

Jan. 23, 1973

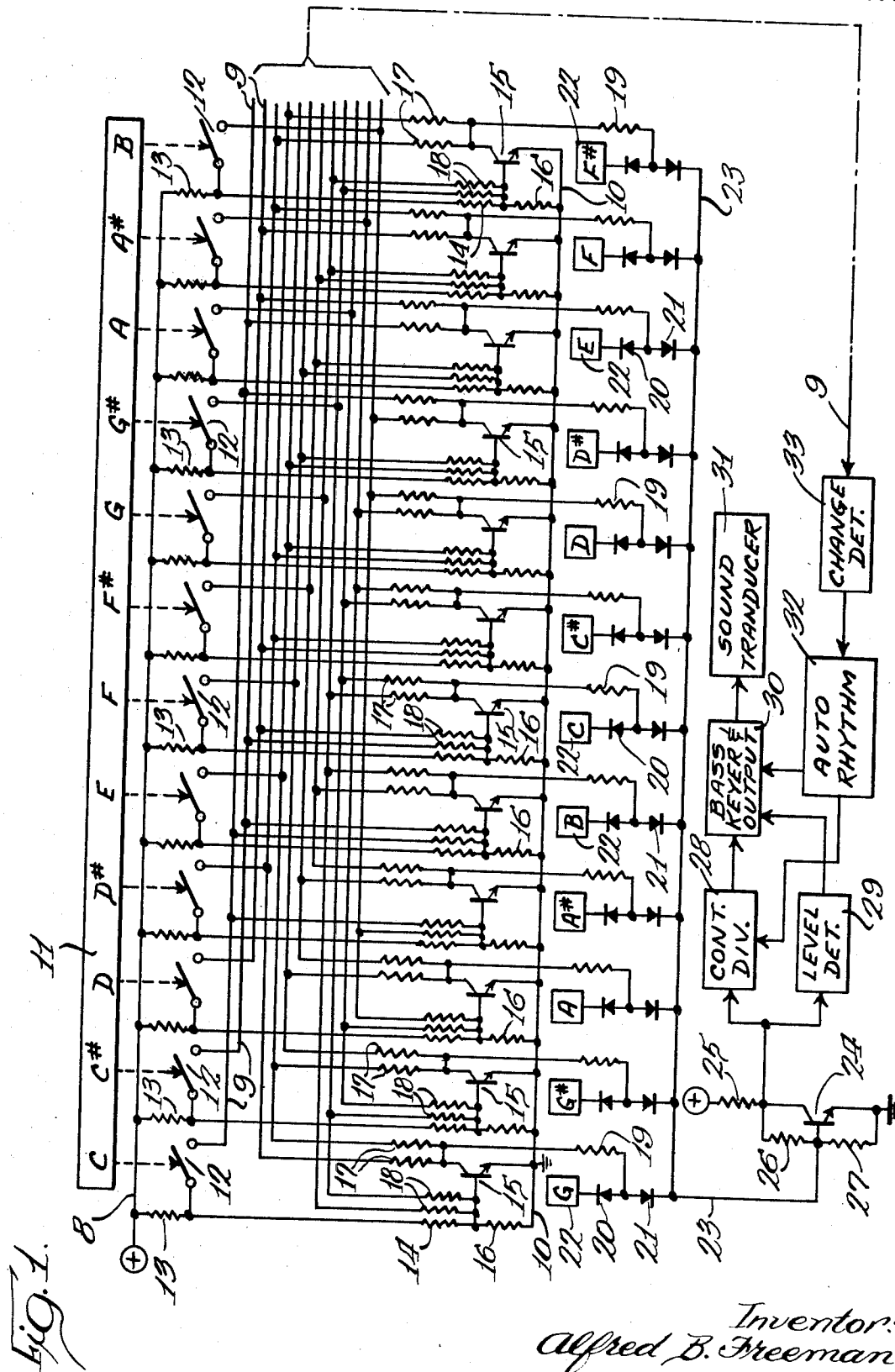
A. B. FREEMAN

3,712,950

AUTOMATIC BASS FROM CHORD APPARATUS

Filed Dec. 14, 1970

4 Sheets-Sheet 1



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AUTOMATIC BASS FROM CHORD APPARATUS

