United States Patent

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[72] Inventors **Bradley J. Plunkett**
Van Nuys;
John R. Brand, Northridge, Calif.

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[73] Assignee **Warwick Electronics Inc.**
Chicago, Ill.
a corporation of Delaware

[54] **MULTI-CHANNEL KEY SWITCH CIRCUIT**
6 Claims, 2 Drawing Figs.

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[51] **Int. Cl.** **G10h 1/00,** G10h 3/00, G10h 1/02
[50] **Field of Search** ..... 328/104, 154; 84/1.01, 1.07, 1.08, 1.19, 1.22, B, D

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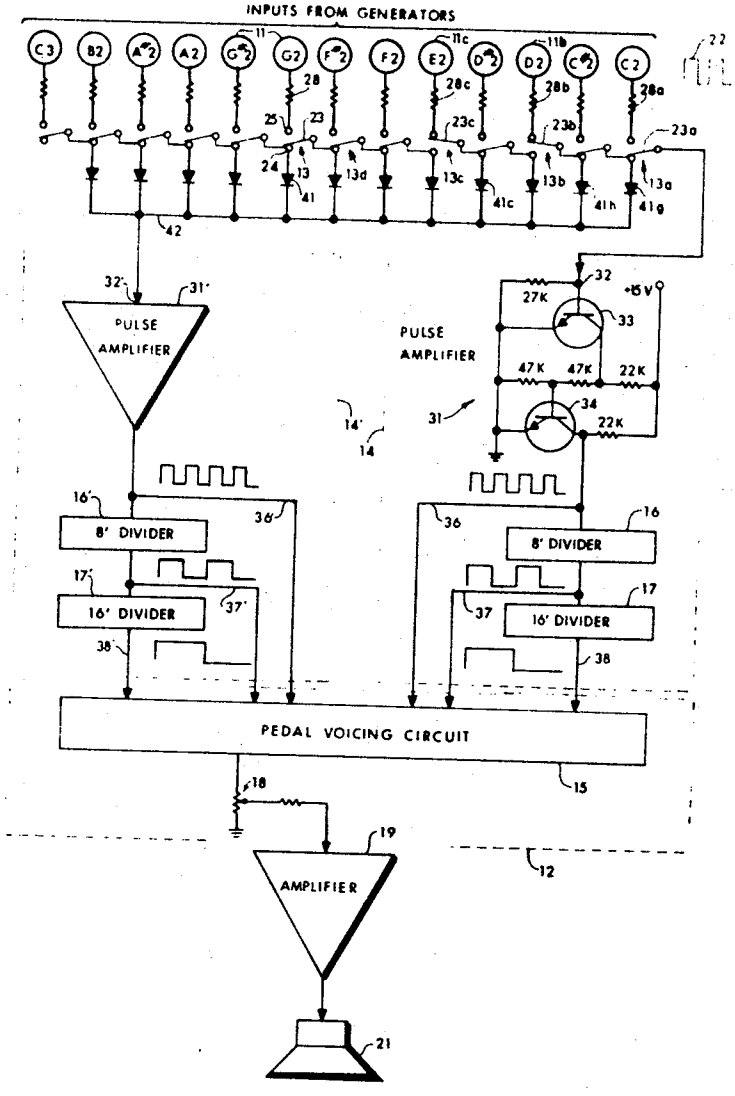
Primary Examiner—Eli Lieberman
Assistant Examiner—T. Vezeau
Attorney—Warren T. Jessup

ABSTRACT: A series of key switches are provided with individual tone sources. From one end of the series, output signal is applied to a first frequency divider circuit, thence to suitable formants and to the output of the musical instrument. From another point, or points, in the series of key switches, a second output is taken and applied through a second frequency divider circuit; thence to the formants and output circuits. If two key switches are closed at the same time, that switch closest to the series end feeding the first channel determines the tone which will pass through the first channel. Selective means are provided to cause the other tone to pass through the second channel. In this way two tones can be simultaneously applied to the output circuit, i.e., loudspeaker, where previously only a single tone could be sounded at any one time (monophonic tone sounding).



