April 13, 1965 H. O. SCHWARTZ ETAL 3,178,500

PREFERENCE NETWORK

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Fig. 1.

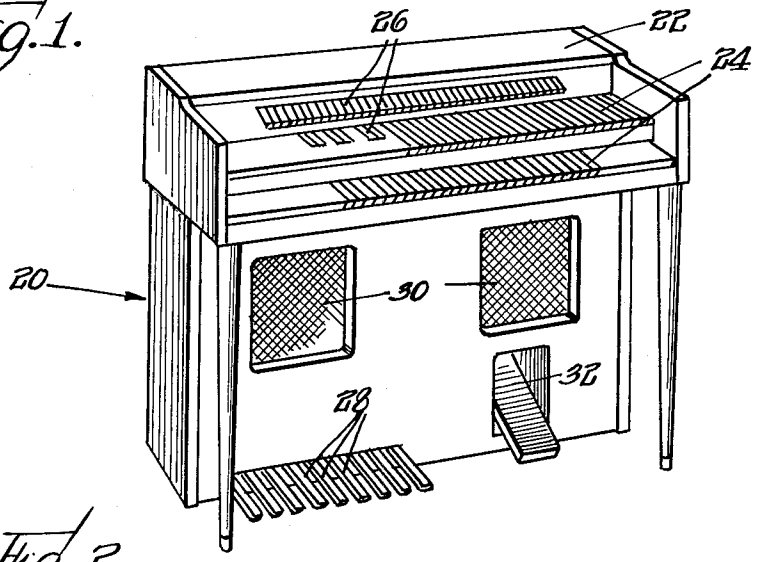

Fig. 2.

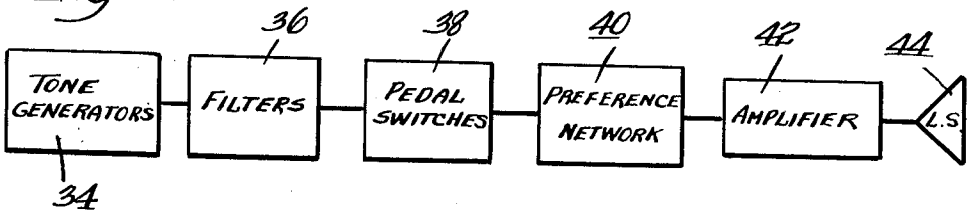

Fig. 3.

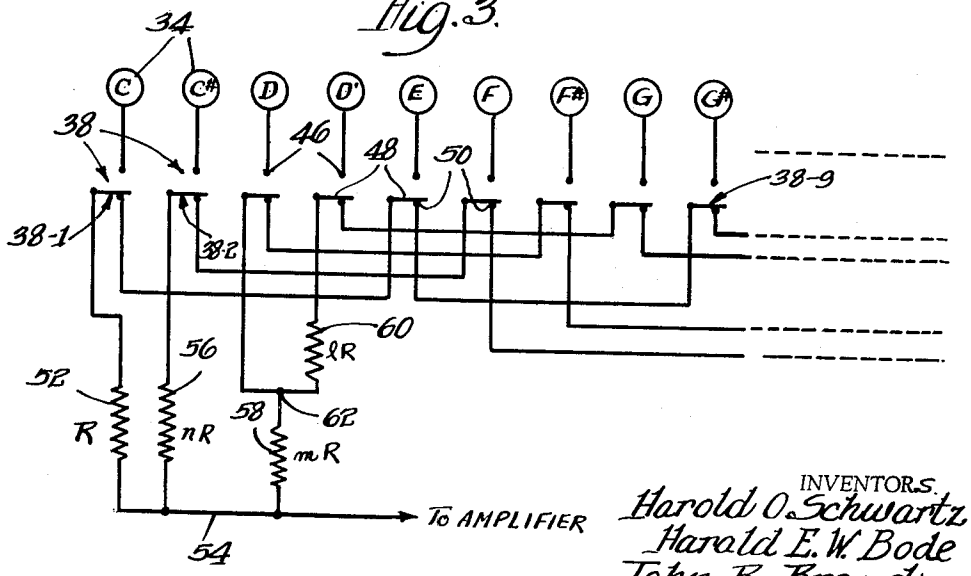

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Fig. 4.

