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ELECTRONIC MUSICAL INSTRUMENT

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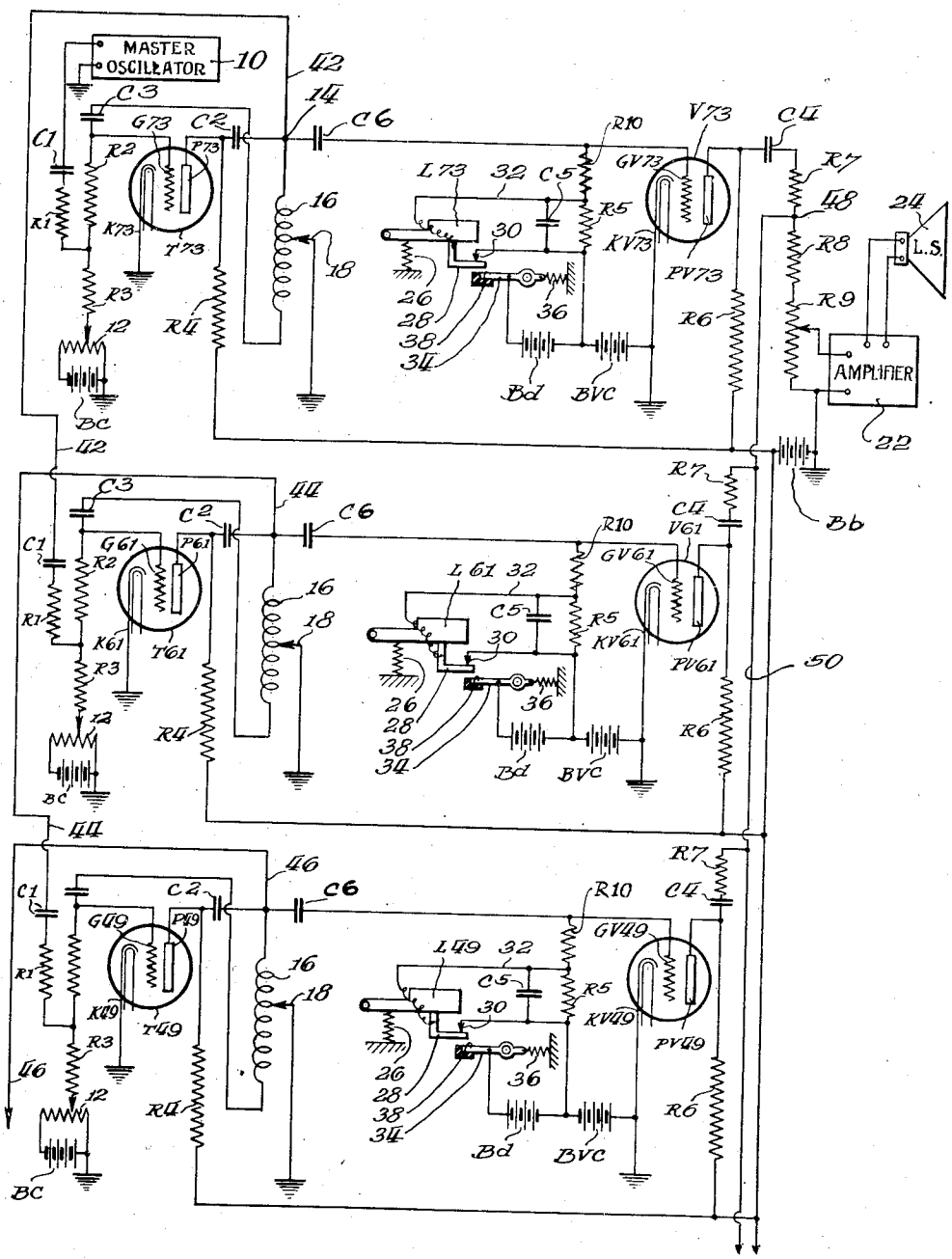

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ELECTRONIC MUSICAL INSTRUMENT

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4 Claims. (Cl. 84—1.26)

My invention relates generally to electronic musical instruments, and more particularly to improved key controlled circuits therefor.

It is an object of my invention to provide an improved electronic musical instrument in which there is provided an oscillator generator for each note of the musical scale which oscillates continuously and supplies a signal to an electrode of a control tube, the grid bias of which is normally such as to render the control tube non-conducting, but in which means are provided to change the bias to permit transmission of the oscillator generator signal to an output circuit wherein the signal may be amplified and translated into sound.

