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Kameoka et al.

[11] **3,711,620**

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[54] MUSICAL TONE SIGNAL GENERATOR

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[30] **Foreign Application Priority Data**

Jan. 29, 1970 Japan 45/7332

[52] **U.S. Cl.** **84/1.24**, 84/DIG. 4, 84/DIG. 5

[51] **Int. Cl.** **G10h 1/02**

[58] **Field of Search** ..... 84/1.24, 1.25, 1.01, DIG. 4; 331/173

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[57] **ABSTRACT**

A musical tone signal generator comprising a generator of a modulation signal consisting of a mixture of vibrato signal, first random noise signal and second random noise signal of higher frequency than the former; burst signal generators each for generating a burst signal in synchronization with fundamental tone signals modulated by output from said modulation signal generator; and a mixer for mixing said vibrato signals, random noise signals and burst signals thereby to obtain musical tone signals.

4 Claims, 11 Drawing Figures

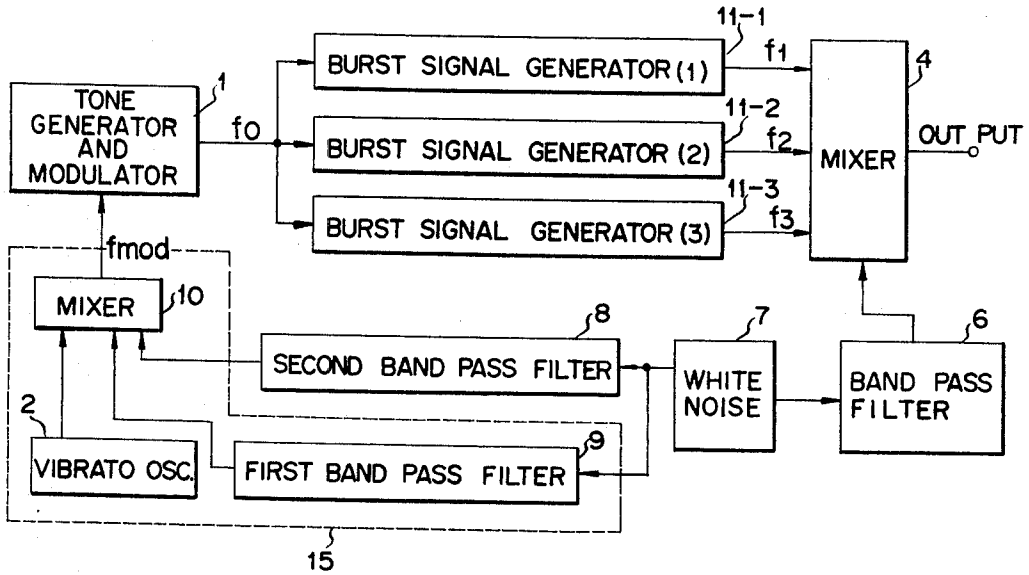


FIG. 1

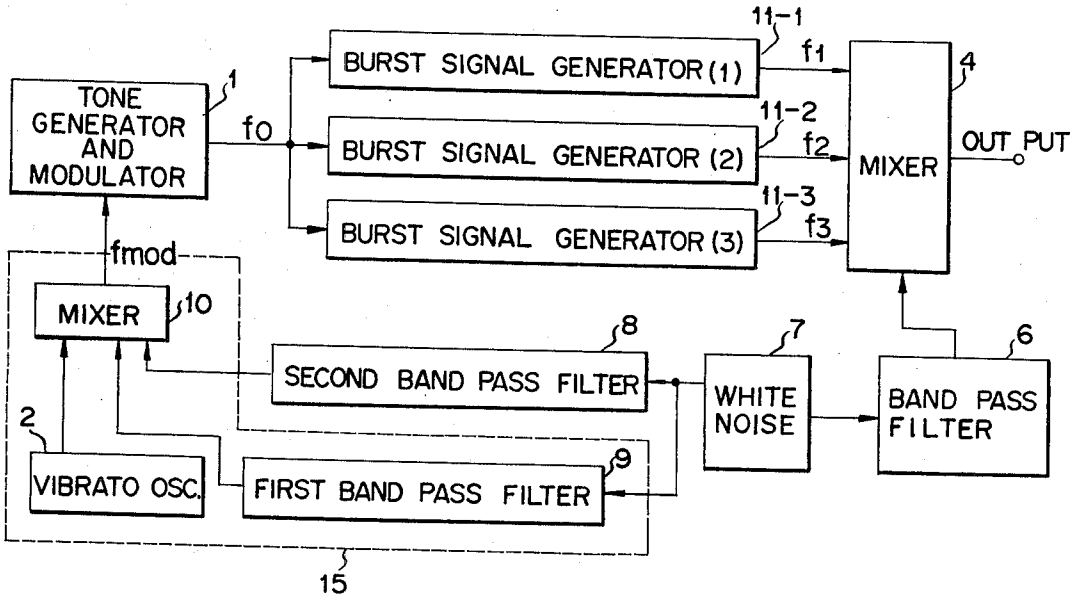
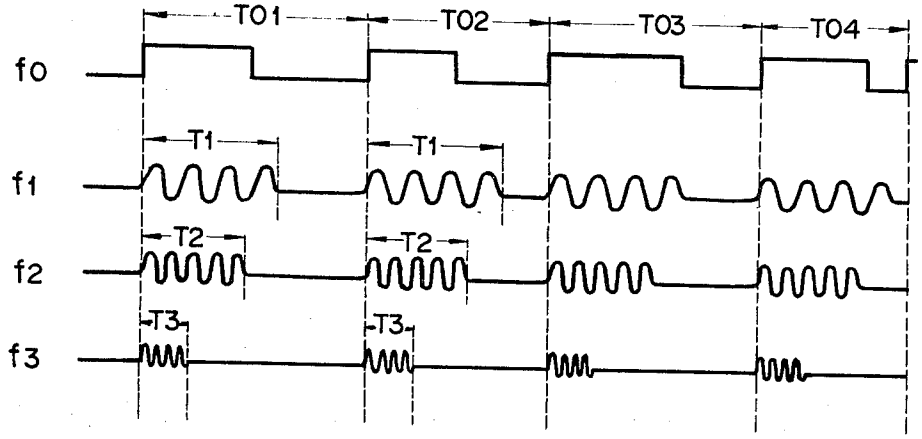


FIG. 2



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FIG. 5

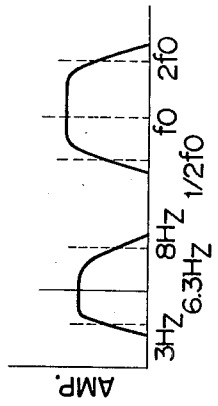


FIG. 4

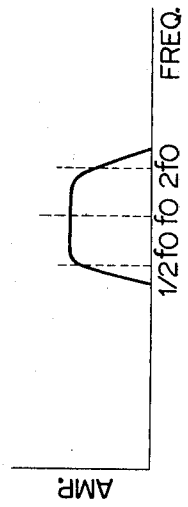


FIG. 3

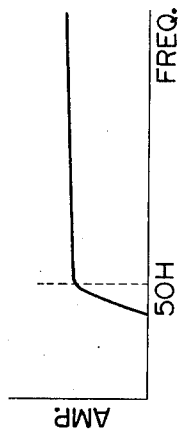
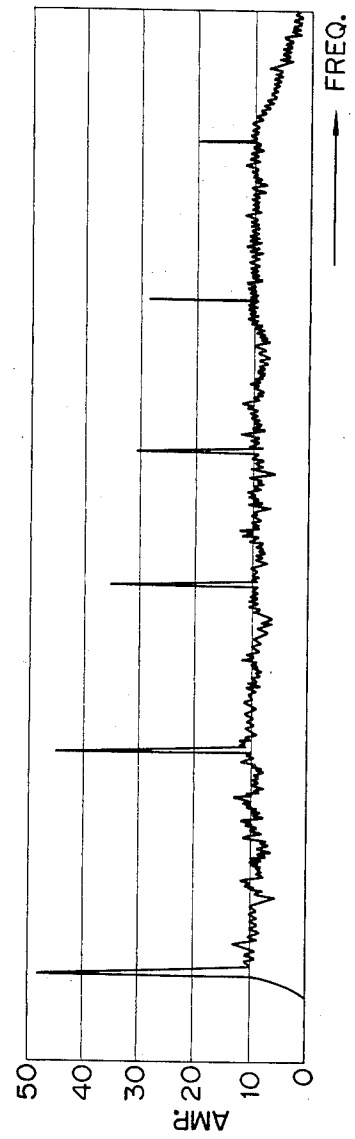


