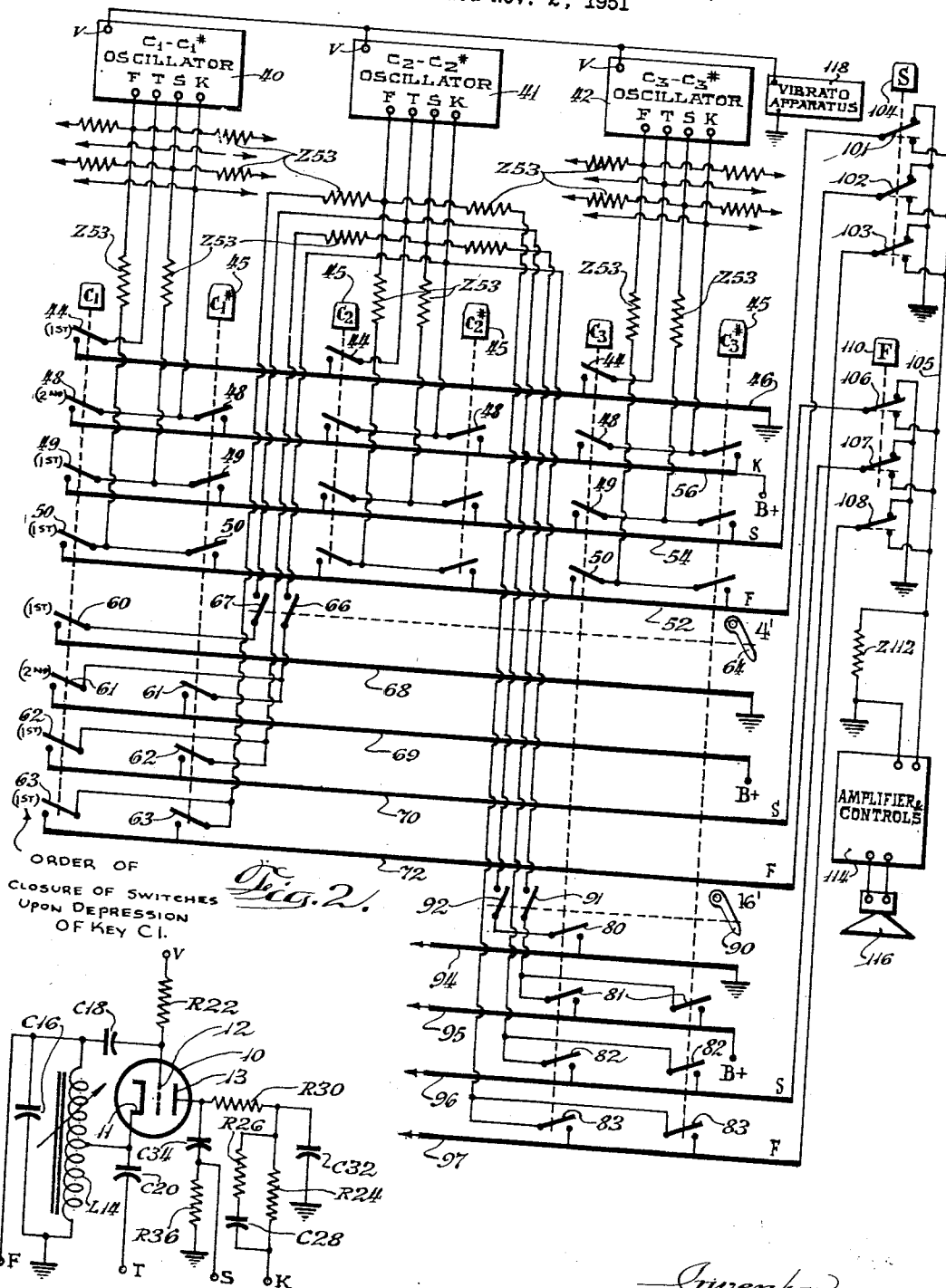


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ELECTRICAL MUSICAL INSTRUMENT

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ELECTRICAL MUSICAL INSTRUMENT

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My invention relates generally to an electrical musical instrument and more particularly to improved electronic organs in which the tone signals are generated by oscillators which are normally not oscillating.