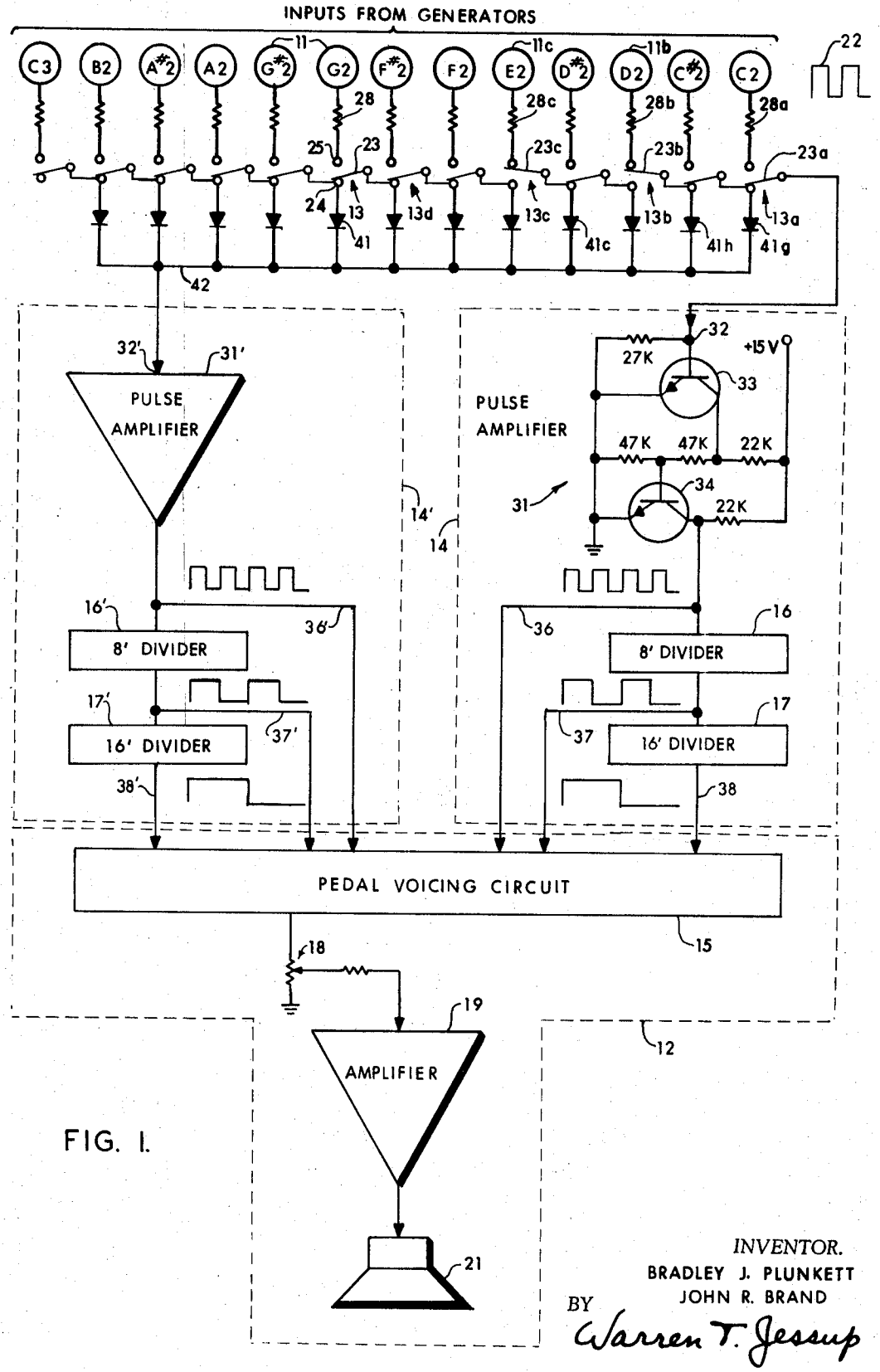


FIG. I.

