(step **S64**) and advance s to step **S52**. After going from step **S64** to step **S52** as well, the estimating unit **3** again executes the processes in steps **S52** to **S62** as mentioned above. However, since the process about the residual component (estimation of the pitch) is executed, a pitch different from the pitch estimated in preceding step **S61** is estimated. For example, therefore, when the original signal has three pitches, each pitch is sequentially estimated by repeating the processes in steps **S52** to **S62** three times. If the original signal comprises, for example, audio components of respective parts of a trio, the pitch frequency of each part sound is obtained.

Since the pitch estimating process explained above estimates the pitch by paying attention to the relation of the harmonics, it is hardly influenced by noises. Such an effect will now be described in detail with reference to FIG. **11**. It is now assumed that in a normal case, when a discrete Fourier transformation at L points is performed for the original signal, a spectrum distribution as shown in (a) in FIG. **11** is obtained. In FIG. **11**, an axis of abscissa indicates a frequency base normalized by the sampling frequency. In this case, it is possible to decide that a fundamental frequency of (a) in FIG. **11** is a frequency corresponding to 2/(2L) of the highest spectrum level.

It is assumed that the frequency components of 3/(2L) or less are lost due to some causes such as noise or the like and a spectrum distribution is as shown in (b) in FIG. **11**. If the changed distribution is simply judged, in this case, it will be estimated that the fundamental wave in (b) in FIG. **11** has a frequency corresponding to 4/(2L) of the highest spectrum level.

Even in the above cases, however, in step **S57**,

$$\sum_{i=1}^{p} M_l(i \cdot k)$$

becomes maximum only when hypothesizing that the fundamental wave has the frequency of 2/(2L). Even if the information of the fundamental wave, therefore, is lost in the original signal as shown in (b) in FIG. **11**, a frequency that is equivalent to the pitch frequency estimated in (a) in FIG. **11** can be estimated.

Although the pitch estimating processes shown in FIGS. **9** and **10** are executed after the spectrum analysis results were previously obtained by the processes shown in FIGS. **2** and **7**, it is also possible to process in a combination form of the spectrum analyzing process and the pitch estimating process as follows.

FIG. **12** shows a processing procedure for the combination type pitch estimation, in which portions similar to those in FIGS. **7**, **9**, and **10** are designated by the same reference numerals.

In FIG. **12**, while obtaining the Fourier coefficients for n=1, 2, 3, . . . every row indicated by the value of each nT in the Table of FIG. **5** or **6**, frequency components including (p−1) harmonics (or overtone) components in the row are evaluated.

In more detail, first, a reading process of the original signal in step **S31** and a setting process of l in step **S32** are sequentially executed. In steps **S33** to **S35**, final Fourier coefficients C(n) and S(n) obtained by averaging the Fourier coefficients corresponding to the row of nT=1 in the Table of FIG. **5** or **6** and derived by two kinds of ranges of k are obtained. The processes in steps **S33** to **S35** are a part of the spectrum analyzing process by the MW-STFT in FIG. **7** and are characterized in that the Fourier coefficients are obtained on a row unit basis in the Table of FIG. **5** or **6**. That is, the Fourier coefficients which are obtained on a row unit basis enable evaluating processes in subsequent steps **S54** to **S58** accompanied with the processes of the row unit to be immediately executed from the processes in steps **S33** to **S35**.

As mentioned above, in the embodiment, the sum of the power spectra of up to the harmonics components of, for example, the fifth degree of the frequencies of the fundamental waves is obtained in accordance with the order from the fundamental wave having a low frequency component and then the frequency of the fundamental wave when the sum is maximum is estimated as a pitch. In this instance, when the fundamental waves in which the sums of the power spectra are equal exist in parallel, since the fundamental wave having a lower frequency component is set to the pitch, for example, if the estimating process of the invention is applied to a specific original signal such that noises are uniformly distributed in a whole band, then there may be a case where the pitch is erroneously estimated.

To avoid the error, it is also possible to use a method whereby by using a principle such that in case of voiced sound, as the sound becomes an harmonics component, the power spectrum exponentially decreases. When the sum of the power spectra is obtained, for instance, the following weights are assigned to the power spectra of the harmonics components.

Power spectrum of the frequency component assuming fundamental tone . . . X 1

Power spectrum of the frequency component assuming 2nd harmonic . . . X 0.8

Power spectrum of the frequency component assuming 3rd harmonic . . . X 0.8 X 0.8

Power spectrum of the frequency component assuming 4th harmonic . . . X 0.8 X 0.8 X 0.8

Power spectrum of the frequency component assuming 5th harmonic . . . X 0.8 X 0.8 X 0.8 x 0.8

By exponentially assigning the weight as the sound becomes the higher harmonics component as mentioned above, the pitch can be accurately estimated.

In the embodiment, since the frequency component of the fundamental wave in which the sum of the power spectra of up to, for example, the harmonics of the fifth degree is maximum is estimated as a pitch, for instance, even in the case where the original signal is constructed by only noises, the pitch may be estimated on the basis of the estimating method above. The following index, therefore, may be introduced as a criteria (a reference of a discrimination) to identify the original signal as noises.

First, the sum ratio

$$\sum_{i=1}^{p} M_l(i \cdot k_l)$$

of the normalized power spectra corresponding to the pitch k_l obtained in the embodiment is obtained.

Then a logarithm value of the sum ratio, namely,

$$10 \log_{10}\left\{\sum_{i=1}^{p} M_l(i \cdot k_l)\right\}$$

is obtained. The logarithm value is compared with a predetermined value, for example, −10 dB in the case where a white color noise of 0 dB has been multiplexed to the