UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

PRINCETON DIGITAL IMAGE CORPORATION, Plaintiff, v. UBISOFT ENTERTAINMENT SA and UBISOFT INC., Defendants.	Case No.: 13-335 (LPS) (CJB) JURY TRIAL DEMANDED

THIRD AMENDED COMPLAINT

Princeton Digital Image Corporation (hereinafter referred to as "plaintiff" or "PDIC"), through its attorneys, for its complaint against defendants Ubisoft Entertainment SA ("Ubisoft SA") and Ubisoft Inc. ("defendants"), demands a jury trial and complains against the defendants as follows:

THE PARTIES

1. PDIC is a corporation organized and existing under the laws of the State of Texas.

2. Ubisoft SA is a corporation organized and existing under the laws of France having its principal place of business at 28 rue Armand Carrel, 93108, Montreuil-sous-Bois, France.

3. Ubisoft Inc. is a corporation organized and existing under the laws of the State of California having its principal place of business at 625 Third Street, San Francisco, CA 94107, and is a wholly-owned subsidiary of Ubisoft SA.

JURISDICTION AND VENUE

4. This action arises under the patent laws of the United States of America, Title 35 of the United States Code. This Court has jurisdiction over this action under 28 U.S.C. §§ 1331 and 1338(a).

5. Defendants Ubisoft SA and Ubisoft Inc. are each doing business and committing acts of infringement in this judicial district, and each is subject to personal jurisdiction in this judicial district.

6. Venue is proper in this judicial district pursuant to 28 U.S.C. §§ 1391 and 1400(b).

THE '129 PATENT

7. Plaintiff PDIC repeats and incorporates herein the entirety of the allegations contained in paragraphs 1 through 6 above.

8. On April 30, 1996, U.S. Patent No. 5,513,129 (hereinafter referred to as "the '129 patent") was duly and legally issued to Mark Bolas, Michael Bolas, and Ian McDowall for a "METHOD AND SYSTEM FOR CONTROLLING COMPUTER-GENERATED VIRTUAL ENVIRONMENT IN RESPONSE TO AUDIO SIGNALS." One of the inventors of the '129 patent, Mr. Mark Bolas, has been awarded the 2005 IEEE Visualization and Graphics Technical Committee Virtual Reality Technical Achievement Award in recognition for his seminal technical achievements in virtual and augmented reality. Intel's former chairman Gordon Moore (of "Moore's Law") has described Mr. Bolas as a "VR trailblazer."

9. By assignment, dated December 14, 2011, PDIC became the owner of all right, title and interest in the '129 patent, including the right to recover damages for past infringement.

10. The ’129 patent generally describes and claims virtual reality computer systems in which a virtual environment is controlled in response to a music signal. A copy of the ’129 patent is attached hereto as Exhibit 1.

THE ’129 PATENT IPR PROCEEDINGS

The Harmonix IPR

11. Harmonix Music Systems, Inc. (“Harmonix” or ”HMSI”), a defendant in Case No. 1:12-cv-01461-LPS-CJB (the “Konami/Harmonix/EA Litigation”), filed a petition for *inter partes* review of claims 1, 5–6, 8–13, 15–19, and 21–23 of the ’129 patent by the USPTO’s Patent Trial and Appeal Board (“PTAB”) on November 15, 2013. *See* IPR2014-00155 (the “Harmonix IPR”); *see also* Konami/Harmonix/EA Litigation, D.I. 67, Ex. 1 (petition in the Harmonix IPR).

12. In a May 9, 2014 institution decision, the PTAB, applying the same claim construction standard that will apply in this litigation, adopted PDIC’s constructions of the two “virtual reality” claim terms proposed to the court in the early claim construction proceedings in the Konami/Harmonix/EA Litigation. Specifically, the PTAB has construed the term “virtual environment” of claims 14, 19, and 20 as “a computer-simulated environment (intended to be immersive) which includes a graphic display (from a user’s first person perspective, in a form intended to be immersive to the user), and optionally also sounds which simulate environmental sounds.” The PTAB has construed the term “virtual reality computer system” of claims 14, 19, and 20 as “a computer system programmed with software, and including peripheral devices, for producing a virtual environment” of claims 14, 19, and 20:

1. "virtual environment"

Petitioner points to the statement in the Specification that "'[t]he terms 'virtual environment,' 'virtual world,' and 'virtual reality' are interchangeably used to describe a computer-simulated environment (intended to be immersive) which includes a graphic display (from a user's first person perspective, in a form intended to be immersive to the user)." Pet. 13 (quoting Ex. 1001, 1:22-28). Petitioner, however, does not proffer any particular proposed construction for the terms.

Patent Owner also argues that the term should be construed as disclosed in the Specification, namely, "a computer-simulated environment (intended to be immersive) which includes a graphic display (from a user's first person perspective, in a form intended to be immersive to the user), and optionally also sounds which simulate environmental sounds." Prelim. Resp. 10-11 (emphasis omitted) (citing Ex. 1001, 1:22-33). Patent Owner's proposed construction quotes the full sentence relied upon from the Specification. *Id*. We agree with Patent Owner that the '129 patent sufficiently sets forth the meaning of the claim term "virtual environment," and we adopt Patent Owner's proposed construction for purposes of this decision. *See In re Paulsen*, 30 F.3d 1475, 1480 (Fed. Cir. 1994) (holding that any special definition for a claim term must be set forth in the specification with reasonable clarity, deliberateness, and precision).

2. "virtual reality computer system"

Although Petitioner points to the statement in the Specification that a "VR system" is a "computer system programmed with software, and including peripheral devices, for producing a virtual environment," Petitioner does not proffer any particular proposed construction. *Id*. at 13 (quoting Ex. 1001, 1:30-33).

Patent Owner urges that the term be construed as "a computer system programmed with software, and including peripheral devices, for producing a virtual environment." Prelim. Resp. 11 (citing Ex. 1001, 1:22-33) ("The abbreviation 'VR' will sometimes be used herein to denote 'virtual reality,' 'virtual environment,' or 'virtual world.' A computer system programmed with software, and including peripheral devices, for producing a virtual environment will sometimes be referred to herein as a VR system or VR processor."). We agree with Patent Owner that the '129 patent sufficiently sets forth the meaning of the claim term "virtual reality computer system," in light of the explanation of the term

> "virtual environment," and we adopt Patent Owner's proposed construction for purposes of this decision.

See Konami/Harmonix/EA Litigation, D.I. 71, Ex. A (institution decision in the Harmonix IPR) at 7–8 (citing '129 patent, col. 1:22–33).

13. Applying these constructions, the PTAB declined to institute *inter partes* review of claim 19 over the prior art, as requested by HMSI. *See id*. at 13–16 ("Consequently, we are not persuaded that Petitioner has demonstrated a reasonable likelihood that independent [claim 16 and dependent claim 19] are unpatentable as obvious over Fallacaro. Accordingly, we do not institute *inter partes* review of [claim 19] on the ground of obviousness over Fallacaro."); *id*. at 19–22 ("For the foregoing reasons, based on the present record, we determine that Petitioner has [not] demonstrated that there is a reasonable likelihood that Petitioner would prevail in showing that [claim 19 is] unpatentable.").

14. The PTAB issued a final written decision in the Harmonix IPR on May 6, 2015, confirming the Board's earlier decision not to institute *inter partes* review of claim 19, as requested by Harmonix, because Harmonix failed to demonstrate a reasonable likelihood that claim 19 is unpatentable. *See* Konami/Harmonix/EA Litigation, D.I. 83, Ex. A (final written decision in the Harmonix IPR) at 2 ("Harmonix Music Systems, Inc. filed a corrected Petition requesting *inter partes* review of claims 1, 5, 6, 8–13, 15–19, and 21–23 of U.S. Patent No. 5,513,129. On May 9, 2014, pursuant to 35 U.S.C. § 314, we instituted an *inter partes* review of claims 10, 11, 22, and 23 . . . ." (parentheticals omitted)).

The Ubisoft IPR

15. Ubisoft SA filed a petition for *inter partes* review of claims 1–23 of the '129 patent on April 15, 2014. *See* IPR2014-00635 (the "Ubisoft IPR"); *see also* Case No. 1:13-cv-

00335-LPS-CJB (the "Ubisoft Litigation"), D.I. 54, Ex. B (petition in the Ubisoft IPR).

16. The PTAB issued an institution decision on October 17, 2014, again construing the term "virtual environment" of claims 14, 19, and 20 as "a computer-simulated environment (intended to be immersive) which includes a graphic display (from a user's first person perspective, in a form intended to be immersive to the user), and optionally also sounds which simulate environmental sounds." *See* Ubisoft Litigation, D.I. 56, Ex. B (institution decision in the Ubisoft IPR) at 4–5. The PTAB also again construed the term "virtual reality computer system" of claims 14, 19, and 20 as "a computer system programmed with software, and including peripheral devices, for producing a virtual environment." *Id*. at 5. Again, applying these constructions, the Board denied institution of *inter partes review* of claims 14, 19, and 20 of the '129 patent. *See id*. at 1–2 ("We do not, however, institute an *inter partes* review of claims 14, 19, and 20 of the '129 patent."); *id*. at 7–11 ("Consequently, we are not persuaded that Petitioner has demonstrated a reasonable likelihood that [claim 14 is] unpatentable as anticipated by Tsumura."); *id*. at 20 ("Consequently, we are not persuaded that Petitioner has demonstrated a reasonable likelihood that [claim 20 is] unpatentable as obvious over Tsumura and Williams."); *id*. at 23–24 ("Consequently, we are not persuaded that Petitioner has demonstrated a reasonable likelihood that the subject matter of [claim 19] is rendered obvious over Thalmann and Williams.").

17. The PTAB issued a final written decision on October 16, 2015, confirming its previous construction of "virtual environment" and agreeing with Ubisoft SA's argument that this claim term encompasses the examples of a virtual environment described in the '129 patent specification:

1. "virtual environment" (claims 1, 5–9, and 12–21)

Petitioner asserts that the term "virtual environment" should be construed to mean "a computer-simulated environment which includes a graphic display, and optionally also sounds which simulate environmental sounds." Pet. 4. Petitioner alleges that "parenthetical statements of 'intent'" appearing in the description of the term "virtual environment," such as "intended to be immersive" and "from a user's first person perspective", should not be accounted for in the claim construction analysis. *Id*. To the extent the parentheticals are incorporated in the construction, Petitioner argues that the construction should encompass the exemplary virtual environments described in the Specification, such as virtual hands clapping, dancing characters, and lyrics. *Id*. at 4–5.

In the Decision on Institution, we included these so-called "parenthetical statements of intent" into our construction, because the '129 patent expressly defined "virtual environment" to include those statements. Dec. on Inst. 8. Petitioner fails to persuaded us to modify that construction; thus, as in the Decision on Institution, we adopt the Specification's express definition of "virtual environment," which is "a computer-simulated environment (intended to be immersive) which includes a graphic display (from a user's first person perspective, in a form intended to be immersive to the user), and optionally also sounds which simulate environmental sounds." *Id*. (quoting Ex. 1001, 1:22–33).

However, we agree with Petitioner that the term should be construed to encompass the specific embodiments that the '129 patent describes. As the Federal Circuit has noted, "the specification is always highly relevant to the claim construction analysis," and, in fact, "is the single best guide to the meaning of a disputed term." *Phillips*, 415 F.3d at 1315 (internal citation and quotation marks omitted). Here, given that the Specification does not elucidate what it means by "intended to be immersive to the user," and given that the phrase is subjective, we find the specific embodiments discussed in the Specification to be particularly informative.

As part of "the preferred VR program," Figure 11 depicts a group of simple cylindrical objects that appear to change height in response to the sound of drums. Ex. 1001, 18:16–33. Also in the "preferred VR program embodiment," words representing the lyrics of a song are displayed as the words are vocalized. *Id*. at 18:49–53. Further, as Petitioner notes, the Specification teaches

> that the graphic display generated by a VR system can be either two-dimensional or three-dimensional, and can be displayed on a single flat screen display that need not be stereoscopic. Pet. 4 (citing Ex. 1001, 1:34–35, 8:7–13). [The Specification also discloses embodiments of the "VR system" that perform operations such as: using a rhythm signal extracted from music "to control the rhythm of a virtual dancer," "displaying virtual hands clapping in time to the beat of the music," or a virtual "stick figure dancing in time" to the music. *Id*. at 5:1–10, 11:36–41, 58–62, 12:18–24.] Given that a claim construction that excludes a preferred embodiment is "rarely, if ever, correct," *Vitronics*, 90 F.3d at 1583, it is appropriate to construe "virtual environment" broadly enough to encompass these displays.

See Konami/Harmonix/EA Litigation, D.I. 88, Ex. A (final written decision in the Ubisoft IPR) at 10–11 & n.7.

18. The Board also confirmed its earlier decision declining to institute *inter partes* review of claims 14, 19 and 20, as requested by Ubisoft, because Ubisoft failed to demonstrate a reasonable likelihood that those claims are unpatentable. *See id*. at 2 ("Ubisoft Entertainment SA filed a Petition requesting an *inter partes* review of claims 1–23 of U.S. Patent No. 5,513,129. . . . We instituted an *inter partes* review of claims 1–13, 15–18, and 21–23 . . . ." (parentheticals omitted)).

The Harmonix/Konami IPR

19. Harmonix and Konami Digital Entertainment, Inc. ("Konami"), defendants in the Konami/Harmonix/EA Litigation, jointly filed a petition for *inter partes* review of claims 1–23 of the '129 patent, along with a motion seeking to join that proceeding with the then-pending Ubisoft IPR, on November 17, 2014. *See* IPR2015-00271 (the "Harmonix/Konami IPR"); *see also* Konami/Harmonix/EA Litigation, D.I. 76, Exs. C–D (the petition and motion for joinder in the Harmonix/Konami IPR).

20. On June 2, 2015, the PTO denied the motion to join the Ubisoft IPR, and issued a final written decision confirming the Board's earlier decisions not to institute *inter partes* review of claims 14, 19 and 20, and applying the statutory estoppel barring subsequent challenges by the petitioners as to these claims. *See* Konami/Harmonix/EA Litigation, D.I. 84, Ex. C (final written decision in the Harmonix/Konami IPR) at 6–8 ("The information presented in the Petition sets forth Petitioner's contentions of unpatentability of claims 1–23 of the '129 patent based on the following specific grounds. . . . Petitioner introduces a new challenge to claims [14, 19 and 20]. Petitioner, among other things, has not presented persuasive argument or evidence to explain why the new challenges asserted in the Petition could not have been asserted in its previous Petition in Case IPR2014-00155. . . . [T]he Petition is denied as to all challenged claims of the '129 patent."); *id.*, Ex. B (decision on motion for joinder in the Harmonix/Konami IPR) at 7–8, 10 ("[T]he art relied upon in the current proceeding was available at the time that Petitioner filed the '155 IPR. . . . Petitioner presents no persuasive argument or evidence to explain why the grounds of unpatentability asserted in the Petition could not have been asserted in the '155 IPR."); *see also* 35 U.S.C 315(e)(1) ("The petitioner in an inter partes review of a claim in a patent under this chapter that results in a final written decision under section 318(a), or the real party in interest or privy of the petitioner, may not request or maintain a proceeding before the Office with respect to that claim on any ground that the petitioner raised or reasonably could have raised during that inter partes review.").

CLAIM FOR PATENT INFRINGEMENT

COUNT ONE

21. Plaintiff PDIC repeats and incorporates herein the entirety of the allegations

contained in paragraphs 1 through 20 above.

Infringement Of The '129 Patent

22. A virtual reality system creates a computer-simulated virtual environment and gives a user the feeling that he or she is immersed within the environment. That is, the virtual reality system displays video and/or creates sounds to give a user the feeling that he or she is part of the virtual environment. In addition, the user can interact with the virtual reality system to alter the virtual environment.

23. A virtual reality system may include a two or three dimensional display for showing video of the virtual environment to a user and speakers to present sounds of the virtual environment to the user. A virtual reality system may also include a device to track the head movements of a user for generating images along the area of viewing interest of the user. A virtual reality system may also include an input device permitting a user to interact and alter the virtual environment.

24. The '129 patent describes and claims a virtual reality computer system controlled by music or control tracks created from music. In other words, the system displays musically driven objects by retrieving music in electronic, acoustic, or optical form and generating control signals from that music to influence activity in a virtual environment. A component of the system called the Acoustic Etch can extricate a rhythm signal indicative of the beat of some frequency band of the music (e.g., a band representing drums), or of some other parameter of the frequency band of the music. The VR system receives the rhythm signal and generates control signals to control the rhythm of a virtual dancer (or some other moving virtual object). In addition, control tracks can be generated automatically (e.g., by electronic signal processing

circuitry) in response to a music signal and then recorded, or can be generated in response to manually asserted commands from a person (while the person listens to some music signals) and then recorded. The placement and rhythm of dancers could, for example, be encoded in prerecorded control tracks. In the claimed virtual reality systems, music or prerecorded control tracks generated from music may be used by the virtual reality system to control a virtual environment.

25. Claims 14, 19, and 20 of the '129 patent describe virtual reality computer systems for controlling and manipulating a virtual environment, and specifically, "a computer-simulated environment (intended to be immersive) which includes a [two-dimensional or three-dimensional single flat screen or stereoscopic] graphic display (from a user's first person perspective, in a form intended to be immersive to the user), and optionally also sounds which simulate environmental sounds," for example, "a group of simple cylindrical objects that appear to change height in response to the sound of drums," "words representing the lyrics of a song . . . displayed as the words are vocalized," "'virtual hands clapping in time to the beat of music,'" or a "'stick figure dancing in time'" to music:

> 14. [A virtual reality computer system, including:
>
> means for supplying a first signal selected from a group consisting of a control signal having music and/or control information generated in response to a music signal, a prerecorded control track having music and/or control information corresponding to the music signal, and a control signal having music and/or control information generated in response to the prerecorded control track; and
>
> means for receiving the first signal and influencing action within a virtual environment in response to said first signal],
>
> wherein said music signal is delayed in time to compensate for delays in other parts of the virtual reality computer system.

> 19. [A virtual reality computer system for producing a virtual environment, including:
>
> means for prerecording a control track having music and/or control information corresponding to a music signal; and
>
> means for producing the virtual environment in response to said prerecorded control track],
>
> wherein said control track contains additional information to that which can be extracted from the music signal.

> 20. [A virtual reality computer system for producing a virtual environment, including:
>
> means for prerecording a control track having music and/or control information corresponding to a music signal; and
>
> means for producing the virtual environment in response to said prerecorded control track],
>
> wherein said control track is time shifted relative to the music signal to compensate for delays in said virtual reality computer system.

Infringement By Ubisoft SA And Ubisoft Inc.

26. Ubisoft SA is a developer of electronic video games, including at least the electronic video games known commercially as *Just Dance, Just Dance 2, Michael Jackson: The Experience, Just Dance Summer Party, Just Dance 3, ABBA: You Can Dance, Just Dance Greatest Hits*, and *Just Dance 4*.

27. Ubisoft SA is also a publisher of electronic video games, including at least the electronic video games known commercially as *Just Dance, Dance on Broadway, Just Dance 2, Just Dance Kids, Michael Jackson: The Experience, Just Dance Summer Party, The Smurfs Dance Party, Just Dance 3, Just Dance Kids 2, The Black Eyed Peas Experience, ABBA: You*

Can Dance, Just Dance Greatest Hits, Just Dance 4, Just Dance Disney Party, and *The Hip Hop Dance Experience* (collectively, "*Just Dance*") and the electronic video game known commercially as *Rocksmith*. Both of these games control a virtual environment in response to a music signal.

28. Ubisoft SA is also a developer of downloadable content such as playable song tracks for use with electronic video games, including at least *Just Dance*, and is a publisher and distributor of downloadable content such as playable song tracks for use with electronic video games, including at least *Just Dance* and *Rocksmith*.

29. Ubisoft Inc. is a developer of electronic video games, including at least *Rocksmith*.

30. Ubisoft Inc. is also a publisher and distributor of electronic video games, including at least *Just Dance* and *Rocksmith*.

31. Ubisoft Inc. is also a developer and distributor of peripheral devices such as cables for connecting a computer or gaming console to a guitar so the guitar can be used as a game controller for use with electronic video games, including at least *Rocksmith*, and is a developer, publisher, and distributor of downloadable content such as playable song tracks for use with electronic video games, including at least *Just Dance* and *Rocksmith*.

32. Ubisoft Inc. has directly infringed claims 14, 19, and 20 of the '129 patent by developing at least the *Rocksmith* electronic video game, and related virtual reality peripheral hardware devices and downloadable content for that game, and testing and otherwise using at least the *Just Dance* and *Rocksmith* electronic video games, and related virtual reality peripheral hardware devices and downloadable content for those games, with computer and gaming console systems.

33. Ubisoft SA and Ubisoft Inc. have also indirectly infringed claims 14, 19, and 20 of the '129 patent by developing at least the *Just Dance* and *Rocksmith* electronic video games, related virtual reality peripheral hardware devices for the *Rocksmith* game, and downloadable content for the *Just Dance* and *Rocksmith* games, and publishing and distributing at least the *Just Dance* and *Rocksmith* electronic video games, related virtual reality peripheral hardware devices for the *Rocksmith* game, and downloadable content for the *Just Dance* and *Rocksmith* games, for use with computer and gaming console systems, and inducing purchasers and other users of the *Just Dance* and *Rocksmith* electronic video games, and related virtual reality peripheral hardware devices and downloadable content for those games, to use the games, peripheral hardware devices, and downloadable content with computer and gaming console systems, for example, by marketing and promoting the use of the games, peripheral hardware devices, and downloadable content with computer and gaming console systems and by providing instructions explaining how to use the games, peripheral hardware devices, and downloadable content with computer and gaming console systems.

34. Ubisoft Inc. has also contributed to the infringement of claims 14, 19, and 20 of the '129 patent by offering for sale and selling at least the *Just Dance* and *Rocksmith* electronic video games, related virtual reality peripheral hardware devices for the *Rocksmith* game, and downloadable content for the *Just Dance* and *Rocksmith* games, for use with computer and gaming console systems, knowing the games, peripheral hardware devices, and downloadable content to be especially made or especially adapted for use in an infringement of claims 14, 19, and 20 of the '129 patent. The games, peripheral hardware devices, and downloadable content constitute a material part of the inventions described in claims 14, 19, and 20 of the '129 patent, and are not staple articles or commodities of commerce suitable for substantial non-infringing

use.