INVENTOR.
BRADLEY J. PLUNKETT
JOHN R. BRAND
BY Warren T. Jessup
ATTORNEY

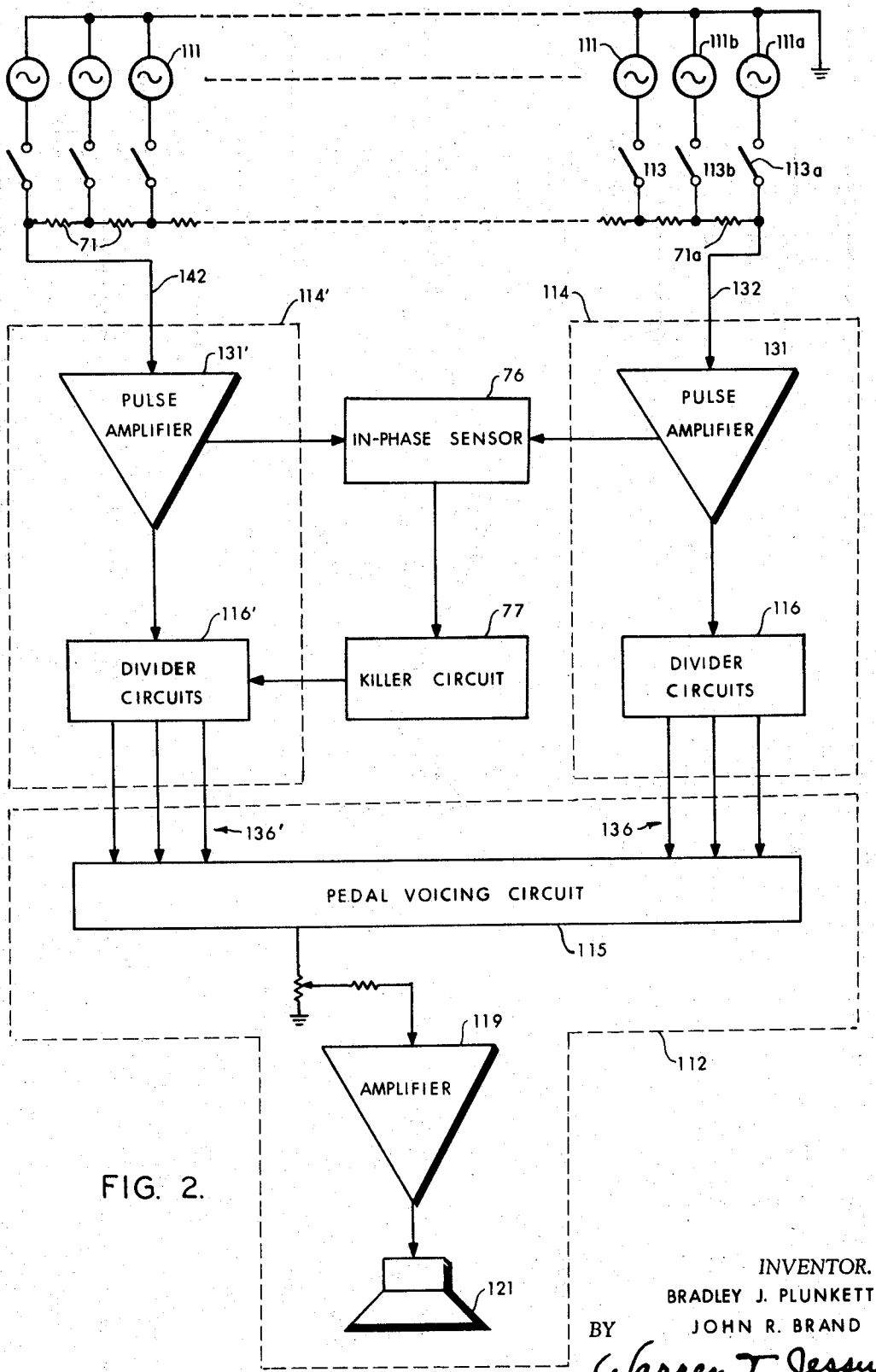


FIG. 2.