FIG. 6



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FIG. 7

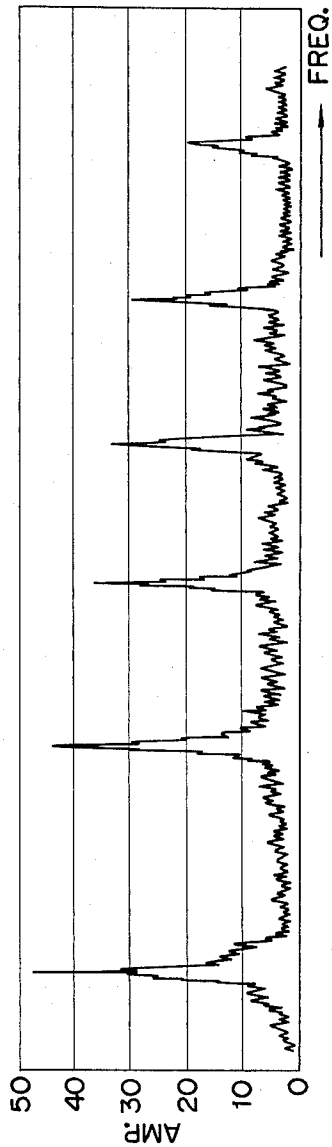
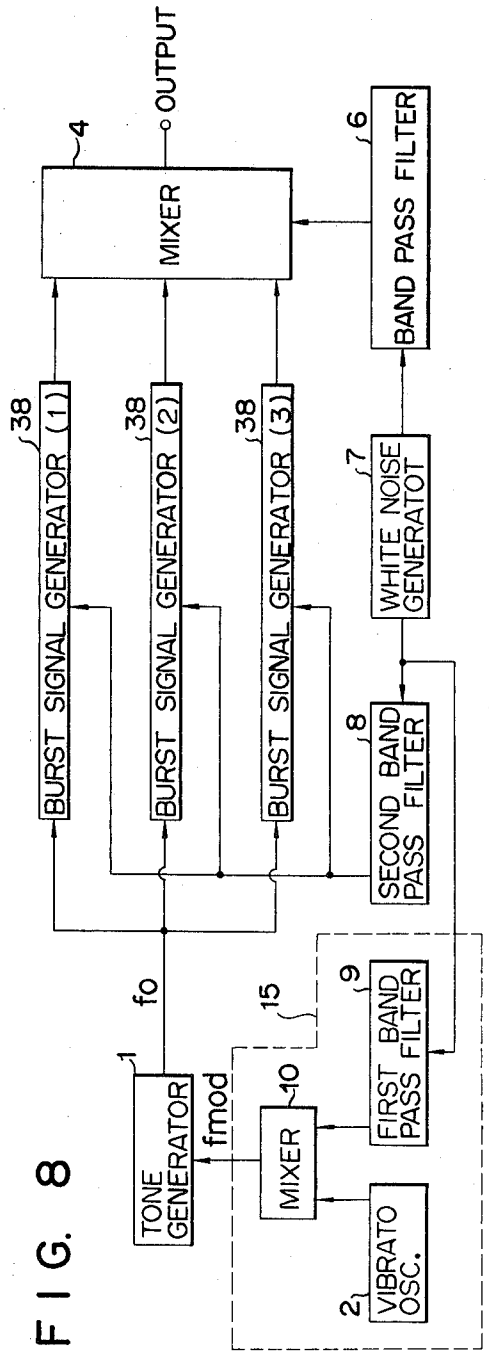


