacts, gestures, user interface objects, tactile outputs, intensity thresholds, focus selectors, animations described above with reference to method **2400** optionally have one or more of the characteristics of the contacts, gestures, user interface objects, tactile outputs, intensity thresholds, focus selectors, animations described herein with reference to other methods described herein. For brevity, these details are not repeated here.

[0269] The foregoing description, for purpose of explanation, has been described with reference to specific embodiments. However, the illustrative discussions above are not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many modifications and variations are possible in view of the above teachings. The embodiments were chosen and described in order to best explain the principles of the invention and its practical applications, to thereby enable others skilled in the art to best use the invention and various described embodiments with various modifications as are suited to the particular use contemplated.

What is claimed is:

1. A method, comprising:

at an electronic device with a touch-sensitive surface, a display, and one or more tactile output generators for generating tactile outputs:

displaying a user interface on the display, wherein the user interface includes an adjustable control;

detecting a contact on the touch-sensitive surface at a location that corresponds to the adjustable control on the display, wherein movement of the contact that corresponds to movement away from the adjustable control changes an adjustment rate for adjusting the adjustable control based on movement of the contact;

while continuously detecting the contact on the touch-sensitive surface:
detecting a first movement of the contact across the touch-sensitive surface; and
in response to detecting the first movement of the contact:
in accordance with a determination that the first movement of the contact corresponds to more than a first threshold amount of movement of a focus selector away from the adjustable control, wherein the first threshold amount of movement triggers a transition from a first adjustment rate to a second adjustment rate:
generating a first tactile output, via the one or more tactile output generators, when the focus selector has reached the first threshold amount of movement; and
adjusting the adjustable control at the second adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the first threshold amount; and
in accordance with a determination that the first movement of the contact corresponds to less than the first threshold amount of movement of the focus selector away from the adjustable control, adjusting the adjustable control at the first adjustment rate in accordance with movement of the contact without generating the first tactile output.

2. The method of claim **1**, including:
while continuously detecting the contact on the touch-sensitive surface:
detecting a second movement of the contact across the touch-sensitive surface; and
in response to detecting the second movement of the contact:
in accordance with a determination that the second movement of the contact corresponds to more than a second threshold amount of movement of the focus selector away from the adjustable control, wherein the second threshold amount of movement triggers a transition from the second adjustment rate to a third adjustment rate;
generating a second tactile output, via the one or more tactile output generators, when the focus selector has reached the second threshold amount of movement; and
adjusting the adjustable control at the third adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the second threshold amount; and
in accordance with a determination that the second movement of the contact corresponds to less than the second threshold amount of movement of the focus selector away from the adjustable control, adjusting the adjustable control at the second adjustment rate in accordance with movement of the contact without generating the second tactile output.

3. The method of claim **2**, including:
while continuously detecting the contact on the touch-sensitive surface:
detecting a third movement of the contact across the touch-sensitive surface; and
in response to detecting the third movement of the contact:
in accordance with a determination that the third movement of the contact corresponds to more than a third threshold amount of movement of the focus selector away from the adjustable control, wherein the third threshold amount of movement triggers a transition from the third adjustment rate to a fourth adjustment rate:
generating a third tactile output, via the one or more tactile output generators, when the focus selector has reached the third threshold amount of movement; and
adjusting the adjustable control at the fourth adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the third threshold amount; and
in accordance with a determination that the third movement of the contact corresponds to less than the third threshold amount of movement of the focus selector away from the adjustable control, adjusting the adjustable control at the third adjustment rate in accordance with movement of the contact without generating the third tactile output.

4. The method of claim **1**, including:
while continuously detecting the contact on the touch-sensitive surface:
detecting a fourth movement of the contact across the touch-sensitive surface; and
in response to detecting the fourth movement of the contact:
in accordance with a determination that the fourth movement of the contact corresponds to more than a fourth threshold amount of movement of the focus selector toward the adjustable control, wherein the fourth threshold amount of movement triggers a transition from the second adjustment rate to the first adjustment rate:
generating a fourth tactile output, via the one or more tactile output generators, when the focus selector has reached the fourth threshold amount of movement; and
adjusting the adjustable control at the first adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the fourth threshold amount; and
in accordance with a determination that the fourth movement of the contact corresponds to less than the fourth threshold amount of movement of the focus selector toward the adjustable control, adjusting the adjustable control at the second adjustment rate in accordance with movement of the contact without generating the fourth tactile output.

5. The method of claim **1**, wherein adjusting the adjustable control at a respective adjustment rate in accordance with movement of the contact includes adjusting the adjustable control by an amount that is proportional to the movement of the contact in a respective direction with a proportionality constant that corresponds to the respective adjustment rate.

6. The method of claim 1, including:

while continuously detecting the contact on the touch-sensitive surface:

in response to detecting the first movement of the contact:

in accordance with a determination that the first movement of the contact corresponds to more than the first threshold amount of movement of the focus selector away from the adjustable control, switching from displaying a visual indication of the first adjustment rate to displaying a visual indication of the second adjustment rate; and

in accordance with a determination that the first movement of the contact does not correspond to more than the first threshold amount of movement of the focus selector away from the adjustable control, maintaining display of the visual indication of the first adjustment rate.

