

[54] **CHORD TONE GENERATOR CONTROL SYSTEM**

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[51] Int. Cl. **G10h 1/00**
[58] Field of Search .. **84/DIG. 22, DIG. 2, 1.03, 1.17, 84/1.22, 1.24; 331/2, 48, 177, 179, 187**

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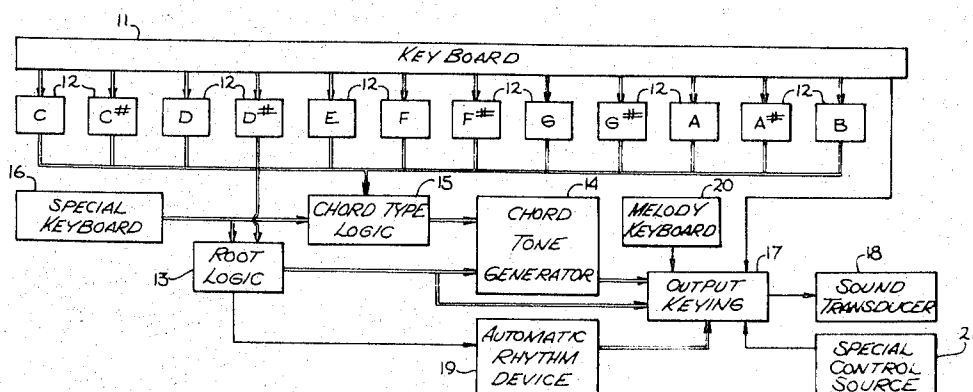
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[57] **ABSTRACT**

Apparatus for playing chords and bass which has a chord tone generator tuned for different root notes by logic devices sensing the playing keys actuated and controlled for different chord types by other logic devices responsive to the first logic devices and actuated playing keys. Specially controlled keyers respond to the root note and the highest pitch playing key actuated to sound sets of outputs in pitch locations according to selected relations that include close and open harmony and direct correspondence. The keyers further pass outputs within a given pitch range to a modulator driven by an automatic rhythm device to sound them in rhythmic patterns. The automatic rhythm device further controls the sounding of other outputs one at a time in a bass register. Special controls are also used to tune for root, control for type, and select pitch locations for sounding.

25 Claims, 6 Drawing Figures



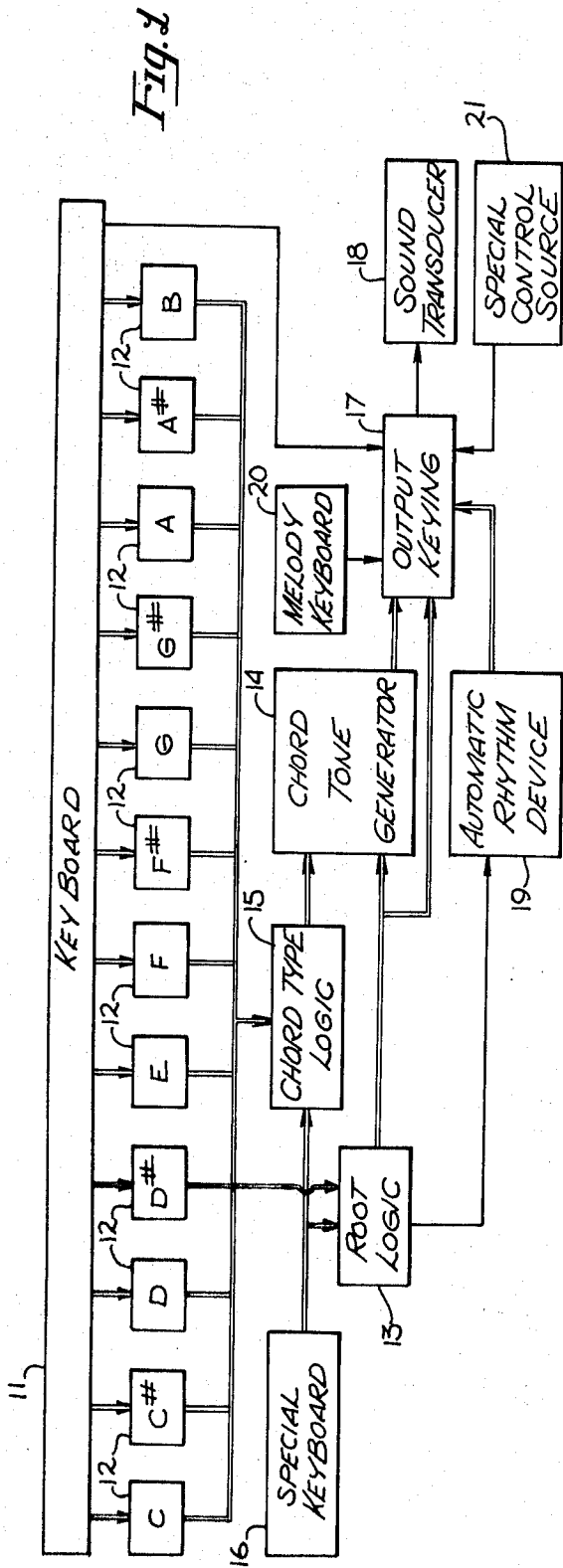


Fig. 3

NOTE	INHIBITS DRIVERS	DRIVER GATED TO BUSSES BY:			
C	D#	46	47	48	49
C#	E	D#	F	G	F#
D	F	F#	F	G	G#
D#	F#	G	F#	A	G#
E	G	G#	G	A	A#
F	G#	A	G#	B	A#
F#	A	A#	A#	B	C
G	A#	B	A#	C#	C
G#	B	C	B	C#	D
A	C	C#	C	D#	D
A#	C#	D	C#	D	E
B	D	D#	D#	F	F#