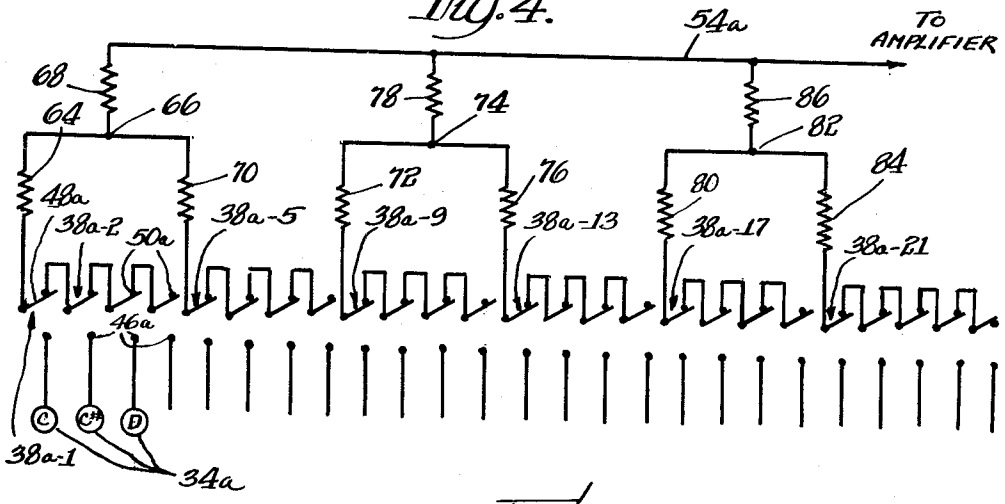


Fig. 5.

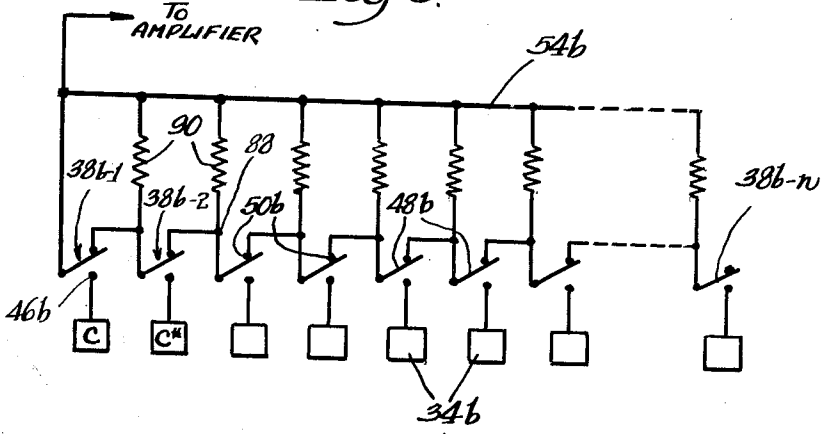
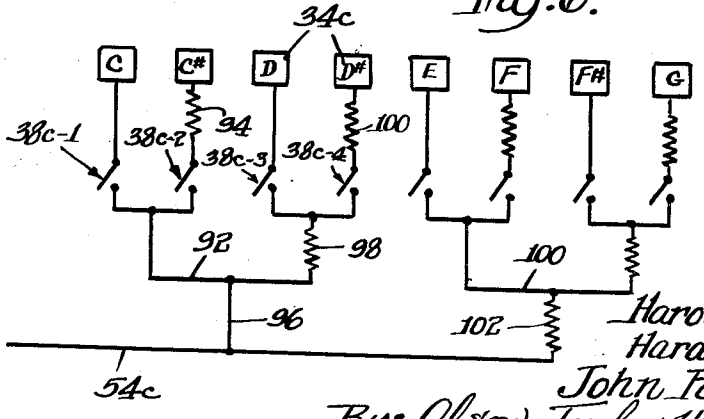


Fig. 6.



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PREFERENCE NETWORK

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Fig. 7.

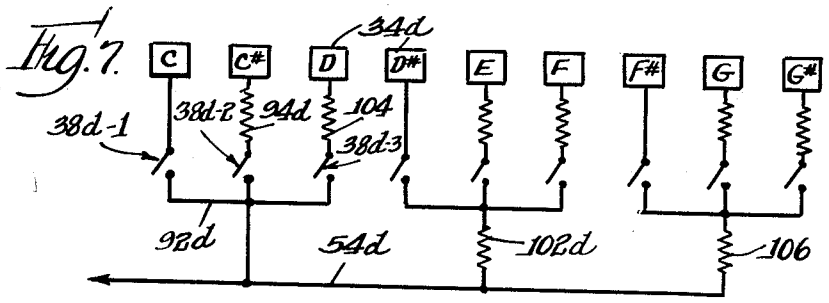


Fig. 8.

