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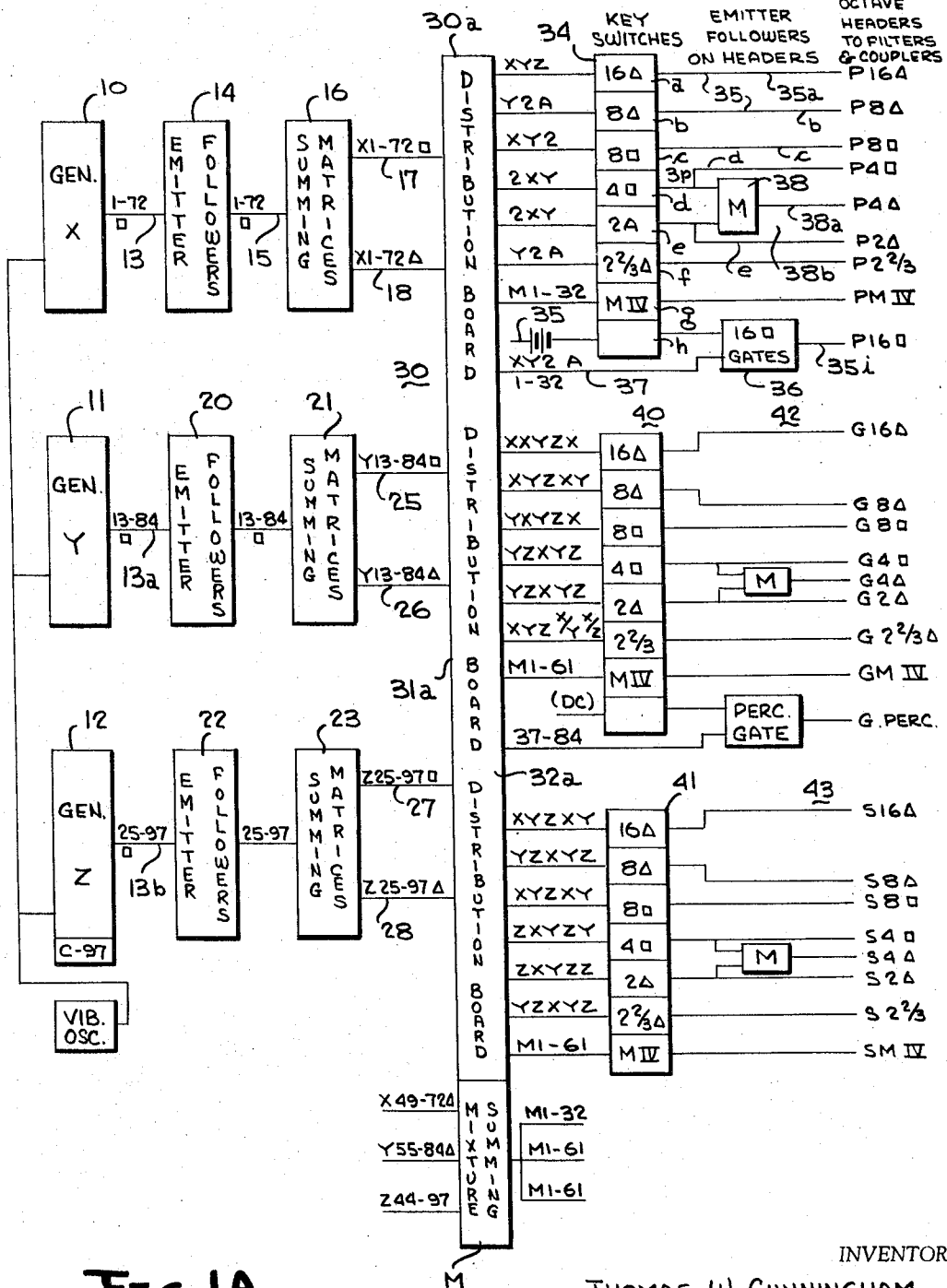


FIG. 1A

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2 Sheets-Sheet 2



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1

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ELECTRONIC ORGAN

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The present invention relates generally to electronic organs, and more particularly to electronic organs employing square-wave primary tone-signal generators, and plural sawtooth wave tone-signal sources, preferably derived from the square wave generators by matrixing, octaval tonal arrays being derived separately from both the generators and the sources on a permuted basis for application via key switches to octaval tone filters, which in turn drive plural acoustic radiators associated with the filters on an optimum utilization basis.