In some electronic organs utilizing vacuum tube oscillators as the tone signal generators the signal output circuit of the oscillator is permanently coupled to the output system of the instrument. Thus, whenever a signal from an oscillator is required, a key operated switch completes a circuit to impress an operating potential upon one of the electrodes of the vacuum tube, usually through a resistance-capacitance delay network so as to cause the oscillator to commence oscillating with gradually increasing amplitude and similarly to cause the cessation of oscillation to occur with gradual decay. This arrangement whereby a direct current potential is applied to one of the electrodes of the vacuum tube is advantageous in that the oscillator is not operating except when a signal therefrom is called for by depression of a key. The vacuum tube and its associated components will therefore have an extended useful life.

However, this type of electronic organ has a disadvantage in common with the unified pipe organ in that, if octave couplers are used, depression of two keys an octave apart will not produce additive results as would be expected after hearing each of the tones sound separately.

For example, if the organ builder were required to supply only one voice, it would be a simple matter to regulate the tone of each key to be of suitable loudness and quality. Under these conditions, the movements of the tenor and alto voices in contrapuntal music would be clear and easily distinguished. Now suppose a second voice in the form of an octave is wanted. One good plan, of course, would be to provide another rank of pipes one octave higher in pitch than the first. This being somewhat expensive, the organ builder is faced with the temptation merely to install a relatively inexpensive octave coupler. But if two keys, separated by the interval of an octave, are played at the same time, an unexpected tone is heard. If one plays the lower key he finds that the key one octave higher in pitch sounds weak because it has no unison component. Unification tends to spoil the ensemble of the organ because the inner voices of contrapuntal music cannot be clearly distinguished. If, on the other hand, all the voices add in proper proportions regardless of the interval played, the

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organ is said to be "straight." It then becomes a vastly superior instrument in which one key does not "rob" anything from the tones of any other key of the instrument.

Other electric organs have been made in which this unification effect has been substantially avoided by the utilization of a decoupling impedance in such manner that when a tone signal source was required to supply the unison component for one note and at the same time supply an octave coupler component for another note, the output of the generator was held at a relatively constant value and additive results were obtained across a signal impedance having a value low compared to the coupling impedance, thereby to produce additive or "straight" effects. An organ of this type is disclosed in the patent to Laurens Hammond No. 1,956,350 and has been in extensive use. In instruments of this type there is difficulty in avoiding transients due to the closing and opening of the signal circuits upon depression and release of the keys, and rather elaborate precautions must be taken even if variable impedance keying elements are employed.

It is therefore a primary object of the invention to provide an improved electronic musical instrument in which electronic oscillators are employed as the tone signal generators, in which signals of different tone quality may be derived, and in which octave couplers are employed without introducing the disadvantage found in so-called unified organs and at the same time to provide the smooth and gradual attack and decay characteristics of a direct current keyed oscillator having a suitable time delay mesh for controlling attack and decay.

A further object is to provide an instrument of the character described in the preceding paragraph in which signals of different tone qualities may be simultaneously produced in both the unison and octave when the octave coupler is employed, thereby making it possible to divide the manual of the single manual organ and employ different quality registrations on each section.

In some types of electronic organs the tone signals are generated by oscillators and since each of these oscillators includes a vacuum tube, the possibility of failure of the instrument to play a note called for by the depression of a key is increased if all the oscillators are operating during the time that the instrument is being used.

In the playing of most selections the musician usually will not have more than six keys depressed at one time. Thus, if the instrument con-

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tains sixty oscillators, only approximately one-tenth of the oscillators will be operating at any one time and the useful life of the tubes will therefore be extended considerably. Of course factors other than the application of plate voltage to a tube which may cause it to age, but the life of most vacuum tubes may be gaged fairly well by the length of time plate current is flowing in the plate circuit tube. Furthermore, the cost of an instrument of this type is determined largely by the number of oscillators employed. In the instrument presently to be described each oscillator serves to supply the tone signals for two adjacent semitone intervals because it is infrequent that adjacent semitones would be played in most musical selections. Thus one oscillator may very well serve to supply the signals for two adjacent semitones, thereby reducing by substantially one-half the number of tubes and oscillator components required.

It is therefore a further object of my invention to provide an improved electrical musical instrument in which the number of oscillators required is reduced by substantially one-half, in which plate current is supplied to the oscillator tubes only while their output is being used, and by which true octave coupler effects may be obtained.