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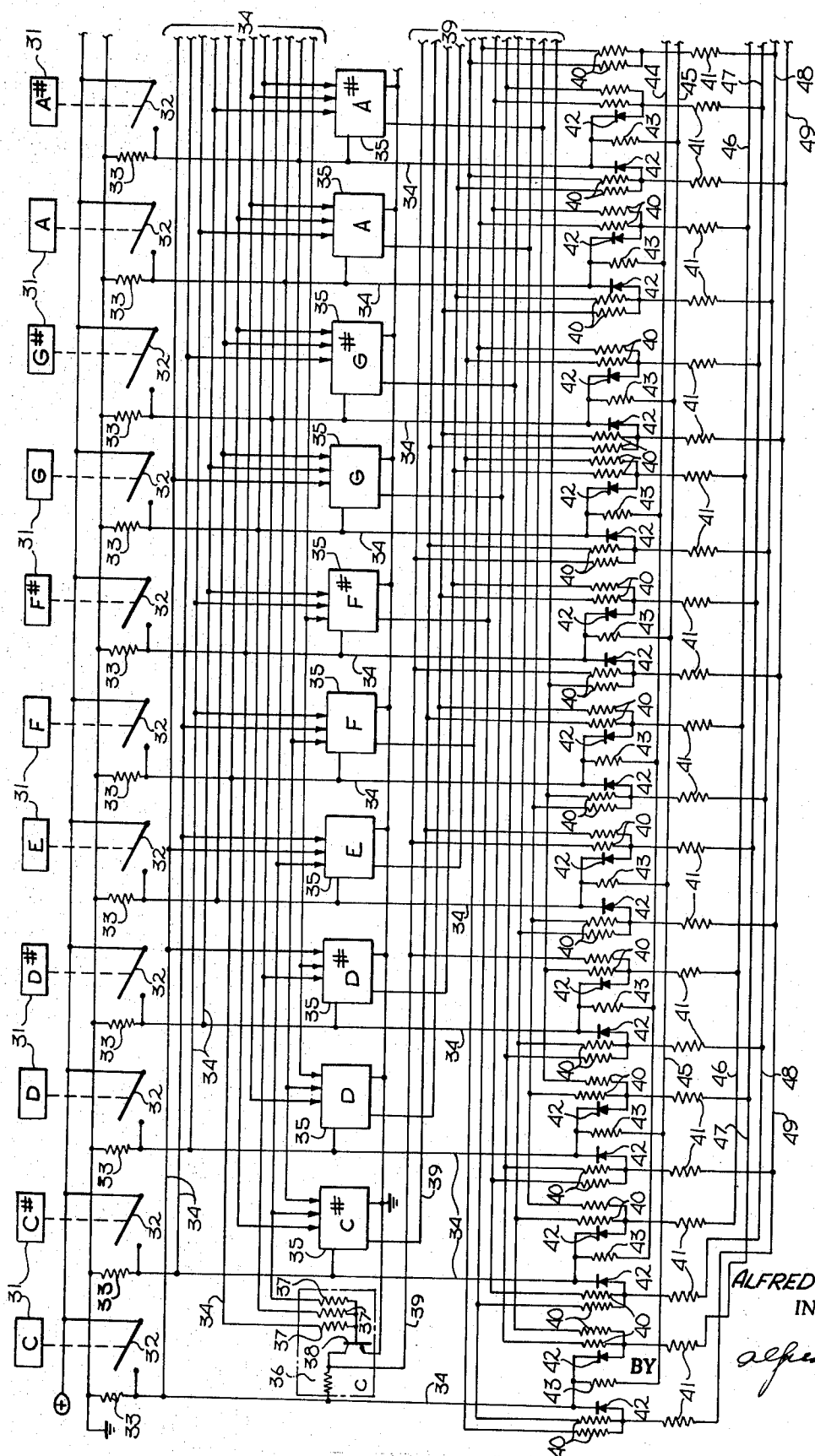
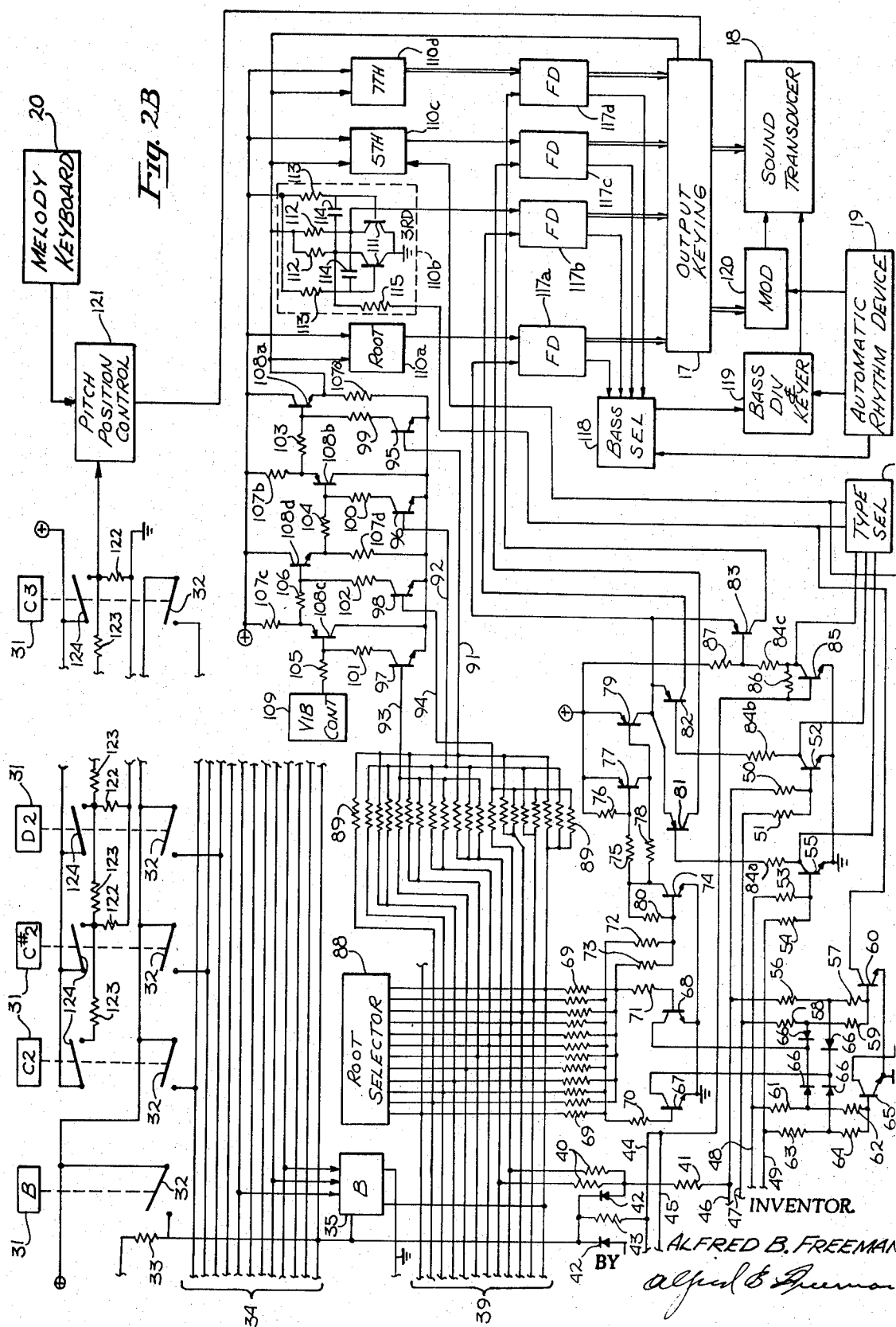


