Sept. 1, 1970 W. V. MACHANIAN 3,526,701

ELECTRONIC ORGAN WITH DIVERSE FILTERS AND ANTI-PLOP BIAS ARRANGEMENT

Filed April 24, 1968 3 Sheets-Sheet 1

Fig. 1.

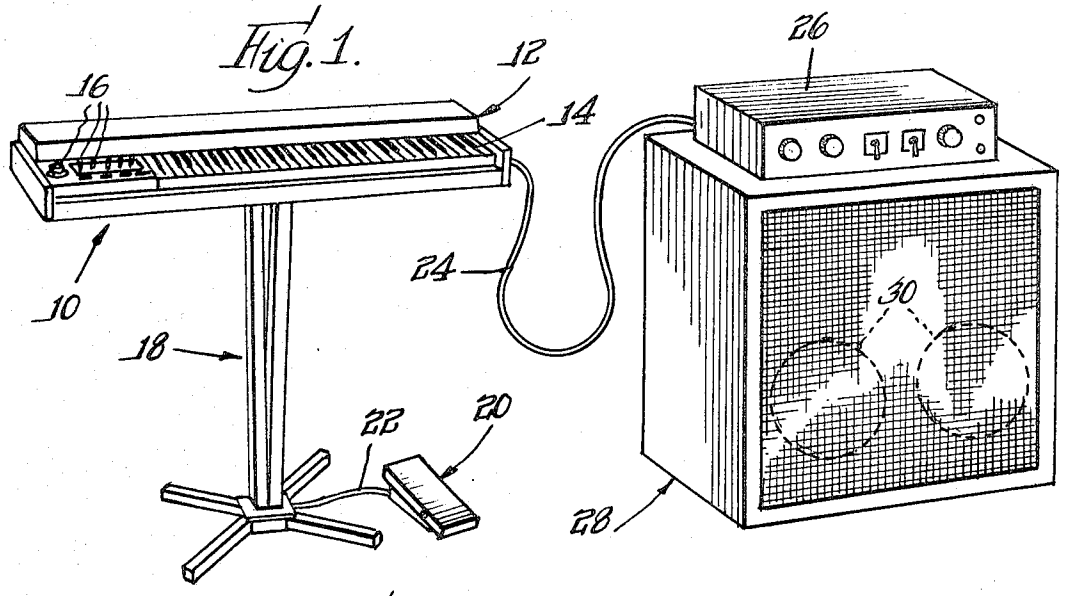


Fig. 2.

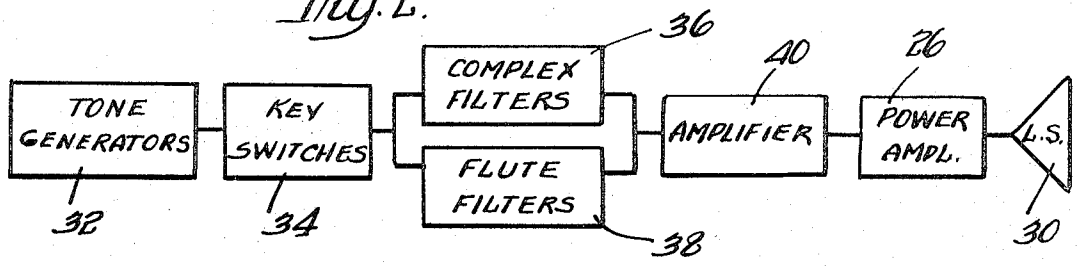


Fig. 6.

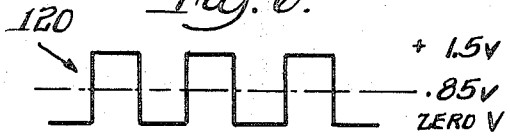


Fig. 7.