Briefly described, a preferred embodiment of the invention includes three primary square-wave generators, each generator including twelve divider chains, each chain providing all the tone-signals of a given nomenclature. The generators may be identified as X, Y and Z, respectively, in order to facilitate exposition of tone permutation. The generators are preferably not identical in frequency range, but overlap, and are deliberately slightly different in frequency composition for any given tone which may be common to a pair of generators. For example, if the instrument has 97 notes, generator X may go from 1-72, generator Y from 13-84, and generator Z from 25-97, where 1 is the lowest note of the organ and 97 the highest. The outputs of the primary generators X, Y and Z being square waves, the latter may be combined in resistance matrices to provide three additional tone-signal sources, of approximately sawtooth wave form, but duplicating the primary tones in respect to fundamental pitch frequency. The square-wave signals and sawtooth signals are usually maintained and utilized separate, in the instrument, in most instances, but may also be combined additively to form special sawtooth wave-forms of the same fundamental frequency as the square waves.

The outputs of the primary generators (square wave) and the derived sources (sawtooth wave) are led to arrays of key switches, in three sets, i.e. Pedal, Great and Swell. Enroute, octaves of fundamentals of tones from the separate generators are permutatively combined to form arrays of tone-signals having "chorus" effect capability, due to the relative slight detuning of the generators. So, the ultimate $16'\Delta$ tonal array has octaves derived from the several Δ tone sources, in the order XYZ, where Δ implies triangular wave shape, whereas the $8'\Delta$ arrays is derived in the order YZX, the $2'\Delta$ in the order ZXY, and the $2\frac{3}{4}'\Delta$ in the order YZX. Since the separate primary tone generators are slightly detuned from each other, some chorus effect occurs *within* footages, and further chorus effect *between* footages. For example, the note C played in three octaves, on the $16'\Delta$ footage, will not be in phase-locked or frequency-locked or precise harmonic relation, because all three tone-signals are derived from different primary tone-signal generators. Similarly, if the $16'\Delta$ and $8'\Delta$ footages are played simultaneously, notes of the same nomenclature in separate octaves do not have the same frequency composition or values.

Closure of any key switch results in transfer of all required tonal components of a given footage to one or more tone filters. The transfer takes place on an octaval basis, however, the octaval derivation of the tone array being maintained through the key switches, for each footage, and to and through the filters. These are also preferably arranged on an octaval basis, i.e. a separate filter

2

section is provided for each octave, taken on the basis of fundamentals, these being provided, however, with a common output terminal which leads to a stop switch. It is, of course, true that in some cases, several footages may proceed to a single filter, or several filters may be fed from a single footage. In any case, the octaval relation of the filter sections, the tonal arrays and the key switches is maintained throughout.

The stop switches lead via pre-amplifiers, with expression controls, to summing amplifiers, which sum outputs of the divisional pre-amplifiers to decrease the number of output channels to an economic minimum. Economic considerations dictate the extent to which radiators may be diversified; in addition, certain tonal types may be enhanced by application to rotor speakers, whereas others are not suitable for this treatment. A selective association of radiators with tone filters is accomplished, giving consideration to factors of cost, tone treatment, and beat production between normally-used-together voices which make up normal choruses of voices.

It is, accordingly, an object of the present invention to provide a novel electronic organ having inherent chorus effect, based on an octaval permutation of tonal derivation from among plural tone sources.