Other objects will appear from the following description, reference being had to the accompanying drawings in which:

Figure 1 is a schematic wiring diagram of a form of oscillator suitable for use in an instrument; and

Figure 2 is a schematic wiring and block diagram of a representative portion of the instrument.

The oscillator shown in Fig. 1 is of the Hartley type, modified as to specific circuit arrangement and values of components, and is more fully described and claimed in my copending application Serial No. 224,276, filed May 3, 1951, now abandoned. The oscillator comprises a vacuum triode 10 having a cathode 11, control grid 12, and anode 13. The cathode is connected to a tap on an inductance L14 which has a tuning capacitor C16 in parallel therewith, one terminal of the L14 and C16 mesh being connected to ground while the other terminal of this mesh is connected to a terminal F and connected to grid 12 through a capacitor C18. The cathode is also connected to a terminal T through a tuning capacitor C20. The grid 12 is connected to a source of vibrato pulses, indicated as a terminal V, through a resistor R22. Plate current is supplied through a keying terminal K which, as will appear hereinafter, is adapted to be connected by a key-operated switch to a B+ terminal of the power supply.

Terminal K is connected to the plate 13 through a mesh comprising a resistor R24 having in parallel therewith a second lower-value resistor R26 which is in series with a capacitor C28. The mesh R24—R26—C28 is connected to the plate 13 through an additional resistor R30 and the plate is connected to ground through a resistor R32 and an attack and decay capacitor C32. The signal appearing upon the plate 13 passes through a blocking capacitor C34 and is impressed across a coupling resistor R36, one end of which is grounded and the other end of which is connected to C34 as well as to a terminal S.

It will be understood that upon applying plate potential to the terminal K an initial surge of plate current will pass through capacitor C28 and relatively low value resistors R26 and R30 and

in addition the capacitor C32 will be rapidly charged. Thereafter the plate current is continuously supplied through R24 and R30 and capacitor C32 will become charged to its normal operating potential. Thus even though the voltage on the control grid 12 is negative, due to the fact that the plate current happens to start being supplied at the instant that the vibrato voltage is in the negative phase of its cycle, the oscillator will start promptly at the correct frequency. However, the rate of attack will be slowed by the time constants of the mesh R24—C32—R30, so that a smooth attack will result. Similarly, upon disconnection of the source of plate potential from the terminal K, the capacitor C32 will continue to supply plate current at a diminishing potential thus assuring a smooth decay of the tone.

The signal appearing between the terminal F and ground will be substantially a sine wave, corresponding to a tone of a flute-like character, whereas the signal appearing across R30 at the terminal S will be highly complex, representative of a tone quality of the string family.

In Fig. 2 there are illustrated as blocks 40, 41, and 42 three oscillators, each of which is of the circuitry shown in Fig. 1, except for minor changes in the values of some of the circuit components. The oscillator 40 is adapted to supply electrical tone signals of pitch corresponding to the notes C1 and C1#, it being understood that the capacitor C20 is of such value that when the terminal T is connected to ground the pitch of the oscillator will be reduced by a semitone interval. Oscillator 41 is adapted to provide tone signals of the pitch C2 and C2# while oscillator 42 is adapted to supply tone signals of the pitch C3 and C3#.

Each of the oscillators is provided with a tuning switch 44 which, upon depression of the lower of the two playing keys 45 with which the oscillator is associated, is adapted to connect the terminal T of its oscillator to a grounded bus bar 48. In addition, each of the keys operates switches 48, 49, and 50. Switches 44, 49, and 50 are arranged so as to close prior to the switch 48 whenever a key is depressed, and to open last upon release of the key. Each of the switches 50 is adapted to connect the F terminals of its associated oscillator to a bus bar 52 through a decoupling impedance Z53, to complete a circuit for conducting the flute signal to the output system of the instrument. The impedances Z53 are illustrated as resistors, but in some instances might be capacitors, or possibly inductance elements. If capacitors, they could be used also as keying switches in the manner shown in Curtis Reissue Patent No. 21,554. Switches 49 are adapted to make connections between the terminal S of the oscillator and a bus bar 54 through a decoupling impedance Z53, to complete circuits for the conduction of the string tone signal to the output system of the instrument. Until one of the switches 48 is closed the oscillator is not operating, so that when this last-to-close switch is closed plate current is supplied from the B+ bus bar 56 to the terminal K of the oscillator. As previously indicated, the oscillator will then commence oscillating with a smooth attack and will transmit flute signals to the bus bar 52 and string type signals to the bus bar 54.

