

# United States Patent

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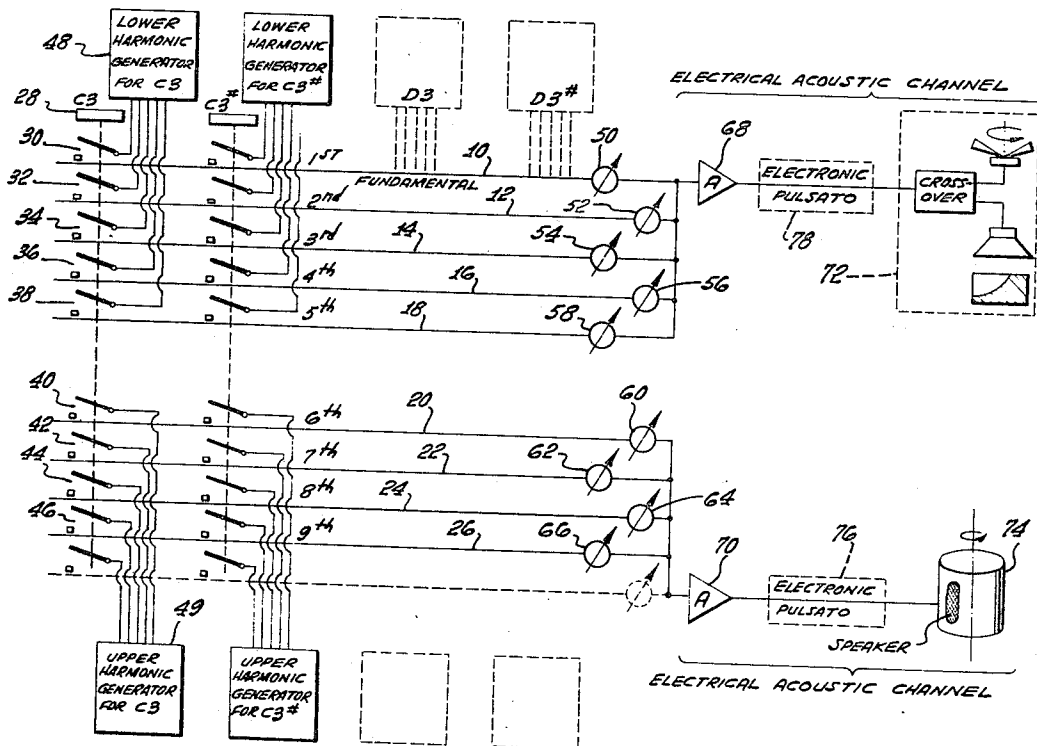
[54] **HARMONICALLY RELATED PULSATO SYSTEM**  
 11 Claims, 3 Drawing Figs.

[52] U.S. Cl. .... 84/1.25  
 [51] Int. Cl. .... G01h 1/04  
 [50] Field of Search ..... 84/1.25,  
 1.24, 1.11, 1.19

