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ELECTRONIC MUSICAL INSTRUMENT

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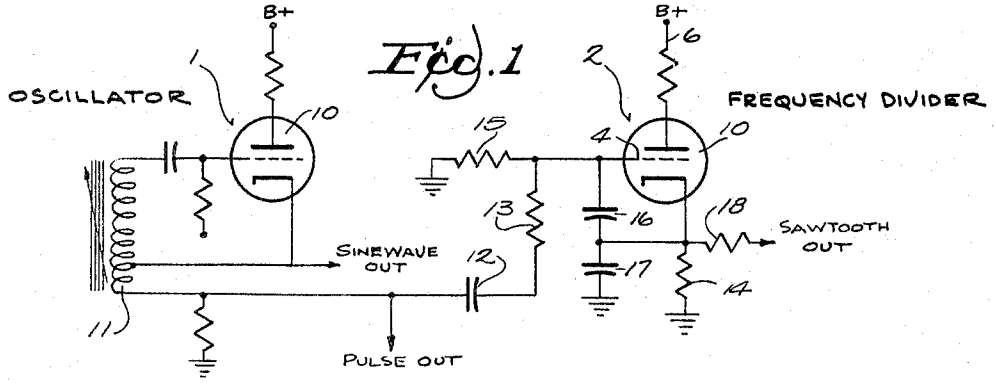


Fig. 1

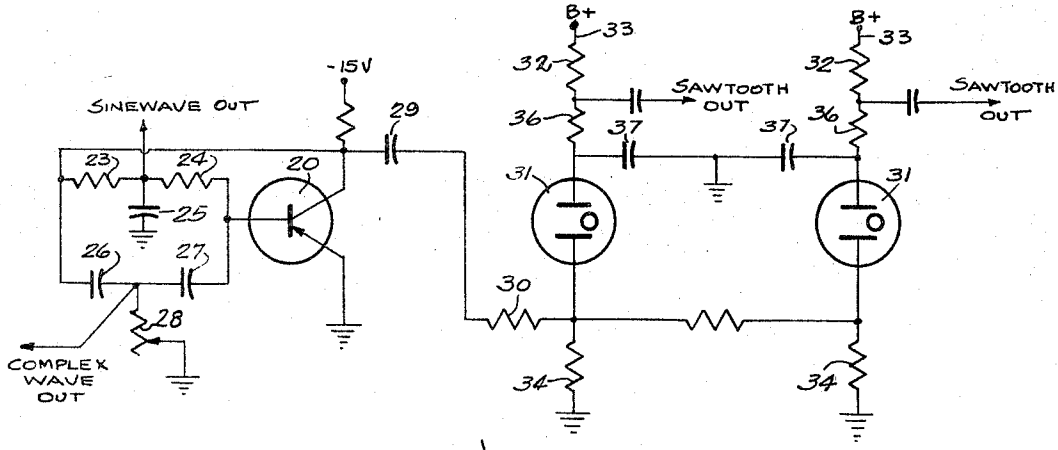


Fig. 2

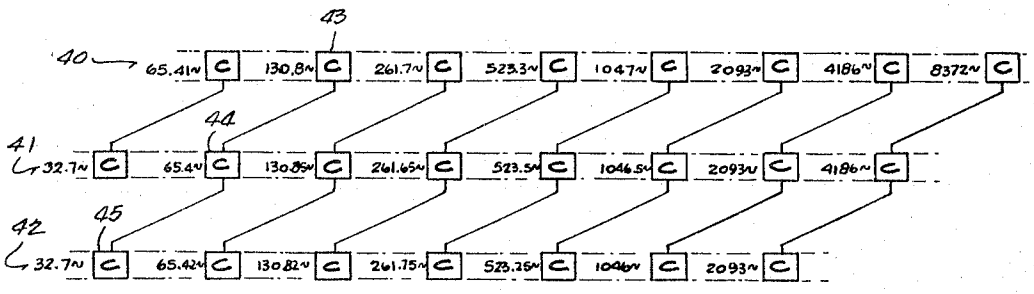


Fig. 3

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ELECTRONIC MUSICAL INSTRUMENT

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ABSTRACT OF THE DISCLOSURE

A means of obtaining two or more independent frequency sources for a substantial portion of the total frequency range of an electronic organ through the use of independent tunable oscillators for one frequency source, and individual frequency dividers or multipliers, each of which is driven by one of the independent oscillators, as a second frequency source. Additional sets of frequency dividers or multipliers may be employed, a second set which would be driven by the first set of frequency dividers, a third set which would be driven by the second set to provide even further sources of frequency.

