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[58] Field of Search 84/1.01, 1.03, 1.17, DIG. 22

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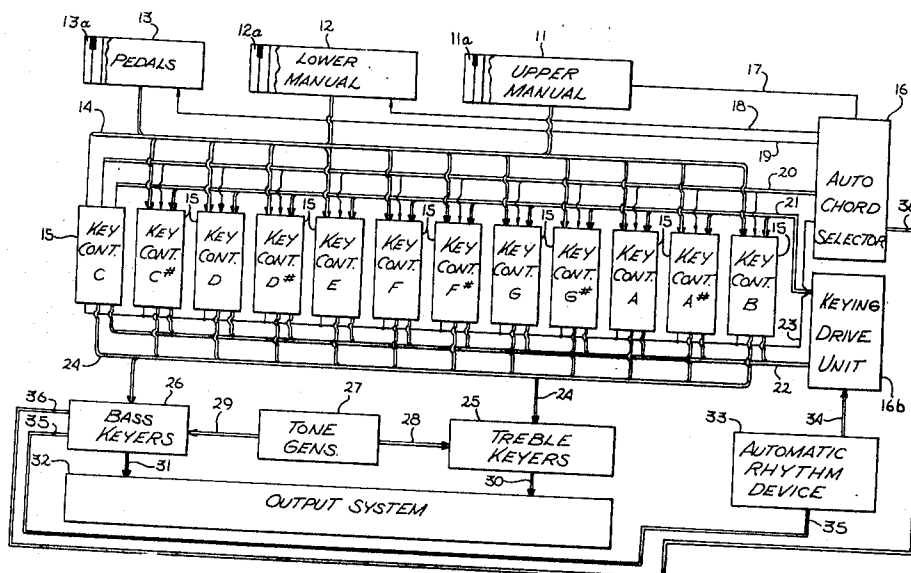
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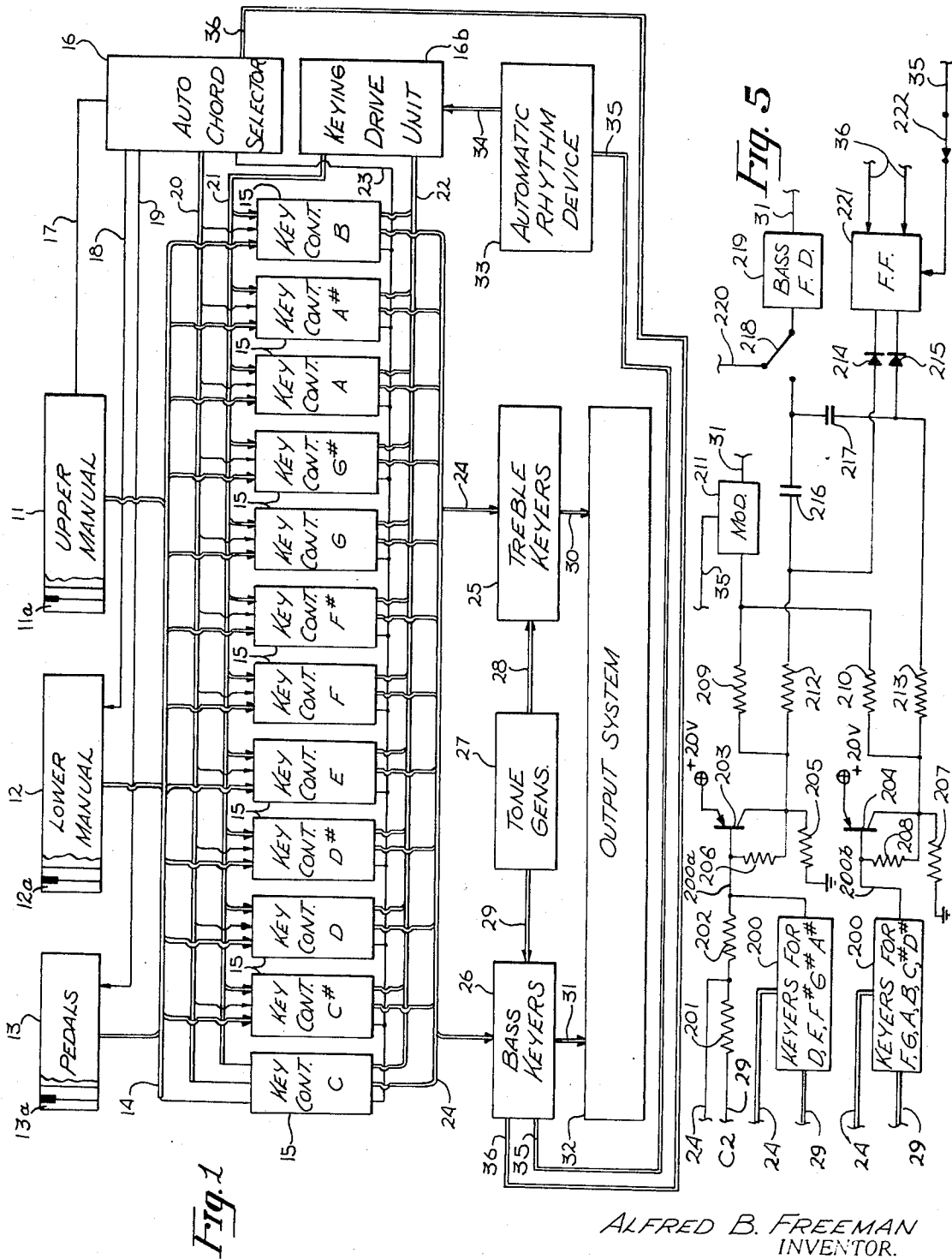
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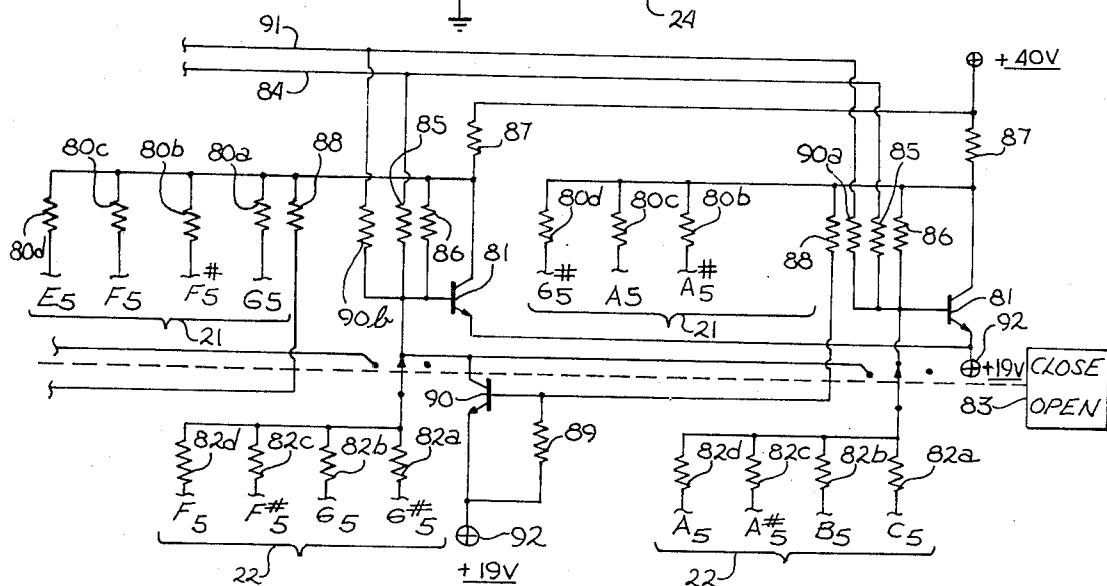
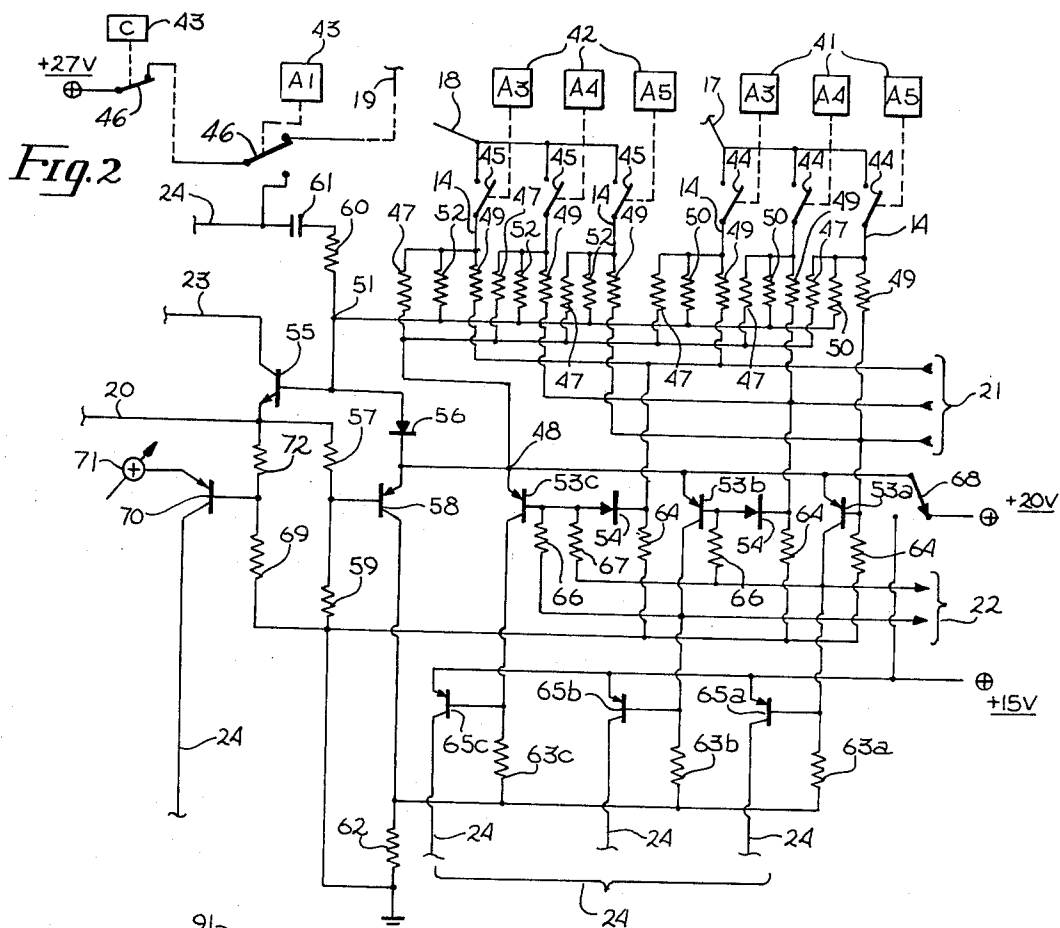
[57] **ABSTRACT**

