United States Patent

Deutsch

[15] **3,697,661**

[45] **Oct. 10, 1972**

[54] MULTIPLEXED PITCH GENERATOR SYSTEM FOR USE IN A KEYBOARD MUSICAL INSTRUMENT

[72] Inventor: **Ralph Deutsch,** Sherman Oaks, Calif.

[73] Assignee: **North American Rockwell Corporation**

[22] Filed: **Oct. 4, 1971**

[21] Appl. No.: **186,360**

[52] U.S. Cl. **84/1.01,** 84/1.11, 84/1.17, 84/1.19

[51] Int. Cl. **G10h 1/00**

[58] Field of Search.....84/1.01, 1.03, 1.24, 1.26

[56] **References Cited**

UNITED STATES PATENTS

3,610,799 10/1971 Watson.....84/1.26

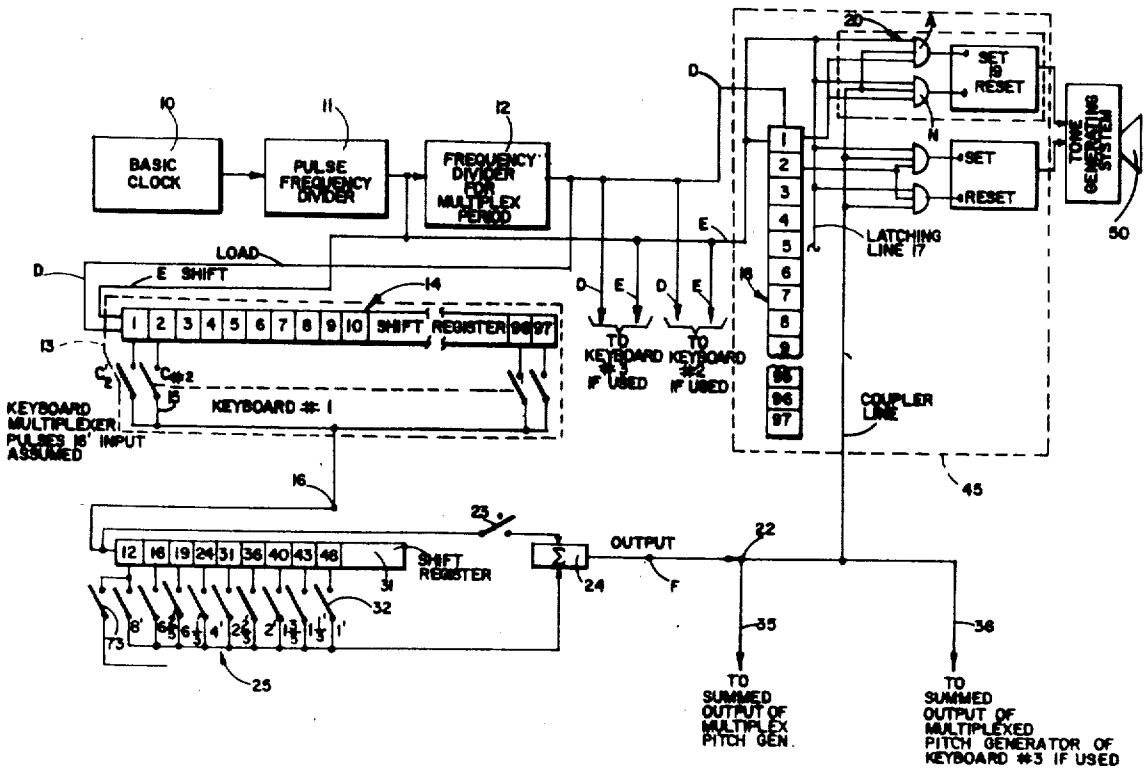
Primary Examiner—Lewis Myers
Assistant Examiner—U. Weldon
Attorney—L. Lee Humphries et al.

[57] **ABSTRACT**

The present invention is a multiplexed pitch generator system for use in a keyboard musical instrument to activate the voice controls of the instrument in accordance with key depressions. In the preferred embodiment of the invention there is provided a means for stepping pulses into a plurality of time slots in a cyclic manner. A plurality of keys are provided with each time slot corresponding to one particular key, and each key corresponding to a particular note. Pitch means are provided for receiving the time division multiplex signal with the gated pulses and for shifting the time slot position of selected pulses to a desired time slot location so as to simulate another note. Comparing means are used to compare the time slot position of the pulses from the pitch means with the time division multiplex signal to determine the final time slot position of a pulse. Latching means corresponding in number to the number of time slot positions are connected to the comparing means with each individual latching means being activated by a pulse occurring only in its associated time slot. The latching means, in turn, activates the voice controls of the keyboard musical instrument to sound the note or pitch associated with the pulses' final time slot location.

In a second embodiment of the invention which is used on a multiple keyboard instrument, each keyboard has one multiplexed pitch generator system associated therewith and, in addition, the output signal from the pitch generating means of one or more keyboards are connectable to the outputs from the other multiplexed pitch generators such that the musician can play a key on one keyboard and have it sound as if played from another keyboard.