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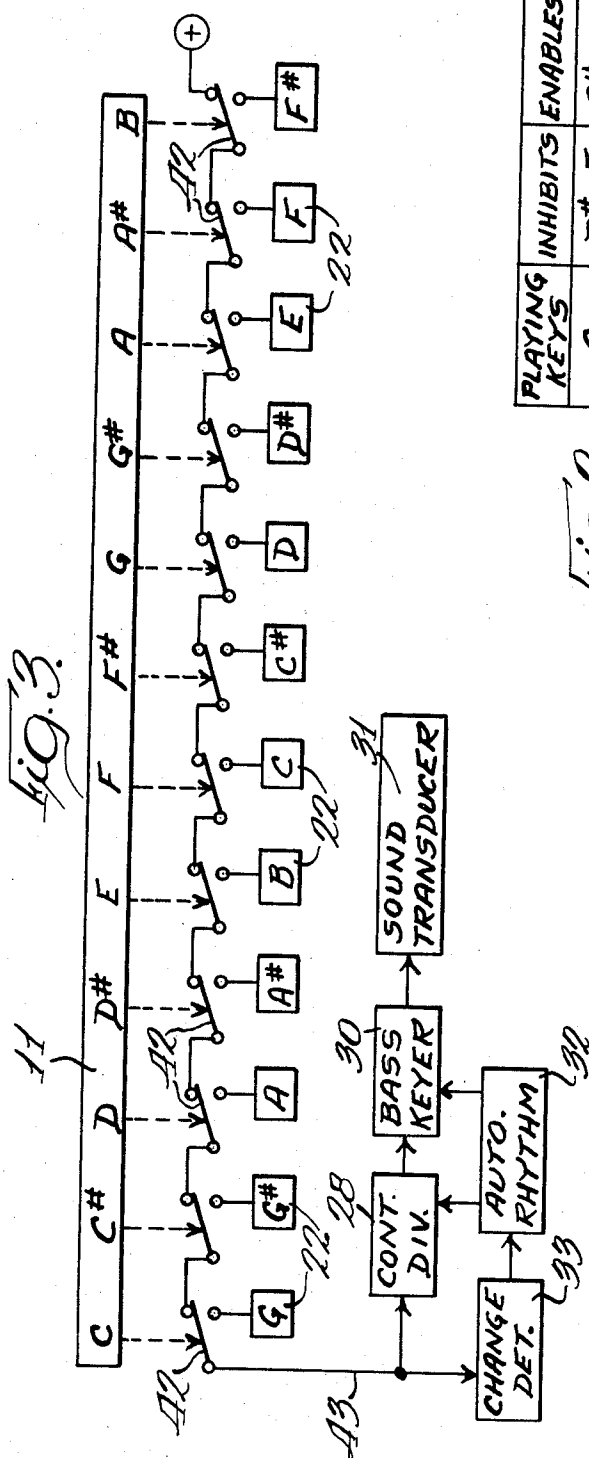


Fig. 2.

PLAYING KEYS	INHIBITS	ENABLES
C	D# E	G# A
C#	E F	A A#
D	F F#	A# B
D#	F# G	B C
E	G G#	C C#
F	G# A	C# D
F#	A A#	D D#
G	A# B	D# E
G#	B C	E F
A	C C#	F F#
A#	C# D	F# G
B	D D#	G G#