A further object is to provide an electronic musical instrument in which the transmission of the tone signal to the output circuit is controlled by a repeater or control tube having key controlled means for changing the grid bias in a manner to produce a note having rapid attack and slow decay.

A further object is to provide an improved key circuit for electronic musical instruments.

A further object is to provide an improved key circuit for electronic musical instruments in which the signal from a generator is distorted to introduce higher harmonics, and thus increase the harmonic development of the tone.

A further object is to provide an electronic musical instrument in which a key controlled repeater or distorter control tube is provided to cause changes in the harmonic development of the note produced as well as changes in the intensity thereof.

Other objects will appear from the following description, reference being had to the accompanying drawing which shows a wiring diagram of a representative portion of the complete instrument embodying my invention.

The instrument comprises generally a keyboard which may be similar to that of the piano or organ, a series of generators, one for each frequency of the musical scale, a control or repeater tube, the grid bias of which is controlled by means of a key circuit so as selectively to render the control tube capable of conducting the signal which is continuously supplied thereto by its associated generator to an output circuit which may comprise an amplifier and a loud speaker.

As generators of the various frequencies required, I prefer to use vacuum tube oscillators which may be of the type disclosed and claimed in my Patent No. 2,083,246 granted June 8, 1937. The oscillators of a harmonically related series are preferably interconnected for frequency stabilization and the highest frequency oscillator of the series preferably has its frequency stabilized by a master oscillator generating a frequency twice that of the controlled oscillator. The master oscillator may be of any suitable construction, but is preferably one of refined design which will very accurately maintain its frequency under varying conditions, and which may be tuned with exactitude. The master oscillator may also be provided with means for periodically shifting its frequency slightly above and below its normal frequency of oscillation, thereby to introduce a vibrato effect which will be reflected by corresponding frequency changes in the series of oscillators controlled by the master oscillator. The master oscillator may also be utilized to provide a tone signal in a manner similar to the method by which the remaining oscillators provide signals, or the master oscillator may function solely as a means for stabilizing the frequencies of oscillation of the series of oscillators stabilized thereby.

Inasmuch as the master oscillator may be of any suitable well-known design or construction, I have illustrated it diagrammatically as a block 10, which is connected through a condenser C1, resistor R1 and resistor R2 with the grid G73 of a tube T73, forming part of the oscillator for the generation of the signal for the note 73. (Assuming the notes of a standard piano to be numbered from 1 to 88, the highest A will be note No. 85, the A of the next lower octave will be note No. 73, etc.) The master oscillator 10 is provided for note No. 85 and in addition to furnishing a stabilizing signal to the grid of tube T73, may supply a signal to a key controlled output circuit (hereinafter to be described), although for the sake of simplicity, the key controlled circuit for the master oscillator has not been shown in the drawing. The grid bias for the tube T73 is supplied from a battery Bc through a potentiometer 12 and resistance R3.

Plate current is supplied from a battery Bb, the negative terminal of which is grounded, and the positive terminal of which is connected to the plate P73 through a resistance R4. A blocking condenser C2 is connected between a terminal 14 and a plate P73, the terminal 14 being connected to the grid G73 through a mutual inductance 16 and a condenser C3 providing a feed-back circuit. A portion of the winding of the mutual inductance 16 is connected to ground through an adjustable contact 18. The cathode K73 may be of

the indirectly heated type, and is illustrated as connected to ground.

The details of the construction and operation of this type of oscillator are disclosed in my aforesaid patent and need not, therefore, be described specifically herein. It will suffice to state that this oscillator is tuned so as normally to oscillate at a frequency of 1760 cycles. Due to changes in the characteristics of the tube, supply voltage, and changes in the other elements of the circuit as a result of aging and changes in atmospheric conditions, its frequency of oscillation might change were it not supplied with a controlling signal from the master oscillator 10. The signal from the master oscillator 10 impressed upon the grid circuit of the tube T73 may be said to constitute a trigger which controls the discharge of tube T73. Each alternate positive peak of the signal wave provided by the master oscillator 10 acts to swing the grid T73 positive sufficiently to insure discharge of the tube, since the characteristics of the circuit for the tube T73 are such that at these times the grid G73 will be very close to the potential necessary to cause discharge of the tube, and the additional positive potential provided by the signal from the master oscillator is sufficient to insure discharge at the proper instant. The intermediate positive peaks of the signal wave provided by the master oscillator 10 are insufficient to raise the potential of the grid G73 to a value sufficient to cause discharge of the tube T73 since at the time of these intermediate positive peaks in the signal wave provided by the master oscillator, the potential of the grid is at the most negative part of its cycle and thus, the small increase in potential provided by the signal from the master oscillator is insufficient to affect the operation of the tube T73. In this way, the frequency of oscillation of the circuit including the tube T73 will be maintained at exactly one half the frequency of the master oscillator 10, and thus generate the proper frequency of 1760 cycles for the note 73.