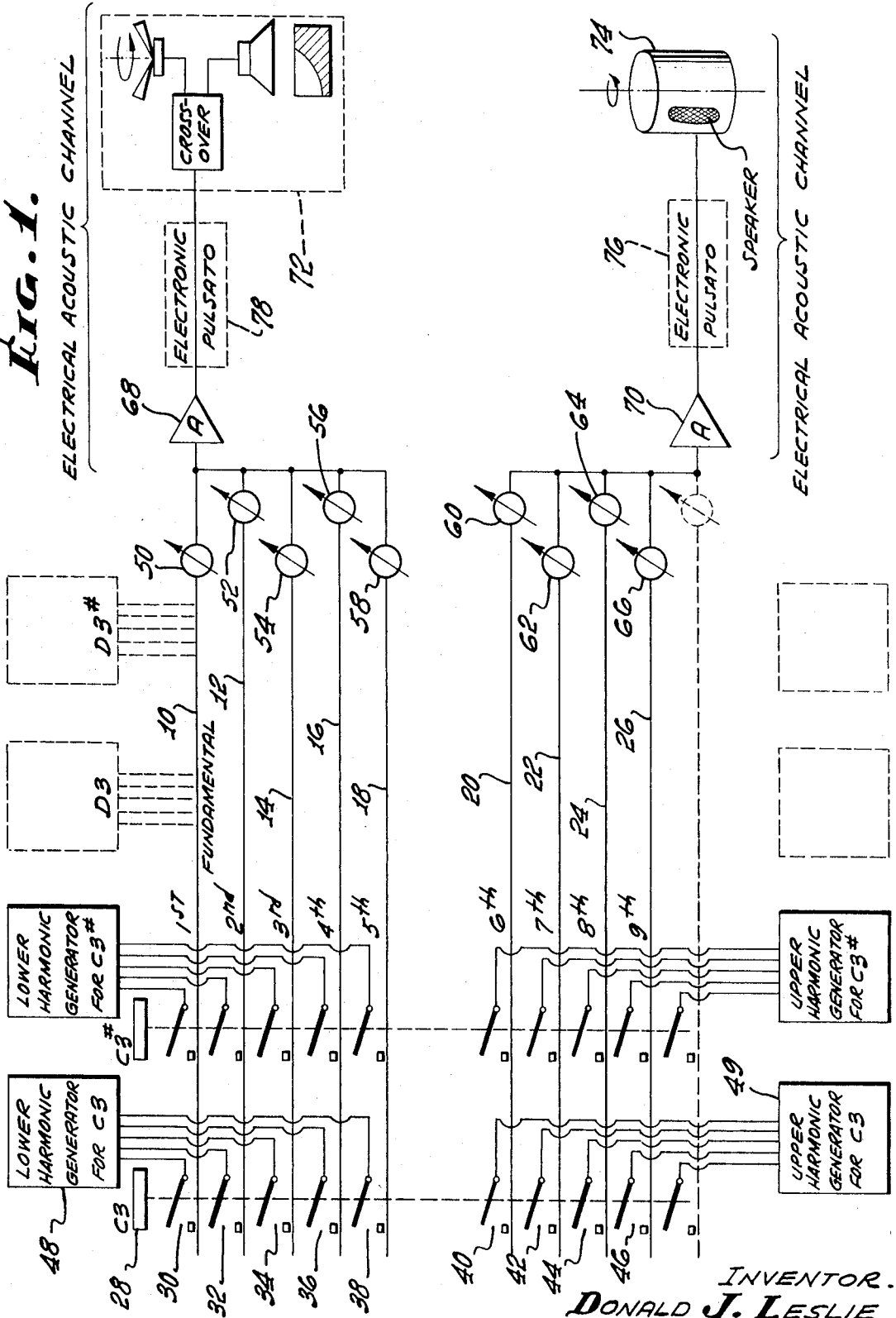
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**ABSTRACT:** A musical instrument produces electrical impulses corresponding to musical tones. The harmonic components of the impulses are segregated into two electrical channels so that, for example, low order harmonics exist in one electrical channel and high order harmonics exist in another channel. A device operating in conjunction with the electrical channel for the low order harmonics adds pulsato in that channel that is more intense than the pulsato, if any, that is added in the other channel. By grouping impulses according to harmonic order rather than according to frequency, accurate simulation of pipe organ characteristics is achieved.