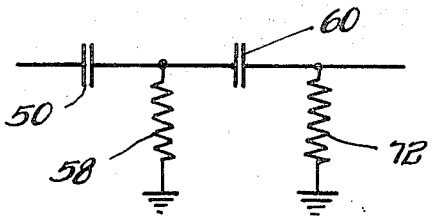
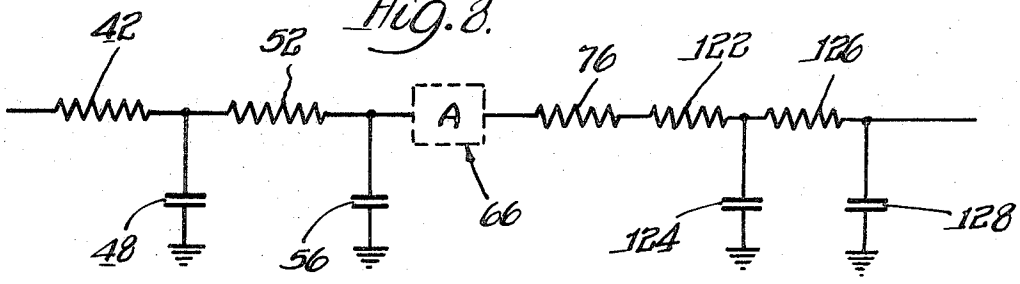


Fig. 8.



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ELECTRONIC ORGAN WITH DIVERSE FILTERS AND ANTI-PLOP BIAS ARRANGEMENT

Filed April 24, 1968 3 Sheets-Sheet 2

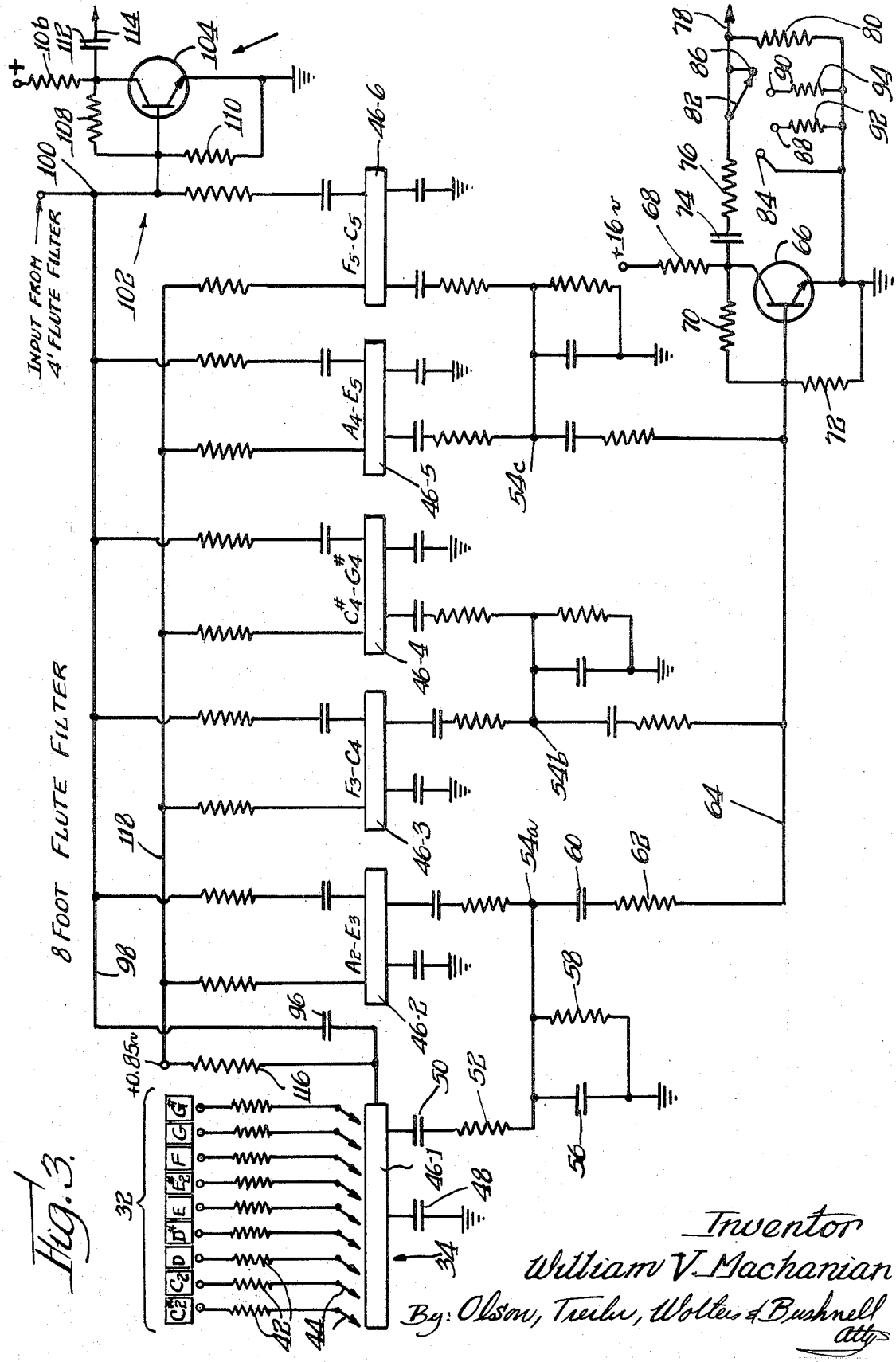


Fig. 3.

