ELECTRONIC ORGAN WITH DIVERSE FILTERS AND ANTI-PLOP BIAS ARRANGEMENT

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16 Claims

ABSTRACT OF THE DISCLOSURE

A portable or "Combo" electronic organ having square wave tone generators and direct contact key switching wherein keying noise or "plop" is eliminated by charging the capacitors in the circuit to approximately half their normal operating charge, and also by the use of wave-shaping filters.

In recent years, small groups of musicians playing electric guitars, drums, and often a portable electronic organ, have become quite popular. Such are often known as Combos, and the portable electronic organs used have become known as Combo organs. The requirements for such Combo organs are somewhat different from those of normal electronic organs. For example, conventional electronic organs include loudspeaker systems and power amplifiers. The acoustic requirements of an enclosure for the loudspeakers has dictated a certain minimum size for such organs. Such minimum size has not been an inhibiting factor, since it is common practice to install such organs in a given location, and to leave them there. However, the situation is quite the converse with the so-called Combo organs. These must be readily portable so that they can be carried from one location to another just like an electric guitar. Acoustic requirements do not dictate size, since such organs are conventionally plugged into a guitar amplifier and loudspeaker system. Furthermore, since such Combo organs are generally used by the younger set, and since they are looked on as being a rather short-term investment as compared to the long-term investment in a conventional electronic organ, it is essential that price be kept at a minimum commensurate with quality and other requirements.

It is known in the art that an excellent electric wave for use as a tone source in an electronic organ is a square wave. This is because such a wave has not only a fundamental frequency, but a large number of harmonics, whereby such waves can be filtered, added, or otherwise treated for shaping to the desired characteristics. Furthermore, it is known that the cheapest way of switching such a wave (or any other wave corresponding to a musical tone) is by the use of a simple single pole or multi-pole switch. Such switching in the past has been prone to accompany by noise known colloquially as "key-plop."

In accordance with the present invention, I have found that by maintaining a square wave of one polarity only, and by charging capacitors in a circuit to which the square wave is switched to about half the maximum potential of the square wave, key-plop is substantially eliminated. I have found that by coupling the foregoing with proper wave-shaping filters, the key-plop can be reduced to the vanishing point.

Accordingly, it is an object of the present invention to eliminate key-plop from electronic organs.

More specifically, it is an object of the present invention to eliminate key-plop from electronic organs by switching a square wave of constant polarity into a circuit having the capacitors therein charged to substantially half the maximum potential to which they would be charged by the square wave.

Yet another object of the present invention is to provide an electronic organ wherein key-plop is eliminated as set forth in the last preceding object, and further in combination with wave-shaping filters.

A more specific object of the present invention is to eliminate key-plop from electronic organs by switching a square wave of constant polarity wherein the square waves corresponding to the plurality of tone generators are respectively switched by movable key switches selectively engageable with bus bar segments, wherein each bus bar segment has a D.C. voltage connected thereto having a potential of about half that of the maximum potential of the square wave.

Other and further objects and advantages of the present invention will be apparent when considered in accordance with the accompanying drawings wherein:

FIG. 1 is a perspective view of a Combo organ constructed in accordance with the principles of the present invention, in combination with a guitar amplifier and loudspeaker system;

FIG. 2 is a block diagram illustrating the electrical circuitry of the invention;

FIG. 3 is a schematic wiring diagram showing the accompanying filters for the 8-foot stop of the organ;

FIG. 4 is a schematic wiring diagram showing the switching of the mixture stop of the present organ;

FIG. 5 is a combined block and schematic wiring diagram illustrating further aspects of the present invention;

FIG. 6 is a diagram illustrating the square wave from a tone generator in the present invention;

FIG. 7 is a simplified schematic representation of a low frequency roll-off filter incorporated in the present invention and used in removing key-plop; and

FIG. 8 is a simplified schematic representation of the high frequency roll-off filter of the present invention.