It is another object of the invention to provide a novel electronic organ having provision for optimum utilization of organ elements.

A further object of the invention resides in the provision of an electronic organ system employing multiple tone generators of tone signals of square wave form, from which are derived, by resistance matrixing, plural arrays of tones of triangular wave form, and wherein two tonal arrays having "chorus effect" capabilities are derived from the wave forms by octave permutation, wherein tone filtering proceeds on an octaval basis, and wherein the acoustic radiators are allocated to the tone filters on a basis which minimizes or reduces production of beats between low-order harmonics.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIGURES 1a and 1b are block diagrams which, taken in side-by-side relationship, comprise a complete organ system.

Referring now more particularly to FIGURES 1a and 1b of the accompanying drawings, reference numeral 10 denotes a primary tone-signal generator X, which provides primary tone-signals, hereinafter referred to as "tones," where tone 1 is the tone of lowest pitch available in the organ. The generator X is conventional in the art, has a range of 72 tones, and consists of 12 divider chains, each chain providing all the tones of any given nomenclature. The divider chains are flip-flop chains, so that the outputs of the primary tone generator X are square waves.

Reference numeral 11 denotes a primary tone generator Y, which provides the tones 13-84 of the musical scale, in square wave form, the structure of the generator being like that of generator X. Reference numeral 12 similarly denotes a primary tone generator which provides tones 25-97 in square wave form. The generators 10, 11 and 12, hereinafter called generators X, Y, Z, respectively, for convenience, are slightly detuned with respect to each other either deliberately, or are detuned as would be expected in the normal course of events because of the impossibility of precisely maintaining tuning between independent generators. Each generator is nominally at true pitch. If deliberate mis-tuning is introduced the mis-

tuning may be of any amount deemed pleasant, usually in the range of 1 to 6 cents (1 cent= $\frac{1}{100}$ of a semi-tone).

The single line 13 (in the drawings) represents in fact 72 conductors, one for each of tones 1-72, inclusive, the tones being of square wave form as indicated by the symbol $\square$ at line 13. The conductors 13a, similarly, convey the tones 13-84, inclusive, from generator Y in square wave form, and the conductors 13b convey the tones 25-97, inclusive, from generator Z, in square wave form.

Leads 13 proceed to emitter followers 14, one for each conductor; leads 13a proceed to emitter followers 20, one for each conductor; and leads 13b go to emitter followers 22, one for each conductor.

The emitter follower groups 14, 20, 22 proceed to resistance matrices 16, 21, 23, respectively, which are designed to provide on lead groups 17, 18, 25, 26, 27, 28 respectively, X $\square$, X Δ , Y $\square$, Y Δ , Z $\square$ and Z Δ arrays of tones, the identifying numerals of the tones being, respectively 1-72 $\square$, 1-72 Δ , 13-84 $\square$, 13-84 Δ , 25-97 $\square$ and 25-97 Δ . The Δ waves are formed in the matrices by suitable addition of square wave forms of suitable frequencies and amplitudes, while the square wave-shapes are the same as are provided by the generators X, Y, Z.

Leads 17, 18 proceed to section 30a of distribution board 30, leads 25, 26 to section 31a of distribution board 30 and leads 27, 28, to section 32a of distribution board 30. The distribution board maintains the identity of the square wave and triangular wave tones, but in cables at its output, which lead to key switches, permutes the tones from the separate generators, so that while the inputs to the board are properly identified by separate reference numerals, at the output cables of the board, taken as a group, any given tonal array starting from 1 and proceeding to 97, may be composed of tones partly derived from generator X, partly derived from generator Y and partly derived from generator Z. The permutation of primary tone generators for each of the different arrays derivable from the cables outgoing from the distribution board is as a general proposition, different from any other, where the arrays might be heard together.