Fig. 2a

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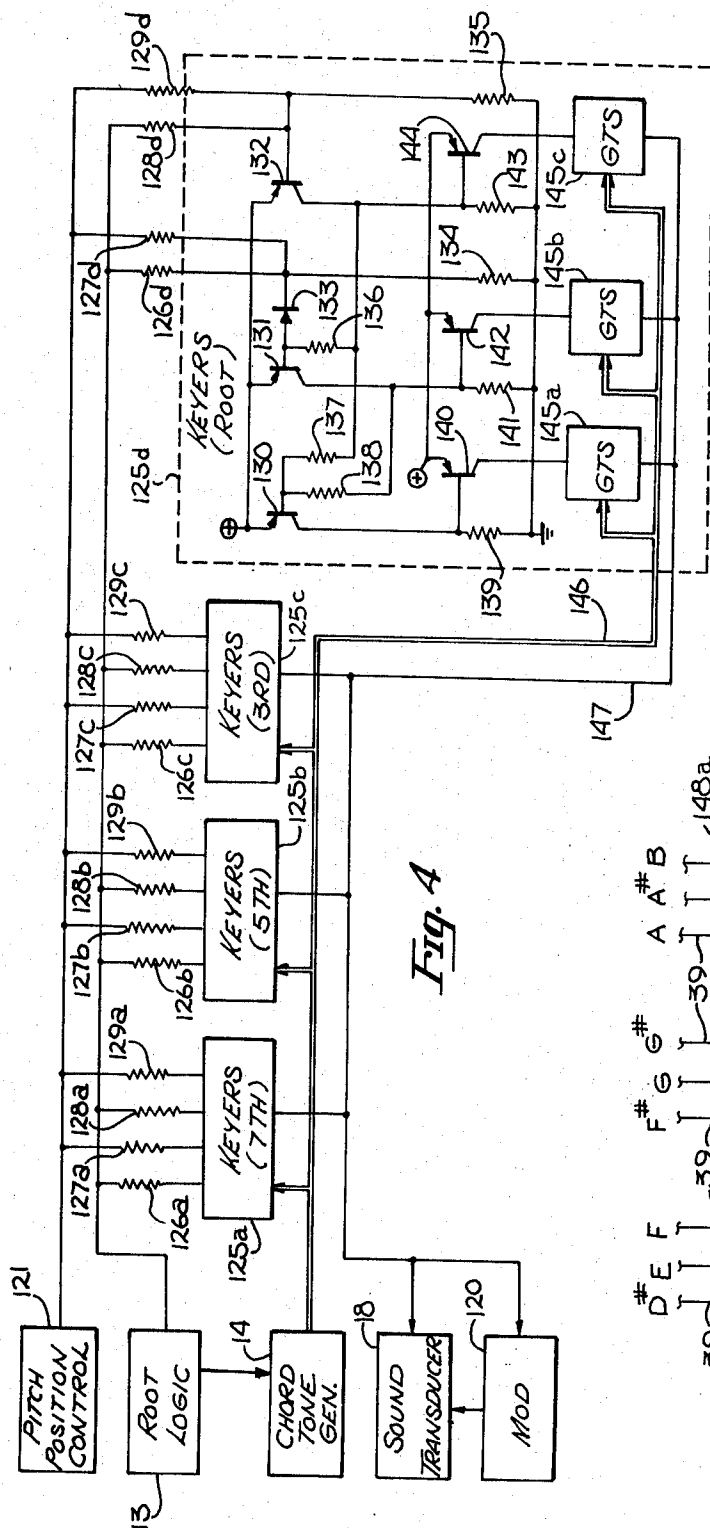


Fig. 4

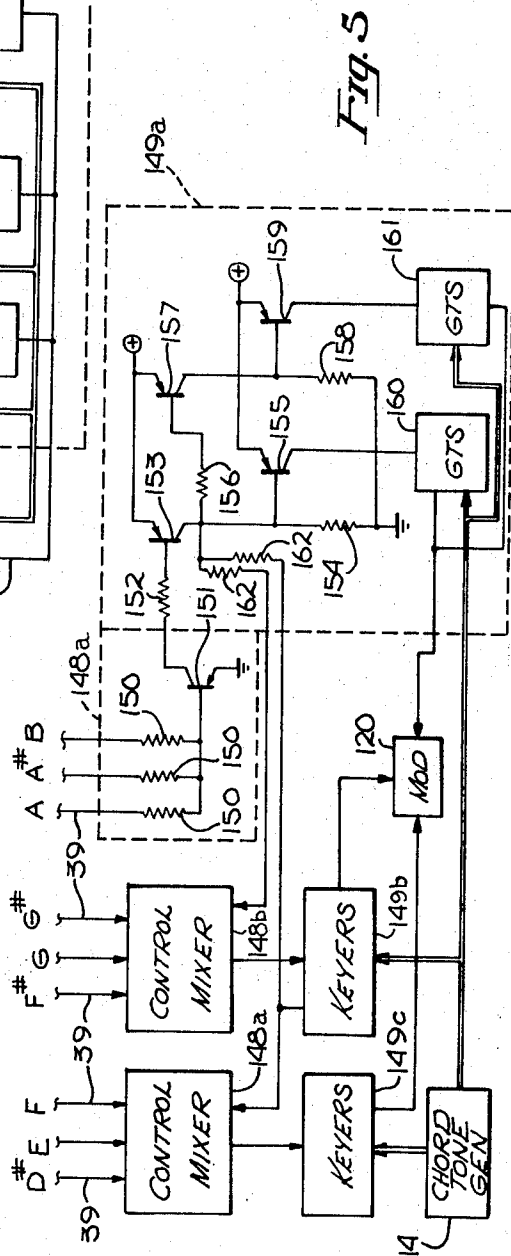


Fig. 5

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CHORD TONE GENERATOR CONTROL SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention is directed to apparatus for playing chords and bass automatically in response to playing on the manual and to an automatic rhythm device and for playing chords in a prescribed relation to the highest pitch playing key actuated.