Inventor:
Alfred B. Freeman

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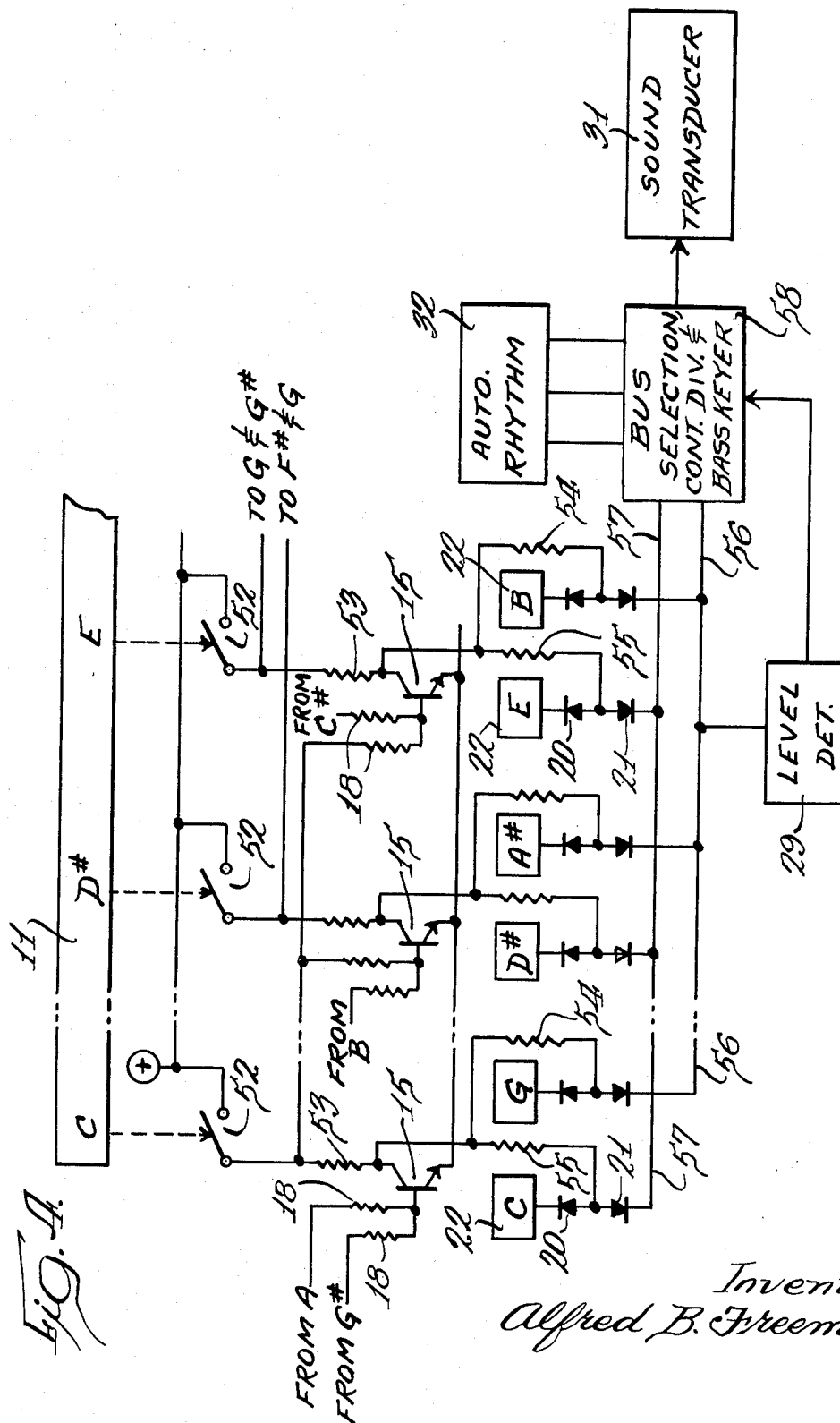
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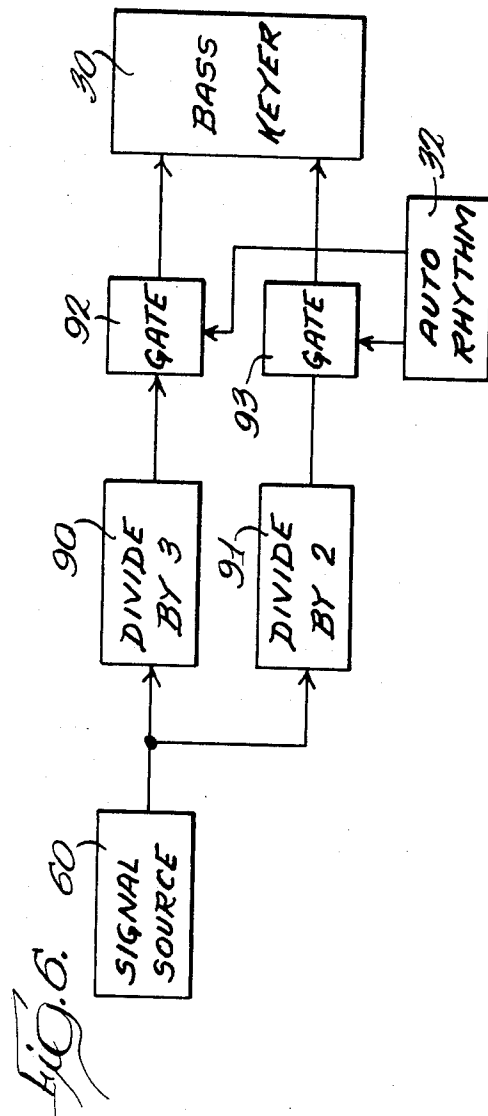
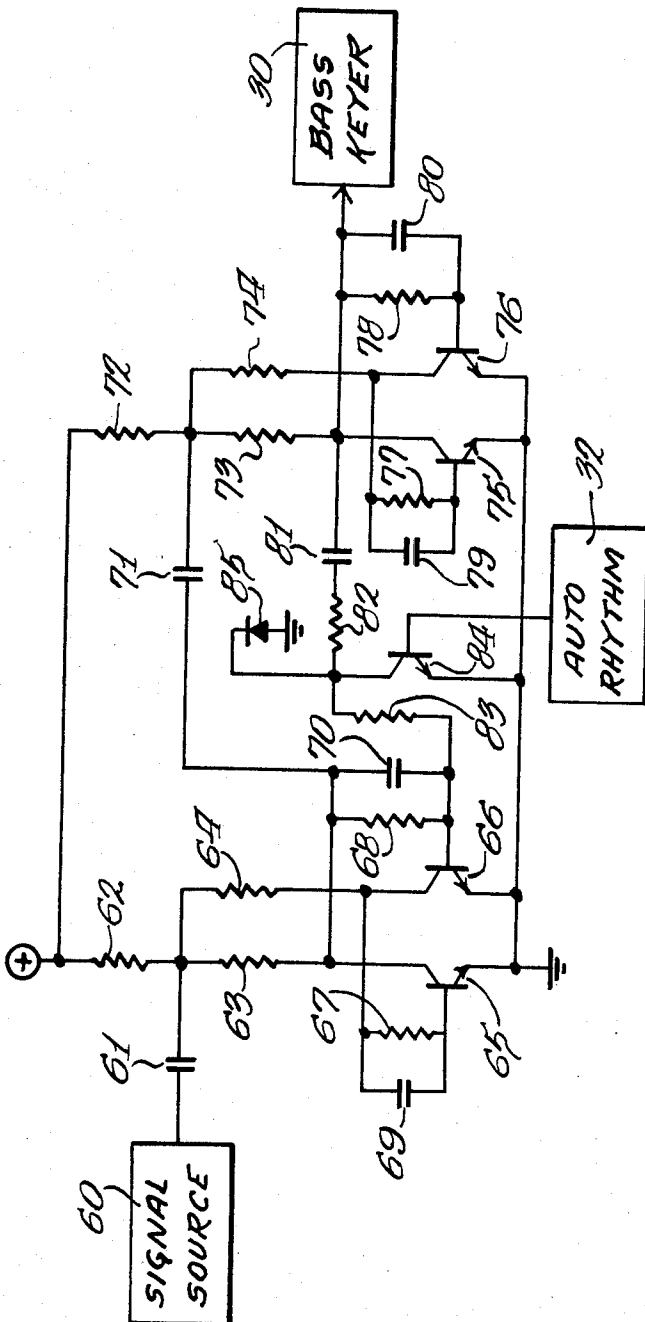
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AUTOMATIC BASS FROM CHORD APPARATUS

