United States Patent [19]

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[11] **3,715,444**

[45] **Feb. 6, 1973**

[54] SWITCHING SYSTEM FOR KEYBOARD

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

[21] Appl. No.: **103,493**

[52] **U.S. Cl.**.....**84/1.01**, 84/1.19, 84/DIG. 7, 84/DIG. 8

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

[58] **Field of Search**.....84/1.01, 1.17, 1.19, DIG. 2; 179/91, 158, 177, 90; 307/112–115; 340/365

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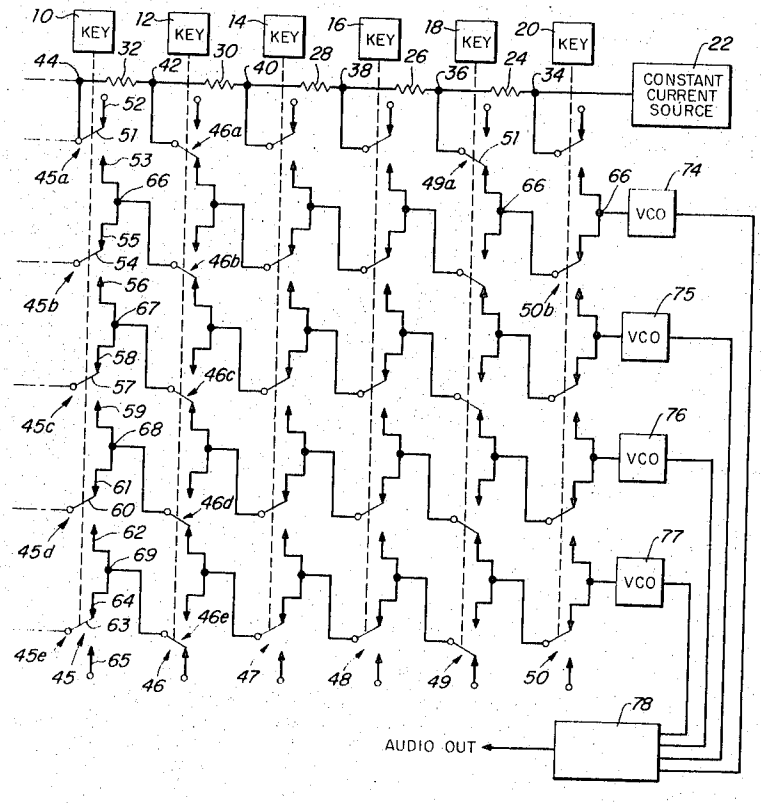
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[57] **ABSTRACT**

A priority switching system for use with a keyboard of an electronic musical instrument comprising a plurality of input terminals having corresponding voltages applied thereto, a switching matrix including a plurality of linear switch arrays with each array responsive to operation of a corresponding key, and a multiplicity of voltage controlled oscillators coupled to the switching matrix. In the switching system the voltage controlled oscillators and the input terminals are selectively interconnected by the switching matrix on a priority basis so that the uppermost key, for example, is assigned to a first voltage controlled oscillator, and the next key, which need not be the next adjacent key, is assigned to a second voltage controlled oscillator, etc. In another embodiment, separate oscillators are coupled to each of the plurality of input terminals and a plurality of audio processing channels are coupled to the switching matrix.