Turning now to the drawings in greater particularity, and first to FIG. 1, there will be seen a portable or Combo organ 10 constructed in accordance with the principles of the present invention. The organ comprises a case 12 of generally rectangular configuration, being of rather small height, and having a keyboard 14 at the front thereof. Suitable operating controls 16 for switching in various tones, as will be brought out hereinafter, are provided at the left of the keyboard. The case is supported on a pedestal 18 to which it is detachably connected. A foot pedal 20 (sometimes called an expression pedal or a swell pedal) is provided for controlling the overall volume of the organ, and is connected by means of a wire or cable 22 to electronic circuits within the case 12.

The output of the organ 10 is connected by means of a lead wire 24 to an amplifier 26, such as a guitar amplifier, and the output of the amplifier 26 is connected to a loudspeaker system identified generally by the numeral 28, and including any suitable loudspeakers, such as, for example, loudspeakers 30 indicated in broken lines.

The over-all electrical aspects of the organ 10 are illustrated in block diagram in FIG. 2. The organ includes a plurality of tone generators 32, and while these may be of any suitable type, they do provide a square wave which is always of one polarity. In the present instance, the square wave is always positive. As is known in the art, one very satisfactory way to provide tone generators in an electronic organ is to provide one octave of stable oscillators, and to have each of these stable or master oscillators synchronize or control a string of divider oscillators to provide the remaining tone generators at
sub-octave intervals. Flip-flop circuits can be used to produce a very nice square wave, and this is the preferred type of tone generator in the present invention.

The tone generators 32 are connected to key switches 34, and as will be set forth in some detail hereinafter, the key switches are connected in parallel to complex filters 36 and to flute filters 38. As will be understood, string, brass, and reed tones are a great deal more complex in harmonic structure than are flute tones. The outputs from the filters 36 and 38 are connected to an amplifier 40 which is in the nature of a voltage amplifier, and this amplifier is connected to a power amplifier which may be the amplifier 26 previously referred to, the latter being connected to loudspeakers 30 as noted heretofore.

The key switches and filters for the 8-foot flute stop are shown in Fig. 3. In an illustrative embodiment of the organ constructed in accordance with the principles of this invention, there are forty-nine keys 14, and a corresponding forty-nine tone generators 32. Nine of these generators are represented schematically at the top left corner of Fig. 3, and each is connected through an isolation resistor 42 to a movable contact 44 of a corresponding one of the key switches 34. Each key switch contact 44 is spaced from a bus bar 46, and is respectively movable into engagement therewith upon depression of a key. As has been noted, the bus bar or rod 46 is long enough to be engaged by any one of the nine key switches identified at 44. There is a total of six bus bars, and these bus bars are identified at 46-1 through 46-6. Nine switch contacts are engageable with bus bar or rod 46-1, as heretofore noted. There are eight switch contacts engageable with each subsequent bus rod, namely 46-2 through 46-6, and the generators associated therewith are indicated immediately adjacent the bus rods. For simplicity of illustration the key switch contacts associated with the bus rods 46-2 through 46-6 have been omitted, but it will be understood that they are there. Similarly, the bus rods have been somewhat shortened. The generators selectively connectable to each bus rod are indicated immediately adjacent thereto.

Each bus rod is shunted to ground by a capacitor 48. Each bus rod further has connected thereto a capacitor 50 and a resistor 52 in series therewith. The series connected capacitors 50 and resistors 52 from the first two bus rods, namely rods 46-1 and 46-2, are connected to a junction 54a, and this junction is shunted to ground by the parallel capacitor 56 and resistor 58. The junction 54b further is connected through a capacitor 60 and series resistor 62 to a collector line 64.

Similarly, the series capacitor and resistor from each of the rods 46-3 and 46-4 is connected to a junction 54b, similarly shunted to ground and connected to the series capacitor and resistor to the collector line 64. In like fashion, the series capacitor and resistor from each of the rods 46-5 and 46-6 is connected to a junction 54c, which is likewise shunted to ground, and connected through a series capacitor and resistor to the collector line 64.