2. Description of the Prior Art

In U. S. Pat. No. 2,645,968, Hanert discloses means to play chords selected by operation of one of a set of buttons. The root and fifth parts can be applied one at a time to a bass divider by means of two pedals so those parts sound in a bass register. The sounding of the chord can be accented by operating a bar with the wrist. Hanert's apparatus is not responsive to playing on a manual nor to an automatic rhythm device and the chord is not sounded in response to melody playing or in different pitch locations.

In U. S. Pat. No. 3,001,432, Greif discloses means for playing a note in the bass in response to chords played on a manual. The note is generally the root of the chord and Greif does not include means for playing the important fifth part alternately with the root. Greif's apparatus does not include means for playing bass or chord with automatic rhythm nor for sounding the chord in different pitch locations other than by standard organ controls.

In U. S. Pat. Nos. 3,283,056 and 3,247,310, J. C. Cookery with G. R. Hall and H. B. Stimson, Jr. respectively disclose apparatus for playing a chord on the lower manual in the usual manner and having the chord also sound with melody notes played on the upper manual in pitch locations which are in close harmony relation to the melody note. It is impractical to change the relation in this apparatus so both close and open harmony relations are not available. The system is further expensive to manufacture and requires a full organ tone generator set with associated keyers. The apparatus also does not provide for automatic bass and chord playing.

SUMMARY OF THE INVENTION

This invention provides for substantially normal playing with one hand on a manual from an economical tone generating system as well as for automatic chord and bass playing in rhythmic patterns from one hand or single finger playing on the manual. The invention further provides for the chord to also sound with melody notes played on another manual in either close or open harmony relation to the melody. The apparatus of the invention combined with a melody playing capability provides a novel and economical musical instrument and combined with a regular electronic organ provides an economical means for accomplishing its special functions and further provides a very musically useful chorus effect with the organ tone generators. The bass playing includes the diminished fifth. Reducing tone generator and keying requirements from twelve units per octave to three or four cuts costs considerably and the added logic over that required for automatic bass playing is modest.

In short, the invention combines a special chord tone generator tuneable by a voltage with logic circuitry for control and playing from a keyboard, with an auto-

matic rhythm device for sounding chords and bass in various rhythmic patterns, and with pitch position keying control to sound chords in close and open harmony relation with a melody played on another manual.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of apparatus forming an embodiment of the invention.

FIG. 2A is a partial block and partial schematic diagram of a section of a particular form for the apparatus of FIG. 1.

FIG. 2B is a partial block and partial schematic diagram of the remaining section of the apparatus of FIG. 2A.

FIG. 3 is a chart showing various relations in the apparatus of FIGS. 2A and 2B.

FIG. 4 is a partial block and partial schematic diagram of the output keying of FIG. 2B.

FIG. 5 is a partial block and partial schematic diagram of another form for the output keying of FIG. 2B.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Keyboard 11 of FIG. 1 operates one of the twelve drivers 12 in response to actuation of its playing controls or keys in various combinations. The driver 12 operated normally corresponds to the root of the chord represented by the combination of notes of the actuated playing controls or keys. In addition to playing controls or keys and key operated switches, keyboard 11 may include other circuitry so that its combination with drivers 12 may be the same or similar to apparatus disclosed in my copending U. S. patent applications, Ser. No. 748,245, filed July 29, 1968, U.S. Pat. No. 3,548,066, and Ser. No. 97,921 filed Dec. 14, 1970 for "Automatic Bass from Chord Apparatus Employing a Multiple Ratio Frequency Divider and Automatic Rhythm Device". Still another form for keyboard 11 and drivers 12, shown herein in FIGS. 2A and 2B, includes further means to provide an output voltage which is proportional to the location of the highest pitch playing control or key operated.

Root logic 13 responds to the driver 12 operated to tune chord tone generator 14 for the corresponding root. Chord type logic 15 controls chord tone generator 14 to produce tone signals for parts other than the root part when the playing keys which would correspond to the part is actuated. Special keyboard 16 consists of a set of controls to select the chord root and another set to select the chord type. Keyboard 16 effects control of chord tone generator 14 through root logic 13 and chord type logic 15 and is an alternative control means to keyboard 11 and drivers 12. Chord tone generator 14 may consist of a set of voltage tuned oscillators each driving a chain of frequency dividers. Root logic 13 then provides a control voltage to tune all oscillators in tracking relation while positioning one for the root note. Chord part logic 15 then differentially tunes one oscillator for either the minor third or major third part, another for the diminished fifth or fifth part, etc.

Output keying 17 receives the tone signal outputs from chord tone generator 14 and passes selected ones to sound transducer 18 in rhythmic patterns in response to control signals from automatic rhythm

device 19. The selected ones of the tone signals may include parts in a bass register sounded one at a time and a group of all enabled chord parts, either in a particular pitch register or in a pitch location which depends on the highest pitch note played on melody keyboard 20 or on keyboard 11. The particular location chord will normally be used for sounding in response to automatic rhythm device 19. The moving location chord will normally be sounded synchronously with actuation of the playing key determining its location.

As the pitch location of all outputs of chord tone generator 14 changes with changes in the root, it is necessary that output keying 17 pass different outputs to maintain a chord in the same pitch register. Root logic 13 provides control to output keying 17 so it can maintain chords in a desired pitch register or so it will provide chords in fixed relation to the highest pitch playing keys operated on keyboards 11 or 20. My copending U. S. patent application Ser. No. 783,205, filed Dec. 12, 1968, for "Automatic Harmony Apparatus," discloses circuitry which can be adapted to accomplish the functions of output keying 17. Special control source 21 represents other means, such as a player operated potentiometer or other control, which can be used to position the chord from output keying 17.