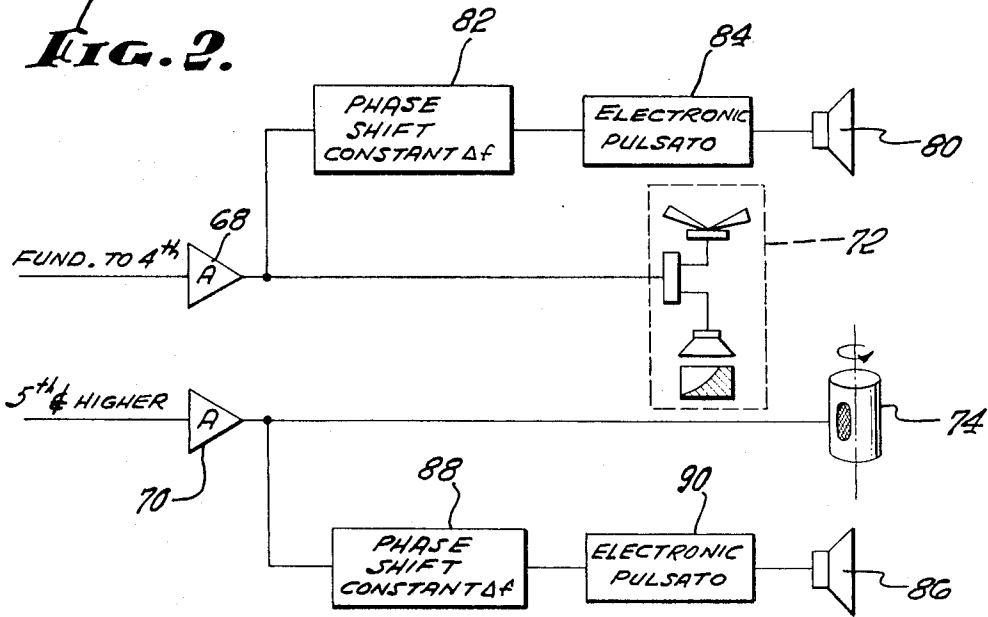


**FIG. 1.**

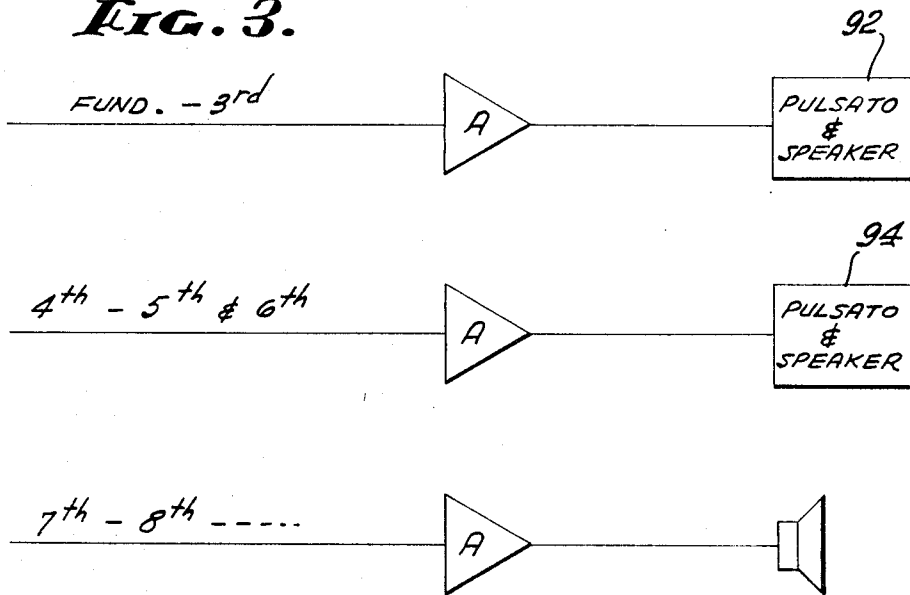


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**FIG. 2.**



**FIG. 3.**



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## HARMONICALLY RELATED PULSATO SYSTEM

### BACKGROUND OF THE INVENTION

This invention relates to a system for adding pulsato (tremolo and/or vibrato) to impulses or sounds. In the past it has been common to provide pulsato in different controlled amounts to different frequency bands. But merely dividing the output into different frequency bands for this purpose does not achieve accurate simulation of the tonal effects of a pipe organ. Investigation reveals that the lower partials of an organ pipe, whatever its fundamental frequency may be, contains a much greater pulsato effect than the upper partials. Thus, the first few harmonic portions of A(440) sounding at 440, 880, 1320, 1,760 Hz. should have a substantial pulsato effect superimposed, whereas the sixth and eighth harmonic partial of A(220) sounding at 1,320 and 1,760 Hz. should have a subdued pulsato effect. Segregating impulses according to frequency ranges accordingly results in the same treatment of the sixth and eighth harmonic of A(220) as the third and fourth harmonic of A(440).

