Sept. 22, 1964 T. B. GIBBS ETAL 3,150,228

ELECTRONIC MUSICAL INSTRUMENT

Filed June 9, 1960 3 Sheets-Sheet 1

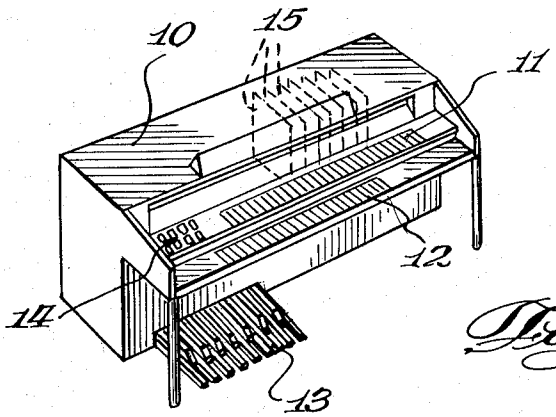


Fig. 1.

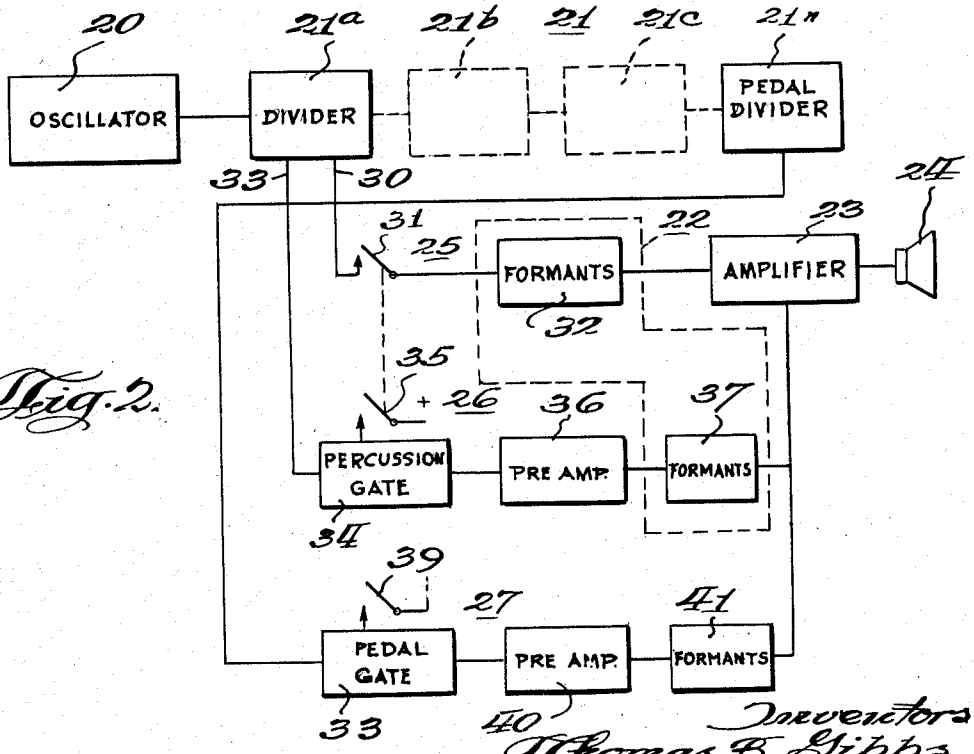


Fig. 2.

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Fig. 3.