In addition to operating the switches previously mentioned, the key C1 is illustrated as arranged to operate a switch 60 and keys C1 and C1# are each adapted to operate similar groups

of switches 61, 62, and 63. Upon operation of an octave coupler tablet 64, a coupler switch 66 connects one pole of each of the switches 61 to the K terminal of the oscillator for the notes C2 and C2#, and also, by closure of switch 67, connects the tuning switch 60 to the T terminal of oscillator 41. The switches 61, which make connections to a B+ bus bar 69, are closed after the other switches 60, 62, and 63 have been closed upon the depression of a key and open prior to the opening of these other switches. The switch 60, when closed, completes a circuit from the T terminal of oscillator 41 to a grounded bus bar 68 to tune the oscillator 41 to the pitch of C2. Closure of either of the switches 62 connects the terminal S of oscillator 41 to a bus bar 70 through a decoupling impedance Z53, and similarly, closure of either of the switches 63 connects the F terminal of oscillator 41 to a bus bar 72 through another decoupling impedance Z53.

Thus if the 4 ft. coupler tablet 64 is operated and one of the keys, for example C1, depressed, closure of its switches 44 and 60 will first tune the oscillators 40 and 41 to the pitch of C1 and C2 respectively. Closure of the switches 49 and 62 will condition circuits for supplying the string signals from oscillators 40 and 41 to the output. Closure of switches 50 and 63 will condition the circuits for transmission of the flute tone signals to the output. Thereafter, closure of the switches 48 and 61 will supply plate current to oscillators 40 and 41 respectively, causing these oscillators to commence oscillating and to supply flute and string quality signals to the output system of the instrument.

The key C3, in addition to operating its switches 44, 48, 49, and 50, operates a tuning switch 80 and each of the keys C3 and C3# operates one of two groups of similar switches 81, 82, and 83. A 16 ft. coupler tablet 90 is adapted to operate switches 91 and 92. The switches 80 to 83, 91 and 92 correspond in function to the switches 60 to 63, 66 and 67 and operate in the same manner to control the tuning and the keying of signals from oscillator 41 whenever key C3 is operated.

Switch 80 co-operates with a grounded bus bar 94, switches 81 are adapted to complete a circuit to a B+ bus bar 95, switches 82 are adapted to complete circuits to a string signal bus bar 96, and switches 83 are adapted to complete circuits to a flute signal bus bar 97. Thus whenever the key C3 is depressed appropriate signals from its associated oscillator 42 and additional signals from the oscillator 41 are supplied to the output system as soon as the late-to-close switches 48 and 81 are closed.

Bus bars 54, 70, and 96 are respectively connected to switches 101, 102, and 103, which are operated by a suitable tablet 104 which is normally in position to ground these bus bars, but when operated, connects these bus bars to a signal collector conductor 105.

In a similar manner the bus bars 52, 72, and 97 are respectively connected to switches 106, 107, and 108, these switches being normally grounded, but being arranged to connect these bus bars to the collector conductor 105 when a tablet 110 is operated. The collector conductor 105 is connected to one end of an impedance element Z112, the value of which is low relative to the values of the decoupling impedances Z53, to obtain additional results when an oscillator has its output coupled to an amplifier 114 through more than one of the impedances Z53. The other end of im-

pedance Z112 is grounded. The amplifier 114 which, may include suitable tone quality and volume controls, and the output of which is supplied to a speaker 116 has its input terminals connected to the ends of the impedance Z112.

It will be understood that some of the principles of the invention may be embodied in instruments in which an oscillator is employed for each note, in which event the tuning capacitors C20 and all switches connected to the terminals T are omitted. If desired, a vibrato signal producing apparatus 118 may be coupled to the V terminals of the oscillators, preferably in the manner more fully disclosed in my copending application Serial No. 223,376, filed April 27, 1951.

