March 11, 1969 D. J. LESLIE 3,432,608

COMPLEMENTARY HARMONIC SYSTEM FOR FLUTE TYPE ORGANS

Original Filed Dec. 4, 1959 Sheet 1 of 2

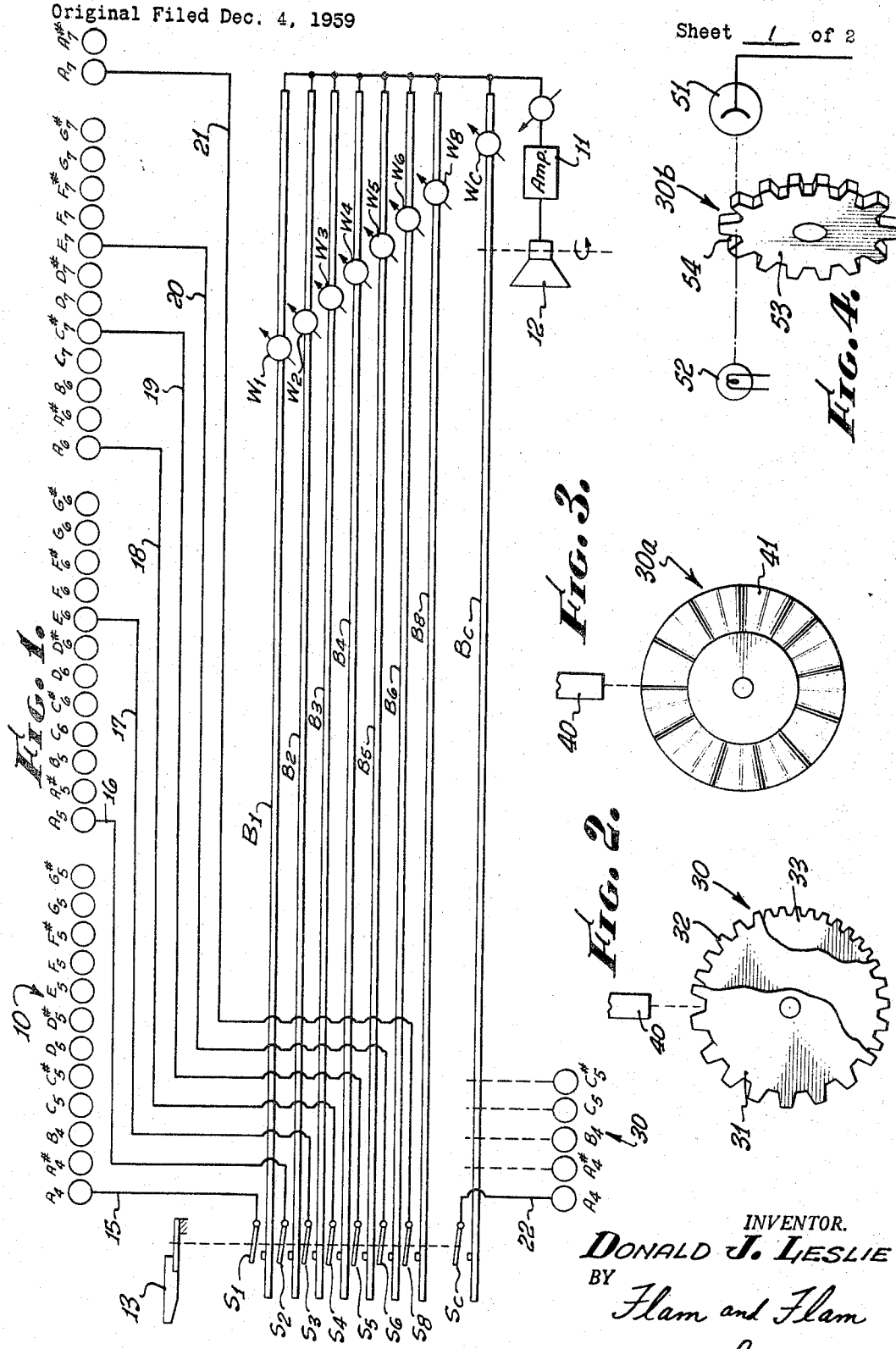

FIG. 1.