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ELECTRONIC ORGAN WITH DIVERSE FILTERS AND ANTI-PLOP BIAS ARRANGEMENT

Filed April 24, 1968 3 Sheets-Sheet 3

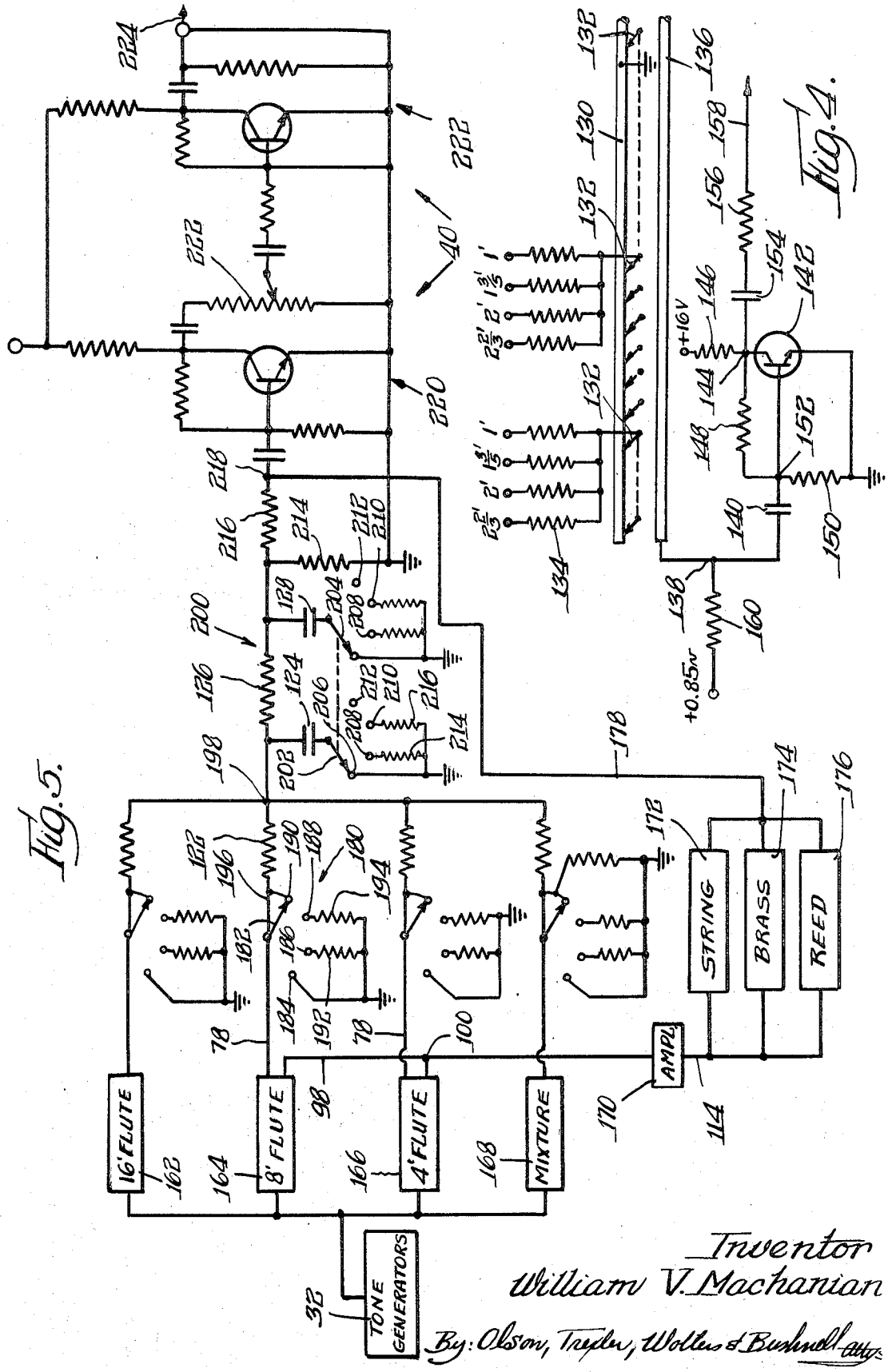


Fig. 4.