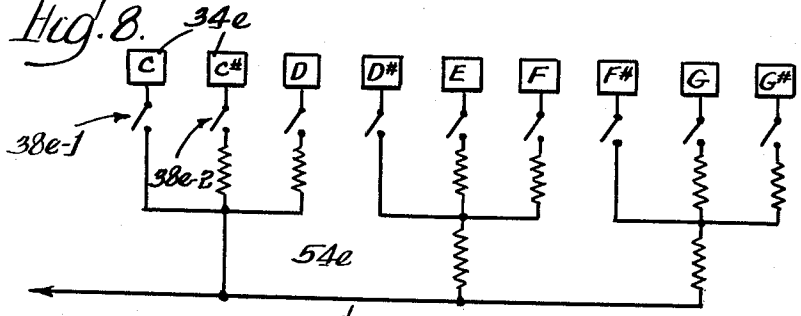


Fig. 9.

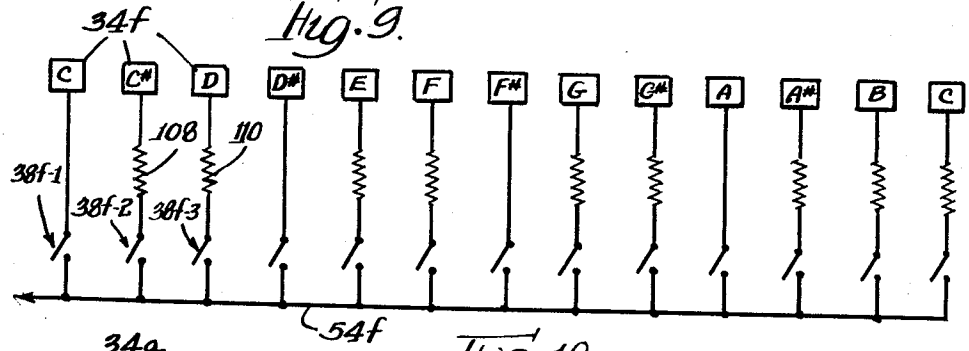
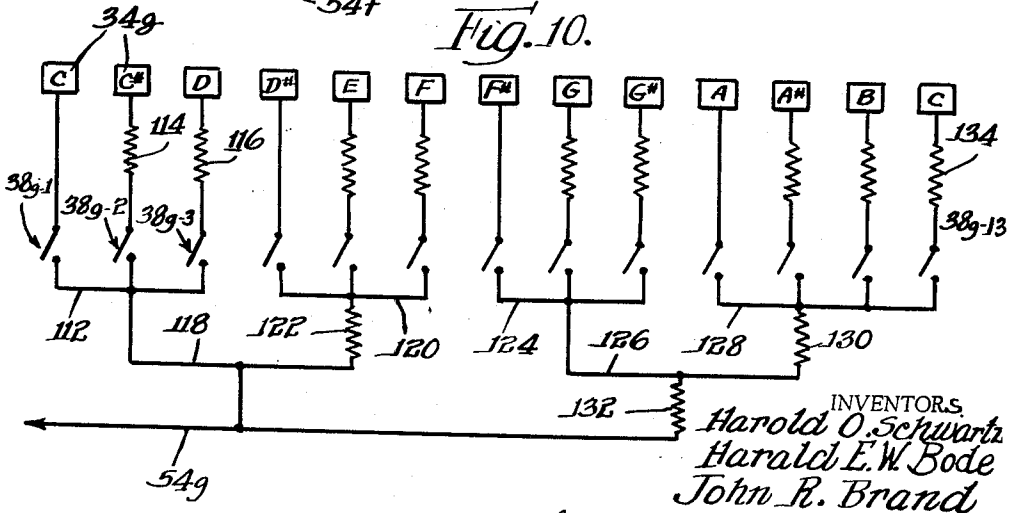


Fig. 10.



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3,178,500

PREFERENCE NETWORK

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Filed June 26, 1962, Ser. No. 205,378
14 Claims. (Cl. 84—1.01)

This invention relates to the electrical reproduction of music, and particularly to a preference circuit for use therein.