With melody keyboard 20, the relation of the chord to the melody note being played can be selected for either an open or close harmony relation. A chord moving in such relation and sounding synchronously with the melody very effectively enhances the melody and would be hard for even a good player to duplicate on a standard instrument. The same chord could also be sounded in a fixed location in response to the automatic rhythm device 19 at the same time. If only one hand is used for playing on keyboard 11, the relation to the highest pitch playing key actuated can be made such that the notes sounding are substantially the ones which correspond to the actuated playing keys. This assumes that the player will not span more than an octave with one hand.

Referring now to FIG. 2A, and FIG. 2B, actuation of a playing key 31 operates its associated switch 32 which connects a positive voltage supply to a line 34 associated with it and with other switches 32 and playing keys 31 for the same note in other octave locations. Each line 34 connects to ground through a resistor 33, to the enable input of a driver 35 for the associated note, and to the inhibit inputs of several drivers 35 for related notes. Columns 2, 3, and 4 of FIG. 3 show the drivers 35 which receive inhibit inputs from each line 34. Line 34 for the note C, for example, provides inhibit inputs for the notes D #, E, and G.

As shown for the driver 35 for the note C, the line 34 for the note C connects through resistor 36 to the collector of transistor 38 while lines 34 for the notes F, G #, and A connect through resistors 37 to the base of transistors 38. If line 34 for the note C is energized by actuation of any playing key 31 for the note C, a positive voltage output will appear out on line 39 from the collector of transistor 38 unless one or more of the lines 34 for the notes F, G #, and A are energized. If playing keys 31 for any of the notes F, G #, and A are actuated, the associated line or lines 34 will be energized and transistor 38 will be held in saturation by the base

drive through the associated resistor 37. The collector of transistor 38 and connected line 39 will then remain substantially at ground potential.

Each line 39 from the collector of a driver 35 connects to four resistors 40 which each connect to another resistor 40 from a different line 39 and to a resistor 41. Diodes 42 connect from each line 34 to pairs of junctions of resistors 40 and 41. Resistors 43 connect from lines 34 alternately to busses 44 and 45. Resistors 41 connect in four groups to busses 46, 47, 48, and 49 respectively. Operation of a driver 35 provides voltage to four resistors 40 which connect through four resistors 41 to the four busses 46, 47, 48, and 49. Resistors 33 are relatively small so their series combination with diodes 42 effectively clamps the junctions of resistors 40 and 41 by limiting any voltage rise to a small value. Operation of their respective switches 32 applies positive voltages to resistors 33 and removes the clamping action by back biasing diodes 42. The last four columns of FIG. 3 show the notes whose associated lines 34 control gates to the four busses 46, 47, 48, and 49 for outputs from drivers 35 for the notes shown in the first column. It will be noted that notes which relate to the note of the driver 35 as the third and minor third parts control gates to busses 46 and 47 and those as the fifth and diminished fifth to busses 48 and 49. It will further be noted that for C, D, E, F #, G #, and A #, the thirds connect to bus 47 and the fifths to bus 48 while for C #, D #, F, G, A, and B, thirds connect to bus 46 and fifths to bus 49.

Busses 46 and 47 go respectively to resistors 50 and 51 which connect to the base of transistor 52 in FIG. 2B. Busses 48 and 49 similarly go respectively to resistors 53 and 54 connecting to the base of transistor 55. Busses 46 and 47 also connect through series pairs of resistors 56 and 57 and resistors 58 and 59 respectively to the base of transistor 60. Busses 48 and 49 connect through resistors 61 and 62 and resistors 63 and 64 respectively to the base of transistor 65. Diodes 66 connect the junctions of resistors 56 and 57 and resistors 63 and 64 to the collector of transistor 67 and the junctions of resistors 58 and 59 and resistors 61 and 62 to the collector of transistor 68. Transistor 67 has its base connected through resistor 70 to the junction of resistors 69 from lines 39 from drivers 35 for the notes C, D, E, F #, G #, and A #. Transistor 68 similarly has its base connected through 71 to the junction of resistors 69 for the notes C #, D #, F, G, A, and B.

When a driver 35 for the note C is operated, for example, transistor 67 is saturated by base drive from the associated line 39 and clamps the junctions of resistors 56 and 57 and resistors 63 and 64. If a playing key 31 for the note E is operated, is also operated, it will produce a positive voltage on bus 47 and transistor 60 will be driven to saturation by current through resistors 58 and 59. Similarly a playing key 31 for the note G will drive transistor 65 to saturation by current through resistors 61 and 62 from bus 48. As will later be explained, saturation of transistor 60 tunes the chord tone generator from the minor third to major third part and saturation of transistor 65 similarly tunes it from the diminished fifth to the fifth part.

Operation of drivers 35 for any of the notes D, E, F #, G #, and A # likewise provides drive through the associated resistor 69 to saturate transistor 67 and so

allow transistors 60 and 65 to respond to voltages on busses 47 and 48 respectively. If a driver 35 for any of the notes C #, D #, F, G, A, and B operates, drive through the associated resistor 69 will cause transistor 68 to saturate and clamp the junctions of resistors 58 and 59 and resistors 61 and 62. Transistors 60 and 65 then respond to voltages on busses 46 and 49 respectively. The net result is that actuation of playing keys 31 for notes which are in the relation of a major third to that of the operated driver 35 will cause transistor 60 to saturate and those in the relation of a fifth will cause transistor 65 to saturate.

Resistors 72 and 73 connect the base of transistor 74 to the junctions of resistors 69 from lines 39 for the groups of notes C, D, E, F #, G #, and A # and notes C #, D #, F, G, A, and B respectively. Resistors 75 and 76 connect the collector of transistor 74 to the positive supply and their junction connects to the base of transistor 77. Resistor 78 connects the collector also to the base of transistor 79 while resistor 80 provides feedback from collector to base to stabilize the gain. Operation of any one driver 35 will provide base drive to transistor 74 through the associated resistor 69 and cause it to conduct sufficiently to saturate transistor 79 but not to drive base current into transistor 77. Operation of more than one driver 35 will produce enough conduction in transistor 74 to also saturate transistor 77. Saturation of transistor 77 clamps resistor 78 nearly to the positive supply and so removes base drive from transistor 79.

