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[54] **ELECTRONIC MUSICAL INSTRUMENTS WITH TWO MASTER OSCILLATORS**


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[58] **Field of Search** ......... 84/1.01, 1.03, 1.11, 1.19, 84/1.22, 1.23, DIG. 11



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[57] **ABSTRACT**

A tone-generator for electronic musical instruments comprising first and second master oscillators of different oscillation frequencies by a semi-tone and 12 master frequency dividers respectively corresponding to 12 notes in an octave, the output of the first master oscillator being applied to first six of the master frequency dividers respectively having frequency dividing ratios to produce every other note along the chromatic scale in an octave, and the output of the second master oscillator being applied to second six of the master frequency dividers respectively having frequency dividing ratios to produce remainder of the notes in the octave.


**3 Claims, 21 Drawing Figures**

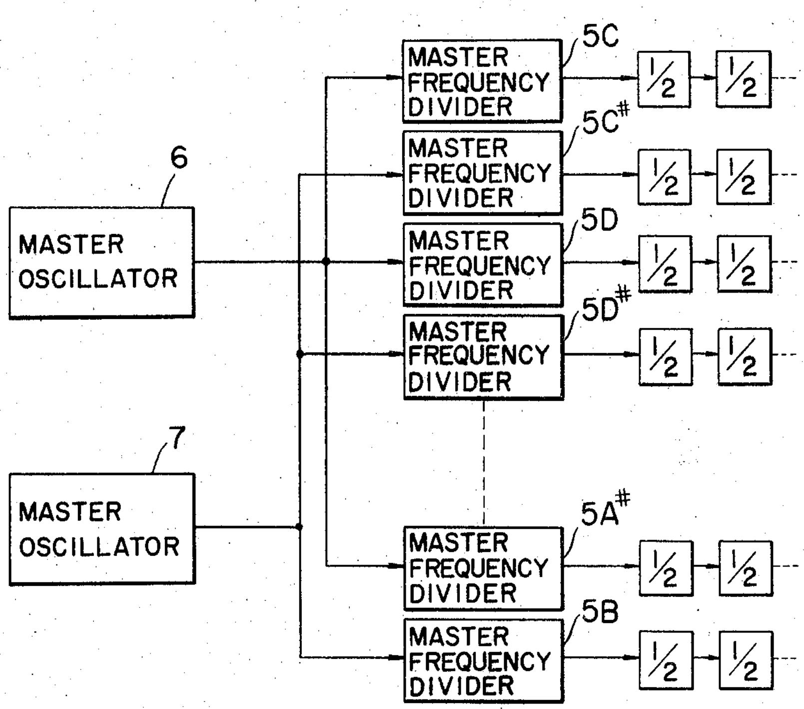


FIG. 1
PRIOR ART

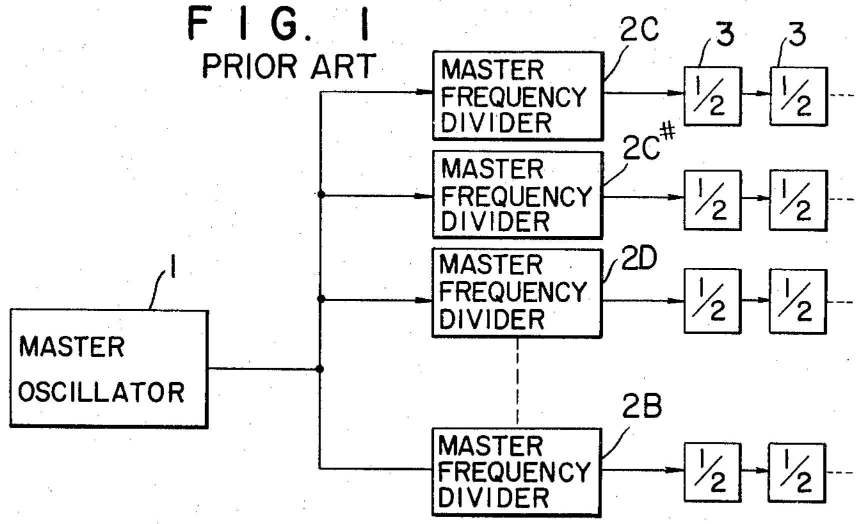
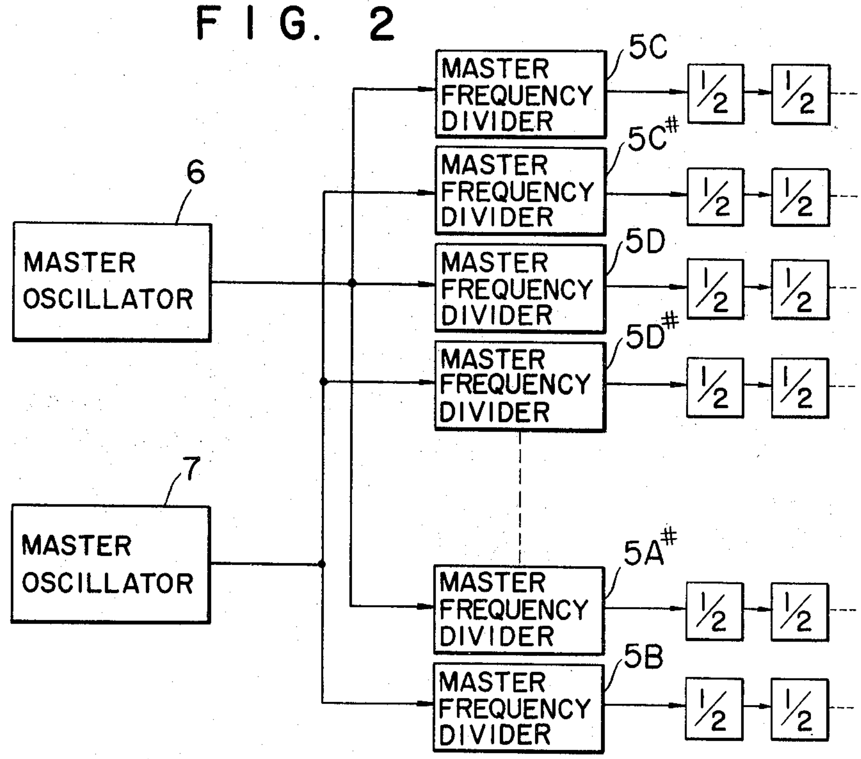



FIG. 2



# ELECTRONIC MUSICAL INSTRUMENTS WITH TWO MASTER OSCILLATORS

## BACKGROUND OF THE INVENTION

This invention generally relates to a tone generator to be used in electronic musical instruments, and more particularly to a type thereof wherein required tones are obtained by frequency dividing procedure.

A typical example of the tone generator heretofore proposed by the inventor has been organized in such a manner that it comprises a master oscillator, 12 master frequency dividers which divide the frequency of the master oscillator and produce 12 tones corresponding to C, C # , D, D # , E, F, F # , G, G # , A, A # , and B in the highest octave in the musical instrument, and a number of ½ frequency dividers each dividing a frequency of one of the 12 tones in a preceding octave into a corresponding tone of the subsequent octave.

However, because of the fact that the frequency-dividing factors (ratios) of the master frequency dividers should be integers, errors to some extent have always accompanied the resultant tones thus obtained, although the frequency of the oscillation in the master oscillator is selected to be a value considerably higher than the tone frequencies. Whenever it is desired that the frequency errors be reduced substantially, the frequency of the master oscillator and accordingly the frequency dividing factors of the master frequency dividers must be selected to be of considerably greater numbers. Such an organization of the tone generator would be exessively complicated.

## SUMMARY OF THE INVENTION

Therefore, a primary object of the present invention is to provide a novel tone generator suitable for use in an electronic musical instrument, wherein the above described drawbacks of the heretofore proposed tone generator can be substantially eliminated.

Another object of the invention is to provide a novel tone generator wherein the frequency errors in the resultant tones can be substantially reduced.

