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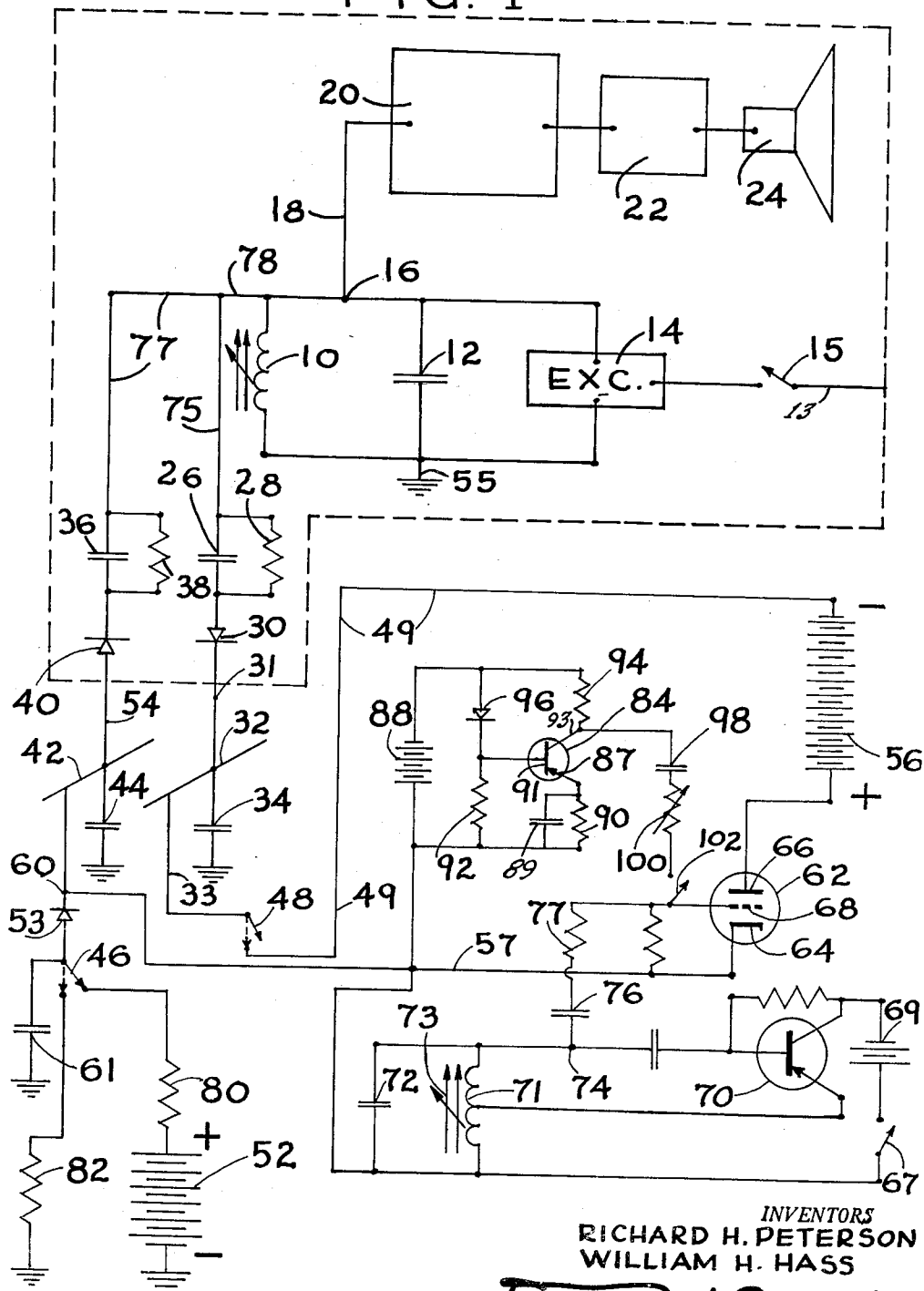
R. H. PETERSON ET AL.
ELECTRONIC MUSICAL INSTRUMENTS WITH TWIN DETUNING
CIRCUITS TO MAINTAIN CONSTANT VIBRATO