Infringement By The *Just Dance* And *Rocksmith* Games

35. As an example, claim 14 of the '129 patent describes a "virtual reality computer system." Claims 19 and 20 of the '129 patent describe a "virtual reality computer system for producing a virtual environment." In the Harmonix IPR and the Ubisoft IPR the Board construed "virtual reality computer system" as "a computer system programmed with software, and including peripheral devices, for producing a virtual environment," i.e., "a computer-simulated environment (intended to be immersive) which includes a graphic display (from a user's first person perspective, in a form intended to be immersive to the user), and optionally also sounds which simulate environmental sounds." The Board specifically and expressly concluded in the Ubisoft IPR that the virtual environments described in the specification of the '129 patent are virtual environments that are "from a user's first person perspective, in a form intended to be immersive to the user."

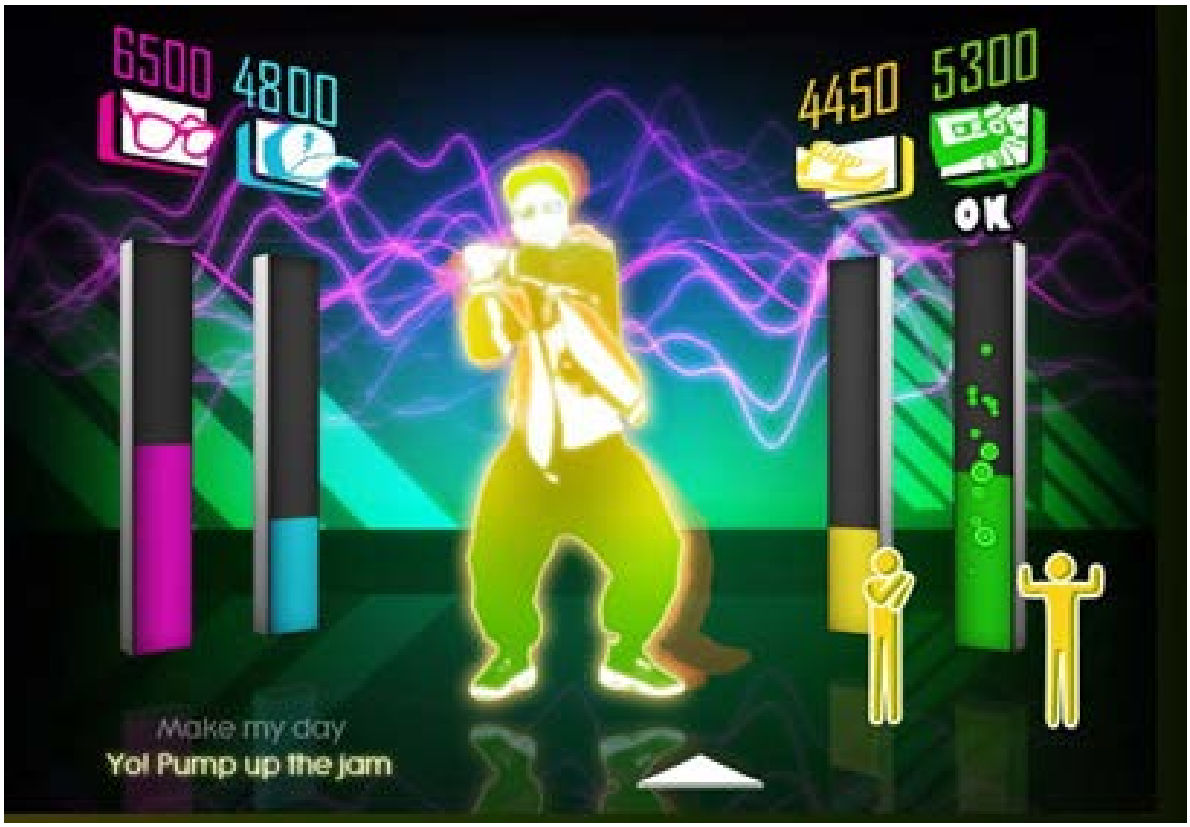
36. Ubisoft SA and Ubisoft Inc. developed the *Just Dance* and *Rocksmith* electronic video games, and related virtual reality peripheral hardware devices and downloadable content for those games, using, and Ubisoft SA and Ubisoft Inc. tested and otherwise used the *Just Dance* and *Rocksmith* games, and related virtual reality peripheral hardware devices and downloadable content for those games, with, computer and gaming console systems that also generate and display virtual environments from a user's first person perspective in a form intended to be immersive to the user, that are the same as those described in the specification of the '129 patent, for example, "a group of simple cylindrical objects that appear to change height in response to the sound of drums," "words representing the lyrics of a song . . . displayed as the

words are vocalized," "virtual hands clapping in time" to the beat of music, or a "stick figure dancing in time" to music, when the games are played on a computer or gaming console using peripheral devices such as a television or display, speakers, keyboards, a mouse, and/or game controllers.

37. Ubisoft SA and Ubisoft Inc. developed the *Just Dance* and *Rocksmith* electronic video games, and related virtual reality peripheral hardware devices and downloadable content for those games, and Ubisoft SA and Ubisoft Inc. published, distributed, offered for sale, and sold the *Just Dance* and *Rocksmith* games, and related virtual reality peripheral hardware devices and downloadable content for those games, intending that the games, peripheral hardware devices, and downloadable content would be used, and knowing that the games, peripheral hardware devices, and downloadable content would be used, by purchasers of the games, peripheral hardware devices, and downloadable content with computer and gaming console systems that generate and display virtual environments that are the same as those described in the specification of the '129 patent, for example, "a group of simple cylindrical objects that appear to change height in response to the sound of drums," "words representing the lyrics of a song . . . displayed as the words are vocalized," "virtual hands clapping in time" to the beat of music, or a "stick figure dancing in time" to music, when the games are played on a computer or gaming console using peripheral devices such as a television or display, speakers, keyboards, a mouse, and/or game controllers.

38. As an example, the specification of the '129 patent describes "a virtual dancer (or some other moving virtual object)" animated in the virtual environment in order to keep time with accompanying music and displayed lyrics. *See, e.g.*, Ex. 1 ('129 patent), col. 1:22–33, 1:34–35, 5:1–10, 8:7–13, 11:36–41, 11:58–62, 12:18–24, 18:38–19:11.

39. The *Just Dance* electronic video game displays an immersive virtual dancer stage, microphone, and/or speakers environment including virtual musical notes, and corresponding song lyrics, as illustrated below:



See, e.g., http://www.amazon.com/Just-Dance-Nintendo-Wii/dp/B002MWSY3O/.

40. The specification of the '129 patent also describes two-dimensional virtual environments displayed on a flat screen, including virtual cylinders 310A and 310B located within fixed lines 330A and 330B, which are animated to represent musical notes in a song, and text elements 320A and 320B which display corresponding song lyrics, as illustrated in Figure 11 of the '129 patent excerpted below:

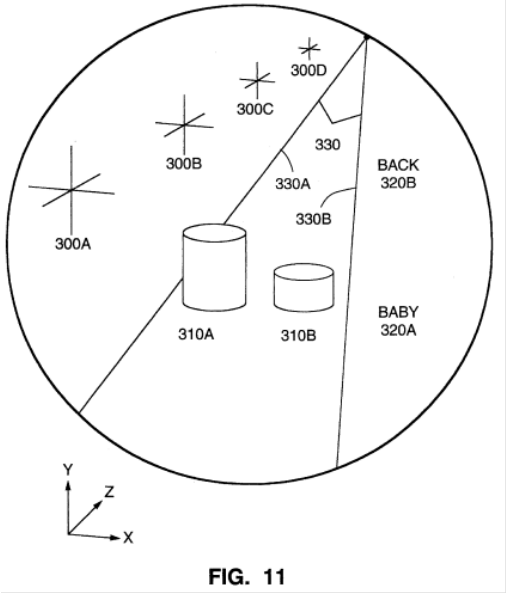


FIG. 11

See, e.g., Ex. 1 ('129 patent), col. 1:22–33, 1:34–35, 5:1–10, 8:7–13, 18:16–19:11 & Fig. 11.

41. The *Rocksmith* electronic video game displays a virtual guitar fingerboard with strings and frets environment, including virtual musical notes played on the guitar and corresponding song lyrics, as illustrated below:

See, e.g., http://www.amazon.com/Rocksmith-Playstation-3/dp/B004S5TDL0.

42. As another example, claim 14 describes "means for supplying a first signal selected from a group consisting of a control signal having music and/or control information generated in response to a music signal, a prerecorded control track having music and/or control information corresponding to the music signal, and a control signal having music and/or control information generated in response to the prerecorded control track." During the Ubisoft IPR, the Board construed the structure described in the specification of the '129 patent performing the function of this term as "(1) a source of music and/or a control track, such as a four-track audio tape, video-game cartridge or compact disk (CD); and (2) a processor programmed to generate control signals from the input music and/or control track and send the control signals to the VR processor." Konami/Harmonix/EA Litigation, D.I. 88, Ex. A (final written decision in the Ubisoft IPR) at 12–17.

43. Ubisoft SA and Ubisoft Inc. developed the *Just Dance* and *Rocksmith* electronic video games, and related virtual reality peripheral hardware devices and downloadable content for those games, using, and Ubisoft SA and Ubisoft Inc. tested and otherwise used the *Just Dance* and *Rocksmith* games, and related virtual reality peripheral hardware devices and downloadable content for those games, with, computer and gaming console systems including microprocessors programmed to generate signals containing music and control information (such as information defining markers in the music files, song tempo, lyrics, animations, and choreography) obtained from electronic files (such as electronic Timeline files, Waveform Audio (.wav) files, Wwise Encoded Media (.wem) files, and/or Ogg container (.ogg) files) corresponding to playable song tracks stored on a removable disc, in memory, or on a hard drive containing the game software.

44. Ubisoft SA and Ubisoft Inc. developed the *Just Dance* and *Rocksmith* electronic

video games, and related virtual reality peripheral hardware devices and downloadable content for those games, and Ubisoft SA and Ubisoft Inc. published, distributed, offered for sale, and sold the *Just Dance* and *Rocksmith* games, and related virtual reality peripheral hardware devices and downloadable content for those games, intending that the games, peripheral hardware devices, and downloadable content would be used, and knowing that the games, peripheral hardware devices, and downloadable content would be used, by purchasers of the games, peripheral hardware devices, and downloadable content with computer and gaming console systems including microprocessors programmed to generate signals containing music and control information (such as information defining markers in the music files, song tempo, lyrics, animations, and choreography) obtained from electronic files (such as electronic Timeline files, Waveform Audio (.wav) files, Wwise Encoded Media (.wem) files, and/or Ogg container (.ogg) files) corresponding to playable song tracks stored on a removable disc, in memory, or on a hard drive containing the game software.

45. As another example, claim 14 describes a "means for receiving the first signal and influencing action within a virtual environment in response to said first signal." During the Ubisoft IPR, the Board construed the structure described in the specification of the '129 patent performing the function of this term as "a processor suitably programmed to carry out the function." *See* Konami/Harmonix/EA Litigation, D.I. 88, Ex. A at 17–18.

46. Ubisoft SA and Ubisoft Inc. developed the *Just Dance* and *Rocksmith* electronic video games, and related virtual reality peripheral hardware devices and downloadable content for those games, using, and Ubisoft SA and Ubisoft Inc. tested and otherwise used the *Just Dance* and *Rocksmith* games, and related virtual reality peripheral hardware devices and downloadable content for those games, with, computer and gaming console systems including

microprocessors programmed to influence action in virtual environments by generating animations and sounds based on signals containing music and control information (such as information defining markers in the music files, song tempo, lyrics, animations, and choreography).

47. Ubisoft SA and Ubisoft Inc. developed the *Just Dance* and *Rocksmith* electronic video games, and related virtual reality peripheral hardware devices and downloadable content for those games, and Ubisoft SA and Ubisoft Inc. published, distributed, offered for sale, and sold the *Just Dance* and *Rocksmith* games, and related virtual reality peripheral hardware devices and downloadable content for those games, intending that the games, peripheral hardware devices, and downloadable content would be used, and knowing that the games, peripheral hardware devices, and downloadable content would be used, by purchasers of the games, peripheral hardware devices, and downloadable content with computer and gaming console systems including microprocessors programmed to influence action in virtual environments by generating animations and sounds based on signals containing music and control information (such as information defining markers in the music files, song tempo, lyrics, animations, and choreography).

48. As another example, claim 14 states that the "music signal is delayed in time to compensate for delays in other parts of the virtual reality computer system."

49. Ubisoft SA and Ubisoft Inc. developed the *Just Dance* and *Rocksmith* electronic video games, and related virtual reality peripheral hardware devices and downloadable content for those games, using, and Ubisoft SA and Ubisoft Inc. tested and otherwise used the *Just Dance* and *Rocksmith* games, and related virtual reality peripheral hardware devices and downloadable content for those games, with, computer and gaming console systems including

microprocessors programmed to delay a music signal based on, for example, latency and calibration settings to ensure that the music and animations are properly synchronized.

50. Ubisoft SA and Ubisoft Inc. developed the *Just Dance* and *Rocksmith* electronic video games, and related virtual reality peripheral hardware devices and downloadable content for those games, and Ubisoft SA and Ubisoft Inc. published, distributed, offered for sale, and sold the *Just Dance* and *Rocksmith* games, and related virtual reality peripheral hardware devices and downloadable content for those games, intending that the games, peripheral hardware devices, and downloadable content would be used, and knowing that the games, peripheral hardware devices, and downloadable content would be used, by purchasers of the games, peripheral hardware devices, and downloadable content with computer and gaming console systems including microprocessors programmed to delay a music signal based on, for example, latency and calibration settings to ensure that the music and animations are properly synchronized.

51. As another example, claims 19 and 20 of the '129 patent describe a "means for prerecording a control track having music and/or control information corresponding to a music signal." During the Ubisoft IPR, the Board construed the structure described in the specification of the '129 patent performing the function of this term as "(i) a first media player unit (e.g., four-track tape player, CD or DAT playback device), a microprocessor for generating a control track from the received data from the media player unit, and a media recorder; *or* (ii) one or more input devices for inputting signals, a microprocessor for generating a control track from the received signals, and a media recorder." *See* Konami/Harmonix/EA Litigation, D.I. 88, Ex. A at 18–20 (record citation omitted).

52. Ubisoft SA and Ubisoft Inc. developed the *Just Dance* and *Rocksmith* electronic video games, and related virtual reality peripheral hardware devices and downloadable content

for those games, using, and Ubisoft SA and Ubisoft Inc. tested and otherwise used the *Just Dance* and *Rocksmith* games, and related virtual reality peripheral hardware devices and downloadable content for those games, with, computer and gaming console systems including microprocessors programmed to receive data or signals from devices such as a signal input device, hard drive, disc drive, and/or network adapter, generate electronic files (such as electronic Timeline files, Waveform Audio (.wav) files, Wwise Encoded Media (.wem) files, and/or Ogg container (.ogg) files) containing music and control information (such as information defining markers in the music files, song tempo, lyrics, animations, and choreography) corresponding to playable song tracks, and store the electronic files corresponding to playable song tracks on a removable disc, in memory, or on a hard drive.

53. Ubisoft SA and Ubisoft Inc. developed the *Just Dance* and *Rocksmith* electronic video games, and related virtual reality peripheral hardware devices and downloadable content for those games, and Ubisoft SA and Ubisoft Inc. published, distributed, offered for sale, and sold the *Just Dance* and *Rocksmith* games, and related virtual reality peripheral hardware devices and downloadable content for those games, intending that the games, peripheral hardware devices, and downloadable content would be used, and knowing that the games, peripheral hardware devices, and downloadable content would be used, by purchasers of the games, peripheral hardware devices, and downloadable content with computer and gaming console systems including microprocessors programmed to receive data or signals from devices such as a signal input device, hard drive, disc drive, and/or network adapter, generate electronic files (such as electronic Timeline files, Waveform Audio (.wav) files, Wwise Encoded Media (.wem) files, and/or Ogg container (.ogg) files) containing music and control information (such as information defining markers in the music files, song tempo, lyrics, animations, and choreography)

corresponding to playable song tracks, and store the electronic files corresponding to playable song tracks on a removable disc, in memory, or on a hard drive.

54. As another example, claims 19 and 20 describe a "means for producing the virtual environment in response to said prerecorded control track." During the Ubisoft IPR, the Board construed the structure described in the specification of the '129 patent performing the function of this term as "a processor suitably programmed to carry out the function." *See* Konami/Harmonix/EA Litigation, D.I. 88, Ex. A at 17–18.

55. Ubisoft SA and Ubisoft Inc. developed the *Just Dance* and *Rocksmith* electronic video games, and related virtual reality peripheral hardware devices and downloadable content for those games, using, and Ubisoft SA and Ubisoft Inc. tested and otherwise used the *Just Dance* and *Rocksmith* games, and related virtual reality peripheral hardware devices and downloadable content for those games, with, computer and gaming console systems including microprocessors programmed to produce virtual environments by generating animations and sounds based on music and control information (such as information defining markers in the music files, song tempo, lyrics, animations, and choreography) obtained from electronic files (such as electronic Timeline files, Waveform Audio (.wav) files, Wwise Encoded Media (.wem) files, and/or Ogg container (.ogg) files) corresponding to playable song tracks stored on a removable disc, in memory, or on a hard drive containing the game software.

56. Ubisoft SA and Ubisoft Inc. developed the *Just Dance* and *Rocksmith* electronic video games, and related virtual reality peripheral hardware devices and downloadable content for those games, and Ubisoft SA and Ubisoft Inc. published, distributed, offered for sale, and sold the *Just Dance* and *Rocksmith* games, and related virtual reality peripheral hardware devices and downloadable content for those games, intending that the games, peripheral hardware devices,

and downloadable content would be used, and knowing that the games, peripheral hardware devices, and downloadable content would be used, by purchasers of the games, peripheral hardware devices, and downloadable content with computer and gaming console systems including microprocessors programmed to produce virtual environments by generating animations and sounds based on music and control information (such as information defining markers in the music files, song tempo, lyrics, animations, and choreography) obtained from electronic files (such as electronic Timeline files, Waveform Audio (.wav) files, Wwise Encoded Media (.wem) files, and/or Ogg container (.ogg) files) corresponding to playable song tracks stored on a removable disc, in memory, or on a hard drive containing the game software.

57. As another example, claims 19 and 20 state that the "control track contains additional information to that which can be extracted from the music signal."

58. Ubisoft SA and Ubisoft Inc. developed the *Just Dance* and *Rocksmith* electronic video games, and related virtual reality peripheral hardware devices and downloadable content for those games, using, and Ubisoft SA and Ubisoft Inc. tested and otherwise used the *Just Dance* and *Rocksmith* games, and related virtual reality peripheral hardware devices and downloadable content for those games, with, computer and gaming console systems including microprocessors programmed to generate electronic files (such as electronic Timeline files, Waveform Audio (.wav) files, Wwise Encoded Media (.wem) files, and/or Ogg container (.ogg) files) containing music and control information (such as information defining markers in the music files, song tempo, lyrics, animations, and choreography) corresponding to playable song tracks that include additional information not extracted from a music signal, including information defining markers in the music files, lyrics, animations, and choreography.

59. Ubisoft SA and Ubisoft Inc. developed the *Just Dance* and *Rocksmith* electronic

video games, and related virtual reality peripheral hardware devices and downloadable content for those games, and Ubisoft SA and Ubisoft Inc. published, distributed, offered for sale, and sold the *Just Dance* and *Rocksmith* games, and related virtual reality peripheral hardware devices and downloadable content for those games, intending that the games, peripheral hardware devices, and downloadable content would be used, and knowing that the games, peripheral hardware devices, and downloadable content would be used, by purchasers of the games, peripheral hardware devices, and downloadable content with computer and gaming console systems including microprocessors programmed to generate electronic files (such as electronic Timeline files, Waveform Audio (.wav) files, Wwise Encoded Media (.wem) files, and/or Ogg container (.ogg) files) containing music and control information (such as information defining markers in the music files, song tempo, lyrics, animations, and choreography) corresponding to playable song tracks that include additional information not extracted from a music signal, including information defining markers in the music files, lyrics, animations, and choreography.

60. As another example, claim 20 states that the "control track is time shifted relative to the music signal to compensate for delays in said virtual reality computer system."

61. Ubisoft SA and Ubisoft Inc. developed the *Just Dance* and *Rocksmith* electronic video games, and related virtual reality peripheral hardware devices and downloadable content for those games, using, and Ubisoft SA and Ubisoft Inc. tested and otherwise used the *Just Dance* and *Rocksmith* games, and related virtual reality peripheral hardware devices and downloadable content for those games, with, computer and gaming console systems including microprocessors programmed to delay the music signal based on, for example, latency and calibration settings to ensure that the music and animations are properly synchronized.

62. Ubisoft SA and Ubisoft Inc. developed the *Just Dance* and *Rocksmith* electronic

video games, and related virtual reality peripheral hardware devices and downloadable content for those games, and Ubisoft SA and Ubisoft Inc. published, distributed, offered for sale, and sold the *Just Dance* and *Rocksmith* games, and related virtual reality peripheral hardware devices and downloadable content for those games, intending that the games, peripheral hardware devices, and downloadable content would be used, and knowing that the games, peripheral hardware devices, and downloadable content would be used, by purchasers of the games, peripheral hardware devices, and downloadable content with computer and gaming console systems including microprocessors programmed to delay the music signal based on, for example, latency and calibration settings to ensure that the music and animations are properly synchronized.

Ubisoft SA's And Ubisoft Inc.'s Knowledge Of Infringement Of The '129 Patent

63. Ubisoft SA and Ubisoft Inc. have been aware of the '129 patent, and of their infringement of the patent, since at least March of 2009. At that time, Ubisoft SA purchased the unreleased electronic video game known as *Guitar Rising* from GameTank, Inc., an independent California video game developer. At the same time, Ubisoft SA acquired GameTank's intellectual property and patent applications relating to the *Guitar Rising* game. One of the patent applications Ubisoft SA acquired from GameTank, Inc. relating to the *Guitar Rising* game was U.S. Patent Application No. 11/865,681 ("INSTRUMENT GAME SYSTEM AND METHOD") filed in October of 2007, and formally assigned to Ubisoft SA in June of 2010.