As is well known, adjacent notes of a musical instrument if played at the same time, particularly in the case of pedal notes of an organ, produce objectionable beats between them, seriously detracting from the quality of the music being played. Accordingly, it is the custom, particularly in pedal notes, to avoid playing adjacent notes concurrently. Unfortunately, even a skilled musician on occasion may accidentally engage two adjacent keys of pedals simultaneously. The problem is particularly acute in the case of a novice.

Accordingly, it heretofore has been proposed to provide switching arrangements in an electronic musical instrument positively to prevent the playing of adjacent notes, even though the keys or pedals therefor might simultaneously be depressed. The most common such switching arrangement utilized a plurality of single-pole, double-throw switches. The switches are wired in series, and any switch that is moved from the "off" to the "on" position by depression of its corresponding key or pedal automatically removes from the circuit all of the switches corresponding to higher notes. Thus, only the lowest note of all the notes incorporated in the switching arrangement will play, regardless of the number of switches actuated. Obviously, the arrangement can be reversed so that only the highest note will play. Such a switching arrangement is prone to malfunctioning due to the large number of series-connected contacts. Each series contact multiplies the chances of malfunctioning due to corrosion and dirt on contact surfaces, breakage of contact arms, etc.

Another preference switching network has been proposed in which there is provided a series of resistors connected to the input of an amplifier. Tone generators, each having an impedance which is low relative to one of the series resistors, are respectively connected to ground and to junctions between successive pairs of the series resistors, thus producing a ladder type network. This preference network is in many respects entirely suitable, but it does have a rather considerable buildup of resistance, whereby the oscillations from the generator most remote from the amplifier input must travel through a very large resistance or impedance relative to that through which the oscillations of the nearest generator must pass.

It is an object of this invention to provide new and improved preference networks for electronic musical instruments.

It is another object of this invention to provide a preference network in an electronic musical instrument using a minimum number of impedance elements.

Yet another object of this invention is to provide impedance networks for an electronic musical instrument in which there is little buildup of impedance from the first note to the last. Still another object of this invention is to provide a preference network in an electronic musical instrument utilizing series-connected, single-pole, double-throw switches, so connected as to minimuze chances of malfunctioning.

Other and further objects and advantages of the present invention will be apparent from the following description when taken in connection with the accompanying drawings wherein:

FIG. 1 is a perspective view of an electronic organ embodying the principles of this invention;

FIG. 2 is a block diagram illustrating the electrical aspects of the organ;

FIG. 3 is a schematic wiring diagram of one preference network in accordance with the principles of this invention; and

FIGS. 4–10 respectively are schematic wiring diagrams of various preference networks in accordance with the present invention.

Reference now should be had to FIG. 1 wherein there is shown an electronic organ generally designated by the numeral 20 and comprising a console, housing or case 22 having two keyboards 24 thereon, as well as a plurality of stop tablets 26 and a pedal clavier comprising a plurality of pedals 28. The console has suitable loudspeakers disposed behind grills 30, and also has a swell pedal 32.

The electrical aspects of the invention are illustrated in FIG. 2 wherein the tone generators are identified at 34. The tone generators are connected to the filters 36, and these in turn are connected to the pedal switches 38. The pedal switches are interconnected with the preference network 40 which leads to the amplifier 42. The amplifier is connected to the loudspeaker 44. The switches for the keys 24 have been omitted for clarity of illustration. It will be appreciated that the showing of the pedal switches and the preference network is somewhat arbitrary, since the pedal switches actually are a portion of the preference networks. Furthermore, it will be appreciated that it is immaterial from the standpoint of the present invention whether the filters are connected between the tone generators and pedal switches, as shown in FIG. 2, or are incorporated in the amplifier 42 or between the amplifier and a pre-amplifier. In subsequent figures, the tone generators are shown as directly connected to the preference network or pedal switches without the intervening filters.

Referring now to FIG. 3, there will be seen a plurality of tone generators 34. Tone generators are shown specifically from note C to G♯ of the same octave. However, it will be understood that any number of notes could be included in the preference network. Typically, the number of notes would be the semi-tones corresponding to the pedals 28. Usually, thirteen such pedals are provided, corresponding to an octave plus one semi-tone.

