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Hirano

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[54] **INTEGRATED CIRCUIT FREQUENCY DIVIDERS IN ELECTRONIC MUSICAL INSTRUMENT**

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[52] **U.S. Cl.** **84/1.01,** 84/DIG. 11

[51] **Int. Cl.** **G10h 1/00**

[58] **Field of Search** .....84/1.01, 1.03, 1.11, 84/1.19, 1.24, DIG. 11; 307/279, 303

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[57] **ABSTRACT**

In an electronic musical instrument, the frequency dividers for the tone generators consist of integrated circuit units connected in cascade. Each unit includes a plurality of independent flip-flops in a number representing a divisor (six, four, three or two) of twelve, the corresponding number of input terminals aligned on one side of the unit and the corresponding number of output terminals aligned on the opposite side thereof. The units are connected in cascade one after another with every flip-flop in one unit dealing with different tone name signal in an octave and the corresponding flip-flops in separate units constituting a divider chain for the same-named tones. Inter-unit wirings become very simple.

7 Claims, 9 Drawing Figures

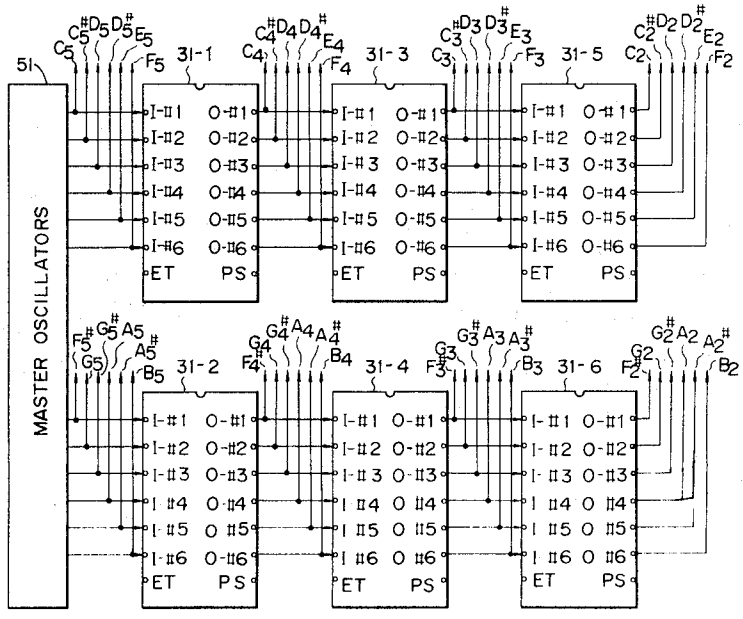


FIG. 1

PRIOR ART

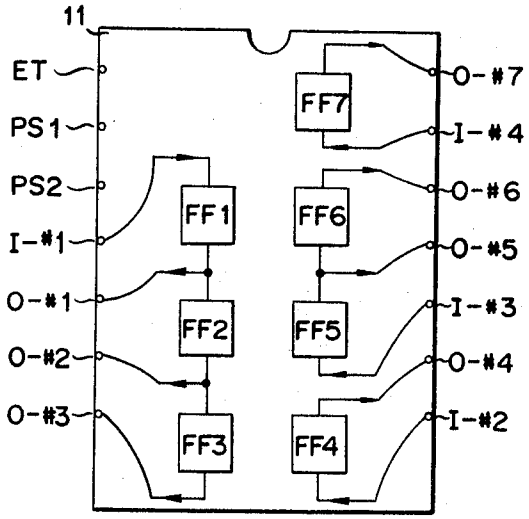


FIG. 2

PRIOR ART

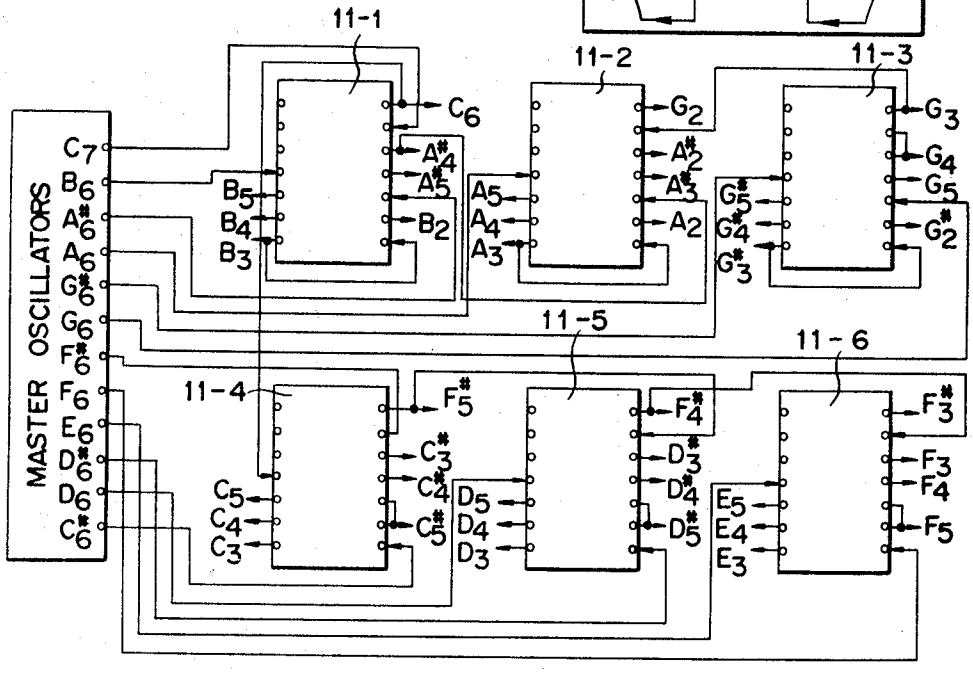
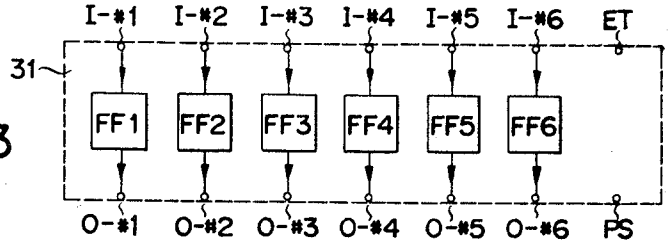


FIG. 3



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FIG. 4

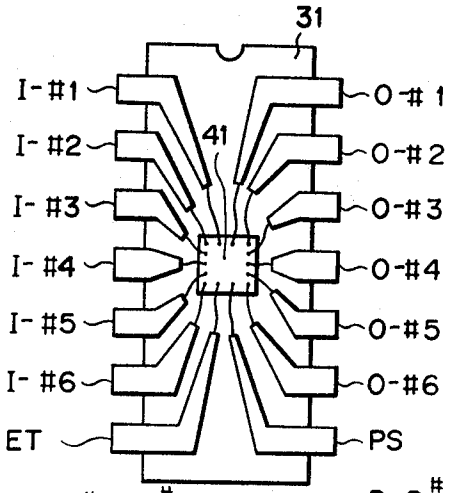
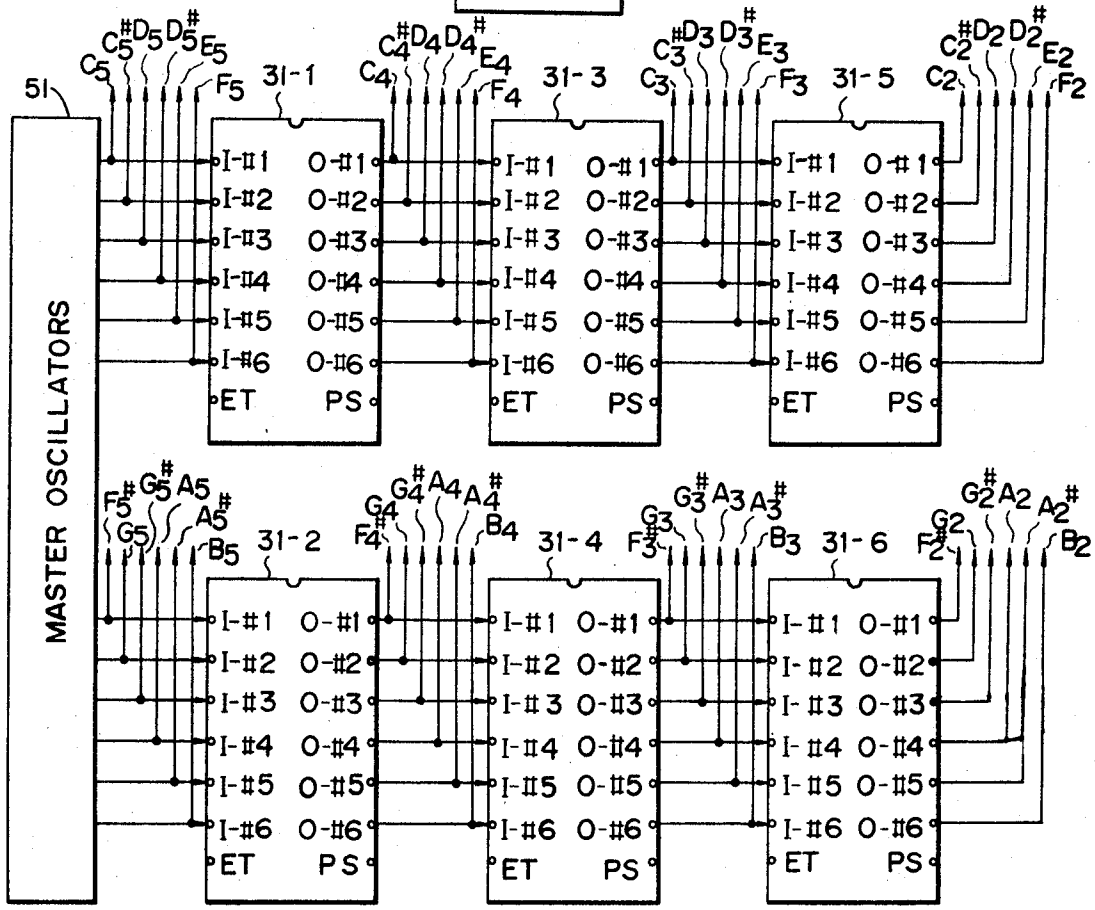