64. After purchasing the *Guitar Rising* game, Ubisoft Inc. continued to develop the game, and subsequently published the game in the United States using the name *Rocksmith*. Mr. Jacob Parks, the CEO and co-founder of GameTank and the inventor named in the '681 patent application, became a software engineer employed by Ubisoft Inc. in April of 2009 working as

part of the Ubisoft Inc. internal start up team that launched the *Rocksmith* electronic video game.

65. The patent attorney representing GameTank and Mr. Parks in connection with the prosecution of the '681 patent application was Mr. Timothy W. Lohse. Ubisoft SA continued to engage Mr. Lohse to represent Mr. Parks and Ubisoft SA in connection with the prosecution of the '681 patent application, as well as other, subsequently-filed U.S. patent applications relating to electronic video games.

66. Ubisoft SA and Ubisoft Inc. were both aware of the '129 patent, and of their infringement of the patent, as a result of Ubisoft SA's acquisition of the *Guitar Rising* game, and GameTank's intellectual property and patent applications relating to the *Guitar Rising* game, as well as a result of Ubisoft Inc.'s employment of Mr. Parks as a software engineer.

67. As an example, in June of 2009, during prosecution of the '681 patent application, Mr. Lohse submitted prior art that both Mr. Parks and Ubisoft SA were aware of relating to that application. One of those patents was U.S. Patent No. 5,990,405 (the "'405 patent"), filed July 8, 1998 and granted November 23, 1999, assigned to Gibson Guitar Corp. ("Gibson"). That patent describes prior art virtual reality systems as "a combination of computer hardware, software, and peripherals which recreate a virtual world or virtual environment using a video display, often in combination with an audio sound system," and as "quite complex, combining the hardware, software, and peripheral devices in a specific manner to immerse or subject the user of the system to visual and sound stimuli which simulate a real world experience."

68. The Gibson patent also referred to PDIC's '129 patent as describing such a virtual reality system, and described the specific elements of the virtual reality systems claimed in the '129 patent:

> Such a system is disclosed in U.S. Pat. No. 5,513,129, which

> describes a virtual reality [system] in which a music source is connected to an electronic interface and to a virtual reality processor. The system is further controlled by one or more input devices, such as a head tracker and manipulator glove. The pre-recorded music, along with an optional pre-recorded control track, controls and manipulates objects within the virtual environment such that the music effectively drives the display of an animated graphical scene.

69. Ubisoft SA and Ubisoft Inc. knew, as a result of Ubisoft Inc.'s employment of Mr. Parks, and Ubisoft SA's engagement of Mr. Lohse as its patent attorney, that the '129 patent described and claimed a virtual reality system in which a music source is connected to an electronic interface and to a virtual reality processor, that is controlled by one or more input devices, and in which pre-recorded music, along with an optional pre-recorded control track, controls and manipulates objects within the virtual environment such that the music effectively drives the display of an animated graphical scene, and that computer and gaming console systems on which the *Rocksmith* game would be played would infringe the '129 patent.

70. Ubisoft SA and Ubisoft Inc. were also both aware of the '129 patent, and of their infringement of the patent, in June of 2011, at the time Ubisoft SA entered into a distribution agreement and partnership with Gibson to promote and authorize Ubisoft Inc.'s sale of Gibson guitars with Ubisoft's *Rocksmith* Real Tone Cable™ and *Rocksmith* electronic video game. Pursuant to this partnership, when *Rocksmith* was released in the Fall of 2011, Gibson Epiphone guitars were bundled together and sold in a package with the *Rocksmith* Real Tone Cable™ and *Rocksmith* electronic video game. The *Rocksmith* Real Tone Cable™ was developed by Ubisoft Inc. to connect electric guitars to a computer or gaming console system and control the "virtual environment" produced by the *Rocksmith* game. After Ubisoft SA and Gibson entered into their partnership, Mr. Lohse continued to represent Mr. Parks and Ubisoft SA in connection with the

prosecution of the Ubisoft SA patent applications, and continued to submit the Gibson '405 patent with its reference to and detailed description of the features of the virtual reality computer systems described and claimed in PDIC's '129 patent as relevant prior art on multiple occasions in 2011 and 2012 during the prosecution of Ubisoft SA patent applications.

71. Ubisoft SA and Ubisoft Inc. also knew, as a result of the company's employment of Mr. Parks, and its engagement of Mr. Lohse as its patent attorney, and Ubisoft SA's partnership with Gibson, that the '129 patent described and claimed a virtual reality system in which a music source is connected to an electronic interface and to a virtual reality processor, that is controlled by one or more input devices, and in which pre-recorded music, along with an optional pre-recorded control track, controls and manipulates objects within the virtual environment such that the music effectively drives the display of an animated graphical scene, and that computer and gaming console systems on which the *Rocksmith* game, and similar games such as *Just Dance*, would be played would infringe the '129 patent.

72. At the time Ubisoft SA acquired the *Guitar Rising* game, and the intellectual property and patent applications relating to the *Guitar Rising* game, from GameTank, Inc., and since then, Ubisoft Inc. knew that its development of at least the *Rocksmith* electronic video game, and related virtual reality peripheral hardware devices and downloadable content for that game, and testing and otherwise using at least the *Just Dance* and *Rocksmith* electronic video games, and related virtual reality peripheral hardware devices and downloadable content for those games, with computer and gaming console systems directly infringed claims 14, 19, and 20 of the '129 patent.

73. At that time and since then, Ubisoft SA and Ubisoft Inc. also knew that customers purchasing at least the *Just Dance* and *Rocksmith* games, and related virtual reality peripheral

hardware devices and downloadable content for those games, would infringe, and were infringing, claims 14, 19, and 20 of the '129 patent when playing those games, and, with full knowledge of the '129 patent, nevertheless induced its infringement by instructing users, for example on their marketing and technical support web sites, in their advertising, marketing and promotional materials, in their technical support documents, on their product packaging, and in their instruction guides distributed with the games, and related virtual reality peripheral hardware devices and downloadable content for those games, including, for example, the *Just Dance 3* instruction booklet and *Rocksmith* instruction guide attached as Exhibits 2 and 3, how to play at least the *Just Dance* and *Rocksmith* games on computers and gaming consoles, using related virtual reality peripheral hardware devices and downloadable content for those games, and infringe claims 14, 19, and 20 of the '129 patent.

74. At that time and since then, Ubisoft SA and Ubisoft Inc. also knew that customers purchasing at least the *Just Dance* and *Rocksmith* games would infringe, and were infringing, claims 14, 19, and 20 of the '129 patent when playing those games, and, with full knowledge of the '129 patent, nevertheless contributed to the infringement of claims 14, 19, and 20 of the '129 patent by offering for sale and selling at least the *Just Dance* and *Rocksmith* electronic video games, related virtual reality peripheral devices for the *Rocksmith* game, and downloadable content for the *Just Dance* and *Rocksmith* games, for use with computer and gaming console systems, knowing the games, peripheral hardware devices, and downloadable content to be especially made or especially adapted for use in an infringement of claims 14, 19, and 20 of the '129 patent, and that the games, peripheral hardware devices, and downloadable content constitute a material part of the virtual reality computer systems claimed in claims 14, 19, and 20 of the '129 patent, and which are not a staple article or commodity of commerce suitable for substantial non-infringing use, but instead,

published and distributed the *Just Dance* and *Rocksmith* games, and related virtual reality peripheral hardware devices and downloadable content for those games, knowing that those games, peripheral devices and downloadable content are suitable only for practicing claims 14, 19, and 20 of the '129 patent when used with and played on computers and gaming consoles, as described above in paragraphs 26–34 and 35–62, as demonstrated, for example, by the *Just Dance 3* instruction booklet and *Rocksmith* instruction guide attached as Exhibits 2 and 3.

Ubisoft SA's And Ubisoft Inc.'s Willful Infringement Of The '129 Patent

75. Ubisoft SA and Ubisoft Inc. have willfully infringed the '129 patent, and each continued to willfully infringe the '129 patent after commencement of this litigation, as described above in paragraphs 21–74, with full knowledge that there was an objectively high likelihood that their conduct, and that of their customers, and users, constituted infringement of claims 14, 19, and 20 of the '129 patent. At the time, Ubisoft SA and Ubisoft Inc. also knew that claims 14, 19, and 20 of the '129 patent were valid and enforceable, as confirmed by the subsequent refusal of the PTAB to institute *inter partes* review based on the prior art presented by Konami, Harmonix, and Ubisoft SA, described above in paragraphs 11–20.

76. More specifically, as described above in paragraphs 21–74, Ubisoft SA and Ubisoft Inc. deliberately infringed the '129 patent, and acted recklessly and in disregard of PDIC's rights in the '129 patent, by developing, testing, otherwise using, publishing, distributing, selling, and offering to sell at least the *Just Dance* and *Rocksmith* electronic video games, and related virtual reality peripheral hardware devices and downloadable content for those games. Ubisoft SA and Ubisoft Inc. were aware of the '129 patent, and the virtual reality computer systems described and claimed in the '129 patent, from several different sources on a number of

different occasions, and knew that at least the *Just Dance* and *Rocksmith* electronic video games, and related virtual reality peripheral hardware devices and downloadable content for those games, practiced the subject matter claimed in the '129 patent, specifically the subject matter of claims 14, 19, and 20 of the '129 patent, when used with computer and gaming console systems, and that those claims were valid and enforceable.

PRAYER FOR RELIEF

WHEREFORE, the plaintiff PDIC prays for judgment against each one of the defendants on all the counts and for the following relief:

A. A declaration that the plaintiff is the owner of the '129 patent, and that the plaintiff has the right to sue and to recover for infringement thereof;

B. A declaration that the '129 patent is valid and enforceable;

C. A declaration that each of the defendants has infringed the '129 patent, and that such infringement was willful;

D. An accounting for damages under 35 U.S.C. § 284 from each of the defendants for its respective infringement of the '129 patent, and an award of damages ascertained against each of the defendants in favor of plaintiff PDIC, together with interest as provided by law;

E. An award of the plaintiff's attorneys' fees and costs; and

F. Such other and further relief as this Court may deem proper, just and equitable.

JURY DEMAND

Plaintiff PDIC demands a trial by jury of all issues properly triable by jury in this action.

Dated: February __ , 2016

Respectfully submitted,

Sean T. O'Kelly (No. 4349)
Daniel P. Murray (No. 5785)
O'KELLY ERNST & BIELLI, LLC
901 N. Market Street, Suite 1000
Wilmington, Delaware 19801
Telephone: (302) 778-4000
Facsimile: (302) 295-2873
Email: sokelly@oeblegal.com
Email: dmurray@oeblegal.com

Michael J. Lennon (admitted *pro hac vice*)
KENYON & KENYON LLP
One Broadway
New York, NY 10004-1007
Telephone: (212) 425-7200
Facsimile: (212) 425-5288
Email: mlennon@kenyon.com

Michael N. Zachary (admitted *pro hac vice*)
KENYON & KENYON LLP
1801 Page Mill Road
Palo Alto, CA 94304
Telephone: (650) 384-4683
Facsimile: (650) 384-4701
Email: mzachary@kenyon.com

Susan A. Smith (admitted *pro hac vice*)
KENYON & KENYON LLP
1500 K Street, NW
Washington, DC 20005-1257
Telephone: (202) 220-4200
Facsimile: (202) 220-4201
Email: ssmith@kenyon.com

By /s/ Sean T. O'Kelly

Attorneys for plaintiff
PRINCETON DIGITAL IMAGE CORPORATION

Exhibit 1

US005513129A

United States Patent [19]

Bolas et al.

[11] **Patent Number: 5,513,129**

[45] **Date of Patent: Apr. 30, 1996**

[54] **METHOD AND SYSTEM FOR CONTROLLING COMPUTER-GENERATED VIRTUAL ENVIRONMENT IN RESPONSE TO AUDIO SIGNALS**

[75] Inventors: **Mark Bolas**; **Ian E. McDowall**, both of Palo Alto; **Michael N. Bolas**, Los Angeles, all of Calif.

[73] Assignee: **Fakespace, Inc.**, Menlo Park, Calif.

[21] Appl. No.: **91,650**

[22] Filed: **Jul. 14, 1993**

[51] **Int. Cl.**[6] **G06F 17/00**

[52] **U.S. Cl.** **364/578**

[58] **Field of Search** ..... 364/578, 514, 364/DIG. 1, DIG. 2; 360/14.2; 340/712; 358/81, 82; 345/156; 84/645, 610, 464 R, 601, 602, 609, 611, 634, 635, 641, 642, DIG. 1, DIG. 2, DIG. 29; 395/152, 153, 154, 155, 156, 157, 159, 161, 200

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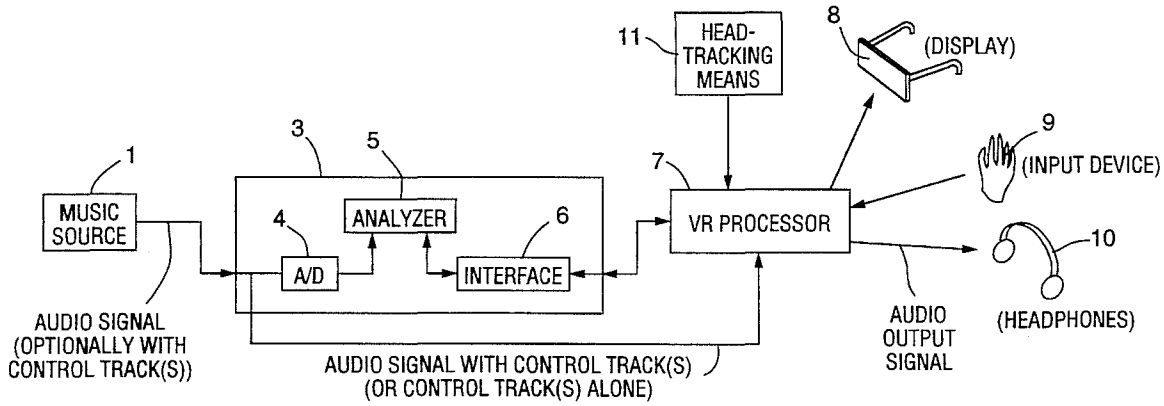
Primary Examiner—Ellis B. Ramirez

Attorney, Agent, or Firm—Limbach & Limbach; Alfred A. Equitz

[57] **ABSTRACT**

A method and apparatus for the control and manipulation of a virtual environment (such as virtual objects therein) in response to a music signal. The music is either interpreted directly to effect the control and manipulation. Alternatively, a control track corresponding to an audio signal (such as a music signal) is prerecorded, played back with the audio signal, and the control track is processed to control and manipulate the virtual world (or to control some other process of a computer system) as the audio signal is playing. In preferred embodiments, a computer creating a virtual world interprets the music, the control track, or both, and uses the resulting information to modify, create, and or control objects in the virtual environment. Preferred embodiments of the inventive system include apparatus for delaying input music to compensate for lag introduced by the system components, such as delay required to implement processing of control tracks corresponding to the input music.

23 Claims, 7 Drawing Sheets



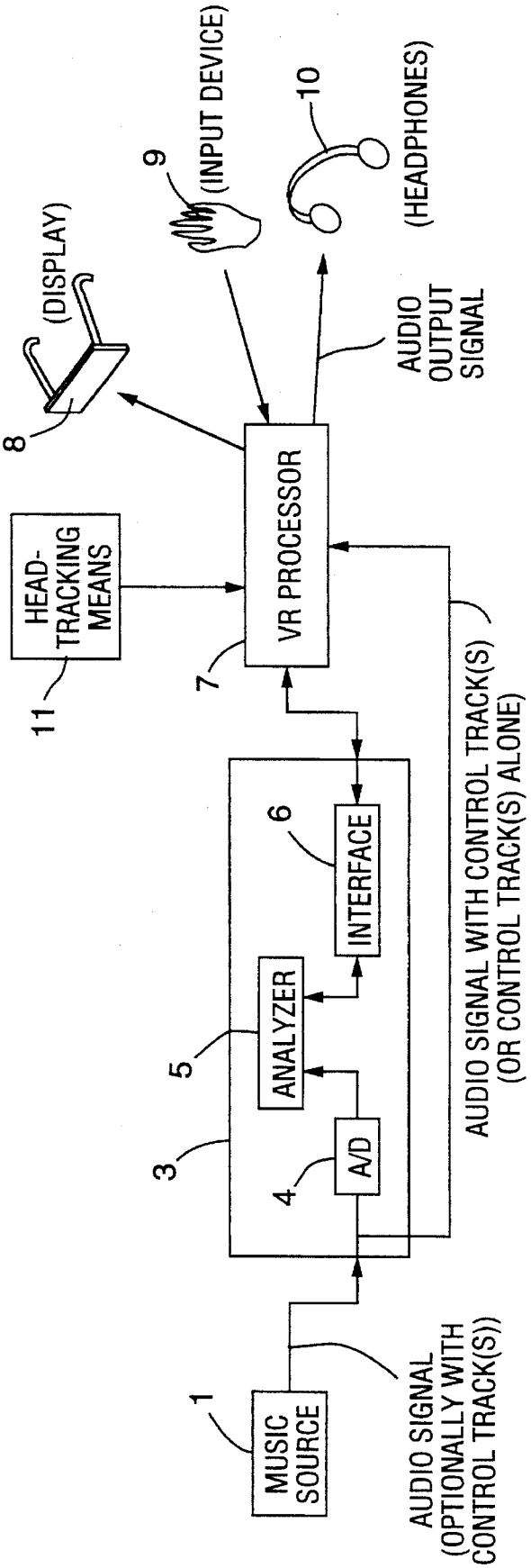

MUSIC SOURCE
1
AUDIO SIGNAL (OPTIONALLY WITH CONTROL TRACK(S))
3
4
A/D
5
ANALYZER
6
INTERFACE
AUDIO SIGNAL WITH CONTROL TRACK(S) (OR CONTROL TRACK(S) ALONE)
7
VR PROCESSOR
11
HEAD-TRACKING MEANS
8
(DISPLAY)
9
(INPUT DEVICE)
10
(HEADPHONES)
AUDIO OUTPUT SIGNAL

FIG. 1

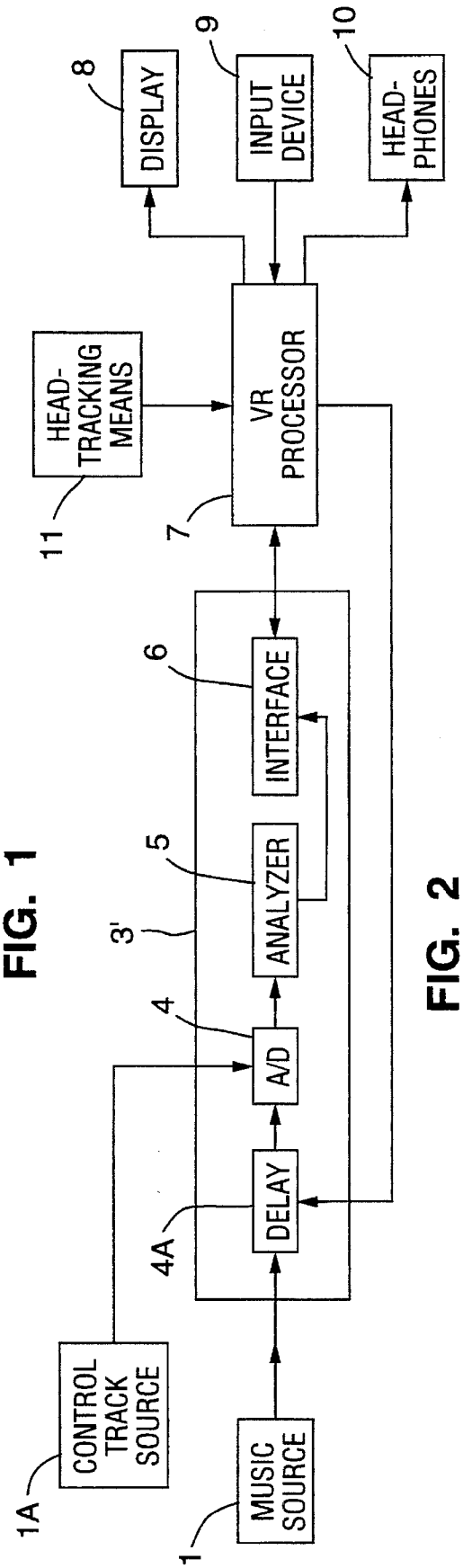

1
MUSIC SOURCE
1A
CONTROL TRACK SOURCE
3'
4
A/D
4A
DELAY
5
ANALYZER
6
INTERFACE
7
VR PROCESSOR
11
HEAD-TRACKING MEANS
8
DISPLAY
9
INPUT DEVICE
10
HEAD-PHONES