INVENTOR.
BRADLEY J. PLUNKETT
JOHN R. BRAND
BY Warren T. Jessup
ATTORNEY

MULTI-CHANNEL KEY SWITCH CIRCUIT

BACKGROUND OF THE INVENTION

This invention relates to the art of key switching of electric musical instruments, such as electronic organs. More particularly it is in the field of key switching using periodicity change circuits, such as dividers, which by their very nature can receive only one fundamental frequency at any given time. The invention has particular application where the fundamental is in the form of a square wave having many harmonics, which is uniquely adapted for frequency division.

In the past it has been customary to apply a series of square wave tone sources to the divider circuit, through key-operated key switches, in such a way that if more than one key switch is closed, the divider circuit will nonetheless feel or effectively receive only one of the tone source signals. This is necessitated by the fact that the frequency divider circuit cannot usefully receive simultaneously square wave tone signals of more than one frequency at any one time. The result was the creation of various forms of what are known as monophonic tone generating circuits, capable of delivering to the loudspeaker, through the divider, only one tone at a time. Such circuits are usually used in pedal claviers where the tone generators are set to deliver tones in the upper portion of the bass range, which after application to one or more dividers, are lowered a corresponding number of octaves to become 8 and 16 foot pedal tones.

There are occasions when a skillful organist could make effective use of two pedal tones simultaneously. The purpose of this invention is to provide a modification or addendum to the prior art type of monophonic key switching circuit which makes possible the simultaneous sounding of a second pedal tone.

SUMMARY OF THE INVENTION

To the conventional series of key switches, there is added a second output line, which takes its tone signals from a different point in the series than the first or primary tone signal taken from one end of the series. This second tone signal is applied through a second and independent divider circuit and thence combined with the (divided) first tone to provide simultaneously two pedal tones to the output of the musical instrument. Means are provided for insuring that the first tone is applied effectively only to the first divider circuit and the second tone only to the second divider circuit.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a composite circuit and block diagram illustrating one form of the invention;

FIG. 2 is a similar diagram illustrating a second form of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, 11 represents a series of sources of audio frequency electrical signals, such as tone sources for an electronic organ. The fundamental frequency of the sources is customarily graduated in accordance with the chromatic scale, as indicated. Tone signal from the sources 11 is applied to an output circuit 12 by way of a corresponding plurality of key switches 13 and a channel or circuit 14, which includes one or more dividers 16 and 17. The output circuit 12 usually includes formant or voicing circuits 15 and a volume control potentiometer 18 feeding tone signal through a final amplifier 19 into a loudspeaker 21. The circuit is usually employed as a pedal circuit in which the tones generated in the tone sources 11 are in the treble range and are stepped down one and two octaves by dividers 16 and 17 before being applied to the output circuit 12. The dividers 16 and 17 can usefully accept only monofrequency tones which customarily are in the form of positive going rectangular pulses 22 having a typical excursion from plus .1 volt to plus 8 volts and return.

To insure that only a single tone signal is applied to the dividers 16 and 17, the series of key switches 13 consists of sequentially connected single-pole, double-throw switches, each having a pole 23, an lower normally closed contact 24, and a lower, normally open, contact 25. The upper contacts 25 are connected to the respective tone sources 11. Each pole 23 is connected to the lower contact 24 of the immediately preceding key switch in the series.

From the FIG. it will be seen that, with the key switches 13 connected in sequence as illustrated, only one tone signal can be applied at any one time to the dividers 16 and 17 in the output channel 14. If more than one switch is closed simultaneously, only that switch which is closest to the front end of the series, i.e., to the switch 13*a*, will apply signal to the channel 14. All other switches in the sequence following the actuated switch are isolated from access to the input of channel 14 by virtue of the opening of the upper or normally closed contact of that actuated switch which is first in the sequence. It will be noted that in FIG. 1 the first of the switches 13*a* is connected to the lowest of the tones. This arrangement is thus a low-preference monophonic tone generator in which only the lowest of the depressed key switches of a plurality of switches will be sounded.