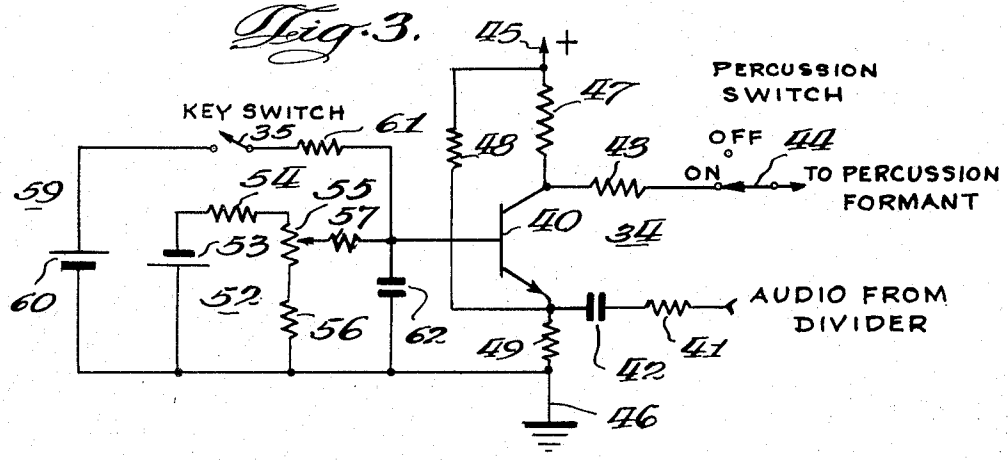
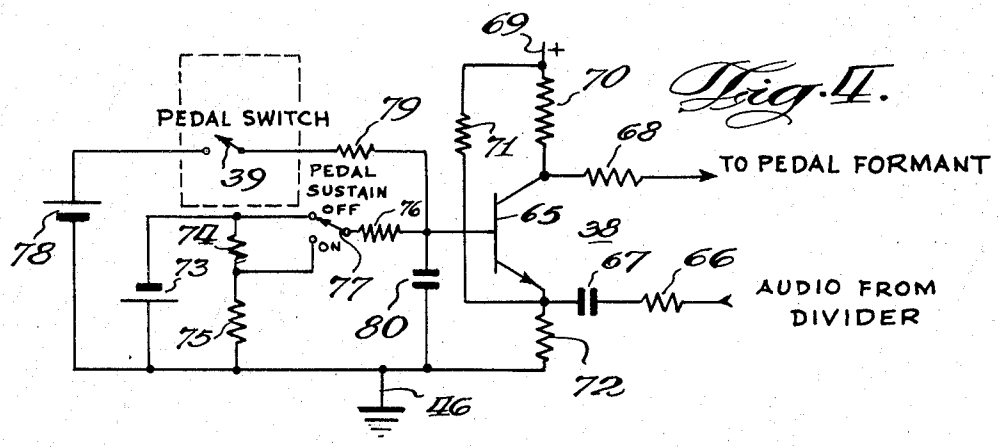


Fig. 4.



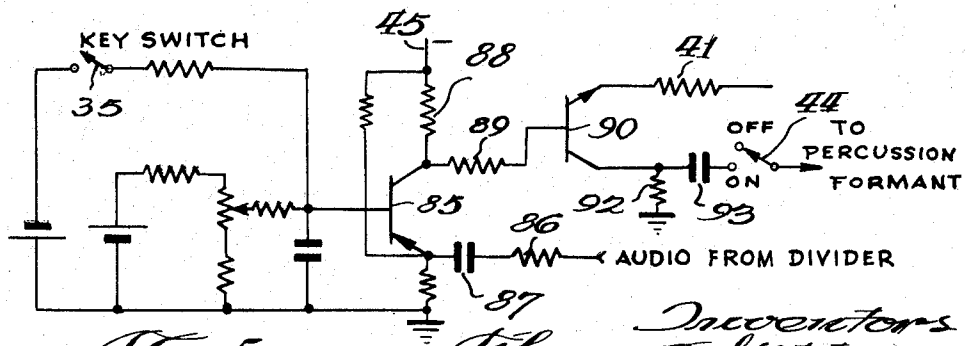


Fig. 5.

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Filed June 9, 1960 3 Sheets-Sheet 3

