June 4, 1940. T. J. GEORGE 2,203,432

ELECTRICAL MUSICAL INSTRUMENT

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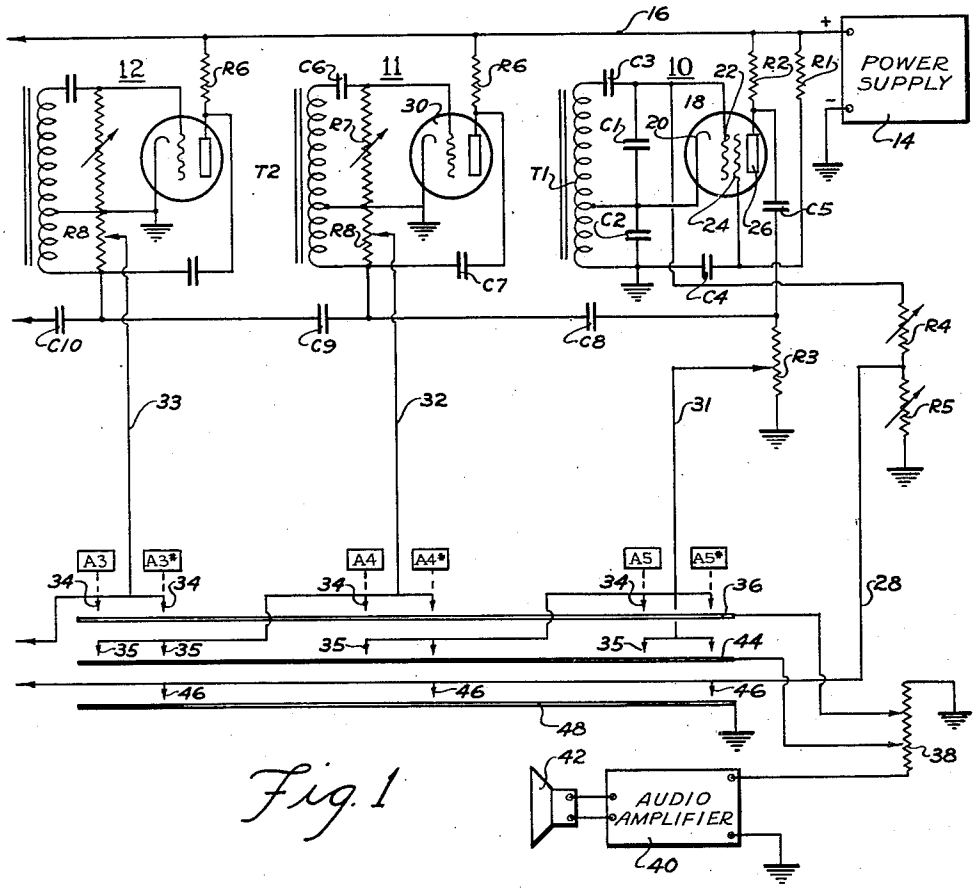


Fig. 1

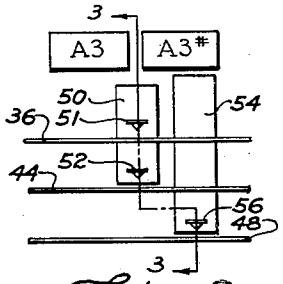


Fig. 2

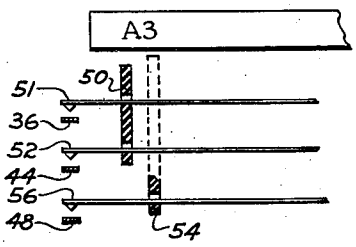


Fig. 3

Inventor
Thos. J. George
By Benjamin F. Wupper
Atty.

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ELECTRICAL MUSICAL INSTRUMENT

Thomas J. George, Chicago, Ill., assignor to Hammond Instrument Company, Chicago, Ill., a corporation of Delaware

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2 Claims. (Cl. 84—1.19)

My invention relates generally to electrical musical instruments, and more particularly to improvements in instruments of this type, whereby a group of generators, comprising a master generator and a plurality of controlled generators, may be utilized to supply frequencies for a plurality of notes greater than the number of generators employed.

A further object is to provide an improved frequency generating system for electrical musical instruments in which generators of a group of harmonically related notes may be tuned simultaneously to generate frequencies of a different group of harmonically related notes.

A further object is to provide an improved electrical musical instrument in which the number of frequency generators required is a fraction of the number usually required.