It has also been found that acoustic pulsato devices that include elements such as rotating speakers, horns, plates, etc. usually give the upper harmonics an undesirable pulsato coloration. This is due in part to the fact that higher frequency components have a highly directional radiation characteristic. The primary object of this invention is to overcome the foregoing disadvantages and to provide an effective pulsato system, especially one in which acoustic pulsato devices can be used without producing an undesirable pulsato color to the upper harmonic partials. In order to accomplish this object, the impulses corresponding to harmonics are segregated into at least two groups. For the group containing the lowest order harmonics, acoustic pulsato is added in substantial intensity by a device such as shown in my U.S. Pat. No. Re. 23,323 issued Jan. 9, 1951. A more moderate form of pulsato may be added for the next group of harmonics. Each group of harmonics may also have a supplemental output in order to provide a chorus effect.

### BRIEF DESCRIPTION OF THE DRAWINGS

A detailed description of the invention will be made with reference to the accompanying drawings, which drawings are all diagrammatic. The description of the invention is of the best presently contemplated modes of carrying out the invention. This description is not to be taken in a limiting sense, but is made merely for the purpose of illustrating the general principles of the invention. Operational characteristics attributed to forms of the invention first described shall also be attributed to forms later described, unless such characteristics are obviously inapplicable or unless specific exception is made.

FIG. 1 is a diagrammatic view of a system incorporating the present invention.

FIG. 2 is a diagrammatic view of a modified form of the present invention.

FIG. 3 is a diagrammatic view of still another modified form of the present invention.

### DETAILED DESCRIPTION

In FIG. 1 there is diagrammatically illustrated a synthesis-type organ in which bus bars 10, 12, 14, 16, 18, 20, 22, 24, 26, etc. are provided for impulses corresponding to the fundamental, second, third, fourth, fifth, sixth seventh, eighth, ninth, etc. harmonics. Thus, for example, at the bus bar 10 a sinusoidal signal having a frequency of 440 Hz. exists when the key corresponding to A(440) is depressed. A sinusoidal signal of 440 Hz. exists at the second harmonic bus bar 12, when the key corresponding to A(220) is operated.

The key 28 for the note C3 operates a series of switches 30, 32, 34, 36, 38, 40, 42, 44, 46, etc. respectively associated with the bus bars 10—26, etc. Switches 30, 32, 34, 36 and 38 of

one group operate to connect appropriate lower harmonic generators 48 for the note C3 respectively to the bus bars 10, 12, 14, 16 and 18. Switches 40, 42, 44, 46, etc. of the second group operate to connect appropriate upper harmonic generators 49 to the bus bars 20, 22, 24, 26, etc. In a similar manner, the keys for the other notes connect lower and upper harmonic generators to the sets of bus bars.

In practice, some of the generators for C3 may be common to some of the generators for the other notes, but they are indicated separately for purposes of generality. Moreover, the upper harmonic generators for the seventh, ninth and higher order harmonics may be a single composite in accordance with my prior U.S. Pat. No. 3,432,608 issued Mar. 11, 1969. However, for purposes of generality, the upper harmonic generators are shown separately.