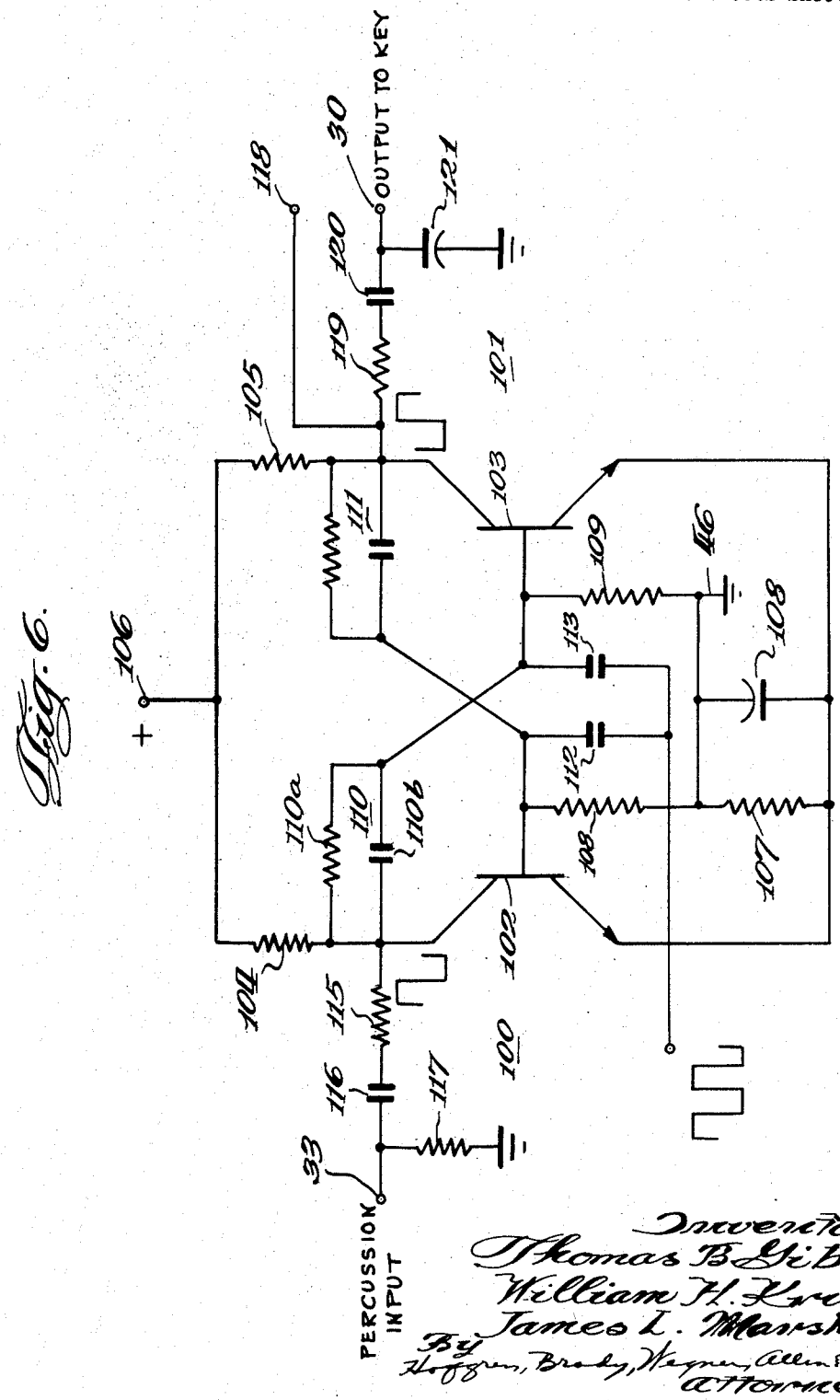


Fig. 6.

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United States Patent Office 3,150,228
Patented Sept. 22, 1964

3,150,228

ELECTRONIC MUSICAL INSTRUMENT

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Filed June 9, 1960, Ser. No. 34,913
5 Claims. (Cl. 84—1.26)

This invention relates to an electronic musical instrument and more particularly to novel systems and circuits for tone representing signal generation and control in an electronic organ.

The novel systems and circuits disclosed and claimed herein are designed for an electronic musical instrument, as an organ, which utilizes transistors for tone generation, control and the provision or special effects, as percussion.

One feature of the invention is the provision in an electronic musical instrument of a percusison system including a source of tone representing signal, a utilization circuit for the signal, a variable impedance switch connecting the source with the utilization circuit and means for varying the impedance of the switch in a predetermined manner. More specifically, a further feature is the provision in a musical instrument of a transistor gate circuit connecting a source of tone representing signal with a utilization circuit, first bias means connected with the transistor maintaining it nonconductive, and second bias means connected with the transistor through a key actuated switch for rendering the transistor conductive. A further feature is that a capacitor connected with the transistor is charged from the second bias source and the charge is dissipated through a resistive circuit, gradually cutting off the transistor and decreasing the amplitude of the signal to the utilization circuit.