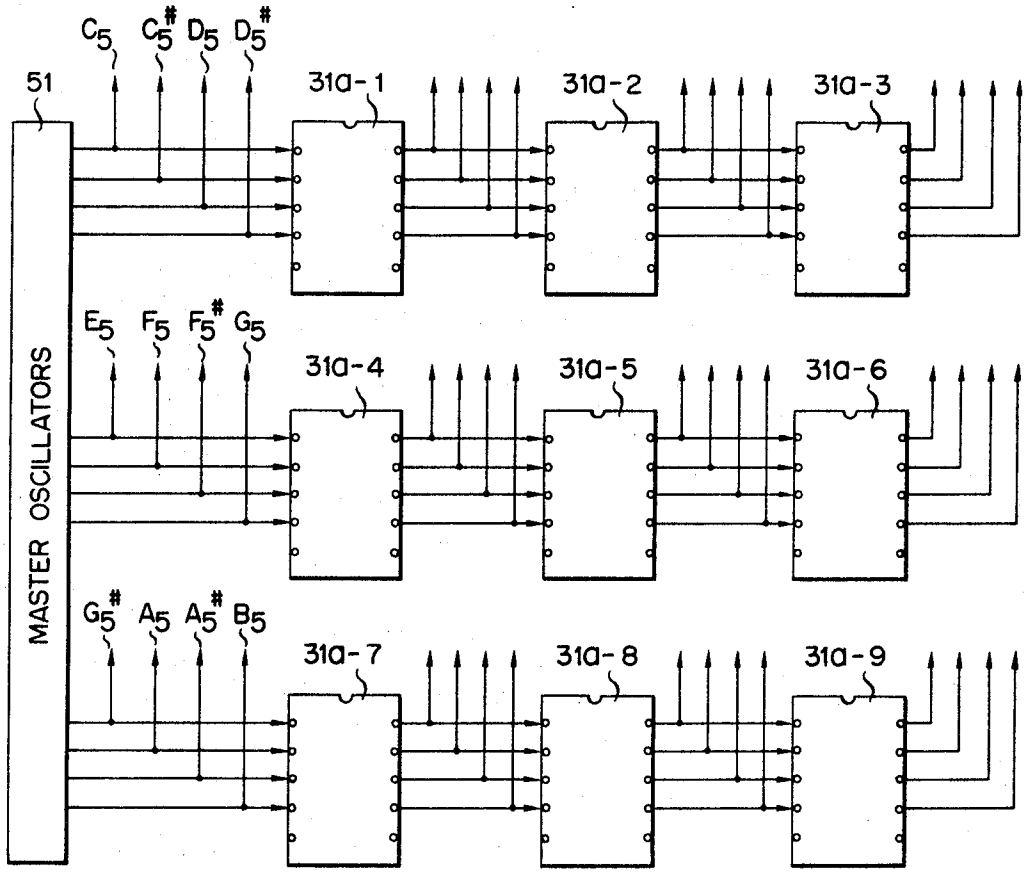
FIG. 5



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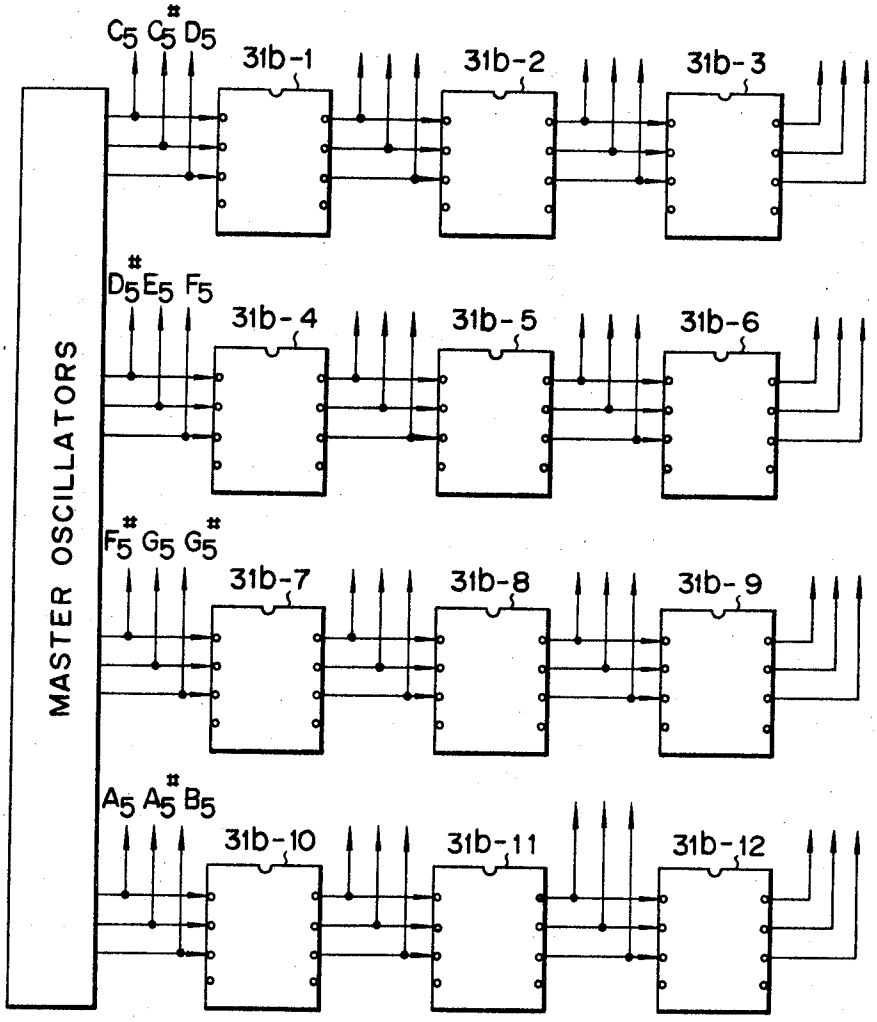
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FIG. 6



