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[54] **APPARATUS AND METHOD FOR SEARCHING A MELODY**

[76] Inventors: **Asif U. Ghias**, 2306 Sultana Dr., Yorktown Heights, N.Y. 10598; **Jonathan A. Logan**, 1186 Palomino Rd., Santa Barbara, Calif. 93105; **David W. Chamberlin**, 206 Flynn Ave., Mountain View, Calif. 94043

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Related U.S. Application Data

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[51] **Int. Cl.**[6] **A63H 5/00**; G04B 13/00; G10H 7/00

[52] **U.S. Cl.** **84/609**; 84/616

[58] **Field of Search** 84/600, 609, 634, 84/616, 654

[56] **References Cited**

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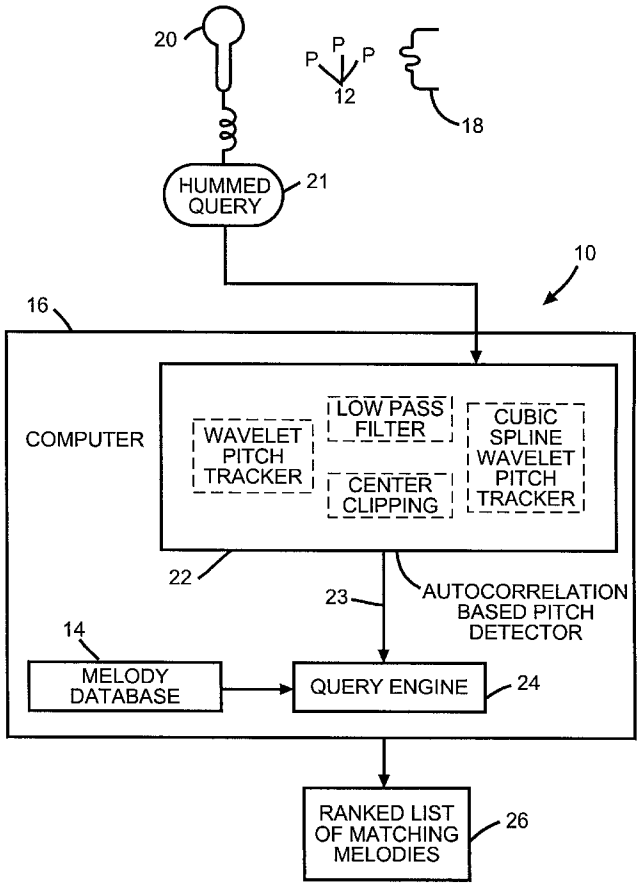
Primary Examiner—William M. Shoop, Jr.
Assistant Examiner—Jeffrey W. Donels
Attorney, Agent, or Firm—Hodgson, Russ, Andrews, Woods & Goodyear LLP

[57] **ABSTRACT**

Apparatus and method for easily, efficiently, and accurately searching melodies. A melody is inputted to a computer and converted into a form of a sequence of digitized representations of relative pitch differences between successive notes thereof. A melody database is searched for at least one sequence of digitized representations of relative pitch differences between successive notes which at least approximately matches the sequence of digitized representations of relative pitch differences between successive notes of the melody.