Provision is made in a key switching arrangement for simultaneous key switching of tones originating from each of the tonal arrays deriving from the distribution board sections 30a, 31a, 32a. For example, in the pedal division of the organ, key switches identified by reference numeral 34 are provided for 16' Δ , 8' Δ , 8' $\square$, 4' $\square$, 2' Δ and 2 $\frac{2}{3}$ ' Δ , mixture (M), and a D.C. gating voltage. Upon depression of any pedal, accordingly, an array of switches 34 is concurrently closed, which pass tones appropriate to each of the available footages to succeeding headers, as 35. The input to the 16' Δ key switches derive from the generators XYZ, on an octaval basis, for fundamentals, in the order recited. Those to the 8' Δ switches derive from the generator YZX, on an octaval basis, in the order recited. Those for the 8' $\square$ wave switches derive from the generators XYZ, on an octaval basis, in the order recited, those for the 4' $\square$ switches from the generator ZXY in the order recited and those from the 2' Δ switches from the generators YZX in the order recited. Separate footages and the corresponding key switches of array 34 may be described by letters a to h, appended to the reference numeral 34. Switches 34h then provide D.C. gating voltage from a suitable source 35 to gates 36. To the gates are provided square wave tones 1 to 32, derived from the generators XYZ in that order, on an octaval basis. Accordingly, when one of switches 34h is closed, the appropriate gate 36 is closed, and an appropriate tone of square wave form is transmitted to the header 35i. Similarly headers 35a to 35g derive from the key switches 34a to 34g, respectively. In addition the outputs of certain of the headers 34a to 34h may be combined to form further tonal arrays, by combination of certain triangular with certain square wave tonal arrays available on the headers. For example, the 4' $\square$ tonal array available on header 35d and the 2' Δ tonal

array available on the header 35e may be applied to combiner 38, where they are combined in a matrixing arrangement from which may be derived a second set of P4 Δ waves on lead 38a. The square wave forms do not contain even harmonic components, whereas the triangular wave forms include both even and odd harmonic components. The two different types of wave shape are accordingly appropriate for different tonal characters and both types are desirable in an electronic organ.

As hereinabove recited, and in a manner similar to that described for the emitter followers 14 and summing matrices 16 appropriate to generator X, further emitter followers 20 and summing matrices 21 are provided in cascade with generator Y, and still further emitter followers 22 and summing matrices 23 in cascade with generator Z. The output of matrix 21 consists of a total of 72 tones of square wave form from the leads 25, and 72 tones of triangular wave form on the leads 26.

The output of the matrices 23 consists of 73 tones of square wave form on the leads 27, and 73 tones of triangular wave form on the leads 28. The tones on the leads 25 are identified as Y13-84 $\square$, the numerals identifying the order of the tone taken from the lowest tone in the organ, and those on the leads 26 as Y13-84 Δ . The tones on the leads 27 and 28 are identified as Z25-97 $\square$ and Z25-97 Δ , on the same basis.

Recapitulating, lead groups 17, 18 proceed to section 30a of distribution board 30, lead groups 25, 26 to section 31a of a distribution board 30 and lead groups 27, 28 to a section 32a of distribution board 30, but, in the cables at the output of distribution board 30 the tones from the respective generators are permuted so that, while the leads leave the matrices properly identified by separate reference numerals, they leave the distribution boards in a manner such that any given tonal array starting from 1 and proceeding to 97 may be composed of tones alternately derived on a consecutive basis from generators X, Y and Z. Thus the permutation of primary tone generators for each of the different arrays derivable from the distribution boards is, as a general proposition, different from any other array.