1 Claim, 2 Drawing Figures



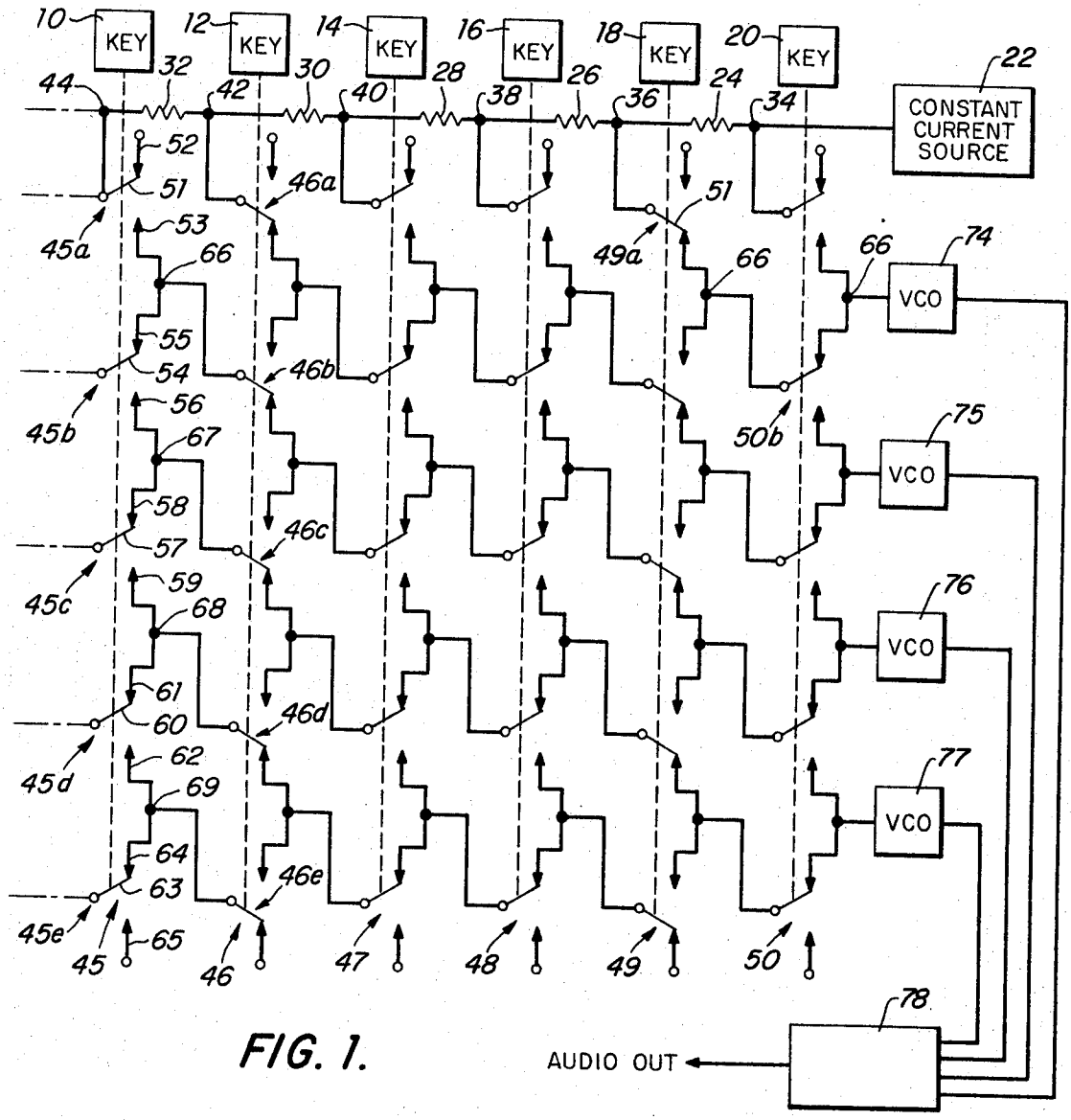


FIG. 1.

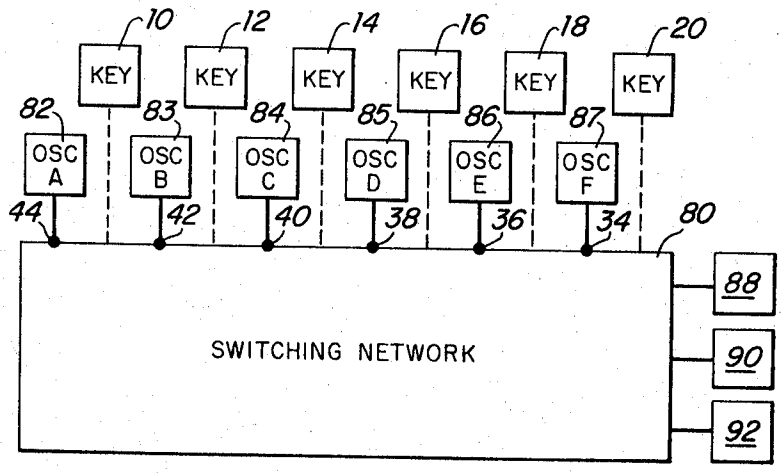


FIG. 2.