Another feature is the provision of a two-stage cascade connected transistor gate circuit between the tone source and the utilization circuit, both stages being turned on and off in accordance with actuation with the associated key switch.

Still a further feature is the provision in an electronic musical instrument of a manual keyboard, a pedal keyboard which is spaced therefrom, electronic tone representing signal generating and handling circuits adjacent the manual keyboard and including pedal gating circuits, pedal switch means adjacent and controlled by the pedals, and gating control circuits connecting the pedal switch means and the pedal gating circuits, and isolated from the tone representing signal circuits. The tone representing signals are not directly switched at the pedal keyboard and unshielded conductors may be used between the pedal switches and the signal circuits.

And another feature is the provision in an electronic musical instrument of a source of tone representing signal having two outputs with signals 180° displaced in phase, a first channel connecting one of the outputs of the source with a reproduction device and the second channel connecting the other of the outputs with a reproducing device, one of the channels including means providing a phase shift of the signal 180° different from the phase shift provided by the other channel.

Further features and advantages of the invention will readily be apparent from the following specification and from the drawings, in which:

FIGURE 1 is a perspective view of an electronic musical instrument embodying features of the invention;

FIGURE 2 is a simplified block diagram of a tone representing signal generating and handling system embodying features of the invention;

FIGURE 3 is a schematic diagram of a percussion circuit illustrating the invention;

FIGURE 4 is a schematic diagram of a pedal keying circuit illustrating the invention;

FIGURE 5 is a schematic diagram of a modified percussion circuit; and

FIGURE 6 is a schematic diagram of a frequency divider multivibrator circuit.

An electronic organ utilizing transistor signal generation and handling circuitry, as contrasted with a system utilizing vacuum tubes or photoelectric cell tone generators, requires specialized circuitry for the provision of certain desired organ effects, in order to utilize the capabilities and meet the limitations of transistors.

Turning now to FIGURE 1 of the drawings, an organ **10** is illustrated having two manual keyboards **11** and **12** and a pedal keyboard **13**, which extends outwardly from the lower portion of the cabinet, adjacent the floor. Various control and stop switches **14** are mounted adjacent upper manual **11**. The tone representing signal generating and handling circuitry, including oscillators, frequency dividers and tone formant and control circuits, as will appear, are mounted on circuit boards **15** located in the upper portion of the instrument cabinet, adjacent the manual keyboards **11** and **12**. This keeps the electronic circuitry as close as possible to the manual keys and the various switches associated therewith. As will appear below, special pedal gating circuitry is utilized to permit the switching of control signals by the switches associated with the pedal keys, controlling circuitry mounted on circuit boards **15** so that it is not necessary to couple the tone representing signals themselves from one part of the instrument cabinet to another.

FIGURE 2 illustrates in simplified block from the system for a single note. An oscillator **20** controls a chain **21** of frequency divider circuits, including dividers **21***a*, **21***b*, **21***c* . . . **21***n*, the number depending upon the range of the particular instrument. Oscillator **20** operates at a frequency one octave above the highest frequency of the particular note, and all of the tones produced from the instrument are derived from the dividers each of which halves the frequency of the preceding stage. The tone producing outputs of the dividers are rich in harmonics, preferably of a square wave configuration, and the signals are passed through suitable filtering or formant circuits **22**, to achieve the desired relationship of harmonics in the output. The output of the formant circuits are amplified at **23** and may be reproduced by the speaker **24**.

Three separate signal handling and control channels **25**, **26** and **27** are illustrated in FIGURE 1. Signals are connected from an output **30** of the divider through a key actuated switch **31** in the channel **25** and through formant networks **32**, selected by stop switches **14**, directly to amplifier **23**.