FIG. 2

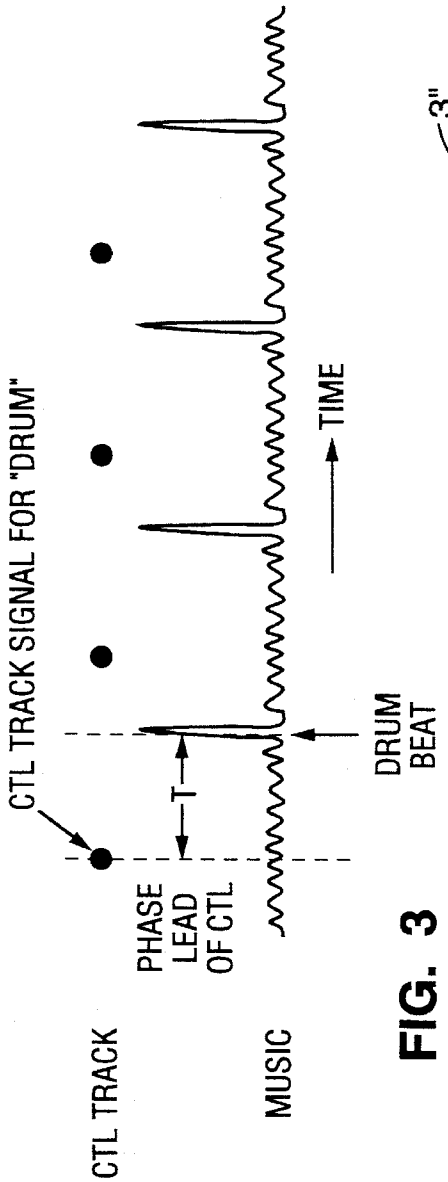

CTL TRACK SIGNAL FOR "DRUM"
TIME
T
DRUM BEAT
PHASE LEAD OF CTL
CTL TRACK
MUSIC

FIG. 3

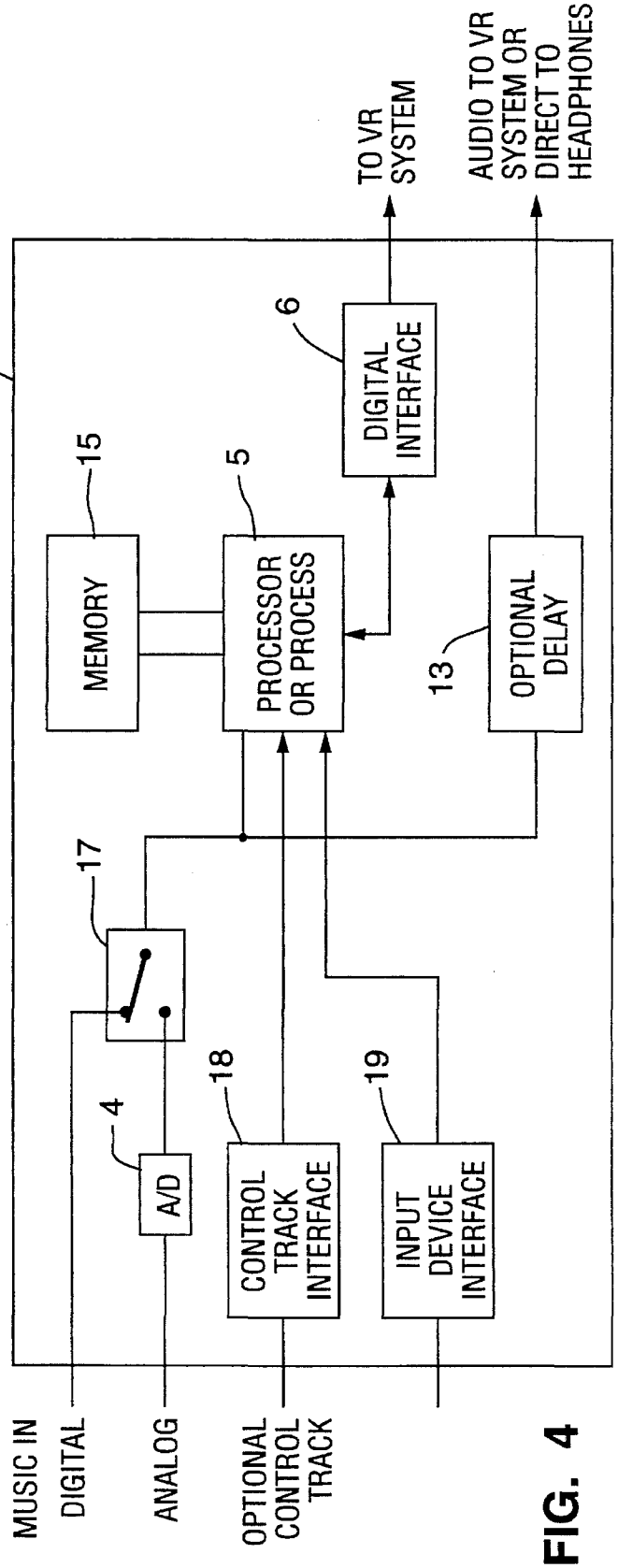

3"
TO VR SYSTEM
AUDIO TO VR SYSTEM OR DIRECT TO HEADPHONES
6
DIGITAL INTERFACE
15
MEMORY
5
PROCESSOR OR PROCESS
13
OPTIONAL DELAY
17
4
A/D
18
CONTROL TRACK INTERFACE
19
INPUT DEVICE INTERFACE
MUSIC IN DIGITAL
ANALOG
OPTIONAL CONTROL TRACK

FIG. 4

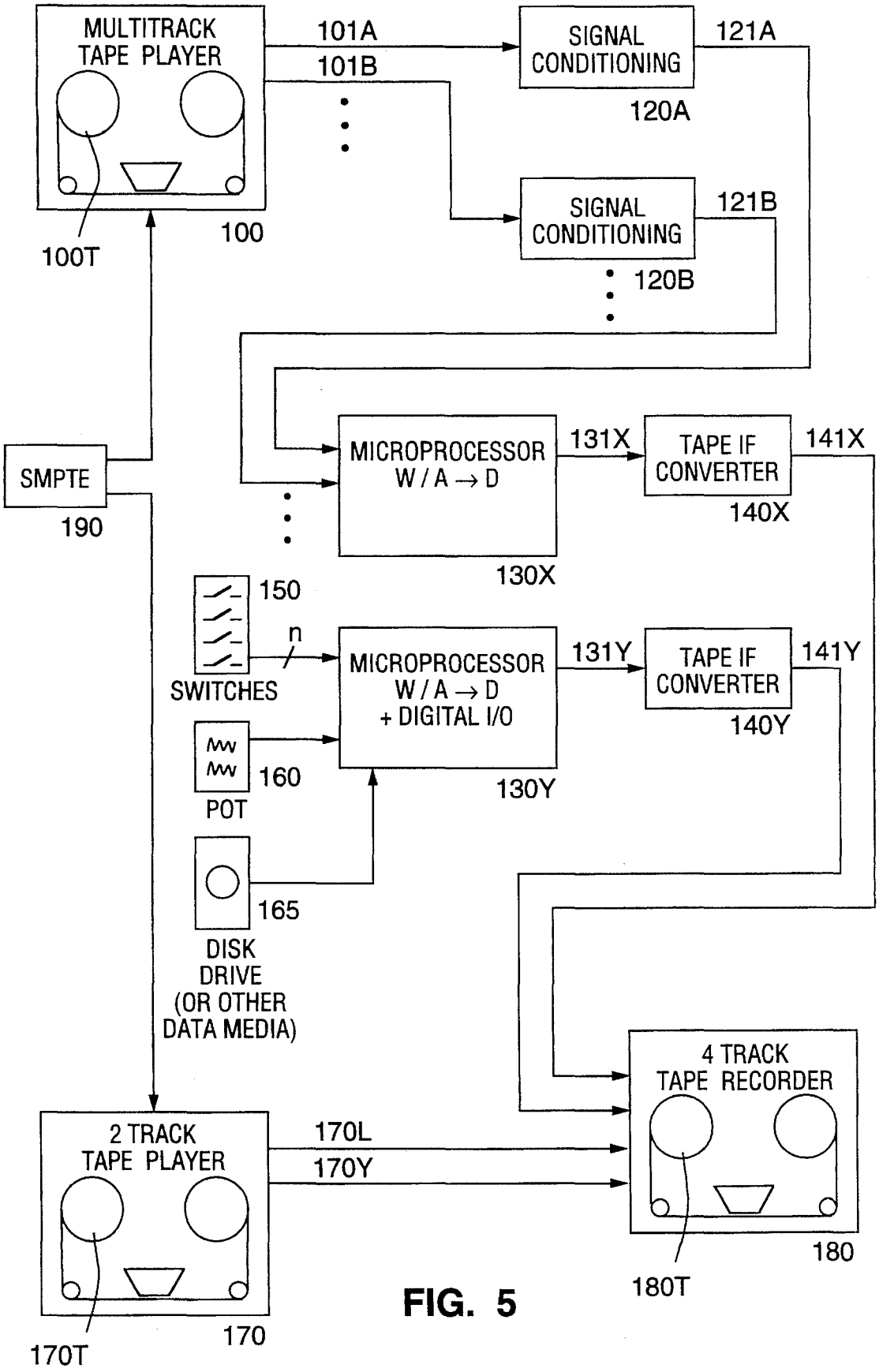

MULTITRACK TAPE PLAYER
100
100T
101A
101B
SIGNAL CONDITIONING
120A
121A
SIGNAL CONDITIONING
120B
121B
SMPTE
190
MICROPROCESSOR W / A → D
130X
131X
TAPE IF CONVERTER
140X
141X
150
SWITCHES
n
MICROPROCESSOR W / A → D + DIGITAL I/O
130Y
131Y
TAPE IF CONVERTER
140Y
141Y
160
POT
165
DISK DRIVE (OR OTHER DATA MEDIA)
4 TRACK TAPE RECORDER
180
180T
2 TRACK TAPE PLAYER
170
170T
170L
170Y

FIG. 5

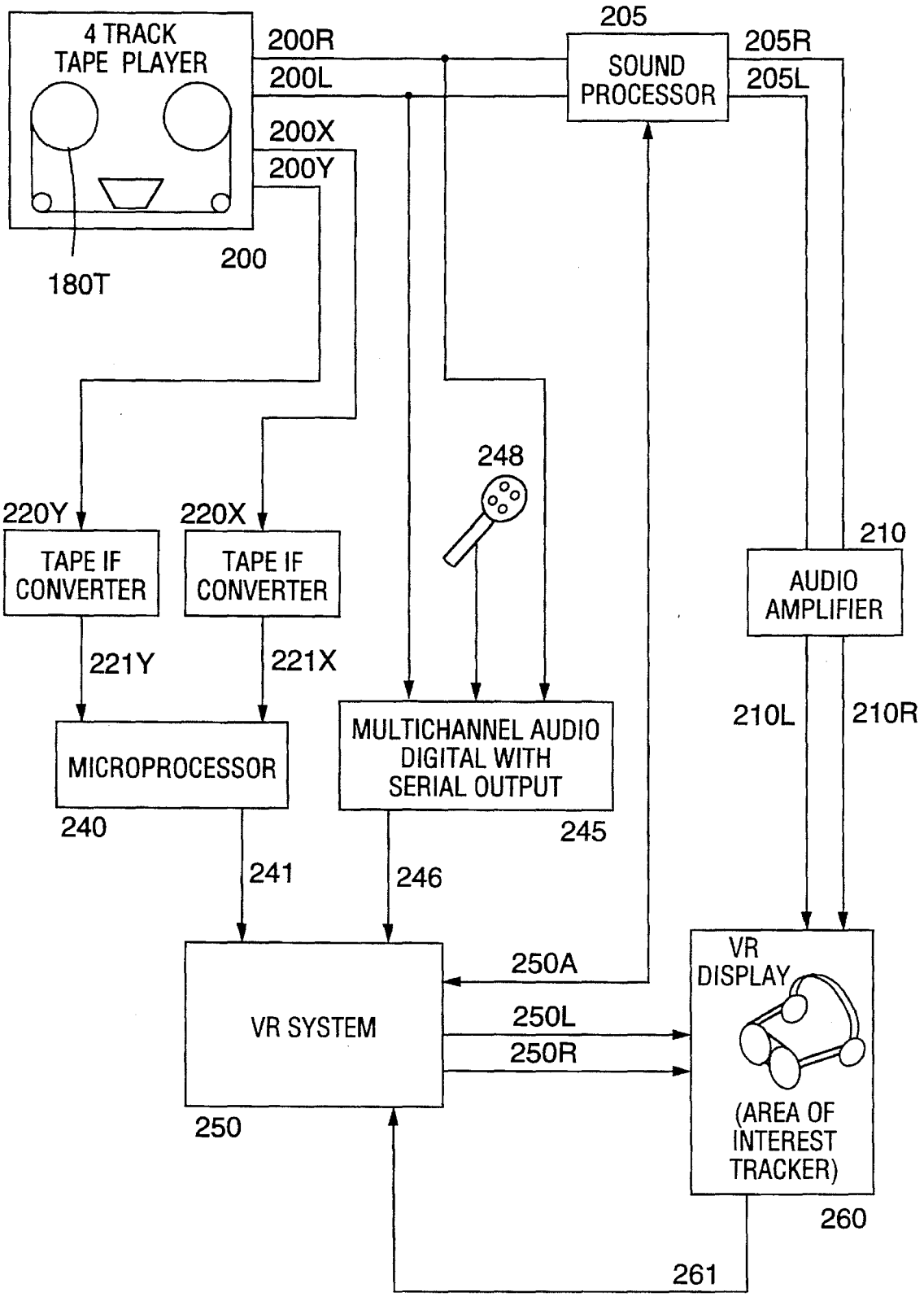

4 TRACK TAPE PLAYER
200R
200L
200X
200Y
200
180T
205
SOUND PROCESSOR
205R
205L
220Y
220X
TAPE IF CONVERTER
TAPE IF CONVERTER
221Y
221X
248
210
AUDIO AMPLIFIER
210L
210R
MULTICHANNEL AUDIO DIGITAL WITH SERIAL OUTPUT
245
MICROPROCESSOR
240
241
246
250A
VR SYSTEM
250L
250R
250
VR DISPLAY
(AREA OF INTEREST TRACKER)
260
261

FIG. 6

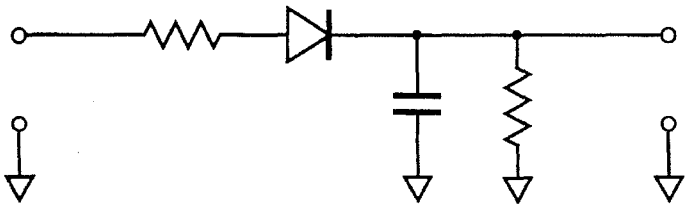


FIG. 7

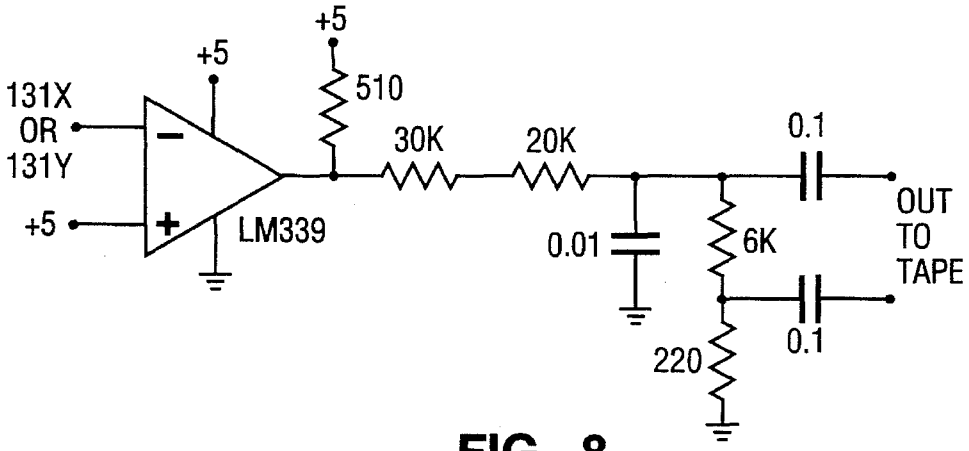


FIG. 8

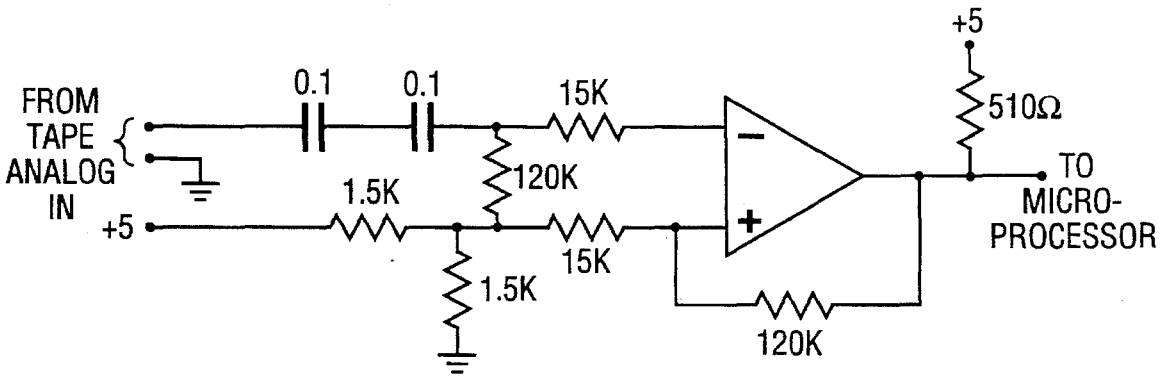


FIG. 9

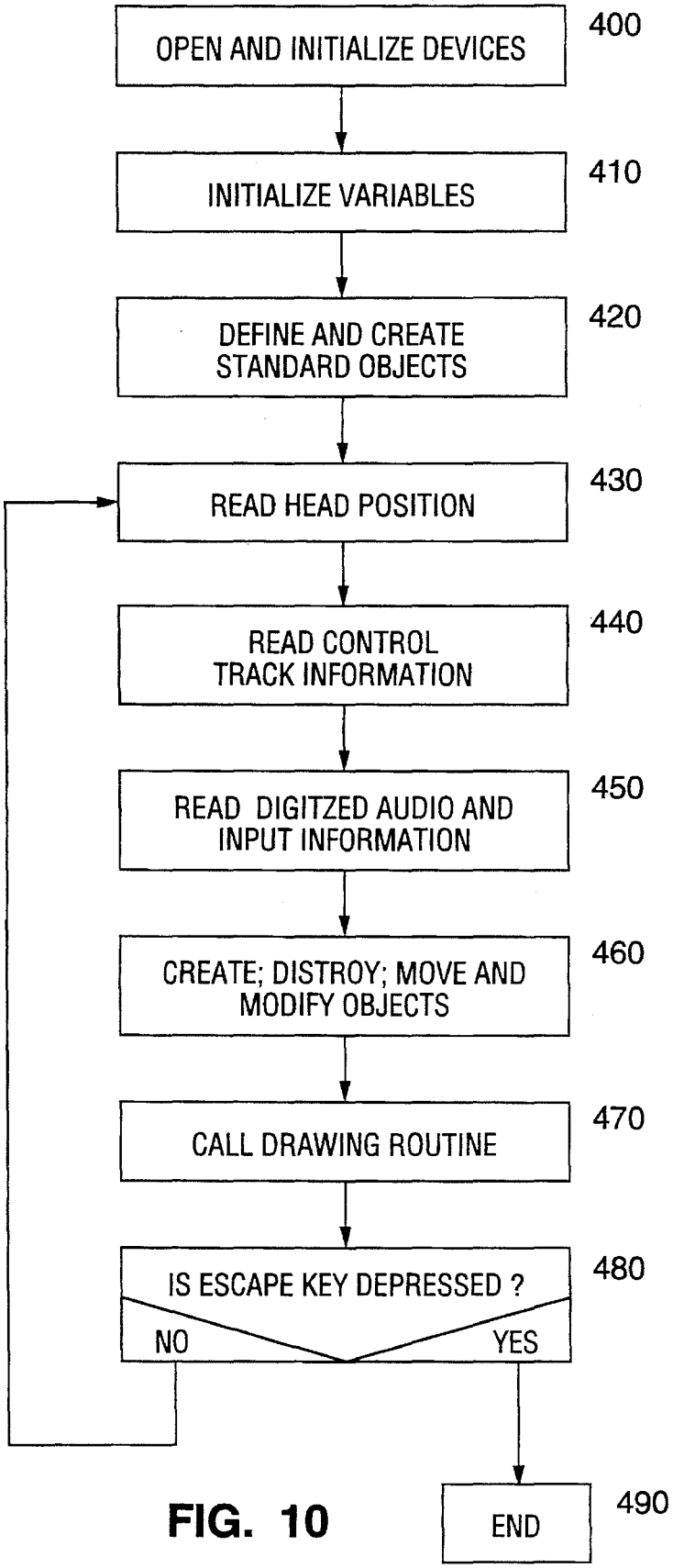

OPEN AND INITIALIZE DEVICES
400
INITIALIZE VARIABLES
410
DEFINE AND CREATE STANDARD OBJECTS
420
READ HEAD POSITION
430
READ CONTROL TRACK INFORMATION
440
READ DIGITZED AUDIO AND INPUT INFORMATION
450
CREATE; DISTROY; MOVE AND MODIFY OBJECTS
460
CALL DRAWING ROUTINE
470
IS ESCAPE KEY DEPRESSED ?
480
NO
YES
END
490

FIG. 10

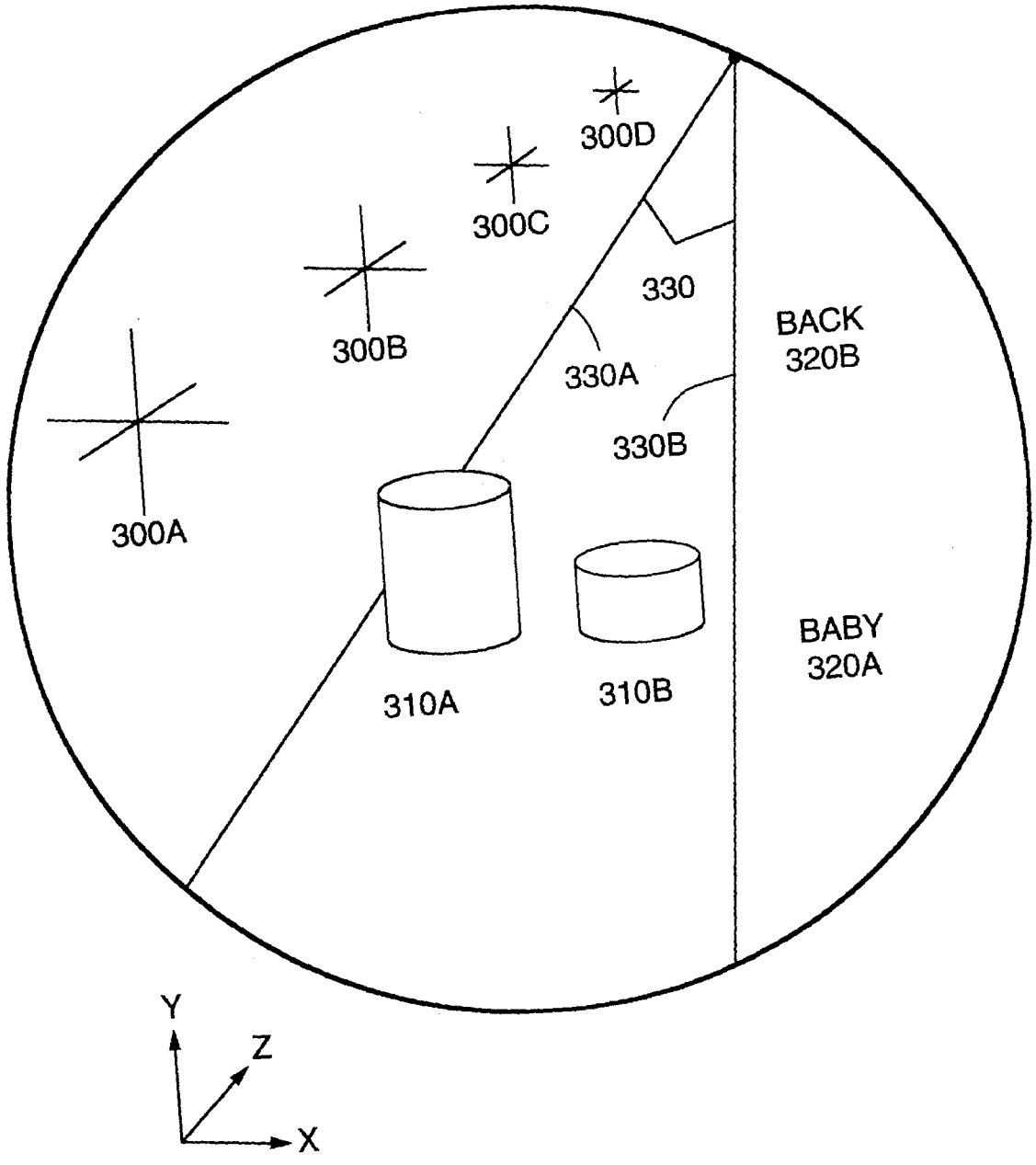

300D
300C
300B
300A
330
330A
330B
BACK
320B
BABY
320A
310A
310B
Y
Z
X

FIG. 11

METHOD AND SYSTEM FOR CONTROLLING COMPUTER-GENERATED VIRTUAL ENVIRONMENT IN RESPONSE TO AUDIO SIGNALS

Field of the Invention

The invention pertains to methods and apparatus for controlling a computer system in response to music signals, or in response to prerecorded control tracks corresponding to audio signals (such as music signals). In preferred embodiments, invention pertains to methods and apparatus for creating and modifying, or otherwise controlling, computer-generated virtual environments (or displayed virtual objects in virtual environments) in response to music signals or in response to prerecorded control tracks corresponding to audio signals.

