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 [33] **Japan**
 [31] **44/123778;**
Dec. 28, 1969, Japan, No. 44/123779

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[54] **TREMOLO EFFECT PRODUCING DEVICE**
3 Claims, 22 Drawing Figs.

[52] U.S. Cl. **84/1.25,**
 84/1.04, 84/1.11, 84/1.24
 [51] Int. Cl. **G10h 1/04**
 [50] Field of Search 84/1.01,
 1.24

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ABSTRACT: A carrier wave having a subaudible frequency is modulated in amplitude by a modulating wave of a tone signal having an audible frequency, which produces a resultant modulated output signal having first and second side band components respectively deviated above and below the tone signal frequency by a deviation equal to the carrier frequency. The frequency of the carrier wave is selected to be much lower than that of the modulating wave, contrary to the known conventional modulation technique. The frequency-deviated signal thus obtained is admixed with the original nonfrequency-deviated musical sound signal thereby to produce a tremolo or chorus effect. The carrier wave is given a distorted waveform in order to produce a richer and more complicated tremolo or chorus effect.

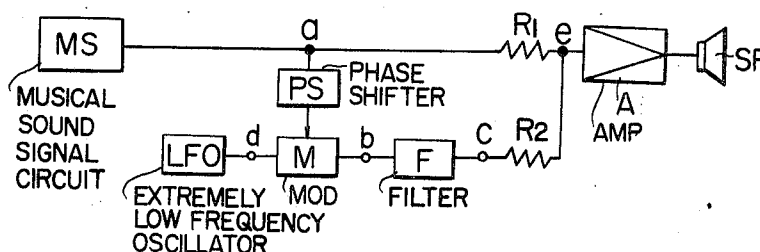


FIG. 1

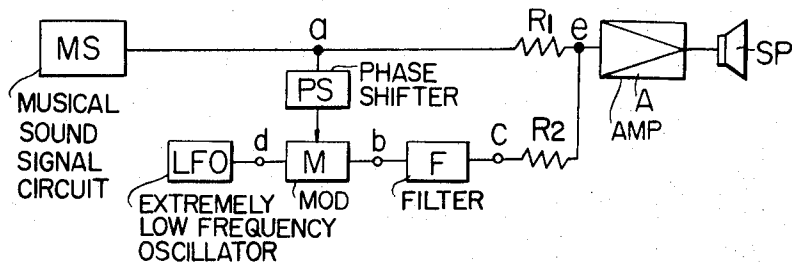


FIG. 2(a₁)



FIG. 2(b₁)

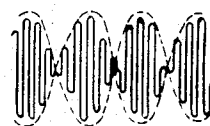


FIG. 2(a₂)



FIG. 2(b₂)



FIG. 2(a₃)



FIG. 2(b₃)



FIG. 3(a)

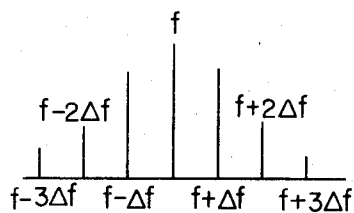


FIG. 3(b)