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

Figure 1 is a wiring diagram showing representative portions of the complete instrument;

Figure 2 is a diagrammatic front elevational view of a modified form of key switch arrangement; and,

Figure 3 is a vertical sectional view taken on the line 3—3 of Fig. 2.

In general, the instrument comprises a plurality of master oscillators generating the frequencies of notes of the highest octave of the instrument. Instead of having twelve such oscillators, a lesser number may be utilized, the instrument disclosed being provided with six such master oscillators.

Each master oscillator stabilizes the frequencies of a series of controlled or slave oscillators which generate frequencies of the notes of the lower octaves, corresponding to the note of the highest octave to which the master oscillator is tuned.

Since, in musical selections, it is very infrequent that adjacent semi-tone notes are simultaneously played, a considerable saving is effected in the present instrument by providing means for shifting the frequency of the master oscillator and its controlled oscillators through a semi-tone interval, controlling such semi-tone frequency shift by depression of the keys.

For example, one of the master oscillators may be tuned to the frequency of the note A5, being the A in the highest octave of the instrument, and oscillating at a frequency of 1760 c. p. s. When the note A5 is to be sounded, the tuning of the oscillator is not disturbed, but when, for example, a note such as A5♯ is to be sounded, the depression of the A5♯ key will tune the master oscillator to a frequency of the note A5♯ (1864.66 c. p. s.) prior to the completion of the circuit through which a signal from the master oscillator is derived. In a similar manner, depression of any of the other A♯ keys of the instrument will complete a parallel circuit tuning the A master oscillator to the A♯ frequency. The controlled oscillators will, of course, be shifted proportionately, and will generate the frequency of A♯ in their respective octaves.

Referring to Fig. 1, the instrument illustrated comprises a master oscillator 10 and two controlled oscillators 11 and 12, the master oscillator 10 being representative of the six master oscillators employed, while the oscillators 11 and 12 are representative of any suitable number of controlled oscillators (depending upon the gamut of the instrument) the frequencies of which are stabilized by the master oscillators.

A power supply 14 has a conductor 16 connected to its positive terminal for supplying the plate and screen voltages for the oscillators. The master oscillator 10 may be of any suitable construction, but is illustrated herein as of the relaxation type, comprising a tetrode 18 having a cathode 20, control grid 22, screen grid 24, and plate 26. The coupling between the input and output circuits is provided by an oscillation transformer T1, a tap of which is connected to the cathode 20. Condensers C1 and C2 are connected between the end terminals of the transformer T1 and the tap thereof, these condensers being provided to improve the frequency stability of the oscillator. A timing and blocking condenser C3 is connected between one end terminal of the transformer T1 and the grid 22.

The operating potential is supplied to the screen 24 through a voltage dropping resistance R1, which is connected between the conductor 16 and screen 24, a by-pass condenser C4 being connected between the screen and ground. The plate 26 is connected to the conductor 16 through a load resistor R2, the signal being derived from the plate 26 through a blocking condenser C5 which is connected to ground through a potentiometer resistance R3.

The frequency of oscillation of the master oscillator 10 is controlled by a variable grid biasing resistor R4 which is connected to ground through a second variable resistor R5, or may be connected to ground through a conductor 28 as will appear hereinafter.

The master oscillator 10 operates in the man-

ner of a triode relaxation oscillator, the screen 24 functioning as the plate in a triode oscillator, the current through the plate 26 being thus ineffective to change the frequency of oscillation. The frequency of oscillation is regulated by the adjustment of the resistance R4 in one instance, and the resistances R4 and R5 under other conditions of operation. The relative values of the resistance R4 (or resistances R4 and R5) and condenser C3 are the major factors determining the frequency of oscillation. The resistance R4 is first adjusted to a value such that when the conductor 28 is grounded, the frequency of oscillation will be that of the note A5♯. Then, after disconnecting the conductor 28 from ground, the combined resistance of R4 and R5 is varied by adjustment of resistance R5 to lower the oscillation frequency to that of the note A5. Thus, the oscillator 10 furnishes the frequency for either the note A5♯ or A5, depending upon whether or not the conductor 28 is connected to ground.