Fig. 5.

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Patented Sept. 1, 1970

3,526,701

ELECTRONIC ORGAN WITH DIVERSE FILTERS AND ANTI-PLOP BIAS ARRANGEMENT

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Int. Cl. G10h 1/02
U.S. Cl. 84—1.11 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 condensers 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 accompaniment 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 switching and 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 isolating 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 foreshortened. 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 **54***a*, and this junction is shunted to ground by a parallel capacitor **56** and resistor **58**. The junction **54***a* 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 **54***b*, similarly shunted to ground and connected to 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 **54***c*, 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 collector to ground, 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 contact **82** 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 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 **100** 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 with 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 **50** 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 transient, and this 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 some of the circuit elements heretofore disclosed, and others subsequently to be disclosed. Thus, resistor **42** is in a series path, and is shunted by capacitor **48**. Likewise, resistor **52** is in a series path shunted by capacitor **56**. Connection is then made to the amplifier including the transistor **66**, and from here, connection is made to the series resistor **76** to another series resistor **122**, shunted by a capacitor **124**, and leading to yet another series resistor **126** and a shunting capacitor **128**. The circuit of FIG. 8 represents a high frequency rol-off filter, and the values of the first resistors **42**, **52** and capacitors **48**, **56** are different for each bus rod or pair of bus rods according to the frequencies applied thereto, whereby to eliminate most of the harmonics and leave a rather pure flute tone.

Turning now to FIG. 4, the mixture amplifier and switching therefor will be seen to include a grounded bus bar **130** extending the entire length of the keyboard. One movable switch or key contract **132** for each key of the keyboard (a total of 49) normally engages the grounded bus bar **130**. Each switch has connected thereto four generators, respectively corresponding to the 2⅔ foot, 2 foot, 1⅗ foot, and 1 foot stops of that note, each generator being connected through an isolating resistor **134**. Upon depression of a key, the corresponding contact **132** is moved from the grounded bus bar **130** to a collector bus rod **136**. The collector bus **136** also extends the entire length of the keyboard, and is engageable by each of the forty-nine movable switch contacts.

The collector bus is connected to a junction **138** which is coupled through a capacitor **140** to the base of an n-p-n transistor **142**. The emitter of this transistor is grounded, and the collector is connected to a junction **144** which leads through a resistor **146** to a positive voltage source indicated as +16 volts. A voltage divider is connected from the junction **144** to ground, and comprises series connected resistors **148** and **150**, the junction **152** therebetween being connected to the base to bias the latter. The output from the amplifier stage including the transistor **142** is taken from the junction **144** through a capacitor **154** and a series connected resistor **156** to an output line **158**.

Anti-plop bias is applied to the collector bus **136** through a resistor **160** connected from the +0.85 volt supply to the junction **138**. The anti-plop bias works the same here as on the 8-foot flute filter stop, and extended discussion therefore is not warranted at this point.

Attention now should be directed to FIG. 5, wherein the tone generators are represented generally at **32**, and are shown as connected to a 16-foot flute filter **162**, an 8-foot flute filter **164**, a 4-foot flute filter **166**, and a mixture filter **168**. It will be appreciated that the 8-foot flute filter **164** comprises all of that which is in FIG. 3 except for the extreme upper right hand corner thereof, while the mixture filter **168** includes all of FIG. 4. As has been noted heretofore, and with reference to the upper right hand corner of FIG. 3 just noted, the 8-foot flute filter is connected to the junction **100** which is also connected to the 4-foot flute filter. This junction is in turn connected to an amplifier **170** which includes the transistor **104** 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 stair-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

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 junction **198** is connected to a high frequency roll-off 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 to ground 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 is controlled by one of the controls **16**, and connection is made from it to another transistor amplifier stage **222**, the two stages together constituting the amplifier **40** previously noted. The output from the amplifier **40** is indicated at **224** in FIG. 5, and this goes to the power amplifier **26** previously mentioned in connection with FIG. 2.

It will now be seen that I have successfully eliminated key-flop from an electronic organ by utilizing a square wave (varying between zero and a positive value in the illustrative embodiment), and by connecting a potential

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 respectviely 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.

84—1.19

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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(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

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Commissioner of Patents