Transistor 79 thus conducts if one and only one of drivers 35 is operated. Conduction of transistor 79 provides positive supply voltage to the emitters of transistors 81, 82, and 83 which connect to its collector and, as will later be explained, enables the root part of the chord tone generator to sound. Resistors 84a, 84b, and 84c connect the bases of transistors 81, 82, and 83 to the collectors of transistors 55, 52 and 85 respectively. Transistor 52 conducts if bus 46 or 47 receives drive from actuation of a playing key 31 for a third or minor third part and transistor 55 conducts from drive on bus 48 or 49 for a fifth or diminished fifth part. Busses 44 and 45 connect together to the base of transistor 85 which has feedback resistor 86 to stabilize its gain. Resistor 87 robs drive from the base of transistor 83 until transistor 85 is receiving drive from more than three operated playing keys 31. As will later be explained, conduction of transistors 82, 81, and 83 enable the sounding of the third, fifth, and seventh parts respectively.

Root selector 88, which represents part of special keyboard 16 of FIG. 1, consists of a set of controls each including a switch connected to apply a voltage to an associated one of lines 39 when actuated. Each line 39 can thus be energized by actuation of an associated control of root selector 88 as well as by operation of its associated driver 35. Resistors 89 connect each of lines 39 except the one for C to one or more of busses 91, 92, 93, and 94 which connect to the bases of transistors 95, 96, 97 and 98 respectively. Each driver 35 can thus operate the transistors 95 through 98 to which its line 39 connects through its group of resistors 89 and each group connects to a unique combination. The collectors of transistors 95 through 98 connect through resistors 99 through 102 respectively to resistors 103

through 106 respectively. Transistors 108a, 108b, 108c, and 108d with emitter resistors 107a, 107b, 107c, and 107d respectively provide alternate PNP and NPN emitter followers isolating the voltage dividers formed by the combinations of resistors 99 through 102 with resistors 103 through 106.

Vibrato control 109 provides an input reference voltage which may be swung about its nominal value at a 5 to 7 cycle per second rate when a vibrato is desired. If transistors 95 through 98 are all cut off, substantially the same voltage as the output of vibrato control 109 appears on the emitter of the last stage transistor 108a and goes to control the frequency of oscillators 110. If transistors 95 through 98 saturate, the voltage is dropped by a fraction depending on the proportions of their respective voltage dividers. If two or more are saturated, the fractions multiply. The fractions corresponding to 1, 2, 4 and 8 semitones associate with transistors 95 through 98 respectively. It will be noted that the groups of resistors 89 provide the proper number of semitones steps from C for their associated notes.

Voltage tuned oscillators 110a, 110b, 110c, and 110d for the root, third, fifth and seventh parts respectively could be any of various types but will here be taken to be multivibrators such as the one shown schematically for the third part which consists of transistors 111, load resistors 112, base current sources 113, and capacitors 114. The voltage from the last stage transistor 108a provides the control for current sources 113 which determines how fast the base voltage will swing and so the period of oscillation. Reducing the voltage increases the frequency with all oscillators 110a, 110b, 110c, and 110d changing by the same percent so that any given type chord relation will be maintained. Resistor 115 connecting from one collector to the collector of transistor 60 provides a vernier tuning control to change the third part from a minor third to major third relation by lowering the voltage on that collector and so raising the frequency of oscillator 110b when transistor 60 is conducting. It will be remembered that this occurs when the playing key 31 for the third part is being actuated.

Transistor 65, which conducts when a playing key 31 for the fifth part is actuated, similarly controls the oscillator 110c for the fifth part. Oscillators 110b and 110c for the third and fifth parts are tuned for the minor third and diminished fifth respectively when transistors 60 and 65 are cut off. Resistors 115 in each oscillator 110b and 110c are then sized so that they tune to the major third and fifth respectively when transistors 60 and 65 go to saturation. Oscillator 110d for the seventh part could be similarly tuned if desired and if more diode gates were added for control. Type selector 116 is another part of special keyboard 16 to be used in combination with root selector 88. Type selector 116 also connects to resistors 115 so the tuning of third and fifth parts can be controlled directly from it rather than through transistors 60 and 65. Type selector 116 also includes switches to ground the collectors of transistors 52, 55, and 85 to allow sounding of all part without the operation of any of playing keys 31. Chords can thus be played using root selector 88 and type selector 116 rather than keyboard playing keys 31.

Each of oscillators 110a, 110b, 110c, and 110d drives a chain of frequency dividers 117a, 117b, 117c, and 117d respectively which provide outputs to output keying 17 and bass selector 118. The power supply for the root part dividers 117a comes from the collector of transistor 79 which conducts if one and only one of drivers 35 or a key of root selector 88 is operated. Dividers 117a, 117b, 117c, and 117d can, of course produce outputs only when they have a supply voltage.) The dividers 117b and 117c for the third and fifth parts receive their supply voltage from transistors 82 and 81 respectively if transistor 79 is conducting and transistors 52 and 53 respectively also conduct. Transistor 83 supplies power to dividers 117d for the seventh part if transistor 79 is conducting and if more than three playing keys 31 are operated to provide bass drive for transistor 83. As mentioned previously, controls for the seventh part similar to those for the third and fifth parts can be provided if a more sophisticated response is desired.

Automatic rhythm device 19 drives bass selector 118 to obtain outputs from the different parts one at a time as desired to drive bass divider and keyer 119. Bass selector 118 consists of a gate for each output to be selected and has its gates arranged similarly to gates 22 and 23 of FIG. 1 of prior referenced U.S. Pat. No. 3,548,066. Output keying 17 produces outputs to modulator 120 which include all chord parts within a particular pitch register, and outputs to sound transducer 18 which also include all chord parts in a pitch location depending upon a control voltage received from pitch position control 121. Output keying 17 also receives an input of the root control voltage from the last stage transistor 108a which it uses to vary its response to the voltage from pitch position control 121 so the pitch to voltage relation remains substantially constant as the pitch of the parts shifts with changes of roots. Bass divider and keyer 119 and modulator 120 are driven by automatic rhythm device 19 to produce outputs in rhythmic patterns to sound transducer 18. The outputs of output keying 17 going directly to sound transducer 18 are produced synchronously with the voltage from pitch position control 121.

