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PREFERENCE CIRCUIT FOR ELECTRONIC MUSICAL INSTRUMENT UTILIZING PULSE AMPLITUDE DISCRIMINATION AND ZERO-CROSSING DETECTOR

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FIG. 1

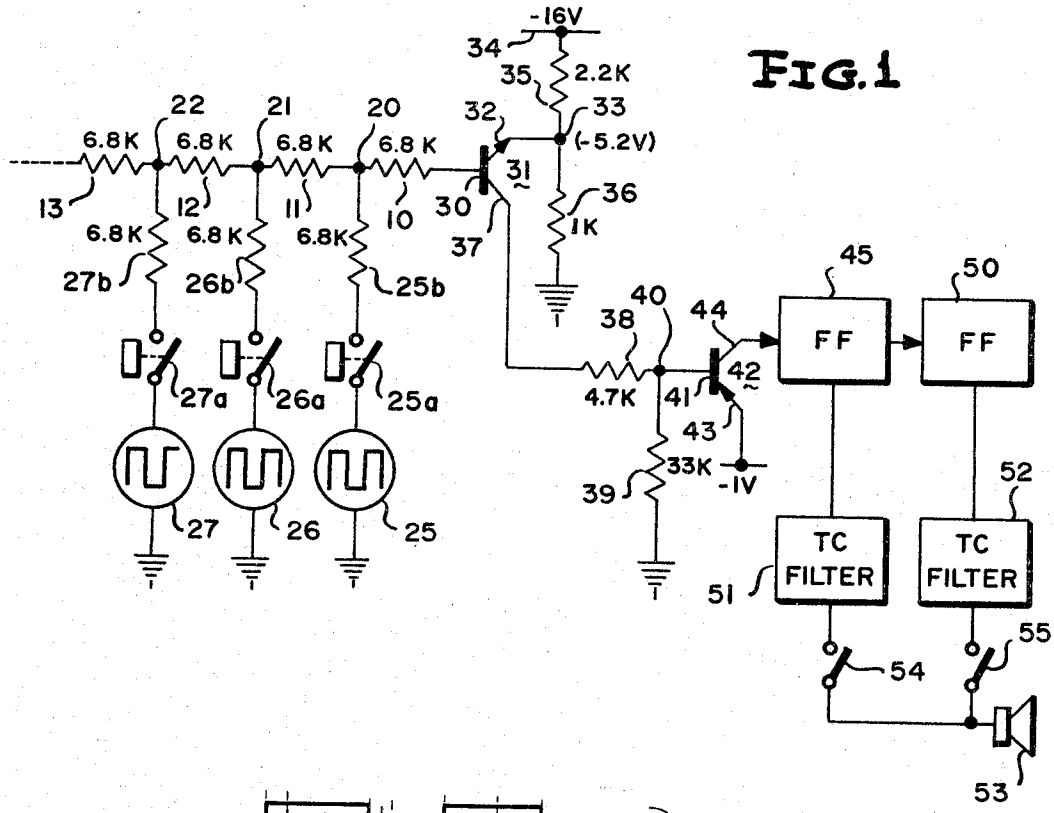
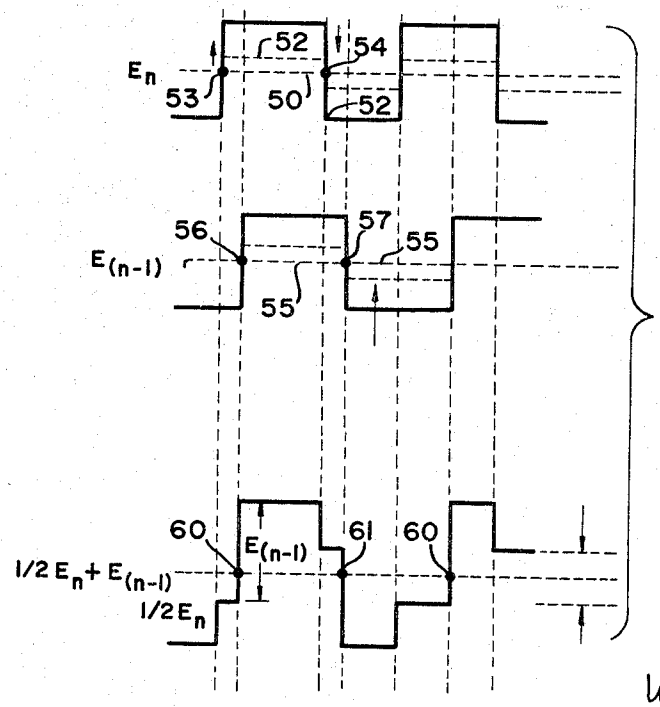