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4 Sheets-Sheet 4



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AUTOMATIC BASS FROM CHORD APPARATUS

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19 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus for automatically playing bass parts to accompany manually held chords which has an automatic rhythm device controlling a special bass divider between dividing ratios of three and two or four to produce bass outputs in root and fourth relation to its input which is received from keyers driven by logic devices sensing the playing keys operated to pass a signal corresponding to the chord fifth. The net result is that the divider output is the root and fifth of the chord. The logic ranges from a simple interlock switching for the lowest playing to key to one requiring root and minor or major third playing keys operated and augmented fifth and sixth part playing keys not operated. The new logic means can alternatively drive two keyers to different busses and the automatic rhythm device selects busses for input to the divider instead of changing its ratio.

BACKGROUND OF THE INVENTION

(1) Field of the invention

This invention is directed to apparatus for playing bass parts automatically in response to playing on the manual and to an automatic rhythm device.

(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. Hanert's apparatus is not responsive to playing on the manual and operation of two chord buttons would disrupt the bass playing.

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 played is determined by switching logic which causes a playing key to inhibit the playing of bass for notes which are its minor or major third. Greif does not include means for playing the important fifth part alternatively with the root. The switching logic is relatively expensive in that it includes extensive hand wiring and it further does not protect against two bass notes at a time for some combination of operated playing keys.

In my prior copending U.S. patent application No. 748,245, filed July 29, 1968, Pat. No. 3,548,066, dated Dec. 15, 1970, I disclose means for keying root and fifth parts to two different busses in response to operation of playing keys. An automatic rhythm device then selects the proper bus for application to the input of a bass divider. The drivers responding to playing keys inhibit operation of other drivers to avoid keying two sets of bass notes. The inhibiting means does not cover all combinations and encounters an oscillatory response under certain conditions. The actual circuitry and logic imposed some critical conditions which add a substantial cost.