Apparatus for use with electronic organs and the like which selects chords automatically in response to melody and other playing on the instrument and which sounds harmony, selected by automatic or manual means, in prescribed relations to the melody being played. The apparatus responds intelligently to melody and other playing in a preselected musical key to select chords from a preselected set in a normal progression order. The apparatus is responsive to an Automatic Rhythm Device for sounding parts of the selected chords in different pitch ranges in various rhythmic patterns including the sounding of the root and fifth parts alternately in the bass. Notes played manually on the instrument add to or replace the notes of the automatically selected chords and the apparatus sounds either or both manually and automatically selected chords and the apparatus sounds either or both manually and automatically selected notes in either close or open harmony relation to the melody being played.

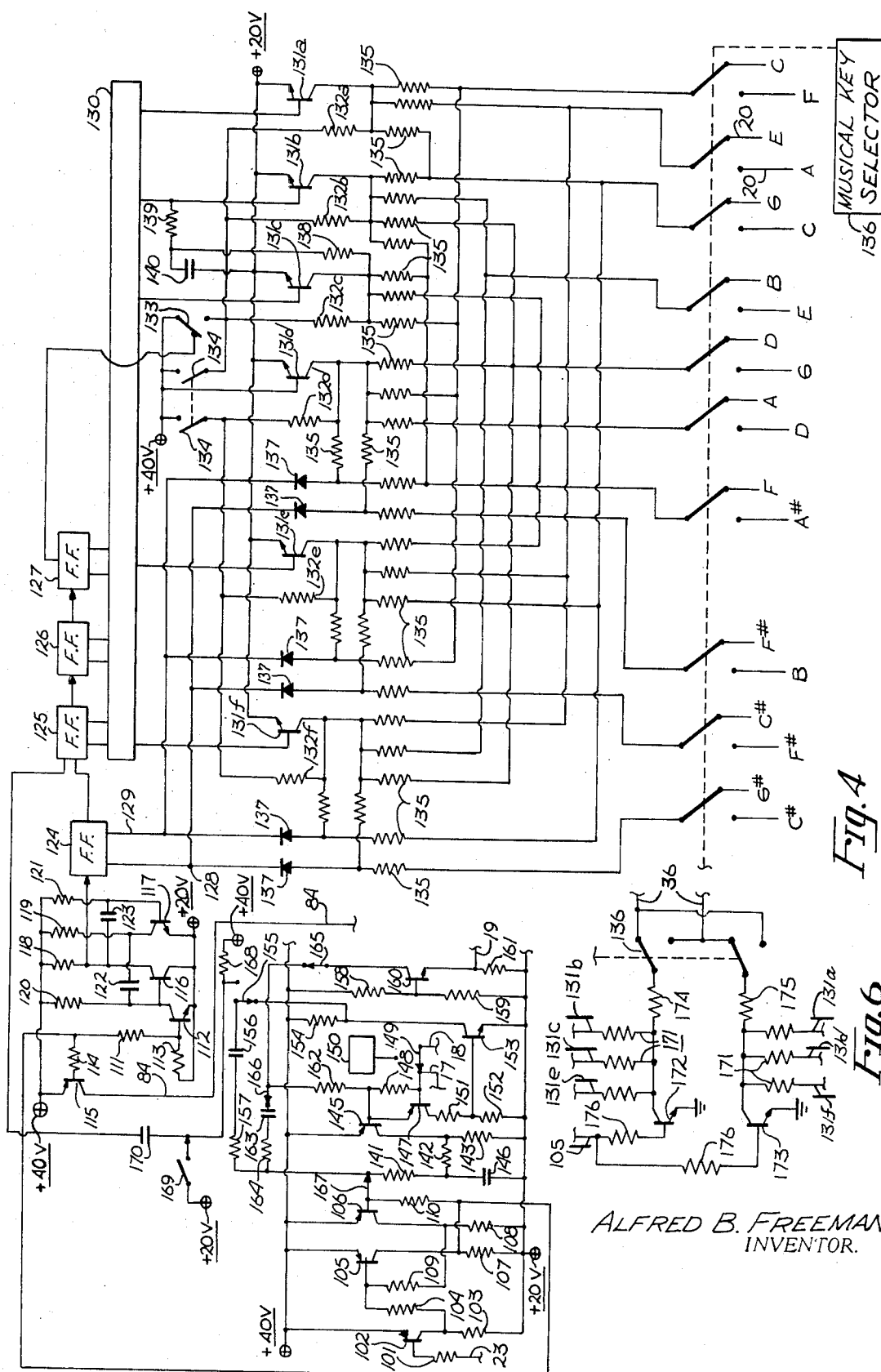
29 Claims, 6 Drawing Figures







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AUTOMATIC HARMONY APPARATUS

Cross Reference to Other Applications

This application is a continuation of application Ser. No. 783,205, filed Dec. 12, 1968, now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention is directed to apparatus for selecting chords automatically from melody and other playing and for adding movement and rhythm to the sounding of harmony which has been selected either by automatic means or by manual manipulation of playing keys.

2. Description of the Prior Art

In U. S. Pat. No. 3,099,700, S. H. Bergman discloses apparatus which plays a predetermined chord with each melody note in response to operation of a single playing control and further changes the chords which sound with particular melody notes in response to operation of other controls. This apparatus does not permit the same chord to be held through the playing of several melody notes as is desired in many musical compositions. It further requires additional playing operations to get the different chords which may accompany each particular melody note.

In U. S. Pat. Nos. 3,283,056 and 3,247,310, J. C. Cookerly, G. R. Hall, and H. B. Stinson, Jr. disclose apparatus for playing a chord on one manual in the usual manner and having the notes also sound in close harmony to the melody note played on the other manual. This apparatus does not include any means for automatic selection of chords and the players must hold the proper keys at the proper time. The apparatus further does not permit the relation of the chord notes to the melody to be changed from close to open harmony in a practical manner and the sounding of bass parts is not included.

SUMMARY OF THE INVENTION

The present invention provides apparatus which automatically selects chords to harmonize with a melody in a preselected musical key by sensing the melody note being played and responding to it and to other player produced clues to maintain harmonizing chord selections from a preselected set of chords for the particular type of composition. The apparatus is capable of a range of responses including maintaining chord selections into which the melody and other notes being played will fit, stepping from chord to chord of the set in a prescribed order in response to operation of a playing control, inhibiting changes during legato playing or while certain player controls are operated, and changing the chords considered when special notes or combinations are played. These features provide good harmony for some compositions from single note melody playing and for many others when the melody playing is supplemented by some simple additional player actions.

The present invention further provides apparatus for sounding harmony, whether selected automatically or manually by operation of playing keys, in preselected relationships to the highest note being played manually. The preselected relationships can be changed easily for selection of close and open harmony relations to the

melody and for other musical effects. The automatically selected harmony includes root and fifth parts in the bass, which can be sounded alternately in response to an Automatic Rhythm Device. The Automatic Rhythm Device can sound the various harmony parts and a sections, including the section relating in location to the melody, in a variety of rhythmic patterns without requiring further effort from the player and can further rhythmically change the relation of sections to the melody.

The apparatus of this invention thus permits the beginner to produce big renditions of musical compositions merely by playing a melody with one finger. The music remains responsive to his playing and he has a sense of accomplishment as his skill improves and the sounds reflect it. Those who like to play but do not have the time to develop very much musical playing capability can produce a lot of music by learning relatively minor additions to melody playing. A serious student can use the apparatus to occasionally break the drudgery of conventional practice. A skilled player can use the apparatus to produce music it would be difficult or impossible for anyone to play on a conventional instrument without the apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