The tone color can be adjusted by scaling the signals at the bus bars. For this purpose adjustable circuit elements 50, 52, 54, 56, 58, 60, 62, 64, 66, etc. are provided that are respectively associated with the individual bus bars. For example, to provide a tone rich in odd order harmonics, the elements 50, 54, 58, 62, 66 are adjusted to pass a substantial amount of the signal, while the elements 52, 56, 60, 64 are adjusted to pass a low level of signal, all in a well understood manner. The adjustable elements may be potentiometers, autotransformers, or other suitable devices.

The bus bars 10, 12, 14, 16 and 18 for the lower order harmonics including the fundamental, second, third, fourth and fifth, are grouped together to form one electrical acoustic output channel, whereas the bus bars 20, 22, 24, 26, etc. are grouped together to form a second electrical acoustic output channel. Separate amplifiers 68 and 70 are provided for these two groups. The output of the amplifier 68 drives an acoustic pulsato device 72 that provides an intense pulsato achieved by relatively large orbits of the sound channels rotating at 5—8 cycles per second. In the present instance, the acoustic pulsato device 72 includes two channels, one for high frequencies and one for low frequencies. The amplifier 70 for the upper order harmonics drives an acoustic pulsato device 74 in the form of a drum that provides a moderate or low level pulsato to the impulses achieved by a relatively small orbit of the sound channel rotating at 5—8 cycles per second. The drum may be housed in a cabinet common to the acoustic pulsato device 72.

In place of the drum, a fixed speaker could be provided together with an electronic pulsato device 76. Similarly, in place of the pulsato unit 72, a fixed speaker could be provided together with an electronic pulsato unit 78. Any combinations of electronic or acoustic pulsato devices can be provided as desired, providing the harmonics are grouped for separate treatment wherein a high level pulsato (electronic or acoustic) is provided for the low order harmonic components, and a lower level pulsato is added (electronically or acoustically) for the group of higher order harmonics. I prefer to use an acoustic pulsato device 72. Its use does not add pulsato color to higher order harmonics since the higher order harmonics are absent in the channel 68—72.

In the form shown in FIG. 2, the amplifiers 68 and 70 are provided as before. In this instance, however, the grouping is slightly different. The amplifier 68 operates in conjunction with the harmonic components to the fourth harmonic, and the amplifier 70 operates in conjunction with the higher order harmonics. The acoustic pulsato unit 72 is provided as before. In this instance, an auxiliary output channel is provided for a fixed speaker 80 also driven by the amplifier 68 but through a phase shift network 82 and an electronic pulsato unit 84. The phase shift unit 82 may be of the type shown in a copending application of Paul H. Sharp, Ser. No. 846,117 filed July 30, 1969 entitled REVERBERATION SYSTEM FOR ELECTRICAL MUSICAL INSTRUMENTS. The sounds issuing from the speaker 80 have a nominal frequency slightly different from the nominal frequency of impulses supplied to the acoustic pulsato unit 72 by virtue of the action of the phase shift device 82. Accordingly, an improved chorus effect is achieved.

The drum 74 is provided as before for the higher order harmonic. In addition, a fixed speaker 86 is provided driven by the amplifier 70 through an auxiliary output channel including a phase shift device 88 and an electronic pulsato unit 90. A chorus effect is likewise achieved for the higher order harmonics. If desired, the phase shift devices 82 and 88, pulsato units 84 and 90, and the speakers 80 and 86 may be combined. However, in the system shown the phase shift and electronic pulsato device can have different operating characteristics to achieve various effects.

In the form shown in FIG. 3, a system is diagrammatically illustrated in which impulses are segregated into three groups. Pulsato unit 92 imposes a high level pulsato for the fundamental, second and third harmonics. The pulsato unit 94 for the intermediate range harmonics (fourth, fifth, and sixth) imposes a low level pulsato, and no pulsato at all is provided for the group consisting of the higher order harmonics.

It will be understood that FIGS. 1, 2 and 3 are highly diagrammatic. The representation of a single speaker will be understood as including multiple speakers such as for high and low frequency components. It will also be understood that suitable isolation networks are provided as required.