This invention relates to apparatus for the electrical generation of musical tones and more particularly to improvements in musical instruments of the type employing electrical oscillators of audible frequency for the production of musical notes.

It is well known that the charm and appeal of a pipe organ is due in no small measure to the combination of numerous types of tone and the slight pitch differences between tones of the same approximate frequency caused by imperfections in tuning. When more than one rank of organ pipes is employed, for each frequency two or more pipes sound which will differ slightly in their exact frequency providing random beat frequencies which give warmth and body to the tone and characterize the sound of a pipe organ. The more closely the tones resemble each other in wave shape, the more pronounced is the effect of slight differences in pitch. It is often desirable to use tones of different pitches as well in combination so that the pressing of a key causes a tone of one frequency and another tone of half that frequency or twice that frequency. While in theory these frequencies have exact mathematical relationship, in a pipe organ this relationship is less than exact since even if tuned perfectly, pipes go quickly out of tune to a slight extent thus destroying the perfect mathematical relationship of octaves. Thus beat frequencies are produced in this fashion as well, and when several keys are held, these beat frequencies beat against each other as well as producing further beat frequencies. As long as the organ does not get too badly out of tune, the effect is exceedingly rich. Also characteristic of the pipe organ is the wide range of different tones available singly and in combination, these tones varying widely in their harmonic structure from tones with little or no harmonic content to extremely complex wave shapes. There is no known wave shape which may be generated electronically or electrically which may be modified to produce an accurate reproduction of all the tones found in even a small pipe organ. While some of the types of pipe organ tone may be duplicated faithfully by a given wave-shape, others formed from this wave-shape are less than a true reproduction.

Heretofore, numerous methods have been employed to product the characteristics which are necessary to duplicate the sound of a pipe organ, but either they have not been successful, or they are so costly as to prohibit manufacture of an organ at a reasonable price. One common method employed is the generation of but twelve frequencies corresponding to the highest octave of musical notes, and to obtain other lower octaves through frequency division, the next octave lower than the generated octave being produced by electronic frequency division of the generated frequencies, the next lower octave by division of the frequencies derived in the octave above through frequency division, and until all required octaves are obtained. Since only one type of waveshape is created, it is apparent that not only will only a limited number of types of pipe organ tone be created, but for a given frequency, all tones since they are created from this single source, must necessarily be of the same exact frequency. Further, all octaves will be exactly in tune. Another method is the employment of individual oscillators for each required frequency where the oscillators produce more than one type of tone, or waveshape. This system solves the problem of having less than perfect octave relationships, but does not solve the problem of obtaining two or more frequencies which are different by a fraction of a cycle or by a few cycles, and thus the effect of more than one rank of organ pipes is not obtained. Still another method employs two or more sets of oscillators, or oscillators with frequency dividers in cascade, and while this method does have the ability to produce all the necessary requirements, it is costly, and may require considerable tuning.

It is therefore an object of this invention to provide a multiple tone source for a musical instrument which is both simple, inexpensive, and satisfactory in operation.

It is another object of this invention to provide a multiple tone source wherein two or more frequencies may be generated which are approximately but not exactly of the same exact frequency for a musical instrument.

A still further object of the invention is to provide a multiple tone source for a musical instrument which yields two or more waveshapes without the requirement of filtering means or other complicated means for creating basic tones comparable to a pipe organ in sound.

Further objects and advantages of the invention will become apparent in the description, and the features of novelty which characterize the invention will be pointed out with particularity in the claims which form a part of this specification.

For a better understanding of the invention reference may be had to the accompanying drawing, in which:

FIG. 1 is a schematic circuit diagram to aid in understanding the basic features of the invention.

FIG. 2 is a schematic diagram of another form of the invention illustrating a further extension of the invention.

FIG. 3 is a block diagram of a complete organ generating system embodying the invention.

