

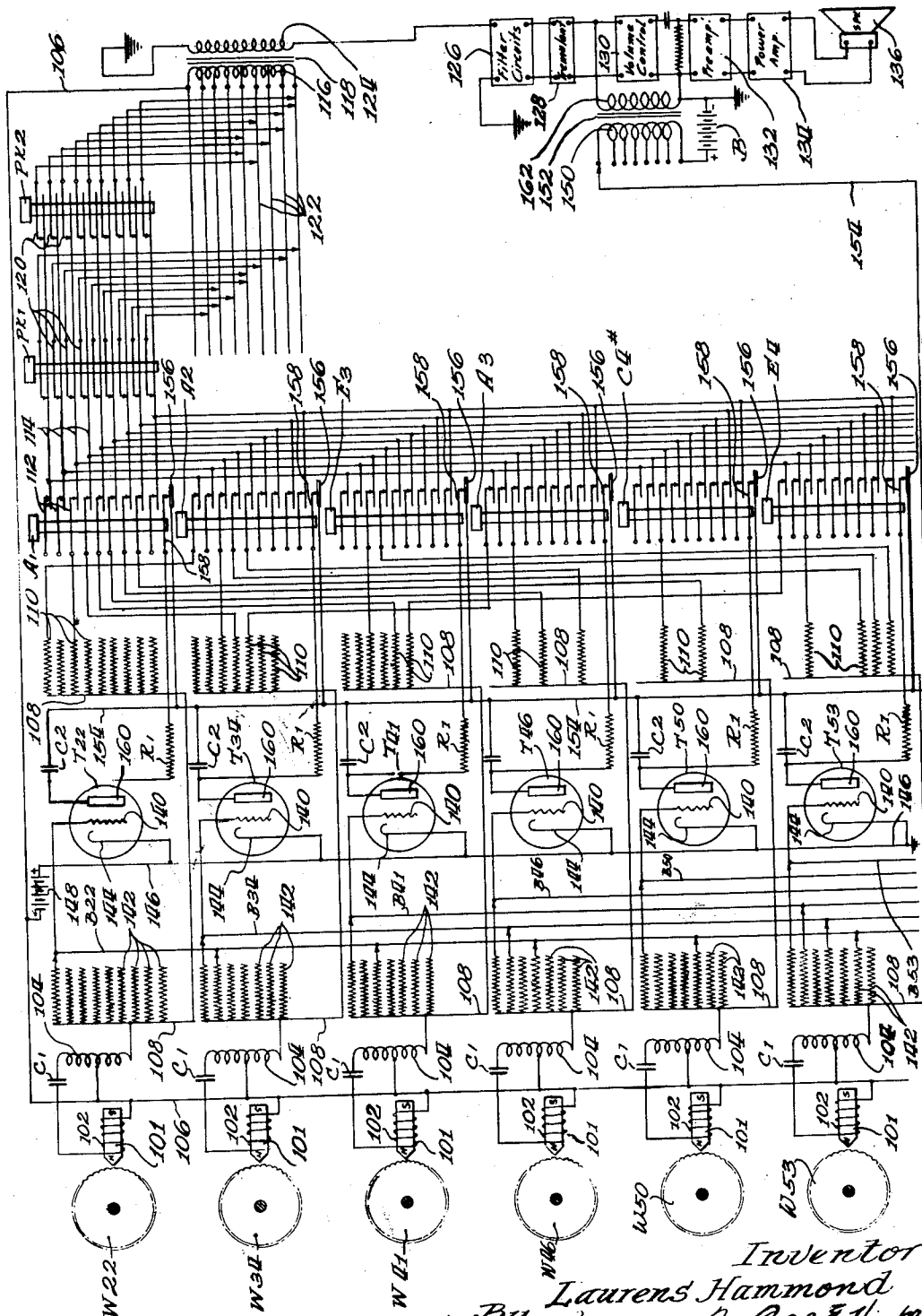
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ELECTRICAL MUSICAL INSTRUMENT

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ELECTRICAL MUSICAL INSTRUMENT

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My invention relates generally to electrical musical instruments, and more particularly to improvements in the control systems for such instruments, whereby improved musical results may be obtained. The invention is an improvement upon the electric organ disclosed in my prior Patent No. 1,956,350, granted April 24, 1934, and has for its primary object to improve the attack and decay characteristics of the tones produced by the instrument.