BACKGROUND OF THE INVENTION

The terms "virtual environment," "virtual world," and "virtual reality" are used interchangeably to describe a computer-simulated environment (intended to be immersive) which includes a graphic display (from a user's first person perspective, in a form intended to be immersive to the user), and optionally also sounds which simulate environmental sounds. The abbreviation "VR" will sometimes be used herein to denote "virtual reality," "virtual environment," or "virtual world". A computer system programmed with software, and including peripheral devices, for producing a virtual environment will sometimes be referred to herein as a VR system or VR processor.

The graphic display generated by a VR system can be a two-dimensional (2D) or a three-dimensional (3D) display. Typically, a VR system includes an input device and user interface software which enable a user to interact with the scene being displayed, typically to simulate motion in the virtual environment or manipulation of displayed representations of objects ("virtual objects") in the virtual environment. Typically, the illusion of immersion in a virtual reality system is strengthened by the use of head-tracking or some other such system which directs the computer to generate images along the area of viewing interest of the user.

The present invention is a method and apparatus particularly useful for creating and/or controlling virtual environments. A VR system which embodies the invention can rapidly and inexpensively create, animate, or otherwise control a wide variety of entertaining virtual environments and virtual objects in response to music or in response to prerecorded "control tracks" which correspond to audio signals (such as music).

While currently being used in the research and scientific communities, VR systems are becoming less expensive and are poised to reach the consumer electronics market as entertainment devices.

VR systems must generate a much greater amount of content data (image data and audio data simulating environmental appearance and sounds) than must be generated in most other electronic media. Whereas video game systems require complex scenes to be generated and themes to be programmed, such systems can easily limit the scope of the game content because they can easily constrain the player to move in a few simple directions (e.g., left and right) and need only produce images to be presented on flat screen monitors or on simple 3D field-sequential type monitors.

In contrast, by their very nature, VR systems allow the user to look around and fly around in many different directions and positions. Even where the user is constrained to look only toward the left or the right, VR systems must construct complete representations of 3D worlds. This complexity has made it very difficult to generate virtual worlds for the consumer entertainment market in a quick fashion.

In addition to the complexity of creating static 3D models for virtual worlds, it has also been difficult to control the dynamics of virtual worlds. VR systems to date are notorious for providing only very boring and nearly static environments. The few VR systems that include dynamic motions of the virtual world either base such motions on physical laws (such as gravity) or base the motions on corresponding motions produced by human users (such as motion of the fingers of a user wearing a conventional "glove" input device).

The present invention overcomes the limitations of conventional VR systems by providing an efficient way to generate content data (i.e., animated image data and audio data) to fill or populate a virtual environment in a choreographed response to input music signals.

There has long been an interest in the virtual reality field with respect to the possibility of virtual musical instruments and the creation of new and novel instruments within a virtual world. The present invention is a radical shift from previous attempts to combine music and virtual environments.

Conventional efforts to integrate music with virtual environments have, to date, all been directed toward creation of music from a virtual environment. The musical expression of the user has been treated as an urge seeking to be brought forth, and virtual environments have been seen as vehicles for the user to perform music or dance without having to learn special physical skills. Much effort has been made to make sounds appear to be coming from virtual objects in the virtual environment. This has been done by running audio into the VR system and then convolving the audio in such a way as to make it appear to come from a certain place in the virtual environment.

For example, at the NASA Ames View Lab, Scott Fisher, Rick Jacoby, and others explored virtual environments. One aspect of the research was the integration of audio into the virtual experience. This included the use of audio cues for such purposes as telling one if one bumped into a virtual object, but there was no tactile feedback for such events. The research pushed into the more artistic realm of creation of music in the context of a virtual world.

Mark Bolas and Phil Stone created the Virtual Theremin and virtual drum kit. In this system, the user wore a glove and a hand tracker and moved the gloved hand to manipulate virtual objects which were in turn linked to various synthesizer parameters. Thus, by manipulating virtual objects (as taught, for example, by U.S. Pat. 4,988,981, issued Jan. 29, 1991), sounds of different qualities could be created. A skilled user could create modern sounding musical interludes. These ideas have been carried forth by people such as Jaron Lanier who has given a number of public performances in which he manipulates virtual objects to create a musical performance. Research and exploration along these lines is expected to continue (the virtual "air guitar" and the like will probably be developed). In all VR systems of this type, manipulation of a virtual object causes the sound or music to change.

Currently, virtual worlds are created by describing a simulation and a number of objects. The interaction of the

objects is described in some form of simulation language or graphical description. Traditionally, the control and creation of the objects is driven by "world building" software. Once a virtual world has been created, a limited number of its parameters may be manipulated by the user from "inside" the virtual world. One example of how these databases are created is described in PCT International Patent Application WO 92/09948, by VPL Research Inc. As is evident from WO 92/09948, it has define animation for all or even some of the virtual objects in a virtual world. Until the present invention, it had not been proposed to interface to nodes in a database defining a virtual environment, and to manipulate such nodes, on the basis of music.

Conventional VR systems and music have thusfar been used together in ways which have the following disadvantages:

(a) a VR system has been used as a virtual musical instrument, so that the user must "play" the virtual instrument (by manipulating an input device) to hear anything. This means that the system creates music, and that the system's musical output is limited by the user's ability to "play" the "instrument;"

(b) VR systems that have given sounds to virtual objects (e.g., the system displays a virtual kitchen sink and produces a "drip-drip" sound which seems to come from the sink's location) have required that the sounds are generated by signals produced within the VR system in response to user manipulation of an input device or internal programs, which signals are then interpreted by a synthesizer. The sounds produced by the synthesizer are thus cued from the VR system in response to manipulation of an input device (which manipulation may, for example, to cause a user to "move" into a position to view or otherwise interact with a virtual kitchen sink from which sounds will then seem to emanate). Thus, these VR systems have depended on user manipulation of an input device to control the appearance or activities of objects in a virtual environment, to cause the VR system to cue production of sound events; and

(c) VR systems have played musical scores as background music for the virtual environment.

Basically, the paradigm to date has been to create systems that have (virtual) object-driven sounds. This invention reverses the paradigm to create a system which has musically-driven objects.

One VR system has been developed in which a VR processor is programmed to perform simple operations to modify a virtual environment in response to voice commands. This VR system, developed at the NASA Ames View Lab during the years 1988–1989, was capable of displaying a virtual object, or terminating the display of a virtual object, in response to a voice command from a human user. However, the system did not produce, modify, or otherwise control a virtual environment in response to music, or in response to a prerecorded control track corresponding to an audio signal.

Outside the VR field, many attempts have been made to produce devices which provide users with visual light effects based on an audio signal, such as music. However, these systems have been disappointing to watch (principally because the light shows are two-dimensional and are not obviously correlated with the audio input), and have typically met with disappointment when marketed.

An example of a conventional apparatus for producing visual light effects based on audio signals is described in U.S. Pat. No. 4,081,829 (issued Mar. 28, 1978). This apparatus controls the display of two-dimensional rings or solid shapes on the screen of a television receiver, in response to audio input signals. However, only a limited set of two-dimensional shapes can be displayed and only limited changes in their shape or color can be accomplished in response to the audio input.

Another example of a conventional apparatus for producing visual light effects in response to audio signals is described in U.S. Pat. No. 4,257,062 (issued Mar. 17, 1981). This apparatus controls a set of lamps which are mounted in eyewear to be worn by the user, by switching individual ones of the lamps on and off in response to music. Peak levels of specific frequency bands of the music are detected and employed to switch on or off different ones of the lamps.

Another system for producing visual effects in response to audio signals has been described in the Jan. 1993 issue of NewMedia magazine (at page 18) as a system which includes a Silicon Graphics Iris Indigo workstation, and which alters the appearance of colored visual representations of sound waves (displayed on a large screen in a concert hall) in response to crowd noise (picked up by a microphone during a concert) and live music in MIDI format (generated by musicians during the concert) supplied to the workstation.

It is believed that prerecorded control tracks (which correspond to prerecorded audio such as music) have not been employed to control operation of a computer system, such as to control generation of a virtual environment by a VR computer system. It is also believed that control signals have not been extracted from music for use in controlling generation of a virtual environment by a VR system (e.g., by populating the virtual environment with animated virtual objects which move in response to the music).

SUMMARY OF THE INVENTION

In a preferred embodiment, the invention is a computer system and computer-implemented method for the creation and control of a virtual world in response to music signals and/or prerecorded control tracks corresponding to the music signals. The system includes means for interfacing between the computer software which controls production of the virtual world, and live or prerecorded music (and/or prerecorded control tracks). The invention transcends traditional use of VR as a musical instrument, and enables a VR system to be employed as a virtual stage driven by music.

In another class of embodiments, the invention controls operation of a computer system (which need not be a VR system) in response to one or more prerecorded control tracks corresponding to audio signals, or in response to both music signals and one or more such prerecorded control tracks.

The component of the inventive system which generates control signals from input music (and/or prerecorded control tracks and/or human generated input signals), or which sends prerecorded control tracks in appropriate format to a VR system or other processor, will sometimes be referred to herein as an "Acoustic Etch" system or an "Acoustic Etch."

In preferred embodiments, the invention employs music to manipulate or control a virtual environment. This can be accomplished in several ways. Since music cannot directly interact with the virtual environment, the Acoustic Etch receives music (in some electronic, acoustic, or optical form) and generates control signals therefrom which are used by a VR system to influence activity in the virtual world.

The control signals derived from the music may be extracted from the music directly. For example, the Acoustic Etch can employ a simple algorithm (of the same type used by well known graphic equalizers) to extract a rhythm signal indicative of the beat of some frequency band of the music (e.g. a band representing drums), or of some other parameter of a frequency band of the music. The rhythm signal is sent to the VR system which in turn generates control signals therefrom to control the rhythm of a virtual dancer (or some other moving virtual object).

As an alternative (or in addition) to extracting signals from music itself for processing by a VR system, the invention can supply to the VR system one or more prerecorded control tracks corresponding to the music, or can generate control signals from prerecorded control tracks and then supply such control signals to the VR system for processing. For example, control tracks can be prerecorded along with left and right tracks of a stereo music signal. The prerecorded control tracks, left stereo track, and right stereo track, can then be played back (simultaneously or with selected delays between them) and received in parallel by the VR system. The control tracks can be generated automatically (e.g., by electronic signal processing circuitry) in response to a music signal and then recorded, or can be generated in response to manually asserted commands from a person (while the person listens to such music signal) and then recorded.

Prerecorded control tracks can be indicative of more sophisticated analysis of a corresponding music signal than could be conveniently performed by some contemplated (e.g., inexpensive) VR system embodiments of the invention. The placement and rhythm of dancers could be encoded in prerecorded control tracks, for example.

The use of prerecorded control tracks has several advantages and features, including the following:

(a) an entire song can be choreographed and prerecorded with a control track (for example, indicative of placement and rhythm of dancers), so that the control track forms part of the prerecorded choreographed musical work;

(b) the control track can include higher level information, such as pictures of a dancer or other performer, which can be used as source data by the VR system to display images of the performer in the virtual environment;

(c) the medium for the control track need not the same as that of the music. For example, the music may be recorded on a compact disk (CD) while the control track is recorded on a computer game cartridge or other medium;

(d) synchronization of the control track and the music can be accomplished under control of the VR system, which could use the control track to synchronize with the music, or vice versa;

(e) the control track can be encoded (or processed) in a way which accounts for the "delay time" required for the VR system to use the information coming from the control track. This will improve the apparent synchronization between the music and the graphics data output from the VR system, even when the VR system requires a long time to "draw" a particular frame of an animated virtual world; and

(f) a prerecorded control track can eliminate the need for some embodiments of the invention to include means for automatically decoding musical expression (the automatic decoding of musical expression is poorly understood).

For example, an operator can record a control track which is emotionally linked with a song. The VR system could then easily convert the control track into a variety of control signals, and can produce more repeatable and interesting results than could be achieved by processing the music directly (in the absence of the control track).

The major disadvantage of using a prerecorded control track is that the control track must be generated and recorded in advance, and then played back in some way. It must be delivered in conjunction with the music, and the easiest way to do this is on the same physical recording medium.

An advantage of embodiments of the invention which directly process music (rather than processing a prerecorded control track) is that the music and the VR control signals generated therefrom are more independent than are a control track and the VR control signals generated therefrom (and can be related in any of a variety of ways). In embodiments which directly process music, the visual experience and emotional coupling between the VR and the music is looser, since the interpretation is generically related to musical signals and their processing. However, specific processing algorithms can be used by the VR system for specific songs-thus tailoring the algorithm to the music.

In essence, preferred embodiments of the invention use music to create a "track" of distilled music which is in a form usable by a VR system. The interpretation of the information is still dependent on the VR system, or the particular VR software being run by a computer system. The same "raw" music or control track can be interpreted differently by different VR systems (or VR software programs) in the sense that different VR systems (or programs) can generate different sets of control signals in response to a single raw input signal. Alternatively, the same VR system (or program) can interpret the same "raw" music or control track differently at different times. The control track can be used to program the VR system's response and thus tailor the system to a specific song.

OBJECTS AND ADVANTAGES

Accordingly, several objects and advantages of various embodiments of the present invention are:

to provide an apparatus which extracts information from music (or other audio) for the control and manipulation of objects within a virtual environment;

to provide an apparatus which uses a control track prerecorded along with audio (music, in preferred embodiments) for the control and manipulation of objects within a virtual environment;

to provide a VR system which delays audio (in response to which control signals are generated) in order to compensate for the lag introduced by other components of the VR system;

to provide a virtual experience in which music effectively drives the display of an animated graphical scene;

to provide a mechanism by which music is used to control and influence a virtual environment in such a way as to relieve the database which describes the virtual environment from having to define all the motions of the objects in the virtual environment;

to provide a control track for the influence and control of a virtual environment in which the control track is created during or following the music recording and production process when individual tracks (of a multitrack musical work) that are used for a particular mix are available before being mixed down; and

to provide a control track which can contain information (such as images of a performer's face, for example) other than information extracted from corresponding music;

Further objects and advantages are to provide for the rapid creation and animation of a virtual environment from music which already has a high level of production quality.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram of a preferred embodiment of the inventive system, in which a music source is interfaced to a VR system by an Acoustic Etch system. The blocks may or may not represent physically distinct objects (several of the blocks could be implemented in a single device).

FIG. **2** is a diagram of a variation on the Fig. **1** embodiment, in which the Acoustic Etch system receives or contains prerecorded control tracks, and music corresponding to the control tracks is used to cue output of the stored control tracks to the VR processor.

FIG. **3** is a graph of a control track and a corresponding music signal, where the control track is phase shifted relative to the music signal by a degree adequate to compensate for delays that are expected to be introduced, in other parts of the system, during processing initiated in response to the control track.

FIG. **4** is a block diagram of a variation on the Acoustic Etch apparatus employed in the FIG. **1** system.

FIG. **5** is a block diagram of a system for creating an audio tape with control tracks for playback by the system shown in FIG. **6**.

FIG. **6** is a block diagram of a system for playback of the audio tape produced by the FIG. **5** system.

FIG. **7** is a schematic diagram of a circuit suitable for implementing any of signal conditioning blocks **120**A and **120**B.

FIG. **8** is a schematic diagram of a circuit suitable for implementing either of tape IF convertors **140**X or **140**Y (of FIG. **5**).

FIG. **9** is a schematic diagram of a circuit suitable for implementing either of tape IF convertors **220**X or **220**Y (of FIG. **6**).

FIG. **10** is a block level description of the software which is preferably run on VR system **250** of FIG. **6**.

FIG. **11** is a representation of a typical single eye image as displayed on display **260** of Fig. **6**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The term "audio signal" is used herein in a broad sense to include not only sound waves but also electrical, optical, or other signals representing sound waves (such as the electrical output of a transducer in response to sound waves). The terms "music signal" and "music" are used interchangeably herein in a broad sense to include not only sound waves that are recognizable by a human listener as music, but also electrical, optical, or other signals representing such sound waves (such as the electrical output of a transducer in response to the sound waves). Typically, a system embodying the invention will receive and process music signals in the form of digitized electrical signals.

FIG. **1** is a diagram of a preferred embodiment of the inventive system. In FIG. **1**, music source **1** is interfaced to VR processor **7** by Acoustic Etch system **3**. VR processor **7** is a computer programmed with software for implementing a virtual environment. Specifically, VR processor **7** can cause image data representing a virtual environment to be displayed on display device **8** and can cause left and right channels of audio signals (simulating sounds in the virtual environment) to be played back to a user wearing headphones **10** (which include left and right speakers). Display device **8** can be any of a variety of devices, such as a device which mounts on the head of a human user (preferably including left and right monitors for providing a stereoscopic display to the user), or a single flat screen display which outputs either a non-stereoscopic display or a stereoscopic display. Head-tracking means **11** (included in both the FIG. **1** and FIG. **2** embodiments) is provided for optionally providing input (to processor **7**) indicative of the position of the head of a human user wearing a head-mounted embodiment of display device **8**.

Processor **7** is a computer programmed with software enabling a human user to interact with the virtual environment by manipulating input device **9**, whose output is supplied to processor **7**. In one embodiment, input device **9** includes a glove and sensors mounted to the glove for detecting movements of a user's hand within the glove. In another embodiment, input device **9** includes a frame and sensors for producing output signals indicative of forces or torques exerted on the frame by a user. The frame is preferably mounted to display device **8** (or to a base supporting the display device) symmetrically with respect to an axis of symmetry the display device, with limited freedom to move relative thereto, and the sensors are preferably mounted at the ends of the limited range of motion of the frame.

An analog-to-digital conversion circuit within Acoustic Etch unit **3** receives and digitizes a music signal from source **1**. The music signal is optionally accompanied by one or more prerecorded control tracks corresponding to the music signal, which control tracks are played back with the music signal. Analyzer **5** within Acoustic Etch unit **3** receives the digitized output of circuit **4**, and generates control signals by processing the music signal (or both the music signal and the control tracks). The control signals output from analyzer **5** are supplied through interface **6** to VR processor **7**, for use within processor **7** for controlling generation of the virtual environment. One or more of the control tracks (or both the music signal and one or more control tracks, or the music signal alone) can be supplied directly to VR processor **7**, to enable processor **7** to cause headphones **10** to play the music signals, and to control generation of the virtual environment in response to the control tracks or music, such as if the functions of the Acoustic Etch unit are embodied in the VR processor.

In the FIG. **1** system, the control track is optionally prerecorded on the same medium as the music signal corresponding thereto. Acoustic Etch unit **3** can, in effect, extract the control track from the medium and pass it (or a control signal generated therefrom) to VR processor **7**.

FIG. **2** shows a variation on the system of Fig. **1** in which a control track and a corresponding music signal are recorded on (and played back from) different media (one from source **1**A; the other from source **1**).

For example, the control track can be recorded on, and played back from, a cartridge (**1**A) for a video game machine and the music can be recorded on, and played back from, a CD (**1**). The cartridge could be synchronized to the CD either by an electrical or other connection, or by the user, or by means used by the audio industry such as the SMPTE

standard. This is a simple approach in the sense that the control track can be created (and prerecorded) in advance by a user listening to the same music.

Then, the CD can be played again and synchronized with the recorded control track to trigger processing of the recorded control track in the Acoustic Etch unit (without the need to re-record the CD with control track information). Note that the cartridge can be part of a separate unit that is interfaced to the Acoustic Etch, or it can be part of the Acoustic Etch.

It may be desirable to delay the music which is heard by the user with respect to the control track and/or the music used for analysis by the Acoustic Etch. In this manner, system delays can be compensated for, and better causality between music and visual images produced by the VR system can be achieved.

The Acoustic Etch can set and control parameters in the VR processor, and the VR processor can set and control parameters in the Acoustic Etch. For example, VR processor **7** can set the delay time for which the music is delayed in circuit **4A** (or such delay time can otherwise be set) to compensate for the delay time required for processor **7** to process control signals produced from the control tracks or control signals generated from the analyzed music (such as by changing a displayed virtual object in response to one such control signal). The delayed music from circuit **4A** and the control tracks from source **1A** are processed in elements **4–7** in the same manner as non-delayed music and control tracks are processed in corresponding elements **4–7** of FIG. **1**. Thus, in the FIG. **2** embodiment, the delay introduced by delay circuit **4A** can be set so that VR processor **7** receives a segment of the music signal at precisely the time it completes the processing of control data from a portion of the control track corresponding to such segment of the music signal. In FIG. **1**, the advantages of delaying the musical source can be achieved by either recording the control track earlier in time on the music source medium, or by delaying the music signal within the Acoustic Etch unit or the VR processor or by a separate audio delay box.