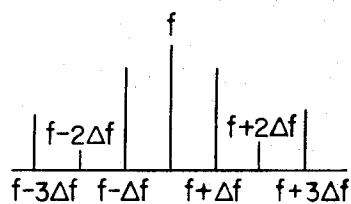


FIG. 4

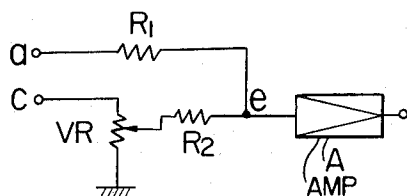


FIG. 5

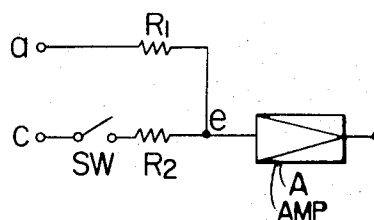


FIG. 6

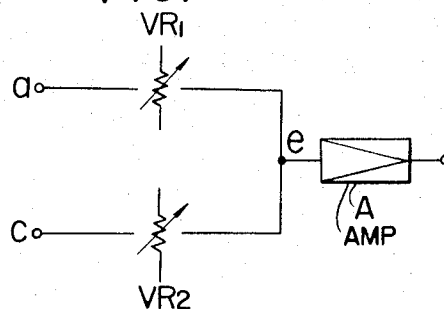


FIG. 9

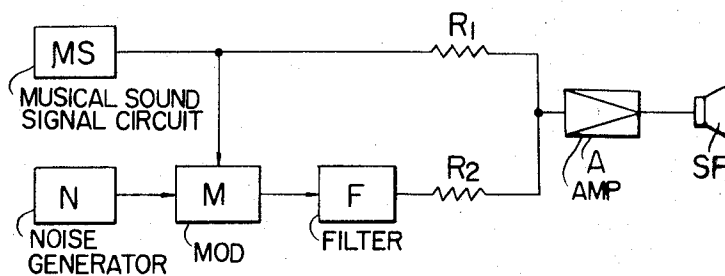


FIG. 10

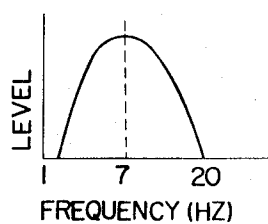


FIG. 7

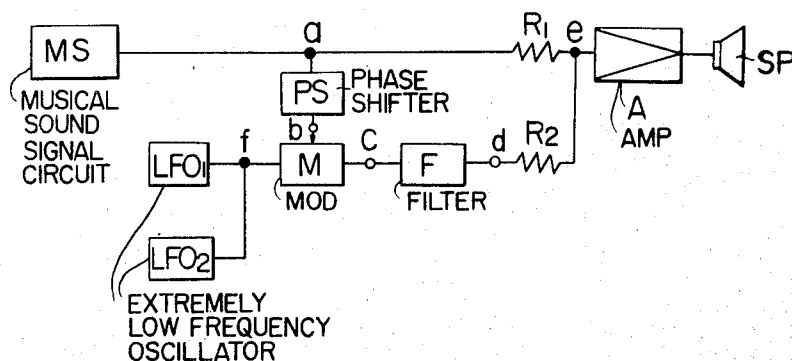


FIG. 8(a)



FIG. 8(b)



FIG. 8(a₁)



FIG. 8(b₁)



FIG. 8(a₂)



FIG. 8(b₂)



FIG. 8(a₃)



FIG. 8(b₃)



TREMOLO EFFECT PRODUCING DEVICE

BACKGROUND OF THE INVENTION

This invention relates generally to a tremolo effect (inclusive of chorus effect) producing device, and more particularly to a type of device for creating tremolo effect sounds in a purely electrical manner.

Heretofore, tremolo or chorus effect producing devices wherein an electrical musical sound signal (as a carrier wave) is amplitude-modulated with a signal (as a modulating wave) having a desired frequency and waveform, or the electrical signal is converted into a sound signal through a loudspeaker rotating at a desired speed, have been proposed. (Hereinafter, as far as an electronic musical instrument is concerned, a tremolo effect represents a modulation by a frequency ranging from 5 to 10 Hz., while a chorus effect represents a modulation by a frequency ranging from 0.5 to 2 Hz. However, in the first-mentioned system, since only the amplitude modulation is employed, a frequency of the musical sound remains unchanged, and therefore the resultant sound is rather monotonous and the sound effect is very poor. On the other hand, in the second system, the Doppler effect is produced in the musical sound signal by the rotation of the loudspeaker, and as a result, the frequency, phase, and directivity are varied in addition to the signal level variation (amplitude modulation) whereby a widespread sensation can be obtained. Therefore, the second method is very effective. However, the rotary system and the driving system of the loudspeaker are excessively complicated, and the production cost thereof is very expensive. Further, there are much possibilities for introducing various undesirable noises such as windbreaking noise, and other mechanical noises at the time of rotation of the loudspeaker.

SUMMARY OF THE INVENTION

It is accordingly a primary object of the present invention to provide a novel organization of a tremolo or chorus effect producing device wherein all of the above-described drawbacks of the conventional devices can be eliminated.

Another object of the present invention is to provide a tremolo effect producing device wherein a tremolo effect which is very effective and rich in natural sound can be produced in a purely electronic manner.

A further object of the present invention is to provide a tremolo effect producing device, wherein a tremolo effect sound which is very rich like that in an instrument having several ranks of tone generators, can be produced by using one extremely low-frequency distorted waveform oscillator.