fig. 1 is a block diagram of apparatus comprising an embodiment of the invention.

FIG. 2 is a schematic diagram of the keying control block for the note A in the apparatus of FIG. 1.

FIG. 3 is a schematic diagram of a partial section of the keying drive unit block of FIG. 1.

FIG. 4 is a partial block and partial schematic diagram of the automatic chord selector block of FIG. 1.

FIG. 5 is partial block and partial schematic diagram of a special section of the bass keyer block of FIG. 1.

FIG. 6 is a schematic diagram of a root reset control circuit which may be added to the apparatus of FIG. 4 in association with the apparatus of FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The upper manual 11 including conventional playing keys 11a, the lower manual 12 including conventional playing keys 12a, and the pedals 13 of FIG. 1 connect via cable 14 to the twelve keying control units 15 and may be standard electronic organ apparatus having at least one single pole single throw switch per playing control. Each of keying control units 15 associate with the twelve notes of the tempered scale and each receives a number of inputs via cable 14 from the playing control for its note in different octave locations. Automatic chord selector 16 connects to manuals 11 and 12 and pedals 13 via lines 17, 18 and 19 respectively for sensing and control, and to keying control units 15 via cable 20 for enabling those for the notes of selected chords. Keying drive unit 16b produces outputs on cables 21 to control units 15 to determine the octave location in which enabled notes will sound so the sounding will be in a predetermined relation to the highest pitch playing key operated as sensed by signals from control units 15 via cable 22. Line 23 from control units 15 to chord selector 16 provides a signal indicating that a note being played is not part of a selected chord.

Control units 15 also connect via cable 24 to treble keyers 25 and bass keyers 26 to effect sounding of tone signals generated by tone generators 27 and applied to keyers 25 and 26 via cables 28 and 29 respectively. The outputs passed by keyers 25 and 26 go via cables 30 and 31 respectively to output system 32. An automatic rhythm device 33 provides drive signals via cables 34 and 35 to keying drive unit 16b and bass keyers 26 for rhythmically interrupting harmony and bass part soundings. Chord selector 16 also connects to bass keyers 26 via cable 36 for selecting the root part after each new chord selection.

The apparatus of FIG. 1 is capable of several different modes of operation and its functioning will next be described for each illustrative of these in turn. In a conventional organ mode, keying control units 15 pass control signals from manual 11 and pedals 13 to their respective keyers 25 and 26 which in turn pass corresponding tone signals from tone generators 27 to output system 32. Output system 32 includes tone filtering circuits, stop controls, amplifiers, and speakers for selection and production of desired tonal qualities. Lower manual 12 may key signals from tone generators 27 to output system 32 by direct switching which is not shown but is well known in the art. Manual 12 may also be coupled to keyers 26 through control units 15 in parallel with manual 11 when an appropriate voltage is applied to line 18 by chord selector 16. All components mentioned except control units 15, keying drive unit 16b, and chord selector 16 may be those of a conventional electronic organ and function substantially in the normal manner. Control units 15 are capable of other functions but in this mode of operation merely relay the control from manuals 11 and 12 and pedals 13. The only function for chord selector 16 in this mode is to provide voltage to line 18 for the lower manual 12 coupling function.

In a second mode of operation, keying drive unit 16b is energized to cause all notes being played on manual 11, and on manual 12 if the proper voltage is applied to line 18, to sound in a predetermined relation to the note of highest pitch being played. Keying control units 15 provide signals out on cable 22 to indicate the location of the highest pitch note being played and drive unit 16b provides driving signals out on cable 21 to play all notes lower in pitch than the highest by some predetermined interval. Only those keying control units 15 which receive drive from manual 11, or manual 12, will respond to the inputs from drive unit 16b. Control units 15 further include octave lockout means so that operation to turn on the note in one octave location will prevent turning on of the note in all lower octave locations. All notes being played on the manuals 11 or 12 thus sound in only one octave location which is in a predetermined relation to the location of the highest pitch note being played.