3,197,544

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2 Sheets-Sheet 1

FIG. 1



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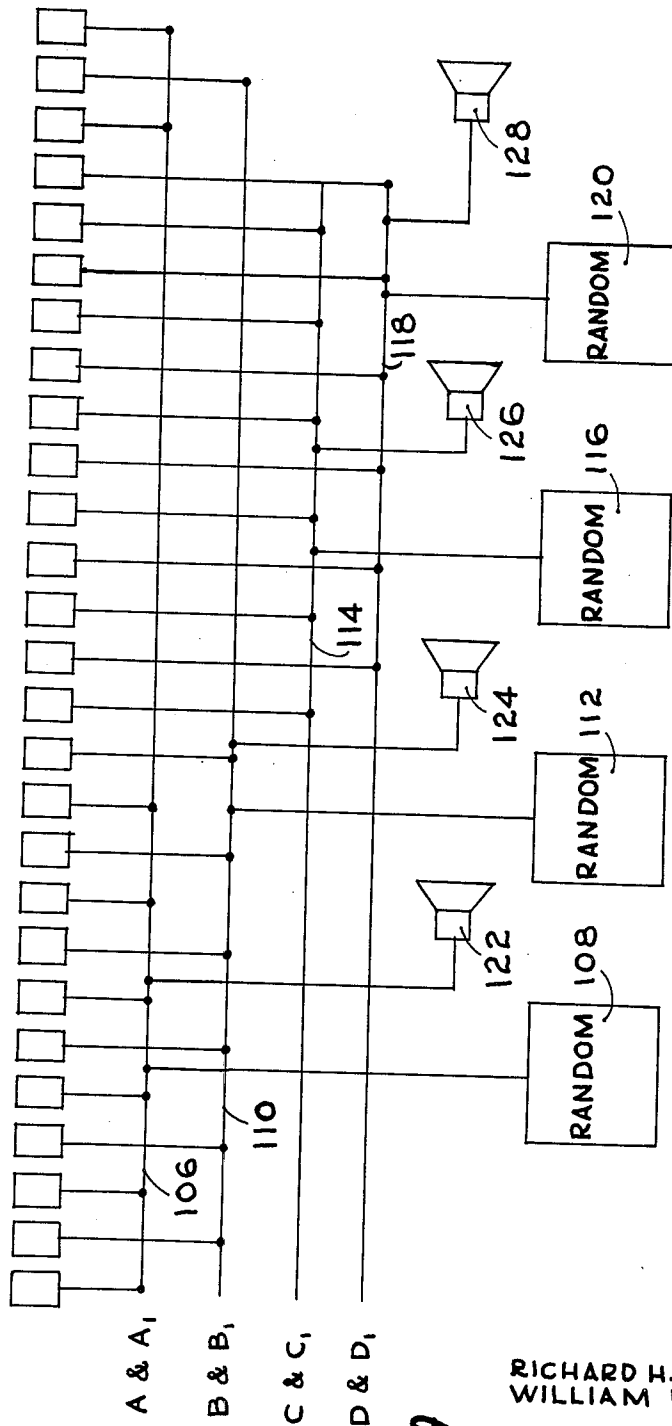
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ELECTRONIC MUSICAL INSTRUMENTS WITH TWIN DETUNING CIRCUITS TO MAINTAIN CONSTANT VIBRATO

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12 Claims. (Cl. 84-1.25)

Our invention relates to electronic musical instruments and includes among its objects and advantages a further refinement of the vibrato circuits disclosed in U.S. Patents 2,953,054 and 2,649,006.

Each of the vibrato circuits illustrated in these patents falls short of perfection, in two respects that are not seriously objectionable when the circuit is used to produce only the relatively small pitch vibrato customary in church music. Specifically: first, when the vibrato is turned on, the apparent pitch of the instrument is lowered slightly because the vibrato causes frequency modulation of the oscillators in a negative or "flat" direction only; second, the circuit is not completely immune from transients caused by the D.C. pulses that are required to operate the diodes or varistors. These defects, while not so serious as to prevent use of the invention, nevertheless are objectionable in very high quality apparatus, and particularly in entertainment instruments where a very heavy vibrato is desired.

It is one object of this invention to provide a means of frequency modulating the tones of a musical instrument symmetrically above and below a mean frequency at tremulant frequency without the introduction of undesired extraneous sounds.

A further object of the invention is to provide means for introducing a random unsteadiness into the pitch of the tones of a musical instrument so as to duplicate more exactly the qualities of a pipe organ.

In the accompanying drawings:

FIGURE 1 is a schematic of an instrument according to the invention, with certain parts indicated by block diagram; and

FIGURE 2 is an all-block diagram of a multi-channel system.