FIG. 8



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FIG. 9

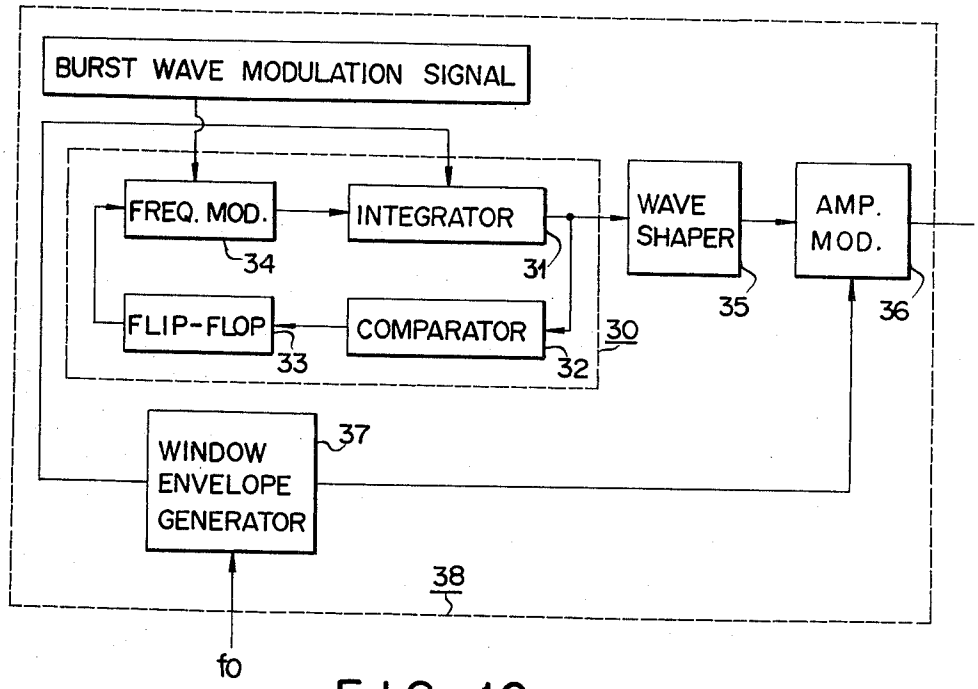
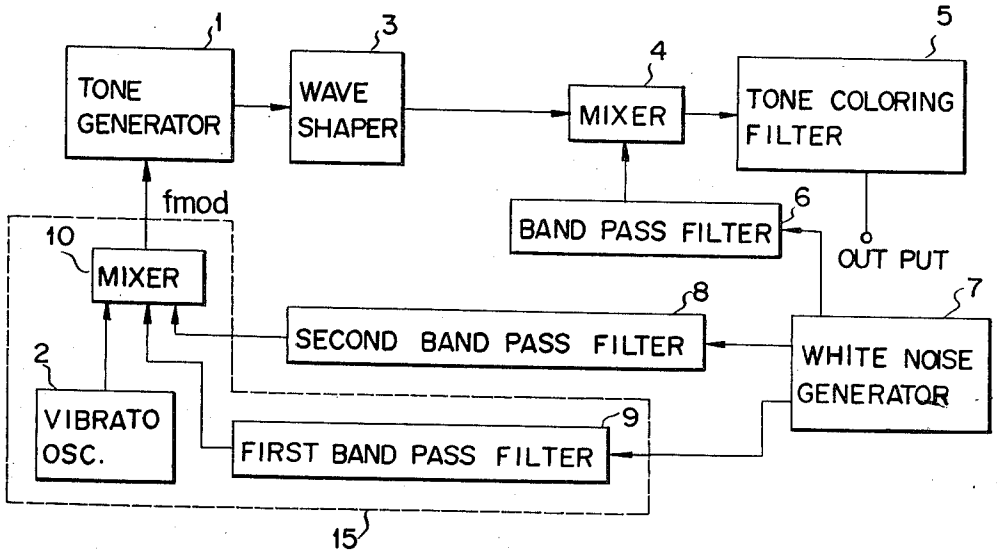
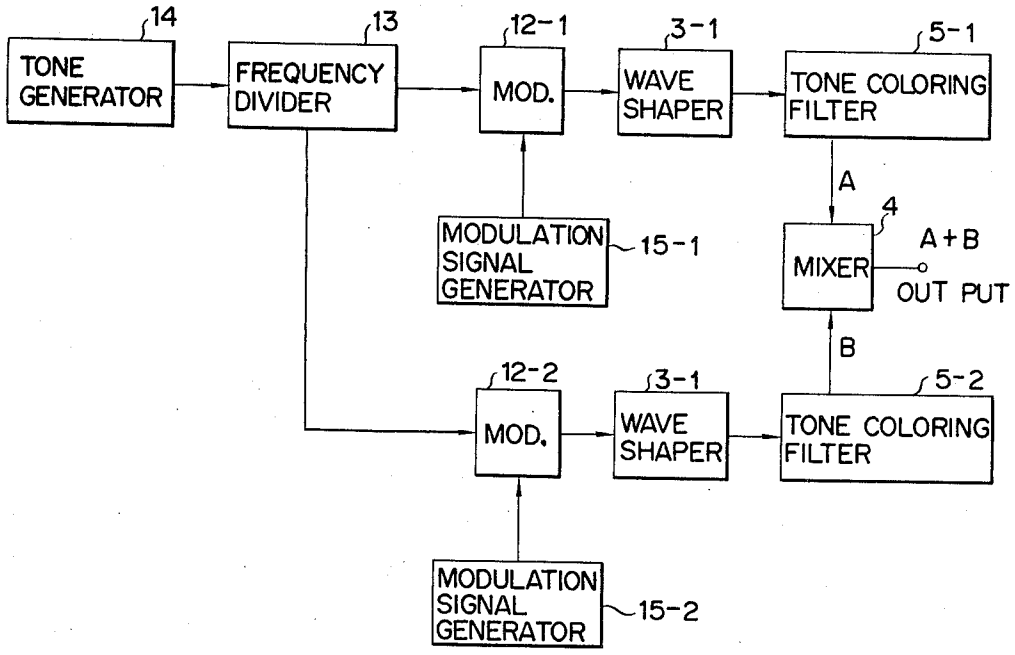