A plurality of single-pole, double-throw switches 38 is provided, one for each note, the switches respectively being identified as 38–1, 38–2, etc. Each switch has a fixed contact 46 connected to the respective note or tone generator 34, and a movable switch contact 48 normally out of engagement with the respective fixed contact 46. Each switch further includes a fixed contact 50 normally engaged by the corresponding movable contact or switch arm 48.

The switch arm 48 of the first switch 38–1 is connected through a resistor 52 having a value R to a collector or bus line 54 leading to the amplifier. The movable switch arm of the second switch 38–2 is connected to the line 54 through a resistor 56 of greater value, indicated as nR.

The movable switch arm of the third switch 38–3 is connected through a higher valued resistor 58, indicated as mR, to the line 54. The movable switch arm of the fourth switch 38–4 is connected through a resistor 60 of value 1R to the junction 62 between the top of the resistor 58 and the arm 48 of the third switch 38–3.

The fifth movable switch arm is connected directly to the fixed contact 50 of the first switch 38–1. Similarly, the sixth movable switch arm is directly connected to the fixed contact 50 of the second switch 38–2. Each succeeding switch arm is directly connected back to the fifth preceding fixed contact 50.

If the first switch 38–1 is operated, obviously the C note will play. If any other switch is operated alone, the note corresponding thereto will play. If the switches 38–1 and 38–2 are simultaneously operated, it being understood that the generators 34 are of low impedance relative to the resistors 52, 56, etc., the C note will play at a relatively high intensity, while the C♯ note, due to the *n* times higher resistance of the resistor 56, and the voltage divider action of the generators and their respective resistors, will play at a much lower volume level, and will be masked by the C note. Hence, there is a preference in favor of the lower note.

Similarly, should the D note be played with either or both of the C and C♯ notes, the lower or lowest note will play, due to the higher resistance of the resistor 58. When the switch corresponding to the D♯ note is operated, the resistor 60 provides a preference between the D note and the D♯ note. Being in series with the resistor 58 58, the resistor 60 augments the preference of the C and C♯ notes relative to the D♯ note.

Subsequent notes are subjected to the preference action just described through the connection of each fifth note in series with one of the four impedance elements. This produces a preference network which provides a low note preference among the first four notes and each succeeding group of four notes, but which is at random relative to the entire selection of tone generators and switches.

Reference now should be had to FIG. 4 wherein a somewhat different preference network is shown. Many parts are similar to those heretofore shown and described, and similar numerals are utilized with the addition of the suffix *a*, to identify similar parts, in this instance, a plurality of generators 34*a* numbering twenty-five is shown for purposes of illustration. A plurality of single-pole, double-throw switches 38*a* is employed, and these switches are respectively identified as 38*a*–1, 38*a*–2, etc. One fixed contact 46*a* of each such switch is connected to a respective tone generator 34*a*. The switch arm 48*a* of the first switch 38*a*–1 is connected to a resistor 64 leading to a junction 66. A resistor 68 is connected from the junction 66 to a collector or bus 54*a*. The movable switch arm of the fifth switch 38*a*–5 is connected through a resistor 70 to the junction 66. The resistor 70 is of higher value than the resistor 64 in order to afford a preference in fiavor of any note oscillations connected through the resistor 64.

The movable switch arms of the second, third and fourth switches are respectively connected to the last preceding fixed switch contact 50*a*. Thus, a preference is provided for the lowest of any of the first four notes through the single-pole, double-throw switch circuitry without the necessity of more than three series-connected switches. A similar preference is afforded amongst the next group of four switches and accompanying tone generators.

As will be observed, the series switch arrangement is interrupted between the fourth and fifth switches. It is interrupted again between the eighth and ninth switches, and the movable switch arm of the ninth switch 38*a*–9 is connected to a resistor 72 leading to a junction 74. There is another break between the twelfth and thirteenth switches, and the movable switch arm of switch 38*a*–13 is connected through a resistor 76 to the junction 74. The junction 74 is connected through a resistor 78 to the collector or bus 54*a*.

Similar breaks are provided after each four switches, and the movable contacts of the switches immediately succeeding the breaks are connected through resistors to a junction which connects through a resistor to the collector 54*a*. For example, the movable arm of the switch 38*a*–17 is connected through a resistor 80 to a junction 82, and the movable arm of the switch 38*a*–21 is connected through a resistor 84 to the junction 82. The junction 82 is connected through a resistor 56 to the collector 54*a*.

