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ELECTRONIC ORGAN SYSTEM UTILIZING BAND ELIMINATION FILTERS FOR MINIMIZING BEAT EFFECTS

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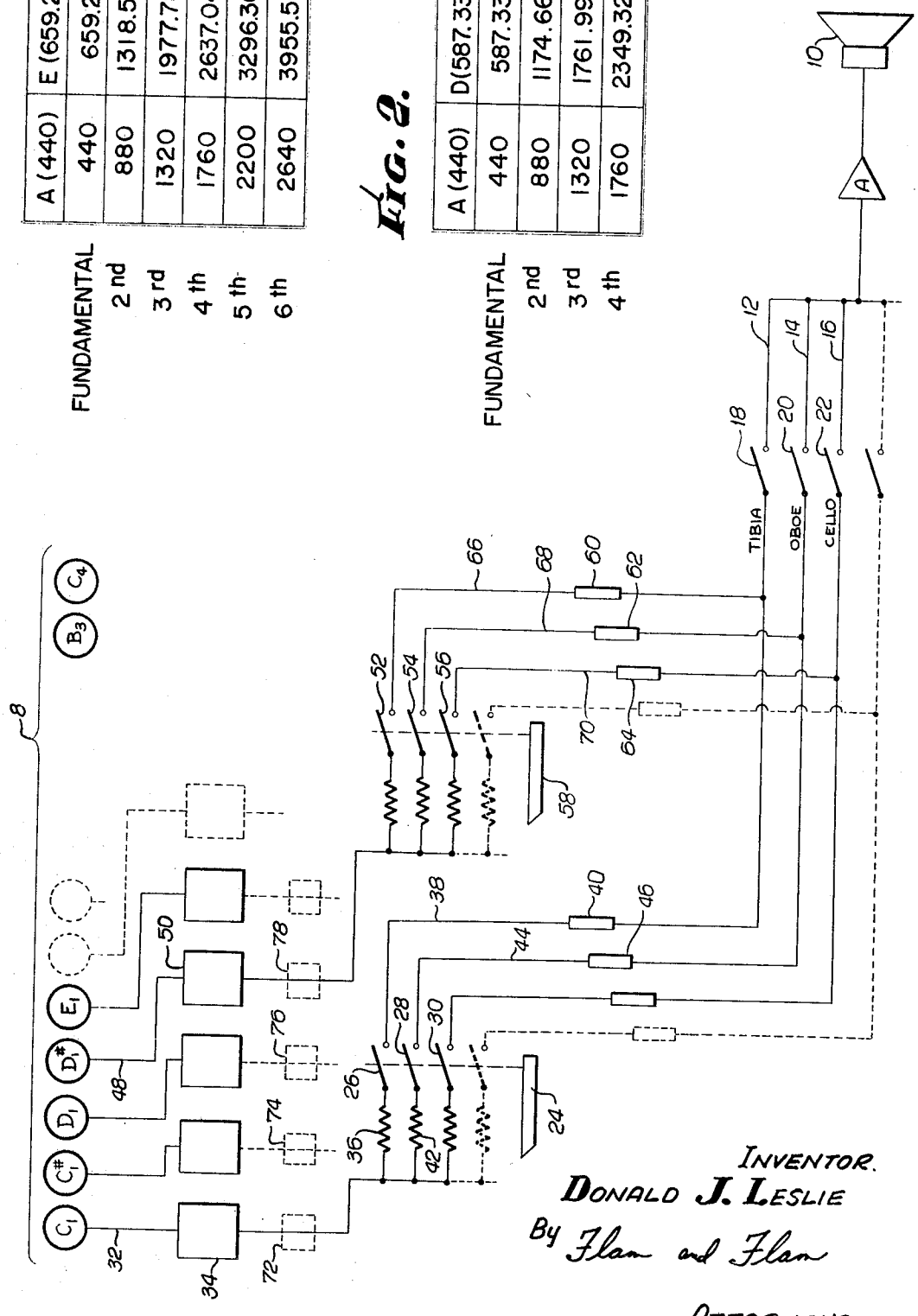
FIG. 1.

	A (440)	E (659.26)
FUNDAMENTAL	440	659.26
2 nd	880	1318.52
3 rd	1320	1977.78
4 th	1760	2637.04
5 th	2200	3296.30
6 th	2640	3955.56

FIG. 2.