In Canadian Pat. No. 801,954, Freeman discloses a bass keying system applying the fifth of desired bass notes to drive two dividers providing outputs to different speakers. One divider divides by two and the other divides by three so that the resultant bass note heard from the combination of outputs in an octave lower than the out-

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put of the one dividing by three. The speakers thus do not have to handle frequencies as low as the desired bass range and can operate more efficiently.

SUMMARY OF THE INVENTION

The present invention replaces the requirement for two sets of keyers and bus selection with a divider whose ratio is controllable between three and two or four. The invention also provides improved logic which gives a better response to some playing conditions and further provides logic circuitry which is inexpensive and reliable.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partial block and partial schematic diagram of one embodiment of the invention;

FIG. 2 is a chart showing functional relations between notes in the apparatus of FIG. 1;

FIG. 3 is a partial block and partial schematic diagram of another embodiment of the invention;

FIG. 4 is a partial block and partial schematic diagram of a representative section of the apparatus of FIG. 1 showing a modification which can be made to the apparatus of FIG. 1;

FIG. 5 is a partial block and partial schematic diagram of one form for the controlled dividers of FIGS. 1 and 3; and

FIG. 6 is a block diagram of another form for the controlled dividers, of FIGS. 1 and 3 using gates and related components.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Playing keys 11 of a standard keyboard couple mechanically to switches 12 as shown in FIG. 1. Switches 12 for playing keys 11 for the same note in other octaves could be added in FIG. 2 of parallel as shown in my aforementioned Pat. No. 3,548,066. Resistors 13 connect the poles of switches 12 to line 8 going to a positive potential source while resistors 14 connect them individually to the bases of transistors 15 and to resistors 16 which have their other terminal connected to ground. When switches 12 are not operated, their associated transistors 15 are held in saturation by the drive to their bases from the associated networks of resistors 13, 14, and 16. When a switch 12 operates, its arm connects to an associated line 9 and the additional load causes an additional voltage drop through its associated resistor 13. This voltage drop reduces the current through resistor 14 which causes the voltage at the junction of resistors 14 and 16 to also drop and remove the current to the base of the associated transistor 15. The operated switch 12 thus allows its associated transistor 15 to cut off.

The load on line 9 to each switch 12 consists of two resistors 17 going to collectors of two transistors 15 and two resistors 18 going to bases of two other transistors 15. The drive through the resistors 18 is sufficient to keep the respective transistors 15 in saturation even though the drive through their respective resistors 14 has been reduced. If a transistor 15 is not held in saturation, the drive through a resistor 17 will pass on to an associated resistor 19 to turn on the associated tone signal keyer consisting of diodes 20 and 21 and pass the signal from tone generator 22. A common wire or bus 23 connects the diodes 21 together. If the transistor 15 has saturation drive applied to its base, however, its collector will remain substantially at ground potential and the tone signal keyer will not be operated.

Each transistor 15 will be considered to be associated with the same note as is the playing key 11 which actuates the switch 12 that removes its inhibiting drive through resistor 14. The tone signal passed by the keyer connected to its collector will, however, be for a note

which is in the relation of a musical fifth to the associated note. As will be later explained, dividing this tone signal by three produces a tone signal for the associated note in the bass. In addition to having its inhibiting drive through resistor 14 removed, each transistor 15 must also receive an enabling voltage to its collector from operation of either of two other playing keys 11 before it can operate its associated keyer. It must also not receive an overriding inhibiting drive from operation of either or both of two other different playing keys 11.

FIG. 2 is a chart and shows the action which each playing key 11 produces upon operation. For example, the one for C removes the inhibit through resistor 14 from its associated transistor 15. It further provides inhibiting drives through resistors 18 to bases of transistors 15 associated with playing keys 11 for the notes D# and E and provide collector supply voltage through resistors 17 to transistors 15 for notes G# and A. Looking further through the chart, it will be seen that playing keys for D# and E provide enabling collector voltage for the transistor 15 associated with C and those for G# and A provide inhibiting drives for it. If playing keys 11 for C and either D# and E are operated and those for G# and A are not, voltage will be produced on the collector of the transistor 15 for C and this voltage will key the output of tone generator 22 for the note G to the bus 23.