FIG. 4.

FIG. 3.

FIG. 2.

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FIG. 5.

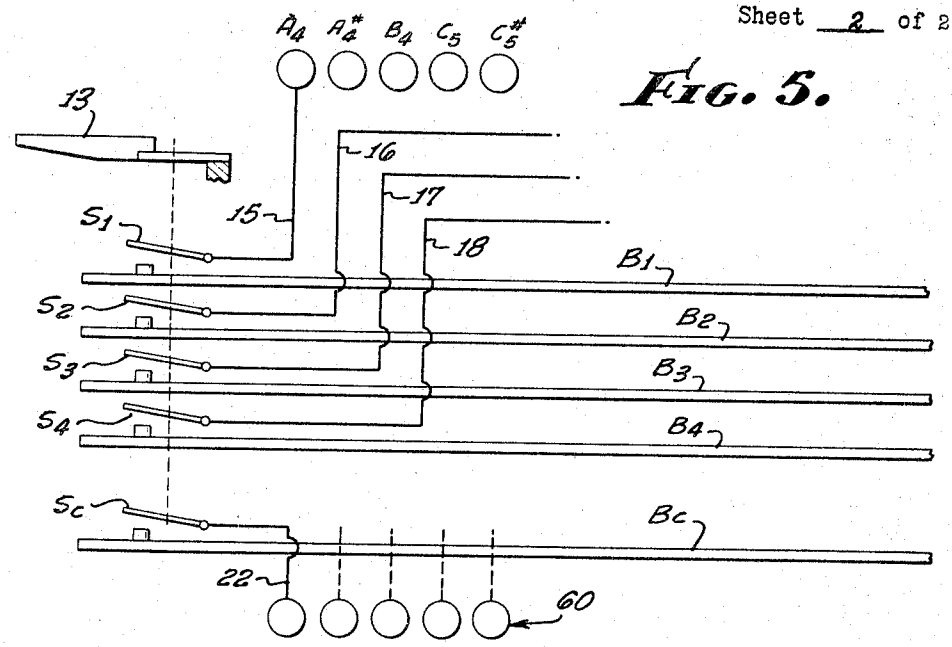
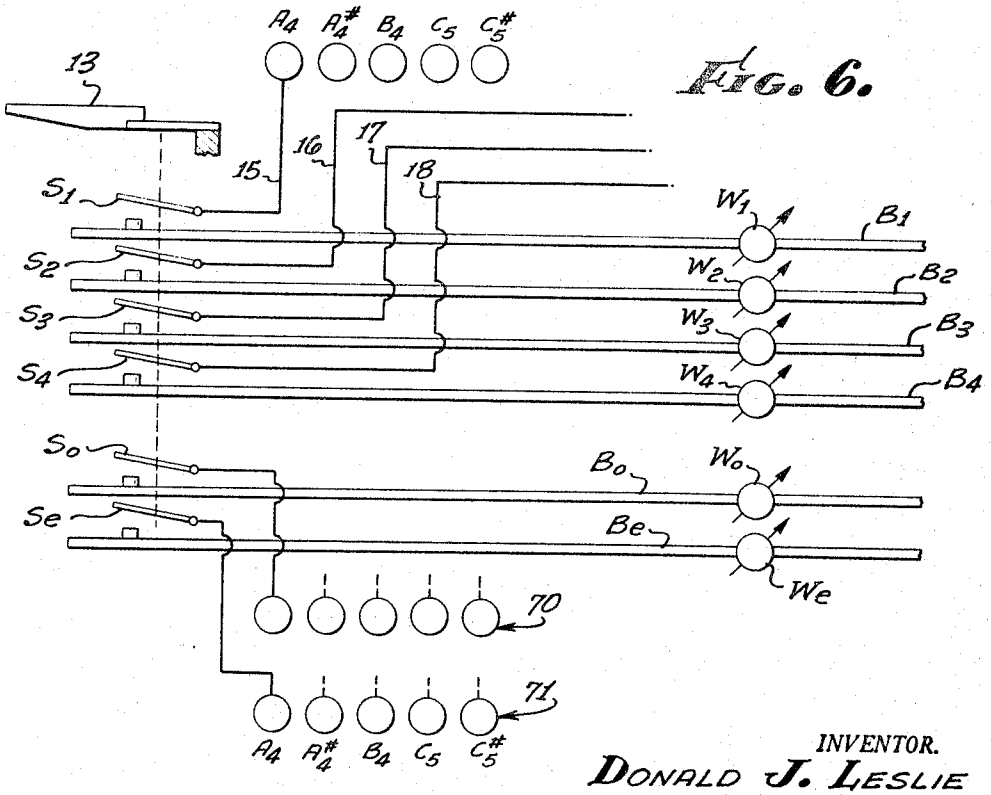