	A (440)	D(587.33)
FUNDAMENTAL	440	587.33
2 nd	880	1174.66
3 rd	1320	1761.99
4 th	1760	2349.32

FIG. 3.



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ELECTRONIC ORGAN SYSTEM UTILIZING BAND ELIMINATION FILTERS FOR MINIMIZING BEAT EFFECTS

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ABSTRACT OF THE DISCLOSURE

In order to avoid a major source of beat effects in an electric organ or other musical instrument having complex generators, the third harmonic is suppressed. Accordingly, the third harmonic of any note cannot beat with the second harmonic of the note in fifth musical interval relationship since the third harmonic doesn't exist. Also, the fourth harmonic of any note cannot beat with the third harmonic of a note in fourth musical interval relationship because the third harmonic doesn't exist.

BRIEF SUMMARY OF THE INVENTION

This invention relates to electronic organs or similar musical instruments that generate complex signals corresponding to the fundamental and harmonic components of musical notes.

It has been well established that certain beat effects are present in such musical instruments. Thus, as explained in my prior patent No. 2,596,258, issued May 13, 1952, and entitled Electric Organ Speaker System, whenever two generators corresponding to notes in fourth musical interval relationship with respect to each other are simultaneously operated, the fourth and third harmonics of the respective generators are separated in frequency by only one or two cycles per second; and whenever two generators corresponding to notes in fifth musical interval relationship with respect to each other are simultaneously operated, the third and second harmonics of the respective generators are similarly separated in frequency by only one or two cycles per second. If a single electrical channel combines signals from such generators, then a new frequency component will be heard that goes on and off at the rate of about once every second or two, and an annoying beat effect results. Since fourth and fifth musical interval chords are common, such beat effects often occur. The beat effect is magnified by addition of tremolo and vibrato, such as by rotary apparatus shown and described in my prior patent No. Re. 23,323, issued Jan. 9, 1951, and entitled Rotatable Tremulant Sound Producer.

In certain organ systems, a set of generators spanning several octaves is derived from a set of twelve master oscillators. In such systems, the second, fourth and eighth harmonics of any generator are precisely tuned to the generators for octaves above and below since generators in octave relationship all derive from a common oscillator. However, the sixth harmonic of a generator has a frequency component that may beat with octave harmonics of a generator in fifth musical interval relationship.

In order to avoid such annoying beat effects, I have heretofore proposed various systems. For example, in said Pat. No. 2,596,258, two electrical-acoustic channels are provided for generators in alternate half-tone relationship whereby electrical mixing of signals of generators in fourth or fifth musical interval relationship is precluded. In my prior patents No. 3,041,910, issued July 3, 1962, entitled Electrical Circuit Arrangement for Complex Wave Generators, No. 3,049,040, issued Aug. 14, 1962, entitled Apparatus for Minimizing Beat Effects, and No. 3,080,786, issued Mar. 12, 1963, entitled Speaker System for Adding Tremolo, multichannel systems are illustrated for solving this problem. While these systems are quite satisfactory, the addition of an extra electrical-acoustic output channel is costly. Accordingly, the primary object of this invention is to provide a system for minimizing beat effects that requires but a single electric-acoustic channel.

The third harmonic component appears to be the major source of difficulty since it may beat with the second harmonic of another generator as well as the fourth harmonic of still another generator. Accordingly, if the third harmonics of all generators can be suppressed, the beat problem will be avoided even though the second and fourth harmonics of the generators remain. I have discovered that the third harmonic can be eliminated without significant loss of characteristic voicing of an organ. Thus only clarinet-type tone requires a strong third. Other tones are not seriously affected by the absence of the third harmonic. Accordingly, an excellent compromise is reached simply by suppressing the third harmonic. The sixth harmonic is never dominant in any tone; hence, its suppression goes without significant notice.

Another object of this invention is to provide a set of complex generators each having a harmonic structure characterized by the absence of the third and sixth harmonics.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of several embodiments of the invention. For this purpose, there are shown a few forms in the drawings accompanying and forming part of the present specification. These forms will now be described in detail, illustrating the general principles of the invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a chart illustrating the frequencies of harmonic components of generators for notes in fifth musical interval relationship;

FIG. 2 is a chart illustrating the frequencies of harmonic components of generators for notes in fourth musical interval relationship; and

FIG. 3 is a schematic diagram of an organ system incorporating the present invention.