A further object is to provide an electrical musical instrument in which some of the tones have a substantially rectangular intensity envelope while others have envelopes in which the intensity of the tone increases gradually upon depression of the key, and upon release of the key decays gradually.

A further object is to provide an improved means for keying the tone signals in an electrical musical instrument.

Other objects will appear from the following description, reference being had to the accompanying drawing which is a schematic wiring diagram showing representative portions of a complete instrument.

As more fully disclosed in my aforesaid patent, the electric organ to which the invention relates comprises a plurality of electromagnetic generators, one for each frequency required in the production of the notes of the musical scale, whether as a fundamental or a harmonic frequency. Each of the generators comprises a tone wheel of which six are shown in the drawing, these tone wheels bearing the reference characters W22, W34, W41, W46, W50 and W53, the numerical portion of the reference character indicating the note number, C₀ being considered as note No. 1. These tone wheels are rotated through a suitable gearing by a synchronous or other constant speed motor, means being provided to assure rotation of the tone wheels at a very accurately maintained constant speed, such means including resilient and frictional driving elements for damping hunting.

Each of the tone wheels is cut to have a plurality of high points equally spaced along its periphery, and these high points pass closely adjacent the wedge-shaped end of permanent magnets 101 to vary the reluctance of the magnetic field thereof at a rate corresponding to the frequency of the signal to be generated. Each of the permanent magnets 101 is provided with a coil 102 which is connected through a condenser C₁ to an auto transformer 104. The other terminal of the coil 102 is connected to a common re-

turn conductor 106 which is likewise connected to the other terminal of the effective primary of the auto transformer 104.

The effective secondary of the auto transformer 104 is connected to a conductor 108 from which the signals are transmitted, through resistors 110, each of approximately 15 ohms resistance. As more fully described in my aforesaid patent, these resistors supply the signals generated by the tone wheels to switches 112 operated by keys of the manuals and pedals, of which the keys A₁, A₂, E₃, A₃, C₄# and E₄ are illustrated. The switches 112 are adapted to make contact with bus bars 114 of which there is one for each of the partials. Thus, for example, the third bus bar 114 may serve as a collector for the fundamental frequencies, while the fourth to ninth bus bars 114 serve as collectors for the second, third, fourth, fifth, sixth and eighth harmonics respectively. There will ordinarily be a set of bus bars 114 for each manual, and a similar set of collector conductors will be provided for the pedal clavier. The first and second bus bars 114 may be utilized as collectors for the sub-fundamental frequency (i. e. a frequency one-half that of the fundamental), and for the "fifth" of the fundamental (i. e. the third harmonic of the sub-fundamental—frequency 1.5 times that of the fundamental).

The signals controlled by the keys A₁, A₂, etc., are supplied to pre-selected taps on the primary 116 of an output transformer 118 through circuits controlled by preset keys of which two, keys PK1 and PK2, are illustrated. These keys operate switches 120 which are adapted to make contact with the bus bar 114 respectively, and are selectively connected to conductors 122.

The conductors 122 are connected to various taps of the primary 116 of the output transformer, the taps being arranged so that successive taps will represent apparently equal increases in intensity of the sound.

The secondary 124 of the output transformer 118 has one terminal grounded and the other connected through suitable filter circuits 126, a tremulant control 128, and a volume control 130 to a preamplifier 132. The preamplifier supplies the signal to a power amplifier which is connected to power amplifier 134, which is connected to a speaker 136.