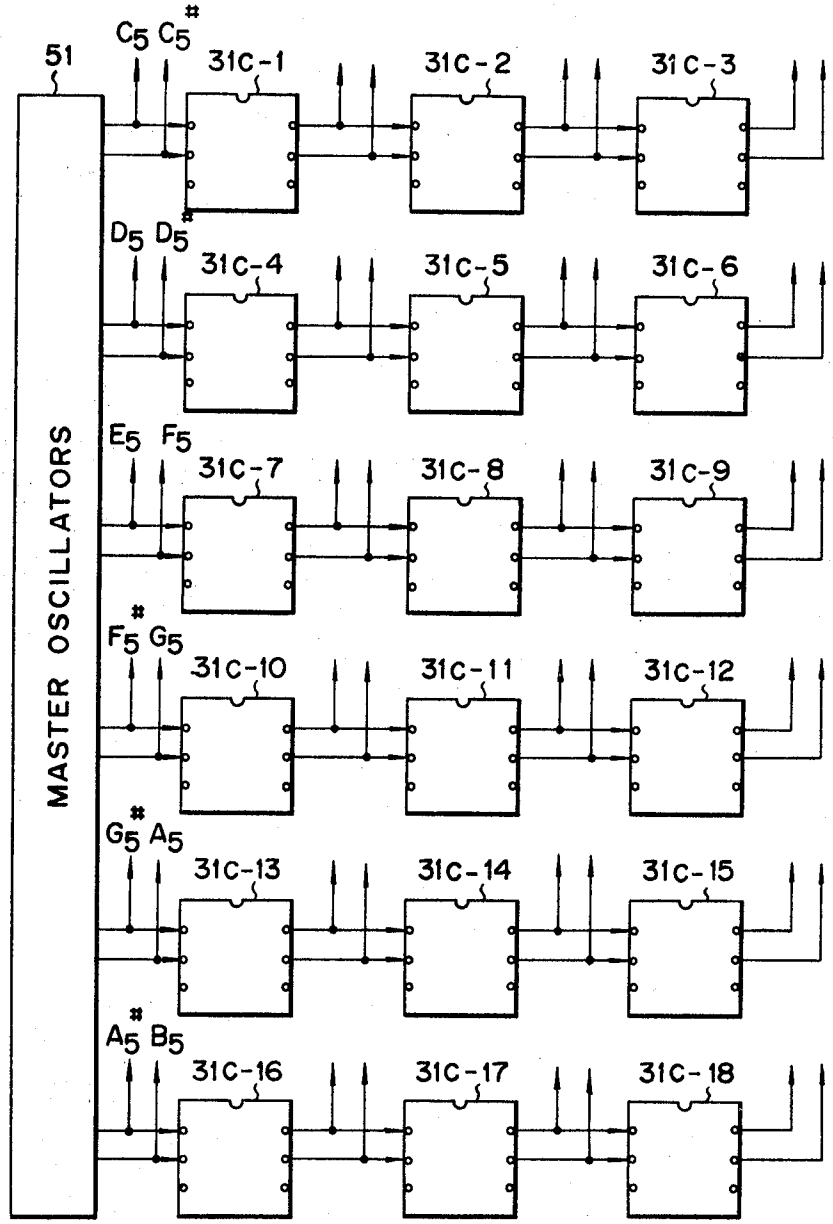
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FIG. 7



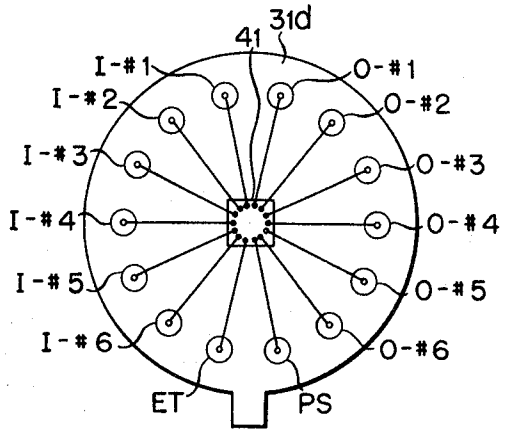
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FIG. 8



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FIG. 9



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INTEGRATED CIRCUIT FREQUENCY DIVIDERS IN ELECTRONIC MUSICAL INSTRUMENT

BACKGROUND OF THE INVENTION

In recent years there has been developed the technique of an integrated circuit (hereinafter referred to as "IC") which offers a great many advantages in design and manufacture such as the reduced volume, the increased reliability and improved mass production of an apparatus using the IC with simplified quality control of required parts. In the field of electric appliances, therefore, there is a prominent tendency to change as many circuits as possible into the IC type. The industry of electronic musical instruments, for example, electronic organs is no exception to this practice. For effective application of the IC technique however, it is important to use as many same common unit circuits as possible. Among the electric circuits used in, for example, an electronic organ adopting the tone generators of frequency divider systems, the frequency dividers and tone keyers are most adapted to application of the IC from the aforementioned point of view.