The net result of these patterns of inhibits and enables will now be discussed in connection for chords on the root C. It will be recognized that results for similar chords on other roots would be correspondingly the same. Actuating the playing keys 11 for the note C and either the note D# or E will allow the transistor 15 associated with C to have voltage on its collector and provide drive to key tone signal G to bus 23. C inhibits the transistors 15 for notes D# and E. Adding G to play GEG or CD#G for C major or C minor chords respectively produces the same result as transistor 15 for G is inhibited by both D# and E while transistor 15 for C remains uninhibited. Changing G to F# for a diminished chord again leaves only transistor 15 for C operating its keyer as F# is inhibited by D# and C remains uninhibited. Playing CEG# or CD#F#A provides a round robin inhibit, that is with each transistor 15 inhibited by playing keys 11 for another note, and no keyer is operated. Adding A# or B to the major or minor chords CEG or to play seventh and major seventh chords changes nothing as G inhibits both and neither inhibit C. With A# or B operated, D can also be operated to also play a ninth as it is inhibited by both. D in turn inhibits F so up to eleventh chords with ninth can be played without causing other than C to operate the keyer for the G tone signal. The limitations are that augmented chords and four part diminished chords will not play a note and playing A with CEG will be taken as an A minor seventh chord rather than a C sixth chord because A inhibits C and is not inhibited by E or G. A with CD#G will likewise be taken as an A diminished seventh rather than a C minor sixth.

In the above, operation for C chords has been discussed and it will be remembered that only the transistor 15 associated with C was both enabled and not inhibited. The resulting tone signal which is keyed is for the note G. The signal on bus 23 goes through a bus amplifier, consisting of transistor 24 and associated resistors 25, 26, and 27, to a controlled divider 28 and a level detector 29. When the controlled divider 28 divides by three, its output for the G signal input is a C in the bass. The C corresponds to the root of the chord being played by playing keys 11. When controlled divider 28 divides by two or four, the output is a G in the bass and corresponds to the fifth of the chord. A limitation is that G would be played for the fifth even if the chord was a C diminished consisting of the notes CD#F# for which the fifth should be F# rather than G. It is not thought that the diminished chord is important enough to the beginner

who would be using this device to justify additional logic to correct this limitation.

The output of the controlled divider 28 goes to bass keyer and output circuit 30 which provides different envelope shapes and tonal qualities to sound transducer 31. Level detector 29 responds to a higher voltage input if two or more keyers are operated and produces a control signal to bass keyer and output 30 to turn off the bass as long as the condition obtains. This prevents a scrambled bass signal if more than one keyer should operate in response to an unusual combination of playing keys 11 operated. Automatic rhythm device 32 provides signals to change controlled divider 28 from one division ratio to another to change the bass from root to fifth and back, and to bass keyer and output 30 to key the root and fifth parts in the bass in rhythmic patterns.

It is desirable to start with the root each time a new chord is selected. Change detector 33 resets the automatic rhythm device 32 for the root in the bass each time a new playing key 11 operates. It receives an input from each of the lines 9 to which switches 12 connect when playing keys 11 operate. The sharp rise in voltage triggers the change detector 33 to produce a reset output.

A more simple form which the invention may take is shown in FIG. 3. Playing keys 11 operate switches 42 which are connected in an interlock chain so the signal from the tone generator 22 associated with the switch 42 for the lowest pitch playing key 11 operated is applied to a bus 43 going to the inputs of the controlled divider 28 and change detector 33. Level detector 29 is not required as only one signal can be applied at a time. The interlocked switches 42 provide the logic and protection for the system, and key the signals which are the fifths of the respective playing keys 11 directly from tone generators 22 to the bus 43.

The change detector 33 operates on the interruptions of voltage as a new lower switch is actuated and resets the automatic rhythm device 32 for the root. Controlled divider 28, bass keyer and output 30, automatic rhythm device 32, and sound transducer 31 operate in the same manner as in the apparatus of FIG. 1. This form of the apparatus requires the player to make the root of the chord the lowest note if the proper root and fifth are to be obtained in the bass.