A still further object of the present invention is to provide a tremolo effect producing device, wherein a tremolo or chorus effect sound same as obtained by a rotatable loudspeaker, can be produced.

A particular object of the present invention is to provide a tremolo effect producing device which is simple in organization, and therefore can be mounted on any desired portion of an electronic musical instrument.

Another and more object of the present invention is to provide a tremolo effect producing device, wherein frequency (phase) variation is accompanied with amplitude variation, and these variations produce tremolo effect sounds which vary irregularly.

A more specific object of the present invention is to provide a novel tremolo or chorus effect producing device which can operate in a purely electronic manner and is simple in organization and economical in production.

The nature, utility and the principle of the present invention will be more clearly understood from the following detailed description with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

In the accompanying drawings:

FIG. 1 is a block diagram showing an example of the tremolo effect producing device according to the present invention;

FIG. 2 is a waveform diagram illustrating the function of the tremolo effect producing device shown in FIG. 1;

FIG. 3 shows the frequency spectra obtained at a point (e) of FIG. 1;

FIGS. 4, 5 and 6 are circuit diagrams showing various modification examples of the mixing circuit of FIG. 1;

FIG. 7 is a block diagram illustrating another example of the tremolo effect producing device according to the present invention;

FIG. 8 illustrates various signal waveforms utilized to explain the function of the device shown in FIG. 7;

FIG. 9 is a block diagram illustrating a still further example of the tremolo effect producing device according to the present invention; and

FIG. 10 shows a frequency spectrum of a carrier wave from a noise generator of FIG. 9.

DETAILED DESCRIPTION OF THE INVENTION

With reference now to FIG. 1, an example of the tremolo effect producing device according to the present invention is shown by a block diagram which comprises a musical sound signal circuit MS of an electronic musical instrument, a phase shifter PS adapted to shift a musical sound signal produced by the musical sound signal circuit as much as a desired phase, amount, an extremely low-frequency oscillator LFO adapted to generate signals having a subaudible frequency (for instance 0.5–10 Hz.) which is much lower than that of the musical sound signal, an amplitude modulator M adapted to amplitude-modulate this extremely low-frequency signal (as a carrier wave) with the musical sound signal (as a modulating wave), a high-pass filter F adapted to eliminate the oscillation frequency component of the extremely low-frequency oscillator LFO, resistors R_1 and R_2 for mixing the output from the filter and that from the musical sound signal circuit, an amplifier A, and a loudspeaker SP. Since the phase-shifting quantity of the phase-shifter increases, for instance as the frequency of the musical sound signal becomes high, the phase difference between the musical sound signal (modulating wave) and the extremely low-frequency signal (carrier wave to be modulated) varies according to frequency. Therefore, there will be obtained at some frequency an amplitude modulation, at some a frequency modulation and at some both modulations, thereby to attain a more complicated effect.

When the extremely low-frequency oscillator LFO generates an extremely low-frequency sine wave signal (approximately 0.5–10 Hz. as shown in FIG. 2(a)) which in turn is amplitude-modulated with the musical sound signal produced from the musical sound circuit, and the thus amplitude-modulated signal is subjected to go through the high-pass filter to cutoff an extremely low-frequency signal component, only the upper sideband signal component and lower sideband signal component as shown in FIG. 2(b₁) can be obtained.

This will be expressed in mathematical formulas as follows:

Assumed that the signal at the terminal (a) is $A \cos \omega t$ ($\omega = 2\pi f$) and the signal at the terminal (d) is $B \cos \Delta\omega t$ ($\omega = 2\pi \Delta f$), the output of the modulator M will be:

$$M \text{ output} = B \cos \Delta\omega t (1 + m \cos \omega t)$$

$$= B \cos \Delta\omega t + mB/2 \cos (\omega + \Delta\omega)t + mB/2 \cos (\omega - \Delta\omega)t,$$

where, $m = KA$ indicates the amplitude modulation factor, and

K is the modulation sensitivity.