The present invention relates to an IC version suitable for the former frequency dividers, and more particularly to improvements in that type of frequency divider chain which comprises a plurality of cascade connected flip-flop circuits.

In an electronic musical instrument using such type of frequency divider circuit, tone signals from the master oscillators generating twelve respective tones in the highest octave are generally divided in frequency successively by a plurality of cascade connected frequency dividers to produce tone signals for the musical notes in the musical scale. In this case, there are generally manufactured various types of electronic musical instrument giving forth sufficiently different numbers of tone signals to cover the musical compass in accordance with object and application for which the instruments are intended. It is demanded, therefore, that the same type of frequency dividing unit IC's be made as much available as possible for common use in various electronic musical instruments generating different numbers of tone signals and that the unit IC's be easily connected by a shortest possible electric wiring.

Among the most elemental integrated circuit units of frequency dividers heretofore devised in consideration of the aforementioned requirements is one wherein there were provided seven cascade connected flip-flop circuits in a unit to meet the broadest musical compass or 96 tones of eight octaves. There were used 12 integrated circuit units of such type. The input terminals of the respective units were connected to the output terminals of the respective master oscillators generating 12 tones of the highest octave with high frequency accuracy. Among electronic musical instruments comprising such frequency divider integrated circuit units, the type which was required to generate frequency divided tone signals through the broadest musical compass did not give rise to an unnecessary flip-flop circuit. However, there was the disadvantage that if it was desired to produce a smaller number of frequency divided tone signals, there would result an increasing number of unused flip-flop circuits.

FIG. 1 is a schematic plan view of a typical example of the prior art dual-in-line type frequency divider IC unit devised in consideration of the aforesaid requirement to reduce as much as possible the occurrence of

such unnecessary flip-flop circuits. On one lengthwise half portion of a substantially rectangular unit package **11** are arranged three cascade connected flip-flop circuits **FF1**, **FF2** and **FF3** having one input terminal **I– #1** and three output terminals **0– #1**, **0– #2** and **0– #3**. At the center of the other lengthwise half portion of the unit package **11** are disposed two cascade connected flip-flop circuits **FF5** and **FF6** having one input terminal **I– #3** and two output terminals **0– #5** and **0– #6**. On both vertical sides of the flip-flop circuits **FF5** and **FF6** are set separate flip-flop circuits **FF4** and **FF7**, with **FF4** provided with one input terminal **I– #2** and one output terminal **0– #4**, and **FF7** provided with one input terminal **I– #4** and one output terminal **0– #7**.

The inputs and the outputs of the flip-flops circuits **FF1** through **FF7** are led out, as shown in FIG. **1**, to the nearest terminals on the side edges of the unit package **11** via shortest paths.

A prior art frequency divider IC unit divided into several flip-flop groups such as three flip-flops in cascade connection, two flip-flops similarly in cascade connection and two other separate flip-flops indeed has the advantage of generating with relatively little waste of flip-flop circuits the frequency divided tone signals of all types of electronic musical instrument ranging from the low to the high musical compass by proper combination of such flip-flop groups. But in case such intra-grouped IC units are mounted on a printed circuit board, there arises the drawback that not only connection between said IC units but also the arrangement of the input and output terminals of the unit packages unavoidably become complicated because said terminals are irregularly connected as illustrated in FIG. **1**. With this construction an electronic musical instrument required to generate tone signals of, for example 42 tones G_2 through C_7 is provided, as shown in FIG. **2**, with six frequency divider IC units of FIG. **1**. The master oscillator provides highest pitch tone signals of $C_6^{\#}$ (1,109 Hz) through C_7 (2,093 Hz), and the divider chains consist of three flip-flops for tones C#, D, D#, E, F and F# respectively and four flip-flops for tones G, G#, A, $A^{\#}$, B and C respectively. However, the input and output terminals of tone signals are connected in irregular, complicated arrangement, as seen from FIG. **2**. Further throughout the cascade arranged unit packages, the input terminal **I– #3** of the flip-flop circuit **FF5** is short-circuited with the corresponding output terminal **0– #4** so as to form a three staged divider chain.