FIG. 4 shows a modification to the apparatus of FIG. 1 in which switches 12 connect to resistors 18 in the same inhibit paths as before but in which resistors 13, 14, 16 and 17 are eliminated and resistors 53 are added. Closing of a switch 12 by operation of playing key 11 for C provides voltage to enable its respective transistor 15 through its collector resistor 53 and to inhibit the transistors 15 for the same notes as the apparatus of FIG. 1 and as shown in column two of FIG. 2. If the enabled transistor 15 is not inhibited by operation of another switch 12, it remains cut off and the voltage is further applied to resistors 54 and 55 of keyers for the notes G and C from tone generators 22. The keyers, further consisting of diodes 20 and 21, provide outputs to busses 56 and 57 respectively for the G and C signals. The bus selector and the bass keyer 58 is then controlled by the automatic rhythm device 32 to pass first the root and then the fifth, C and G respectively, to its conventional binary divider and produce a corresponding bass output to sound transducer 31.

The dual keyers and bus selection in lieu of a controlled divider 28 is an option with the apparatus of FIG. 1 as well as with that of FIG. 4. The controlled divider 28 and one set of keyers could be used with the apparatus of FIG. 4 as it was with that of FIG. 1. It will be recognized that transistors 15 in either the apparatus of FIG. 1 or FIG. 4 can provide drive for the keyers in the other apparatus. The FIG. 4 logic results in root fifth bass notes being played when only one key is operated. Conflicting bass notes can occur for more combinations than with the logic of FIG. 1. Level detec-

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tor 29 senses two or more signals on bus 56 and turns off bus selector and bass 57 for the same reason as in the apparatus of FIG. 1.

FIG. 5 diagrams a circuit which can function as the controlled divider 29 of FIGS. 1 and 3. Signal source 60 may be the collector of the transistor 24 amplifying the signal on the bus 23 of FIG. 1 or the bus 43 of FIG. 3. The signal source 60 provides drive through capacitor 61 to the junction of resistors 62, 63, and 64 which are part of a standard flip-flop circuit completed by transistors 65 and 66, resistors 67 and 68, and capacitors 69 and 70. This circuit is substantially the same as the frequency divider used in many organ tone generators and so is well known to those skilled in the art. Negative going sections of the input square wave cause the flip-flop to change state. The collector of the transistor 65 connects through capacitor 71 to similarly trigger a like flip-flop circuit made up of resistors 72, 73, 74, 77 and 78, transistors 75 and 76, and capacitors 79 and 80. If no other circuits were added the flip-flops would successively divide by two and the last one would thus provide an output to bass keyer 30 which is one-fourth the frequency of the input signal from the source 60.

Capacitor 81 and resistors 82 and 83 are connected in series between the collector of the transistor 75 and the base of the transistor 66. Transistor 84 clamps the junction of resistors 82 and 83 to ground when receiving drive to its base from the automatic rhythm device 32. The network is thus ineffective, and the circuit divides by four. When the transistor 84 does not receive drive from automatic rhythm device 32 it cuts off and the network couples the collector of the transistor 75 to the base of the transistor 66. Diode 85 from the junction of the resistors 82 and 83 to ground when receiving drive to its base from the automatic rhythm device 32. The network is thus ineffective, and the circuit divides by four. When the transistor 84 does not receive drive, from automatic rhythm device 32 it cuts off and the network couples the collector of the transistor 75 to the base of the transistor 66. Diode 85 from the junction of the resistors 82 and 83 to ground prevents appreciable negative voltage from being passed. The positive going changes on the collector of the transistor 75 couple through the network to drive transistor 66 into conduction. As the first flip-flop, in order to trigger the second, had just changed to the state in which transistor 66 was cut off, driving transistor 66 back into conduction effectively advances the count by one. As this occurs once every cycle of the second flip-flop, the number of input pulses required per cycle is reduced from four to three. Automatic rhythm device 32 can thus cause the circuit to divide by three or four by driving transistor 84 to cut off or saturation respectively.

FIG. 6 illustrates in block diagram a system having a signal source 60 similar to that of FIG. 5. It is connected to a controlled divider 90 which divides by three and a parallel controlled divider 91 (e.g. a single flip-flop circuit) which divides by two. The dividers 90 and 91 may be of conventional flip-flop type more fully shown in FIG. 5. The divider 90 is connected to a conventional gate device 92, and the divider 91 is connected to a like conventional gate device 93. The automatic rhythm device 32 is connected to render effective alternatively the gates 92 and 93 to pass the root and the fifth to the bass keyer 30 to which the gate devices are connected.

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 electronic musical instrument, the combination of

- (a) a multiple ratio frequency divider,
- (b) means for applying a tone signal to the input of said divider,
- (c) a sound transducer, and

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(d) means for producing different ratio outputs from said divider to said sound transducer in rhythmic patterns.