In a third mode of operation, chord selector 16 is also operative to provide enabling signals via cable 20 to keying control units 15 for the notes of selected chords so that they may be played in relation to the note of highest pitch played on manual 11. Chord selector 16 is responsive to the signal on line 23 and to the loads applied to busses 17, 18, and 19 to select different chords in turn. The functioning of chord selector 16 also has several different modes of operation which

will be discussed after a later description of its internal structure. Keying control units 15 further pass signal derived from chord selector 16 inputs to bass keyers 26 to sound the notes of the selected chord in a low register. Those so sounded can be limited to the root and fifth parts of the cord and these may be sounded alternately with each other in response to a signal on cable 35 from automatic rhythm device 33. Signals on cable 36 from chord selector 16 to keyers 26 start the keying with the root part after each chord change. Signals from automatic rhythm device 33 to keying drive unit 16b on cable 34 can control the sounding of the selected chord notes through treble keyers 25 in rhythmic patterns also and these will, of course, be synchronized with the soundings from bass keyers 26.

As described for the second mode of operation, keying control units 15 and keying drive unit 16b provide a useful function in causing manually played harmony to sound in a prescribed relation to the melody which is, of course, the highest pitch note played. In the third mode of operation, chords can also be selected by automatic means and the notes sounded in similar relation to the melody. The automatically selected chords can also cause the notes to sound in a lower register and can further provide special treatment for different prescribed parts of the selected chords. It will be recognized that the automatically selected chords could be used in different ways without necessarily including the functioning set forth in the second mode of operation. The combination of automatic selection and this type of operation is, however, particularly desirable.

The schematic of FIG. 2 shows an embodiment of the playing key control 15 for the note A in the apparatus of FIG. 1. Playing keys 41, 42, and 43 of upper manual 11, lower manual 12, and pedal keyboard 13 respectively have their octave locations. Switches 44, 45, 46 operate in response to depression of playing keys 41, 42, and 43 respectively to make contact with busses 17, 18 and 19 respectively. Switches 44 and 45 connect through resistors 47 to line 48 and through resistors 49 to the lines 21 for their respective octave locations. Switches 44 further connect through resistors 50 to line 51 which also connects to switches 45 through resistors 52.

Lines 21 for the different octave locations connect individually to the bases of transistors 53a, 53b, and 53c in the order of higher to lower octave and with diodes 54 interposed in the paths to transistors 53b and 53c. Line 51 connects to the base of transistor 55 and the anode of diode 56. The collector of transistor 55 connects to line 23 which goes to automatic chord selector 16 which provides a supply potential and senses the conduction. The emitter of transistor 55 connects to line 20 from selector 16 and through resistor 57 to the base of transistor 58 which is normally held in saturation by resistor 59 connected from its base to ground. Line 51 also connects through resistor 60 and capacitor 61 to switch 46 which further connects to a bass keyer 26 via line 24.

Transistor 58 can be pulled out of saturation by a more positive voltage than that on line 48 applied to line 20 from chord selector 16 or by conduction of transistor 55 in response to a positive voltage drive from switches 44, 45, and 46. Cut off of transistor 58 allows voltage to be supplied through resistor 62 to col-

lector resistors 63a, 63b, and 63c for transistors 53a, 53b and 53c respectively. Transistors 53a, 53b, and 53c are normally held in saturation by resistors 64 connected between their respective lines 21 and ground. A more positive voltage applied to a line 21 can pull a transistor 53a, 53b, and 53c out of conduction. The collectors of transistors 53a, 53b, and 53c are connected to the bases of transistors 65a, 65b, and 65c respectively so that cutoff of one of the former causes the corresponding one of the latter to be driven into conduction. The collectors of transistors 65a, 65b, and 65c connect to lines 24 to provide drives to treble keyers 25.

The collectors of transistors 53a and 53b also connect to lines 22 to chord selector 16 and through resistors 66 and 67 to the bases of the respective lower octave stage transistors 53b and 53c. The emitters of transistors 65a, 65b, and 65c connect to a lower positive voltage supply than the emitters of transistors 53a, 53b, and 53c when switch 68 is in the position shown. A non conducting transistor 53a or 53b can thus provide drive to hold transistors 53b and 53c respectively in saturation through resistors 66 and 67. Resistor 67 is smaller than resistor 66 to insure that drive from transistor 53a will pull transistor 53c into saturation at least as soon as transistor 53b to avoid a possible transient response under a control condition which will be discussed later. Diodes 54 prevent voltage on lines 21 from interfering with the holding in saturation from a higher operated stage.

Only one of transistors 65a, 65b, or 65c will be providing keying drive at a time under these conditions. Voltage on line 17 will normally be set so that transistor 58 is cut off by drive from transistor 55 when any of switches 44 operates, and the corresponding transistor 53a, 53b, or 53c for the particular switch will also be cut off unless held in saturation by cutoff of the stage 53a or 53b for a higher octave stage. Cutoff of the higher stage can be caused by operation of the corresponding switch 44 or voltage supplied on line 21 for the stage from chord selector 16. The voltage on line 18 may be set so that the same action results for operation of switches 45 as just described for switches 44. The voltage can also be set so that there will be no response for operation of these switches or so that transistor 58 will be pulled out of saturation but transistors 53a, 53b, and 53c will not. This latter condition is made possible by making resistors 52 smaller than resistors 50 so that a small voltage can pull transistor 55 into conduction without substantially affecting transistors 53a, 53b, and 53c.

Resistors 47 are small compared to resistors 49, 50 and 52 so that line 48 and lines 21 are effectively decoupled from each other despite the interconnecting resistors. Placing switch 68 in its other position connects line 48 and the emitters of transistors 53a, 53b, 53c and 58 to the supply for the emitters of transistors 65a, 65b, and 65c. Transistors 53a, 53b, and 53c will control conduction of their respective transistors 65a, 65b, and 65c as before; however, the holding in saturation of stages for lower octaves through resistors 66 and 67 will be eliminated because the bases of transistors 65a, 65b, and 65c will clamp the collectors of transistors 53a, 53b, and 53c before appreciable drive is provided through resistors 66 and 67. In this mode of

operation, each transistor 65a, 65b, and 65c will respond to operation of its corresponding switches 44 or 45 when buss 17 or 18 is suitably energized.

Resistor 60 and capacitor 61 are sized to drive transistor 55 momentarily into conduction when switch 46 first operates. If transistor 58 is pulled out of conduction, it will be for such a short time that no keying of signals will result even if voltages are present on lines 21 for causing operation. The only effect will be the momentary conduction of transistor 55 which can be sensed by chord selector 16. Keying of the corresponding bass note in response to operation of switch 46 will be accomplished via the connection to bass keyers 26 via line 24 from switch 46.

Automatic chord selector 16 provides drive on line 20 to pull transistor 58 out of conduction by drawing current from resistor 59 through resistor 57. With transistor 58 cut off, the respective transistors 65a, 65b, and 65c can then be driven to key the respective notes by voltages applied to lines 21 as previously discussed. The drop across resistors 57 and 59 is sufficient to back bias the emitter of transistor 55 so that it remains cut off even when line 51 is pulled positive by operation of switches 44, 45, or 46. Diode 56 limits the degree to which line 51 can be pulled positive under any circumstances. Signals are thus not received on line 23 from transistor 55 when an enabling signal from chord selector 16 is present on line 20.