The description heretofore given represents the state of the art to which the present invention applies.

In accordance with the present invention, certain additions are made as follows:

In the connection from each tone generator or source 11 to the respective upper contact 25 of its switch 13 is connected a voltage dropping resistor 28.

If it is not already intrinsic in the circuit, the coupling channel or circuit 14 is provided with an input circuit, preferably in the form of a pulse amplifier shown at 31, which has a non-linear impedance. The impedance of the input circuit 31 is such that it presents at its input terminal 32 a relatively high input impedance to all tone signals 22 below a predetermined threshold voltage, and a relatively low impedance to signal above that threshold voltage.

Pulse amplifier 31 consists of two transistors 33 and 34. To input signal at 32 the transistor 33 looks like a diode connected to ground, which presents to the input signal an input impedance which is relatively high as long as the signal stays below a predetermined threshold, for example, 0.6 volts. Above this threshold the transistor 33 conducts and presents a relatively low impedance to the input signal. Amplified signal pulses, of frequency determined by whichever switch 13 is closed, is then applied first to the divider 16 and then in cascade to the divider 17, producing three octavely related tones at output points 36, 37, and 38, respectively.

Also in accordance with the present invention, connections are made to each of the key switches 13, specifically to each of the lower, normally closed, contacts 24. Each connection includes a diode 41 having one terminal connected to the lower contact 24 and the other terminal connected to a common line 42, which in turn feeds to the input 32′ of a second channel 14′, which is substantially identical to the first channel 14. Like channel 14, channel 14′ includes a pulse amplifier 31′ and a pair of frequency dividers 16′ and 17′. The output of the channel 14′, like that of 14, is applied to the output circuit 12 and specifically to the pedal voicing circuits 15 which suitably combine the outputs onto a single output lead 47 connected to the pedal volume potentiometer 18.

The diodes 41 are poled to pass signal from the switches 13 to the common output lead 42. Since in this example the generated signals 22 are assumed to be positive going, the diodes are poled as shown to pass positive going signals. Each diode, like the transistors of the circuit 31, has a threshold voltage below which a high impedance is presented and above which a relatively low impedance is presented. Thus, as long as the signal on the lower contact 24 remains below typically .6 volts, only an insignificant amount of signal will leak through on to the output lead 42. When the signal rises above .6 volt, however, virtually all of the excess above .6 volt is ap-

plied through the diode **41** and through the output circuit **14** **14'**.

As noted, the signal generators **11** typically generate output pulses rising to approximately plus 8 volts.

OPERATION

Operation of the circuit of FIG. **1** will now be described. Let it be assumed that switches **13***b* and **13***c* are both in depressed condition at the same time. Tone signal from generator **11***b* passes through resistance **28***b*, pole **23***b*, and thence down the line of normally closed lower contacts **24** to the first pole **23***a* and into the first channel **14**. As noted, the transistor **33** prevents the voltage on its base **32** from rising substantially above .6 volts. The output signal traveling along the sequence of switches from poles **23***b* and **23***a*, therefore, does not rise high enough to pass through any of the diodes **41** and pulse amplifier **31'** connected in series, since when so connected, a voltage of 1.2 volts is required before channel **14'** feels any signal. Thus the signal from generator **11***b* will be felt only in the channel **14**.

Tone signal from the tone source or generator **11***c* passes through its resistor **28***c*, switch pole **23***c* and thence appears on the lower terminal of the diode **41***c*. Since this point is isolated from the input point **32** on which the voltage has dropped to .6 volts, by the actuation of switch **13***b*, there is initially available on diode **41***c* the full 8 volt output of the tone source **11***c*. There is thus more than sufficient voltage to pass through the series-connected diode **41***c* and pulse amplifier **31'**, which, as noted, when in series require 1.2 volts to pass current. The voltage at the pole **23***c*, therefore, drops to 1.2 volts, and signal is continuously passed from the tone generator **11***c* to the second channel **14'** and thence to the output circuit **12**. Tone signal from **11***c* cannot penetrate into the first channel **14**, because the diodes **41***g* and **41***h* are poled against signal from **11***c*, thus confining it to the common line **42**.