In the embodiment selected to illustrate the invention, the tuned circuit comprising the inductor coil 10 and the capacitor 12 is kept in oscillation by a conventional exciting circuit 14, whenever the individual key switch 15 is closed by the player to deliver activating potential from a conventional source, indicated by the supply line 13. The signal in the tuned circuit is delivered at 16 to the conductor 18 leading to a conventional coupling circuit 20, amplifying means 22 and a loud speaker 24.

The point 16 is also connected to two separate pitch-changing instrumentalities. The first instrumentality is the ancillary capacitor 26 provided with a shunt resistor 28, and connected through the diode 30 to the bus 32, which is grounded to A.C. signal only through capacitor 34.

The second pitch-changing instrumentality includes another ancillary capacitor 36 and shunt resistor 38, connected through diode 40 to bus 42, which is grounded to signal through capacitor 44. Capacitors 26 and 36 are given predetermined values such that capacitor 36 lowers the pitch of the signal a predetermined amount and the addition of capacitor 26 lowers it additionally by an equal amount. Diodes 30 and 40 and resistors 28 and 38 are substantial duplicates of each other.

It will be apparent that if only capacitor 12 is functioning in the tuned circuit one constant signal of maximum frequency will be delivered at point 16. But if

either one of the capacitors 26 and 36 are connected to be effective, the signal will be lowered in frequency by a predetermined amount, and if both are effective the lowering will be substantially twice as great because the two capacitors have equal values. Accordingly, the adjustable inductor 10 is used to tune the oscillator to the exact frequency desired when there is no vibrato, and this tuning is made with the capacitor 36 functioning along with the capacitor 12. Then if capacitor 36 is rendered ineffective, a higher pitch will be produced, predetermined by the constants of capacitor 12 only. Also if both capacitors 26 and 36 are operative, the signals at 16 will be lowered below normal by an equal amount.

D.C. control means are provided for securing a steady tone with capacitor 36 operative or for automatically changing from a higher pitch with neither capacitor operative to a lower pitch with both capacitors operative and back again at tremulant frequency. This will secure a perfectly balanced vibrato of any predetermined amount, and the listener's ear will always perceive the same identical pitch, even while the vibrato is taking place, which will be exactly the pitch determined by the constants of the inductor 10 and the capacitors 12 and 36.

It will be noted that diode 40 is arranged to become conductive when the conductor 54 below it has a positive potential, but diode 30 is pointed in the opposite direction. To secure signal of constant pitch at the intermediate frequency value it is only necessary to pass a very small D.C. current continuously through the diode 40 to keep it in conducting condition, and to leave diode 30 nonconductive.

The player's control of the vibrato effect is by means of stop switches 46, and 48. With the switches 46, and 48 in full line position, a D.C. circuit may be traced from ground at 55 through the coil 10 and conductors 78 and 77, resistor 38 diode 40 conductor 54, bus bar 42 common to the conductors 54 of all the oscillators, diode 53, switch 46 and resistor 80 to a potential source 52. The potential of the source 52 would also cause current to flow down through conductor 75 and resistor 28 and keep the diode 30 in conductive condition, but this is prevented because bus 32 is grounded to signal only through capacitor 34 and the D.C. circuit comes to an open end at the open switch 48. Bus 42 is also permanently grounded to signal through capacitor 44, and therefore only capacitor 36 is effective to lower the frequency of the signal at point 16. This is the condition for delivering the exactly predetermined constant frequency to which the instrument is tuned for the steady note involved.

To secure balanced excursions above and below the constant tuned frequency, means are provided for automatically rendering both diodes 30 and 40 conductive at the same time and then nonconductive at the same time in a cycle of tremulant frequency. With the switches 46 and 48 in dotted line position a circuit for holding both diodes conductive may be traced as follows: from point 60 to bus 42, conductor 54, diode 40, resistor 38, conductors 77 and 75, resistor 28, diode 30, and conductor 31 to bus 32. From bus 32 through conductor 33 to switch 48. From switch 48 the circuit is completed through conductor 49 to potential source 56, triode 62 when conductive, and conductor 57 back to point 60.

Means are provided for rendering the circuit through source 56 operative to keep diodes 40 and 30 both conductive or nonconductive in a repetitive cycle at tremulant frequency. The passage of current from cathode 64 to plate 66 is controlled by the grid 68. The potential of the grid 68 is varied at tremulant frequency by signal coupled through capacitor 76 and resistor 77 from a

suitable oscillator, illustrated as comprising a P-N-P transistor 70 and tuned circuit comprising the capacitor and the coil 71 with an adjustable core 73. A source 69 of activating potential for the vibrato oscillator is indicated in the drawing.