Resistor 69 provides drive to the base of transistor 70 which has its emitter connected to adjustable supply 71. Resistor 72 connects the base of transistor 70 to the junction of line 20 and the emitter of transistor 55. Supply 71 can be set at substantially the same value as line 48 and transistor 70 will then be cut off whenever transistor 58 is cut off. The collector of transistor 70 connects to a line 24 to treble keyers 25 or bass keyers 26 where it may be used to key the note A in a particular location. The keyers driven can be conventional or of a special type which will be discussed later in connection with the description of bass keyers 26.

Supply 71 may also be set slightly more positive than line 48 so that transistor 70 will not be cut off by any drive supplied through transistor 55. The setting may be such that transistor 70 will respond to all of the drives on line 20 or such that it will respond only to those drives for the root and fifth parts of chords on line 20. The latter response can be obtained because chord selector 16 provides more drive for the root and fifth parts of chords than it does for the other parts. Restriction of response to root fifth parts is useful when the output of transistor 70 is used for bass keying as will be described later.

In summary for the apparatus of FIG. 2, switch 68 is placed in the position which connects the emitters of transistors 53a, 53b, and 53c to the 15 volts supply feeding the emitters of transistors 65a, 65b, and 65c to provide the first mode of operation described in connection with the apparatus of FIG. 1. With the keying busses 17 and 18 energized, operation of a playing key 41 or 42 drives transistor 55 to pull transistor 58 to cut off and further pulls its respective transistor 53a, 53b, or 53c also to cut off. Octave interlocking by the resistors 66 and 67 is disabled by the clamping of the collectors of transistors 53a, 53b, and 53c by the bases of transistors 65a, 65b, and 65c respectively. Each play-

ing key operated thus pulls its respective transistor 53a, 53b, or 53c to cut off which in turn drives the respective transistor 65a, 65b, or 65c to saturation to turn in the respective keys 25.

When switch 68 is in the position shown connecting to the 20 volt supply, the operation is similar except that cut off of transistor 53a also provides drive to hold transistors 53b and 53c in saturation. Cut off of transistor 53b likewise provides saturation drive to transistor 53c so that only one of the set can be cut off at a time. The swing in collector voltage is also applied via cable 22 to keying drive unit 16b to provide an indication of the location of the notes being played. Keying drive unit 16b then provides drive back on lines 21 to pull transistors 53a, 53b, and 53c to cut off if they correspond to notes lower in pitch by a prescribed interval than the note of highest pitch being played. Only those in note groups in which transistor 58 is cut off can respond and the octave lockout feature further limits the response to one in each of these note groups.

For the third mode of operation described for FIG. 1, chord selector 16 provides drive via line 20 to the emitter of transistor 55 of those groups whose notes are part of the selected chord. This drive pulls transistor 58 to cut off and also cuts off transistor 55 even though it is being driven by an operated key. This occurs because the base of transistor 55 is clamped by diode 56 and its emitter is pulled more positive. With transistor 58 cut off, the note group can respond to pull-off signals on lines 21 from keying drive unit 16b, and the note is then keyed in relation to the melody note being played. The drive via line 20 may also pull transistor 70 to cut off as well and thereby key the note in another location independent of the action of keying drive unit 16b. Conduction of a transistor 55 indicates to chord selector 16 that a note is being played which is not part of the selected chord and this indication is used in making further chord selections as will be discussed later.

Referring now to FIG. 3, lines 21 for the respective notes connect through resistors 80a through 80d to the collectors of transistors 81. Resistors 80a through 80d decrease in size progressively so that a progressive increase in the voltage on the collector of a transistor 81 will provide enough drive to pull off the stages connected to resistors 80a through 80a in turn. Lines 22 likewise connect through resistors 82a through 82d and the contacts of close-open switch 83 to the bases of transistors 81. Resistors 82a through 82d increase in size so that the pull-off drive when their respective lines 22 swing negative is progressively less for notes of lower pitch.

The bases of transistors 81 also connect to line 84 through resistors 85 to receive enough drive to just hold them in saturation. Resistors 86 interconnect the bases and collectors of transistors 81 and control the amount of voltage which will appear across collector load resistors 87 for a given pull-off drive. The collectors of transistors 81 also connect through resistors 88 to resistors 89 and the bases of transistors 90 which have their respective collectors connected to the bases of transistors 81 of the next lower stage. The minimum pull-off drive, which is received through the largest resistor 82d, is just sufficient to pull the respective transistor 81 out of saturation far enough to drive the associated transistor 90 into saturation. This cuts off

the transistor 81 in the next lower stage causing it to provide pull-off drive to its associated stages through resistors 80a through 80d and also to provide far more than enough drive to saturate the next transistor 90 which cuts off the transistor 81 in the next stage, etc., so that all lower pitch stages receive pull-off drive through their associated resistors 80a through 80d.

The next hardest pull-off drive will be received through a resistor 82c and will cause the collector of the associated transistor 81 to rise a step more positive than for pull-off through a resistor 82d. This collector voltage will saturate the associated transistor 90 with the results previously described and will also provide enough pull-off drive through the associated resistor 80d to allow its associated stage to cut off. Pull-off drive through resistors 82b and 82a provides progressively larger voltage steps on the collector to provide adequate pull-offs through resistors 80c and 80b in turn. Adequate pull-off through a resistor 80a requires the associated transistor 81 to be cut off by saturation of its associated transistor 90.

The pull-off drive determines the highest pitch stage which in turn receives pull-off drive. All lower pitched stages also receive pull-off drive but the octave lockout feature of the FIG. 2 apparatus permits each note to sound only in the one octave. Movement of switch 83 counterclockwise shifts the pull-offs from lines 22 down one stage with the result that the response is lowered by four semitones and an open harmony relation is obtained with the highest pitch note providing the pull-off drive on a line 22 and the chord notes being pulled off via lines 21.

The pull-off response can be inhibited by pulling line 84 and thereby providing saturation drive to transistors 81 through resistors 85 despite the maximum pull-off drive possible through lines 22. Except when inhibiting, line 84 will be at a voltage which just keeps transistors 81 in saturation when no pull-off drive is being received from lines 22. The emitters of transistors 81 and 90 may be at the same potential as the emitters of transistors 53a, 53b, and 53c if the various resistors are sized properly. Less interaction and less incidental loading is imposed, however, if the emitters of transistors 81 and 90 are approximately a volt more negative so that the base and collector voltages more nearly match those of transistors 53a, 53b, and 53c for the rest condition. Supply 92 will thus be approximately 19 volts when this circuit is functioning.

Pull-off response can also be removed by removing the collector supply or by placing switch 83 in its open position. The latter action allows another type of control to be exercised through a voltage applied to line 91. Line 91 connects to the bases of transistors 81 through resistors 90a, 90b, etc, which progressively decrease in size. An increasingly negative voltage thus pulls the transistors 81 progressively to cut off from the lower pitched stages to the highest. With the octave lockout characteristic of the circuit of FIG. 2, the notes for which transistors 58 are cut off will sound in locations determined by the negative voltage on line 91. Voltage on line 91 could also be used to assist in inhibiting by being made positive with respect to the emitters.