The collector line 64 is connected to the base of an n-p-n transistor 66. The emitter is grounded, and the collector is connected through a resistor 68 to a positive voltage source, indicated as +16 volts. A voltage divider, comprising resistors 70 and 72, is connected from the base, and the junction thereof is connected to the base to provide bias for the base.

The output of the transistor is taken from the collector through a capacitor 74 and a series resistor 76 to an output line 78 leading to the amplifier 40. The output line is shunted to ground by a resistor 80, and a movable switch is connected to the output line 78. The movable switch contact 82 is selectively engageable with a fixed switch contact 84 connected to ground, for shunting the output, to a full-on fixed contact 86 connected to the line 78 for producing full output, or to 82 either of two fixed contacts 88 and 90 respectively connected to ground through resistors 92 and 94 of different values. The position of the movable contact 82 is determined by one of the controls 16 on the organ.

A second output is taken from each rod, and, for example, there is a capacitor 96 connected to the rod 46-1 leading to a resistor 97 which is connected to a collector line 98. A similar series capacitor-resistor connection leads to the collector line 98 from each of the subsequent rods 46-2 through 46-6. The collector line leads to a junction-voltage amplifier which is connected to the input of an amplifier stage 102. The foregoing circuitry comprises an 8-foot flute filter, and there is also an input from the 4-foot flute filter to the junction 100, as indicated in Fig. 3. The input from the 4-foot flute filter is at one-half the level or amplitude of the input from the 8-foot flute filter, whereby a step wave is produced which approaches a sawtooth for subsequently producing the reed, string, and brass tones.

The amplifier stage 102 comprises an n-p-n transistor 104, the emitter of which is grounded. The collector is connected through a resistor 106 to a positive voltage source indicated as +16 volts. A voltage divider comprising resistors 108 and 110 is connected from the collector to ground, and the junction of these two resistors is connected to the base of the transistor 104, as is a connection from the junction 100. The output of the amplifier stage 102 is taken from the collector of the transistor through a capacitor 112 to an output line 114 which leads to the respective string, brass, and reed filters, as will be noted hereinafter.

One further connection of critical importance remains to be considered in Fig. 3. Each bus rod has connected thereto a resistor 116 from a voltage or distribution line 118 which is supplied by a small positive potential, indicated as +0.85 volt. This is to reduce the key-plop as will be set forth in some detail hereinafter.

Attention should now be directed to Fig. 6 wherein there is shown the waveform 120 as applied by any of the various generators to a respective bus rod 46. The waveform is a square wave, and it will be noted that the wave is always of positive potential, the base line or trough thereof being at zero volts, and the peak amplitude being a positive 1.5 volts. The broken line indication of .85 volt in Fig. 6 is representative of the voltage applied to each bus rod from the voltage distribution line 118 through the respective resistors 116. It will be observed that this is just slightly over half the maximum potential of the square wave.

I have discovered that most of the key-plop is caused by charging of the capacitors connected to the various bus rods, primarily the capacitors 48, 50, and 56, and possibly also including capacitor 60. With application of the positive potential at about the average D.C. potential of the square wave, there is no D.C. shift when a key switch is closed, and hence substantially no key-plop. If a square wave were used that varied between two fixed D.C. voltages other than zero (either of like or opposite sign), the biasing potential applied to the bus bar would be the average of these two voltages to produce the same results.

Key-plop is further reduced, or substantially eliminated by a filtering action as will be seen with reference to Fig. 7. Fig. 7 comprises a simplified showing of the combination of capacitor 59 shunted to ground by resistor 58 and in series with capacitor 60 shunted to ground by resistor 72. As will be appreciated, the series resistance of resistors 52 and 62 has been omitted from this simplified diagram. The circuit will be recognized as being a low frequency roll-off filter. The key-plop is essentially a D.C. or low frequency-true-for low frequency roll-off filter discriminates against it. The combination of the prebiasing of the capacitors and the low frequency roll-off filter substantially eliminates key-plop, which is indiscernible in the output of the organ.
As is known, a flute tone is essentially a fundamental only, with little or no harmonics. Thus, it is desired to filter out substantially all of the harmonics as applied to each bus rod 46 before the output appears on the line 78. This is illustrated schematically in FIG. 8, which is a simplified representation of the entire line 78, previously noted, to three filters, respectively a string filter 172, a brass filter 174, and a reed filter 176, all leading to an output line 178. As will be appreciated, each of the string, brass, and reed filters incorporates a switch to turn it on or off.