Provision is made in a key switching arrangement for simultaneous key switching of tones, originating from each of the tonal arrays deriving from the distribution board sections 30a, 31a, 32a. For example, in the pedal division of the organ, key switches identified by reference numeral 34 are provided for 16' Δ , 8' Δ , 8' $\square$, 4' $\square$, 2' Δ , 2 $\frac{2}{3}$ ' Δ , Mixture M, and a D.C. gating voltage for Mixture M. Upon depression of any pedal, accordingly, an array of switches 34 is concurrently closed, which pass tones appropriate to each of the available footages to succeeding headers, as 35. The input to the 16' Δ key switches derive from the generators XYZ, on an octaval basis, in the order recited (Bass to Treble). Those to the 8' Δ switches derive from the generator YZX, on an octaval basis, in the order recited. Those for the 8' $\square$ wave switches derive from the generators XYZ on an octaval basis, in the order recited, those for the 4' $\square$ switches from the generator ZXY in order recited, those from the 2' Δ switches from the generators YZX in order recited and those from the 2' switches from the generators ZXY in the order recited. Separate footages and the corresponding key switches of array 34 may be described by sub-script letters a to h, appended to the reference numeral 34. Switches 34h then provide D.C. gating voltage from a suitable source 35 to gates 36. To the gates are provided square wave tones 1 to 32, derived from the generators XYZ, in that order, on an octaval basis. Accordingly, when one contact of switch 34h is closed, the appropriate gate 36 is closed, and an appropriate tone of square wave form is transmitted to the header 35i. Headers 35a to 35h derive from the key switches 34a to 34h, respectively. In addition, the outputs of certain of the headers 35a to 35g and 35i may be combined to form

further tonal arrays, by combination of certain triangular with certain square-wave tonal arrays available on the headers. For example, the $4'\square$ tonal array available on header 35d and the $2'\Delta$ tonal array available on the header 35e may be applied to a combiner or matrixing arrangement 38 from which may be derived a set of $4'\Delta$ waves on lead 38. The Great and Swell key switches 40 and 41 and their headers 42, 43 are arranged like the pedal switches 34, and pedal headers 34. Tonal arrays derive from all the generators XYZ. Reference is made to FIGURE 1a for the composition of the tonal array on any one of the headers or at any one of the available footages of wave forms. Each one of the header arrays 35, 42, 43, is connected to a tone filter for forming the desired voice or tone color. The array of filters may be identified by the reference numeral 45. The inputs to the separate filters and the voice to be formed is indicated in FIGURE 1b, to which reference is made. It will be noted that certain of the filters have applied thereto a pair of headers, but that the majority of the filters are connected to only a single header. Each one of the filters is composed of plural filter sections, which have their pass frequencies different from one another, and which are independent at their inputs but parallel at their outputs. The fact that the tonal arrays, and key switches are maintained on an octave basis is necessary for the provision of octave filters. However, in principle, it is not essential that the filters be fed in octave groups, nor is it essential that the primary generators be permuted on an octave basis. While it is within the scope of the present invention to permute the generators on a semi-octave basis or on any other desired basis which may be economical or convenient, it is found that permutation on an octave basis provides advantages of tonal character and chorus effect in the organ on a reasonable cost basis, which does not appear to be attainable in any other way. It is further found that provision of filter sections, on an octave basis, or on some other basis, provides greatly improved flexibility in designing the tone filters, a flexibility which is absent where a single filter section is required to perform the entire tone coloring function.

Frequency response shifts from one filter section to another, within a group, may occur for ratios anywhere in the range 1.0 to 2.0, rather than precisely at 2.0 (octave). For example, in diapason stops a ratio of 1.7 to 1.8 may be employed. In reed stops, 1.2 to 1.4 may be employed.

Stop switches for the filters 45 are provided in the outputs of the filters and are generally indicated by the reference numeral 46. Provision of the stop switches at the outputs of the filters permits a single pole stop switch to be utilized for each stop, despite the fact that the input to the stop may include one or more wires leading to each of the filter sections employed. The outputs of the tone filters 45 as selected by the stop switches 46 are applied to an array of preamplifiers 47. Nine preamplifiers are employed in the presently described embodiment of the invention, although 36 stops are available, so that each one of the preamplifiers serves to amplify a group of voices. Selection is made on the basis that certain voices may be radiated from a single speaker, whereas other voices should not be radiated together but should be radiated from separate speakers, to avoid undesirable or unmusical effects, and further on the basis that certain types of tones are enhanced by radiation from a rotating reflector. On the other hand, other types of tones must be radiated in pure tone form without extraneous effect and hence must be radiated from stationary speakers. As a general proposition, the selection is made on the basis that the outputs of the preamplifiers 47 are to be summed in summing amplifiers, which in turn lead to acoustic radiators. In total, seven different output channels are provided, and accordingly seven sum-