I claim:

1. In a pulsato system for an electrical musical instrument:
  - a. a first output channel;
  - b. a second output channel;
  - c. a set of keys for notes in a musical range;
  - d. first circuit means operated by said keys for transmitting to said first output channel only impulses corresponding to the fundamental and lower order harmonics thereof;
  - e. second circuit means operated by said keys for transmitting to said second output channel impulses corresponding only to higher order harmonics of the note corresponding to said keys; and
  - f. means for adding pulsato in the first output channel in a manner markedly different than the manner in which pulsato, if any, is added to the second channel.
2. The combination as set forth in claim 1 in which said first circuit means includes a first set of bus bars or leads, one for each lower order harmonic partial, a first set of switches for each key all operated by the key to connect generators for the corresponding harmonic partial to the corresponding bus bar or lead, and adjustable circuit means for each bus bar or lead for scaling the corresponding partials; and in which said second circuit means includes a second set of bus bars or leads, a second set of switches for each key all operated by the key to connect generators for the corresponding harmonic partials to the corresponding bus bars or leads, and adjustable circuit means for each bus bar or lead of the second set for scaling the corresponding partials.
3. The combination as set forth in claim 1 in which said pulsato adding means includes a device having rotary sound channels.
4. In a pulsato system for an electrical musical instrument:
  - a. two or more separate output channels;
  - b. means producing groups of impulses for said channels respectively, one group of impulses corresponding to the fundamental of the notes together with lower order harmonics of said notes, another group of impulses corresponding to higher order harmonics of said notes sub-

- stantially devoid of components corresponding to said fundamental and lower order harmonics; and
- c. means for adding pulsato in the first output channel in a manner markedly different from the manner in which pulsato, if any, is added to the second channel.
  5. The combination as set forth in claim 4 in which said pulsato means comprises, for said first channel, acoustic apparatus having rotary sound channels.
  6. In a synthesis organ:
    - a. a first set of bus bars for impulses corresponding to the fundamental and lower order harmonic partials;
    - b. a second set of bus bars for impulses corresponding to higher order harmonics;
    - c. a set of keys for notes in a musical range;
    - d. a set of key switches for each key, some of the switches of each set cooperating with said first set of bus bars, and some of each set cooperating with said second set of bus bars;
    - e. a set of generators;
    - f. circuit means connecting the generators to the bus bars under the control of the key switches for applying to the bus bars impulses corresponding to fundamental and the harmonic partials respectively;
    - g. a first output channel for the first set of bus bars;
    - h. a second output channel for the second set of bus bars; and
    - i. means for adding pulsato in the first output channel in a manner markedly different from the manner in which pulsato, if any, is added to the second channel.
  7. The combination as set forth in claim 6 together with an auxiliary output channel for said first set of bus bars; phase shift means for said auxiliary output channel for changing the nominal pitch of impulses; and electrical pulsato means in said auxiliary channel.
  8. The combination as set forth in claim 6 together with auxiliary output channel means for said bus bars; phase shift means for said auxiliary output channel means for changing the nominal pitch of impulses; and electrical pulsato means for said auxiliary output channel means.
  9. The method of producing music which comprises:
    - a. providing two separate output channels;
    - b. applying to one of said channels impulses corresponding to the fundamental of the notes together with lower order harmonics thereof;
    - c. applying to the other of said channels impulses corresponding to higher order harmonics of said notes substantially devoid of components corresponding to said fundamental and lower order harmonics; and
    - d. adding pulsato in the first channel to an extent markedly greater than the extent to which pulsato, if any, is added in the second channel.
  10. The process as set forth in claim 9 in which said pulsato is added in the first output channel by acoustic apparatus having rotary sound channels.
  11. The process as set forth in claim 9 in which pulsato is added in said output channels acoustic means having rotary sound channels, the rate of rotation of the sound channels in both output channels being substantially the same, but in which the orbit of the mouth of the channel in the second output channel is relatively small.