FIG. 2



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PREFERENCE CIRCUIT FOR ELECTRONIC MUSICAL INSTRUMENT UTILIZING PULSE AMPLITUDE DISCRIMINATION AND ZERO-CROSSING DETECTOR

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The present invention relates generally to electronic musical instruments, and more particularly to preference circuitry for electronic musical instruments employing a plurality of tone generators which may individually control tone available in an output circuit, the preference circuitry providing that simultaneous actuation of plural keys will produce only one tone in the output circuit.

Adjacent notes of a musical instrument, when played simultaneously, are not harmonious. In the pedal division of an electronic organ, particularly, it is usual to provide a preference circuit to avoid sounding two notes simultaneously, when these are inadvertently called forth by actuation of two pedal keys and usually the lower of any two notes is preferred to the higher. Various types of preference circuitry have been devised. Many of these have involved complex switching arrangements and are therefore undesirable. Other arrangements have involved networks of the ladder type. These networks involve simple switching arrangements, i.e. one single pole single throw switch per note, but have the disadvantage that different tone signals pass to an output circuit via paths of different impedances, which modifies the relative levels of the several tones. In one such system the tone generator output circuits are required to be of low impedance, in order to suppress non-preferred notes by acting as bypass circuit elements, but cross talk occurs because the bypass is not complete.

It is an object of the present invention to provide a novel preference circuit which operates with generator output impedances of relatively high impedance, and provides output signals of the same amplitude at all frequencies.

It is another object of the invention to provide a system for generating zero crossings, responsive to the sum of plural tone signals of different amplitudes, which correspond in timing to the zero crossings of only the tone signal of highest amplitude in the composite signal, and to produce tones in any output system for the system in response to the generated zero crossings, whereby preference is achieved without requiring total suppression of non-preferred tones in the preference network itself.

It is a further object of the invention to provide response to that one of two superposed, square waves, of unequal amplitude, which has the larger amplitude.

A further object of the invention resides in providing a novel root tone selection system, i.e. a system in which only the lowest note of a chord played by a musician calls forth an audible response.

Briefly describing a preferred embodiment of the invention, a plurality of square wave tone generators is connected in parallel between ground and separated points of a resistive string. The output impedances of the generators may be higher than or equal to the impedances between adjacent points of a string. Assuming the generators to be of decreasing frequency progressively in proceeding from one end to the other of the resistive string, and that the latter end is the output end, the several generators meet different impedances in proceeding to the output end, so that the tone signal of lower frequency is always of greater amplitude. The sum of adjacent tone signals can then be shown to have adjacent zero crossings at times

established by the periods of the lower frequency tone signal only, with successive crossings of opposite slopes. The zero crossings can be used to generate square waves, which can control output tone generators, in the form of flip-flops. Zero crossings are controlled by the higher amplitude square waves, regardless of relative frequencies, so that the system can be designed to prefer higher frequencies or lower, as desired.

Reference is now made to the accompanying drawings, wherein:

FIGURE 1 is a schematic circuit diagram of a system according to the invention; and

FIGURE 2 is an explanatory wave shape diagram, pertaining to FIGURE 1.