In addition to the flute filter output at 98 to the junction 100, it has been noted previously that the flute filter has an output line 78, and this leads to an intensity selector switch 180, and specifically a movable switch arm 182 thereof. The switch arm 182 is selectively engageable with any of four fixed switch contacts 184, 186, 188, and 190. The switch contact 184 is connected to ground to shunt the output of the 8-foot flute tones to ground, and thereby to produce no 8-foot flute output. The switch contact 186 is grounded through a relatively low value resistor 192 to shunt the 8-foot flute output to a lesser extent, while the contact 188 is grounded through a resistor 194 of higher value to shunt the 8-foot flute output to a lesser extent. The contact 190 is connected direct to the line 196 which forms a continuation of the line 78, and which further leads to the resistor 122 previously mentioned in connection with the high frequency roll-off filter of FIG. 8. This resistor 122 is connected to a junction 198.

The 16-foot flute filter is connected to a switch arrangement and resistor identical to that just disclosed, and the same is true also of the 4-foot flute filter 166 and of the mixture filter 168, all being connected to the junction 198.

The mixture control 200 that aids in determining the purity of the flute tones. This control includes the series resistor 126 and shunting capacitors 124 and 128 previously mentioned in connection with FIG. 8. The capacitors are respectively connected to movable switch arms 202 and 204 which are ganged together for operation by one of the controls 16. The various movable switch arms 182 discussed just above are likewise operated by respective ones of the controls 16. The movable switch arms 202, 204 are respectively and selectively engageable with like fixed contacts 206, 208, 210, and 212. Each switch contact 206 is connected direct to ground for providing the maximum effect of the respective capacitor 124 or 128, and hence the maximum high frequency roll-off. Each fixed contact 208 is connected to ground through a resistor 214 of relatively low value, while each fixed contact 210 is connected through a resistor 216 of relatively higher value, progressively to decrease the effect of the respective capacitor 124, 128. Finally, each fixed contact 212 is an open contact, not being connected to anything, whereby to render the respective capacitors 124 and 128 completely ineffective in producing any high frequency roll-off. As will be appreciated, as the high frequency roll-off is diminished, small amounts of harmonic will be present, and this will be almost exclusively odd harmonic due to the square wave input. As is recognized, a flute with a degree of such overtones comprises the tibia stop of an organ.

From the roll-off filter control 200, connection is made to a shunting resistor 214 and a series resistor 216 to a junction 218. The output line 178 from the string, brass, and reed filters is connected to this junction. From this junction, connection is made to a transistor amplifier stage 220 of generally conventional construction, and having a potentiometer 222 across the output. The slider on the potentiometer includes the transistor amplifiers and related parts. The 4-foot flute filter as connected to the junction 100 presents a signal at one-half the amplitude of that presented by the 8-foot flute filter 164, and also at twice the frequency. The composite or added wave is of a stairs-step variety closely approximating a sawtooth, and, as will be appreciated, a sawtooth wave has a complete spectrum of harmonics as compared with a square wave which has mostly only odd harmonics. The amplifier is connected to the output line 114, previously noted, to three filters, respectively a string
of approximately the average potential or value of the square wave to the pick-up or collector from the switches, whereby there is no D.C. shift when a key switch is closed. The elimination of key-flop is furthered by the incorporation of a low-frequency roll-off filter, while a high frequency roll-off filter of adjustable characteristics converts the square waves into flute tones.

The specific example of the invention as herein set forth is for illustrative purposes only. Various changes in structure will no doubt occur to those skilled in the art, and will be understood as forming a part of the present invention insofar as they fall within the spirit and scope of the appended claims.