ming amplifiers are required. For example, the Principal 16' stop, the Sub-bass 16' stop, the Octave 8' stop, the Bourdon 8' stop and the Posaune 16' stop are all collected in a single preamplifier 47-1, the output of which proceeds to a summing amplifier 48-1. The output of the summing amplifier 48-1 is radiated to radiator 49-1. No further treatment is accorded these stops, but the speakers utilized for these stops are not utilized for other stops. On the other hand, the Bourdon 8' stop, derived from a square wave, and the Octave 4' stop, derived from a triangular wave in the Great Division of the organ, are jointly applied to pre-amp 47-2, which leads to summing amplifier 48-2. This summing amplifier, however, also is provided with tones from pre-amp 47-3 which is connected to a considerable number of stops from the Swell division of the organ, some of which are triangular and some of square wave form. Selection is then made on the basis that the two sets of inputs to the summing amplifier 48-2 are not of similar harmonic content at the same footage level and that those inputs which may occur simultaneously, during playing of a musical composition from the Great and Swell division would give rise to a minimum of beats between low order harmonics due to slight detuning of the generators and due to tempered intervals or ratios in the equally tempered scale. The total number of speakers and summing amplifiers employed could readily be expanded with improvements in musical quality were it not for cost considerations. Ingenuity is utilized in selecting the distribution of stops to the separate speakers in order to achieve optimum utilization of a reasonable number of speakers for the number of stops employed, giving full effect to the consideration that beats between low order harmonics of any two stops which would frequently be played together, and which might give rise to such beats, should be avoided and the tones involved should therefore be diverted to diverse or different radiators. A further consideration is that certain of the speakers are rotary and certain of the speakers are not rotary. For example, speaker 49-6 is a rotary speaker. To it are applied a group of flue stops, from the Swell division, and from the Great division. On the other hand, certain stops, such as percussion, trumpet, oboe, clarinet, i.e. reed type instruments should be radiated without speaker rotation.

While I have described and illustrated one specific embodiment of my invention, it will be clear that variations 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 an electronic musical instrument, a plurality of tone generators, each tone generator providing a gamut of musical tones, the separate gamuts including plural tones of common nomenclature, means permutatively selecting groups of tones from all said gamuts to form a set of musically different coherent tone gamuts well ordered in the chromatic scale, whereby each of said coherent tone gamuts consist of an ordered array of tones selected from all of said plurality of tone generators, key switches for selecting related tones from each of said coherent tone gamuts, said sets being selectable in order and combination of selection by said key switches, separate tone color filter sections having input circuits connected to said key switches and each arranged to receive a different one of said groups of tones, and an acoustic output system connected to said tone color filters, wherein each group includes at least one tone.

2. The combination according to claim 1 wherein each of said groups of tones comprises one octave of tones.

3. In a musical instrument, means for forming an array of tones including plural octaves, a plurality of tone color filters, each of said tone color filters including a separate

filter section having an input circuit responsive to one of said octaves only, a common connection to all the outputs of the filter sections of each tone color filter, a plurality of tone color switches, acoustic radiators connected with said common connections via said switches, said acoustic radiators being individually connected to selected ones of said tone color filters, selection being accomplished to minimize acoustic radiation from a single radiator of tones capable of forming beats between low order harmonics of the tones passed by said tone color filters.