Closing of a third switch, e.g. **13***d*, would present an ambiguous signal to channel **14'**, but this contingency is ruled out by the fact that organists have only two feet, and organ duets are rarely attempted.

SECOND SPECIES

Referring to FIG. **2**, a second form of the present invention is shown. In this FIG. **111** represents a series of tone sources substantially identical to the sources **11** of FIG. **1**. The output of each tone source **11** is connected to a respective single-pole, single-throw key switch **113**. The other side of each switch **113** is connected sequentially down the line to the junction points of a series of voltage dropping resistors **71**. The "low" end **132** of the series **71** is connected to the input of a first channel **114**, which includes divider circuits **116**. The forward or input end of the channel **114** is provided with a very high impedance pulse input amplifier **131**.

As in the case of FIG. **1**, the output **136** from the channel **114** is applied to voicing circuits **115** and thence to a loudspeaker **121**.

The circuit is so designed that the internal resistance of the tone generators **111** is very low compared to the resistance of any one of the resistances **71**, and the input impedance of the pulse amplifier **131** is very high compared to **71**. Under these circumstances, if say the switch **113***a* is closed, the output of the tone source **111***a* will be applied through the lead **132** to the channel **114**, thence through the dividers **116**, to the loudspeaker **121**. If another key switch **113** farther to the left (higher) in the series, i.e. farther away from the end of the series to which the lead **132** is connected, is now closed, for example switch **113***b*, all the signal voltage generated in **111***b* will be dissipated in the resistor **71***a*, because the internal impedance of **111***a* is very low compared to **71***a*. Thus, the tone source **111***b* will have but negligible effect on the channel **114**, leaving the tone source **111***a* as the only source sounding through the loudspeaker **121**.

In accordance with the present invention, the opposite end of the series of resistors **71** is connected by an output conductor **142** to another output channel **114'**, substantially identical to the channel **114**. Under these conditions when both switches **113***a* and **113***b* are closed, tone from **111***b* will pass to the left and to the output conductor **142**, because none of the switches **113** lying to the left of the switch **113***b* is closed to short circuit or bypass tone from **111***b* to ground through the relatively low impedance of any one of the tone sources **111**. Hence, under this condition the tone from **111***a* will sound through channel **114**, while simultaneously tone from **111***b* will sound through channel **114'**.

When only one switch **113** is closed, tone signal from its tone source **111** will pass in both directions through the series-connected resistors **71**, through both the leads **132** and **142**, and hence simultaneously into both channels **114** and **114'**. There is no assurance that the dividers **116** and **116'** might not start up out of phase, so that their respective outputs would cancel each other when applied to the formant circuits **115**. To preclude this, there is spanned between the two channels **114** and **114'**, an in-phase sensor **76**, which senses when synchronous, in-phase voltages are being received simultaneously by the two high-impedance input circuits **131** and **131'**. When the circuit **76** senses that there is such synchronism, it actuates a killer circuit **77**, which precludes one of the dividers, e.g., the divider **116'** from operating.

As soon as a second key switch, e.g., **113***b*, is closed, this simultaneous signal condition no longer exists, inasmuch as the amplifier **131'** is now receiving its predominant signal from the source **111***b*. Under these conditions, the in-phase sensor **76** no longer operates to disable the divider **116** via the killer **77**, and both signals (of different frequency) now are permitted to pass through their respective channels to the output circuit **112**.

Whereas the present invention has been shown and described herein in what is conceived to be the best mode contemplated, it is recognized that departures may be made therefrom within the scope of the invention which is, therefore, not to be limited to the details disclosed herein, but is to be afforded the full scope of the invention as hereinafter claimed.