FIG. 10



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FIG. 11



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MUSICAL TONE SIGNAL GENERATOR

BACKGROUND OF THE INVENTION

The present invention relates to a musical tone generator. The conventional system for generating musical tones, particularly those of a string musical instrument of the violin family consists in frequency-modulating the frequency of a fundamental oscillator by signals having as low a frequency as about 5 to 10 Hz to obtain a vibrato effect and using a tone coloring filter to produce a desired tone color approximating the frequency spectrum of tones generated by such instrument. In some cases, output tone signals are also amplitude modulated to obtain a tremolo or mandolin effect. Further for simulation to the tone colors of the violin family, there are added noise signals to the fundamental signals. The above-mentioned prior art has failed fully to give forth tone colors bearing close truthfulness to those derived from a natural musical instrument, and has presented considerable difficulties in producing tone colors resembling those of a violin in particular.

SUMMARY OF THE INVENTION

The present invention is an outcome of close study on the intricate vibrations of the strings of a natural string musical instrument of the violin family and the irregular excitation of tones by a bow in order to find out fundamental important factors in producing violin-like tone colors. As a result, it has been found that the tones of the violin family and the like present wave forms indicating that their harmonic components fluctuate very quickly and irregularly in frequency and amplitude. An object of the invention is to provide a musical tone generator producing the natural tone of the violin family by modulating fundamental tone signals by at least noise signals having frequency components of frequency more than 50 Hz or equal to ½ to 2 fold that of the fundamental tone signals.

According to this invention, the fundamental tone signals generated by a tone generator are modulated by modulation signals having at least high frequency noise signals having frequency components of more than 50 Hz. The modulated tone signals are applied to a burst signal generator to produce burst signals therefrom in synchronization with the modulated fundamental tone signal. The burst signals are applied in turn to a mixer and a tone filter to obtain musical tone signals.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a musical tone signal generator according to an embodiment of the present invention;

FIG. **2** represents the wave form of signals produced by the generator of FIG. **1**;

FIG. **3** shows frequency characteristics of high pass filter;

FIG. **4** represents frequency spectrum of high random noise signals;

FIG. **5** represents frequency spectrum of modulation signal including low and high random noise signals;

FIG. **6** is a curve diagram showing the characteristics of tone color signals generated by the generator of the invention;

FIG. **7** is a curve diagram indicating the characteristics of tone color signals given forth by the prior art device;

FIG. **8** is a block diagram of a musical tone signal generator according to another embodiment of the invention, wherein the burst signal generating circuit is supplied with modulated fundamental tone signals and high frequency noise signals;

FIG. **9** is a block circuit diagram showing in detail the burst signal generating circuit of FIG. **8**; and