Still another object of the invention is to provide a novel tone generator suitable for use in an electronic musical instrument wherein the required circuit components are decreased in spite of such a reduction in the frequency errors.

These and other objects of the present invention can be achieved by a novel type of tone generator which comprises first and second master oscillators each oscillating at a frequency different from that of the other, and a plurality of master frequency dividers corresponding respectively to required notes in an octave, whereby the output frequency of the first oscillator is imparted to a first plurality of the master frequency dividers corresponding respectively to every other note along the chromatic scale in an octave, and the output frequency of the second oscillator is imparted to a second plurality of the master frequency dividers corresponding respectively to the remainder of the notes in the octave.



The nature, principle, and the utility of the present invention will be more clearly understood from the following detailed description of the invention when read in conjunction with the accompanied drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a block diagram showing a heretofore proposed tone generator used in an electronic musical instrument; and

FIG. 2 is a block diagram showing a tone generator according to the present invention employed in an electronic musical instrument.

## DETAILED DESCRIPTION OF THE INVENTION

As conducive to a full understanding of the present invention, a typical example of the heretofore proposed tone generator will be first described in more detail with reference to FIG. 1. As described before, when the oscillation frequency of a master oscillator **1** is applied to 12 master frequency dividers **2C**, **2C #** , **2D**, **2D #** , **2E**, **2F**, **2F #** , **2G**, **2G #** , **2A**, **2A #** , and **2B**, 12 tones are obtained from the output terminals of the 12 frequency dividers, and these tones correspond to the 12 notes in the highest octave in the musical instrument. The frequencies of the 12 tones are further divided into halves by means of ½ frequency dividers **3**, whereby octaves subsequent to the highest octave can be obtained.

Then, if it is desired to obtain the tones of the twelve notes in the highest octave having frequencies as shown in Table 1, and if the frequency of the master oscillator is selected at 1.9445 MHz, 12 tones having frequencies as shown in Table 2 will be obtained.

TABLE 1

| Notes | C | C# | D | D# | E | F | F# | G | G# | A | A# | B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Frequency (Hz.) | 4186.0 | 4435.0 | 4698.5. | 4978.0 | 5274.0 | 5587.7 | 5919.9 | 6271.9 | 6644.9 | 7040.0 | 7458.6 | 7902.1 |

TABLE 2

| Note | C | C# | D | D# | E | F | F# | G | G# | A | A# | B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dividing factor | 464 | 438 | 414 | 391 | 369 | 348 | 328 | 310 | 293 | 276 | 261 | 246 |
| Frequency (Hz.) | 4190.7 | 4439.4 | 4696.8 | 4973.1 | 5269.6 | 5587.6 | 5928.3 | 6272.5 | 6636.4 | 7045.2 | 6450.1 | 7094.4 |
| Error (cents) | +1.88 | +1.71 | −0.65 | −1.67 | −1.42 | −0.02 | +2.37 | +0.15 | −2.13 | +1.24 | −1.92 | +0.48 |

It will be apparent from these tables that when the frequency of the master oscillator is selected at 1.9445 MHz, and the dividing factors of the frequencies are selected to be integers as shown, the frequency errors in this case fall within a range of from −2.13 to +2.37 cents. This means that the total width of the error range is 4.50 cents.

Generally speaking, frequency errors of more than 3 cents can be heard by ear, and hence it is desirable that these errors be further reduced to less than 3 cents. But, if it is desired that the frequency errors be reduced substantially, the frequency of the master oscillator and accordingly the frequency dividing factors of the master frequency dividers must be selected to be of considerably greater numbers. Such an organization of the tone generator would be exessively complicated.

Referring now to FIG. 2, there is indicated an example of a tone generator according to the present invention. In this example, two master oscillators **6** and **7** are provided for the twelve master frequency-dividers **5**C, **5**C #, **5**D, **5**D #, **5**E, **5**F, **5**F #, **5**G, **5**G #, **5**A, **5**A #, and **5**B, and one of the master oscillators, for instance, **6**, is connected to every other master frequency divider, for example **5**C, **5**D, **5**E, **5**F #, **5**G #, and **5**A #, while the other master oscillator **7** is connected to the remainder of the master frequency dividers **5**C #, **5**D #, **5**F, **5**G, **5**A, and **5**B.