4. In a musical instrument, plural primary generators of first wave shapes arranged on a frequency basis corresponding with the chromatic scale, further plural sources of wave shapes comprising means for combining said first wave shapes to form said second wave shapes, said first and second wave shapes having respectively harmonic contents of different character, means for forming separate arrays of tones deriving from said primary independent generators and from said plural independent sources, each of said arrays of tones including a chromatic progression of tones formed of a group of tones selected from each of said generators and each of said sources in accordance with an essentially different permutation of tones for each progression, tone color filter arrays, each tone color filter array including a separate filter for each of said groups of tones which may be keyed thereto, keying means for selectively connecting said means for forming separate arrays of tones with said tone color filter according to the requirements of a musical composition, acoustic radiation system selective switches for at will connecting said tone color filters with said acoustic radiation system, said acoustic radiation system including plural radiators individually connected to selected ones of said tone color filters, selection being accomplished to minimize acoustic radiation from a single acoustic radiator of tones capable of forming beats between low order harmonics.

5. The combination according to claim 4 wherein each group of tones covers an octave.

6. In a musical instrument, plural primary independent generators of first musical tones in the chromatic scale, said first musical tones having substantially only odd order harmonics, further plural sources of tones comprising means for combining said first musical tones to form second musical tones in the chromatic scale, said second musical tones each including both even and odd harmonics proportioned in relative amplitudes to provide essentially sawtooth wave forms, means for forming separate arrays of tones deriving from said primary independent generators and from said plural independent sources, each of said arrays of tones including a chromatic progression of tones formed of a group of tones selected from each of said generators and each of said sources in accordance with an essentially different permutation of tones for each progression, tone color filter arrays, each tone color filter array including a separate filter for each of said groups of tones which may be keyed thereto, keying means for selectively connecting said means for forming separate arrays of tones with said tone color filters according to the requirements of a musical composition, an acoustic radiation system, selective switches for at will associating said tone color filters with said acoustic radiation system, said acoustic radiation system including plural radiators individually connected to selected ones of said tone color filters, selection being accomplished to minimize acoustic radiation from a single acoustic radiator of tones capable of forming beats between low order harmonics.

7. The combination according to claim 6 wherein said plural radiators include rotating radiators and stationary radiators, said stationary radiators being coupled to reed type stops.

8. The combination according to claim 6 wherein said means for forming separate arrays of tones includes a separate emitter follower amplifier having an input con-

nected to each of said generators and said sources, and a resistance matrix connected to the outputs of said emitter follower amplifiers.

9. In an electrode organ having a plurality of continuously-operating sources of signals corresponding to consecutive note of a musical scale,

- (a) a plurality of signal amplifiers respectively associated with said sources,
- (b) a lesser plurality of signal collectors for groups of consecutive signals,
- (c) a plurality of keying means respectively connecting said amplifiers to said collectors by groups,
- (d) a first plurality of signal filters equal in number to and respectively connected to said collectors,
- (e) first common stop means connected to said first plurality of filters, and
- (f) an output system connected to said first stop means.

10. The combination claimed in claim 9, wherein said sources comprise transistor flip-flops and wherein said signal amplifiers comprise emitter-follower transistor circuits.

- 11. The combination claimed in claim 10, including
 - (a) a second plurality of signal collectors for groups of consecutive signals,
 - (b) a second plurality of keying means connected in groups to said second plurality of collectors,
 - (c) a plurality of summing networks each connecting a plurality of sources to one of said second plurality of keying means,
 - (d) a second plurality of signal filters equal in number to and respectively connected to said second plurality of collectors, and
 - (e) second common stop means connecting said second plurality of signal filters to said output system.