In the drawings, resistances **10**, **11**, **12**, **13** . . . are connected in series to form a resistance string. As many resistances as there are tone generators may form the string, and the resistances may be equal or unequal, but are shown as equal in the preferred embodiment. The junctions between resistance pairs, **10**, **11**; **11**, **12**; **12**, **13** etc. are denoted **20**, **21**, **22** . . . , and between these junctions and ground are connected tone generators **25**, **26**, **27** . . . each in series with a switch and a generator output impedance, denoted respectively by reference numerals **25***a*, **25***b*; **26***a*, **26***b*; **27***a*, **27***b*. Resistances **25***b*, **26***b*, **27***b* may be equal to each other and to resistances **10**, **11**, **12**, **13**, if desired.

Resistance **10** proceeds to the base **30** of a transistor **31**, having an emitter **32** connected to a negative voltage terminal **33**. The latter is the midpoint of a voltage divider extending from a negative voltage source **34** to ground. The voltage may be −16 v. and the divider may be composed of a 2.2K resistor **35** and a 1K resistor **36**, so that junction **33** is at approximately −5.2 v. Collector **37** of an NPN transistor **31** proceeds to ground via series resistances **38**, **39**, of 4.7K and 33K, respectively. The junction **40** of resistances **38**, **39** is connected directly to the base **41** of an PNP transistor **42**, having an emitter **43** and a collector **44**. The emitter **43** is supplied with a −1 v. supply and the collector **44** proceeds to a flip-flop **45**, for control of the latter.

Transistor **42** operates over a small range of voltages above or below which it saturates. Thereby it acts as a square wave clipper, when supplied at its base with irregularly shaped waves, and the square wave output is severely amplitude limited, for all amplitudes of the irregularly shaped waves, and has periods which are the same as time intervals between the zero crossings of the irregularly shaped waves.

The generators **25**, **26**, **27** provide 8 v. peak-to-peak superposed on 4.5 v. D.C. Circuit values are then established so that approximately zero voltage appears at point **40**, in response to the 4.5 v. D.C. alone. The 8 v. peak-to-peak square waves provided by generators then drive base **41** of transistor **42** alternately more and less negative. However, a small change in signal at base **41** is adequate to drive the output of transistor **42** between cut-off and −1 v., its emitter voltage.

Assume (FIGURE 2) that only E_n is present, i.e. the voltage derived, for example, from generator **26**, switch **26***a* alone being closed. Variations of voltage at base **41** occur, about zero base line **50**, which gives rise to control voltage **52** for flip-flop **45**, driving flip-flop **45** into one state at zero crossing **53**, and into the opposite state at zero crossing **54**. A similar set of events occurs in respect to generator **25**, alone, having a voltage wave form $E_{(n-1)}$, a lower frequency than is provided by generator **26**. Here the zero base line is **55**, and the changes of state occur at zero crossings **56**, **57**.

If switches **25***a* and **26***a* are closed together, signal from tone generator **26**, i.e. E_n, is attenuated more than is signal from tone generator **25**, i.e. $E_{(n-1)}$. Assume that

for 1 $E_{(n-1)}$ we have ½ E_n, merely to simplify expositon. This will be the situation for any two adjacent tone generators, if generator output impedance is equal to impedance between adjacent connection points of the string. The sum of $E_{(n-1)}+½\ E_n$ is then illustrated as the lowermost wave form of FIGURE 2, and it will be observed that both the rising and falling zero crossing, at points **60**, **61** are controlled by the zero crossings of the $E_{(n-1)}$ wave form alone, and are well defined, i.e. occur between values $+½\ E_n$ and $-½\ E_n$. It follows that the control signal applied to flip-flop **45** is at the frequency of $E_{(n-1)}$, the lower frequency of the two active generators. However, were higher frequency signals of greater amplitudes, preference would be in favor of the higher frequency tones, rather than the lower.