The output which is obtained by passing the M output through the filter F to eliminate the extremely low-frequency component will be as follows:

$$mB/2 \cos (\omega + \Delta\omega)t + mB/2 \cos (\omega - \Delta\omega)t.$$

FIG. 2(b₁) shows a waveform diagram in case of the 100 percent modulation where $m=1$. When this output and the original musical sound signal are mixed at a point (e) through the resistors R_1 and R_2 , obtained is a signal of $A_1 \cos (\omega t + \theta) + A_2 \cos (\omega + \Delta\omega)t + \cos (\omega - \Delta\omega)t$

where A_1 and A_2 are amplitudes and θ is a phase difference angle between signals at points (a) and (e). This signal is a signal which is obtained by combining the amplitude modula-

tion by a frequency Δf and the phase variation with the same frequency as that of the amplitude modulation. This signal is amplified by the amplifier A, and then converted into a sound through the loudspeaker SP thereby to obtain a tremolo effect sound which periodically varies in amplitude and in phase.

And, if the oscillation output signal of the extremely low-frequency oscillator LFO is of a pure sine waveform as described above, the amplitude, frequency and phase of the musical sound signal merely repeat with a certain frequency. Therefore, the obtained tremolo effect sound has lack of natural feeling and depth of sound.

In order to overcome such disadvantages; in the present invention, the extremely low-frequency oscillator LFO is so constructed as to give out a distorted waveform signal as shown in FIG. 2(a₂) or FIG. 2(a₃) containing harmonics. The waveform shown in FIG. 2(a₂) is a distorted waveform which contains a great amount of second harmonic component $2\Delta f$, while the waveform shown in FIG. 2(a₃) is a distorted waveform which contains a great amount of third harmonic component $3\Delta f$. The modulated waveforms are as shown in FIG. 2(b₂) and FIG. 2(b₃) respectively, and further, the frequency spectra of tremolo effect sounds obtained by mixing them with the original musical sound signal f are as shown in FIGS. 3(a) and 3(b) respectively. As a result, various higher harmonic components are interfered with one another, and therefore the tremolo effect sound produced through the loudspeaker becomes complicated and loses a simple periodicity in the variation of amplitude, phase and frequency thereof thereby to obtain tremolo effect sounds rich in natural feeling. Further, the tremolo effect sound can be regarded as the sound from the multirank sound source which has a plurality ranks of individual or frequency dividing tone generators the number of which is same as that of the higher harmonic components, and therefore becomes rich.

In addition, in the mixing circuit comprising resistors R_1 and R_2 , the output signal level from the filter F may be varied by providing the variable resistor VR in the circuit of the resistor R_2 as shown in FIG. 4, or the musical sound signal only and the effect sound signal may be selectively switched by providing a switch SW in series to the circuit of the resistor R_2 as shown in FIG. 5, or each of the output levels may be individually adjusted by providing the variable resistors VR₁ and VR₂ in place of the resistors R_1 and R_2 as shown in FIG. 6, thereby properly combining these output levels.

FIG. 7 shows a modified embodiment to achieve almost the same object as that of the example of FIG. 1.

Shown in FIG. 7 is a block diagram in which two oscillators LFO₁ and LFO₂ are employed instead of the extremely low frequency signal oscillator LFO of the tremolo effect producing device illustrated in FIG. 1, and any parts other than the extremely low-frequency signal oscillators are completely same as those included in FIG. 1. In this arrangement, it goes without saying that the extremely low-frequency signal oscillators more than two may be employed.

For convenience in explanation, it is assumed that no output is produced from the oscillator LFO₂, only the oscillator LFO₁ produces the output signal, the waveform of this output signal is a sine wave such as shown in FIG. 8(a), and the phase-shift angle of the musical sound signal to be shifted by the phase shifter is 0°. The analysis will be same as about FIG. 2(a₁).

Assumed that a musical sound signal (modulating wave) the musical sound signal circuit MS is a $\cos \omega t$ ($\omega = 2\pi f$, where, f is frequency), and an extremely low-frequency carrier signal from the extremely low-frequency oscillator LFO₁ is $A \cos \Delta \omega t$ ($\Delta \omega = 2\pi \Delta f_1$, where, Δf_1 is frequency), obtained at the output terminal C of the amplitude modulator M is a signal of

$$A \cos \Delta \omega t (1 + m \cos \omega t) = A \cos \Delta \omega t + mA/2 [\cos (\omega + \Delta \omega)t + \cos (\omega - \Delta \omega)t],$$

where, $m = ka$ shows the modulation factor and k is the modulation sensitivity. When the thus modulated signal is passed through the high-pass filter to eliminate the extremely low-frequency component, obtained at the output terminal d of the filter F is a signal expressed by the formula of

