helping determine if a sound characteristic is present which is to be mapped to a haptic sensation, and the particular haptic sensation that is to be mapped. In other embodiments, such as where haptic sensation magnitude continuously follows sound amplitude (see FIGS. **9***a* and **9***b*), no specific features of the sound may need to be found.

In next step **316**, haptic effects are sent to the haptic device to be played based on the sound characteristics found in step **314**. For example, if a rise in sound amplitude has been found, a detent sensation can be output, similarly as if the method had found a marker in the preprocessing method of FIG. **7**. Alternatively, a haptic sensation can be output having a magnitude that is continuously based on the sound amplitude. For example, FIG. **9***a* is a diagrammatic illustration showing two waveforms **330** and **332** in basic time vs. amplitude form. Waveform **330** represents the sound amplitude of the sound data over time. In the present real-time processing embodiment, the method can compute an amplitude for the haptic sensation, represented by waveform **332**, which is continuously proportional to the sound amplitude of the sound data in the secondary buffer. For example, a resistance can be output on a manipulandum, such as a knob, where the magnitude of resistance corresponds to the current sound amplitude and varies with the sound amplitude. In FIG. **9***b*, sound waveform amplitude **330** is similarly shown, but the haptic sensation amplitude **336** can be continuously inversely varied from the sound amplitude to provide a different haptic experience to the user. Other continuous haptic sensation mappings or sound characteristic haptic mappings can also be used.

Preferably, after the sound characteristics have been found and haptic sensations mapped and commanded to be output, the haptic sensations will be felt by the user at approximately about the time that the sound samples corresponding to the haptic sensations are played by speakers. Once the haptic effect(s) are played for the found sound characteristics, the method returns to step **304** to check if sound playback is continued.

FIG. **10** is a diagrammatic illustration of a graphical user interface **400** which can allow the user to input preferences and settings for the present invention as well as control sound playback in simple ways to test the user settings. For example, these settings can be incorporated into an application program such as a sound/music editing program, or can be used in a separate test program.

Sound control parameters **402** can include a sound file field **404**, which allows the user to select a desired sound file to playback including the sound data to which haptic sensations will be correlated. The sound file can be loaded entirely into memory, and in some embodiments a reversed version of the file can be loaded into a second buffer to allow reverse playback. Status field **406** can display the current status of the program, such as opening the file, processing the sound data, creating a reverse buffer for reverse playback, etc. Playback adjustment fields **408** allow the user to enter values to customize the playback of the sound data, and include a frequency field to adjust the speed of playback (where the normal frequency of playback for that file can be automatically initially set), a pan field to adjust the balance of playback between left and right speakers, and a volume field to adjust output amplitude of the sound. Slider bars **410** can also be used to input these user settings. A loop sound box **412** allows the user to select whether the sound file will repeat playback or stop when reaching the end of the data in the sound file. Buttons **414** allow the user to start, stop, or pause playback of the sound file.

Processing parameters **420** allow a user to adjust the parameters that influence the way the haptic sensations are generated based on sound data. Peak threshold parameter **422** can be used to designate the amount of rise in the sound signal, compared to the average sound level, that will trigger a haptic event, as explained above. The parameter can be designated as a percentage of the mean sound amplitude, e.g. a rise of 50% of the mean amplitude or greater will be a significant enough rise to allow a haptic sensation to be associated with that rise. The peak reset parameter **424** allows the user to specify the percentage drop in sound amplitude (compared to the mean sound amplitude), after a detected rise, that will be deemed significant enough to be a peak in sound amplitude and warrant a haptic sensation, and to prevent finding false multiple peaks as explained above. The minimum beat interval parameter **426** is another error checking parameter that allows the user to specify a time interval (e.g. in milliseconds) that is the minimum interval that must be present between two peaks for the second peak to be counted; otherwise the second peak is considered a false peak caused by noise, as described above. The window size parameter **428** allows the user to specify the window size, in number of sound samples, which defines the resolution used in averaging the sound data amplitude; the method can average the samples in each window and then average all the windows together to find a mean sound amplitude.

Device selections **430** allow the user to select what type of haptic device **12** is currently being used in the system and by which the haptic sensations are to be output. Different devices may require different commands to output the haptic sensations. A knob device having position control or rate control, a tactile feedback mouse, and a kinesthetic feedback mouse are shown as options, but any haptic device can be used. The mouse control fields **432** allow the user to control the sound playback using a mouse cursor, and can be used to test the sound playback and haptic sensation output as modified by the user's preferences and settings. For example, shuttle field **436** allows the user to move a cursor within the shuttle field to play back the sound file in a position control mode. While the cursor is moving left or right in the shuttle field **436** and a button is held down, music is played back at a rate proportional to the speed of the cursor; movement to the right causes forward playback, and movement to the left causes reverse playback. Scroll field **434** allows the user to move a cursor within the field to play back the sound file in a rate control mode. The user places or moves the cursor to affect the direction and rate of playback. The position of the cursor to the right of the middle point of the field **434** causes forward playback at a rate proportional to the distance between the cursor and the middle point, and a position of the cursor to the left of the middle point similarly causes proportional reverse playback.

Test button **438** allows the user, in the pre-processing embodiment described for FIG. **5**, to initiate the reprocessing of the sound data in memory if the processing parameters or device selections have been changed.

FIG. **11** is a diagrammatic illustration of another graphical user interface **500** which can allow the user to input additional preferences and settings for the present invention. Any or all of these settings can be included with some or all of the settings of FIG. **10**, if desired, in a single interface. Sound file field **502** allows the user to specify a sound file, and haptic device settings **504** allow the user to select a type of haptic device.

Filters **506** allow the user to customize frequency ranges for filters that can be used in some embodiments of the present invention in the sound data processing steps of the methods of FIG. **5** or FIG. **8**. A low-pass filter, a high-pass