The various resistors referred to are correlated in valve so as to give a preference to the lowest group in each instance, and preference among the notes of each group is afforded by the series-connected single-pole, double-throw switches. It will be observed in no instance can more than three tone generators possibly be rendered silent by failure of a series switch, due to the inclusion of only four generators in each group. Meanwhile only a rather small number of resistors is required for the network.

A further preference network is shown in FIG. 5. Similar numerals again are used to identify similar parts, with the suffix *b* being added in this instance. A plurality of single-pole, double-throw switches 38*b*, respectively labeled 38*b*–1, 38*b*–2, etc. is provided, one fixed contact 46*b* of each being connected to the respective tone generator 34*b*. The other fixed contact 50*b* of each switch is connected at 88 to the movable switch contact 48*b* of the next switch above. The movable contact of the first switch 38*b*–1 is connected directly to the collector 54*b*. Each of the movable switch contacts of the remaining switches 38*b*–2 through 38*b*–*n* is connected through a resistor 90 to the collector 54*b*. Each of these resistors is of the same value, for example, one megohm.

If all of the series-connected switch sections were to be removed, a conventional circuit would remain in which there would be no preference, except that the one lowest note would take preference over all other notes. Conversely, if all of the resistors 90 were removed, the standard series connection low note preference circuit would remain. With the switches and resistors together, the pedals all continue to function in the event of a switch failure. In the event of a series switch failure, a preference will continue in effect on most, if not all of the notes. Furthermore, there is no buildup of series resistance.

A further modification of the invention is shown in FIG. 6. Similar parts again are identified by similar numericals with the addition of the suffix *c*. In this embodiment of the invention, single-pole, single-throw switches are used. The lowest tone generator 34*c* is connected through a normal open switch 38*c*–1 to a bus or sub-collector 92. The second tone generator is connected through a resistor 94 and a switch 98*c*–2 to the bus 92. This bus is connected by a line 96 to the collector 54*c*.

The third generator is connected through the third switch 38*c*–3 to the top of a resistor 98 leading to the bus 92. The fourth generator is connected through a resistor 100 and a switch 38*c*–4 to the resistor 98.

The next four notes are similarly connected, but the connection is made from the bus or sub-collector 54*c* through a resistor 102.

It will be appreciated that preference is afforded between each pair of notes by the resistor connected to the second note or tone generator of the pair of notes. For example, in the illustrative embodiment, the C note takes preference over the C♯ note due to the resistor 94, etc. In each set of four notes, the first pair takes preference over the second pair by virtue of the resistor connected to the second pair, for example, the resistor 98.

Between successive sets of four notes, the first four have preference due to the resistor connected to the second four note or tone generators, for example, the resistor 102. Further preferencing can be obtained by connecting eight additional notes in the same manner as disclosed for the first eight, with the common collector therefore connected to the collector 54*c* through a resistor. The first group of eight notes thus would take preference over the second group of eight notes, and preference among each group would be in the manner just described.

The resistor in each pair of resistors, for example, the resistor 94, for illustrative purposes may be considered to be 33,000 ohms. The second resistor of each group, for example the resistor 98, is on the order of 100,000

ohms, while the resistor 102 is on the order of 390,000 ohms.

The network just described in connection with FIG. 6 may be termed a "tree" configuration. Another tree configuration network is shown in FIG. 7. Similar parts are again identified by similar numerals with the suffix *d*. The circuit is quite similar to that described in connection with FIG. 6 except that the generators are in sets of three rather than in pairs. Thus, the first or C generator 34*d* is connected through a switch 38*d*–1 to a bus 92*d*. The C♯ note is connected through a resistor 94*d* and switch 38*d*–2 to the bus 92*d*. The third or D generator is also connected through a resistor 104 and switch 38*d*–3 to the bus 92*d*. The resistor 104 is of rather substantially higher value than the resistor 94*d* to provide preference for the C♯ note over the D note. For illustrative purposes, the resistor 94*d* might be 33,000 ohms and the resistor 104 might be 100,000 ohms. Similar values prevail for the other resistors connected to the generators in FIG. 7.

The resistor 102*d* may be 330,000 ohms, while the resistor 106 connected to the third set of generators might be 1.2 megohms.

The circuit of FIG. 8 is substantially the same as that of FIG. 7 except that the switches are disposed directly at the tone generators, i.e., between the tone generators and resistors, rather than on the remote sides of the resistor. The illustrative values are the same, and similar parts are identified by similar numerals with the addition of the suffix *e*. Further description of this circuit is believed to be unnecessary.