$$mA/2 [\cos (\omega + \Delta \omega)t + \cos (\omega - \Delta \omega)t].$$

This signal is, as shown in FIG. 8(b), both a sideband signal consisting of a frequency $f + f_1$ and a frequency $f - f_1$. This signal is mixed at a proper ratio with the original musical sound signal in the mixing circuit composed by the resistors R_1 and R_2 , and the thus mixed signal is amplified in the amplifier A, and then converted into sound through the loudspeaker. The mixed signal is such as shown by the following formula:

$$a_1 \cos (\omega t + \theta) + a_2 \cos (\omega + \Delta \omega)t + \cos (\omega - \Delta \omega)t,$$

where, a_1 and a_2 are the amplitudes, and θ is a phase difference angle between signals at the points (a) and (c).

This signal is a signal which is composed by the amplitude modulation by the extremely low frequency Δf_1 plus the phase variation with the same frequency as that of the extremely low-frequency signal. Therefore, a sound produced through the loudspeaker is accompanied with the variation of amplitude and with the frequency of the musical sound signal is varied with the frequency of Δf_1 ; in other words the tremolo effect sound can be obtained.

As mentioned above, in case that the extremely low-frequency signal is of a sine wave such as shown in FIG. 8(a), the obtained tremolo effect sound feels monotonous and has disadvantageously lack of natural feeling in an actual musical performance.

In order to overcome the above-mentioned disadvantages, the present invention utilizes the extremely low-frequency oscillators more than two, the oscillation signals therefrom are mixed together, and then are amplitude-modulated, whereby the obtained tremolo effect sound is more complicated and richer than the tremolo effect sound obtained by means of the conventional tremolo effect producing means.

In the example illustrated in FIG. 7, assumed that the oscillation frequencies of the extremely low-frequency oscillators LFO₁, LFO₂ are Δf_1 and Δf_2 respectively, and the amount of the signal Δf_1 is greater than that of Δf_2 in the mixing signal voltage level, the waveform of the signal resulted from mixing becomes a distorted waveform which always varies its configuration at a slow speed, as shown in FIGS. 8(a₁), 8(a₂) and 8(a₃) (The waveforms shown in FIGS. 8(a₁) through 8(a₃) are for the case where $\Delta f_1 = 7$ Hz. and $\Delta f_2 = 15$ Hz.). This mixed signal contains the frequency components of Δf , $-\Delta f_1$, Δf_1 , Δf_2 , and $\Delta f_1 + \Delta f_2$. These components are amplitude-modulated in the modulator M, and the thus amplitude-modulated components go through the filter F thereby to eliminate the extremely low-frequency components Δf_1 and Δf_2 . As a result, obtained at the terminal (d) is a signal of

$$B \cos \{\omega + \Delta(\omega_2 - \omega_1)\}t + B \cos \{\omega - \Delta(\omega_2 - \omega_1)\}t \\ + B \cos (\omega + \Delta \omega_1)t + B \cos (\omega - \Delta \omega_1)t + B \cos (\omega + \Delta \omega_2)t \\ + B \cos (\omega - \Delta \omega_2)t + B \cos \{\omega + \Delta(\omega_1 + \omega_2)\}t \\ + B \cos \{\omega - \Delta(\omega_1 + \omega_2)\}t,$$

where B is the amplitude, $\Delta \omega_1 = 2\pi \Delta f_1$ and $\omega_2 = 2\pi \Delta f_2$ the waveform becomes a complicated configuration, the envelope of which always varies at a slow speed, as shown in FIGS. 8(b₁), 8(b₂) and 8(b₃).

By mixing this signal with the original musical sound signal, obtained is a signal of

$$B_1 \cos (\omega t + \theta) + B_2 \cos \{(\omega + \Delta(\omega_2 - \omega_1))t \\ + B_2 \cos \{\omega - \Delta(\omega_2 - \omega_1)\}t + B_2 \cos (\omega + \Delta \omega_1)t \\ + B_2 \cos (\omega - \Delta \omega_1)t + B_2 \cos (\omega + \Delta \omega_2)t \\ + B_2 \cos (\omega - \Delta \omega_2)t + B_2 \cos \{\omega + \Delta(\omega_1 + \omega_2)\}t \\ + B_2 \cos \{\omega - \Delta(\omega_1 + \omega_2)\}t\},$$