If the dual-in-line type frequency divider IC of FIG. **2** is replaced by a flat package type, then the irregular connection of the input and output terminals of the unit package will be, as is well known, appreciably eliminated. In practice, flip-flop circuits are first formed, as described later, on a semiconductor unit chip, which in turn is placed on a unit package. Accordingly, the fitting of the unit chip is not only accompanied with great difficulties, but also results in increased cost.

It is, therefore, the object of the present invention to provide frequency dividers consisting of a plurality of IC units which enable the frequency divided tone signals of all types of electronic musical instruments ranging from the low to the high musical compass to be generated with little waste of flip-flop circuits, not only the arrangement of the input and output terminals of flip-flop circuits within each unit package but also the connection of the terminals throughout a cascade series of said packages to be effected in most regular form, and

the mounting of a unit chip provided with the flip-flop circuits on a unit package to be easily carried out.

SUMMARY OF THE INVENTION

The present invention provides frequency dividers consisting of a sufficient number of IC units cascade-connected to the master oscillators generating 12 tones of the highest pitch to cover the desired musical compass, the improvement wherein the frequency divider IC unit is prepared by independently mounting on a unit package flip-flop circuits in a number constituting a divisor of 12; the input terminals of the flip-flop circuits are provided on the edge of that side of the unit package which faces the master oscillators or the preceding dividers and the output terminals of said circuits are provided on the edge of the opposite side of the unit package; and connection of the respective IC units is effected by connecting the output terminals of the preceding one of adjacent IC units to the input terminals of the succeeding one.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic plan view of a typical example of a prior art frequency divider IC unit in block diagram notation;

FIG. 2 illustrates a concrete arrangement of the prior art frequency divider tone generators for an electronic musical instrument consisting of a plurality of the IC units of FIG. 1;

FIG. 3 is a schematic plan view (in block diagram notation) of a frequency divider IC unit for an electronic musical instrument according to an embodiment of the present invention;

FIG. 4 is a schematic plan view of the IC unit (with a cover taken off) of FIG. 3 prepared by mounting the IC unit on a dual-in-line type unit package;

FIG. 5 shows a concrete arrangement of the frequency divider tone generators comprising a plurality of IC units of FIG. 3;

FIGS. 6 to 8 indicate frequency divider tone generators for an electronic musical instrument according to other embodiments of the invention; and

FIG. 9 is a schematic plan view of such IC unit (with a cover taken off) according to still another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS:

FIG. 3 shows in a block diagram form a construction of a frequency divider IC unit according to an embodiment of the present invention. Lengthwise of, for example, a rectangular dual-in-line type unit package **31** are separately arranged at an equal space flip-flop circuits in a number representing a divisor (for example, 6) of 12, such as **FF1, FF2, FF3, FF4, FF5** and **FF6.**

The input terminals **I– #1, I– #2, I– #3, I– #4, I– #5** and **I– #6** of the flip-flop circuits **FF1** to **FF6** are provided at an equal interval on one lengthwise edge of the unit package **31.** The output terminals **0– #1, 0– #2, 0– #3, 0– #4, 0– #5** and **0– #6** are provided at an equal interval on the opposite lengthwise edge of the unit package **31.**

FIG. 4 is a plan view of a dual-in-line type package (with a cover taken away) in which there are arranged six flip-flop circuits as in FIG. 3 each of said flip-flops having a trigger point and an output point. The six flip-flop circuits **FF1** to **FF6** are first formed on a unit chip **41** consisting of a semiconductor substrate (a plurality of standardized unit chips of the same construction are formed parallel at the same time on a semiconductor substrate and separately cut out therefrom by, for example, a diamond cutter). Thereafter the unit chip **41** is fitted to the unit package **31.**

The flip-flop circuits **FF1** to **FF6** arranged as described above on the unit chip **41** should be substantially free from electric short-circuiting and interference across adjacent terminals. To this end, leads to the input terminals **I– #1** to **I– #6** and output terminals **O– #1** to **O– #6** on the unit package **31** are drawn out radially at a substantially equal peripheral interval from the entire edge of the unit chip **41** so as to shorten said leads as much as possible. (The leads generally consist of aluminum or gold wires set in place by bonding.)