It will be noted that during the continuous operation of the vibrato, there is no D.C. potential on conductor 78 with respect to ground, and therefore no transient signal is introduced into the signal generated by the oscillator. When the switches 46 and 48 are in full line position there is a very small current in coil 10 and when that current is discontinued the discontinuance might cause a slight click or thump. I prefer to make the potential provided by source 56 twice that provided by source 52 so that the value of the current flowing to keep the diodes conductive is the same at all times. For complete elimination of any click or thump when the player operates the stop switches 46 and 48, point 60 is connected to ground through a capacitor 61. At the instant switch 46 starts over to the dotted line position, the potential from source 52 disappears but the capacitor 61 will supply the same potential at that instant and the charge will leak out gradually through resistor 82. It is easy to proportion the parts so that this gradual decrease in potential, and in current in coil 10, produces no perceptible sound effect.

Similarly, when switch 46 is returned to the full line position, the rise in the potential of point 60, and of the current in coil 10, is retarded by the delay circuit comprising resistor 80 and the same capacitor 61.

Because the primary determinant for the falling potential is resistor 82 and for the rising potential resistor 80, each of these timing functions can be predetermined to have its own independent time value if desired. We prefer to have the impedance of resistor 80 materially greater than that of resistor 82.

Great progress has been made in recent years in the development of electronic instruments of the organ type and such instruments can now duplicate with great fidelity most of the tonal characteristics of pipe organs. On a side by side comparison however, the electronic instrument usually has a somewhat "simpler" sound that is not quite as satisfactory esthetically as the more complex sound of the pipe organ.

One difference appears to be due to a random unsteadiness in the pitch and amplitude of the pipe tone, due to unavoidable variations in the pipe organ's wind supply. Further, when a number of notes are sounded together each note usually is experiencing a substantially different random modulation, because the pressure at one point in a wind chest is dynamically different from the pressure at any other point in the chest. This tends to complicate the beat patterns that normally occur due to slight tuning errors and due to the use of a tempered scale. It is this complication of beat patterns that appears to be a subtle but important factor in the superiority of pipe organ tone.

Means are provided for introducing into the signal at 16, slight random modulations similar to the modulations that render the organ output distinctive and esthetically desirable.

The random noise generator comprises a transistor 84, and potential source 88. From the emitter 87 the circuit is through capacitor 89 and by-pass resistor 90 to the positive terminal of source 88. The base 91 is connected to the same terminal through resistor 92. The collector 93 is connected to the negative terminal of source 88, through resistor 94. The diode 96 is between the base 91 and the negative terminal of source 88.

This is a common type of random noise generator in which the leakage in the diode 96 creates irregular variations in the current through it and in the potential delivered to the coupling capacitor 98, which is connected through resistor 100 and switch 102, when closed, to the grid 68 of the triode 62. It is desirable to provide an

adjustment of resistor 100 accessible to the player so that the amount of random effect may be varied to taste. It will be obvious that such random effect, when supplied, will remain present with or without operation of the transistor 70 and associated parts to deliver a vibrato also. There is no random noise in the signal at point 16, but the random fluctuations of the grid 68 cause corresponding random variations in the frequency of the signal at point 16.

In FIGURE 2 we have indicated a portion of a tone-generator including twenty-seven oscillators 104 for producing twenty-seven consecutive semi-tones. The lowest twelve semi-tones are delivered alternately to bus 106 carrying random effect from generator 108, and to bus 110 carrying random effect from generator 112. The next twelve semi-tones are similarly connected alternately to bus 114 carrying random effect from generator 116 and bus 118 carrying random effect from bus 120. In the third octave connections go back to buses 106 and 110.

This is one effective arrangement such that the player playing musical intervals known as fourths, fifths and octaves, will always have the two notes making up such an interval modulated at random from two different generators.

The overall effect is also materially enhanced if each bus has its own separate loud speaker 122, 124, 126 and 128 and if those loud speakers are in materially separated locations.

Summarizing the various effects available to the player: (1) Continuous steady tone at normal pitch is obtained with stop switch 46 closed and stop switch 48 open, and the condition of switches 67 and 102 is immaterial. (2) To add the random pitch variations characteristic of an acoustic pipe organ, leave stop switch 67 open and close the other three. (3) To secure full vibrato and steady tone, close stops 48 and 67 and leave stops 46 and 102 open. (4) To add the random effect to that of paragraph 3 close stop 102. (5) To secure a slightly higher pitch that will produce a celeste effect with other instruments played simultaneously, with steady tone from the organ, open stops 46 and 48 and the condition of the other stops is immaterial. (6) To secure a random celeste pitch close stops 48 and 102 and leave stops 46 and 67 open. (7) To secure a half size steady tone vibrato for sombre music in church, close stops 46 and 48 and 67, leaving stop 102 open. (8) To add the random effect to that of paragraph 7 close stop 102.