FIGS. **10** and **11** are block diagrams of musical tone signal generators according to other embodiments of the invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** relates to an embodiment of the present invention where there are used high frequency random noise signals as modulating signals for, for example, frequency or width modulation. Signals from a fundamental tone signal generator **1** which have frequencies corresponding to the tone pitches of a musical instrument are frequency-modulated by modulation signals from a modulation signal generator **15**. The modulated signals for a vibrato effect are formed by mixing in a mixer **10** signal frequency signals from a vibrato signal oscillator **2** having a frequency of, for example, 6.3 Hz and first random noise signals obtained by passing output from a white noise signal generator **7** for generating noise signals having frequencies falling within a certain frequency band through a band pass filter **9** allowing the passage of signals having frequency components of, for example, 3 to 8 Hz. The present invention is further characterized in that there are supplied to the mixer **10** second random noise signals which were obtained by causing output from the white noise signal generator **7** to pass through a high pass or band pass filter or second filter **8** capable of passing through signals having frequency components of more than 50 Hz. Fundamental tone signals are generated by the fundamental tone signal generator **1** and also frequency-modulated in the modulator included in the tone signal generator **1** by modulation signals fmod formed in the aforementioned manner to be produced as an output f_0. This modulated output f_0 is conducted to burst signal generators **11-1**, **11-2** and **11-3**, from which there are obtained burst signals f_1, f_2 and f_3. Burst signal generators are known and one example may be found in the July, 1952 issue of Electronics in an article entitled "Tone-Burst Generator" which beings on Page 132. The circuits shown in that article could be used in the musical instrument of the present invention but a more convenient form would be that of the pulse generator described in a book entitled Waveforms which is one of the Radiation Laboratory series published by the Massachusetts Institute of Technology in 1948. The pertinent circuits are described beginning at Page 140 and continuing to Page 149. The output of the mixer **4** is passed through a wave shaper and tone coloring filter not shown to be drawn out as musical tone signals.

There will now be detailed the aforementioned circuit arrangement in connection with the setting of parameters and the resulting tone coloring effect.

(1) FIG. **3** shows the frequency characteristics of the high pass filter or second filter **8** (full stop). Where the cut off frequency of the second random noise signals is

chosen at 50 Hz, there are obtained desired irregular variations in frequency and amplitude with respect to all the tone pitches of the violin family, giving forth delightful tone colors closely resembling those of the violin family. However, in case the cut off frequency is chosen lower than 50 Hz, the tone obtained will be rough, unclear and dissonant, and therefore an improper tone as a violin tone. Since a high pass filter only cuts off signals of a specified frequency, it can be used singly in common to all tone pitches, and is more adapted for use in an electron musical instrument due to its economical advantage.

(2) For as much simulation as possible to the tone colors of the violin family, it may sometimes be necessary to limit the frequency band of second random noise signals according to the pitches of musical tones to be produced. FIG. **4** exemplifies the case in point. Referring to the embodiment of FIG. **1**, however, where the frequency band of the aforementioned noise signals is so chosen as to be $\frac{1}{2}f_0$ to $2f_0$ in relation to the fundamental frequency f_0, there are most effectively obtained fully natural tone colors resembling those of the violin family.

FIG. **5** indicates the frequency spectrum of modulation signals fmod used in the above-mentioned case. As seen from the figure, modulation signals formed by adding first random noise modulation signals to sine wave signals of 6.3 Hz are further blended with second random noise signals having higher frequency than that of the first noise signals. Experiments show that where the lower cut off frequency $\frac{1}{2}f_0$ of the filter **8** (shown in FIG. **1**) was a lower frequency than 50 Hz, there appeared undelightful produced tones as those of the violin family, and the higher cut off frequency $2f_0$ of the filter **8**, did not affect noticiable change in the tone colors. Modulated signals carried to an extent of about ±10 percent by second random noise signals produced delightful tones bearing close truthfulness to those of the violin family. The upper limit of the degree of modulation carried by second random noise signals was about ±20 percent. When modulation was conducted to a degree of less than 1 to 2 percent it was found that there was not obtained any above-mentioned effect.

The fundamental tone signals were modulated to the less degree of modulation than several percents thereof by sine wave of 6.3 Hz and further modulated by random noise signals passing through the first band pass filter **9** permitting the passage of 3 to 8 Hz in order to produce vibrato tones closely simulating the natural tones of the violin family. When the filter **9** cuts off low frequency signals of less than 3 Hz, then there appeared tone whose pitches seemed undesirably unstable. The degree of modulation conducted by first random noise signals, which is defined by the ratio of the frequency of sine wave signals to that of first random noise signals, was limited to several percents.