FIG. 5 represents a frequency divider assembly consisting of six unit IC's of FIG. 4 for generating tone signals for the musical notes of four octaves. To the output terminals of a high frequency precision master oscillators **51** generating 12 tone signals of the highest octave are cascade connected the corresponding input terminals **I– #1** to **I– #6** of each of every paired unit packages **31–1** and **31–2** arranged parallel in cascade form with respect to the master oscillators **51.** The output terminals **O– #1** to **O– #6** of each of the preceding paired unit packages **31–1** and **31–2** are connected to the corresponding input terminals of each of the succeeding paired unit packages **31–1** and **31–4** disposed adjacent to the opposite side of the preceding two unit packages **31–1** and **31–2** respectively. This form of connection applies throughout the remaining paired unit packages **31–5** and **31–6** in cascade arrangement.

According to the present invention, the input terminals **I– #1** to **I– #6** of each of the first paired unit packages **31–1** and **31–2** are connected to the corresponding output terminals of the master oscillators **51** adjacent to said first paired unit packages. The mutually facing output and input terminals of adjacent groups of paired unit packages in cascade arrangement can be easily connected by a shortest possible lead. Further, tone signals drawn out from the corresponding output terminals **O– #1** to **O– #6** of each succeeding group of paired unit packages are always displaced by one octave in pitch. Accordingly, the positions of tone signal input and output terminals can be defined quite distinctly throughout an electronic musical instrument as a whole.

As mentioned above, each IC unit has, for example, six separate (independent) flip-flop circuits, a number representing a divisor of 12, thereby substantially eliminating the occurrence of an unnecessary flip-flop circuit, as has heretofore been the case, with respect to an electronic musical instrument generating tones of any kind of musical compass.

FIGS. 6 to 8 represent frequency divider assemblies for an electronic musical instrument according to other embodiments of the present invention. While the embodiment of FIG. 5 has each unit package **31** provided with six separate flip-flop circuits, formation of flip-flop circuits in numbers constituting other divisors of 12, for example, four as in FIG. 6, three as in FIG. 7 and two as in FIG. 8, still permits the same operation with the same result as in FIG. 5.

FIG. 9 shows the arrangement of a unit package **31*d*** according to still another embodiment of the present invention. While there was used a dual-in-line type

package in the embodiments of FIGS. **5** to **8**, the unit package **31***d* will preferably consist of a can-sealed type as seen from FIG. **9**.

Theoretically, the divisors of 12 include 12 and 1 in addition to 6, 4, 3 and 2. With the present day technique, a maximum number of terminals that can be formed on a unit package is about 14. If a unit package is to be provided with 12 separate flip-flop circuits, then the required number of unit package terminals will amount to as many as 24. With the present day technique, it will be difficult to provide such a large number of terminals on a unit package. Further, formation of a single flip-flop circuit on a unit package will be unadvisable, because the IC version will then become meaningless.

Throughout FIGS. **1** to **9**, the reference characters ET and PS respectively denote earth terminals and power supply terminals.

What is claimed is:

1. An assembly of frequency dividers in an electronic musical instrument, comprising a plurality of integrated circuit units connected in cascade, each unit including a plurality of independent flip-flops in a number which is exactly divisiable into twelve, each flip-flop having a trigger point and an output point, the corresponding number of input terminals each connected to each of said trigger points and aligned on one side of the unit, and the corresponding number of output terminals each connected to each of said output points and aligned on the opposite side thereof, said units being connected in cascade one after another with every flip-flop in one unit dealing with a different tone name signal in an octave and the corresponding flip-flops in separate units constituting a divider chain for the same-named tones.

2. The frequency divider assembly according to claim **1** wherein the integrated circuit unit are formed on a dual-in-line type package.

3. The frequency divider assembly according to claim **1** wherein the integrated circuit unit are mounted on a can-sealed type package.

4. The frequency divider assembly according to claim **1** wherein the integrated circuit unit is provided with six flip-flop circuits.

5. The frequency divider assembly according to claim **1** wherein the integrated circuit unit is provided with four flip-flop circuits.

6. The frequency divider assembly according to claim **1** wherein the integrated circuit unit is provided with three flip-flop circuits.

7. The frequency divider assembly according to claim **1** wherein the integrated circuit unit is provided with two flip-flop circuits.

* * * * *