Referring more particularly to FIG. 1, the numeral **1** refers to an oscillator of the Hartley type comprised of an electron discharge valve **10**, an inductor **11**, and various resistances and capacitors. This particular oscillator is shown by way of illustration only. The numeral **2** refers to a device known as a frequency divider comprised of an electron discharge valve **10** and various resistances and capacitors, and again is shown by way of illustration only, in the arrangement of the various components. From the oscillator **1** may be obtained one or more waveshapes and in the drawing, two points are shown where these waveshapes may be obtained, one wave being a sinusoidal wave, and the other a pulse or spike wave. These waves would be passed to keying means operable by the player of the instrument, and would after passing through other circuits be heard as sound. They would however be of the same exact frequency when heard in combination. The frequency divider will through means well known to those versed in the art of electronics, produce a frequency of exactly one-half of that which is fed into it. In the drawing, the pulse wave generated by the oscillator **1** is fed to the frequency divider **2** through the capacitor **12** and re-

sistor 13 where it then appears on the grid 4 of the valve 10. Through proper selection of the voltage applied at 6, values of capacitor 16 and 17, values of resistors 14 and 15, a sawtooth or other complex wave will be produced through resistor 18, the frequency of this wave being exactly one-half of the frequency appearing at the grid 4 and supplied by the oscillator 1. If there are oscillators for the required range of the organ in the number of 73 covering the range of frequencies 4186 to 65.41 and each oscillator has a frequency divider associated therewith, the frequencies 2093 to 32.7 will be obtained from the frequency dividers. It will be seen that the two ranges overlap each other to some extent, more particularly from 2093 to 65.4 and thus there may be considered to be two sources of frequencies for any frequency falling within this overlapping range. Since one of these two is produced directly by the oscillator while the other is produced by a frequency divider driven by a different oscillator which is separate from the oscillator producing the first frequency, it may be seen that the two frequency sources will be close to each in frequency but will not be exactly the same frequency due to slight imperfections in tubing of the two oscillators. Since only the oscillators require tuning it will be seen that tuning the 73 oscillators will actually tue all 143 sources of tone present. Whatever frequency is fed to the divider, the divider will produce a new frequency exactly one-half of that, so that tuning the oscillator also automatically tunes the divider.

It may also be seen that the divider is somewhat less complex than the oscillator since it requires no inductor 11, and may therefore be made more economically. Thus an oscillator and a frequency divider will be less expensive than two oscillators, and will require less tuning, while providing the same results as two oscillators.

In FIG. 2, another embodiment of the invention is shown, employing a transistor 20, resistors 23, 24, 28, and capacitors 25, 26, 27 comprising an oscillator of the twin-T type. Connected to this oscillator are two frequency dividers comprised of a gas discharge valve 31, resistors 32, 34, 36, and capacitor 37. Oscillations from the oscillator are fed to the frequency dividers through capacitor 29 and resistor 30. The proper selection of resistances 36 and capacitors 37, as well as the voltage applied to 33 will cause the frequency dividers to act as oscillators whose frequency is based on the components cited above. For the first frequency divider, these components are selected such that the frequency of oscillation is a little less than one-half that produced by the transistor twin-T oscillator associated with it, and for the second frequency divider so that the frequency of oscillation is one-quarter of that produced by the transistor twin-T oscillator.

The signal from the transistor oscillator, reaching the dividers through capacitor 29 and resistors 30 will lock the oscillations of the frequency dividers into exact relationship, so that in effect they become true frequency dividers, producing frequencies of exactly one-half and one-quarter of those produced by the transistor oscillator. Since gas discharge valves are inexpensive, it may be seen that their employment as frequency dividers leads to substantial cost savings while still providing the benfits of several frequency sources. The transistor twin-T oscillator produces more than one useful waveshape also, two being shown by way of illustration.

It will be understood that the circuits illustrated are by way of example only and in no way limit the scope of the invention. The Hartley oscillator in FIG. 1 may be coupled with the gas discharge frequency dividers of FIG. 2 while the electron discharge valve of the frequency divider in FIG. 1 may be coupled with the transistor twin-T oscillator of FIG. 2. In addition, numerous other types of oscillators may be employed as well as numerous other types of frequency dividers, and in any combination.