A further embodiment of the invention is shown in FIG. 9. This embodiment provides preference among groups of three notes, but not among the entire group of tone generators. It is intended for use in a single note pedal clavier which is to be played with one foot only. Various parts are similar to those heretofore shown and described, and are identified by similar numerals with the addition of the suffix *f*.

The first generator is indicated as that for the note C, and it is directly connected to a single-pole, single-throw switch 38*f*–1, which is directly connected to the collector 54*f*. The second tone generator is connected through a resistor 108 to the switch 38*f*–2, which in turn is connected to the collector 54*f*. The third tone generator also is connected through a resistor 110 to the switch 38*f*–3, which is in turn connected to the collector 54*f*. The resistor 110 is of substantially higher resistance than the resistor 108. For example, the resistor 108 may be 30,000 ohms and the resistor 110 may be 100,000 ohms. Thus, the second or C♯ note will take preference over the third or D note if both of the switches 38*f*–2 and 38*f*–3 are closed at the same time. The direct connection of the first or C generator to the switch 38*f*–1 causes this note to take preference over the C♯ and D notes.

The remainder of the generators are connected in similar groups of three, i.e., with no resistors, with a low resistance, and with a relatively high resistance, to give successive three note preference groups. Obviously, the groups could be extended above three in number by the use of further resistors of successively higher values.

Yet another embodiment of the invention is shown in FIG. 10, again using single-pole switches. Similar parts are again identified by the use of similar numerals, this time with the addition of the suffix *g*. The first tone generator, indicated as for the note C, is directly connected to the switch 38*g*–1, and this switch is connected to a sub-collector 112. The second tone generator is connected through a resistor 114 of rather low value, for example, 33,000 ohms, to the switch 38*g*–2 and the opposite side of the switch is connected to the sub-collector 112. The third tone generator is connected through a resistor 116 of relatively higher value, for example, 100.000 ohms, to the switch 38*g*–3. The opposite side of the switch is connected to the sub-collector 112. The sub-collector 112 is connected to a bus 118.

The next three notes, D♯ through F, are connected the same way as previously described through notes C–D to a sub-collector 120. This sub-collector is connected through a resistor 122 of higher value, for example 330,000 ohms, to the bus 118. The bus 118 is directly connected to the collector 54*g*.

The next three notes, F♯–G♯, are connected in the same manner as the first three notes to a sub-collector 124, which is directly connected to a bus 126. The next three notes, A–B, are also similarly connected to a sub-collector 128. This sub-collector is connected through a resistor 130 to a bus 126. The resistor 130 is of the same value as the resistor 122, or 330,000 ohms. The bus 126 is connected through a resistor 132 of relatively highest value, for example 1.2 megohms, to the collector 54*g*.

The fourth note, indicated as C, is connected through a resistor 134 to the switch 38*g*–13 to the sub-collector 128. The resistor 134 is of higher value than any of the others connected to the generators, and for example, is 330,000 ohms.

The network of FIG. 10 provides preference for the lowest note for any two or more key or pedal switches that might be closed. As will be understood, the resistor 132 could be omitted to provide preference only among the lowest six notes and among the top seven notes. In such a case, if the switches were to be closed for two adjacent notes at the border between such groups, preference would be given to the higher of the two notes.

In all of the preference networks heretofore shown and described, preference is given to the lowest note. Obviously the connections could be reversed to provide preference for the highest note. In many of the circuits, there are no series switches to cause possible malfunctioning. In others, series switch are kept to a minimum. Furthermore, in each instance, buildup of resistance from one note to another is held to a minimum. All of the circuits prevent the playing of two adjacent notes, to the extent disclosed.

It will be appreciated that all of the resistors of adjacent notes are in a generally shunting arrangement. Indeed, the networks might all properly be described as shunt networks, inasmuch as there are only a few resistors that are ever in series with any other and even these are in shunt with other similar resistors. It further will be appreciated that where a direct connection (a zero value resistor) is shown, there could be inserted a resistor of finite value greater than zero and less than the value of the adjacent resistor over which preference is to be taken without departing from the ambit of this invention.

The several embodiments of the invention disclosed will be understood as being for illustrative purposes only. Various changes in structure will no doubt occur to those skilled in the art and will be understood as forming a part of the present invention insofar as they fall within the spirit and scope of the appended claims.