21 Claims, 13 Drawing Figures



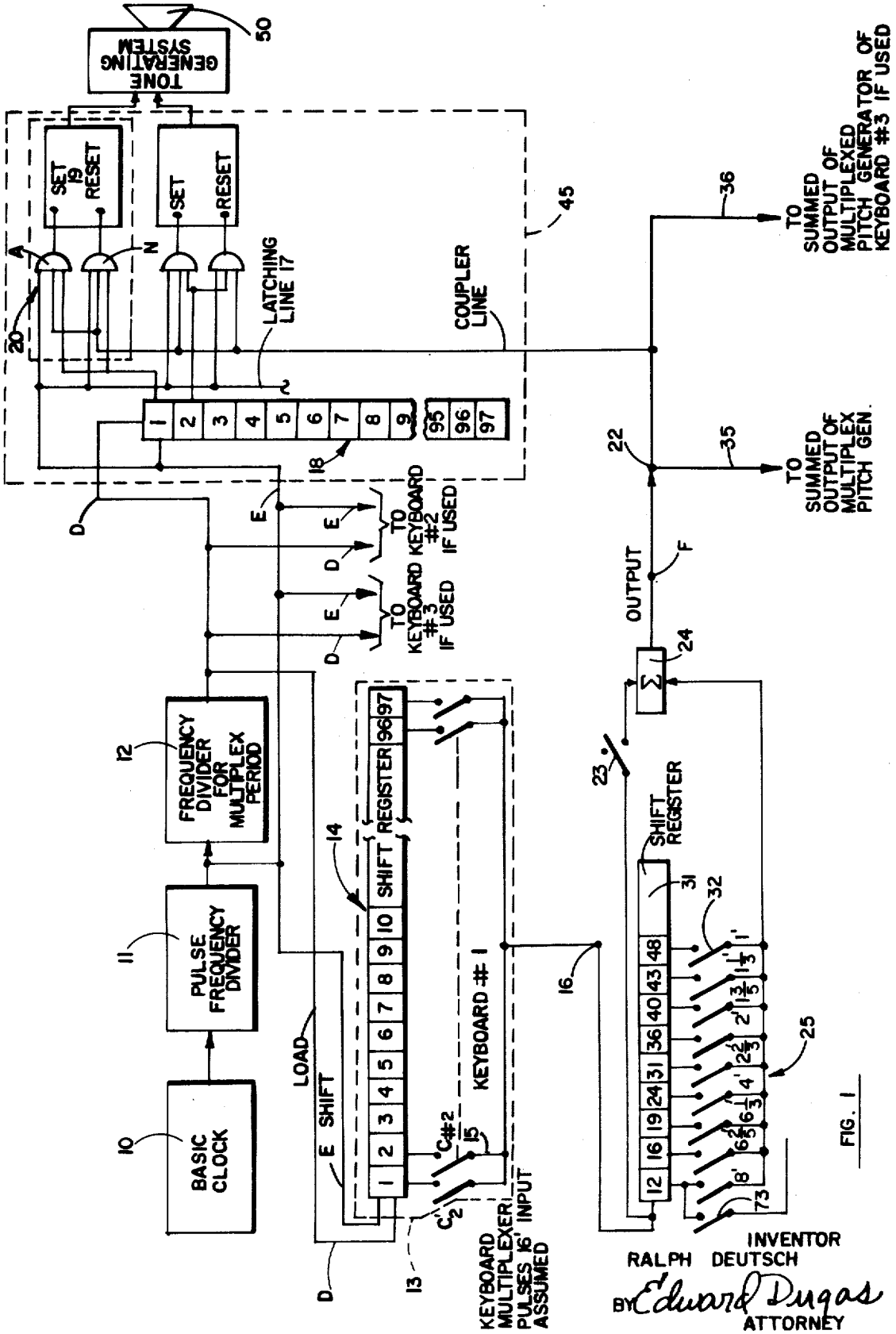

TONE GENERATING SYSTEM
50
SET
RESET
19
SET
RESET
N
20
LATCHING LINE 17
COUPLER LINE
45
1
2
3
4
5
6
7
8
9
95
96
97
18
D
E
TO KEYBOARD #2 IF USED
TO KEYBOARD #3 IF USED
36
TO SUMMED OUTPUT OF MULTIPLEXED PITCH GENERATOR OF KEYBOARD #3 IF USED
22
35
TO SUMMED OUTPUT OF MULTIPLEX PITCH GEN.
OUTPUT
F
24
23
SHIFT REGISTER
31
32
48
43
40
36
31
24
19
16
12
25
8'
73
INVENTOR
RALPH DEUTSCH
BY Edward Dugas
ATTORNEY
12
FREQUENCY DIVIDER FOR MULTIPLEX PERIOD
11
PULSE FREQUENCY DIVIDER
10
BASIC CLOCK
14
SHIFT REGISTER
96
97
SHIFT
10
9
8
7
6
5
4
3
2
1
KEYBOARD # 1
LOAD
E SHIFT
C#2
15
C2
13
16
KEYBOARD MULTIPLEXER PULSES 16' INPUT ASSUMED