The circuits thus far described are, with minor exceptions, identical to those disclosed in my aforesaid patent. In the present instrument, however, additional circuits are provided for transmitting signals from the generators to the

output of the instrument, there being an additional circuit for each of the keys of the instrument, although if desired, similar notes of the manuals and the pedal clavier may each be provided by a single additional circuit. These additional signal transmission circuits each comprises a triode, of which six are illustrated in the drawing, being designated T22, T34, T41, T46, T50 and T53, to indicate the note numbers of the circuits with which they are associated. While these triodes are indicated as being separate tubes, it will be understood that in actual practice, twin triode tubes may be used, or special tubes incorporating three or more triodes in a single tube envelope may be employed.

The grid 140 of each of the tubes T22, T34, etc., is connected to a bus B22, B34, etc. Resistors 142 are connected between the conductors 108 and the buses. These resistors are of relatively high value, ranging from .25 to 4 megohms, and may thus be arranged to supply a mixture of harmonically related frequencies to each of the grids 140 of the triodes. For example, the grid 140 of the tube T22 may have its bus B22 connected to the conductors 108 associated with the generators for notes 22, 34, 41, 46, 50, 53 and 58, and thus be supplied with signals of the frequencies of the fundamental and the second, third, fourth, fifth, sixth and eighth harmonics. Resistors 142 by which such connection is made are of selected values, so that the voltages derived from these generators bear the value relationships necessary to produce the desired tone quality.

The value of the resistors 142 is so high with respect to the values of the resistors 110 that they will not appreciably affect the amplitude of the signals supplied through the latter resistors. Similarly, the values of the resistors 142 are so high with respect to the impedance of the generators that even though a plurality of resistors 142 are connected in parallel between a single grid 140 and the common return conductor 106, there will be no appreciable "robbing."

The cathodes 144 of the triodes are connected to ground through a common conductor 146. The conductor 106, connected to one of the terminals of each of the tone wheel generators, is biased negatively with respect to ground by a battery 148 so as to provide the necessary grid bias upon the triodes.

The plate potential for the triodes is provided by a suitable potential source B which is connected, through a tapped primary 150 of a transformer 152 and a conductor 154, to key switch contacts 156. The contacts 156 have associated therewith a switch 158 which may be similar to the switches 112 and operated by the keys A₁, A₂, etc., in a similar manner. The switch 158 is connected through a resistor R₁ to the plate 160 of the associated triode, the plate being likewise connected to the common conductor 154 through a condenser C₂. The resistor R₁ may have a value in the order of 3000 ohms.

The secondary 162 of the transformer 152 has one terminal grounded, and the other terminal connected to the live input line of the tremolo control device 130. In this way, any signals transmitted through the triodes are combined with the signals transmitted through the resistors 110 and coalesce therewith.

The instrument is played in the usual manner of an organ. Upon depression of one of the keys, for example, A₁, circuits from the plurality of harmonically related generators are completed through the resistances 110 and switches 112, and

hence through the preset switches 120 and through the conductor 122 to the tapped primary 116.

The relative intensities of the partials are controlled by the adjustment of the connections between the preset key switches 120 and the conductors 122, so that a signal in which the partials are of the desired relative amplitude is produced in the secondary 124 of the output transformer 118. This signal is suitably filtered through filter circuits 126 (which may be of a type more fully disclosed in my aforesaid patent), and have their over-all intensity modulated at will by a tremulant device 128. A suitable swell pedal provided for the operation of the volume control may be adjusted to provide the desired intensity of the signal supplied to the preamplifier, and thus control the loudness of the sound produced by the speaker 136.

In addition to the above results, depression of any one of the keys, A₁, etc., closes its associated switch 156, 158 and thus connects the B supply to the plate 160 of the associated triode. This connection is, however, through the resistor R₁, which is of sufficiently high value (approximately 0.5 megohm) with respect to the capacitance of the condenser C₂, so that the potential on the plate 160 does not rise instantaneously to the potential of the B supply, but instead, rises gradually to this value. As a result, the plate current through the tube, as controlled by the voltage signal on the grid 140 thereof, builds up gradually to its maximum value. Similarly, upon releasing the key and opening the switch 156, 158, the potential on the plate will not immediately drop to zero, but due to the condenser C₂, will drop gradually to a value at which the tube is cut off. This gradual increase in the plate current, and the subsequent gradual decrease of the plate current, causes a signal having a gradual attack and gradual decay to be produced in the secondary of the transformer 152.