We claim:

1. Switching system for an electric music system, comprising:

a plurality of sequentially connected key switches;

a corresponding plurality of tone sources connected respectively to said key switches;

an output circuit for the system;

first circuit means connecting the first of said switches in the sequence to said output circuit, characterized by said first circuit means having a nonlinear input impedance which is relatively high to tone signals when the voltage thereof is below a first predetermined threshold, and relatively low when said voltage is above said threshold;

second circuit means connecting each of said key switches to said output circuit and having a nonlinear input impedance which is relatively high to tone signals below a second predetermined threshold voltage, and relatively low to signals above said threshold voltage, said second threshold voltage being substantially greater than said first threshold voltage; and

the peak voltage of tone signals delivered by said tone sources being greater than said second threshold voltage.

2. Switching system for an electric music system, comprising:

a plurality of sequentially connected key switches;

a corresponding plurality of tone sources connected respectively to said key switches;

an output circuit connected to the first of said switches in the sequence, characterized by a corresponding plurality of nonlinear impedances, each having one terminal thereof connected to a respective key switch, and characterized by a relatively high impedance when the voltage

thereacross is below a predetermined minimum and a relatively low impedance when such voltage is above said minimum; and

circuit means connecting all the respective other terminals of said impedances to said output circuit.

3. In a key switching circuit for an electric musical instrument, comprising:

a plurality of sequentially arranged, single-pole, double-throw key switches, each having a pole, a first contact, and a second contact;

a corresponding plurality of electric tone signal sources connected to the respective second contacts of said key switches;

an output circuit including speaker means;

first circuit means including frequency divider means for connecting said output circuit to the pole of the first key switch in the sequence of key switches;

second circuit means for connecting the poles of the remaining key switches respectively to the first contact of the immediately preceding key switch in the sequence, the improvement which comprises providing a plurality of voltage dropping resistors in the respective connections between said tone sources and said second contacts;

providing the input of said first circuit means with a nonlinear impedance which presents a relatively high input impedance to tone signal below a first predetermined threshold voltage and a relatively low input impedance to signal above said first threshold voltage;

third circuit means connected from each of the first contacts of said key switches to said output circuit and including frequency divider means, and a plurality of diodes connected respectively to said first contacts and poled to pass signal from said first contacts to said output circuit;

said third circuit presenting to tone signal applied to said first contacts a nonlinear impedance which is relatively high when signal voltage is below a second predetermined threshold and relatively low when above said second predetermined threshold voltage;

said second threshold voltage being substantially greater than said first threshold voltage; and

the amplitude of signal voltage delivered from said tone sources being above said second threshold voltage.

4. In an electric musical instrument, comprising:

a plurality of sources of audio frequency electric signals;

a corresponding series of key switches;

first circuit means for coupling each switch to a corresponding signal source;

second circuit means for connecting said key switches together;

output circuit means;

first channel circuit means for connecting one end of the series of key switches to said output circuit means, whereby if and when a plurality of key switches are closed simultaneously, only that key switch in the series closest to said one end will effect the application of signal to said output circuit means; and

the improvement which comprises second channel circuit means connected to said second circuit means and to said output circuit means, said second channel means including means for applying signal from a given key switch to said output circuit means only if a key switch closer to said one end than said given key switch is simultaneously closed.

5. The combination of Claim 4, wherein:

said second circuit means comprises a plurality of series-connected impedances, said key switches being connected respectively to the junction points between said impedances;

said second channel circuit means comprises circuit means for connecting the opposite end of said series of key switches to said output circuit means; and

means connected to said first and second channel circuit means for inhibiting the signal applying operation of one of said channel circuit means when only a single key switch is closed.

6. The combination of Claim 4, wherein:

said first channel circuit means comprises threshold impedance means for passing only audio frequency signals above a first predetermined threshold voltage; and

said second channel circuit means comprises circuit means connected to each of said key switches and includes threshold impedance means for passing only audio frequency signals above a second predetermined threshold voltage higher than said first threshold voltage.