FIG. 1

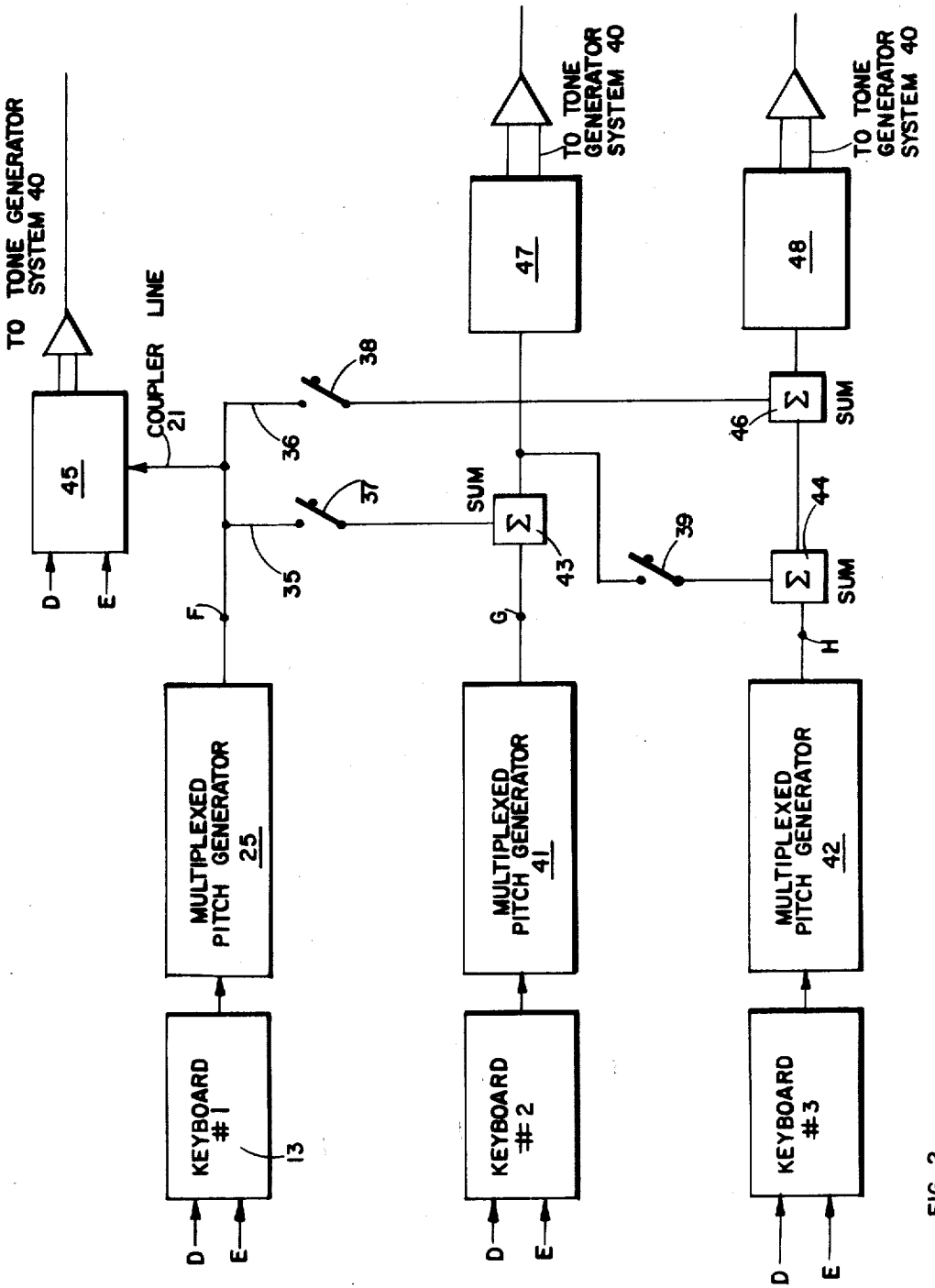


FIG. 2

INVENTOR
RALPH DEUTSCH
BY
Edward Dugas
ATTORNEY

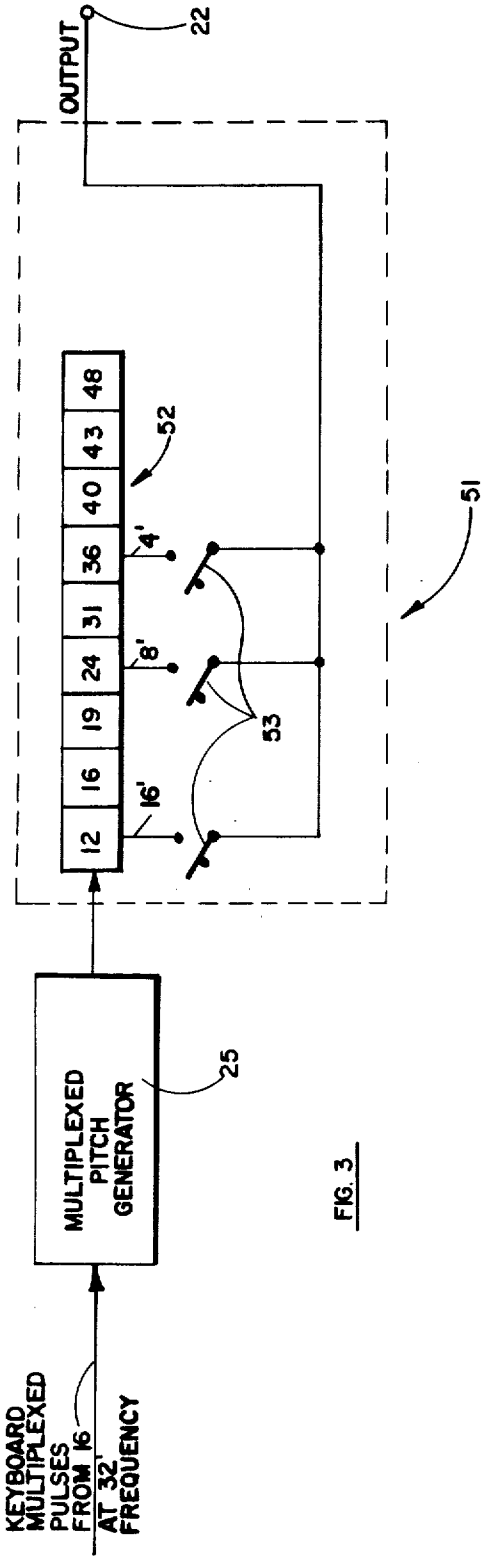


FIG. 3

INVENTOR
RALPH DEUTSCH
BY
Edward Dugas
ATTORNEY

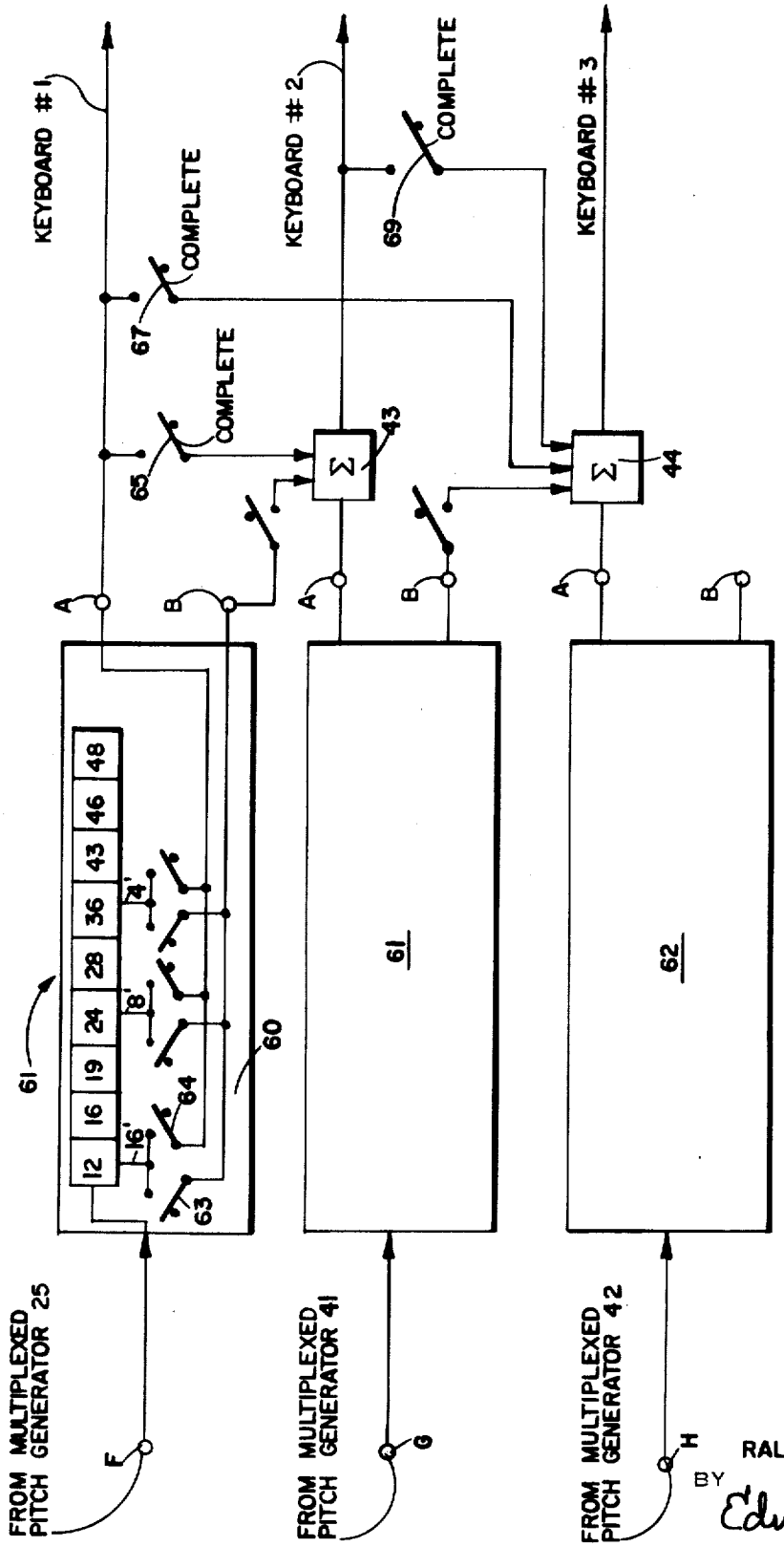


FIG. 4

INVENTOR
RALPH DEUTSCH
BY Edward Dugas
ATTORNEY

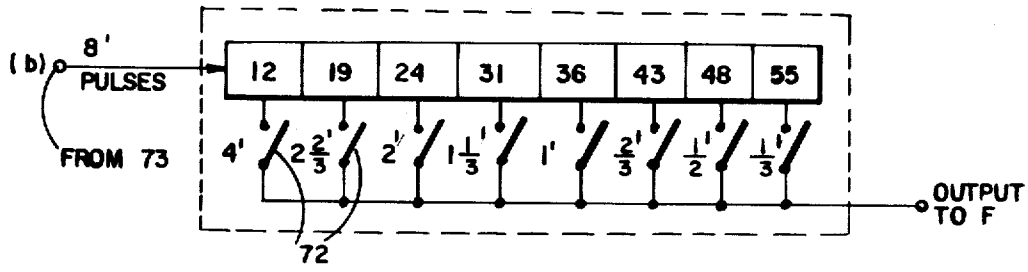


FIG. 5

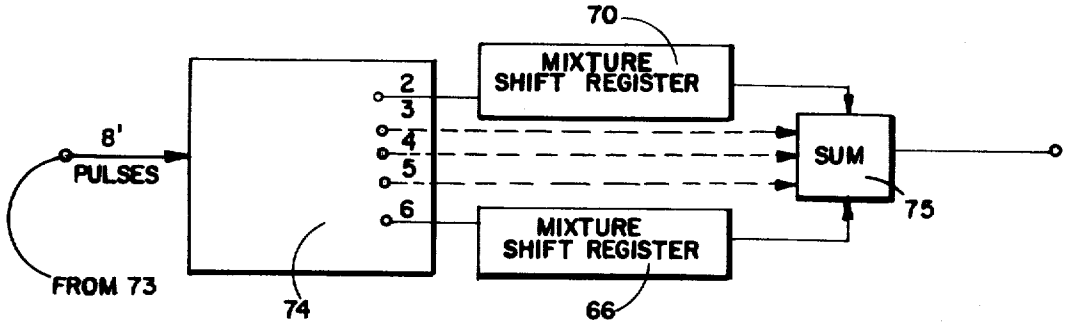


FIG. 6

INVENTOR
RALPH DEUTSCH
BY
Edward Dugas
ATTORNEY

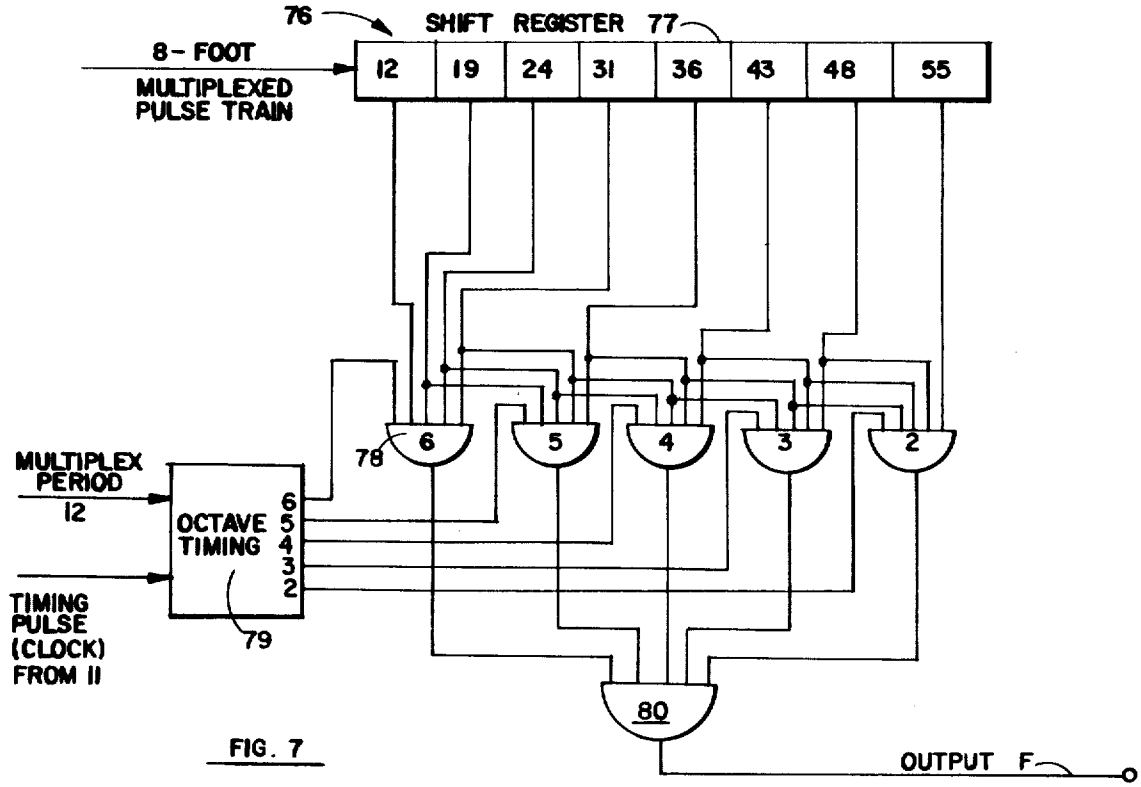
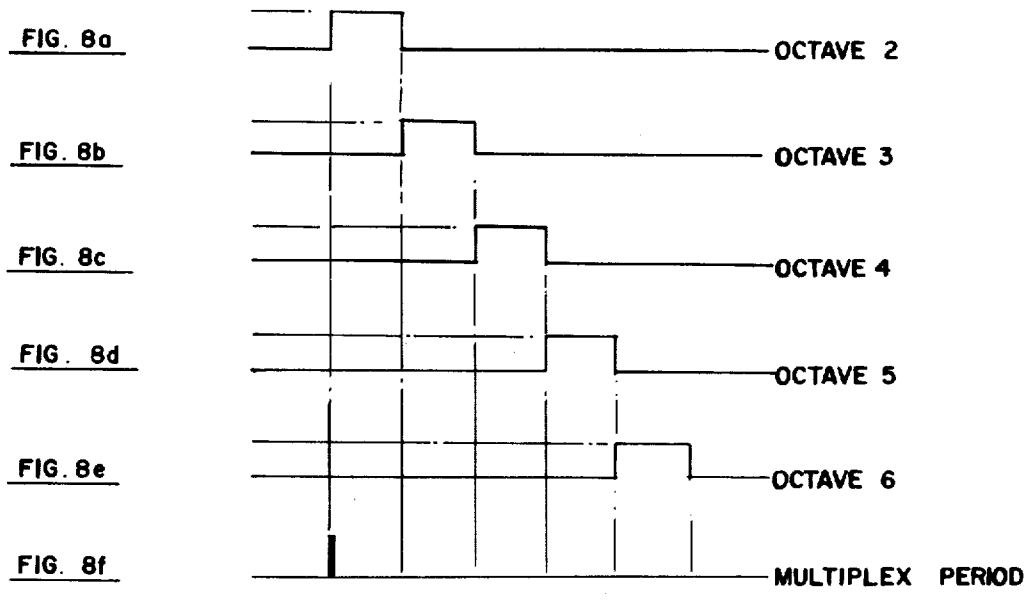


FIG. 7



INVENTOR
RALPH DEUTSCH

BY
Edward Dugas
ATTORNEY

MULTIPLEXED PITCH GENERATOR SYSTEM FOR USE IN A KEYBOARD MUSICAL INSTRUMENT

BACKGROUND OF THE DISCLOSURE

The invention is directed to a system for unifying and coupling the keyboards of a musical instrument, which system eliminates the large amount of conventional cabling and multicontact keys. The invention is further directed toward an economical and reliable solution to a construction problem in the design of electronic and pipe organs. With prior solutions, the general directives were to obtain increased capability. Except for very early instruments, the subsystems that have been in use are substantially identical in operation and require no special training on the part of the organist. More specifically, the present invention is concerned with pitch generation and the couplers which accomplish this generation. In the musical world, a set of couplers is a subsystem designed to obtain multiple usage from a rank of pipes. One of the simpler examples of a coupler is that of the unison pitch intermanual coupler. This is the organist's term denoting that the pitch of each note corresponds to the nominal pitch of the keys on the keyboard. For example, with the organist playing on the Great manual, to obtain the particular sound desired, the organist wishes to draw upon the pipes that are assigned to the Swell manual, which is done by causing the Swell pipes to sound from the Great manual by activating the Swell-to-Great intermanual coupler. With this coupler actuated, the action is equivalent to keying each Swell key as each of the corresponding Great keys are depressed. Older organs accomplished this type of coupling by using a subsystem of levers so that the Swell keys were mechanically depressed at the same time that a Great key was depressed. The present invention accomplishes this electronically.