DETAILED DESCRIPTION

As shown in FIG. 1, the third harmonic of A (440) has a frequency that falls quite close to the frequency of the second harmonic of E (659.26). If generators corresponding to A (440) and E (659.26) are simultaneously operated and mixed in the same electrical-acoustic channel, the listener will perceive a frequency component of about 1320 c.p.s. but which goes on and off or at least increases and decreases in amplitude at the rate of about one and a half cycles per second. Thus the frequency components 1320 c.p.s. and 1318.52 c.p.s. move into and out of reinforcing and bucking relationship at a rate corresponding to the frequency difference.

In FIG. 2, the fourth harmonic of A (440) has a frequency that falls quite close to the third harmonic of D (587.33). Accordingly, when generators for these notes are simultaneously operated and translated in the same electrical-acoustic channel, the listener will perceive a frequency component of about 1760 c.p.s., the amplitude of which increases and decreases at a rate of about two cycles per second, corresponding to the difference in frequency between 1760 c.p.s. and 1761.99 c.p.s.

The charts shown in FIGS. 1 and 2 are typical, and it can similarly be shown that the third harmonic of a generator for any note produces like beat problems with the second and fourth harmonics of other generators. Accordingly, by suppressing the third harmonic for all of the generators, the source of such beat effects will be eliminated.

In FIG. 3, there is illustrated a set of generators **8**. Each generator of this set produces signals rich in all harmonics. A transducer for converting the electrical impulses into another form in the present instance is a speaker system **10**. The speaker system **10** is shown in this instance as driven by several electrical output channels **12**, **14**, **16**, etc. Each of these electrical channels **12**, **14** and **16** is controlled by a stop switch **18**, **20** and **22** labeled, for example, "Tibia," "Oboe," "Cello," etc. The number of electrical output channels is immaterial, but several are shown for illustrative purposes.

An electrical signal having a pitch C_1 and a timbre corresponding to tibia is applied to the Tibia channel **12** by operation of a key **24**. Associated with the key **24** are a series of key switches **26**, **28**, **30**, etc. for the electrical output channels **12**, **14**, **16**, etc. Thus when the key switch **26** is closed, a circuit is established from the generator C_1 as follows: a lead **32**, a band elimination filter **34** of conventional design, an isolation resistor **36**, key switch **26**, a lead **38**, a shaping circuit **40** designed to impart suitable tibia characteristic to the signal, the stop switch **18**, and the electrical output channel **12**.

Similarly, the switch **24**, when closed, transmits to the Oboe channel **14** a signal corresponding to the generator C_1 but shaped to produce a characteristic Oboe tone. Thus a circuit from the generator C_1 may be traced through the lead **32**, the band elimination filter **34**, an isolation resistor **42**, the key switch **28**, a lead **44**, a shaping circuit **46**, and the stop switch **20** to the electrical output channel **14**.

The key switch **30** operates in a similar manner in connection with the Cello output channel **16**. Of course, a single key switch could serve in place of the switches **26**, **28** and **30** which transmit a common pitch. Other switches of the set could be used for coupling purposes.

Similar circuits are provided for the other generators of the set **8**. Thus, associated with the electrical output lead **48** of the generator $D^{\#}_1$ is a band elimination filter **50** that connects to one side of key switches **52**, **54** and **56** operated by a key **58**. Serially associated with the switches **52**, **54** and **56** are Tibia, Oboe and Cello shaping circuits **60**, **62** and **64** that are interposed in leads **66**, **68** and **70** to the electrical output channels **12**, **14** and **16**. In a well-understood manner the keying system for the organ is thus provided, only a few of the connections being shown by way of illustration.

Each generator, however, is provided with a band elimination filter, such as filter **34** or **50**, that substantially attentuates the third harmonic. Thus the band elimination filter **34** for the generator C_1 is tuned to the frequency corresponding to the third harmonic of C_1, and the band elimination filter **50** for the generator $D^{\#}_1$ is tuned to a frequency corresponding to the third harmonic of D_1. The third harmonics of all of the generators accordingly are suppressed, and no beat effects occur due to the interaction of the third harmonics either with the second or fourth harmonics of other notes. Of course, the second and fourth harmonic components of the generators are passed by the band elimination filters, the tuning of the filter being sufficiently sharp for this purpose.