Others may readily adapt to the invention for use under various conditions of service by employing one or more of the novel features disclosed or equivalents thereof.

As at present advised, with respect to the apparent scope of our invention, we desire to claim the following subject matter:

1. In an electronic musical instrument of the type comprising a plurality of oscillators, one of each semi-tone of the musical scale; vibrato means comprising two pitch changers for altering the frequency of each oscillator; means for altering the operativeness of said two pitch changers to secure a maximum pitch, or a minimum pitch, or a normal, intermediate pitch; said maximum and minimum pitches differing from said intermediate pitch by the same amount, but in opposite directions; automatic timing means for keeping the pitch maximum or minimum and for changing from maximum to minimum at tremulant frequency; player-controlled stop means for rendering said automatic timing means operative, or for rendering said automatic, timed means inoperative, and adjusting said pitch changers to secure normal, intermediate pitch; and player-controlled means for normal control of the delivery of signal from each individual oscillator, regardless of the condition of said pitch changers.

2. A combination according to claim 1 in which each

5

pitch changer is a component of the oscillator per se, and said player-controlled stop means renders said component operative or inoperative to affect the frequency of the complete oscillator.

3. A combination according to claim 2 in which both pitch changers operate to lower the frequency of oscillation, and said intermediate pitch is secured with one pitch changer continuously operative and the other continuously inoperative.

4. A combination according to claim 3 in which said automatic timing means alters the condition of said pitch changers from both operative to both inoperative, and back again.

5. In an electronic musical instrument, in combination; an oscillator having a tuned circuit comprising two cooperating components affecting the frequency of the circuit; one of said components being an inductor and the other a capacitor; first and second ancillary circuits each adapted to affect the pitch of said tuned circuit; each of said first and second ancillary circuits comprising a capacitor and a voltage-sensitive impedance in series with said capacitor; said first and second ancillary circuits producing frequency changes of equal amount and of vibrato magnitude; whereby said oscillator can deliver signal of three frequencies, with the intermediate frequency midway between the other two frequencies; a first direct current control circuit for causing said oscillator to deliver constant frequency; a second direct current control circuit; an automatic means for varying the operativeness of said second direct current control circuit to produce first maximum frequency and then minimum frequency in a cycle of tremulant frequency.

6. A combination according to claim 5 in which both ancillary circuits function to lower the frequency; said direct current control circuit for constant frequency maintaining one of said ancillary circuits continuously operative; said direct current control circuit for vibrato maintaining both ancillary circuits operative or both inoperative in a timed cycle of tremulant frequency.

7. A combination according to claim 6 in which said direct current control circuit for constant frequency operation comprises one voltage-sensitive impedance, the associated series capacitor and a bypass resistor in shunt with said capacitor, and said inductor coil; and the direct circuit control circuit for vibrato comprises the

6

same voltage-sensitive impedance and associated series capacitor and bypass resistor, and the other voltage-sensitive impedance, associated series capacitor and a bypass resistor in shunt with said capacitor; whereby said direct current control circuit for vibrato does not impress a change in voltage across said inductor.

8. A combination according to claim 7 in which energy storage delay circuit means is provided to delay the inception of direct current flow in said inductor when the player-controlled stop means is shifted to the circuit for constant frequency, and to delay the decay of direct current flow in said inductor when the player-controlled stop means is shifted to the circuit for vibrato.

9. A combination according to claim 8 in which said delay circuit means comprises a first delay circuit for delaying the inception of direct current flow, and a different delay circuit for delaying decay of flow.

10. A combination according to claim 9 in which said two delay circuits have a common capacitor, but different resistors.

11. A combination according to claim 10 in which said delay circuit for delaying inception has a higher valued resistor than the circuit for delaying decay.

12. In an electronic musical instrument, in combination: an oscillator having a tuned circuit comprising an inductor and a primary capacitor; first and second detuning circuits each having one end connected to a common point on said tuned circuit; each detuning circuit having a detuning capacitor and a voltage-sensitive impedance in series; and a circuit connecting the other ends of said detuning circuits; and means in said last-mentioned circuits for passing current through both detuning circuits to render them both conductive or both non-conductive.

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