FIG. 6.



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COMPLEMENTARY HARMONIC SYSTEM FOR FLUTE TYPE ORGANS

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Continuation of application Ser. No. 315,425, Oct. 7, 1963, which is a continuation of application Ser. No. 190,199, Apr. 23, 1962, which in turn is a continuation of application Ser. No. 857,371, Dec. 4, 1959. This application May 17, 1965, Ser. No. 461,586
U.S. Cl. 84—1.21 7 Claims
Int. Cl. G10h 3/00

ABSTRACT OF THE DISCLOSURE

In a typical flute organ, the seventh, ninth and higher harmonics are missing. Accordingly, string and reed tones cannot effectively be provided. To remedy this deficiency, I provide a supplemental set of composite generators, one for each note, together with means for variably coupling the signals produced thereby to the electrical output channel.

Brief summary of the invention

This application is a continuation of my prior application Ser. No. 315,425, filed Oct. 7, 1963, now abandoned, which application was a continuation of application Ser. No. 190,199, filed Apr. 23, 1962, now abandoned, which application was a continuation of application Ser. No. 857,371, filed Dec. 4, 1959, now abandoned.

This invention relates to electronic organs and particularly to apparatus for improving the tonal quality.

Certain unmusical sounds may be created by many organs as a result of their very nature. Certain "heat effects" may be created if generators in octave relationship with respect to each other are not accurately tuned. The second harmonic of one generator may have a frequency slightly different from the fundamental frequency of the other. Upon electrical mixture, these wave components move into and out of phase with respect to each other, and at a rate corresponding to the frequency discrepancy or mistuning. The result is an unmusical recurrent "beep."

Beat effects may also result despite perfect tuning due to the very characteristics of the tempered scale. Thus the third harmonic of A_4, for example, has a frequency of 1320 cycles per second, whereas the second harmonic of E_5 has a frequency of 1318.52 cycles per second. Accordingly, a recurrent "beep" at the pitch of 1320 cycles, more or less, will recur cyclically, and at the rate of one and a half cycles per second.

These beat effects, as they are produced from various sources as numerous generators are simultaneously used, may cumulatively produce severe musical annoyances.

Various systems have been devised for eliminating these beat effects. Many of them are, in essence, compromises. Many of them are fairly expensive. One solution (either accidental or intentional) is inherent in a so-called flute organ. In such an organ, the generators are entirely devoid of harmonics; harmonics are built up combining the various flute tones by a borrowing system. If it is desired to add second harmonic, for example, a variable circuit element operated by a draw bar is provided. This draw bar conditions for operation and at a level determined by the position of the draw bar, generators for notes twelve half-tones above the note corresponding to the key. Thus second harmonic is added by cross-wiring or borrowing. Similarly, a third harmonic draw bar conditions for operation by any key, generators for notes nineteen half-tones above the note corresponding to the key, etc. By way of example, the second harmonic and third harmonic draw

bars borrow from the A_5 and E_6 generators, impulses for use with the generator for A_4. Generators are available to provide, approximately or exactly, second, third, fourth, fifth, sixth and eighth harmonics.