16 Claims, 3 Drawing Sheets



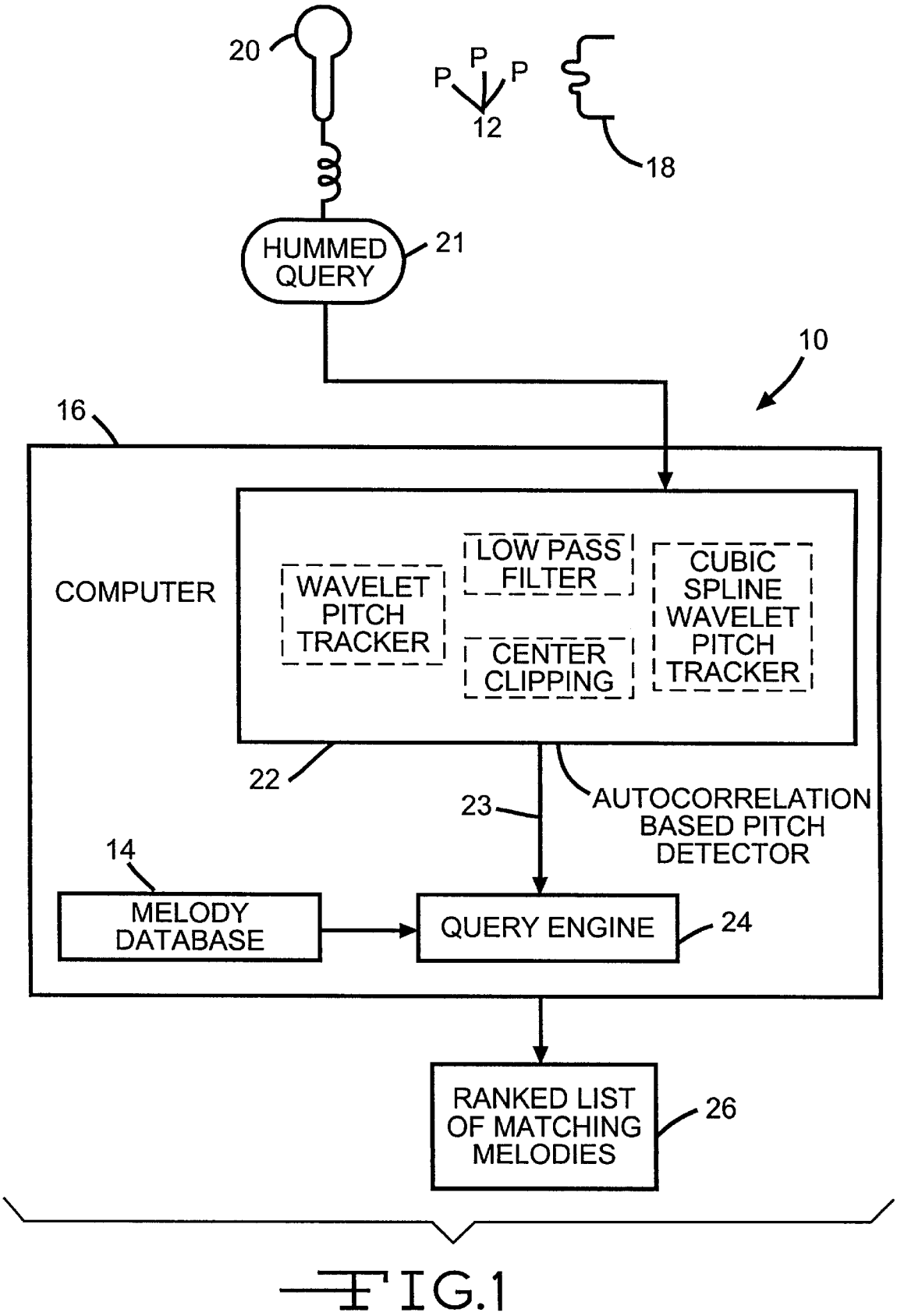


FIG.1

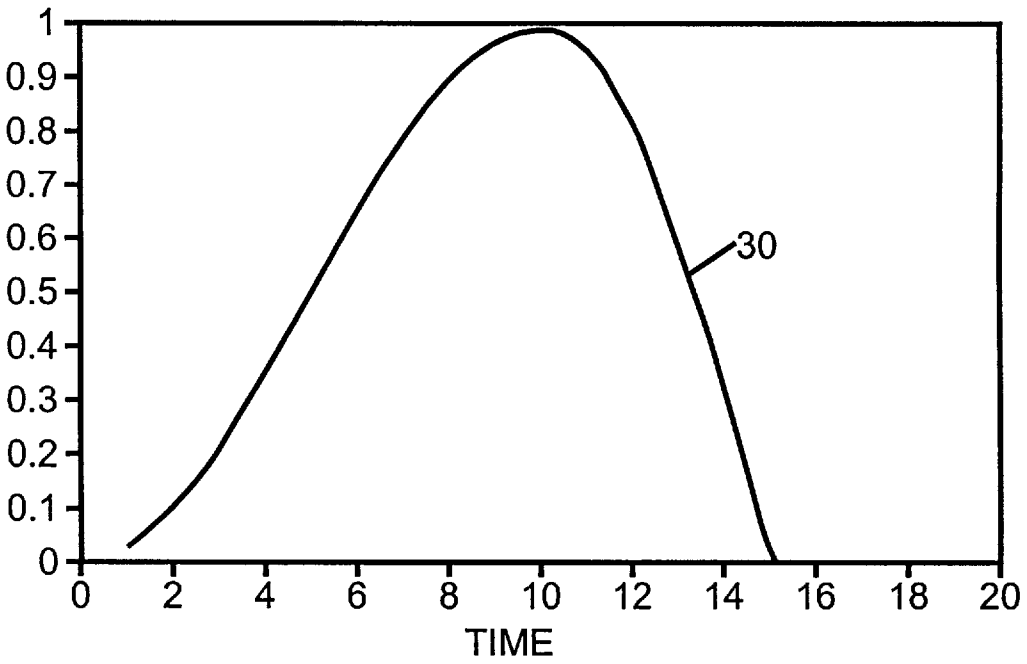


FIG. 2

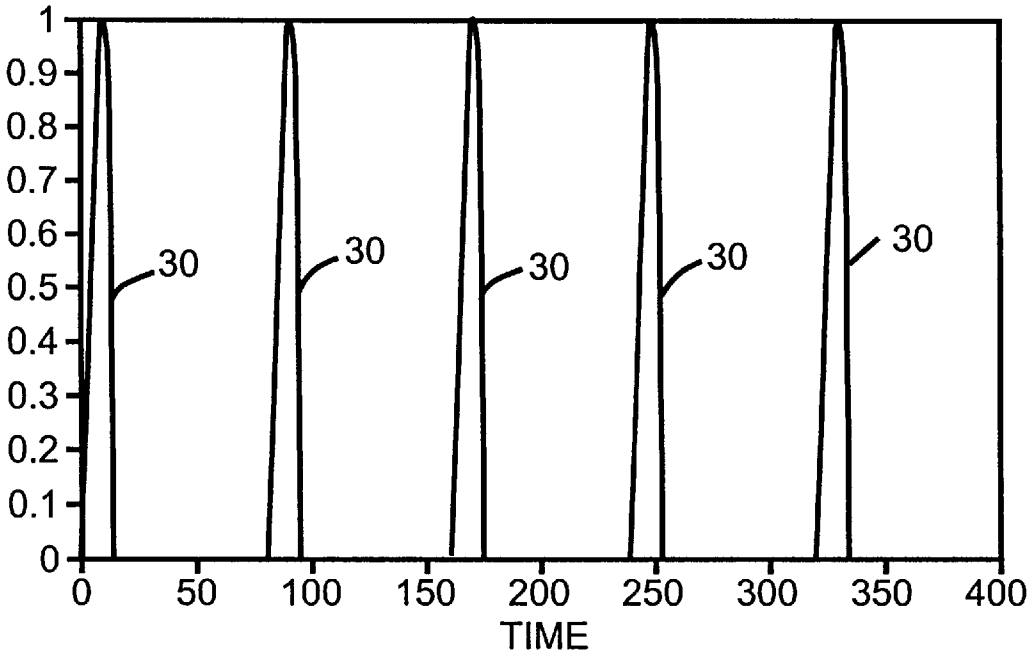


FIG. 3

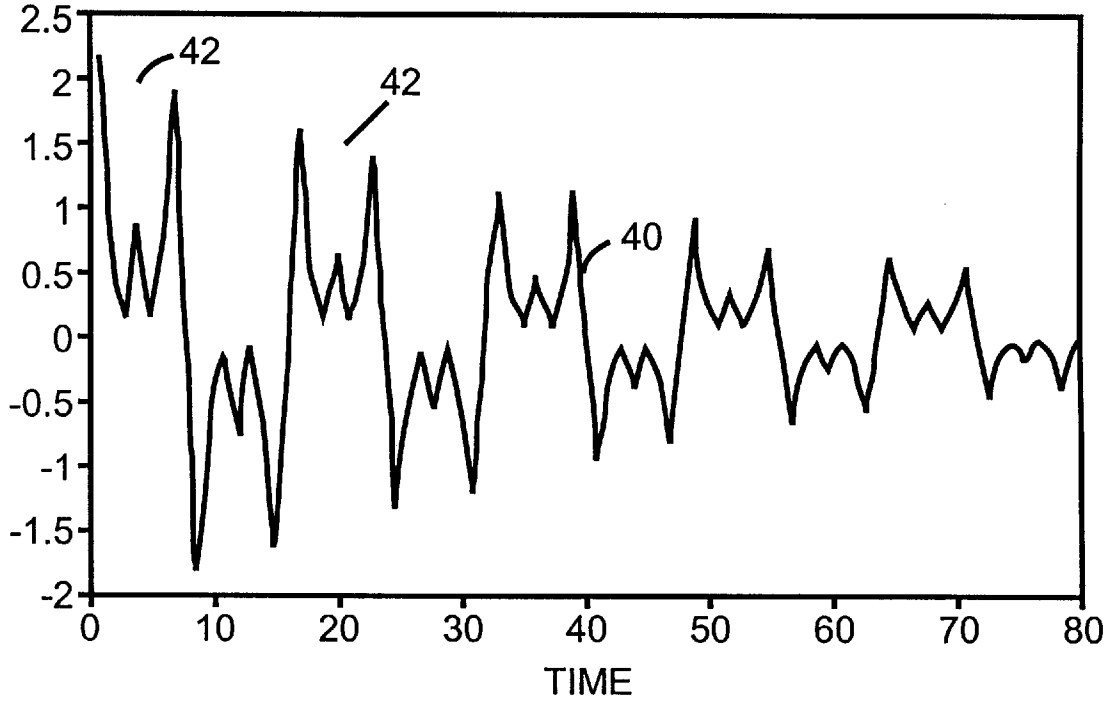


FIG. 4

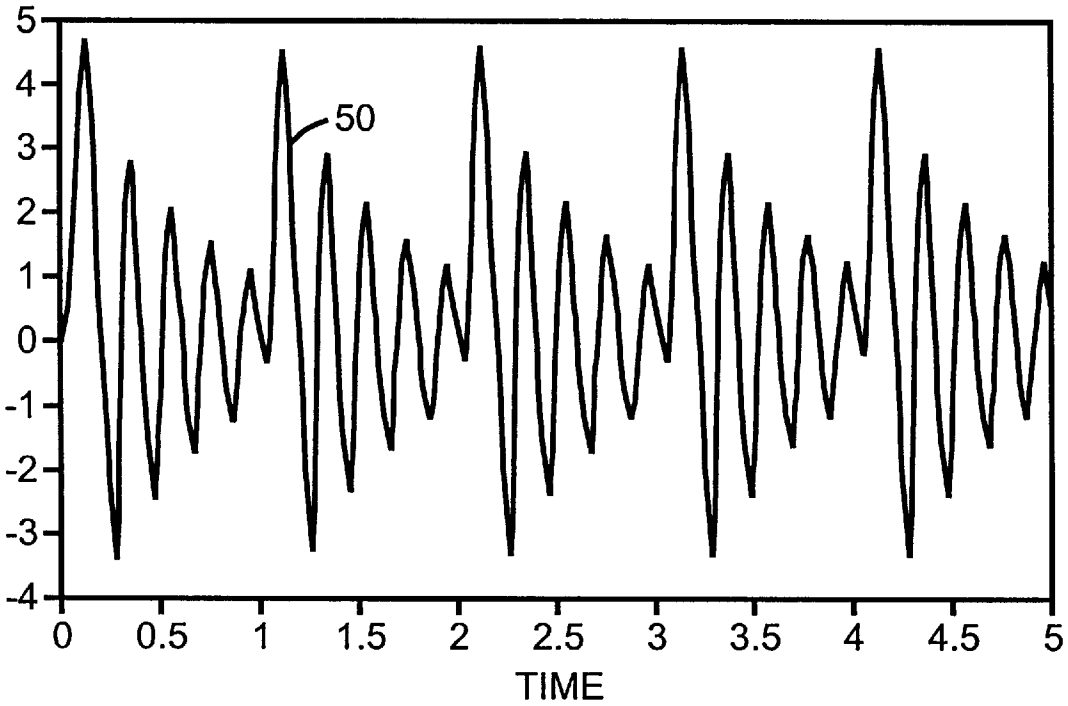


FIG. 5

APPARATUS AND METHOD FOR SEARCHING A MELODY

CROSS REFERENCE TO A RELATED APPLICATION

This application claims priority of provisional application Ser. No. 60/008,177, filed Oct. 31, 1995, which is hereby incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention relates generally to database searching. More particularly, the present invention relates to melody searching.

Next generation databases should include image, audio, and video data in addition to traditional text and numerical data. These data types will require query methods that are more appropriate and natural to the type of respective data. For instance, a natural way to query an image database is to retrieve images based on operations on images or sketches supplied as input. Similarly, a natural way of querying an audio database (of songs) is to hum the tune of a song, as apparently addressed in T. Kageyama and Y. Takashima, "A Melody Retrieval Method With Hummed Melody" (language: Japanese), *Transactions of the Institute of Electronics, Information and Communication Engineers D-II,* J77D-II(8): 1543–1551, August 1994. Such a system would be useful in any multimedia database containing musical data by providing an alternative and natural way of querying. One can also imagine a widespread use of such a system in commercial music industry, music radio and TV stations, music stores, and even for one's personal use.