Referring now to FIG. 4, line 23, which connects to all of the collectors of transistors 55 in keying control

units 15, goes through resistor 101 to the base of transistor 102. Conduction of any transistor 55 indicates that its note is not enabled by automatic chord selector 16 and a playing key for the note in some octave location is depressed. Conduction of any transistor 55 drives transistor 102 to saturation, a condition which indicates that a non matching note is being played. The collector of transistor 102 connects to the junction of resistors 103 and 104 which are connected to provide saturation drive to the base of transistor 105. When transistor 102 saturates, the drive to transistor 105 is removed and it cuts off.

Transistor 106 completes a flip flop circuit with transistor 105, their collector resistors 107 and 108, and their base collector interconnecting resistors 109 and 110. Transistor 106 may receive additional drive to its base from a number of sources as will be described later. If transistor 106 is cut off when transistor 102 saturates, transistor 105 will still receive saturating drive through resistor 109 from the collector of transistor 106. If transistor 106 is being held in saturation from external drive, transistor 105 will cut off when transistor 102 saturates, thereby providing saturating drive to transistor 106. Cut off of transistor 102 is then necessary to restore transistor 105 to its normally conducting state.

When transistor 105 cuts off, its collector provides drive to transistor 106 as previously mentioned and removes drive from resistor 111 going to the base of transistor 112 and resistor 113. The collector also provides drive through resistor 114 to the base of transistor 115 whose collector than pulls line 84 positive to hold transistors 81 in saturation and inhibit the action of the apparatus of FIG. 3 as previously discussed. With drive removed, transistor 112 cuts off and its collector no longer clamps the base of transistor 116. This allows the multivibrator, consisting of transistors 116 and 117, collector resistors 118 and 119, base resistors 120 and 121, and capacitors 122 and 123, to run.

Flip flop 124 is the first stage of a binary counter chain consisting of flip flops 125, 126, and 127 and receives its trigger input from the collector of transistor 116. Flip flop 124 provides clamping voltage drives on lines 128 and 129 alternately as it changes condition and flip flops 125, 126, and 127 drive resistor matrix 130. Resistor matrix 130 provides drive to the bases of each of transistors 131a through 131f from one or the other side of the three flip flops 125, 126, and 127. One drive is sufficient to hold each of transistors 131a through 131f in saturation so that they cut off only when each of the particular combination of sides of flip flops 125, 126, and 127 from which they individually receive drives through matrix 130 is in the off condition. This occurs for each of transistors 131a through 131f at a different count so that they cut off one at a time as flip flops 125, 126, and 127 run as a counter in response to a series of triggers from flip flop 124. Two of the possible eight counts are not used in this embodiment.

Removal of drive to transistors 131a through 131f has no effect unless their respective collector resistors 132a through 132f are supplied with power by switch 133 or switch 134. Switch 134 supplies power to resistors 132a through 132f so transistors 131a through 131f are included in the operation. Switch 133 limits

operation to transistors 131a through 131c by supplying power only to resistors 132a through 132c and removing power from last stage flip flop 127. If supplied with power, the voltage on the collectors of transistors 131a through 131f goes positive one at a time as the counter driving resistor matrix 130 runs. Stopping the counter holds the one of transistors 131a through 131f for the stopped position cut off and its collector remains positive.

The collectors of transistors 131a through 131f each connect to a particular combination of resistors 135. Each combination of resistors 135 connects to a different set of arms of musical key selector switch 136. The arms of switch 136 connect to lines 20 to provide enabling drives to control units 15 when voltage is applied to an associated resistor 135. The connections to lines 20 made by switch 136 in its shown position are for operation in the musical key of C. Its other position makes connection for operation in the musical key of F and it will be recognized that other positions could be added for operation in the other musical keys.

When transistor 131a cuts off, and switch 136 is in the position shown, the notes of the Tonic triad of the key of C, namely C, E, and G, are enabled. If switch 136 were in its other position, the Tonic triad of the key of F, namely F, A, and C, would be enabled. In similar manner, transistor 131b always enables the notes of the Dominant Seventh chord which are G, B, D, and F for the key of C and C, E, G, and A # for the key of F. The other transistors 131c through 131f drive notes for other diametric chords, Dm7, Am7, and Em7, respectively, when flip flop 124 applies clamping voltage to the diodes 137 connected to line 128. When flip flop 124 is in its other condition clamping line 129 for diodes 137 connected thereto, the Dm7, Am7, and Em7 chords associated with transistors 131d, 131e, and 131f are changed to D7, A7, and E7 chords respectively. This occurs as a result of drives to the notes F #, C #, and G # from transistors 131d, 131e, and 131f respectively being clamped by diodes 137 connected to line 128, and drives to notes F, C, and G from the same transistors being clamped by diodes 137 connected to line 129 in the other case.

It will be recognized that both the number and type of chords provided could easily be changed and that more different sets could be provided than the two afforded by switches 133 and 134. While the particular sets shown are useful, they are illustrative only and the invention is by no means limited thereto. Resistors 135 may be of different sizes to provide the required enabling drive for different conditions. Series combinations to allow clamping of some paths by diodes 137 in response to flip flop 124 and different numbers of resistors 135 in different combinations impose different drive requirements. Different sizes of resistors 135 are also required to provide more drive for root and fifth parts to discriminately operate transistors 70 as previously mentioned.

When transistor 112 cuts off as previously mentioned, the multivibrator runs and drives the binary counter consisting of flip flops 124 through 127. Flip flop 124 alternates in applying clamping voltage to lines 128 and 129 for different sets of diodes 137. The other counter stages matrix 130 to cause transistors 131a through 131f to cut off one at a time in reverse

order starting with 131f and ending with 131a if switch 134 is operated, and starting with 131c and ending with 131a if switch 133 is operated. (The scanning is continuous and the naming of starting and ending points in the preceding is merely to indicate the order.) The chords are enabled in turn until one is reached which includes all of the notes being played on manual 11 or 12 or pedals 13. All transistors 55 then become non conducting and transistor 102 cuts off causing transistor 105 to return to saturation and likewise pull transistor 112 back into conduction to reapply the clamp to the multivibrator.

The enabled chord then remains until a subsequent non match and other conditions allow the multivibrator to run for further scanning. The frequency at which the multivibrator runs is made sufficiently high to cause the delay for scanning to be imperceptible. Resistors 138 and 139 from the collector of transistor 131c to the base of transistor 131b together with capacitor 140 from their junction to ground provide a means for modifying the order for considering chords. Since their time constant is long compared with the natural period of the multivibrator, they exert a negligible effect, except when scanning has been stopped for a period of time on transistor 131c. Capacitor 140 then has time to charge so that transistor 131b will be held in saturation by the drive from it through resistor 139 during the first cycle of the multivibrator after restarting a scan. The first possible stopping place is then with transistor 131a cut off. Capacitor 140 quickly discharges so transistor 131b can react normally on the next scanning.

It will be remembered that a necessary condition for cutting transistor 105 off and unclamping the multivibrator is that transistor 106 be conducting. The series chain of resistors 141, 142, and 143 from the base of transistor 106 to the positive 20 volt supply will pull transistor 106 into saturation if transistor 145 has been cut off long enough for capacitor 146 to have discharged. The collector of transistor 145 is connected to the junction of resistors 142 and 143 to pull it to the positive 40 volt supply when transistor 145 conducts. Capacitor 146 is connected between the junction of resistors 141 and 142 and the 20 volt supply to delay the application and removal of drive from transistor 106 as transistor 145 cuts off and conducts.