While a simple ladder circuit design according to the present system, permits equality of all ladder resistances, such equality is not required and may not be optimum. Resistances **25***b*, **26***b*, **27***b* may be located on either side of switches **25***a*, **26***a*, **27***a*, and in either position represent generator output impedances. As one moves to the left in the ladder configuration of FIGURE 1, the ratio of amplitudes, as between $E_{(n-1)}$ and E_n, remains constant, although the total current supplied to transistor base **30** decreases the total current being adequate out to thirteen tone generators, the usual condition in organs, which have thirteen pedal keys.

The flip-flop **45** may drive a further flip-flop **50**, to form a frequency divider stage, i.e. the output of flip-flop **50** may be an octave below that of flip-flop **45**. By the same token, flip-flop **45** may itself be a frequency divider. In such case, if keys **25***a*, **26***a*, **27***a* are key operated switches of an accompaniment manual, flip-flop **45** may form an output of a root tone system, i.e. a system which plays a single tone one octave below the lowest note of a chord played on the accompaniment manual, however complex that chord may be.

The flip-flops **45**, **50** may each be in cascade with a tone color filter, as **51**, **52**, selectively connectible to an output system, such as a loud speaker **53**, by means of tone color filter selection switches **54**, **55**.

Essentially, the present invention provides that, of an array of tone generators of an electronic organ having progressively decreasing frequencies, the lowermost frequencies shall have progressively the higher amplitudes. Tones called forth by key switches are additively combined. It can then be shown that the combined tones, although forming a complex wave shape, have clear cut zero crossings at the frequency of the tone of lowermost frequency. The zero crossings are utilized to generate or control output tones for the organ. The ladder network of FIGURE 1 then represents only one system for generating the required array of tones. The principle of the invention permits the highest amplitude square wave of a plurality of such waves to be selected, whether or not of lowest frequency, and the ladder network utilized represents merely a convenient device for assuring the required amplitude differentials where the tone generators have the same output voltages.

While I have described and illustrated one specific embodiment of my invention, it will be clear that variation of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

What I claim is:

1. In a preference system for square waves of different frequencies,

a plurality of sources of square wave tones of progressively decreasing frequencies and correspondingly modified amplitudes,

means for at will selecting a combination of said sources and transferring the corresponding square wave tones to a common circuit element, and

means responsive only to zero crossings of signal in said common circuit element for generating a musical tone, whereby the generated musical tones have a frequency locked to the frequency of only one preferred frequency source of the selected combination of said sources.

2. In a preference network,

a plurality of tone signal generators of progressively decreasing frequencies, each of said tone signal generators having a relatively high output impedance,

an impedance string having plural taps distributed therealong,

means for selectively connecting said tone generators one for one to said taps,

an output system connected to one end of said resistance string,

means for detecting zero crossings of signals in said output system, and

means responsive to said zero crossings for generating wave forms locked in frequency to the frequency of the lowermost signal generator selectively connected to said taps by said means for selectively connecting

3. In a preference system,

a plurality of tone signal generators of progressively decreasing frequencies,

means for progressively modifying the amplitudes of the tone signals as a function of said frequencies,

a control device,

means for at will selectively connecting said tone signal generators to said control device,

said control device including means for generating rectangular waves having transitions occurring in response only to zero crossings of tone signal at said output system, whereby only the frequency tone signal having greater amplitude of plural tone signals at said control device controls said transitions.

4. In a root tone generating system,

a plurality of musical tone generators of progressively decreasing tone frequencies,

switch means for at will selecting combinations of said tone frequencies, and

means for generating a single tone octavely related to the lowermost frequency of the selected tone frequencies to the exclusion of the remaining selected tone frequencies, said last means comprising

means for relatively decreasing the amplitudes of the musical tones as a function of increasing frequency to form leveled tone signals,

means for additively combining said leveled tone signals into a composite wave form,

said composite wave form having zero crossings corresponding in time with the zero crossings of only that one of said leveled tone signals having the lowest frequency, and

means responsive to the zero crossings of said composite wave form for generating said root tone.

No references cited.

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