Channel **26** provides for a percussion effect in which the amplitude of the signal starts at a high level when the key switch is closed and decreases gradually when the switch is opened. The signal for the percussion channel is derived from the second output **33** of the divider and is coupled through a percussion gate **34** controlled by a key actuated switch **35**, a preamplifier **36** and percussion formants **37** to amplifier **23**. The pedal notes are derived from the last divider **21***n* of the series and are coupled through the pedal gate **38** controlled by pedal switch **39**, preamplifier **40** and pedal formants **41** to amplifier **23**.

In the interests of simplicity only a single signal channel of each type is illustrated in FIGURE 2. In practice, there are twelve oscillators and twelve associated divider chains, with one divider for each octave within the range of the instrument. Connected with each divider, except the pedal dividers, is a key switch **31** connecting selected signals with formant circuits **32**, and a percussion gate **34** controlled by a key switch **35**. The desired formant cir-

cuitry for each of the channels is selected by operation of the appropriate selector switches 14 (FIGURE 1).

During the course of the following description, more specific values and type designations will be made for various components of the circuits. It is to be understood that this specific disclosure is made for purpose of illustrating an operative embodiment of the invention and many changes and modifications will readily be apparent to those skilled in the art.

Turning now to FIGURE 3 of the drawing, one form of percussion gate circuit is shown. The percussion gate utilizes a gating transistor 40, Sylvania type 1288. The audio signal from output 33 of the associated divider network is coupled through resistor 41, 10,000 ohms, and capacitor 42, 0.1 μf., to the emitter of transistor 40, and the gated output derived at the collector is coupled through resistor 43, 100,000 ohms, and percussion on-off switch 34 to the selected percussion formant circuits as shown in FIGURE 2. The operating bias for transistor 40 is provided by a positive 10 volt D.C. power supply connected between terminal 45 and ground 46. The collector of transistor 40 is connected through load resistor 47, 10,000 ohms, with the power supply while the emitter is connected to a voltage divider including resistors 48, 68,000 ohms and 49, 2200 ohms, connected across the power supply.

The base or control element of transistor 40 is connected with bias control networks which effect the desired variation of transistor resistance, and thus control the amplitude of the tone representing signal to the formant circuits. Except during those periods of time when a percussed note is actually being keyed, transistor 40 is maintained nonconductive or "cut off" by a first bias network 52 including a potential source or battery 53, 11.5 volts, and a voltage divider comprising resistors 54, 1500 ohms, 55, 1000 ohm potentiometer and 56, 220 ohms. The movable tap of potentiometer 55 is connected through series resistor 57 with the base of transistor 40, applying to it a desired negative potential from battery 53, rendering it nonconducting. A second bias circuit 59 includes battery 60, 1.5 volts, key switch 35 and resistor 61. When key switch 35 is closed, a positive potential from bias source 60 is applied to the base of transistor 40, modifying the negative potential from source 53, dropping the resistance of transistor 40 to a low value, rendering it highly conductive. Capacitor 62, connected with the base of transistor 40, assumes a charge determined by the relative potential of batteries 53 and 60 and the setting of potentiometer 55. When key switch 35 is released, transistor 40 remains conductive under the influence of the potential across capacitor 62 which returns to its original value at a predetermined rate through several parallel paths including resistors 54, 55, 56 and 57. The resistance of the transistor increases and the signal amplitude decreases gradually as the potential across capacitor 62 returns to its original value. The time required to return the transistor 50 to cut off is determined by the setting of the adjustable arm of potentiometer 55.

In the percussion bias networks, the bias sources 53 and 60, and the voltage divider including resistors 54, 55 and 56 are common to all of the percussion circuits in the instrument. Resistors 57 and 61 and capacitor 62 are individual in each percussion gate circuit. The resistor 61, in series with key switch 35, introduces a slight lag in turning transistor 40 on when the key switch is closed, eliminating a "pop" which otherwise is produced.

FIGURE 4 illustrates a gating circuit utilized in the pedal channel 27. Transistor 65, Sylvania type 1288, has its emitter-collector circuit connected in the signal handling channel, between the pedal divider and the pedal formant circuits. An input coupling network includes resistor 66, 10,000 ohms, and capacitor 67, 0.1 μf. The output circuit includes series resistor 68, 100,000 ohms. Transistor 65 is connected with a suitable source of operating potential connected with terminal 69, as +10 volts.