The emitter of transistor 147 and one end of resistor 148 connect to the base of transistor 145 while the base of transistor 147 and the other end of resistor 148 connect to the keying bus 17 for manual 11 and through switch 149 to keying bus 18 for manual 12. When any key is operated, transistor 145 is pulled into saturation. If transistor 145 has previously been cut off for an appreciable period, transistor 106 will be in saturation and will remain so long enough for transistor 105 to cut off when the note played is a non match with any chord note. After transistor 145 has been conducting for a short period, capacitor 146 becomes charged so that little or no drive is provided for transistor 106 through resistor 141. Upon release of all notes being played, a short period will be required before capacitor 146 discharges sufficiently to pull transistor 106 into saturation through resistor 141. If another note is played before this condition is reached, the drive will remain removed.

The time constants for charge and discharge of capacitor 146 can be set so that transistor 106 will not receive appreciable drive through resistor 141 while notes are being played in legato fashion, but will only be pulled into saturation when there is an appreciable break between notes, such as occurs in staccato type playing. Chords can then only be changed with staccato playing. Alternately the time constant can be made quite short so that one note must be played as the other is released, or a note continuously held, to prevent changes from occurring when non-matches do. Non-matches, after a very short break in which no notes are played, will then produce changes. When switch 149 is in the position shown, playing on manual 12 will have the same effect as playing on manual 11. In its other position, switch 149 connects bus 18 to control 150 which can provide it with suitable voltages for different control responses.

Bus 17 and switch 149 can connect directly to the base of transistor 145 as far as the action just described is concerned, but transistor 147 permits an additional type of control to be exercised. The collector of transistor 147 connects to the 20 volt supply through the series combination of resistors 151 and 152 which have their junction connected to the base of transistor 153. The size of resistor 148 can be selected so that transistor 147 will not conduct until more than a given number of notes are being played on manual 11 or on manual 12 or both when bus 18 is connected to the base of transistor 147 by switch 149. Conduction of transistor 147 with keying of the prescribed number of notes (or greater) causes transistor 153 to conduct in turn and drop voltage across its collector resistor 154. The collector of transistor 153 connects through switch 155 and the series combination of capacitor 156 and resistor 157 to the base of transistor 106 so that the conduction will momentarily pull transistor 106 into saturation. Playing the prescribed number of notes is thus another way to make the apparatus respond to a non match.

Resistors 158 and 159 are connected in series between the positive 40 and 20 volt supplies and have their junction connected to the base of transistor 160. The emitter of transistor 160 connects to ground through resistor 161 and to bus 19 from pedals 13. If no pedal 13 is operated, bus 19 has a positive voltage which holds transistor 160 cut off. If any pedal 13 is operated, the positive voltage on line 19 is removed and transistor 160 is pulled into conduction by its emitter resistor 161. The collector of transistor 160 then provides drive through resistor 162 to transistor 145 and through capacitor 163 and resistor 164 to transistor 106. The first drive provides the same inhibiting action to change while a pedal 13 is held as is furnished for the playing keys of manual 11. Switch 165 provides a means for disconnecting this action. The drive to transistor 106 pulls it momentarily into saturation to permit response if the pedal note produces a non-match. This action can be disconnected by switch 166.

Switch 167 provides a holding action against any non-match by disconnecting the base of transistor 106 from any of its possible sources of drive. If a non-match is in process when switch 167 is operated, the counter can continue to run until a match is made. When switch

155 is in its other position, it connects capacitor 156 to the positive 40 volt supply through resistor 168, to switch 169, and through capacitor 170 to the trigger input of second stage flip flop 125. Operation of switch 169 connects the junction of resistor 168 and capacitor 170 to a lower voltage to produce a pulse to stop flip flop 125 and thereby change the chord selection. If switch 155 connects capacitor 156 to switch 169, operation of switch 169 will also cause transistor 106 to conduct momentarily and thereby allow response to a non-match. While all switches will be operable by the player, switches 167 and 169 will be located as conveniently as possible for easy operation. Other variations of operating controls are, of course, possible within the scope of the invention.

Various combinations of less than the full set of controls and associated apparatus of FIG. 4 can also function satisfactorily. One of those combinations, for example, could have switch 167 replaced by a permanent connection of the base of transistor 106 only to resistor 141. The remaining associated components would consist only of resistors 142 and 143, capacitor 146, transistor 145, and resistor 148 connected to bus 17. Resistor 148 could be eliminated and a direct connection of bus 17 made to the base of transistor 145. Response to passing tones could be inhibited by playing them legato so that transistor 106 would remain cut off and mismatches would be ineffective in producing chord changes. Playing staccato would produce response to any mismatch and changes could be made even when the melody note was part of the old chord by playing simultaneously a second note which is not part of the old chord but is part of the new one. With such playing techniques, supplementary controls would be unnecessary.

Referring now to FIG. 5, bass keys 26 includes conventional bass keyers which are not shown and special keyers 200 which receive outputs from tone generators 27 via cable 29 and keying signals from keying control units 15 via cable 24. Each of special keyers 200, as shown for the note C, consists of a pair of resistors 201 and 202 connected in series between the respective line of cable 29 and common output line 200a or 200b. The junction of resistors 201 and 202 for each keyer 200 connects to its respective line of cable 24 going to the collector of transistor 70 for its respective note. The base of transistor 203 receives the outputs of keyers 200 on line 200a for the notes C, D, E, F#, G#, and A# and transistor 204 receives those on line 200b for the remaining notes, F, G, A, B, C#, and D#.

The signals can pass when their respective transistors 70 are cut off and will be clamped off when transistors 70 are saturated. As previously explained, the setting of adjustable supply 71 determines whether transistors 70 will cut off in response to operation of playing keys 41 and 42 for their respective notes, or whether they will cut off only when their respective notes are enabled from automatic chord selector 16. In either case, the keyed signals are mixed in the two groups by transistor 203 with its collector resistor 205 and feedback and bias resistor 206, and by transistor 204 with its collector resistor 207 and feedback resistor 208. The two groups of signals then go via resistors 209 and 210 to the input of modulator 211 where they are mixed

together. Modulator 211 receives a rhythmic drive from automatic rhythm device 33 via a line or cable 35 and provides an output on a line of cable 31 to output system 32.

The output of supply 71 may also be set so that transistors 70 will be cut off only when receiving an extra drive from chord selector 16 when the respective note is a root or fifth part of the selected chord. For this condition, transistors 203 and 204 will be receiving one signal each, one the root of the chord and the other the fifth. The output of modulator 211 will be the combination of the two. The outputs of transistors 203 and 204 also go through resistors 212 and 213 respectively to the anodes of diodes 214 and 215 respectively and further through capacitors 216 and 217 respectively to a contact of switch 218. Switch 218 connects the input of bass frequency divider 219 either to the output of the conventional bass keyer (not shown) on line 220 or to the junction of capacitors 216 and 217. Flip flop 221 has its two outputs connected to the cathodes of diodes 214 and 215 so that the signal through resistor 212 or 213 will be clamped while the other signal can pass to drive divider 219. The signal passed depends on the position of flip flop 221.