FIG. 4 illustrates a complete generating system employing 85 oscillators of which 73 have two frequency dividers associated with them, and 12 have one frequency divider. The oscillators together comprise one generator 40 having a frequency range of 8372 to 65.41 cycles per second. One set of frequency dividers comprises another generator 41 having a frequency range of 4186 to 32.7 cycles per second, while the other set of frequency dividers comprises a third generator 42 having a frequency range of 2093 to 32.7 cycles per second. The oscillator 43 drives frequency divider 44 which in turn drives frequency divider 45. While the frequencies shown indicate perfect tuning, in practice the actual frequencies would vary slightly from those shown. Even with the perfect tuning shown, it will be seen that for middle C of approximately 261.7 cycles per second, three frequencies are generated which differ slightly, being 261.7, 261.5, and 261.75 from generators 1, 2, and 3 respectively.

While use of but one or two frequency dividers associated with each oscillator are illustrated, more may be employed giving even better results. Generator 1, consisting of the actual oscillators, may be more or less than eighty-five oscillators.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent of the United States, is:

1. In an electronic musical instrument the combination of a first generating system comprised of individual oscillators producing frequencies of the musical scale at normal pitch, a second generating system comprised of individual frequency dividers producing frequencies of the musical scale at normal pitch, each frequency divider in said second generating system being supplied with an input frequency from a separate oscillator in said first generating system and producing an output frequency which is some sub-multiple of its input frequency, said first generating system spanning essentially the entire range of frequencies required for said electronic musical instrument, said second generating system spanning essentially the entire range of frequencies required for said electronic musical instrument such that for a substantial portion of the total frequencies generated in said electronic musical instrument, there are two separate sources for a given frequency, one such source being said first generating system, the other such source being said second generating system.

2. In a combination with claim 1, a third generating system comprised of individual frequency dividers producing frequencies of the musical scale at normal pitch, each frequency divider in said third generating system being supplied with an input frequency from a separate frequency divider in said second generating system and producing an output frequency which is some sub-multiple of its input frequency, said third generating system spanning at least a substantial portion of the entire range of frequencies required for said electronic musical instrument such that for a substantial portion of the total frequencies generated in said electronic musical instrument there are three separate sources for a given frequency, one such source being said first generating system, another such source being said second generating system, and another such source being said third generating system.

3. In a combination with claim 2, additional generating systems comprised of individual frequency dividers producing frequencies of the musical scale at normal pitch, each such generating system comprised of individual frequency dividers, each of said frequency dividers receiving an input frequency from an individual frequency divider of the previous generating system and producing an output frequency which is some sub-multiple of the input frequency.

4. In a combination with claim 1, the combination of a first generating system comprised of individual oscillators producing frequencies of the musical scale at normal pitch, a second generating system comprised of individual frequency dividers, a third generating system

comprised of individual frequency multipliers, said second generating system receiving input frequencies from said first generating system and producing output frequencies of some sub-multiple of said input frequencies, said third generating system receiving input frequencies from said first generating system and producing output frequencies of some multiple of said input frequencies, said systems constituting three separate sources for most of the frequencies within the range required for said electronic musical instrument.

5. In a combination with claim **4**, in generating systems which may be composed of any combination of frequency dividers and frequency multipliers in combination with a first generating system comprised of individual oscillators producing frequencies of the musical scale at normal pitch.

6. In an electronic musical instrument the combination of the first generating system comprised of individual oscillators producing frequencies of the musical scale at normal pitch, a second generating system comprised of individual frequency multipliers producing frequencies of the musical scale at normal pitch, each frequency multiplier in said second generating system being supplied with an input frequency from a separate oscillator in said first generating system and producing an output frequency which is some multiple of its input frequency,

said first generating system spanning essentially the entire range of frequencies required for said electronic musical instrument, said second generating system spanning essentially the entire range of frequencies required for said electronic musical instrument such that for a substantial portion of the total frequencies generated in said electronic musical instrument, there are two separate sources for a given frequency, one such source being said first generating system, the other such source being said second generating system.

7. In a combination with claim **6**, additional generating systems comprised of individual frequency multipliers producing frequencies of the musical scale at normal pitch, each frequency multiplier receiving an input signal from an individual frequency multiplier of the previous generating system and producing an output frequency which is some multiple of the input frequency.

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