where B_1 and B_2 are amplitudes, and θ is the phase difference angle between signals at the points (a) and (e). This signal is a signal carrying an amplitude modulation by a frequencies $\alpha(f_2 - f_1)$, Δf_1 , Δf_2 , and $\Delta(f_1 + f_2)$ and the phase variation with the same frequencies as that of the amplitude modulation. Therefore, when the signal is properly amplified by the amplifier A and then the thus amplified signal is converted into sound through the loudspeaker SP, the sound accompanied with the variations in amplitude and phase, that is, the tremolo effect sound can be obtained. In this case, the modulated signal includes the frequency components of $\Delta(f_2 - f_1)$, Δf_1 , Δf_2 , and $\Delta(f_1 + f_2)$, so that a chorus effect is obtained (if these are properly selected) by the components of approximately 1 Hz., while the tremolo effect sound is obtained by the

components of approximately 7 Hz. Accordingly, if the oscillation frequency of the extremely low-frequency oscillator is set so as to obtain the values as stated above, the chorus effect and the tremolo effect can be obtained respectively, and further distorted waveforms also can be obtained by components other than these described above thereby to attain a multirank sound source effect. Furthermore, these signals always vary their waveforms with the passage of time, so that no simple periodicity is felt and the tremolo or chorus effect sound rich in natural feeling can be obtained.

In the above explanation, the phase shift angle of the phase shifter is assumed 0°. However, if the phase shift angle is changed to 90°, the signal obtained by mixing the output of the filter F with the original musical sound signal in the same manner as found in the Armstrong modulator, becomes such a signal that is obtained by phase-modulating the extremely low-frequency signal. Therefore, when the phase characteristic of the phase shifter PS is so set that the phase shift is varied with frequency, the obtained signal contains both amplitude modulation and phase modulation, as a result of which much richer tremolo effect sound can be obtained.

In addition, all the frequencies of the oscillation signals from a plurality of extremely low-frequency oscillators are preferably not in integral multiple relationship with one another.

Mixing of the output of the filter F and the original musical sound signal may be obtained by connecting the variable resistor VR to the circuit of resistor R_2 as shown in FIG. 4, or by connecting the variable resistor to the circuit of the resistor R_1 as shown in FIG. 5 in addition to the mixing circuit shown in FIG. 1, and further the tremolo effect may be removed by a switch inserted in the mixing circuit as shown in FIG. 6.

In addition, in case where a balanced modulator is employed in place of the modulator M in FIG. 7, the extremely low-frequency component from the extremely low-frequency oscillator is not included in the modulated signal, and therefore it is not necessary to use the filter F.

FIG. 9 shows still another embodiment of this invention

wherein there is employed a noise generator N generating a band noise of a spectrum as shown in FIG. 10. In this case, a carrier wave of the band noise signal is amplitude modulated by the modulating signal of the musical sound signal from the circuit MS. The resultant signal includes rich frequency band components, and as a result, the final output sound becomes very rich in multitone sensation with tremolo or chorus effect.

While a few embodiments of the present invention have been illustrated and described in detail, it is particularly understood that the invention is not limited thereto and thereby.

We claim:

1. A tremolo effect producing device comprising an extremely low-frequency oscillator which generates an extremely low-frequency signal having a distorted waveform and much lower frequency than the frequency of a musical sound signal; a modulator which modulates the extremely low-frequency signal produced from said extremely low-frequency oscillator by said musical sound signal, a filter means to remove extremely low frequencies from the output of said modulator, and a mixer which is adapted to mix at a desired mixing ratio said musical sound signal and the signal left after removing said extremely low-frequency signal component from the output signal of said modulator.

2. A tremolo effect producing device comprising a plurality of extremely low-frequency oscillators which produce extremely low-frequency signals the frequencies of which are sufficiently lower than the frequency of a musical sound signal and are not in integral multiple relationship with one another; a modulator which amplitude-modulates a signal obtained by mixing said extremely low-frequency signals, by said musical sound signal; a filter means to remove extremely low frequencies from the output of said modulator, and a mixing circuit which is adapted to mix a signal left by removing only the extremely low-frequency signal component from the modulation output signal of said modulator.

3. A tremolo effect producing device according to claim 1, wherein said extremely low-frequency oscillator is a band noise generator in the region of extremely low frequencies.

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