In this flute organ, there is no beating problem at all because there is but one source for each required frequency, be it a fundamental or a low harmonic of another note or a high harmonic of still another note. Thus the third harmonic of A_4 cannot beat with the second harmonic of E_5 because the impulses for both purposes are derived from the generator for E_6.

One of the limitations of the flute organ, however, is that the seventh harmonic is missing. The reason is that no note has a fundamental that reasonably corresponds to the seventh harmonic of another note. Furthermore, the ninth and higher harmonics are deleted primarily because of limitations as to the space, but also because borrowing is not always possible, as in connection with the seventh harmonic. Despite the claims of manufacturers to the contrary, string and reed tones cannot be effectively provided because seventh, ninth and higher harmonics are essential components of such tones.

The primary object of this invention is to retain the advantages of a flute organ system particularly with respect to the beating problem, and at the same time provide more versatility in terms of reed and string sounds. For this purpose, there is provided a separate single source of harmonics providing the seventh, ninth, tenth and higher harmonics for each note. By using a single source for seventh, ninth and higher harmonics, reed and string tones can be produced. At the same time, there will be no serious beat effect. The reason for this is that the second, third and fourth harmonics in the tempered scale are the major source of beat effects, and no beat effects in these harmonic ranges are created by the additional complex wave generators because the first operative harmonic is the seventh.

Another object of this invention is to provide an electronic organ in which string and reed tones create no beat effects despite the fact that but a single electrical-acoustic channel is used. Heretofore it has been necessary to use at least two electrical-acoustic channels in order to accomplish this result.

My invention is not limited for use specifically with a flute organ that provides any specific number of harmonics. However, in order to achieve the effects desired, flute generators should be available for producing at least the second and third harmonics and perhaps the fourth harmonics since beat problems arise mostly from interaction of lower harmonic components.

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 a 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 this invention is best defined by the appended claims.

Brief description of the drawings

FIGURE 1 is a diagrammatic view of an organ of the flute type in which harmonics are synthesized by borrowing fundamentals from other notes, connections from only one note being illustrated for purposes of clarity;

FIGS. 2, 3 and 4 show, respectively, three different devices for use as composite generators in the system of FIG. 1;

FIG. 5 is a diagrammatic view of another organ of the flute type and illustrating another embodiment of the present invention; and

FIG. 6 is a diagrammatic view of an organ of the flute type, illustrating still another modified form of the present invention.

Detailed description

In FIG. 1, a series of sinusoidal generators **10** is illustrated having frequencies corresponding to the fundamentals of the notes indicated by the legends adjoining the generators **10**. Also indicated in FIG. 1 are an output power amplifier **11** and a speaker **12**, indicated diagrammatically, in this instance, as a rotary speaker.

In order to obtain a complex wave form at the output **11–12**, a borrowing system is provided. For this purpose, each key **13** has associated therewith a series of switches designated as S_1, S_2, S_3, S_4, S_5, S_6, S_8, and S_c. The key **13** and switches illustrated are for the note A_4, by way of example. The switch S_1, and by the aid of a connection **15**, is adapted to connect the generator **10** for A_4 to a bus bar B_1. This bus bar is connected to the input of the amplifier **11** via an adjustable control W_1, which may be a potentiometer, autotransformer, or any other suitable element. The bus bar B_1 is engaged by all of the switches S_1 for all of the keys typified by the key **13**. Accordingly, if the element W_1 is adjusted for substantial signal transmission, all of the fundamentals for the various notes will be operative.