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SWITCHING SYSTEM FOR KEYBOARD

This invention relates to electronic musical instruments and particularly to music synthesizers.

Music synthesizers are electronic systems for producing a huge variety of sounds which can be varied at least in pitch, timbre and loudness by a number of techniques such as modulating a tone with sinusoidal, saw-tooth, square wave or other wave forms. However, because of the complexity of the system, such synthesizers have been limited in that they are single-voiced or monophonic; i.e., only one note at a time may be played. However, it would be highly desirable to provide a synthesizer capable of playing a number of voices simultaneously; i.e., a polyphonic instrument.

Therefore, a primary object of the present invention is to provide a polyphonic electronic musical instrument. Another object of the present invention is to provide a channel selector switching system for an electronic synthesizer or other normally monophonic system. Yet another object of the present invention is to provide such a channel selector switching system in which the switching occurs only in a predetermined switching order.

The above objects, advantages and features of the present invention are accomplished by providing in combination with an electronic musical instrument, a switching system comprising: means for providing a different input signal at each of a plurality of input terminals arranged in an array; a plurality of switch means for permitting simultaneous switching of selected ones of the input signals; and output means for responding to the switched signals only in a sequence determined by the successive proximity from a predetermined end of the array of the terminals corresponding to the selected signals.

Other objects of the invention will, in part, be obvious and will, in part, appear hereinafter. The invention accordingly comprises the apparatus possessing the construction, combination of elements, and arrangement of parts which are exemplified in the following detailed disclosure, and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the present invention, reference should be made to the following detailed description taken in connection with the accompanying drawings, wherein:

FIG. 1 is a schematic diagram partly in circuit and partly in block form of one embodiment of the present invention; and

FIG. 2 is a block diagram of another embodiment of the present invention.

FIG. 1 shows a channel selector switching system for a musical keyboard having a plurality of manually operable keys **10**, **12**, **14**, **16**, **18**, and **20**, it being understood that these are merely representative of any desired plurality. These keys are usually spring loaded and are, therefore, movable between a pair of extreme positions when operated by manual depression against the spring bias and subsequent release of the key. Each of keys **10**, **12**, **14**, **16**, **18**, and **20**, is mechanically connected (as shown in dashed lines) to a corresponding ganged switch means **45**, **46**, **47**, **48**, **49**, and **50**, such that each of the latter is operable by its respective key.

The system also includes a plurality of voltage sources, each providing a unique potential level. To this end there is provided constant current source **22** connected to one end of a multi-tap voltage divider which comprises an array of series-connected resistors **24**, **26**, **28**, **30** and **32** respectively connected between taps **34** and **36**,**36** and **38**,**38** and **40**,**40** and **42** and taps **42** and **44**. Ganged switch means **45**, **46**, **47**, **48**, **49**, and **50**, are respectively electrically connected to taps **44**, **42**, **40**, **38**, **36**, and **34**.

Each ganged switching means is formed of a plurality of switches (shown as a vertical array) each of which has a movable contact or armature, all of the armatures being mechanically connected to one another for simultaneous movement in concert with movement of the respective key to which they are coupled. The armatures are each movable between a pair of positions at which electrical contact is achieved with a respective pole. Thus, array **45**, which will be considered exemplary, comprises switches **45***a*, **45***b*, **45***c*, **45***d*, and **45***e*, it being understood that the array is not limited to this particular number of switches. The number of precision resistors in the voltage divider and number of vertical arrays or ganged switching means shown depends upon the number of keys and is not limited to the few shown, as indicated by the broken lines leading into the switch armatures of means **45** and into the voltage divider at tap **44**.

Switch **45***a* thus includes armature **51** and poles **52** and **53**, switches **45***b*, **45***c*, **45***d*, and **45***e*, respectively, including armature **54** and poles **55** and **56**, armature **57** and poles **58** and **59**, armature **60** and poles **61** and **62**, and armature **63** and poles **64** and **65**.