Resistors 122 and 123 form a ladder voltage divider from switches 124 actuated by playing keys 31 for the second and higher octaves of the keyboard. If no playing keys 31 in this range are operated, no voltage from the ladder is applied to position control 121. If a playing key 31 within the range is operated, the voltage output will be proportional to its pitch position with a higher pitch producing a higher voltage. Pitch position control 121 can pass the full voltage onto output keying 17 in which case the chord parts will sound in substantially the same position as the actuated playing keys 31 if one hand is used as previously discussed. Control 121, which may consist of a voltage divider across the input and a switch to connect the output to the input or taps on the voltage divider, can also divide the voltage input by different factors so the parts sounded will be in either a close or open harmony relation to the playing key 31 operated. These latter relations would normally be used where a separate manual is used for playing a melody to be accompanied by the chords. Melody keyboard 20 could, of course, include an arrangement such as switches 124 and resistors 122 and 123 to pro-

vide a voltage output proportional to the pitch of the highest operated playing key. Pitch positioning control 121 would include a switch to select different control inputs.

Keyers 125a, 125b, 125c, and 125d of FIG. 4 key seventh, fifth, third, and root chord parts respectively in a plurality of octave locations with the octave location depending upon the voltage outputs of pitch position control 121 and root logic 13. Resistors 126a, 126b, 126c, and 126d go from root logic 13 to keyers 125a, 125b, 125c, and 125d for the seventh, fifth, third, and root parts respectively in their second octave location. Resistors 127a, 127b, 127c, and 127d go from pitch position control 121 to the same points as resistors 126a through 126d respectively. Resistors 128a through 128d similarly connect from root logic 13 to the third octave location of keyers 125a, 125b, 125c, and 125d respectively to work in combination with respective resistors 129a through 129d from pitch position control 121.

Keyer 125d for the root part shows transistors 130, 131 and 132 controlling gate driving transistors 140, 142 and 144 to accomplish the desired functions. This arrangement is similar to that disclosed in my prior referenced U. S. patent application Ser. No. 783,205 filed Dec. 12, 1968. Resistors 126d and 127d connect to resistor 134 and through diode 133 to the base of transistor 131 while resistors 128d and 129d connect to the base of transistor 132 and resistor 135. Resistors 134 and 135 normally hold transistors 131 and 132 respectively in saturation. Transistor 130 is then cut off as it receives no base drive through resistors 137 and 138 from the collectors of transistors 132 and 131 respectively. Transistor 140 then receives saturating base drive through resistor 139 and turns on its associated set of gates 145a, 145b, and 145c.

Gates 145a, 145b, and 145c receive tone signal inputs from chord tone generator 14 when any one driver 35 is operated by an actuated playing key 31 to turn on transistor 79 as discussed in connection with FIG. 2B. While gates 145a for the lowest octave will be open when no voltage is being received from pitch position control 121, no output going to sound transducer 18 will be produced because no input tone signals are received. The voltage from control 121 necessary to pull transistor 131 out of conduction depends on the voltage from root logic 13 and the sizes of resistors 126d and 127d with respect to resistor 134. When transistor 131 cuts off, transistors 130 and 142 are pulled to saturation by drive through resistors 138 and 141 respectively. The positive supply on the emitters of transistors 140, 142 and 144 is less than that to the emitters of transistors 130, 131 and 132 to permit enough drive through resistor 138 to hold transistor 130 in saturation. Conduction of transistor 142 turns on the second octave set of gates 145b while the lowest octave set of gates 145c are turned off as transistor 140 is cut off by saturation of transistor 130.

Resistors 128d and 129d are larger with respect to resistor 135 than resistors 126d and 127d to resistor 134 so a larger voltage from control 121 is necessary to pull transistor 132 out of conduction. When this occurs, transistors 130 and 131 are pulled into saturation by drive through resistors 137 and 136 respectively and transistors 140 and 142 respectively are thereby cut

off. Transistor 144 is saturated by drive through resistor 143 and turns on the gates 145d for the highest octave. Resistors 126a through d, 127a through d, 128a through d, and 129a through d are sized so keyers 125a, 125b, 125c, and 125d for the different parts operate in turn for each higher octave in succession as the output voltage from control 121 is progressively raised, as will occur as successively higher pitched playing keys 31 are operated. The output of root logic 13 becomes less to raise the pitch of the root and other parts and the smaller voltage from it to keyers 125a,b,c, and d makes it necessary to obtain a higher voltage from control 121 to turn on the same part in a particular octave. The relation between the pitch of the actuated playing key 31 and the pitch of the output signal keyed remains the same, however as the parts are now higher in pitch.

If a fixed voltage is provided by control 121, the outputs keyed with changes in output from root logic 13 will change but the opposing change in pitch for different roots will keep the keyed signals in the same pitch register. Such outputs through modulator 120 when it is operated by automatic rhythm device 19 as previously discussed, provide an accompaniment chord in rhythmic patterns. The alternative means for producing outputs in a particular pitch register to modulator 120 shown in FIG. 5 uses a set of three control mixers 148a, 148b, and 148c each receiving inputs from lines 39 for three notes upon operation of their respective drivers 35. The mixers 148a, 148b, and 148c each drive a keyer 149a, 149b, and 149c respectively for a particular part to shift its output by an octave. The higher pitch mixers 148a or 148b also cause all the lower pitch mixers 148b and cor 148c respectively to operate so the outputs remain within a range of slightly more than an octave.

As shown for the highest pitch mixer 148a, lines 39 for the three notes connect through resistors 150 to the base of transistor 151 so it is pulled into saturation if any of the respective drivers 35 operate. The resulting drive through resistor 152 to the base of transistor 153 pulls it into saturation thereby cutting off transistors 155 and 157 by removal of drives through resistors 154 and 156 respectively. With transistor 157 cut off, transistor 159 is then pulled into saturation by base drive through resistor 158. Gates 160 are thus turned off and gates 161 turned on as transistor 157 cuts off and transistor 159 saturates so the output for the part to modulator 120 is shifted an octave lower. The collector of transistor 153 also connects through resistors 162 to the base of transistors 151 in the other two mixers 148b and 148c so their parts will also be shifted an octave lower. The next lower mixer 148b similarly drives the lowest mixer 148c.