Furthermore, as the potential of the plate approaches cut-off potential, the alternating current signal in the plate circuit will gradually be distorted more and more, thus causing increasing harmonic distortion of the signal as a lesser and lesser portion of the signal wave is transmitted through the tube. This latter effect is desirable musically since it induces new frequencies which are exact harmonics of the frequencies in the input, and which therefore differ from the frequencies of the tempered musical scale.

If desired, the grid bias may be made adjustable so that the signal will be distorted throughout the period that the key remains depressed. By properly regulating the grid bias, the distortion may be made to take place mainly with respect to the lower frequencies, and the frequencies of highest amplitude.

Since the frequencies supplied by the generators are not, in all instances, exact harmonics of one another, but instead, are as close to the exact harmonics as is permitted due to the tempering of the musical scale, the distortion of a given frequency supplied to one of the triodes will result in frequencies which differ slightly from the corresponding harmonic frequencies supplied by the tone wheel generators. Consequently there may be in the combined output, various frequencies which differ slightly from one another, and which will therefore produce slight beats and sum and difference frequencies which will add to the richness and fullness of the tone when such effect is desired.

The relative intensities of the signals supplied to the volume control device by the transformers 118 and 152 may readily be controlled by connecting the conductor 154 to a selected one of the taps of the primary 150 of the transformer 152. In this way, the degree of effectiveness of the gradual attack of the signals provided by the triodes may be easily adjusted, it being understood that when the conductor 154 is connected to the plus terminal of the current supply B, no portion of the signals supplied by the triodes will be transmitted to the amplifier, and the instrument may then be played to produce tones of the character produced by the electric organ shown in my aforesaid Patent No. 1,956,350.

In the complete instrument, it may be desirable to provide several buses, such as the bus B22, for each of the triodes together with suitable switching means, whereby any one of the buses may be selectively connected to the grid 140 of the triode. In this way, each bus could be connected to its associated generators through resistors 142 of different pre-selected values, so that the quality of the tone signal transmitted through the triode could be readily selected.

It is interesting to note that if the attack is not made too rapid (i. e., if the value of the resistor R_1 is not too small with respect to the value of the condenser C_2), there will be no appreciable transients set up upon closing and opening the switch 156, 158, because the current which starts flowing at the instant the key is depressed, flows through a local circuit including the resistor R_1 and condenser C_2 , and does not flow through the primary 150 of the transformer 152. Thus, the possibility of "key clicks" is eliminated.

While I have shown a particular embodiment of my invention, it will be apparent to those skilled in the art that numerous modifications and variations thereof may be made without departing from the underlying principles of the invention. Furthermore, while particular values of various circuit elements are specified, it will be apparent that these values are merely illustrative and that they may in general be changed throughout a wide range, especially if compensatory changes are made in other portions of the circuit. I therefore desire, by the following claims, to include within the scope of my invention, all such modified and similar equivalent constructions whereby substantially the results of my invention may be obtained by substantially the same means.

I claim:

1. In an electrical musical instrument, the combination of a plurality of generators of the frequencies of the notes of the tempered musical scale, an output circuit having means for amplifying and translating electrical impulses into sound, key operated signal control means comprising an electron discharge device having a cathode, grid, and plate, and having its plate current controlled by the key, and a plurality of high resistance elements connecting the grid of said device to a plurality of said generators.

2. The combination set forth in claim 1 in which said signal control means includes a condenser and resistance network in the plate circuit of said device.

3. The combination set forth in claim 1 in which said generators are of relatively low impedance, and in which the impedances of said resistance elements are many times as great as the impedance of one of said generators.

4. The combination set forth in claim 1 in

which there is a source of plate current, a condenser connected between said source and said plate, a resistor having one terminal connected to said plate, and a circuit including said key operated switch connecting said source to the other terminal of said resistor.