The output of bass frequency divider 219 goes via a line of cable 31 to output system 32. When switch 222 is closed, automatic rhythm device 33 provides a signal on a line of cable 35 to alternate the position of flip flop 221. The tone signals for the root and fifth parts of the selected chord through resistors 212 and 213 are then alternately passed to drive bass frequency divider 219. The output of divider 219 on the line of cable 31 to output system 32 then provides signals for the root and fifth parts alternately in the bass. Flip flop 221 also receives set or reset inputs via the two lines of cable 36 from automatic chord selector 16 after each chord change. These inputs position flip flop 221 to pass the root signal first after each chord change so the root part of the new chord will sound first in the bass. The production of these set or reset signals on the two lines of cable 36 will be described next.

Referring now to FIG. 6, resistors 171 connect in two groups of three from the collectors of transistors 131a through 131f to the collectors of transistors 172 and 173. The collectors of transistors 172 and 173 also connect through resistors 174 and 175 respectively to the arms of switch 136 which in turn make contact with the two lines of cable 36 to flip flop 221 of FIG. 5. Resistors 176 connect from the bases of transistors 172 and 173 to the collector of transistor 105 so that transistors 172 and 173 will be held in saturation except when the multivibrator is running to search for a new chord. With transistors 172 and 173 cut off during the search for a new chord, transistors 131a through 131f provide a drive to their respective sides of flip flop 221 as each cuts off in turn. When a chord is selected and transistors 172 and 173 are again in saturation, they clamp the drives on cable 36 and flip flop 221 will be in the position to which it was last set by the one of transistors 131a through 131f whose cut-off selected the chord.

For the key of C, transistors 131b, 131c, and 131e correspond to chords whose roots are in the group of notes which are applied to transistor 204 of FIG. 5. Resistors 171 from the collectors of these transistors go to

that line of cable 36 which will set flip flop 221 to first pass the signal from transistor 204. Resistors 171 from the other transistors 131a, 131d, and 131f go to the other cable 36 which will set flip flop 221 to the other condition to pass the signals from transistor 203 first. Transistor 203 handles signals for the notes which are the roots for chords of those transistors. For the key of F, the roots associated with transistors 131b, 131c, and 131e are handled by transistors 203 and those with transistors 131a, 131d, and 131f by transistor 204. Musical key selector switch 136 reverses the connections to the lines of cable 36 when it switches to the key of F so flip flop 221 will be set to first pass the root part of new chords for bass playing.

What Is Claimed Is:

1. In an electronic musical instrument having a set of playing keys for the notes of a musical scale in each of a plurality of octave locations, the combination of:

- a. means for sounding said notes in each of their octave locations,
- b. means coupled to said sounding means for enabling the sounding of selected notes in each of a plurality of octave locations,
- c. means coupled to said sounding means for activating the sounding of each said enabled notes in an octave location responsive to a control voltage, and
- d. means coupled to said applying means for applying a control voltage to said actuating means.

2. The combination according to claim 1 wherein said selected notes are those for which a playing key is operated in any octave location.

3. The combination according to claim 2 wherein said activating means includes means for limiting the sounding of each note to one octave location at a time.

4. The combination according to claim 1 wherein said applying means is responsive to the highest pitch playing key operated and produces a control voltage which is a function of the pitch location of said highest pitch playing key.

5. The combination according to claim 4 including means for shifting the relation between said highest pitch playing key operated and the octave locations for said activating means.

6. The combination according to claim 5 wherein said shifting means changes said relation by four semi tone intervals.

7. The combination according to claim 4 wherein said activating means is responsive to a voltage and said changing means alters the voltage to said activating means.

8. The combination according to claim 1 including means for selecting chords and wherein said selected notes are the notes of the current chord of said selecting means.

9. The combination according to claim 8 wherein said selecting means comprises means for driving said enabling means for the notes of a different chord of each of a set of conditions, and means for changing said driving means from one condition to another.

10. The combination according to claim 9 wherein said changing means is responsive to operation of said playing keys.

11. The combination according to claim 9 including means for sensing operation of playing keys for notes

incompatible with the chord for the current condition of said driving means and wherein said changing means is responsive to said sensing means.

12. In an electronic musical instrument having a set of playing keys for the notes of a musical scale, the combination of:

- a. means for selecting each of a plurality of chords,
- b. means coupled to said selecting means and said playing keys for sensing operation of a playing key for a note not compatible with the currently selected chord of said selecting means,
- c. means coupled to said sensing means and said selecting means for changing said selecting means from one chord to another responsive to said sensing means and,
- d. means coupled to said selecting means for sounding notes of the current chord of said selecting means.

13. The combination according to claim 12 including means for inhibiting the responsiveness of said changing means.

14. The combination according to claim 13 wherein said inhibiting means is disabled for short intervals following a period during which no playing key is operated.

15. The combination according to claim 12 wherein said sensing means is limited in operation to short intervals following a period during which no playing key is operated.

16. The combination according to claim 12 including an auxiliary control and wherein said changing means is also responsive to said auxiliary control.

17. The combination according to claim 12 including means for interrupting the sounding of different parts of the chords in different rhythmic sequences.

18. The combination according to claim 17 wherein said interrupting means sounds the root and fifth parts of the chords alternately in the bass register.

19. In an electronic musical instrument having a set of playing keys for the notes of a musical scale in each of a plurality of octave locations, the combination of:

- a. first means coupled to said playing keys for sounding notes in octave locations corresponding to operated playing keys, and
- b. second means coupled to said playing keys for sounding notes in a particular octave locations responsive to operation of their corresponding playing keys in any octave location.

20. In an electronic music instrument having a set of playing keys for the notes of a musical scale, a set of tone generators, and an output system, the combination of:

- a. a set of drivers individually associated with each of the notes of the scale in each of a plurality of octave locations,
- b. a plurality of keyers coupled to and operable by said drivers to apply signals from said tone generators to said output system,
- c. means coupled to said drivers for enabling the drivers for selected notes in each of a plurality of octave locations,
- d. means coupled to said drivers for activating one of said enabled drivers for each of said selected notes in a particular octave location responsive to a control voltage, and

e. means for applying a control voltage to said activating means.

21. The combination according to claim 20 including means for shifting the response of said activating means to said applying means.

22. In an electronic musical instrument having a set of playing keys for the notes of a musical scale and an output system, the combination of:

a. means for producing a plurality of sets of tone signals for different chords to drive said output system,

b. a multistable circuit coupled to and controlling said producing means to select a different one of said sets for each of its different stable conditions, and

c. means coupled to said multistable circuit for stepping said multistable circuit from one stable condition to the next responsive to operation of different ones of said playing keys for each different condition of said multistable circuit.

23. The combination according to claim 22 including means coupled to said playing keys and said multistable circuit for sensing operation of playing keys for notes incompatible with the set of signals from said producing means for the current stable condition of said multistable circuit, and wherein said stepping means is coupled to and responsive to said sensing means.

24. The combination according to claim 22 including

means for interrupting different signals from said producing means in different rhythmic sequences.

25. The combination according to claim 24 wherein said interrupting means causes signals for the root and fifth chord parts in a bass register of the sets to occur alternately.

26. The combination according to claim 24 wherein said interrupting means includes an automatic rhythm device.

27. In an electronic musical instrument having a set of playing controls and an output system, the combination of:

a. means coupled to said playing controls and responsive to actuation of any one of said playing controls for selecting a set of signals including those for a chord, and

b. means coupled to said selecting means for producing said selected signals in rhythmic patterns to drive said output system.

28. The combination according to claim 27 wherein said set includes signals for a plurality of base notes and said set includes signals for a plurality of base notes and said producing means applied said signals one at a time in turn to said output system.

29. The combination according to claim 28 wherein said signals are for the root and fifth parts of a chord.

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