The adjustable control element W_2 is adapted to determine the extent that second harmonics are present at the output. The second switches S_2 for each switch set cooperate with a single bus bar B_2 for this purpose. Thus the switch S_2 for the note A_4 by the aid of a lead **16**, when the key **13** is depressed, connects the A_5 generator **10** to the bus bar B_2. Similarly, the switch S_2 associated with the key for note G_4 (not shown) will connect with the generator for G_5.

The switches S_3, S_4, S_5, S_6 and S_8 for the A_4 group similarly connect by the aid of leads **17**, **18**, **19**, **20** and **21** to generators for E_6, A_6, $C\sharp_7$, E_7 and A_7. Bus bars B_3, B_4, B_5, B_6 and B_8 are provided and serve as third, fourth, fifth, sixth and eighth harmonic bus bars, cooperable with switches for the other notes. Adjustable circuit elements W_3, W_4, W_5, W_6 and W_8 are likewise provided to control the relative strength of the third, fourth, fifth, sixth and eighth harmonics.

A second set of generators **30** is provided. These generators contain seventh, ninth, tenth and upper harmonics of the successive notes. Thus, for example, the generator **30** for A_4 produces an output containing only the following signal components: 3080.00 cycles per second corresponding to the seventh harmonic; 3960.00 cycles per second corresponding to the ninth harmonic; 4400.00 cycles per second corresponding to the tenth harmonic; 4840.00 cycles per second corresponding to the eleventh harmonic, etc. Similarly, the output from the generators **30** for other notes contain frequencies corresponding to like harmonics of the corresponding note.

By the aid of a supplemental set of generators **30**, reed and string tones can be provided and by the use of a single supplemental switch S_c associated with each group of switches. These switches S_c connected to the generators **30** by the aid of leads **22**, engage a composite or supplemental bus bar B_c when the corresponding key **13** is depressed. An adjustable circuit element W_c controls the energy or signal applied to the amplifier **11**. Accordingly, when string or reed type tones are desired, the adjustable circuit element W_c is adjusted for substantial transmission to the amplifier **11**, and the generators **30** will then be simultaneously operable with the other operative generators for the note in question.

The representation in FIG. 1 will be understood to be diagrammatic. For example, the adjustable circuit elements such as W_6 or W_c may be located in advance of the switches S_6 or S_c. Thus bus bars may be controlled by simple on-off organ stops. The connections such as **15**, **16**, **17**, **18**, **19**, **20**, **21** and **22** may be direct or indirect or even switched. For example, they may connect via alternate networks to the generators by the aid of pre-set switches. Various other modifications are, of course, possible that do not modify the essential operation of the second generator set **30**.

In FIG. 2, there is illustrated a composite generator **30** for use as one of the generators **30** diagrammatically illustrated in FIG. 1. In the present instance, the generator **30** comprises a series of stacked tone wheels **31**, **32**, **33**, etc. Each tone wheel may be of a form designed to produce a sinusoidal output and of a type usable for the generators **10**. The first of the wheels **31** produces a sinusoidal output at the frequency of seven times the fundamental frequency for the note with which the generator **30** is intended to cooperate; the second tone wheel **32** produces a sinusoidal output at the frequency of nine times the fundamental frequency; etc.

Each tone wheel **31**, **32**, **33**, etc. is provided with peripheral teeth that appropriately modify the magnetic field in the vicinity of the common pickup **40** in a well understood manner.

In FIG. 3, a different generator **30*a*** is provided. This generator is in the form of a single tone wheel **41** having on its face an appropriate magnetic structure of varying thickness, carefully formed and fashioned to provide only the seventh, ninth, tenth and upper harmonics.

Still another generator structure **30*b*** is illustrated in FIG. 4. In this instance, a photoelectric cell **51** cooperates with a source of light **52** and a rotary mask **53** having a suitably shaped aperture **54** whereby only the seventh, ninth, tenth and upward harmonics are produced by the aid of a circuit associated with the photoelectric cell **51**.