In all the intermediate switches in the array (i.e., those having switches adjacent both sides), the right-hand pole is connected to the left-hand pole of the neighboring switch on one side and the left-hand pole is similarly connected to the right-hand pole of the switch adjacent to the other side. In FIG. 1 the right-hand pole refers to the uppermost pole and the left-hand the lowermost pole. In the end switches of the array, the pole at the side having no abutting switch is a dummy or dead pole unconnected to anything. Thus, as shown, poles **53** and **55** are connected to common junction **66**, poles **56** and **58** are connected to common junction **67**, poles **59** and **61** are connected to common junction **68**, and poles **52** and **65** of end switches **45***a* and **45***e* respectively are dummy poles. Obviously, the latter poles can be omitted if desired as they serve no electrical function.

Note that the armatures are ganged and the poles connected so that a current in any armature cannot flow to any other armature of an array, regardless of the position of the impelling key. Each of these arrays are termed herein "linear" inasmuch as the switches are identical and arranged in a simple open-ended sequence in which the electrical connection one to the other is to the next adjacent switch.

In a similar manner, each of the other ganged switch means is a like linear array of switches wherein each possesses the requisite poles, common junction and armatures identified where desirable for further exposition in this specification, by numerals corresponding to those employed in the description of ganged switching means **45**.

Each linear array of switches is connected to the adjacent arrays on either side such that the first common

junction of the array operated by the first key (i.e., junction **66** of switch means **45** operated by key **10**) is connected as the input to the second switch of the second array operated by the second key (i.e., to the armature of switch **46***b* of gauged switching means **46** operated by key **12**). In like manner, the second common junction of the first array (i.e., junction **67** of switching means **45**) is connected as the input to the third switch of the second array (i.e., switch **46***c* of switching means **46**). Similarly the third and fourth common junctions **68** and **69** of switching means **45** are connected as the input to switches **46***d* and **46***e*. Similarly, the first common junction **66** of the second array (i.e., switching means **46**) is connected to the input of the second switch (i.e., armature of switch **47***b*) and so forth. The outputs from common junctions of the last ganged switching means **50** are respectively connected as inputs to means such as voltage controlled oscillators **74**, **75**, **76**, and **77**, for converting voltages to frequencies.

Generally, the switches can be said to be arranged in a lattice in which each of a number of different voltages are respectively applied at the input of the first switch of each of a like number of ganged switching means. The common junction of an adjacent pair of switches (the n^{th} and $(n-1)^{th}$) of the $(m-1)^{th}$ ganged switching means is connected to provide the input to the n^{th} switch of the m^{th} ganged switch means (n and m both being at least 2), the common junctions, however, of the last ganged switching means being the output terminals of the lattice.

The operation of the channel selector switching system shown in FIG. **1** is as follows. When a single key of the keyboard, such as key **10** is operated by manual pressure, all armatures **51**, **54**, **57**, **60** and **63** in the corresponding ganged switching means all move simultaneously from a first position wherein they respectively contact poles **52**, **55**, **58**, **61** and **64** to a second position wherein they respectively instead contact poles **53**, **56**, **59**, **62**, and **65**. The voltage at the tap which is connected to the first depressed key which is nearest the end of the keyboard at which is located the key operating the last switching means of the lattice, namely switching means **50**, is applied to first oscillator **74**. The voltage at the tap connected to the next or second depressed key to the left of that first depressed key is applied to second oscillator **75**. The voltage at the tap connected to the next or third depressed key to the left of the second depressed key is applied to voltage-controlled oscillator **76** and so forth. Thus, oscillators **74**, **75**, **76** and **77** may each receive an input and are responsive in an order in accordance with the positioned order in which the simultaneously depressed keys are arranged.

The exact nature of this switching order will best be understood by a specific example. Assume that keys **12** and **18** are in depressed position at the same time. Thus, the armatures of ganged switching means **46** and **49** respectively are all in their down positions as shown in FIG. **1** of the drawing. The armature of each of the remaining ganged switching means are all shown to be in their "up" positions since their corresponding keys have not been manually depressed. Because of the structure of the lattice of switches, it will be seen that the voltages V_1 corresponding to the depressed key nearest to the right hand end of the keyboard (in the example shown) will be applied to voltage controlled oscillator **74**. This key, of course, is **18**. The path can be traced from tap **36** through armature **51** of switch **49***a* of switching means **49**, through common junction **66** of switching means **49** to armature **54** of switch **50***b* of switching means **50**, thence to common junction **66** of switching means **50** and thence to the input of VCO **74**. The key next depressed (positionally) to the left of key **18** is key **12** and a similar path can be traced whereby the voltage at tap **42** is applied to VCO **75**. If yet another key is depressed further to the left of key **12**, namely key **10** its corresponding voltage would be applied to VCO **76**. Clearly, for those keys which are not depressed, the voltage at the respective tap is applied only to dummy pole **52** of the appropriate ganged switching means.