Another frequent use of couplers is to get multiple use of a rank of pipes while playing on the same keyboard to which the rank of pipes is assigned. An example of this type of coupler is the intramanual coupler.

For an illustration, suppose that the organist is playing on the Swell manual and actuates the "Swell-to-Swell 4'" coupler. Now each note he plays will automatically sound at the 8' pitch (unison) and will also sound at the 4' pitch (an octave higher). It is also common to have intramanual couplers at other pitches. Thus, a "Swell-to-Swell 16'" will cause the unison note to be played as well as the note an octave lower in pitch.

The use of couplers to add new pitches can also be extended to intermanual couplers. Thus, a "Swell-to-Great 4'" will cause the Great keys to actuate all the stops drawn on the Swell manual but will have these coupled stops sound an octave higher than the unison pitch. Similarly, a "Swell-to-Great 16'" will cause the Great keys to actuate the Swell stops at an octave below unison pitch.

Another use of couplers is to "unify" the various voices of an organ. Unified organs were first extensively used in theatre pipe organs as a method of getting a lot of mileage from each rank of pipes. Although the average theatre organ had only about 8 ranks of pipes, the consoles contained approximately 50 stops. There was a period of pipe organ construction in this country during which church organ builders also succumbed to unification; partly from mistaken ideas on tonal quality and partly because unification provides a very large number of stops which leads to an impressive console. Unification is used almost universally and extensively in the design of electronic organs. Unification is a form of manual coupler but is restricted to a single voice. For example, suppose that the organ has a rank of flute tones at the 8' or unison pitch. To obtain a 4' flute from this same rank, the organ keyboard is wired so that when the 4' stop is actuated, each key operates a pipe which is an octave higher than unison pitch. Similarly a 16' flute is obtained by unifying so that the keyboard operates a pipe which is an octave lower than the unison pitch that is keyed.

There have been many systems proposed and implemented for unification. Conventional unification schemes use a system of multiple contacts associated with each key on the keyboards. In some cases these multiple contacts have been removed from the immediate vicinity of the keyboard by employing such contact multiplying devices as multicontact electrical relays or, for example, keying diodes.

SUMMARY OF THE INVENTION

In a preferred embodiment of this invention, the system is comprised of a means for stepping a pulse into a plurality of time slots in a cyclic manner. A plurality of keying means are provided with the number of keying means corresponding in number to the number of slots for gating a pulse into a time slot of a time division multiplex signal, with each time slot corresponding to one particular key, and each key corresponding to a particular note, such that the time slot position of the pulse corresponds to a particular note. Pitch means are provided for receiving the time division multiplex signal and for shifting the time slot position of selected pulses to a desired time slot location so as to simulate a note other than the one played. Comparing means are used to correlate the location of the pulse in the time division multiplex signal to a corresponding organ note.

In another embodiment of the invention, two or more identical systems are provided, one for each keyboard. The output from one pitch means is connectable to the output of a second pitch means to allow the organist to play a key on one keyboard and have it sound as if played on another keyboard.

From the foregoing, it can be seen that it is an object of the present invention to provide an improved multiplexed pitch generator.

It is a further object of the present invention to provide a pitch generator which is capable of intermanual and intramanual coupling.

It is another object of the present invention to provide a system for coupling keyboards of a musical instrument.

It is a further object of the present invention to allow the playing of a key on a musical instrument and having a note sound other than the one normally associated with the key.

It is an additional object of the present invention to provide a system for intercoupling of keyboards.

These and other objects of the present invention will be better understood when taken in conjunction with the following description and drawings in which like

characters indicate like parts and which drawings form a part of this application.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates, in electronic block diagram form, one embodiment of the present invention;

FIG. 2 illustrates, in electronic block diagram form, a second embodiment of the present invention for use in conjunction with the embodiment of FIG. 1.

FIG. 3 illustrates, in electronic block diagram form, an intramanual coupler which may be used with the embodiment of FIG. 1 or FIG. 2.

FIG. 4 illustrates, in electronic block diagram form, couplers which may be used with the embodiment of FIG. 1.

FIG. 5 illustrates a one octave mixture generator for use with the system.

FIG. 6 illustrates a multi-octave mixture generator for use with the system.

FIG. 7 illustrates another embodiment of a multi-octave mixture generator.

FIGS. 8*a* to 8*f* illustrate waveforms used in gating the multi-octave mixture generator of FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The circuits illustrated in FIG. 1 comprise the circuits necessary for one multiplexed keyboard. If two or more keyboards are used, the circuits of FIG. 1 will be duplicated for each keyboard. The multiplexed keyboard circuit is comprised of a basic clock generator **10** which feeds pulses at a fixed repetitious rate to a pulse frequency divider **11**. The output of pulse frequency divider **11** is fed to a pulse locator means **13** which is comprised of shift register **14** and a corresponding number of keys **15**. The output pulse from pulse frequency divider **11** controls the rate of shifting between stages of the shift register. These pulses are also fed to a frequency divider **12**. Frequency divider **12** supplies a locator pulse once each multiplex period to the input shift register **14**. The locator pulse is stepped through each of the shift register stages at a rate corresponding to the pulse rate of the pulses from frequency divider **11**. The pulse frequency divider **11** operates to divide the basic clock frequency from clock **10** such that 97 times slots, corresponding to the 97 notes for a full keyboard (4' and 2' pitches added), can be scanned in T seconds, with T seconds corresponding to the multiplex period. Therefore, once every T seconds frequency divider **12** provides a locator pulse. The multiplex period, T, for good performance, should be in the range of 2 to 5 milliseconds. As previously stated, the second frequency divider **12** is set to establish a pulse for the input to the shift register **14** once each multiplex period which pulse travels from one stage of the shift register to another stage until it finally reaches the last stage at the end of one multiplex period (cycle). The normal open keys **15**, which correspond to notes, connect one associated shift register stage to the output terminal **16** when depressed (closed). Therefore, the output signal appearing at terminal **16** can be viewed in terms of a repeating picture having 97 individual time slots, with the occurrence of a locator pulse in a particular time slot providing an indication that the key associated with that particular time slot is being depressed. The actual pulse location can be determined through coincidence, that is, the occurrence of a pulse in a particular time slot is compared against a pulse positioned in a known time slot and when the two coincide, the particular note associated with that pulse position is sounded by the keyboard instrument. The coincidence comparing circuit used with the present invention consists of a shift register **18** which is identical in construction to shift register **14**. The shift register **18** steps the locator pulses from pulse frequency divider **12** through its stages at a rate controlled by the output pulses from pulse frequency divider **11** in phase with the operation of shift register **14**. The shift register **18**, in an identical manner as shift register **14**, operates to provide locator pulses which are stepped sequentially through each of its stages, with each stage corresponding to one time slot in a total time frame of at least **97**. In practice, about **128** time slots would be used with only **97** latching circuits so that a pulse delayed **48** positions from the top key on the manual (time slot **61**) will fall in an empty latching slot and not fall into a slot assigned to the low end of the keyboard. For example, in **97** units of time, one locator pulse will appear sequentially at the output of each stage. The time slot position of the locator pulse in shift register **14** will therefore correspond exactly to the locator pulse time slot position in shift register **18** because the two registers are in phase. A plurality of latching means **20**, at least one for each stage of shift register **18**, senses the presence of a locator pulse when it appears at the output of its associated register stage. The existence or non-existence of a locator pulse at the particular shift register stage output is compared against the existence or non-existence of a locator pulse on a latching line **17**. When coincidence of pulses occurs, the latching means **20** activates a corresponding voice in the keyboard instrument. When one of the two locator pulses do not appear simultaneously, the associated voice is not sounded.