Load resistor 70, 10,000 ohms, is connected in the collector circuit and the emitter bias for the transistor is provided by a voltage divider including resistors 71, 68,000 ohms, and 72, 2,200 ohms. A first control bias battery 73, 11.5 volts, has a voltage divider including resistors 74, 2,000 ohms and 75, 470 ohms connected across it. The base of transistor 65 is connected through resistor 76, 10,000 ohms, and pedal sustain switch 77 with either the negative terminal of battery 73 or the juncture between resistors 74 and 75. Second control bias battery 78, 1.5 volts, is connected through pedal switch 39 and resistor 79, 100 ohms, with the base of transistor 65. Capacitor 80, 50 μf. is connected between the base and ground 46. With pedal switch 39 open, bias source 73 maintains transistor 65 in a nonconductive condition. When the pedal switch is closed, the positive potential applied from battery 78 to the transistor base renders it highly conductive, passing a high amplitude of audio signal to the pedal formant circuits. With pedal sustain switch 77 in the "Off" position, the charge assumed by capacitor 80 is dissipated rapidly, when pedal switch is opened, primarily through battery 73. With pedal sustain switch 77 in the "On" position, the discharge path for capacitor 80 includes resistors 74 and 75, providing a sustained or holding effect for the tone.

As mentioned briefly above, the only component of the pedal channel 27 which is located at the bottom of the instrument housing adjacent the pedal keyboard 16 is the pedal switch 39, as indicated in broken lines in FIGURE 4. Most of the remaining circuit elements, and particularly the elements which handle the audio tone representing signals at a low amplitude level are located on one or more of the circuit boards 15 in the upper portion of the housing and closely adjacent each other. This minimizes the length of the conductors which carry audio signals, reducing undesired coupling effects. Only D.C. control potentials are handled by pedal switch 39 and shielded conductors are not required.

A modified gating circuit is illustrated in FIGURE 5. It has been found that in some cases the turned off resistance of a single gating transistor is insufficient to prevent a portion of the audio signal from leaking through the gate to the amplifier 23 and loud speaker 24. This causes an undesirable background noise made up of all of the frequencies of the instrument. FIGURE 5 illustrates a two stage gating circuit which eliminates this problem. Transistor 85, type R331, has its emitter connected through an input network including resistor 86, 10,000 ohms, capacitor 87, 0.1 μf., with the output audio signal from the associated divider network. The output of transistor 85 developed across collector load resistor 88, 10,000 ohms, and is conductively coupled through series resistor 89, 100,000 ohms, to the base element of transistor 90, Sylvania type 1288. The operating and control bias circuits for transistor 85 are the same as those in FIGURE 3, except for a reversal of polarity of the batteries required by the use of PNP transistor 85 in place of NPN transistor 40.

Transistor 90 is connected in a common emitter circuit with its emitter connected through resistor 91, 2,200 ohms, to a suitable negative potential source. The collector element of transistor 90 is returned to ground through the resistor 92, 10,000 ohms, and the output of the second gating stage is coupled through capacitor 93, 4 μf., and percussion switch 44 with the percussion channel formant networks. The additional amplification in transistor gate 90 permits the elimination of preamplifier 37 shown in FIGURE 2.

With key switch 35 open and first gating transistor 85 cut off, the full negative operating bias potential from terminal 45 is applied to the base element of second transistor 90, through resistor 88 and 89. This negative potential is sufficient to render transistor 90 nonconductive. Accordingly, with key switch 35 open, both transistors are cut off and a relatively high resistance is

presented between the divider network and the percussion formants. When the key switch 35 is closed, rendering transistor 85 conducting, the flow of current through collector resistor 88 raises the potential at the collector of transistor 85 and thus at the base of transistor 90, rendering it conductive. Thus, both transistors are switched on and off concurrently.

The use of a common emitter configuration in the second gating stage introduces a 180° phase shift in the signal passing through the percussion channel, which is required for proper phasing of the signals in loud speaker 24, as will appear.