Various other generators, of course, can be provided, but it is important naturally that the output of any of the generators such as **30**, **30*a*** and **30*b*** be relatively devoid of the lower harmonics which are otherwise produced by the organ.

In FIG. 5, there is illustrated diagrammatically a flute type organ which is adapted, in this instance, to synthesized tones by borrowing only second, third and fourth order harmonics. Thus associated with the key **13**, corresponding to the key of the previous form, are switches S_1, S_2, S_3 and S_4 and leads **15**, **16**, **17** and **18** to generators to A_4, A_5, E_6 and A_6. Generators in this instance provide the remaining harmonics respectively for the notes. Thus the generator **60**, by the aid of a lead **22**, connects to a switch S_c, also operated by the key **13** and engageable with the composite bus bar B_c. Each generator **60** thus provides components corresponding to the fifth, sixth, seventh, eighth, ninth and other harmonics.

In the form illustrated in FIG. 6, two sets of supplemental generators **70** and **71** are provided, there being two generators, one from each set, for each note. Operated by the key **13**, for example, are two switches S_o and S_e that connect the two generators **70** and **71** for the note to bus B_o and B_e. Switches such as S_o and S_e are provided for each key to connect corresponding generators of the sets **70** and **71** to the bus bars B_o and B_e. The signal intensities at the bus bars B_o and B_e are controlled by variable circuit elements W_o and W_e.

In the present instance, the generator **70** provides only odd order harmonics, beginning with the fifth; and the generator **71** provides even order harmonics, beginning with the sixth. By providing such generators, various characteristic tones can be created. For example, the diapason tone can readily be provided since, for each tone, the even order harmonics characteristically have a different relative intensity than the odd order harmonics.

Since the supplemental generators are substantially devoid of lower order harmonics, and since the major source of beat effects is interaction of such lower order harmonics, the supplemental generators do not create any significant beat effect problem. This is true even if the supplemental generators are slightly mistuned or tuned to a tempered scale.

The inventor claims:

1. In an electronic organ having a set of substantially sine wave generators for notes of the organ, an audio output channel, a plurality of bus means connectible with said audio output channel, keys for the notes, a set of key switches for each note and operated by the corresponding keys and cooperable respectively with the bus means, and connection means between the key switches for borrowing signals from generators of said set of sine wave generators whereby at least the second, third and fourth order harmonics are provided, the second, third and fourth hormonics being thereby precisely in tune with the other sine wave generators whereby no beat effects are created in said common audio output channel by virtue of the simultaneous operation of said key switches, the combination therewith of: a second supplemental set of composite generators for the notes, there being a supplemental generator for each note; a supplemental bus means connectible with said audio output channel, and a supplemental switch for each set of key switches for operation simultaneously therewith for connecting the corresponding supplemental generator to the said supplemental bus means on operation of the corresponding key: each supplemental generator producing signal components having frequencies corresponding to a complementary set of upper harmonics for the corresponding notes, the frequencies of said upper harmonics being substantially whole number multiples of the frequency of the corresponding fundamental, said supplemental generators being substantially free of signal components corresponding to the fundamental, second, third and fourth harmonics whereby beat effects are minimized in said common audio output channel upon the simultaneous operation of said supplemental switches with said key switches, at least one of the signal components of each of the supplemental generators having a frequency different from the frequencies of any of the sine wave generators.