5. In an electrical musical instrument, the combination of a plurality of generators of electrical impulses corresponding in frequency to the notes of the tempered musical scale, an output circuit including means for amplifying and translating said impulses into sound, a key, a plurality of circuits controlled by said key for supplying impulses from said generators to said output circuit, and additional switch controlled by said key, an electron discharge device having a cathode, grid and plate, resistors of relatively high value connecting a plurality of said generators to said grid, a source of plate current, a transformer having a primary and a secondary and having one terminal of its primary connected to said source, a conductor connecting the other terminal of said primary with said additional switch, a resistor connected between said additional switch and said plate, a condenser connected between said conductor and said plate, and means for connecting the secondary of said transformer to said output circuit.

6. In an electrical musical instrument, the combination of a generator of electrical impulses of a musical frequency, an output circuit including an amplifier and electroacoustic translating means, an electron discharge device having a cathode, grid and plate, a high resistance element connecting said generator to said grid, a source of a plate current, a resistor, a manually operable switch for connecting said source to said plate through said resistor, and a condenser permanently connecting said plate to said source, the relative values of said resistor and condenser being such that upon closure of said switch, the plate potential will increase at a perceptibly gradual rate, and upon opening said switch, the potential on said plate will decrease at a perceptibly gradual rate.

7. In an electrical musical instrument, the combination of a plurality of low impedance generators of electrical impulses of harmonically related frequencies, an output circuit including electroacoustic translating means, a manually operable key, a plurality of switches operated by said key, a plurality of high impedance circuits controlled by some of said switches for connecting said generators respectively with said output circuit, an electron discharge device having input and output circuits, a connection between each of a plurality of said generators and the input circuit of said device, each of said connections having an impedance much greater than that of said high impedance circuits, means for connecting the output of said device to said output circuit, and means including one of said switches for conditioning said device for operation.

8. The combination set forth in claim 7 in which the means for conditioning said device for operation includes means for causing the device to commence operating gradually.

9. The combination set forth in claim 7 in which the means for conditioning said device for operation includes means for causing the device to commence operation with gradually increasing effectiveness upon depression of said key, and upon release of said key to continue operation with gradually decreasing effective-

ness, thereby to obtain gradual attack and decay in the tone produced.

10. The combination set forth in claim 7 in which the means for conditioning said device for operation includes a condenser and resistance network in circuit with one of said switches.

11. The combination set forth in claim 7 in which said device has a cathode, grid and plate, and a source of plate current, and in which said means for conditioning said device for operation includes a condenser and a resistor arranged to be connected in parallel between said plate and said source upon closure of one of said switches.

12. The combination set forth in claim 7 in which said device has a cathode, grid and plate and in which a biasing potential source is connected in said input circuit of said device.

13. In an electrical musical instrument, the combination of a low impedance generator of electrical impulses, an output circuit including electroacoustic translating means, a manually operable key, a switch operated by said key, an electron discharge device having input and output circuits, a connection between said generator and the input circuit of said device, said connection having an impedance at least ten times greater than that of said generator, means for connecting the output of said device to said output circuit, and means including said switch for conditioning said device for operation.

14. The combination set forth in claim 13 in which the means for conditioning said device for operation includes means for causing the device to commence operating gradually.

15. The combination set forth in claim 13 in which the means for conditioning said device for operation includes means for causing the device to commence operation with gradually increasing effectiveness upon depression of said key, and upon release of said key to continue operation with gradually decreasing effectiveness, thereby to obtain the desired gradual attack and decay in the tone produced.

16. The combination set forth in claim 13 in which the means for conditioning said device for operation includes a condenser and resistance network in circuit with said switch.

17. The combination set forth in claim 13 in which said device has a cathode, grid and plate, and a source of plate current, and in which said means for conditioning said device for operation includes a condenser and a resistor connected in parallel between said plate and said source upon closure of said switch.

18. The combination set forth in claim 13 in which said device has a cathode, grid and plate and in which a biasing potential source is connected in said input circuit of said device.

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