Each of the controlled oscillators 11, 12, etc., comprises a triode 30 having its cathode connected to ground, its plate connected to conductor 16 through a load resistance R6, an oscillation transformer T2, one terminal of which is connected to the grid of the tube 30 through a timing condenser C6, the grid bias being controlled by an adjustable timing and biasing resistance R7 connected between the grid and cathode. The plate circuit includes a blocking condenser C7 connected between the plate and one of the terminals of the oscillation transformer T2. The cathode is connected to the tap on the transformer winding T2. The signal is derived from the oscillator through a potentiometer resistance R8, which shunts the plate winding of transformer T2. The resistance R3 of the master oscillator and the resistance R8 serve as means for adjusting the amplitude of the output signal, for voicing purposes.

The frequency of oscillation of the oscillator 11 is stabilized by a signal derived from the signal output of the oscillator 10 through a coupling condenser C8, which is connected to one end of the plate winding of transformer T2 associated with the oscillator 11. The oscillator 11 is tuned by means of its adjustable resistance R7 so as to oscillate at a frequency of 880 c. p. s., the signal of 1760 c. p. s. impressed upon the oscillator 11 serving to stabilize the frequency of oscillation of the oscillator 11 at 880 c. p. s. in a well known manner.

The oscillator 12, and oscillators for the notes A of other lower octaves may be identical with the oscillator 11 except for such variations in the circuit constants as is necessary to facilitate adjustment thereof to secure the required frequencies of oscillation. It will be noted that the plate circuit of oscillator 11 is coupled to the plate circuit of oscillator 12 by condenser C9, and a similar condenser C10 is provided for coupling the oscillator 12 to the oscillator generating a frequency an octave lower than that of oscillator 12.

It will be noted that the stabilizing signal from the higher frequency oscillator, as for example, the signal from the master oscillator 10, is impressed upon the oscillator 11 across the plate winding of the transformer T2 of the oscillator 11. Thus, the voltage of this stabilizing signal is stepped up by the transformer T2 and impressed upon the grid of the tube 30. By virtue of the fact that the voltage of the stabilizing signal is effectively increased due to the step-up ratio of the transformer, it is possible to use a coupling condenser C8 of relatively low value. It is, of course, desirable that the coupling condensers C8, C9, C10, etc. be of low value to minimize the possibility of a signal of appreciable amplitude being derived from a lower frequency oscillator when the signal output circuit of a higher frequency oscillator is completed.

The useful signals from the master oscillator 10 and the controlled oscillators 11 and 12 are derived from their respective potentiometer resistors R3 and R8, through conductors 31, 32, and 33 respectively.

In the instrument herein described, it will be assumed that when the conductor 28 is connected to ground, the master oscillator 10 will be tuned to the frequency of the note A♯ of the highest octave, whereas when the grid of the oscillator 10 is connected to ground through both the adjustable resistors R4 and R5, the oscillator 10 will be tuned to the note A of the highest octave. The controlled oscillators 11, 12, etc. will of course change in frequencies from the notes A♯ to A of their respective octaves as the frequency of the master oscillator 10 is changed from the frequency of the note A5♯ to that of A5.

In Fig. 1, keys A3, A3♯, A4, A4♯, A5, and A5♯ are diagrammatically illustrated as representative of the complete keyboard of the instrument. Each of the keys A5, A4 and A3, upon depression, closes two switches 34, 35, connecting their respective conductors 31, 32, and 33 to a bus 36, which is adjustably connected to a coupling resistance 38, one terminal of which is grounded and the other terminal of which is connected to an amplifier 40 which supplies a speaker 42. At substantially the same time, the depression of the keys A5 and A4, and A3, by the closure of their switches 35, respectively connect conductors 31 and 32 to a bus bar 44, which is likewise connected to an adjustable tap on the coupling resistor 38. The closure of these switches 34, 35 thus results in the transmission to the amplifier of a signal derived from one or more of the oscillators 10, 11, 12, etc. The relative amplitudes of the signals derived from the two oscillators upon depression of a single key are controlled by the adjustment of the connection of the bus bars 36 and 44 to the coupling resistor 38.

The depression of a single key may therefore result in the simultaneous transmission to the output circuit of signals from two of the oscillators 10, 11, 12, etc., in desired relative amplitude relations, thus producing the effect of organ couplers. If the signal from one of the two oscillators is not desired, one of the buses 36 or 44 may be connected to the grounded end of the coupling resistance 38.