The invention is claimed as follows:

1. An electronic organ comprising means for providing a plurality of electrical oscillations respectively corresponding to musical tones, said oscillations being predominantly of one polarity, a plurality of keys and a plurality of key switch means respectively operated thereby and respectively connected to said oscillation providing means, output means to which said key switch means are connected and including at least one capacitor tending to charge with said one polarity upon closure of said key switch means, and a potential source of said one polarity connected to said output means to maintain said capacitor at least partially charged with said predetermined polarity.

2. An electronic organ as set forth in claim 1 wherein the electronic oscillations comprise square waves, and wherein the output means includes a filter of which said capacitor forms a part.

3. An electronic organ as set forth in claim 1 wherein the electronic oscillations have a predetermined average potential, and wherein said potential source charges said capacitor substantially to said predetermined potential.

4. An electronic organ as set forth in claim 3 wherein the electronic oscillations comprise square waves of one polarity only.

5. An electronic organ as set forth in claim 2 wherein said filter comprises a low frequency roll-off filter.

6. An electronic organ as set forth in claim 2 wherein said filter comprises a high frequency roll-off filter.

7. An electronic organ as set forth in claim 5, and further including a high frequency roll-off filter.

8. An electronic organ comprising means for providing a plurality of electrical oscillations respectively corresponding to musical tones, a plurality of keys and a plurality of key switch means respectively operated thereby and respectively connected to said oscillation providing means, a predetermined number of collectors less in number than said plurality of key switch means, each of said collectors having connected thereto a predetermined subplurality of said key switches, a predetermined number of filters each connected to one of said collectors, means combining the outputs of said filters in groups, additional filter means connected to said groups, and output means connected to said additional filter means.

9. An electronic organ as set forth in claim 8 wherein said filters and said filter means include a low frequency roll-off filter.

10. An electronic organ as set forth in claim 8 wherein said electric oscillations comprise square waves, and wherein said filters and filter means include a high frequency roll-off filter.

11. An electronic organ as set forth in claim 10 wherein said filters and filter means further include a low frequency roll-off filter.

12. An electronic organ as set forth in claim 11 and further including means for adjusting the high frequency roll-off.

13. An electronic organ as set forth in claim 8 wherein said oscillations are of predominantly one polarity, and wherein said filters and filter means include capacitors, and further including a potential source of said one polarity connected to said collectors to maintain said capacitors at least partially charged with said predetermined polarity.

14. An electronic organ comprising means for providing a plurality of square wave electric oscillations respectively corresponding to musical tones, a plurality of keys and a plurality of key switch means respectively operated thereby and respectively connected to said oscillation providing means, each key switch means having a plurality of contacts corresponding to different organ footages and respectively connected to oscillation providing means of such footages, collector means connected to said key switch means according to said footages, means for connecting certain of said output means in predetermined combination to add certain footages to produce a square wave approximating a sawtooth wave, filter means connected to said footage connecting means to produce complex organ voices, filter means connected to said collector means for producing the footage voices of an organ, and means for selectively connecting said footage filters and said complex voice filters for combining the footage and complex voices.

15. An electronic organ as set forth in claim 14 wherein the footage filters include high frequency roll-off means, and means for simultaneously adjusting the high frequency roll-off characteristics of said high-frequency roll-off filters.

16. An electronic organ as set forth in claim 14 wherein the square waves are predominantly of one polarity, and further including a potential source of said one polarity connected to said collector means, said filters including capacitors, and said potential source maintaining said capacitors at least partially charged with said predetermined polarity.

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WARREN E. RAY, Primary Examiner
U.S. Cl. X.R.
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,526,701 Dated September 1, 1970
Inventor(s) William V. Machanian

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 1, line 23, after "such" insert --groups--;
Col. 5, line 16, change "rol-off" to --roll-off--;
Col. 7, line 28, change "electronic" to --electrical--;
Col. 7, line 32, change "electronic" to --electrical--;
Col. 7, line 34, after "predetermined" insert --average--;
Col. 7, line 36, change "electronic" to --electrical--;
Col. 7, line 52, change "switches" to --switch means--; and
Column 8, line 1, change "electric" to --electrical--;

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