2. The combination set forth in claim 1, wherein said divider consists of plural dividing means of different ratios, and said producing means applies the plural output one at a time to said sound transducer.

3. The combination set forth in claim 1, wherein said divider is controllable to divide in different ratios, and said producing means produces signals to said divider to control its dividing ratios.

4. The combination set forth in claim 1, wherein said tone signal applying means comprises a set of playing keys, a set of tone generators, and means for keying a signal from said tone generator to said divider responsive to operation of said keys.

5. The combination set forth in claim 4, wherein said keying means includes means for limiting the signals to said divider to one at a time.

6. The combination set forth in claim 4, wherein said keying means consists of a set of series connected switches, each operated by one of said playing keys to connect one of said tone generators to said divider through the series chain of unoperated switches of lower order.

7. The combination set forth in claim 4, wherein said keying means includes a set of drivers having enable and inhibit inputs, means for applying a signal from one of said tone generators to said divider responsive to operation of each of said drivers, a set of switches each operated by an associated one of said playing keys, and a network from each of the switches to the enable input of at least one of said drivers and inhibit the input of at least another said drivers.

8. The combination set forth in claim 4, wherein said keying means consists of a set of keyers each having an enable input and an inhibit input.

9. The combination set forth in claim 4, wherein said keying means is responsive only to pairs of actuated playing keys.

10. The combination set forth in claim 1, wherein said producing means comprises an automatic rhythm device producing signals to control said dividing means.

11. The combination set forth in claim 4, including means for blocking the output of said divider when more than one signal is applied to said divider.

12. The combination set forth in claim 4, including means for resetting said producing means each time a new signal is applied to the input of said divider.

13. The combination set forth in claim 4, wherein the tone signal keyed by actuation of a playing key corresponds to its music fifth, and wherein said divider divides by 3 and by a number equal to 2 times an integer.

14. In an electronic musical instrument having a set of playing controls, the combination of:

- (a) a bass frequency divider capable of dividing by an odd or an even ratio,
- (b) means for applying a tone signal to the input of said divider responsive to actuation of said playing controls,
- (c) means for controlling said divider to divide by its odd and even ratios at different times, and
- (d) a sound transducer driven by the output of said divider.

15. In an electronic musical instrument having a set of playing controls, the combination of:

- (a) a bass frequency divider,
- (b) a set of means for applying a tone signal to said divider each having an enable input and an inhibit input,
- (c) a set of switches responsive to actuation of said playing controls,
- (d) a set of networks each connecting one of said switches to the enable input of at least one of said applying means and to the inhibit input of at least another of said applying means, and

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(e) a sound transducer driven by the output of said divider.

16. The combination according to claim 15 wherein said applying means each consists of a tone generator and a keyer controlling passage of the output of said tone generator to said divider and having an enable input and an inhibit output.

17. In an electronic musical instrument having a set of playing controls, the combination of:

- (a) a set of drivers each having at least one enable input and at least one inhibit input,
- (b) means coupled to and responsive to actuation of any one of said playing controls for energizing the enable input of at least one of said drivers and the inhibit input of at least another of said drivers, and
- (c) a set of load devices each coupled to the output of an associated one of said drivers.

18. The combination according to claim 17 including

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a bass frequency divider coupled to said drivers and wherein said load devices consists of means for applying tone signals to said divider.

19. The combination according to claim 18 including means for changing the ratio by which said divider divides.

References Cited

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RICHARD B. WILKINSON, Primary Examiner

S. J. WITKOWSKI, Assistant Examiner

U.S. Cl. X.R.

84-DIG 22

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,712,950 Dated January 23, 1973

Inventor(s) Alfred B. Freeman

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the Title after "APPARATUS" insert -- EMPLOYING A MULTIPLE RATIO FREQUENCY DIVIDER AND AUTOMATIC RHYTHM DEVICE --. Column 1, line 72, after "outputs", "in" should read -- is --. Column 3, line 15, after "drives", "trhough" should read -- through --; line 35, after "play", "GEG" should read -- CEG --; line 45, after "or" insert -- CD#G --; line 69, after "28", "divdes" should read -- divides --; line 70, after "two", "or four" should be cancelled. Column 4, line 48, after "53" the word "are", second occurrence, should be cancelled. Column 5, line 5, after "divider", "29" should read -- 28 --; line 33, cancel "Diode 85 from the junction of the", cancel lines 34, 35, 36, 37, 38, 39 and in line 40, cancel "66.".

Signed and sealed this 19th day of March 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

UNITED STATES PATENT OFFICE
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