FIGURE 6 illustrates the circuit of one of the triggered multivibrator frequency divider stages which form a part of the transistorized organ. The multivibrator circuit includes two sections 100 and 101, each utilizing a transistor, 102 and 103, respectively, both Sylvania type 1553. The collectors of the two transistors are connected through load resistors 104 and 105, each 2,200 ohms, with a positive 10 volt source 106; and the emitters are returned to ground 46 through a common emitter resistor 107, 1000 ohms, bypassed by capacitor 108, 4 μf. The bases of the two transistors are returned to ground through resistors 108 and 109, each 10,000 ohms. Coupling networks 110 and 111 are connected between the base of each transistor and the collector of the other transistor, and comprise a resistor 110*a*, 10,000 ohms, and capacitor 110*b*, 0.002 μf., connected in parallel. A trigger input pulse from the master oscillator for a particular note or from a preceding divider stage, is connected with the base elements of the transistors through capacitors 112 and 113, each 220 μμf. The divider is synchronized by the trigger signal, and provides a plurality of outputs at the collectors of the two stages 100 and 101. It will be noted that the output wave forms at the two transistors are 180° out of phase.

In accordance with the invention, use is made of both outputs from the divider. As indicated in FIGURE 6, the output of transistor 102, derived across resistor 104, is coupled through series resistor 115, 10,000 ohms, and capacitor 16, 0.1 μf., and across shunt resistor 117, 2,200 ohms, to the input of the associated percussion circuit. A circuit connected with the collector of transistor 103 includes series resistor 119, 10,000 ohms, capacitor 120, 0.1 μf., and shunt capacitor 121, 0.003 μf., and is connected through the associated key switch, as key switch 31, with the selected tone formant circuitry. If both tone signals were obtained from one section of the multivibrator, the load on that section would be excessive and the divider operation impaired. A further output derived from transistor 103, across resistor 105, is coupled directly, through terminal 118, to the trigger input circuit of the next succeeding frequency divider.

If the signals from the two sections of the frequency dividing multivibrator were coupled directly with the amplifier loud speaker, they would have a tendency to cancel each other, reducing the useful output power. However, as pointed out in connection with FIGURE 5, the second stage of the transistor percussion gate effects a 180° phase reversal of the signal passing through it, so that the percussed signal is in phase with the signal derived from multivibrator section 101, at the loud speaker.

The decoupling networks connected with each of the tone signal outputs of the multivibrator prevent signals from other portions of the system feeding to the multivibrator circuit and improperly triggering it.

While we have shown and described certain embodiments of our invention, it is to be understood that it is capable of many modifications. Changes therefore, in the construction and arrangement may be made without departing from the spirit and scope of the invention as disclosed in the appended claims.

We claim:

1. In an electronic musical instrument: a source of tone representing electrical signals having two outputs with signals 180° displaced in phase; a first channel connecting one of the outputs of said source with a reproducing device; a second channel connecting the other of said outputs with said reproducing device, one of said channels including means providing a phase shift of the signal 180° different from that of the other channel.

2. In an electronic musical instrument: a source of tone representing electrical signals having two outputs with signals 180° displaced in phase; a first channel connecting one of the outputs of said source with a reproducing device; a second channel connecting the other of said outputs with said reproducing device, one of said channels including a phase inverter providing a phase shift of the signal 180° different from that of the other channel.

3. In an electronic musical instrument: a tone representing signal source including a control oscillator and a series of frequency divider multivibrators; each of said frequency divider multivibrators having two sections, with outputs 180° displaced in phase from each other being derived from each section; a first channel including selectively actuable key switch means connecting one of the outputs of said multivibrators with a reproducer; a second channel including selectively actuable percussion gate circuits connecting the other output of said multivibrators with said reproducer, one of said channel having a signal phase shift 180° different from that of the other channel.

4. The electronic musical instrument of claim 3 wherein said percussion gate circuit includes a transistor amplifier connected in a common emitter circuit and introducing a 180° phase shift in said signal.

5. In an electronic musical instrument: a source of tone representing signal including a series of frequency dividing multivibrators each having two sections; a first signal handling channel connecting tone representing signals from one section of each multivibrator with a reproducer; a second signal handling channel connecting tone representing signals from the other section of each multivibrator with said reproducer and imparting a percussion effect thereto; and means connecting a trigger signal from said one section of the multivibrator to the next multivibrator.

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