In the upper graph of FIG. **3**, each dot represents a pulse of a control track. The lower graph of FIG. **3** represents a delayed version of a music signal produced by a drum and corresponding to this control track (in the lower graph, vertical displacement represents amplitude of the drum beat and the horizontal axis represents time). Each pulse of the control track corresponds to a peak amplitude of the music signal. However, the music signal of FIG. **3** has been delayed (phase shifted) by a delay period T (such as by remaining in delay circuit **4A**) chosen to compensate for processing delays that are expected to be introduced in other parts of the inventive system (such as the VR processor) in order to accomplish processing initiated in response to the control track (or control signals generated from the control track, or control signals generated from analyzed music).

FIG. **4** is a block diagram of a variation (Acoustic Etch unit **3**") of Acoustic Etch unit **3** which is employed in the FIG. **1** system. FIG. **4** implements an optional method for compensating for the delay introduced by the analysis of the control track or the music and the manipulation of the virtual environment. Acoustic Etch unit **3**" of FIG. **4** can receive digital prerecorded music and/or control track or analog prerecorded music and/or control track. Each such analog signal is digitized in A-to-D converter **4** and then supplied to one input of switch **17**. The other input of switch **17** receives the digital music signals. Switch **17** is controlled to select one of the two inputs, and is connected so as to supply the selected signal to processor **5** (which can implement computer software stored in memory **15**).

Delay circuit **13** can be operated to delay the music signal corresponding to the control track(s) to enable activity in the virtual world to appear to be synchronized or even non-causal. This is important because the delay between hearing an event (such as through headphones **10**) and seeing action as a result (on display device **8**) is disconcerting. In the real world one usually sees the event then hears the sound. In the virtual case (without delay circuit **13**), one would hear sound (e.g., thunder) and then VR processor **7** would draw a corresponding visual event (e.g., lightning) so that user would see the visual event a fraction of a second later. This is the exact opposite of what one is used to in the real world where one sees an event and then hears the result. The amount of delay implemented by circuit **13** will typically need to be constant or shifted during a silent period or the user will perceive the pitch of the sounds (e.g., heard through headphones **10**) as having changed as the amount of delay is adjusted.

With reference again to FIG. **3**, in a variation on the scheme implemented by delay unit **4A** (of Fig. **2**) or delay circuit **13** of FIG. **4**) instead of delaying the music, a pre-selected delay between music and control tracks is implemented at the time when both the control tracks and the music are prerecorded. The control track is, in effect, phase shifted in advance to account for lags expected to be introduced by the analysis (i.e., the time required by analyzer **5** of FIG. **2** to generate control signals from music) and/or by VR graphics system **7**. The advantage of implementing this phase shifting when prerecording the control track(s) is that it minimizes the hardware required to implement the Acoustic Etch unit. There is also no need to delay the music, which could be expensive.

To summarize, because there is inherently a finite amount of time between the receipt of control track or digitized audio information and the time a VR system can cause a change in its visual output in response to the received information, preferred embodiments of the invention will implement one of two delay compensation techniques. One of the techniques is to shift the control tracks in time relative to the audio information (musical tracks). For example, if the control tracks are shifted by 10 milliseconds (e.g., if the control tracks are played back with a lead time of 10 milliseconds prior to the corresponding audio), then the VR system would have 10 millisecond in which to create and display the objects (and then simultaneously display the objects and play the corresponding audio). By accounting for the delay time in this way, virtual objects can be displayed very closely in time with corresponding music with little noticeable time difference, or even a reversed time difference.

The second one of the delay compensation techniques is to delay the music that is being played (relative to the prerecorded control track which is also being played back). This can be done in a variety of ways including but not limited to the use of a digital delay box between the music source (e.g., tape player **200** shown in FIG. **6**, described below) track and an amplifier which receives the music from the source (e.g., amplifier **210** of FIG. **6**). Alternatively, the music can be delayed, and then replayed and processed, by a digital VR computer itself (e.g., VR system **250** of FIG. **6**), if the VR computer has digital-to-analog audio capabilities (e.g., means for converting the replayed digital audio into analog signals such as signals **250**L and **250**R of FIG. **6** for transmission to headphones worn by the user).

With reference again to FIG. **4**, unit **3**" typically extracts control information from the input music or control track(s)

or both. Processor **5** and memory **15** and optionally also associated peripheral hardware (not shown) implement the extraction of the control information from a control track and/or from the music itself. The FIG. **4** system includes both a digital and an analog input port for the input audio. In a consumer product, only one of these would be used and the other left out for cost savings. Since most music is stereo, usually there would in fact be two (left and right) channels of audio output from switch **17** although probably only one processor **5** for receiving and processing both channels. Control track interface **18** of unit **3"** receives one or more prerecorded control tracks and converts them (if necessary) into form for processing by processor **5**. Input device interface **19** receives input signals, generated in response to user manipulation of an input device, and converts them (if necessary) into form for processing by processor **5** (processor **5** can then generate control signals therefrom).

An important advantage of the FIG. **4** embodiment is in its flexibility to modify and expand the capabilities of the algorithms implemented by processor **5**.

In operation, the FIG. **4** device takes in music and processor **5** processes it to produce control information. The control information is then passed on to the VR computer which is actually rendering the virtual environment. Although in FIG. **4**, delay element **13** is within Acoustic Etch unit **3"**, it could alternatively be physically located in the VR computer system itself, or external to both.

One embodiment of the internal algorithms that can be implemented by processor **5** (which is sometimes referred to herein as "analyzer" **5**) of Acoustic Etch unit **3"** are those related to simple filtering and analysis. In this case, means are provided (for example within processor **5**) for filtering the incoming music, so that processor **5** can analyze the music in terms of its spectral components. By examining the level of a particular frequency range processor **5** can make a determination as to the rhythm or beat of the music. The beat of the music is passed on to the VR system which can then perform operations such as displaying virtual hands clapping in time to the beat of the music. The overall level of the music could be used to determine how many pairs of clapping hands there are at any particular time. As the music rises and falls in overall level, the VR processor could create and destroy virtual objects.

When the Acoustic Etch unit is used in conjunction with a control track, the potential complexity and richness of the virtual environment is enhanced. Processor **5** of Acoustic Etch unit **3"** could extract the control track from either the music media or process a prerecorded control track from a separate source. Processing of a control track (or a control signal generated therefrom, rather than from a corresponding music signal) within the VR processor is more powerful than analysis of music in the Acoustic Etch followed by processing of the resulting control signal in the VR processor, because it does not have to be quickly determined and enables the VR processor to respond to control track information not present in the music. At the start of or before the start of the song, for example, the control track could contain compressed images of the performers. As the song is played, the control track is processed by the Acoustic Etch unit which instructs the VR system to show the images of the performers texture mapped onto dancing characters which dance in time to the music. Note that the Acoustic Etch unit could be incorporated as part of another device, e.g., the player of the input music signal or the prerecorded control tracks or the VR system. One can imagine the integration of an Acoustic Etch unit into a cartridge for a video game machine with CD capability, for example. A program in the cartridge and a track on the CD would be employed or both could be contained on the CD. In addition to minimizing the cables, this is also cost effective.

The audio can bypass the VR system and go directly to headphones **10**, however, note that in FIGS. **1** and **2**, the music is passed through VR processor **7** rather than directly into the headphones **10**. In this way the VR processor may convolve the sound in such a way as to create the illusion of having it coming from a particular location in the virtual environment.

In summary, the invention is a novel way of interfacing music to VR. The inventive apparatus stands in contrast to traditional approaches which have tried to interface VR to music. The inventive apparatus allows for the highly produced and refined qualities of music to be expressed in a virtual environment.

There are several exciting possibilities with this apparatus and method. In the case of an Acoustic Etch unit which analyses music and controls a virtual environment of a dancer dancing, one could play any musical piece and the Acoustic Etch would extract the low frequency beat which would tell the VR system when to have the dancer step. Thus, one could watch a displayed (virtual) stick figure dancing in time. By using the delay mechanism disclosed, the virtual dancer and the music would occur far more synchronously than if the music was not delayed.

System cost may be reduced by incorporating the delay in the music player itself. Many current digital units employ a delay for error correction.

Employing the control track method with the Acoustic Etch unit allows one to create more advanced choreographs and minimizes cost as the processing requirements would be much less.

The invention may also lead to new ways to analyze real time data streams in order to look for patterns and interesting sequences.

Next, a more detailed description of a preferred implementation of the invention will be provided, with reference to FIGS. **5** and **6**. FIG. **5** is a diagram of a system for creating an audio tape with control tracks, for use in the playback system shown in FIG. **6**.

FIG. **5** shows Multitrack Tape Playback Unit **100**, Multitrack Master Audio Tape **100T**, Single channel audio signal **101A** (output from **100**), additional "n" Single channel audio signals **101B** output from **100**, Audio Signal Conditioning circuit **120A**, additional "n" Audio Signal Conditioning circuits **120B**, Analog Data Signal **121A**, additional "n" Analog Data Signals **121B**, Microprocessor Unit **130X** with an "n" channel analog to digital converter, Serial Data Stream **131X**, Tape interface (IF) Converter **140X**, Audio Quality Data Signal **141X**, switches (or other Digital Data Input Devices) **150**, Analog Data Input Devices **160**, Data Storage and Input Device **165**, Microprocessor Unit **130Y** (including digital input and multiple channel analog to digital converter), Audio Quality Data Signal **131Y**, Tape IF Converter **140Y**, Audio Quality Data Signal **141Y**, Two-Track Audio Tape Playback Unit **170**, Two-Track Master Tape **170T**, Left Channel Audio Signal **170L**, Right Channel Audio Signal **170R**, **4**-Track Audio Tape Recorder **180**, **4**-Track Audio and Virtual Control Track Tape **180T**, and SMPTE Synchronizer **190**.

FIG. **6** shows **4**-Track Audio and Virtual Control Track Tape **180T**, **4**-Track Tape Player **200**, Right Channel Audio Signal **200R**, Left Channel Audio Signal **200L**, X-Channel control signal **200X**, Y-Channel control signal **200Y**, sound processor **205**, **2**-Channel Audio Amplifier **210**, audio sig-

nals **205**R, **205**L, **210**R, and **210**L, Tape IF Converter **220**X, Tape IF Converter **220**Y, Microprocessor Unit with two-channel analog to digital converter **240**, Serial Data Stream **241**, serial data stream **250**A, multi-channel Analog-to-Digital Converter **245** with serial data output, Serial Data Stream **246**, Microphone **248**, Virtual Reality Graphics System **250**, Left Eye Video Signal **250**L, Right Eye Video Signal **250**R, Virtual Reality Audio and Visual Display Unit **260** (with Headtracking means), and Head Tracking Signal **261**.

With reference to FIG. **5**, multitrack tape player unit **100** is of the type typically found in audio recording studios. Unit **100** is loaded with a multitrack master tape **100**T and outputs multiple channels of audio (typically music) signals **101**A, **101**B, and so on.

These signals are fed to signal conditioners **120**A, **120**B and so on, via standard audio patch cords. Each of the signal conditioners consists of electronic circuitry, and each outputs an analog control signal (**121**A or **121**B) which is fed to one of the analog input pins of microprocessor unit **130**X. Microprocessor **130**X can be, for example, a M68HC11EVBU Universal Evaluation Board made by the Motorola Company, and is programmed with software for generating a control track from the conditioned audio data that it receives, and outputting a serial data stream to tape IF converter **140**X. Tape IF converter **140**X is comprised of electronic circuitry and outputs a data signal **141**X (indicative of the control track) of the type that can be stored on standard audio magnetic tape. This signal is fed to 4-track audio tape recording unit **180** that is loaded with a 4-track audio cassette tape **180**T.

An assembly of switches (or other means by which a human operator can input digital signals) **150** feeds parallel digital data to microprocessor **130**Y (which can be identical to or similar in type to microprocessor **130**X). Also connected to microprocessor Unit **130**Y are analog input devices **160** (such as a "multiple degree of freedom" joystick or other input device), and a data storage device **165**. Device **165** can be a magnetic disk drive or other data storage and retrieval device (or alternatively, a data entry device). Microprocessor Unit **130**Y is programmed with software for generating a control track in response to the input data it receives, and outputs a serial data stream to a tape IF converter **140**Y. Tape IF converter **140**Y is comprised of electronic circuitry and outputs a data signal **141**Y (indicative of the control track) of the type that can be stored on standard audio magnetic tape. This signal is fed to four-track audio tape recording unit **180**.

A two-track tape playing unit **170** is loaded with a two track mixed down master tape **170**T and is time synchronized with the multitrack unit **100** via SMPTE synchronizer **190** or other such device. The two-track tape player **170** outputs a left audio signal **170**L and a right audio signal **170**R that are input to the **4** track tape recorder **180**. Recorded cassette tape **180**T thus has two tracks containing audio signals **170**L and **170**R (which are typically music signals), and two other tracks containing control tracks corresponding to the audio signals.

FIG. **6** represents the system used to play back and experience the audio tape **180**T (which has control tracks). A four-track audio tape player **200** outputs four audio signals: left and right audio signals **200**R and **200**L, and control track signals **200**X and **200**Y consisting of data encoded as audio signals. Signals **200**X and **200**Y are input to two tape IF converters **220**Y and **220**X which extract serial data streams **221**Y and **221**X therefrom, which streams are input to a microprocessor unit **240** of a type identical (or similar) to microprocessor unit **130**X. Microprocessor unit **240** is programmed with software for generating control signals for VR graphics system **250** in response to one or both of data streams **221**Y and **221**X, and outputs a serial data stream indicative of such control signals to virtual reality (VR) graphics system **250**, which can be, for example, a Silicon Graphics Crimson Computer with Reality Engine graphics, serial port board, and VLIB software available from Fakespace, Inc. (of Menlo Park, Calif.).

VR system **250** outputs two video signals **250**L and **250**R representing the left and right eye viewpoints of a virtual environment to head-coupled display unit **260**.

Audio signals **200**R and **200**L are input to a sound processor **205**, for example, a Convolvotron sound spatializer available from Crystal River Engineering (of Groveland, Calif.) or other sound processing equipment which feeds the processed sound signals **205**R and **205**L to an audio amplifier **210** which feeds two amplified audio signals **210**R and **210**L to head-coupled display unit **260**. The audio signals **200**R and **200**L, and input from a microphone **248** are also input to multichannel audio digitizer **245** which outputs a serial data stream **246** to VR system **250**.

Virtual reality system **250** also receives head position or other area of interest information from head-coupled display **260**.

FIG. **7** is a schematic diagram of a circuit fragment suitable for implementing any of signal conditioning blocks **120**A and **120**B. It consists of four electronic components.

FIG. **8** is a schematic diagram of a circuit fragment suitable for implementing either of tape IF convertors **140**X or **140**Y. It consists of various electronic components.

FIG. **9** is a schematic diagram of a circuit fragment suitable for implementing either of tape IF convertors **220**X or **220**Y. It consists of various electronic components.

FIG. **10** is a block level description of the software which is preferably run on VR system **250** of FIG. **6**.

FIG. **11** represents a typical single eye image as displayed on the display **260**. Images are virtual objects. Objects **300**A, **300**B, **300**C, and **300**D are objects comprised of three orthogonal lines of the same size that are positioned at the same x and y location, but recede backwards form the user along the z axis over time. Objects **310**A and **310**B are fixed in space, but change height over time. Lines **330** (including lines **330**A and **330**B) are fixed in space and remain stationary over time. Words BABY **320**A and BACK **320**B are fixed along the XY plane and have no depth in along the Z axis.

In operation, the systems of FIG. **5** and **6** can implement the following embodiment of the invention. The overall process can be broken into two halves: the recording of the medium and the playback. Figure **5** represents the recording phase while FIG. **6** represents the playback phase.

In FIG. **5**, a multitrack tape playing unit **100** is of the type typically found in professional recording studios. It is loaded with the master tape **100**T that recorded the raw and unmixed audio efforts of artists recording a song. In the typical production of recorded music products, this tape is later mixed and processed to produce a two-track master tape **170**T which is later mass produced for the consumer market. The multitrack master tape **100**T and the two track master tape **170**T are playing at the same time in synchronization with each other through the use of a standard commercially available time synchronization unit, for example SMPTE synchronizer **190** that works in conjunction with the tape playing units **100** and **170**.

In this embodiment, the 2-track audio signals **170**L and **170**R are recorded on 4-track tape **180**T via a standard four track tape recording unit **180**. This unit can be a consumer type 4-track cassette tape unit, or a high quality professional tape recorder that will produce a master tape for acoustic etch type tapes. The audio signals **170**L and **170**R represent the original audio content of a commercial tape and are not typically processed further. That is to say that two tracks of four-track tape **180**T are the music that the user of the tape would expect to hear without the Acoustic Etch device of the invention. However, it may be desired to delay the music in time with respect to the control tracks.

The other two tracks that are recorded from signals **141**X and **141**Y are the control tracks that are derived as shown in FIG. **5** and will be used during playback to create and control and manipulate the virtual environment that a user experiences while listening to the original audio signals.

While there are a multitude of ways to create these control tracks, this embodiment generates such tracks in either (or both) of two ways. The first way automatically derives control signals from original multitrack master tape **100**T and the second way allows a human operator to create control signals via input means **150** and **160** and a computer data storage device **165**.

To create the control track in the first way, the "n" multiple audio output channels **101**A, **101**B and so on, which represent each audio channel on the original multitrack tape **100**T are fed into signal conditioning blocks **120**A and **120**B. These blocks serve to distill the audio information on each track into a lower frequency signal that will serve as an aesthetically valuable control variable in the virtual environment. In the preferred embodiment, it has been determined that a modified peak detection circuit serves this function very well. An example of this circuit is shown in FIG. **7**. It is important to point out that there are many forms of signal processing which can be used to derive this control signal and the FIG. **7** circuit is a simple one which works well for some cases only. A variety of digital signal processing techniques and analog signal processing techniques may be used which include, but are not limited to, phase detection, frequency spectrum analysis, phase vocoding techniques and so forth. Additionally, the signals can be processed to produce control signals which are in some way related to the perceived three-dimensional spatial structure of the original music signal. The signals output from the "n" signal conditioning blocks are fed into the analog signal input ports of microprocessor unit **130**X. If "n" is less than or equal to seven, a standard microprocessor card product such as the M68HC11EVBU available from Motorola Corporation can be used. This microprocessor is programmed to successively read each channel and to then output the magnitude of each channel in a serial data stream **131**X to a tape IF converter **140**X. An example code fragment which outputs a test data block of ASCII characters to tape IF converter **140**X is included for reference in Appendix A of this disclosure. The desired analog data should be read with the microcontroller within unit **240** and used in a fashion similar to the ASCII characters in the code fragment. Instructions on how to program this are described in Motorola publications M68HC11EVBU/AD1 and M68FCASS/AD1and further literature, all provided with the MC68HC11EVBU product by Motorola.

A circuit diagram fragment for tape IF converter **140**X is shown in FIG. **8**. We contemplate that RS232-to-tape or MIDI-to-tape units could be used as substitutes for the IF converters described herein. This converter type is described in the book *Microcomputer Interfacing* by Harold S. Stone and can be built in a variety of ways. This circuit takes the serial data stream which represents the conditioned levels of the "n" channels of information from the multitrack master tape and converts this serial data to a format **141**X that can be recorded on standard audio tape. In this fashion, the control track is recorded side by side with the original two tracks of audio information.

In addition to the information derived from the multitrack master tape, it is desirable for control information to be produced manually by a human operator. This information may take on many forms and can (in many applications) practically be generated only by a human operator. Elements that an operator may wish to control include: display modes that correspond to overall thematic changes in a musical score or special analog controls that relate to quickly paced musical expressions. Elements of these types may be easily input via digital switches **150** or analog controls **160**. Likewise, the operator may wish to include information that will later be used by the playback (Acoustic Etch) system. This information could include for example, digital photographs of the musical artists, or textual information that corresponds to the words or themes in the music. This information can also be input via a disk drive **165** or other type of electronic data storage and retrieval mechanism or directly by a computer system. Such information may be created in a multiple of ways including paint programs, 3D modeling programs, digitizing scanners and so on. This information could also consist of system codes and program codes for the VR system **250**.

All these alternative controls and information are fed into the microprocessor unit **130**Y which contains a program similar to that with which microprocessor unit **130**X is programmed. The program for unit **130**Y contains additional code that reads the digital I/O ports on the unit in addition to the standard code which reads the analog to digital ports as for microprocessor unit **130**X.

The output data (indicative of a control track) is fed to tape IF converter **140**Y in a manner similar to that for microprocessor **130**X and signal **131**X. The converted data stream **141**Y output from converter **140**Y is then recorded on the remaining track of tape **180**T.

FIG. **6** describes the playback phase of the invention. A mass produced copy of the four-track tape **180**T, or the actual tape **180**T is loaded into a four-track tape playing unit **200**. This unit plays the tape and produces **4** audio signals, two of which are standard signals meant to be listened to, while the two others contain control track data that will be processed and sent to VR system **250**. The two music audio signals **200**R and **200**L are fed to a sound processor system which can process the audio signals **200**R and **200**L in response to control signals **250**A from the VR system. The processed audio signals **205**R and **205**L are fed to an audio amplifier **210** which drives a pair of stereophonic headphones **260** or speakers for the user to listen with.

The other two signals **200**X and **200**Y are fed to tape IF converters **220**Y and **220**X which translate the audio signal format control track data into a digital form **221**X and **221**Y. A circuit diagram fragment for tape IF converter **220**Y or **220**X is shown in FIG. **9**. This converter type is described in the book *Micropcomputer Interfacing* by Harold S. Stone.

Microprocessor unit **240** then combines both control signals **221**Y and **221**X and converts this digital data into a serial data stream suitable for processing by the VR system, for example in the format of an RS232 or MIDI data stream. An example code fragment which accepts a test data block of ASCII characters from tape IF converter **220**X or **220**Y is

included for reference in Appendix A. The desired data should be read with a microcontroller in a suitable format. Instructions on how to program this are described in Motorola publications M68HC113VBU/AD1 and M68FCASS/AD1 and further literature, all provided with the M68HC11EVBU product from Motorola.