2. In an electronic organ having a set of substantially sine wave generators for notes of the organ, an audio output channel, a plurality of bus means connectible with said audio output channel, keys for the notes, a set of key switches for each note and operated by the corresponding keys and cooperable respectively with the bus means, and connection means between the key switches for borrowing signals from generators of said set of sine wave generators whereby a set of lower order harmonics are provided, the lower order harmonics being thereby precisely in tune with the other sine wave generators whereby no beat effects are created in said common audio output channel by virtue of the simultaneous operation of said key switches, the combination therewith of: a second supplemental set of composite generators for the notes, there being a supplemental generator for each note; a supplemental bus means connectible with said audio output channel, and a supplemental switch for each set of key switches for operation simultaneously therewith for connecting the corresponding supplemental generator to the said supplemental bus means on operation of the corresponding key; each supplemental generator producing signal components having frequencies corresponding to a complementary set of upper harmonics for the corresponding notes, the frequencies of said upper harmonics being substantially whole number multiples of the frequency of the corresponding fundamental, said supplemental generators, being substantially free of signal components having lower frequencies whereby beat effects are minimized in said common audio output channel upon the simultaneous operation of said supplemental switches with said key switches, at least one of the signal components of each of the supplemental generators having a frequency different from the frequencies of any of the sine wave generators.

3. In an electronic organ having a set of substantially sine wave generators for notes of the organ, an audio output channel, a plurality of bus means connectible with said audio output channel, keys for the notes, variable circuit elements for controlling the signal at the bus means, a set of key switches for each note and operated by the corresponding keys and cooperable respectively with the bus means, and connection means between the key switches for borrowing signals from generators of said set of sine wave generators whereby second, third, fourth, fifth, sixth and eighth harmonics are provided by operation of the variable circuit elements, the second, third, fourth, fifth, sixth and eighth harmonics being thereby precisely in tune with the other sine wave generators whereby no beat effects are created in said common audio output channel by virtue of the simultaneous operation of said key switches, the combination therewith of: a second supplemental set of composite generators for the notes, there being a supplemental generator for each note; a supplemental bus means connectible with said audio output channel, a variable circuit element for controlling the signal at said supplemental bus means; and a supplemental switch for each set of key switches for operation simultaneously therewith for connecting the corresponding supplemental generator to the said supplemental bus means on operation of the corresponding key; each supplemental generator producing signal components having frequencies corresponding to the seventh, ninth, tenth, eleventh and other higher harmonics of the corresponding note, the frequencies of the said seventh, ninth, tenth, eleventh and other higher harmonics corresponding substantially to whole number multiples of the frequency of the corresponding fundamental, said supplemental generators being substantially free of signal components having lower frequencies whereby beat effects are minimized in said common audio output channel upon the simultaneous operation of said supplemental switches with said key switches, at least one of the signal components of each of the supplemental generators having a frequency different from the frequencies of any of the sine wave generators.

4. In an electronic organ having an audio output channel, a set of substantially sine wave generators for notes of the organ, key means operatively connecting the generators to said output channel, and selectively operable circuit means for borrowing from the sine wave generators, signals corresponding to certain lower order harmonics, and means transmitting said borrowed signals to said output channel upon operation of the corresponding key means whereby the said lower order harmonics are precisely in tune with other sine wave generators to preclude beat effects in said common output channel upon simultaneous operation of a number of said key means, the combination therewith of: a set of composite supplemental generators, one for each of the notes; means operatively associating the supplemental generators individually and respectively with said key means; said supplemental generators each producing signals substantially free of said certain lower order harmonics, but relatively rich in complementary and higher order harmonics whereby beat effects are minimized in said common audio output channel upon simultaneous operation of said supplemental generators with said sine wave generators; said complementary and higher order harmonics having components the frequencies of which correspond substantially to whole number multiples of the frequency of the corresponding fundamental.

5. The combination as set forth in claim 4 in which said lower order harmonics are the first, second, third and fourth.

6. The combination as set forth in claim 4 in which said lower order harmonics are the first, second, third, fourth, fifth, sixth and eighth, and in which said complementary and upper order harmonics include the seventh, ninth, tenth and other higher harmonics.

7. The combination as set forth in claim 4 in which the supplemental generator for each note includes two

companion generator parts, one part providing primarily odd order harmonics and the other part providing primarily even order harmonics, means collectively controlling the effective intensity of the odd order harmonic generator parts, and means collectively controlling the effective intensity of the even order harmonic generator parts.

No references cited.

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