To accomplish the above electronically, each latching means **20** is comprised of one AND gate "A", one NOT gate "N", and a flip-flop **19**. Each output stage of shift register **18** is connected to one input of a respective AND gate "A" and the NOT impulse of a NOT gate "N". The AND gate output is connected to the set terminal of flip-flop **19** with the output of the NOT gate connected to the reset terminal of flip-flop **19**. For each pitch to be keyed on the main keyboard, there is a corresponding flip-flop **19** along with one AND gate "A" and one NOT gate "N". The output from the flip-flop may be connected to a standard music voicer circuit **40** for converting the signal corresponding to a depressed key into an audible note by means of a speaker **50**. Also connected as independent inputs to an input of the AND gate "A" and the NOT gate "N" is the signal from pulse frequency divider **11**. In operation, the pulses received on line **17**, which pulses will be called latching pulses, are fed as inputs to the AND gate and to the NOT gates. A coupler line **21** feeds locator pulses to inputs of the AND gates and the NOT gates.

In operation, if no key **15** is depressed, then there will be no locator pulses on the coupler line **21**. With this condition, each of the AND gates contain in successive time slots an ON state from the latching pulse

on line 17 and an OFF state from the coupler line. Because the coupler line is connected to a NOT input, each NOT gate will, in turn, provide a pulse to its associated reset terminal of its flip-flop. Thus, if no key is depressed, all the flip-flops 19 are, in turn, placed in their OFF states. When a key is depressed, a locator pulse will appear on coupler line 21. When the locator pulse on coupler line 21 occurs simultaneously with an output pulse from a stage of shift register 18 along with a latching pulse on line 17, the particular NOT gate will not provide a pulse to the reset terminal. But the AND gate will have pulses on all its inputs, therefore, a pulse will be passed on to the flip-flops set terminal to place the flip-flop in its ON state.

Inserted between terminals 16 and 22 is a multiplexed pitch generator 25 which functions to selectively reposition the locator pulses from terminal 16 into newly selected timing slots. The new slot positions correspond to the generation of a new coupled note. In this particular embodiment, it has been assumed that the first 12 pulse locations in the keyboard multiplexed sequence correspond to octave 1. This octave cannot actually be played from a standard keyboard because it is an octave below the bottom octave of the keyboard. The reason for allowing for these additional time slots is to allow for 16′ pitch generation and a 16′ coupler. The multiplexed pitch generator 25 is comprised of a shift register 31 having at least 48 stages. Outputs are not taken from every stage, but are taken from the stages corresponding to the numbers contained within the shift register 31, namely, 12, 16, 19, 24, 31, 36, 40, 43 and 48. Stops (keys) 32 connect the output of the selected stages to the input of a summing circuit 24 when actuated. For example, if the stop corresponding to 8′ is closed, the output from the 12th delay stage of shift register 31 is fed to the input of summing means 24. An additional stop (key) 23, corresponding to the 16′ pitch is fed to another input of summing means 24 such that when stop 23 is closed, the output locator pulses from terminal 16 are fed directly to terminal 22 at the output of the pitch generator, thereby bypassing entirely the multiplex pitch generator 25. Again, the numerals appearing for each stage of the shift register correspond to the time slot delays introduced by the shift register preceding the particular output point. All of these delays are measured from the input to the shift register. For example, if the 8′ tap switch is closed, a pulse will appear on the output for each note keyed on the manual. If, for example, the 2⅔′ tap switch is also closed, then a pulse will appear for the 8′ keyed note and a companion pulse will also appear for the 2⅔′ keyed note. In this fashion, the described subsystem which will be called a unification subsystem, can generate the 10 most used pitches for a unified organ. The system thus far shown is complete for one keyboard.

In FIG. 2, there is shown an intermanual unison coupler system for three keyboards which system is comprised of three identical systems as shown in FIG. 1 except that there is no need to duplicate the basic clock 10, pulse frequency divider 11, and frequency divider 12 because these units can service all three systems. The outputs at points D and E are, therefore, fed to the corresponding points in the other keyboard circuits to eliminate duplication of the clock and frequency dividers. Cross-coupling is accomplished as shown by the use of switches 37, 38 and 39. For the unison couplers there is utilized three identical multiplexed pitch generators 25, 41 and 42, with the output of pitch generator 25 being connectable by means of switches 37 or 38 to an input of summer 43 or 46, respectively. The other input of summer 44 is connected to the output of pitch generator 41. The output of pitch generator 42 is connected to one input of summer 44. The other input of summer 44 is connectable by switch 39 to the output of summer 43. In turn, the output of summer 44 is connected to the other input of summer 46. In operation, if, for example, switch 37 is closed, the output from keyboard 1 is fed to the comparing means 45 of keyboard 1, but, in addition, is also fed to and added to the output from keyboard 2, which output is used to activate the comparing means 47 associated with keyboard 2. The operation is the same for switch 38 in that it couples the output of keyboard 1 to the output of pitch generator 42 which, in turn, feeds the comparing means 48 of keyboard 3. Switch 39, in a similar manner, feeds the output of pitch generator 41 to the comparing means 48 associated with keyboard 3. The outputs of comparing means 47 and 48 are connected to the tone generating system 40. In some applications it may be desirable to have three separate tone generating systems, each activated by an individual keyboard.

Referring now to FIG. 3, an intramanual coupler 51 is shown connected between the output of multiplexed pitch generator 25 and terminal 22. The intramanual coupler 51 is comprised of a shift register 52 which is identical in construction to shift register 31, with switches 53 connectable to the outputs of the 12th, 24th and 36th time slots (output stages). These outputs correspond to the 16′, 8′ and 4′ pitches, respectively. Each of the three switches are connected directly to the output terminal 22. With the multiplexed pitch generator 25 preceding the intramanual coupler, it is necessary, in order to permit a 16′ intramanual coupler operation, that the keyboard be multiplexed at a 32′ frequency, or two octaves below unison pitch. The reason for this is that the multiplexed pitch generator requires an octave leeway to generate a 16′ unified pitch while the intramanual coupler requires an additional octave leeway to allow for a 16′ intramanual coupler.