The music audio signals are also fed to a multichannel audio digitizer **245** with a serial data output that is read by VR system **250**. This digitizer converts the music audio signals to digital form for processing by VR system **250**, and can also convert other audio sources such as a live microphone **248**.

The VR system receives three signals: a signal **261** representing head position and orientation from the VR display **260** or other forms of area of interest tracking information (such as that from an input device of any of the types described above with reference to input device **9** of FIG. **1**); a control and data tape signal **241** that is related to the control tracks prerecorded on four-track tape **180**T; and digitized audio signals **246** that digitally represent the original audio (which is typically music), and/or any other audio source desired, such as a live microphone **248**.

In a preferred embodiment, a VR system **250** comprises a Silicon Graphics Crimson computer outfitted with Reality Engine graphics, a serial port card, and the GL software library and the Fakespace, Inc. VLIB Virtual Reality software package.

In addition to systems administration and miscellaneous programs, the VR system runs the program (comprising steps **400**, **410**, **420**, **430**, **440**, **450**, **460**, **470**, **480**, and **490**) which is shown and described in FIG. **16**. This program begins by opening the serial port and initializing attached devices (step **400**) and then goes on to initializing variables (step **410**). The program then creates a table of virtual objects (step **420**). Each object comprises an x, y and z location and a geometric description of the object that conforms to GL and VLIB software requirements. A standard set of objects is defined and created and will later be controlled in response to one or both of control signal **241** (representing data in one or more prerecorded control tracks) and audio signal **246**.

The system then reads the head position of the tracker **260** (step **430**) and then reads the "control track" control signal **241** and audio control signal **246** (steps **440** and **450**). In response to this information, any number of programs can be implemented (step **460**) to control and create and manipulate the virtual environment in a manner choreographed with the original music signal.

One example of such a virtual reality (VR) program will next be described. This example (which assumes that the VR processor receives both a music signal, and control track information from a prerecorded control track corresponding to the music signal) is provided for illustrative purposes only, and should not be construed to limit the scope of the invention, as broadly defined.

The VR program initially reads the control track information, which may precede the music information on a prerecorded tape (such as tape **180**T played by playback device **200** of FIG. **6**). The control track information may have been created by an operator during recording of the tape (e.g., using the above-described FIG. **5** apparatus) and can contain descriptions of virtual objects, virtual reality system settings, virtual reality hardware and software settings. The control track information may also contain the body of a software program to be run on the VR processor, in which case the VR program initially residing on the VR processor serves only as a monitor with which to read the program defined by the control track information.

After the control track data is read by the VR program, the VR system reads any digitized music information which corresponds to the control track data, and/or the output of any input devices that are connected to the VR system such as instrument gloves, six-degree-of-freedom trackers, custom human input devices, mice, and the like.

The VR program then creates, destroys, moves or modifies the virtual environment, or virtual objects therein. This can be done using standard VR library software calls, and is preferable based upon all of the forms of data read by the system (including the control track information and corresponding music information) as described above.

Examples of virtual objects that can be created by the VR program will next be described with reference to the display of a virtual environment shown in FIG. **11**. Two such virtual objects (**310**A and **310**B) are cylinders of equal diameter and different height. Cylinders **310**A and **310**B themselves are default objects that are always available in the preferred VR program described herein. The bases of the cylinders are located at the same X and Y and Z location. Preferably, the height of each cylinder is controlled via the control track information and the two heights indirectly represent the first two audio channels **101**A and **101**B (which are typically music channels) of master tape **100**T after being conditioned by the signal conditioners **120**A and **120**B. If these two audio channels are recordings of, say, a bass drum and a snare drum, then if the user chose to turn and face these objects, the user would see one cylinder (e.g., **310**A) which appeared to change height in response to the bass drum, and another (e.g., **310**B) which appeared to change height in response to the snare drum. The VR program can be easily written to display other objects in response to the same sounds or to display these or other objects in response to other aspects of the control track.

The data representing the text for objects **320**A and **320**B (of FIG. **11**) is preferably loaded from the control track into the VR program while the tape is playing music and the VR program is running. While running (i.e., reading the control track information from the tape), the VR program loads these objects, along with instructions to display each object at a fixed X and Y (and optional Z) location when the VR program receives a certain signal on the control track. In this manner, lyrics or other song dependent data can be loaded into the VR program using a prerecorded control track, and then displayed based upon the prerecorded control track information. In the preferred VR program embodiment described herein, each of words **320**A and **320**B is displayed at the same time a singer (represented by a control track corresponding to the music signal) vocalizes the words in the music. In order to achieve this controlled timing, a human operator uses the switches **150** (of FIG. **5**) to record the "display" signal as part of the control track, and uses the data in storage device **165** to load the song dependent data.

A model of object **300**A (which is shown at later times at positions **300**B, **300**C, and so on) is loaded into the VR program directly from the control track. After the VR program has loaded the model, the control track instructs the VR program to display the object upon detecting a certain threshold of energy at a specific frequency band of the music information. The VR program performs a spectral analysis of the digitized music information (e.g., digital data **246** in FIG. **6**) and tests the specified frequency band for energy level. Upon detecting the threshold level, the VR program creates (displays) the object at a given X, Y, and Z location.

Regardless of the status of the spectrum analysis, the VR program automatically changes the Z location (at which the object is to be displayed) by a certain amount once per each increment of elapsed time during running of the program. In this fashion the object **300**A can be displayed in a manner so that it appears to recede backwards toward position **300**B, and then to position **300**C, and so on. A new object would appear on the display at the initial X, Y, and Z location only at instants coinciding with a certain music event, and thus an intermittent stream of objects with a relationship to the frequency content of the source music would appear.

We next discuss several variations on the above-described embodiments of the invention.

The VR processor itself can play digitized music. For example, VR system **250** of FIG. **6** can play digitized music (e.g., generate original music), rather than merely routing digitized music from an external source (e.g., digitizer **245** of FIG. **6**).

Sound processing equipment (such as sound processor **205** shown in FIG. **6**) can optionally be connected between audio source **200** and amplifier **210**. If the sound processing equipment is a convolvotron, then the apparent location of the source of the music (when it is output to the user from speakers) can be altered. The sound processing equipment can be controlled to operate in response to the control track information (or in response to the analyzed audio), and the audio (which is typically music) can thus be used to describe as well as control virtual objects, and the control track information (or analyzed audio) can be used to process the audio heard by the user to relocate the apparent source thereof. This technique allows for a much greater realism and correspondence between music and the virtual environment and its objects (assuming that the user wears a head-mounted display, which is preferably a stereoscopic display, along with headphones, so that the user immersively experiences the virtual environment including three-dimensional placement of its virtual objects, using both the senses of sight and hearing).

The audio (e.g., music) can be analyzed (e.g., by analyzer **5** of FIG. **1** or **2**) to determine certain aspects of its original three-dimensional nature. One embodiment of this would analyze the delay between right ear and left ear correlated sounds. This delay can then be mapped roughly to an angle relative to the user's head orientation.

The foregoing describes two basic methods to enable the user to experience sounds with a controlled apparent source location: one is to convolve the sound and place it in space; the other is to analyze the sound and determine where the user will think it is placed in space.

Many conventional recording studios process music to achieve a three dimensional effect. Such processing information could be stored in the control track of the invention, for later use by a VR system to help place virtual objects and to set system parameters in instruments (such as a convolvotron) that may be used as part of the VR system. This would be especially useful if the music recording is made using binaural heads and other such spatial recording equipment and techniques.

The recording medium for the inventive prerecorded control tracks does not need to be a four-track audio tape. In fact, the compact disk (CD) and Digital Audio Tape (DAT) formats already offer control track capabilities. In addition to these capabilities, these and other formats can be modified to contain more control track information. For example, the prerecorded control track(s) need not be recorded as a separate track. In order to retrofit to existing consumer audio equipment, the control track information could be stored in a subsonic or supersonic fashion on the existing audio information. Provision of such subsonic modulations would decrease the data rate, and thus the signal conditioning blocks would need to have their values adjusted. Provision of such supersonic modulations would likely introduce difficulties when using audio tape systems to implement the invention.

The original multitrack and two-track tape machines employed in the systems of FIGS. **5** and **6** can be replaced by any form of an audio source. In the near future, it is expected that audio recording and playback devices suitable for use in embodiments of the invention, will be inexpensively implementable as completely digital machines.

FIGS. **5** and **6** describe a principally analog device, which can easily be implemented digitally, in alternative embodiments of the invention.

When prerecording the control track(s), the recording does not need to be performed in a continuous real-time fashion. It can be edited over time much as master audio tapes are created, using many passes to get it right, building up or deleting control track information in multiple passes.

It should be understood that components can be exchanged between the various embodiments described herein.

Various other modifications and alterations in the method and apparatus of the invention will be apparent to those skilled in the art without departing from the scope and spirit of this invention. Although the invention has been described in connection with specific preferred embodiments, it should be understood that the invention as claimed should not be unduly limited to such specific embodiments.

APPENDIX A

```
0001                    ****************************************
0002                    ****** Tape IF Software for 68HC11 *******
0003                    ****************************************
0004                    ****** Copyright Fake Space Labs *********
0005                    ****** 1990 - By I.E.M and K.T.B *********
0006                    ****************************************
0007
0008                    * Buffalo definitions
0009
0010 1000               REGBS       EQU     $1000
0011 1003               PORTC       EQU     $1003   * Port C is input (Data from HP2020)
0012 1004               PORTB       EQU     $1004   * 0:5 - /OE for HP2020s  6: Hi/Lo byte 7: /Reset
0013 102b               BAUD        EQU     $102B
0014 102c               SCCR1       EQU     $102C
0015 102d               SCCR2       EQU     $102D
0016 102e               SCSR        EQU     $102E
0017 102f               SCDAT       EQU     $102F
0018
0019 100e               TCNT        EQU     $100E       * Timer 16 bits
0020 1018               TOC2        EQU     $1018       * Timer out comp 2
0021 1020               TCTL1       EQU     $1020       * Timer control
0022 1023               TFLG1       EQU     $1023
0023 1022               TMSK1       EQU     $1022
0024
0025 1010               TIC1        EQU     $1010       * TIMER INPUT CAPTURE 1
0026 1021               TCTL2       EQU     $1021       * Timer input capt ctl reg
0027
0028                    * Pseud vect for TIC1
0029
0030 00e8                ORG $00E8
0031
0032 00e8 7e 01 87       JMP        TIC1INT
0033
0034 0100                ORG $0100              * RAM 0100-01ff
0035
0036                    START
0037 0100 86 30          LDAA       #$30
0038 0102 b7 10 21       STAA       TCTL2       * Set TIC1 to capture on either edge
0039 0105 86 04          LDAA       #$04
0040 0107 b7 10 22       STAA       TMSK1       * Enable interrupts
0041
0042 010a 7f 01 83       CLR        DELTA
0043
0044 010d fc 10 0e       LDD        TCNT        * read timer
0045 0110 fd 01 81       STD        PEDGE       * current time stored in PEDGE
0046
0047 0113 c6 00          LDAB       #$00
0048 0115 f7 10 04       STAB       PORTB
0049
0050 0118 7c 01 85       INC        VALID
0051
0052 011b 0e             CLI
0053
0054                    LOOP
0055 011c 18 ce 00 00   HEADER      LDY        #$0
0056 0120 8d 32          BSR        GETBYTE
0057 0122 18 09          DEY
0058 0124 26 f6          BNE        HEADER      * Must be only 1 bit set
0059 0126 b6 01 86       LDA        DATA
0060 0129 81 80          CMPA       #$80
0061 012b 27 04          BEQ        SYNCED
0062 012d 8d 42          BSR        MID
0063 012f 20 eb          BRA        HEADER
0064                    SYNCED
0065 0131 8d 21          BSR        GETBYTE
0066 0133 b6 01 86       LDA        DATA
0067 0136 81 80          CMPA       #$80
0068 0138 27 f7          BEQ        SYNCED
0069
0070 013a 8d 18         INSYNC      BSR        GETBYTE
0071
0072 013c c6 ff          LDAB       #$FF
0073 013e f7 10 04       STAB       PORTB
0074 0141 7f 10 04       CLR        PORTB
0075
0076                    *           LDAA       DATA
0077                    *           JSR        $FFB2
0078                    *           LDAA       DATA
0079                    *           JSR        $FFB5
0080                    *           LDAA       #'_
0081                    *           JSR        $FFB8
0082                    *           LDAA       #'_
0083                    *           JSR        $FFB8
0084
0085 0144 b6 01 86       LDAA       DATA
0086 0147 81 41          CMPA       #'A
0087 0149 2d d1          BLT        HEADER
0088 014b 81 7a          CMPA       #'z
0089 014d 2e cd          BGT        HEADER
0090 014f bd ff b8       JSR        $FFB8
0091
0092 0152 20 e6          BRA        INSYNC
0093
0094                    * ************************
0095
0096                    GETBYTE
0097 0154 3c             PSHX                           * sets DATA to read value
0098 0155 ce 00 08       LDX        #$8                 * and Y to number of 1 bits
0099 0158 7f 01 86       CLR        DATA
0100
0101 015b 8d 14         BYTEL       BSR        MID
0102 015d 2e 09          BGT        ITIS0
0103
0104 015f 8d 10          BSR        MID
0105 0161 2e 05          BGT        ITIS0
0106
0107 0163 18 08         ITIS1       INY
0108 0165 0d             SEC
```

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```
0109 0166 20 01              BRA       GOTBIT
0110
0111 0168 0c                 ITIS0     CLC
0112
0113 0169 79 01 86           GOTBIT    ROL       DATA
0114
0115 016c 09                 DEX
0116 016d 26 ec              BNE       BYTEL
0117
0118
0119 016f 38                 PULX
0120 0170 39                 RTS
0121
0122                         * ..................
0123
0124
0125 0171 7d 01 85           MID       TST       VALID
0126 0174 26 fb              BNE       MID
0127 0176 7c 01 85           INC       VALID
0128
0129 0179 fc 01 83           LDD       DELTA
0130 017c 1a 83 02 58        CPD       #600
0131 0180 39                 RTS
0132
0133                         * **********************
0134
0135 0181                    PEDGE     RMB       2
0136 0183                    DELTA     RMB       2
0137 0185                    VALID     RMB       1
0138 0186                    DATA      RMB       1
0139
0140                         * **********************
0141
0142 0187 fc 10 10           TIC1INT   LDD       TIC1
0143 018a b3 01 81           SUBD      PEDGE     * D - PEDGE - This edge
0144 018d fd 01 83           STD       DELTA     * store in DELTA
0145 0190 fc 10 10           LDD       TIC1
0146 0193 fd 01 81           STD       PEDGE
0147 0196 86 04              LDAA      #$04
0148 0198 b7 10 23           STAA      TFLG1     * Clear the interrupt
0149 019b 7f 01 85           CLR       VALID
0150 019e 3b                 RTI
0151
0152
```

APPENDIX A

```
0001                    ********************************************
0002                    ****** Tape IF Software for 68HC11 ********
0003                    ********************************************
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0005                    ****** 1990 - By I.E.M and N.T.B **********
0006                    ********************************************
0007
0008                    * Buffalo definitions
0009
0010 0033                ORG $33
0011
0012 0033                RMB       20
0013 0047               USTACK     RMB       30
0014
0015 1000               REGBS      EQU       $1000
0016 1003               PORTC      EQU       $1003   * Port C is input (Data from HP2020)
0017 1004               PORTB      EQU       $1004   * 0:5 = /OE for HP2020s  6: Hi/Lo byte 7: /Reset
0018 102b               BAUD       EQU       $102B
0019 102c               SCCR1      EQU       $102C
0020 102d               SCCR2      EQU       $102D
0021 102e               SCSR       EQU       $102E
0022 102f               SCDAT      EQU       $102F
0023
0024 100e               TCNT       EQU       $100E     * Timer 16 bits
0025 1018               TOC2       EQU       $1018     * Timer out comp 2
0026 1020               TCTL1      EQU       $1020     * Timer control
0027 1023               TFLG1      EQU       $1023
0028 1022               TMSK1      EQU       $1022
0029
0030
0031                    * Pseud vect for TOC2
0032
0033 00dc                ORG $00DC
0034
0035 00dc 7e b6 90      PSVECT1    JMP       TOC2INT
0036
0037                    * Ram vars
0038
0039 0100                ORG $0100
0040
0041 0100               PWIDTH     RMB       2
0042 0102               DONE       RMB       1
0043
0044                    * Main program
0045
0046 b600                ORG $B600
0047
0048                    START
0049 b600 8e 00 47       LDS       #USTACK
0050
0051 b603 86 7e          LDAA      #$7E      * JUMP OPCODE
0052 b605 97 dc          STAA      PSVECT1
0053 b607 ce b6 90       LDX       #TOC2INT
0054 b60a df dd          STX       PSVECT1+1
0055
0056                    INITDON
0057
0058
0059 b60c 86 40          LDAA      #$40
0060 b60e b7 10 20       STAA      TCTL1     * Set TOC2 to toggle mode
0061 b611 b7 10 22       STAA      TMSK1     * Enable interrupts
0062
0063 b614 7f 01 02       CLR       DONE
0064
0065 b617 cc e0 00       LDD       #$E000
0066 b61a fd 01 00       STD       PWIDTH
0067
0068 b61d fc 10 0e       LDD       TCNT      * read timer
0069 b620 f3 01 00       ADDD      PWIDTH
0070 b623 fd 10 18       STD       TOC2      * store in TOC2
0071
0072 b626 86 ff          LDAA      #$FF
0073 b628 c6 00          LDAB      #$00
0074 b62a f7 10 04       STAB      PORTB
0075
0076 b62d 0e             CLI
0077
0078                    LOOP
0079
0080 b62e 86 80          LDAA      #$80
0081 b630 8d 28          BSR       SENDA
0082 b632 86 80          LDAA      #$80
0083 b634 8d 24          BSR       SENDA
0084 b636 86 80          LDAA      #$80
0085 b638 8d 20          BSR       SENDA
0086 b63a 86 80          LDAA      #$80
0087 b63c 8d 1c          BSR       SENDA
0088 b63e 86 80          LDAA      #$80
0089 b640 8d 18          BSR       SENDA
0090 b642 86 80          LDAA      #$80
0091 b644 8d 14          BSR       SENDA
0092 b646 86 80          LDAA      #$80
0093 b648 8d 10          BSR       SENDA
0094 b64a 86 80          LDAA      #$80
0095 b64c 8d 0c          BSR       SENDA
0096
0097 b64e c6 1a          LDAB      #26
0098 b650 86 41         ALPHA      LDAA      #'A
0099 b652 1b             ABA
0100 b653 8d 05          BSR       SENDA
0101 b655 5a             DECB
0102 b656 26 f8          BNE       ALPHA
0103
0104 b658 20 d4          BRA       LOOP
0105
0106                    * ****************
0107
0108 b65a 18 ce 00 08   SENDA      LDY       #8
```

APPENDIX A