As mentioned above, frequency modulation according to the present invention of composite signals formed by adding high frequency random noise modulation signals to the vibrato signals heretofore used in producing the tone colors of the violin family had the advantage that there were multiplicatively produced tone colors assuming a greater degree of truthfulness to the nature than in the case where there were used separately both high frequency random noise modulation signals and vibrato signals, realizing a truer simulation to the tone characteristics of the violin family. This favorable result arises from the fact that frequency modulation of fundamental tone signals from the fundamental tone signal generator eventually leads to irregular variations in the intervals T_{01}, T_{02}, T_{03} ... T_{0i} shown in FIG. **3** during which burst signals are to be generated.

Application of particularly second random noise modulation signals results in quick variations in the intervals of the burst signals, reducing correlation between the adjacent intervals. The prior art modulation using only low frequency signals of 5 Hz to 10 Hz has failed to generate tone colors approximating those of the violin family, which fluctuate quickly and irregularly in frequency and amplitude. In contradistinction to this, the present invention has succeeded in simulating said quick and irregular fluctuation and producing tone colors closely resembling those of the violin family.

The conventional device of simply mixing noise signals in an attempt to approach the tone colors of the violin family causes frequency components to be distributed, as shown in an analytical specimen of FIG. **6**, independently of the component arrangement of musical tones. In contrast, the present invention enables the frequency of vibrato signals to be prominently randomized by means of frequency modulation and in consequence modulation of the width of burst signals, thus always causing side band components to be distributed, as illustrated in FIG. **7**, in dependence on the components of musical tones. In the prior art device modulation noise signals are unrelated to the components of musical tones, whereas, in the present invention, the side band noise components bear correlation with the components of musical tones. Further, the present invention causes the side band components of FIG. **7** to be gently distributed near the harmonics, so that the tone colors obtained by the present invention are saved from sharp irritability shown in FIG. **6**. The conventional method strongly impresses the hearer with the so-called harsh sounds, whereas the present device is prominently improved in that the tone colors produced are free from rasping components and rich and sweet with a greater degree of truthfulness to those of the violin family.

The embodiment of FIG. **1** relates to the case where fundamental tone signals from the fundamental tone signal generator were modulated in frequency and in consequence the widths of burst signals were modulated. However, the high frequency random noise modulation signals may be applicable not only to frequency modulation but also to phase or pulse position modulation with the same effect.

In the embodiment of FIG. **1**, randomization of frequency and amplitude was effected by frequency modulation of the fundamental tone signals. However, said randomization can also be realized by modulating, as shown in FIGS. **8** and **9**, the momentary frequency or widths T_1, T_2 and T_3 of burst signals in synchronization with the fundamental tone signals by said second random noise signals in a burst signal generator. It has been found that additional application of first random noise modulation signals has a new effect of imparting increased delicacy to the tones produced. FIG. **8** is a

concrete arrangement of the associated device and FIG. 9 is a detailed illustration of the burst signal generator of FIG. 8.

There will now be described the embodiment of FIGS. 8 and 9. The embodiment of FIG. 8 has three burst signal generator 38. The generator 38 is supplied with white noise signals from the high pass or band pass filter 8. The resulting high frequency random noise modulation signals modulate the burst signals in synchronization with the fundamental tone signals f_0. Since said burst signals have different momentary frequencies and widths, modulation may be performed similarly in different degrees corresponding thereto. Referring to FIG. 9, a loop consisting of an integrator 31, comparator 32, flip-flop circuit 33 and frequency modulating circuit 34 is a known voltage control type generator 30 of triangular waves of variable frequency. Intermittent operation of this loop using pulses synchronized with fundamental tone signals f_0 produces triangular wave burst signals. In this case, the correlation between the tone signals f_0 and the triangular wave frequency may be arbitrarily defined. The triangular wave burst signals are converted to sine wave burst signals by a wave shaper 35. The burst signals are enveloped with window wave signals by an amplitude modulator 36 to allow them to have an arbitrary width. Modulation of the momentary frequency of burst signals is conducted by supplying second random noise modulation signals to a frequency modulating circuit 34. Modulation of the interval of burst signals can be effected simply by modulating the interval of window signals from a window envelope generator 37 used in controlling said amplitude modulator 36.