Depending upon the effects desired, one or both of the tablets 64, 90 may be operated to close their associated switches whereupon depression of any of the keys, such for example as the key C2, will result in tuning the oscillators 40, 41, and 42 to the pitches of the notes C1, C2, and C3 respectively; condition the circuits to supply flute quality, string quality, or both types of signals to the amplifier, depending upon which of the tablets 104, 110, or both, have been operated; and finally, render each of the three oscillators operative by supplying plate current thereto.

It will be understood that in Fig. 2 only a representative portion of the instrument is illustrated and that each octave of keys, except the keys for the lowermost octave, will be provided with switches 80 to 83. Each except the uppermost octave of keys will be provided with switches 60 to 63, and all switches will be connected in the manner illustrated and described.

The instrument is played in the customary manner of an organ, operating the various controls and depressing the playing keys 45. Full organ and flute-like tone qualities may readily be obtained. If the instrument has but one manual it may be "split" below the note A3, utilizing separate bus bars for collecting the flute and string tones respectively from the treble section, and the accompaniment and bass section, and providing switches operable by tablets such as 104 and 110 for each register. Since the tuning circuits and the circuits connecting the oscillator outputs to the output system are operated prior to rendering the oscillators operative, the tones produced may have the desired intensity envelope.

While I have shown and described particular embodiments of my invention, it will be apparent to those skilled in the art that numerous modifications and variations may be made in the form and construction thereof, without departing from the more fundamental principles of the invention. I therefore desire, by the following claims, to include within the scope of my invention all such similar and modified forms of the apparatus disclosed, by which substantially the results of the invention may be obtained by substantially the same or equivalent means.

I claim:

1. In an electrical musical instrument having an output system, the combination of an electrical musical tone signal generator having input and output terminals, said generator supplying a signal to its output terminals only when an operating potential is impressed across its input terminals, a playing key, two switches operated sequentially thereby, a circuit including the first-operated switch to couple the output terminals of the generator to the output system, and a second circuit including the second-operated switch

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for impressing an operating potential across the input terminals of the generator.

2. In an electrical musical instrument, the combination of an output system having a low impedance input circuit, a plurality of electrical musical tone signal generators each having input and output terminals and supplying a signal to its output terminals only when an operating potential is impressed across its input terminals, a playing key, two groups of switches operated sequentially thereby, circuits each including one of the first-operated group of switches and a relatively high value impedance to couple the output terminals of at least two octavely related generators to the output system, and additional circuits each including one of the second-operated group of switches for connecting the input terminals of said octavely related generators to a source of operating potential.

3. In an electrical musical instrument having an output system with an input circuit of relatively low impedance, the combination of two octavely related electrical tone signal generators, each generator having output and input terminals and operable to supply a tone signal to its output terminals when an operating potential is impressed across its input terminals, first and second playing keys, at least four switches operable by each key and arranged so that two of the switches will be operated before the other two are operated, parallel circuits each including an impedance of relatively high value and one of the early-operated switches for coupling the output terminals of the generators respectively to the output system, and additional circuits each including one of the late-operated switches for impressing operating potentials across the input terminals of the generators respectively.

4. In an electrical musical instrument having an output system, the combination of a first and a second electronic oscillator, a first key, a second

key spaced an octave from the first key, decoupling impedances and switch means operable by the first key to couple the outputs of the first and second oscillators to the output system, decoupling impedances and switch means operable by the second key to couple the output of the second oscillator to the output system, two switches in parallel operable by the first and second keys respectively to supply energizing current to the oscillators, said last named switches being operated on the downstrokes of the keys after all of the other switch means have been operated.

5. In an electrical musical instrument having an output system, the combination of a first electronic oscillator, a second electronic oscillator having a tuning circuit including an impedance to change its pitch, a first key, a second key spaced an octave from the first key, decoupling impedances and switch means operable by the first key to couple the outputs of the first and second oscillators to the output system, decoupling impedances and switch means operable by the second key to couple the output of the second oscillator to the output system, a switch operable by the first key effectively in the tuning circuit of the second oscillator to change the pitch of the latter, two switches in parallel operable by the first and second keys respectively to supply energizing currents to the oscillators, said last named switches being operated on the downstrokes of the keys after all of the other switch means have been operated.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,403,090	Larsen	July 2, 1946
2,432,152	Hanert et al.	Dec. 9, 1947
2,505,182	Haller et al.	Apr. 25, 1950