Individual generators of the set **8** together with their filters **34** may as a unit be considered a "generator circuit" that produces complex signals containing the second, fourth and other harmonics of the note, but substantially devoid of the third harmonic.

If desired, the suppression devices **34**, **50**, etc. could be split into components and associated serially with the outputs of the shaping circuits **40**, **46**, etc. Optionally the shaping circuits could be located between the key switches and the generators.

Illustrated in dotted lines in FIG. 3 are band elimination filters **72**, **74**, **76**, **78**, etc., which are designed to suppress the sixth harmonic components. Accordingly, these harmonic components cannot interfere with the other harmonic components of companion generators of the set.

The inventor claims:

1. In an electrical instrument: a set of generators for producing complex signals rich in harmonics corresponding to notes in a musical range; an electrical-acoustic output channel; key switches for operatively connecting the generators to the output channel; and a set of suppression circuits for the generators, each suppression circuit being interposed between the respective generators and the electric-acoustic channel, each of said suppression circuits being individually tuned to suppress the third harmonic of the corresponding generator whereby beat effects with second and fourth harmonics of other generators are minimized; said tuned suppression circuits imposing a characteristic to the instrument that compromises its versatility.

2. The musical instrument as set forth in claim **1** together with a second set of suppression circuits for the generators, each of said suppression circuits of the second set being individually tuned to suppress the sixth harmonic of the corresponding generator whereby beat effects with octave harmonics of other generators are minimized.

3. In an electrical musical instrument: a plurality of selectively operable electrical output channels; common transducer means having an input connected to all of said channels; a set of generators for producing complex signals rich in harmonics corresponding to notes in a musical range; key switch means for each of the generators; a set of circuits for the generators, each circuit being serially associated with the generators and said electrical output channels, and controlled by the respective key switch means, each of said circuits including shaping means for imparting characteristic tonal quality, and each of said circuits also including individually tuned means for suppressing the third harmonic of the corresponding generator; said tuned means imposing a characteristic to the instrument that compromises its versatility.

4. The musical instrument as set fotrh in claim **3** in which a common suppressing means is provided for all of said circuits for each generator.

5. The musical instrument as set forth in claim **3** in which each of said circuits also includes individually tuned means for suppressing the sixth harmonic of the corresponding generator.

6. In a musical instrument: an electric-acoustic output channel; a set of parallel input circuits for said channel, and corresponding to notes in a musical range; generator circuit means applying to said input circuits respectively, complex signals corresponding to the individual notes, and containing the second, fourth and other harmonics of the note, but substantially devoid of the third harmonic; means for individually keying said generator circuit means; and a plurality of selectively operable shaping circuit means separate from said generator circuit means and serially associated therewith for determining characteristic voices of the instrument.

7. In a musical instrument: an electric-acoustic output channel; a set of parallel input circuits for said channel, and corresponding to notes in a musical range; generator circuit means applying to said input circuits respectively complex signals corresponding to the individual notes and containing the second, fourth and other harmonics of the note but substantially devoid of the third and sixth harmonic; means for individually keying said generator circuit means; and a plurality of selectively operable shaping circuit means separate from said generator circuit means and serially associated therewith for determining characteristic voices of the instrument.

8. In an electrical musical instrument: a set of generators for producing complex signals rich in harmonics

corresponding to notes in a musical range; an electrical-acoustic output channel; key switches for operatively connecting the generators to the output channel; and a set of suppression circuits for the generators, each suppression circuit being interposed between the respective generators and the electric-acoustic channel, each of said suppression circuits being individually fixed and narrowly tuned to suppress the third harmonic of the corresponding generator while passing the second, fourth and other harmonics whereby beat effects with second and fourth harmonics of other generators are minimized.

9. The musical instrument as set forth in claim 8 together with a second set of suppression circuits for the generators, each of said suppression circuits of the second set being individually fixed by and narrowly tuned to suppress the sixth harmonic of the corresponding generator while passing the fifth, seventh and other harmonics

whereby beat effects with octave harmonics of other generators are minimized.

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