Referring again to the embodiment of FIG. 1, where the fundamental tone signals alone are modulated, burst signals from the three burst signal generators are modulated in the same pattern and degree. In the embodiment of FIG. 8, however, burst signals from the three burst signal generator can be modulated to different extents. If there are further provided a plurality of modulation signal generating circuits, then it will be possible to modulate the burst signals in different patterns. With an actual string musical instrument of the violin family, harmonics of low and high orders often have their frequency periodically varied in different degrees, that is, at random. The embodiment of FIG. 8, therefore, is very convenient for simulation to such random frequency variations. Throughout the embodiments of the present invention, the same parts as those of FIG. 1 are denoted by the same numbers. In the embodiment of FIG. 8, the second random noise signals from the high pass filter 8 may be conducted to the mixer 10 as well as the burst signal generators 38.

The foregoing embodiments relate to a device for composing tone colors using the burst signal generator 38. However, the present invention is easily applicable to general electronic musical instruments. Namely, the object of the present invention can also be attained by a circuit arrangement of, for example, FIG. 10. In this embodiment, fundamental tone signals from the generator 1 thereof are modulated by output fmod from the modulation signal generating circuit 15. The modulated signals are passed through the wave shaper 3 to form tones of the desired wave form and conducted to mixer 4 to be mixed with the output from the white noise signal generator 7 through the band pass filter 6. The output signals from the mixer 4 are applied to the tone coloring filter 5 to be composed into a spectrum structure having a desired formant. In the embodiment, the modulated signals passed through the wave shaper 3 do not always have to be mixed at the mixer with the noise signals from the filter 6.

FIG. 11 is a block circuit diagram of another embodiment of the present invention. Second random noise modulation signals having frequencies of more than 50 Hz are applicable not only to frequency modulation, but also to phase, amplitude and pulse position modulation. Where, therefore, the device of the present invention is incorporated in an actual electronic musical instrument, it is possible, to divide output from the fundamental signal generator 14 into desired frequencies and modulate the signals thus divided in frequency using one or more modulators 12. Namely, a tone signal from the tone generator 14 is divided into two signals by a frequency divider 13. These signals are modulated in the respective modulators 12-1, 12-2 by the modulation signals from the respective modulation signal generators 15-1, 15-2 and supplied to the respective tone coloring filters 5-1, 5-2 through the wave shapers 3-1, 3-2. The output signals A and B from the tone coloring filters 5-1, 5-2 are mixed in a mixer 4 to obtain desired tone signals. Provision of a single fundamental tone signal generator and addition of a group of circuits using different modulation signals and systems after the frequency divider 13 are only required to produce two or more tone colors and realize the same effect as the concert performance of two or more natural musical instruments. With an electronic musical instrument where there are formed fundamental tone signals by mixing outputs from two frequency dividers, said outputs can be modulated separately and harmonics of low and high orders can be modulated in different degrees and patterns.

What we claim is:

1. A muscial tone generator comprising:
- a tone signal generator for generating fundamental tone signals,
- a modulation signal generator for producing modulation signals including a mixture of vibrato signal components, noise components of frequencies of more than 50 Hz and noise components of frequencies of 3 Hz to 8 Hz, which includes:
  - a vibrato oscillator producing the vibrato signal components;
  - a white noise signal generator generating white noise signals;
  - a high pass filter coupled to said white noise generator to pass noise signal components having frequencies of more than 50 Hz;
  - a band pass filter coupled to said white noise generator to pass noise components having frequencies of 3 Hz to 8 Hz; and
  - a mixer coupled to said vibrator oscillator, high pass filter and band pass filter to mix said three signal components there from; and
- a modulator included in said tone signal generator and coupled to said modulation signal generator to modulate said fundamental tone signal with said modulation signals.

2. The musical tone generator according to claim 1 wherein said high pass filter passes noise components having frequencies between ½ and 2 (times) those of the fundamental tone signals.

3. The musical tone generator according to claim 1 further including at least one burst signal generator coupled to the modulated output of said tone signal generator in order to generate a burst signal in synchronization with the modulated signal from said tone generator.

4. The musical tone generator according to claim 1 further including a plurality of burst signal generators coupled to the modulated output of said tone signal generator to generate respective burst signals in synchronization with the modulated output of said tone signal generator and a mixer coupled to the output of said burst signal generators to mix together respective burst signals therefrom.

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