Drivers 35 for the notes C, C#, and D allow a particular set of outputs from chord tone generators 14 to be keyed to modulator 120. Drivers 35 for the notes D#, E, and F then shifts the outputs for the highest pitch part an octave lower to compensate for all parts being shifted higher in pitch when these notes are the root. Drivers 35 for the notes F#, G, and G# shift the two highest pitch parts an octave lower and drivers 35 for A, A#, and B shift the three highest to compensate for the still higher pitch roots. It will be recognized that only two mixers 148a, b, and c and of keyers 149a, b, and c would be required if chords were restricted to

triads and the pattern of inputs from drivers 35 would be adjusted accordingly.

It will be recognized that the apparatus of the instant invention will provide a unique and economical musical instrument when combined with a solo oscillator or other means for producing a melody. If combined with a regular electronic organ, it also produces a chorus effect with the organ tone generators that further enhances the instrument. The tuning deviation between the two tone generating systems and so the chorus animation rate could be controlled as a function of pitch location by applying a fraction of the melody note produced voltage to also differentially tune the chord tone generator. The player can produce chords and bass with one finger playing as well as with normal playing on the manual. An automatic chord selection means, such as that show in my copending U. S. Pat. application Ser. No. 783,205 filed Dec. 12, 1968 for "Automatic Harmony Apparatus," could be adapted to control the apparatus of this invention.

It will further be recognized that the apparatus of the instant invention might be used for automatic bass playing only. It has an advantage over some other automatic bass systems in that it plays the diminished fifth part when it is part of the chord played. Two oscillators operating in the bass region would be sufficient and even one would suffice if the automatic rhythm device was made to change its tuning by the interval of a fifth. This could be done by various means such as adding another stage to the tuning voltage control set of FIG. 2B and applying the automatic rhythm device to control it. The frequency dividers, bass selector, and bass divider would then not be necessary.

From the foregoing it is clear that the advantages of my invention set out under the heading "Summary of the Invention" are fully attained.

I claim:

1. In an electrical musical instrument having a set of playing controls for the notes of a musical scale and a sound transducer, the combination of:

- a. a chord tone generator producing a set of tone signal outputs,
- b. means for determining the roots of chords represented by actuated combinations of said playing controls,
- c. means for tuning said chord tone generator (for selected note notes) responsive to said determining (actuation of said playing controls), and
- d. means for applying (the) outputs from (of) said chord tone generator to said sound transducer.

2. The combination according to claim 1 including means for controlling said chord tone generator for production of different type chords.

3. The combination according to claim 2 wherein said chord tone generator includes a plurality of oscillators controlled in frequency in tracking relation by said tuning means and wherein said controlling means differentially tunes one of said oscillators to shift its relation to the others.

4. The combination according to claim 1 including means responsive to said determining means and said actuated playing controls for selectively gating outputs of said chord tone generator to said applying means.

5. The combination according to claim 1 including means responsive to said determining means and said

actuated playing controls for controlling said chord tone generator for production of different type chords based on the selected root notes.

6. The combination according to claim 5 wherein said chord tone generator includes a plurality of oscillators and wherein said controlling means differentially tunes one of said oscillators to shift its relation to the others.

7. The combination according to claim 1 wherein said applying means is responsive to said determining means and said actuated playing controls to select which outputs are applied to said sound transducer.

8. The combination according to claim 7 wherein said chord tone generator produces outputs for each of said chord parts in a plurality of octave locations and said applying means responds to the highest pitch playing control actuated to determine which outputs to apply to said sound transducer.

9. The combination according to claim 1 wherein said applying means is responsive to the highest pitch playing control actuated to select the outputs of said chord tone generator to apply to said sound transducer.

10. The combination according to claim 9 wherein said applying means is further responsive to said tuning means.

11. The combination according to claim 7 including means for changing the relation of the pitch position of the outputs applied to said sound transducer with that of said highest pitch playing control actuated.

12. The combination according to claim 1 wherein said applying means includes an automatic rhythm device.

13. The combination according to claim 12 including a bass frequency divider having its output connected to said applying means and means for switching outputs of said chord tone generator to said bass frequency divider one at a time responsive to said automatic rhythm device.

14. The combination according to claim 1 including a bass frequency divider having its output connected to said applying means and means for switching outputs from said chord tone generator to said bass frequency divider one at a time.

15. The combination according to claim 1 wherein said determining means includes a set of drivers each operable in response to actuation of an associated one of said playing controls and means for inhibiting operation of each of said drivers responsive to actuation of another of said playing controls.

16. The combination according to claim 15 wherein said inhibiting means is also responsive to operation of another of said drivers.

17. In an electronic musical instrument having a set of playing controls and a sound transducer, the combination of;

a. a plurality of oscillators controllable in frequency tracking relation responsive to an electrical control signal,

b. means for producing an electrical control signal to tune said oscillators responsive to the combination of said playing controls actuated, and

c. means for applying signal derived from said oscillators to said sound transducer, wherein said producing means comprises a set of electronic switches, a set of voltage dividers controlled by said electronic switches to determine the magnitude of the electrical control signal to tune said oscillators, a set of dividers responsive to actuation of said playing controls, and resistor networks connecting said drivers to each operate a different combination of said electronic switches.

18. The combination according to claim 17 wherein said drivers have operate and inhibit inputs and each of said playing controls provides an operate drive to one of said drivers and an inhibit drive to another of said drivers.

19. The combination according to claim 18 wherein said applying means includes a set of gates responsive to operation of said drivers and actuation of said playing controls to pass signals derived from said oscillators to said sound transducer.

20. The combination according to claim 19 including means responsive to said gates for differentially tuning one of said oscillators to shift its relation to the others.

21. The combination according to claim 17 including a plurality of frequency divider chains driven by said oscillators and means for selecting different sets of outputs from said dividers for said applying means.

22. The combination according to claim 21 wherein said selecting means is responsive to the highest pitch one of said playing controls actuated.

23. The combination according to claim 26 wherein said selecting means is responsive to an electrical control signal.

24. The combination according to claim 17 wherein said applying means includes an automatic rhythm device.

25. The combination according to claim 24 wherein said applying means further includes a bass frequency divider having its output connected to drive said sound transducer and wherein said automatic rhythm device applies signals derived from said oscillators one at a time in turn in rhythmic patterns to said bass frequency divider.

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