It has been observed that melodic contour, defined as the sequence of relative differences in pitch between successive notes, can be used to discriminate between melodies. See Stephen Handel, *Listening: An Introduction to the Perception of Auditory Events,* The MIT Press, 1989, which indicates that melodic contour is one of the most important methods that listeners use to determine similarities between melodies. In Michael Jerome Hawley, *Structure out of Sound,* PhD thesis, MIT, September 1993, a method of querying a collection of melodic themes by searching for exact matches of sequences of relative pitches input by a MIDI keyboard is briefly discussed.

U.S. Pat. No. 5,510,572 discloses utilizing pitch differences between successive notes in classifying motion for a melody analyzer and harmonizer, wherein a search may be incidentally used to find an appropriate chord progression to, for example, harmonize music so as to accompany a singer. Other art which may be of interest includes U.S. Pat. Nos. 5,040,081; 5,146,833; 5,140,886; 4,688,464, and 5,418,322.

SUMMARY OF THE INVENTION

It is an object of the present invention to easily, efficiently, and accurately search melodies.

In order to easily, efficiently, and accurately search melodies, in accordance with the present invention, a computer means is provided which has a database of melodies each including a plurality of notes in a form of a sequence of digitized representations of relative pitch differences between successive notes, a melody is inputted to the computer means and converted into a form of a sequence of digitized representations of relative pitch differences between successive notes thereof, and the melody database is searched for at least one sequence of digitized representations of relative pitch differences between successive notes which at least approximately matches the sequence of digitized representations of relative pitch differences between successive notes of the melody.

The above and other objects, features, and advantages of the present invention will be apparent in the following detailed description of a preferred embodiment thereof when read in conjunction with the accompanying drawings wherein the same reference numerals denote the same or similar parts throughout the several views.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram illustrating an apparatus and method which embodies the present invention.

FIGS. **2** and **3** are graphs illustrating an excitation signal and train of such excitation signals respectively used to create a synthesized pitch for the method and apparatus.

FIG. **4** is a graph of a formant structure which is formed from certain formant frequencies.

FIG. **5** is a graph of a synthesized pitch created by convolving the train of excitation pulses of FIG. **3** and the formant structure of FIG. **4**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1**, there is illustrated generally at **10** apparatus for searching a melody, which is represented by a series of successive notes, illustrated at **12**, which of course have different pitches. In other words, it may be desirable to know the identity of the particular melody or tune **12**, and a database, illustrated at **14**, of melodies or tunes is searched, as described hereinafter, to locate at least one melody or tune which at least approximately matches the tune **12**. The database **14** is shown to be contained within a general purpose computer **16**, but, alternatively, the database **14** may be located apart from the computer **16** and suitably connected thereto for communicating between the computer and database. Both of these alternatives are meant to come within the scope of the present invention.

In accordance with the present invention, the tune **12** is hummed by a person **18** into a microphone **20**, and the hummed query, illustrated at **21**, is suitably digitized, in accordance with principles commonly known to those of ordinary skill in the art to which this invention pertains, and the digitized signals of the hummed query **21** are fed to a pitch tracking module **22** in computer **16**. The pitch tracker assembles a contour representation of the hummed melody **12**, as hereinafter discussed in greater detail, which is fed to a query engine, illustrated at **24**. The query engine **24** searches the melody database **14** and outputs a ranked list of approximately matching melodies, as illustrated at **26**. A preselected error tolerance may be applied to the search. The query engine **24** may of course alternatively be programmed to output the single most approximate matching melody or, if desired, to output an exact matching melody. However, by searching for an approximate matching melody, as hereinafter discussed, various forms of anticipated errors may be taken into account.

The database **14** of melodies may be acquired, for example, by processing public domain MIDI songs, or may otherwise be suitably acquired, and may be stored as a flat-file database. Pitch tracking may be performed in, for example, Matlab software, a product of the Matworks, Inc. of Natick, Mass., chosen for its built-in audio processing capabilities and the east of testing a number of algorithms within it. Hummed queries may be recorded in a variety of

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