It will be noted that each of the keys A3♯, A4♯, and A5♯ is adapted to operate not only its switches 34 and 35, corresponding to those for the keys A3, A4, and A5 respectively, but also operates a switch 46, closure of which connects the conductor 28 to a grounded bus bar 48, thus short-circuiting the adjustable resistance R5 and tuning the master oscillator 10 to the frequency of the note A5♯, consequently tuning the oscillators 11, 12, etc., to the notes A♯ of their respective octaves. The switches 46 are arranged to close before the switches 34 and 35 close, upon the depression of a key, so that the oscillators will have been shifted to their A♯ frequencies before the switches 34, 35 close, and the transmission to the output of undesirable transients incident

to the changing of the frequencies of oscillation of the oscillator is thereby avoided.

In Figs. 2 and 3 is shown a modified key switching system whereby the results of the switching arrangement shown in Fig. 1 may be obtained, using fewer switches. As shown, the key A3 is adapted to depress an actuator 50 of insulating material, which operates switch contact arms 51 and 52 to complete circuits with bus bars 36 and 44 respectively. Beneath the key A3♯ is an actuator 54 which, upon depression of the key, causes completion of a circuit between a switch arm 56 and grounded bus bar 48. The actuator 50 is so arranged that it will be operated upon depression of either the key A3 of the key A3♯, while the actuator 54 is operated only upon depression of key A3♯.

The spacing between the upper ends of the actuators 54 and the keys is such that when the key A3♯ is depressed, the actuator 54 will be engaged first so as to complete the tuning circuit for the oscillator (by connecting the switch 56 to the bus 48) before the key operates the actuator 50 to complete the circuits between the switch 51 and bus 36, and switch arm 52 and bus 44. Thus, upon the depression of the key A3♯, the oscillators 10, 11, and 12 will be tuned to their A♯ frequencies before the signals derived from these oscillators are transmitted to the output circuit.

In playing the instrument, it seldom happens that adjacent notes, such as A4 and A4♯ will be simultaneously depressed. However, even if they are depressed simultaneously, it will be noted that the only undesired result will be that the note A4 will not be sounded. In a complete instrument, the octave interval notes, i. e., all of the notes having the same musical scale designations, for example, all the A notes will have their frequency supplied by one series of frequency stabilized generators, such as is represented by the oscillators 10, 11, and 12. This series of oscillators will also, as previously described, furnish the frequencies for the A♯ octave interval notes, i. e., all of the A♯ notes within the gamut of the instrument. In a similar manner, a group of frequency-interlocked generators will be provided for all the octave interval notes B and the octave interval notes C. Similarly, another series of frequency-interlocked generators will be provided for all of the C♯ and D notes, for all the D♯ and E notes, for all the F and F♯ notes, and for all the G and G♯ notes.

Since, upon completion of the signal circuit by which the signal impulses from the oscillators are transmitted to the amplifier and speaker, the oscillators are tuned to the desired frequency because of the prior completion of the tuning circuits, the undesired transient frequencies incident to tuning the oscillators through the semitone interval are not transmitted to the amplifier and speaker. By utilizing the key switch arrangement shown in Figs. 2 and 3, it will be apparent that a large number of key switch contacts may be eliminated. Although in Fig. 1 the circuit is illustrated in a simplified form wherein the depression of a key results not only in sounding the note corresponding to the key, but also sounds the note an octave higher, the coupler system may be extended so that other harmonic frequencies may be simultaneously transmitted in controlled amplitudes to the amplifier and speaker.

Furthermore, it will be understood that while I have shown and described preferred embodiments of my invention, it will be apparent to those skilled in the art that numerous variations and modifications may be made without departing from the basic principles of the invention. I therefore desire, by the following claims, to include within the scope of my invention all such equivalent or similar constructions whereby substantially the same results may be obtained by substantially the same or equivalent means.

I claim:

1. In an electrical musical instrument having an output circuit, in combination, a master generator, a second generator having a fundamental frequency different from said master generator but locked thereto in a simple fractional ratio, a keyboard including a first key and a second key, two electrical circuits completed by operation of said first key, one of said circuits being connected to said master generator and being effective to alter the frequency thereof, the other of said circuits connecting said second generator to the output circuit of the instrument to produce a given note, and means operated by said second key connecting said second generator to the output circuit of the instrument to produce a note of frequency differing from that of the note produced by operation of said first key.

2. The combination set forth in claim 1, in which said master generator is an electron discharge device oscillator of relatively high frequency and in which said second generator is an electron discharge device producing a frequency which is one octave lower than that provided by said master generator.

THOMAS J. GEORGE.