This invention is claimed as follows:

1. In an electronic musical instrument of the type having a plurality of tone generators respectively generating electric oscillations corresponding to musical tones and further having output means including amplifier means and electro-acoustic transducing means connected thereto, the combination with said tone generator and said output means of a preference network comprising a plurality of resistors corresponding to at least some of said tone generators, first connecting means connecting said resistors to at least some of said tone generators, and second connecting means connecting said resistors to said output means, at least one of said first and second connecting means comprising a plurality of manually operable switches, the number of said switches being substantially equal to the number of said tone generators and each being electrically connected to at least one respective tone generator, at least some of said plurality

of resistors being connected substantially in parallel from respective tone generators to said output means.

2. The combination as set forth in claim 1 wherein at least two successive resistors are of nominally different values.

3. In an electronic musical instrument of the type having a plurality of tone generators respectively generating electric oscillations corresponding to musical tones and further having output means including amplifier means and electro-acoustic transducing means connected thereto, the combination with said tone generator and said output means of a preference network comprising a plurality of single-pole double-throw switches substantially equal in number to said tone generators and each having first and second fixed contacts and a movable contact, the first fixed contact of each of said switches being connected to a respective one of said tone generators, a plurality of resistors, means connecting said resistors to said output means, means connecting said resistors to the movable contacts of at least some of said switches, said movable contacts normally engaging said second fixed contacts and being manually movable therefrom into engagement with said first fixed contacts, at least some of said second fixed contacts being connected to movable contacts of other of said switches.

4. The combination set forth in claim 3 wherein the plurality of resistors is less in number than the plurality of tone generators, and wherein successive resistors are of successively greater value.

5. The combination set forth in claim 4 wherein at least two resistors are directly connected to the movable contacts of corresponding switches, and wherein at least one additional resistor is connected in series between a movable switch contact and another resistor.

6. The combination set forth in claim 3 wherein the switches are arranged in groups, there being one resistor for each group connected to the movable contact of a switch at one end of said group, all of the switches in a group being connected in series, there being an open circuit between the last switch of one group and the first switch of the next group.

7. The combination set forth in claim 6 wherein there is provided a plurality of collectors, a plurality of said resistors being connected to each collector, and further including resistance means connecting said collectors to said output means.

8. The combination set forth in claim 7 wherein the resistance means comprises a plurality of resistors respectively connecting the collectors to said output means.

9. In an electronic musical instrument of the type having a plurality of tone generators respectively generating electric oscillations corresponding to musical tones and further having output means including amplifier means and electro-acoustic transducing means connected thereto, the combination with said tone generator and said output means of a preference network comprising a plurality of manually operable single-pole single-throw switches substantially equal in number to said tone generators, and a plurality of substantially parallel circuit means respectively including said single-pole single-throw switches connecting said tone generators and said output means, adjacent circuit means being of different resistance.

10. The combination set forth in claim 9 wherein the resistors of said circuit means repeats cyclically.

11. The combination set forth in claim 10 and further including a plurality of collectors, the circuit means being connected in groups to said collectors, the circuit means of each group increasing in resistance from one to another, said groups being similar, and additional circuit means connecting said collectors to said output means.

12. The combination set forth in claim 11 wherein the additional circuit means comprises a plurality of circuit means respectively connected between said collectors and said output means, said last mentioned plurality of circuit means having different resistances.

13. In an electronic music instrument of the type having a plurality of tone generators respectively generating electric oscillations corresponding to musical tones and further having output means including amplifier means and electroacoustic transducing means connected thereto, the combination with said tone generator and said output means of a preference network comprising a plurality of first resistors, a plurality of manually operable switch means, a plurality of first collectors, said tone generators being connected in groups to said first collectors respectively by said first resistors and switch means, said first resistors of each group differing in value, and each having a finite value of zero or greater, second collector means, and a plurality of second resistors respectively connecting a plurality of said first collectors to said second collector means, adjacent second resistors being of different value and having a value of zero of greater, said second collector means being connected to said output means.

14. The combination set forth in claim 13 wherein the second collector means comprises a plurality of second collectors, and further including third collector means, and a plurality of third resistors respectively connecting the second collectors to the third collector means, the third resistors differing in value and each having a value of zero or greater, said third collector means being connected to said output means.

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