Referring now to FIG. 4, an intercoupler is shown which utilizes the system of FIG. 2. The system of FIG. 2 is modified by the insertion of intermanual nonunison couplers 60, 61 and 62 at the outputs of the multiplexed pitch generators 25, 41 and 42. The intermanual unison-nonunison coupler 60 is shown comprised of a shift register 61 which is identical to shift registers 31 and 52. The outputs of shift register 61 are taken from the 12th, 24th and 36th time slots to correspond to the 16′, 8′ and 4′ pitches, respectively. Two separate output terminals are provided, labeled A and B, which output terminals are connectable by separate switches 63 and 64 to the 16′ output. A similar switch configuration is provided for the 8′ and 4′ output. The arrangement is such that, for example, a 16′ pitch output signal can appear on the A and B output terminals simultaneously if both switches 63 and 64 are in the closed position. The two sets of switches for each of the used register output stages is required so that the inter-

manual and intramanual couplers will be independent. That is, if, for example, a 4' coupler (output at A) is drawn on an intramanual coupler, this will in no way affect the intermanual coupling (output at B) from the same keyboard. To provide for complete keyboard coupling, switches **65** and **67**, when closed, feed the signal from the A terminal of intermanual unison-nonunison coupler **60** to an input of summer **43** and summer **44**, respectively, to be summed with the output of coupler **61** and/or **62**. In addition, the B terminal output is connectable by means of switch **66** as an input to summer **43**. In addition, switch **69** connects the output of summer **43** to the input of summer **44** when in a closed position. Switch **68** in its closed position is used to connect the B terminal output from unison coupler **61** to an input of summer **44**.

Referring now to FIG. **5**, in conjunction with FIG. **1**. FIG. **5** illustrates a unified mixture generator **70** comprised of a shift register **71** having switches **72** connectable between an output terminal and the output stages corresponding to 12th, 19th, 24th, 31st, 36th, 43rd, 48th and 55th time slots, respectively. The switches **72**, when actuated, correspond to the 4', 2⅔', 2', 1⅗', 1', ⅘', ½', and ⅓', respectively. When one or more switches are closed, the information stored in the associated shift register stage is passed to the output of generator **70**. The input of generator **70** is taken from the 8' pulse stage of shift register **31** (FIG. **1**) via switch **73**. The output signal of mixture generator **70** is fed to point F and the organ voicer **40**.

In FIG. **6**, five mixture shift registers **70**, one for each octave of the instrument, are connected to receive independent outputs from the octave time gate means **74**. The output of each of the registers **70** is summed together in summing circuit **75** and fed to point F in the system. The input to the octave gate means is received from the 8' stage of shift register **31** via switch **73**, when it is closed. The octave times gates **74** also receive the basic clock pulses from the basis clock **10**. In operation, the 8' pulses received at the input of the octave time gate means **74** are fed to each of the five octave outputs sequentially in turn. The basic clock pulses are counted and for each octave quantity of pulses the input to the octave time gate means is connected to the input of a mixture shift register **70**. The process continues cycling through each shift register in turn for so long as there are 8' pulses present on the input of gate means **74**.

Referring to FIG. **7** wherein is shown an alternate embodiment of a mixture generator **76**, which could be substituted for the mixture generator of FIG. **6**. The mixture generator **76** is comprised of a multistage shift register **77** having outputs at the numerically designated staged. For example, at stages **12, 19, 24, 31, 36, 43, 48** and **55**. Five logic gates **78** are used, with each gate corresponding to a desired octave. For the embodiment shown, these are octaves **2** through **6**.

The following chart lists the input connections to the logic gates **78** from the shift register **77** and the octave timing means **79**.

Octave Logic Gate	Footages	Delay Outputs of Shift Register 77
2	1, ⅘, ½, ⅓	36, 43, 48, 55
3	1⅗, 1, ⅘, ½	31, 36, 43, 48
4	2, 1⅗, 1, ⅘	24, 31, 36, 43
5	2⅔, 2, 1⅗, 1	19, 24, 31, 36
6	4, 2⅔, 2, 1⅗	12, 19, 24, 31

The outputs of logic gates **78** are summed together in summer **80**. The summed output is then fed to terminal F in FIG. **2**.

The octave timing generator **79** receives multiplex period pulses from the output of frequency divider **12** and timing pulses from pulse frequency divider **11**.

The octave timing generator **79** has five outputs corresponding to the octaves **2** through **6** which are connected to the inputs of corresponding logic gates **78**.

In FIG. **8**, the octave timing pulses *a* through *f* are shown for the five octaves. When an octave pulse is in its true state, the gate corresponding to that octave pulse passes the pulses collected from the shift register. When an octave pulse is in its false state, the corresponding gate blocks the pulses from the shift register.

While there has been disclosed what is considered to be the preferred embodiment of the invention, it will be manifest that many changes and modifications may be made therein without departing from the essential spirit of the invention.

I claim:

1. In an electronic musical instrument having keys selectively activable to cause the production of sounds corresponding to respective notes on the musical scale, the combination comprising:

means for generating a first train of pulses wherein each pulse represents a particular time slot;

means for generating a second train of pulses wherein each pulse represents a cycle corresponding to a plurality of time slots;

first shift register means having a plurality of stages corresponding in number to the number of time slots in one cycle of said second pulse train for receiving said first and second train of pulses wherein said shift register steps a pulse from said second pulse train sequentially through each of said stages in time sequence with the pulses from said first pulse train;

a keyboard comprised of a plurality of keys corresponding in number to said plurality of shift register stages, with each of said keys connected to corresponding stages of said shift register so that activation of a key passes the stepped pulse stored in the corresponding stage of said shift register as an output signal;

tone generating means for producing a tone for each of said plurality of keys;

second shift register means having a plurality of stages corresponding in number to the number of time slots in one cycle of said second pulse train for receiving said first and second train of pulses wherein said shift register steps a pulse from said second pulse train sequentially through each of said stages of said shift register in time sequence with the pulses from said first pulse train; and

comparing means for comparing the time slot position of the stepped pulse at the output of said keyboard with the pulse slot position in said second shift register so as to activate a tone in said tone generating means when there is a coincidence of pulses in the compared signals.

2. The musical instrument according to claim **1** and further comprising:

pitch keyboard means interposed between the output of said keyboard and the input to said comparing means for selectively shifting the time slot position of the stepped pulse in the output signal so as to activate another tone in said tone generating means other than the one corresponding to the activated key.

3. The musical instrument according to claim 1 and further comprising:

a third shift register means connected to receive said first and second train of pulses;

a second keyboard connected to said third shift register means;

a second tone generating means for producing tones different for each of the associated plurality of said second keyboard keys;

fourth shift register means having a plurality of stages corresponding in number to the number of time slots in one cycle of said second pulse train, for receiving said first and second train of pulses wherein said fourth shift register steps a pulse from said second pulse train sequentially through each of said stages of said shift register in time sequence with the pulses form said first pulse train;

a second comparing means for comparing the time slot position of the stepped pulses from the second keyboard with the pulse slot position in said fourth shift register so as to activate a tone in said second tone generating means when there is a coincidence of pulses in the compared signals; and

coupling means for coupling the output signal of said first keyboard to the input of said second comparing means when said coupling means is activated, whereby a key activated on said first keyboard causes a tone to be generated by said second tone generating means.