7. The method of claim 1, wherein generating the first tactile output, via the one or more tactile output generators, when the focus selector has reached the first threshold amount of movement includes:

determining a movement metric that corresponds to movement of the contact when the focus selector reaches the first threshold amount of movement; and

generating the first tactile output in accordance with a tactile output pattern that is adjusted in accordance with the movement metric.

8. The method of claim 7, wherein when the first threshold amount of movement is reached, an amplitude of the tactile output pattern is adjusted in accordance with a movement speed of the focus selector when the threshold amount of movement is reached.

9. The method of claim 1, wherein:

the adjustable control includes a movable indicator that is configured to move along a linear path in accordance with the movement of the focus selector, and

movement of the focus selector in a direction perpendicular to the linear path is required to move the focus selector from a first region in the user interface that corresponds to the first adjustment rate to a second region in the user interface that corresponds to the second adjustment rate.

10. The method of claim 1, wherein:

the adjustable control includes a rotatable indicator that is configured to rotate around an axis in accordance with the movement of the focus selector, and

movement of the focus selector in a radial direction away from axis is required to move the focus selector from a first region in the user interface that corresponds to the first adjustment rate to a second region in the user interface that corresponds to the second adjustment rate.

11. The method of claim 1, including, in response to detecting the first movement of the contact, in accordance with a determination that the first movement of the contact corresponds to more than the first threshold amount of movement of the focus selector away from the adjustable control, wherein the first threshold amount of movement triggers a transition from the first adjustment rate to the second adjustment rate, adjusting the control at the first adjustment rate in accordance with movement of the contact that is detected before the focus selector has moved more than the first threshold amount.

12. The method of claim 1, including, in response to detecting the first movement of the contact:

in accordance with a determination that the first movement of the contact corresponds to more than a second threshold amount of movement of the focus selector away from the adjustable control, wherein the second threshold amount of movement triggers a transition from the second adjustment rate to a third adjustment rate:

generating a second tactile output, via the one or more tactile output generators, when the focus selector has reached the second threshold amount of movement; and

adjusting the adjustable control at a third adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the second threshold amount.

13. The method of claim 1, including, in response to detecting the first movement of the contact:

in accordance with a determination that the first movement of the contact corresponds to more than a third threshold amount of movement of the focus selector away from the adjustable control, wherein the third threshold amount of movement triggers a transition from a third adjustment rate to a fourth adjustment rate:

generating a third tactile output, via the one or more tactile output generators, when the focus selector has reached the third threshold amount of movement; and

adjusting the adjustable control at a fourth adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the third threshold amount.

14. An electronic device, comprising:

a display;

a touch-sensitive surface;

one or more tactile output generators for generating tactile outputs;

one or more processors;

memory; and

one or more programs, wherein the one or more programs are stored in the memory and configured to be executed by the one or more processors, the one or more programs including instructions for:

displaying a user interface on the display, wherein the user interface includes an adjustable control;

detecting a contact on the touch-sensitive surface at a location that corresponds to the adjustable control on the display, wherein movement of the contact that corresponds to movement away from the adjustable control changes an adjustment rate for adjusting the adjustable control based on movement of the contact;

while continuously detecting the contact on the touch-sensitive surface:

detecting a first movement of the contact across the touch-sensitive surface; and

in response to detecting the first movement of the contact:

in accordance with a determination that the first movement of the contact corresponds to more than a first threshold amount of movement of a focus selector away from the adjustable control, wherein the first threshold amount of movement triggers a transition from a first adjustment rate to a second adjustment rate:

generating a first tactile output, via the one or more tactile output generators, when the focus selector has reached the first threshold amount of movement; and

adjusting the adjustable control at the second adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the first threshold amount; and

in accordance with a determination that the first movement of the contact corresponds to less than the first threshold amount of movement of the focus selector away from the adjustable control, adjusting the adjustable control at the first adjustment rate in accordance with movement of the contact without generating the first tactile output.

15. A computer readable storage medium storing one or more programs, the one or more programs comprising instructions, which when executed by an electronic device with a display, a touch-sensitive surface, and one or more tactile output generators for generating tactile outputs, cause the electronic device to:

display a user interface on the display, wherein the user interface includes an adjustable control;

detect a contact on the touch-sensitive surface at a location that corresponds to the adjustable control on the display, wherein movement of the contact that corresponds to movement away from the adjustable control changes an adjustment rate for adjusting the adjustable control based on movement of the contact;

while continuously detecting the contact on the touch-sensitive surface:

detect a first movement of the contact across the touch-sensitive surface; and

in response to detecting the first movement of the contact:

in accordance with a determination that the first movement of the contact corresponds to more than a first threshold amount of movement of a focus selector away from the adjustable control, wherein the first threshold amount of movement triggers a transition from a first adjustment rate to a second adjustment rate:

generate a first tactile output, via the one or more tactile output generators, when the focus selector has reached the first threshold amount of movement; and

adjust the adjustable control at the second adjustment rate in accordance with movement of the contact that is detected after the focus selector has moved more than the first threshold amount; and

in accordance with a determination that the first movement of the contact corresponds to less than the first threshold amount of movement of the focus selector away from the adjustable control, adjust the adjustable control at the first adjustment rate in accordance with movement of the contact without generating the first tactile output.

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