In the case where the 12 notes in the highest octave as shown in Table 1 are to be obtained, if the frequency $fM_1$ of the first master oscillator **6** is selected at 1.8335 MHz, and the frequency $fM_2$ of the second master oscillator **7** is selected at 1.9425 MHz (that is, the ratio of $fM_2/fM_1 = 1.0594$ which corresponds to a semitone), results as shown in the following Table 3 will be obtained.

TABLE 3

| Note | C | C# | D | D# | E | F | F# | G | G# | A | A# | B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dividing factor | 438 | 438 | 391 | 391 | 348 | 348 | 310 | 310 | 276 | 276 | 246 | 246 |
| Frequency (Hz.) | 4186.0 | 4435.0 | 4689.2 | 4968.1 | 5268.6 | 5582.0 | 5914.4 | 6266.2 | 6643.0 | 7038.2 | 7453.1 | 7896.5 |
| Error (cents) | 0 | 0 | −0.91 | −0.91 | −1.73 | −1.73 | −1.50 | −1.50 | −0.47 | −0.47 | −1.20 | −1.20 |

As is apparent from Table 3, the frequency dividing factors for the first group of the master frequency dividers **5**C, **5**D, **5**E, **5**F #, **5**G #, and **5**A # and the frequency dividing factors for the second group of the master frequency dividers **5**C #, **5**D #, **5**F, **5**G, **5**A, and **5**B are selected to be identical, respectively ranging from 438 to 246.

With the above described arrangement, the errors of the individual notes from the desired frequencies shown in Table 1 can be greatly reduced as will be apparent when the values shown in Table 2 is compared with those in Table 3, falling within a range of from 0 to −1.73 cents, whereby the width of the frequency errors as a whole becomes 1.73 cents. Thus, the frequency errors of the individual notes obtained from the tone generator according to this invention which is shown in FIG. 2 are substantially reduced from the values for the same notes obtained from the heretofore proposed tone generator as shown in FIG. 1.

Furthermore, as is apparent from a comparison of Tables **2** and **3**, the frequency dividing factors for obtaining all 12 notes in the case of Table 3 are equal to or less than the frequency dividing factors in the case of Table 2, whereby the required number of circuit components in this invention is much reduced from that required in the heretofore proposed device.



As stated before, the frequency dividing factors of the first group of the master frequency dividers are equal to the frequency dividing factors of the second group of the master frequency dividers, whereby each of the master frequency dividers in the first group can be interchanged with the corresponding one of the second group of the master frequency dividers, and the design and the production of these master frequency dividers can be simplified remarkably.

The specific internal construction of the various frequency dividers form no part of the instant invention which, as aforestated, is directed to the disclosed combination and interconnection of frequency divider units. Any well-known and conventional frequency divider can be used, the dividing ratio of which can be selected at will in conventional fashion. Some of such conventional frequency divider constructions can be found in a publication entitled "Functional Circuits and Oscillators" by Herbert J. Reich, D. Van Nostrand Co., Inc., 1961, page 162, paragraph 37.5.

I claim:

**1.** A tone generator for electronic musical instruments comprising first and second master oscillators of different oscillation frequencies and a plurality of master frequency dividers corresponding respectively to all of the notes in an octave, the output of said first master oscillator being applied to a first plurality of said master frequency dividers corresponding to every other note in said octave, and the output of said second master oscillator being applied to a second plurality of said master frequency dividers corresponding to the remainder of the notes in said octave.

**2.** A tone generator as set forth in claim **1** wherein the number of said plurality of master frequency dividers is 12, corresponding to the 12 notes in said octave, and said first and second pluralities are six in number, respectively.

**3.** A tone generator as set forth in claim **1** wherein said octave is the highest frequency octave in the electronic musical instrument, and subsequent octaves can be obtained by dividing the frequencies of said notes into halves by the use of a plurality of ½-frequency dividers, successively.

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