4. The musical instrument according to claim 3 and further comprising:

a fifth shift register means connected to receive said first and second train of pulses;

a third keyboard means connected to said fifth shift register means;

a third tone generating means for producing tones different for each of the associated plurality of said third keyboard keys;

a sixth shift register having a plurality of stages corresponding in number to the number of time slots in one cycle of said second pulse train, for receiving said first and second train of pulses wherein said sixth shift register steps a pulse from said second pulse train sequentially through each of said stages of said sixth shift register in time sequence with the pulses from said first pulse train;

a third comparing means for comparing the time slot position of the stepped pulses from the third keyboard with the pulse slot position in said sixth shift register so as to activate a tone in said third generating means when there is a coincidence of pulses in the compared signals; and

second coupling means for coupling the output signal of said second keyboard to the input of said third comparing means when said second coupling means is activated, whereby a key activated on said second keyboard causes a tone to be generated by said third tone generating means.

5. The musical instrument according to claim 4 and further comprising:

third coupling means for coupling the output signal of said first keyboard to the input of said third comparing means when said third coupling means is activated, whereby a key activated on said first keyboard causes a tone to be generated by said third tone generating means.

6. The musical instrument according to claim 3 and further comprising:

a second pitch keyboard means interposed between the output of said second keyboard and the input to said second comparing means for selectively shifting the time slot position of the stepped pulse from the second keyboard output signal so as to activate another tone in the second tone generating means other than the one corresponding to the activated key of the second keyboard.

7. The musical instrument according to claim 6 and further comprising a summing means for receiving as an input the signal from said second pitch keyboard means; and

a key connecting the output signal of said coupling means to another input of said summing means when said key is activated.

8. The musical instrument according to claim 7 wherein each of said pitch keyboard means is comprised of an intramanual shift register having a plurality of stages for receiving the output signal from said keyboard means and having an intramanual keyboard comprised of a number of keys which keys are connected to desired stages of said shift register, whereby activation of said keys passes to said comparing means the pulses stored in the corresponding stage of said intramanual shift register.

9. The musical instrument according to claim 8 and further comprising:

a first and second intermanual coupler means connected to receive the output of said first and second pitch keyboard means, respectively, for altering the time slot position of the stepped pulse signals from said first and second pitch keyboard means and for feeding said altered signal to said first and said second comparing means, respectively.

10. The musical instrument according to claim 9 wherein said intermanual couplers are comprised of an intermanual shift register having a plurality of stages; and

an intermanual keyboard comprised of a number of keys which keys are connected to desired stages of said shift register whereby activation of said keys passes to said comparing means the pulse signal stored in the corresponding stage of said intermanual shift register.

11. The musical instrument according to claim 4 and further comprising:

a third pitch keyboard means interposed between the output of said third keyboard and the input to said third comparing means for selectively shifting the time slot position of the stepped pulse from the third keyboard output signal so as to activate another tone in said third tone generating means other than the one corresponding to the activated key of the third keyboard.

12. The musical instrument according to claim 11 wherein each of said pitch keyboard means is comprised of an intramanual shift register having an in-

tramanual keyboard comprised of a number of keys which keys are connected to desired stages of said shift register, whereby activation of said keys passes to said second comparing means the pulses stored in the corresponding stage of said intramanual shift register.

13. The musical instrument according to claim 11 and further comprising:

a first, second and third intermanual coupler means connected to receive the output of said first, second and third pitch keyboard means respectively for altering the time slot position of the stepped pulse signals from said first, second and third pitch keyboard means and for feeding said altered signals to said first, second and third comparing means, respectively.

14. The musical instrument according to claim 8 and further comprising:

an octave time gate connected to receive the pulses stored in one stage of said intramanual shift register and the pulses from said first pulse train, said time gate having a plurality of outputs each indicative of a separate octave whereby the received pulses are gated sequentially to each of the outputs;

a plurality of mixture shift register means, one each connected to receive the output of said octave time gate, each of said mixture shift registers operating to shift the time slot position of said stepped pulse by a selected amount; and

summing means for summing the outputs of said plurality of mixture shift register means and for feeding said summed signal to said comparing means.

15. The musical instrument according to claim 8 and further comprising:

an octave time gate for receiving said first and said second train of pulses and for providing non-overlapping timing pulses corresponding to different octaves of the musical scale;

an octave mixer shift register having a plurality of stages for receiving as an input the pulses stored in one stage of said intramanual shift register;

a plurality of gates corresponding in number to the octaves of said musical instrument for receiving the signals from selected ones of said octave mixer shift register stages and wherein each gate receives a timing pulse from said octave time gate whereupon coincidence of said received signals causes said gate to pass the signals present on its inputs; and

summing means for summing the outputs of said gates and for feeding said summed signal to said comparing means.

16. In an electronic musical instrument having a keyboard with a number of selectively actuable keys for causing the production of sounds corresponding to respective notes of the musical scale, the combination comprising:

means for sequentially positioning a pulse into individual time slots of a cyclically repeating signal for passing a pulse contained in a corresponding time slot of said repeating signal when said key is activated;

keyboard means having a plurality of keys corresponding to each time slot of said cyclically repeating signal for passing a pulse contained in a corresponding time slot of said repeating signal when said key is activated;

comparing means for receiving said passed pulse and said cyclically repeating signal and for providing a latching signal when the time slot position of said passed pulse corresponds to the pulse position of said cyclically repeating signal;

tone generating means responsive to said latching signal for sounding a note corresponding to the key depressed; and a pitch keyboard means for receiving the passed signal of said keyboard means and for selectively shifting the time slot position of the passed pulse and for feeding the shifted pulse signal to said comparing means so as to cause another note to sound other than the one corresponding to the activated key.

17. The musical instrument according to claim 16 wherein there is provided a plurality of keyboard means and a corresponding plurality of comparing means with the output of each keyboard means being coupled to the other keyboard means such that a key activated on one keyboard will sound a selective note in said tone generating means as if the note were played on said other keyboard means.

18. The musical instrument according to claim 17 and further comprising:

intramanual coupler means interposed between the output of said pitch keyboard means and the input of said comparing means for selectively providing a shift to the pulse time slot position of the signal from said pitch keyboard means.

19. The musical instrument according to claim 18 wherein said intramanual coupler means is comprised of:

an intermanual shift register having a plurality of stages; and

an intermanual keyboard comprised of two keys connected to each used stage of said intermanual shift register with one key from each stage connectable to the comparing means associated with said intermanual keyboard and with the other key from each stage of said intermanual shift register connectable to the input of another comparing means.

20. The musical instrument according to claim 17 and further comprising:

an octave time gate connected to receive the pulses stored in one stage of said intermanual shift register and the pulses from said first pulse train, said time gate having a plurality of outputs each indicative of a separate octave whereby the received pulses are gated sequentially to each of the outputs;

a plurality of mixture shift register means, one each connected to receive the output of said octave time gate, each of said mixture shift registers operating to shift the time slot position of said stepped pulse by a selected amount; and

summing means for summing the outputs of said plurality of mixture shift register means and for feeding said summed signal to said comparing means.

21. The musical instrument according to claim 17 and further comprising:

an octave time gate for receiving said first and said second train of pulses and for providing non-overlapping timing pulses corresponding to different octaves of the musical scale;

an octave mixer shift register having a plurality of stages for receiving as an input the pulses stored in one stage of said intramanual shift register;

a plurality of gates corresponding in number to the octaves of said musical instrument for receiving the signals from selected ones of said octave mixer shift register stages and wherein each gate receives a timing pulse from said octave time gate whereupon coincidence of said received signals causes said gate to pass the signals present on its inputs; and

summing means for summing the outputs of said gates and for feeding said summed signal to said comparing means.

* * * * *