```
0109 b65e 37             PSHB
0110 b65f c6 00          LDAB      #$00
0111 b661 f7 10 04       STAB      PORTB
0112 b664 c6 ff          LDAB      #$FF
0113 b666 f7 10 04       STAB      PORTB
0114 b669 33             PULB
0115
0116 b66a 48             BITLOOP   LSLA
0117 b66b 24 04          BCC       BIT0
0118
0119 b66d 8d 0e          BIT1      BSR       SEND1
0120 b66f 20 02          BRA       DONEBIT
0121
0122 b671 8d 05          BIT0      BSR       SEND0
0123
0124 b673 18 09          DONEBIT   DEY
0125 b675 26 f3          BNE       BITLOOP
0126 b677 39             RTS
0127
0128                     * ..................
0129
0130
0131 b678 ce 03 20       SEND0     LDX       #800
0132 b67b 20 07          BRA       PULSE
0133
0134 b67d ce 01 90       SEND1     LDX       #400
0135 b680 8d 02          BSR       PULSE
0136 b682 20 00          BRA       PULSE
0137
0138 b684 ff 01 00       PULSE     STX       PWIDTH
0139 b687 7c 01 02        INC       DONE
0140 b68a 7d 01 02       WAIT4IT   TST       DONE
0141 b68d 26 fb          BNE       WAIT4IT
0142 b68f 39             RTS
0143
0144
0146                     * **********************
0146
0147                     * X has next pulse width and is cleared when used
0148 b690 fc 01 00       TOC2INT   LDD       PWIDTH
0149 b693 f3 10 18        ADDD      TOC2      * Add pulse width
0150 b696 fd 10 18        STD       TOC2      * and store in TOC2
0151 b699 86 40           LDAA      #$40
0152 b69b b7 10 23        STAA      TFLG1     * Clear the interrupt
0153 b69e 7f 01 02        CLR       DONE
0154 b6a1 3b              RTI
0155
0156
```

What is claimed is:

1. A method for controlling production of a virtual environment by a virtual reality computer system, including the steps of:

(a) processing music signals to generate control signals having music and/or control information; and

(b) operating the virtual reality computer system in response to the control signals to generate said virtual environment.

2. The method of claim 1, wherein step (b) includes the step of:

producing a graphic display of the virtual environment on a display device of a type coupled to a head of a human user which provides an immersive visual experience of said virtual environment to the user.

3. The method of claim 2, wherein the graphic display is populated with at least one animated virtual object, where at least one characteristic of the virtual object changes in response to at least one of the music signals.

4. The method of claim 2, wherein the graphic display is a stereoscopic representation of a three-dimensional virtual environment.

5. A method for controlling production of a virtual environment by a virtual reality computer system, including the steps of:

(a) prerecording a control track having audio and/or control information corresponding to an audio signal; and

(b) operating the virtual reality computer system in response to said prerecorded control track to generate said virtual environment.

6. The method of claim 5, wherein step (b) includes the step of producing a graphic display of the virtual environment on a display device, and also including the steps of:

(c) supplying the audio signal to the virtual reality computer system; and

(d) operating the virtual reality computer system in response to both said audio signal and said prerecorded control track to generate said virtual environment.

7. The method of claim 6, wherein step (c) includes the step of supplying the audio signal to the virtual reality computer system with a first delay relative to the prerecorded control track, wherein the first delay is selected to enable generation of sounds in response to the audio signal in a manner so that the sounds have a desired time relationship to the graphic display.

8. The method of claim 5, wherein step (a) includes the step of automatically generating the control track by processing the audio signal.

9. The method of claim 5, wherein step (a) includes the step of manually operating an input device to generate the control track.

10. A method for controlling a computer system, including the steps of:

(a) prerecording a control track having audio and/or control information corresponding to an audio signal; and

(b) operating the computer system in response to said prerecorded control track.

11. The method of claim 10, also including the steps of:

(c) supplying the audio signal to the computer system; and

(d) operating the computer system in response to both the audio signal and the prerecorded control track.

12. A virtual reality computer system, including:

means for supplying a first signal selected from a group consisting of a control signal having music and/or control information generated in response to a music signal, a prerecorded control track having music and/or control information corresponding to the music signal, and a control signal having music and/or control information generated in response to the prerecorded control track; and

means for receiving the first signal and influencing action within a virtual environment in response to said first signal.

13. The apparatus of claim 12, wherein the means for supplying the first signal includes an analysis apparatus having means for receiving said music signal in digital or analog form, and processing said music signal to produce control information for modification of objects in the virtual environment.

14. The apparatus of claim 12, wherein said music signal is delayed in time to compensate for delays in other parts of the virtual reality computer system.

15. The apparatus of claim 12, wherein the means for supplying the first signal includes a music playing means for supplying said music signal.

16. A virtual reality computer system for producing a virtual environment, including:

means for prerecording a control track having music and/or control information corresponding to a music signal; and

means for producing the virtual environment in response to said prerecorded control track.

17. The system of claim 16, wherein the means for producing the virtual environment includes:

a display device; and

a means for producing a graphic display of the virtual environment on the display device.

18. The system of claim 16, also including:

means for supplying the music signal to the means for producing the virtual environment, and wherein the means for producing the virtual environment includes means for producing said virtual environment in response to both said music signal and said prerecorded control track.

19. Apparatus as in claim 16, wherein said control track contains additional information to that which can be extracted from the music signal.

20. The system of claim 16, wherein said control track is time shifted relative to the music signal to compensate for delays in said virtual reality computer system.

21. A virtual reality computer system, including:

a source of a music signal; and

an apparatus for extracting information from the music signal for modification of objects in a virtual environment.

22. A computer system, including:

means for prerecording a control track having audio and/or control information corresponding to an audio signal; and

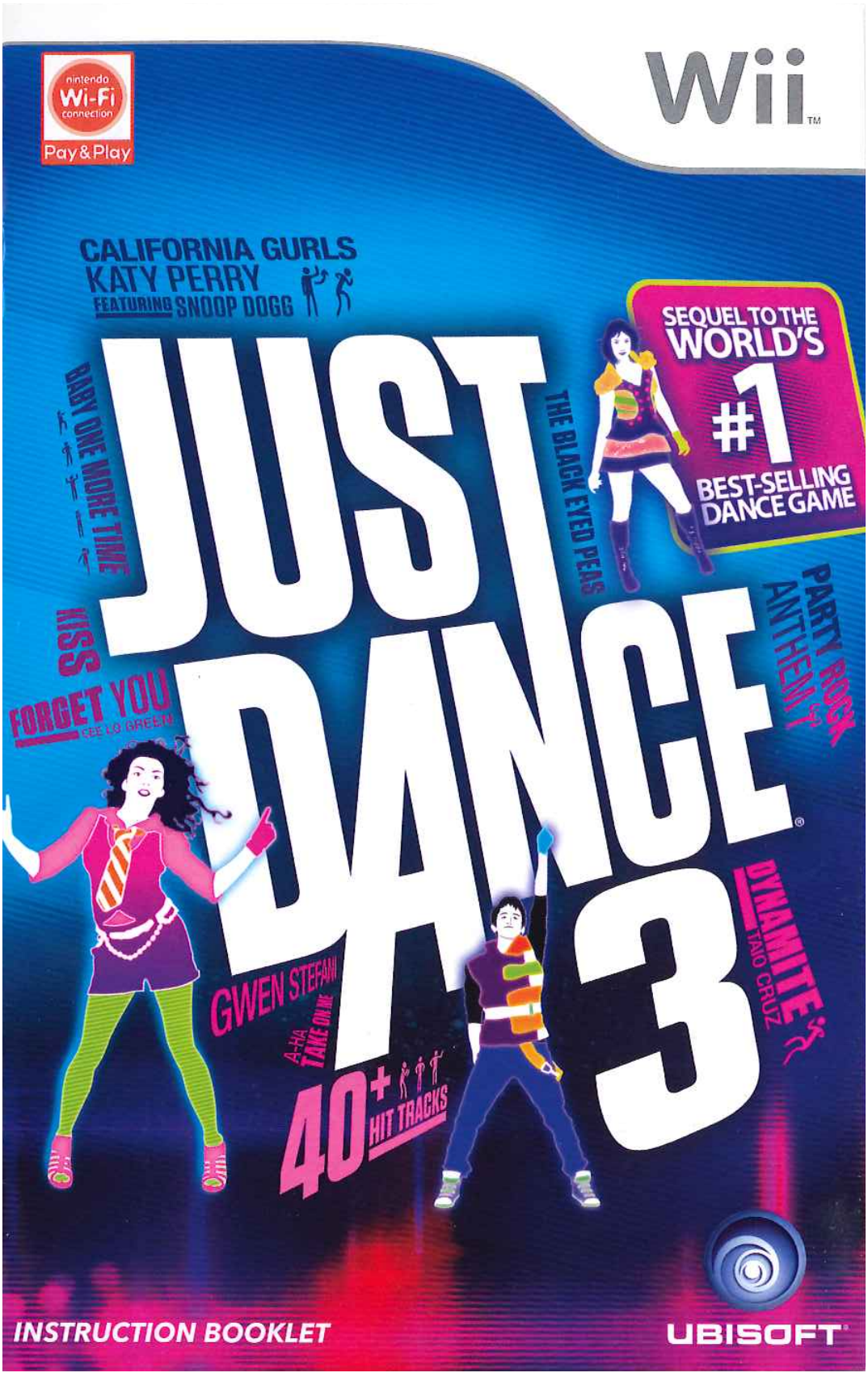
a processor which receives the control track and which is programmed with software for operating the computer system in response to said control track.

23. The system of claim 22, also including:

means for supplying the audio signal to the processor, and wherein the processor is programmed with software for operating the computer system in response to both the audio signal and the control track.

* * * * *

Exhibit 2


nintendo Wi-Fi connection
Pay & Play
Wii
CALIFORNIA GURLS
KATY PERRY
FEATURING SNOOP DOGG
SEQUEL TO THE WORLD'S #1 BEST-SELLING DANCE GAME
JUST DANCE 3
BABY ONE MORE TIME
THE BLACK EYED PEAS
KISS
FORGET YOU
CEE LO GREEN
PARTY ROCK ANTHEM
GWEN STEFANI
A-HA TAKE ON ME
DYNAMITE
TAIO CRUZ
40+ HIT TRACKS
INSTRUCTION BOOKLET
UBISOFT

PLEASE CAREFULLY READ THE Wii™ OPERATIONS MANUAL COMPLETELY BEFORE USING YOUR Wii HARDWARE SYSTEM, GAME DISC OR ACCESSORY. THIS MANUAL CONTAINS IMPORTANT HEALTH AND SAFETY INFORMATION.

IMPORTANT SAFETY INFORMATION: READ THE FOLLOWING WARNINGS BEFORE YOU OR YOUR CHILD PLAY VIDEO GAMES.

⚠ WARNING - Seizures

- Some people (about 1 in 4000) may have seizures or blackouts triggered by light flashes or patterns, and this may occur while they are watching TV or playing video games, even if they have never had a seizure before.
- Anyone who has had a seizure, loss of awareness, or other symptom linked to an epileptic condition should consult a doctor before playing a video game.
- Parents should watch their children play video games. Stop playing and consult a doctor if you or your child has any of the following symptoms:

Convulsions	Eye or muscle twitching	Altered vision
Loss of awareness	Involuntary movements	Disorientation

- To reduce the likelihood of a seizure when playing video games:
  1. Sit or stand as far from the screen as possible.
  2. Play video games on the smallest available television screen.
  3. Do not play if you are tired or need sleep.
  4. Play in a well-lit room.
  5. Take a 10 to 15 minute break every hour.

⚠ WARNING - Repetitive Motion Injuries and Eyestrain

Playing video games can make your muscles, joints, skin or eyes hurt. Follow these instructions to avoid problems such as tendinitis, carpal tunnel syndrome, skin irritation or eyestrain:

- Avoid excessive play. Parents should monitor their children for appropriate play.
- Take a 10 to 15 minute break every hour, even if you don't think you need it.
- If your hands, wrists, arms or eyes become tired or sore while playing, or if you feel symptoms such as tingling, numbness, burning or stiffness, stop and rest for several hours before playing again.
- If you continue to have any of the above symptoms or other discomfort during or after play, stop playing and see a doctor.

⚠ CAUTION - Motion Sickness

Playing video games can cause motion sickness in some players. If you or your child feel dizzy or nauseous when playing video games, stop playing and rest. Do not drive or engage in other demanding activity until you feel better.

IMPORTANT LEGAL INFORMATION This Nintendo game is not designed for use with any unauthorized device. Use of any such device will invalidate your Nintendo product warranty. Copying of any Nintendo game is illegal and is strictly prohibited by domestic and international intellectual property laws. "Back-up" or "archival" copies are not authorized and are not necessary to protect your software. Violators will be prosecuted.

REV-E

Official Nintendo Seal	*The Official Seal is your assurance that this product is licensed or manufactured by Nintendo. Always look for this seal when buying video game systems, accessories, games and related products.*
EVERYONE 10+ CONTENT RATED BY ESRB	Trademarks are property of their respective owners. Wii is a trademark of Nintendo. © 2006 Nintendo. Licensed by Nintendo

⚠ CAUTION: WRIST STRAP USE

Please use the wrist strap to help prevent injury to other people or damage to surrounding objects or the Wii Remote in case you accidentally let go of the Wii Remote during game play.

Also remember the following:

- ***Make sure all players put on the wrist strap properly when it is their turn.***
- ***Do not let go of the Wii Remote during game play.***
- ***Dry your hands if they become moist.***
- ***Allow adequate room around you during game play and make sure that all areas you might move into are clear of other people and objects.***
- ***Stay at least three feet from the television.***
- ***Use the Wii Remote Jacket.***

SYSTEM MENU UPDATE

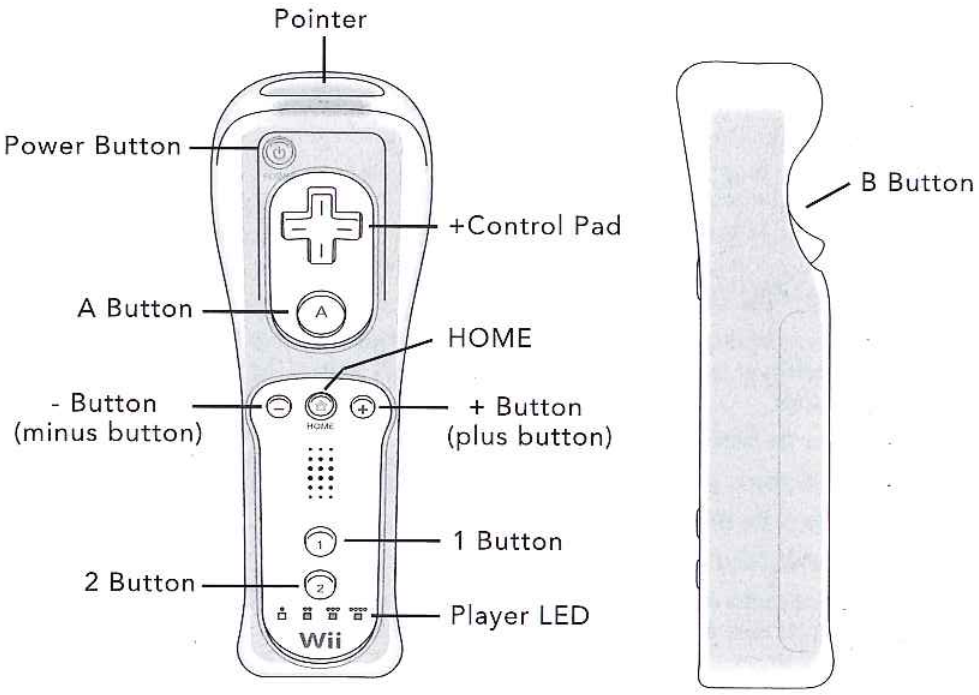
Please note that when first loading the Game Disc into the Wii console, the Wii will check if you have the latest system menu, and if necessary a Wii system update screen will appear. Press OK to proceed.

When the system menu is updated, unauthorized hardware and/or software modifications may be detected and unauthorized content may be removed causing the immediate or delayed inoperability of your console. Failure to accept the update may render this game, and future games, unplayable. Please note that Nintendo cannot guarantee that unauthorized software or accessories will continue to function with the Wii console after this or future updates of the Wii system menu.

GETTING STARTED

To begin playing, insert the Just Dance® 3 Game Disc into the disc slot of your Wii™ console.

CONTROLS



To dance and navigate the menus, all you need is a Wii Remote™. Put on the wrist strap and tighten it accordingly. You will need four Wii Remotes if you want four players to dance at the same time.

Note: The Nunchuk™ is not used in this game.

Navigate the Menus

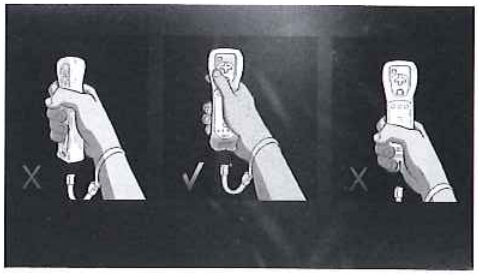
Point the Wii Remote at the screen and confirm your choice with the A Button. In most screens, you can go back with the B Button. In-game, press the + Button to go to the Pause menu.

INTRODUCTION

Welcome to Just Dance 3! Invite your friends, have fun, and dance to the dancer's choreography! There are over 40 songs and many new modes to choose from!

Basics

- Make sure that you have enough space to dance in.
- You can dance in two lines if you do not have enough room to stand side by side.
- Check your Wii Remote battery; a low battery can affect your performance.
- Always hold the Wii Remote firmly in your right hand like a stick.



- Follow the on-screen dancer as if it were your reflection in a mirror.
- Copy the dancer's movements as closely as possible – upper and lower body.
- Follow the dancer, follow the rhythm, and loosen up!
- When you're more advanced and have learned the choreography, the pictograms will help you anticipate the step changes.

THE GAME

The goal of the game is to dance in rhythm, as closely as possible, with the dancers on-screen. The flow of your movements is sensed by the Wii Remote and compared with those of professional dancers in order to evaluate your performance precisely. The amount of energy you put in is also detected and affects your score, so give it your all!

Score System

Dance Moves

For each movement, the system evaluates your performance in terms of rhythm and quality of execution. Your Score Ball indicates how good you are.

You didn't try very hard, did you?

Nice move! Try to synchronize with the dancer better or be more energetic

That's not quite it, but it's a start.

Nice style! Keep up the good work!

Note: If you're not sure which Score Ball is yours, press the A Button to illuminate it in your color.

Gold Moves

Some moves are more than just moves – they are Gold Moves. You will recognize them by the golden pictogram and the special effects around the dancer. Performing a Gold Move correctly nets you many points.

Successful Gold Move

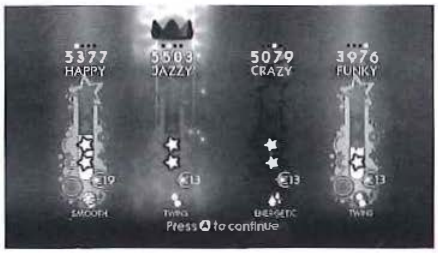
On Fire

If you obtain several Good or Perfect moves in a row, you can catch On Fire. While you're On Fire, every move you make earns you even more points. You can see the On Fire sign on your Score Ball and hear the associated sound effect from your Wii Remote.

Stars

Stars indicate your overall performance over the course of a song. While you're playing, the gauge above your name will show you how many stars you have.

In the Endgame screen, the number of stars you've accumulated over several games is tallied so that you can track which player won the most stars.



Style

The style comment in the score recap supplies advanced feedback on your performance:

Twins: Two players danced the same way.

In Rhythm: You had the best sense of rhythm!

Creative: You have your own style!

Energetic: You put the most energy into your moves!

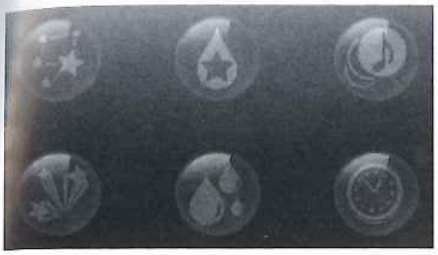
Smooth: You danced well without breaking a sweat.

Wild: You shook around the most!

Lazy: You were the least energetic! Try a little harder.

Mojo and Gifts

This is your experience gauge: the more stars you earn, the higher you fill the Mojo Gauge. When the gauge is full, you are rewarded with a special choreography or game mode. The more players there are and the more stars you gain, the more you fill your Mojo Gauge. That's a good reason to invite all your friends to come over and dance!



Medals

When you achieve specific conditions, you will be awarded with a medal. Medals can be bronze, silver, or gold, according to your performance. You can browse locked and unlocked medals in the Extras menu and in the Song/Gift Collection.

Try unlocking all of the medals!

SONG SELECTION

In Just Dance 3 you have access to numerous game modes, playlists, and choreography types. All of them can be accessed from the Song Selection screen. The content is organized in three menus: Songs, Specials, and Playlists.

Songs

You'll find all your core songs in the Songs menu.

Duets

In Duet mode, up to four players can perform complementary dances at the same time.
You can choose which dancer you'd like to play with by clicking his or her picture.

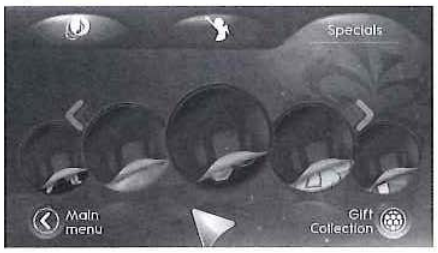
Dance Crew

Like in Duet mode, you can choose your dancer. This time, though, each player has a different dancer!

Hold My Hand

Up to eight players can dance together! In this mode, two players take one Wii Remote and hold it as described on-screen.

Specials



You can unlock special gifts, like new choreographies and new game modes! The more you play, the more special gifts you will earn.

Simon Says

While dancing, perform the actions that appear on your Score Ball.

Don't move or you will lose points.

Spin around once while opening your arms.

Clap in time to the song.

Fill in the gauge by shaking your Wii Remote. The faster you fill it, the more points you'll receive.

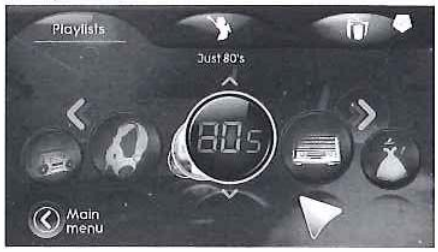
Dance Mash-Ups

Coaches from all songs team up to create a new choreography mash-up! Pay attention, you may notice that several danceres from previous Just Dance games make an appearance!

Medleys (Solo, Duet, and Dance Crew)

Dance to a selection of the best excerpts from various songs.

Playlists



Playlists allow you to play several songs in a row without interruption. Just select the playlist you like and you're ready to party!

If you want to skip the current song, press the + Button and choose Next.

Note: You can choose which song you play first with the +Control Pad.

Non-Stop Shuffle and Speed Shuffle

If you select Non-Stop Shuffle on the Song Selection screen, all songs will be played without interruption.

If you select Speed Shuffle, short versions of the songs will be played without interruption.

Song and Gift Collections

You can view all of the choreographies from the Songs menu or from the Specials menu. You can launch a song directly by clicking on it.

JUST SWEAT

If you're looking for a dance workout, you've come to the right place!

Free Sessions

Up to four players can play! Invite your friends to choose a song or a playlist and sweat together! You're free to play with or without a profile.

7-Day Challenges

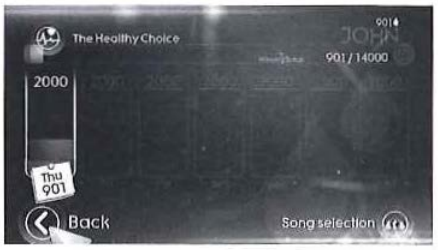
Create or select a profile; choose a sweat challenge, song, or playlist, and start sweating! You can follow your performance both daily and weekly.

Select a Challenge

Choose between three programs: The Fresh Start, The Healthy Choice, and The Sweat Explosion.

Be careful though: If you start a new program, the current one will be erased.

Note: Once you have chosen your challenge, it will stay active even if you quit the 7-Day Challenge and use your profile in Dance mode.



Week Progress

You can track your progress toward your fitness objective day by day.

Sweat Points

While you are Just Sweating (in Free Sessions, 7-Day Challenges, or in Dance mode when your profile is active), your real-time sweat points will appear next to your name.

Now that you have all the info, get ready to groove, sweat, and shake it! Just dance!

ONLINE

Add-on Content: Expand your choreography collection with all new add-on content for Just Dance 3 via your Nintendo Wi-Fi Connection. Add-on content is only playable from the game's Song Selection menu.

Note: Additional fees may be required for add-on content. You must be able to connect to the Internet in order to enjoy "Nintendo Wi-Fi Connection Pay & Play." This game allows you to connect to the Internet to download add-on songs in exchange for Wii Points™. Wii Points are required to use fee-based network services. For information on how to purchase Wii Points, refer to the Nintendo home page:

http://www.nintendo.com/consumer/systems/wii/en_na/channelsShop.jsp#points.

Be aware that network services may be discontinued without warning. Add-on content purchased within Just Dance 3 and stored on an SD Card can only be accessed within Just Dance 3. Do not use the Wii menu to manage this content. Just Dance 3 is able to save individual songs to a compatible SD Card. These individual songs cannot be copied using the Wii menu. Use the Archive to copy these songs to the SD Card. Wii data saved to an SD Card using the Data Management screen of the Wii menu cannot be directly used by Just Dance 3.

Register Your Game for Insider Access!

It's painless, we swear. Not to mention you'll enjoy all the benefits of registration, including:

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- Invitations to join private betas and preview upcoming game demos
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