Assuming that the higher voltages (i.e., those closest to the voltage of source **22**) cause a VCO to provide the higher frequencies, it will be seen that of any simultaneous actuation of a number of the oscillators, the highest frequency output will be from oscillator **74**, the next highest from oscillator **75** and so forth. The oscillator outputs are usually fed to known processing means, shown generally at **78**, for ultimately providing an audible output signal. It will be appreciated that with the switching system of the present invention, one need only provide, for example, 10 voltage controlled oscillators to yield the frequency output representation of the standard 88-key keyboard.

The embodiment in FIG. **2** shows in block form only, identified by numeral **80**, the same lattice of switches shown as ganged switching means **45**, **46**, **47**, **48**, **49**, and **50**, in FIG. **1**, operated responsively to manipulation of keys **10**, **12**, **14**, **16**, **18**, and **20**. However, instead of a voltage divider, the embodiment of FIG. **2** includes a plurality of oscillators **82**, **83**, **84**, **85**, **86**, and **87**, each for providing a unique fixed frequency output signal and respectively having their output terminals coupled to taps **44**, **42**, **40**, **38**, **36** and **34**. The output terminals of lattice **80** are connected to separate audio voltage processor devices **88**, **90**, and **92**.

It will be seen that the embodiment of FIG. **2** operates much as that of FIG. **1** in that, assuming, for example, oscillators **82**, **83**, **84**, **85**, **86**, and **87**, respectively, provide the sequence of full tones from A below middle C to F above middle C, the highest tone of all the keys depressed will appear at processor **88** and the lowest tone at processor **92**, regardless of which three keys are selected for depression.

In both embodiments, it will be apparent that, for a full range of keys (e.g. 88) and corresponding sequence of half-tones, the lowest frequency tone to be provided need be switched through only one switch (corresponding to **45***a*) operated by the corresponding key inasmuch as all of the other switches (such as those corresponding to **45***b*, **45***c*, **45***d*, **45***e*) have no inputs and are, therefore, superfluous. Similarly, the next key producing the higher frequency tone need have only two switches, one having an input connected to the requisite voltage divider tap and one having an input connected to the output of the lower tone switch. Thus, each ganged switching means need generally have only as many switches as are required by the number of desired inputs, and the maximum number of the latter

is one more than the number of final outputs from the keyboard.

Since certain changes may be made in the above apparatus without departing from the scope of the invention herein involved, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted in an illustrative and not in a limiting sense.

For example, while the switching system hereinbefore described has been illustrated as comprising mechanical switching, it will be appreciated that it is not so limited and that other systems such as electro-optical, electro-mechanical, all electronic switching and the like can be employed.

What is claimed is:

1. A keyboard system for an electronic musical instrument comprising, in combination:

a resistive voltage divider having a plurality of series-connected resistors defining a plurality of taps;

a current source coupled to the voltage divider for establishing predetermined different voltages at each tap of the voltage divider;

the voltage at each said tap providing an input signal;

a multiplicity of voltage controlled output means each capable of being operated by one of said input signals;

audio processing means coupled from said multiplicity of output means;

and a switching matrix comprising;

a plurality of linear switching arrays with each array including a plurality of switches and each array being responsive to operation of a corresponding key of said keyboard,

each said switch including an armature and first and second poles,

means connecting each tap of the voltage divider to the armature of the first switch of the corresponding array,

means intercoupling the first pole of each switch except an end switch of each array to the second pole of the next adjacent switch of the same array,

said second pole of said first switch of each array being unconnected,

the joined poles of the $(n-1)^{th}$ and $(n)^{th}$ switch of the $(m-1)^{th}$ array being connected to the armature of the n^{th} switch of the m^{th} array in said matrix except that the joined poles of at least one of said arrays are connected to respective ones of said voltage controlled output means,

wherein the joined poles of the array that couples to the tap having the highest voltage applied thereto are connected to respective ones of said voltage controlled output means.

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