- 12. In an electronic organ, the combination of
 - (a) at least one generating system having individual tone signal sources each providing both square waves and saw tooth waves at a particular note frequency,
 - (b) keying means including at least one switch for each note for square waves and at least one for saw-tooths,
 - (c) a plurality square-wave collecting means respectively associated with groups of adjacent key switches for square waves,
 - (d) a plurality of saw tooth collecting means respectively associated with groups of adjacent key switches for saw-tooths,
 - (e) at least one plurality of filters connected respectively to said square wave collecting means and having a common output,
 - (f) at least one plurality of filters connected respectively to said saw-tooth collecting means and having a common output,
 - (g) a stop switch for said square wave filter common output,
 - (h) a stop switch for said saw tooth filter common output,
 - (i) an output system associated with said stop switches.

13. The combination claimed in claim 12, wherein said output system comprises

- (a) an amplifier and loudspeaker associated with said square wave filter common output and
- (b) an amplifier and loudspeaker associated with saw-tooth filter common output.

14. In an electronic organ of the type wherein generator signals from a plurality of harmonically-related relatively-low-voltage square wave sources are summed at appropriate levels prior to keying for simulating a saw-tooth wave form, the combination comprising

- (a) a plurality of key switches respectively corresponding to said sources,
- (b) a plurality of emitter-follower transistor circuits respectively connecting said sources to said key switches through resistors in summing configurations,

9

- (c) a signal collector associated with said switches,
- (d) an output system, and
- (e) tone color means connected between said collector and said output system.

15. In an electronic organ having a plurality of continuously-operating sources of signals corresponding to consecutive notes of a musical scale, a plurality of signal amplifiers respectively associated with said sources, a lesser plurality of signal collectors for groups of consecutive signals, a plurality of keying means respectively connecting said amplifiers to said collectors by groups, a first plurality of signal filters equal to and respectively connected to said collectors, first common stop means connected to said first plurality of filters, and an output system connected to said first stop means.

16. The combination claimed in claim 15, wherein said sources comprise transistor flip-flops and wherein said signal amplifiers comprises emitter-follower transistor circuits.

17. The combination claimed in claim 16, including a second plurality of signal collectors for groups of consecutive signals, a second plurality of keying means connected in groups to said second plurality of collectors, a plurality of summing networks each connecting a plurality of sources to one of said second plurality of keying means, a second plurality of signal filters equal to and respectively connected to said second plurality of collectors, and second common stop means connecting said second plurality of signal filters to said output system.

18. In an electronic organ of the type wherein generator signals from a plurality of harmonically-related relatively-low-voltage square wave sources are summed at appropriate levels prior to keying for simulating a saw-tooth wave form, the combination comprising:

- (a) a plurality of key switches respectively corresponding to said sources,
- (b) a plurality of emitter-follower transistor circuits respectively connecting said sources to said key switches through resistors in summing configurations,
- (c) a signal collector associated with said switches,
- (d) an output system, and
- (e) tone color means connected between said collector and said output system.

10

19. In an electronic organ, the combination comprising:

- (a) a plurality of square wave sources respectively corresponding in frequency to notes of a musical scale,
- (b) a plurality of emitter-follower circuits respectively connected to said sources,
- (c) a plurality of first key switches corresponding to said sources,
- (d) a plurality of decoupling resistors respectively connected between said emitter-follower circuits and said key switches,
- (e) a plurality of summing resistors respectively connected between emitter-follower circuits of higher-octave sources and key switches nominally corresponding to said sources, and
- (f) signal collecting means connected to said key switches,
- (g) tone color means connected to said collecting means, and
- (h) electroacoustic output means connected to said tone color means.

20. The combination claimed in claim 19 including

- (a) a second plurality of key switches respectively corresponding to said sources and arranged for substantially simultaneous action therewith,
- (b) a second plurality of decoupling resistors respectively connected between said emitter follower circuits and said second plurality of key switches,
- (c) second signal collecting means connected to said second plurality of key switches, and
- (d) further tone color means connected between said second signal collecting means and said output system.

21. The combination claimed in claim 19, wherein said signal collecting means comprises:

- (a) a collector for each octave of consecutive key switches, and wherein said tone color means comprises
- (b) a tone color circuit for each of said collectors.

No references cited.

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