The signal produced by the oscillator including the tube T73 is transmitted through a blocking condenser C6 and impressed upon the grid GV73 of a volume control tube V73, which has a cathode KV73 and a plate PV73. A grid biasing potential source BVc is connected between the cathode KV73 and grid GV73 through a resistance R5 and another resistance R10, the biasing potential being normally sufficient to bias the tube beyond cutoff. Plate current for the tube V73 is supplied through a resistance R3 from the plate current supply source Bb, and the signal transmitted by the tube V73 flows through a circuit including the blocking condenser C6, resistor R7, current limiting resistor R8 and the potentiometer R9. An amplifier 22 is adjustably connected across the potentiometer R9 and supplies the amplified signal to a loud speaker 24.

Key controlled means are provided to change the grid biasing potential on the tube V73 to render this tube capable of conducting the signal to the output circuit which includes the amplifier and loud speaker. This means comprises a key L73 which is held in its uppermost position by the spring 26 with its switch arm 28 completing a circuit with a fixed contact 30. The contact 30 thus completes a circuit shunting resistor R5, and providing a low resistance path including conductor 32 for maintaining the grid GV73 at a potential beyond cutoff by an amount sufficient to prevent the tube from transmitting the signal supplied by the associated oscillator, hereinafter termed the "extinction potential". The resistance R5 is shunted by a condenser C5. Upon depression of the key, its switch arm 28 first breaks the circuit with the contact 30 and then makes contact with a movable switch finger 34 which may be suitably damped and which may swing in either direction from the position in which it is shown, but is resiliently returned to the position illustrated by a spring 36. The switch finger 34 has a block 38 of insulating material secured at the end thereof, so that the switch arm 28 will make electrical contact with the switch finger 34 only during the initial portion of the downward stroke thereof, and will not make electrical contact during any portion of the return stroke of the key. As the key L73 is depressed it swings in a clockwise direction about its pivot, and the extremity of its contact arm 28 engages the upper surface of the switch finger 34. Continued depression of the key causes the switch finger 34 to swing counter-clockwise about its pivot until the end of the switch contact arm 28 slides from the end of the metallic part of the switch finger 34, and thereafter slides past the insulation secured at the end of the switch finger. As the switch arm 28 slides past the insulating part of the switch finger 34, the spring 36 swings the switch arm clockwise to its normal position, in which position the switch contact arm 28 will lie beneath the insulated portion of the switch finger 34. Upon releasing the key L73, its spring 26 will raise it to normal position, and during the course of such return movement, the upper surface of the end of the switch contact arm 28 will engage the lower surface of the insulation on the switch finger 34 and swing this switch finger clockwise, but, since during this upward movement of the key the switch contact arm 28 engages only the insulated part 38 of the switch finger, no electrical contact between the switch finger 34 and contact arm 28 is made. Shortly prior to the completion of the return stroke of the key, the end of the contact arm 28 wipes past the insulating block 38 and permits the spring 36 to swing the switch finger 34 counter-clockwise to its normal position in which it is shown in the drawing. The switch finger 34 is connected to the positive terminal of a direct current potential supply Bd, the negative terminal of which is connected to the grid GV73 through the resistors R5 and R10.

With the key L73 in normal position, as shown, the grid GV73 will be biased negatively beyond extinction potential by the potential source BVc and thus the tube V73 will be incapable of transmitting the signal impressed upon its grid by the oscillator comprising the tube T73. Upon depression of the key, the switch arm 28 will leave the contact 30 and shortly thereafter engage the switch finger 34, whereupon the grid GV73 will immediately have a positive or less negative direct current potential impressed thereon, sufficient to cause the tube V73 to transmit the signal to the output circuit, and the condenser C5 will almost instantaneously be charged to the potential of source Bd. However, the contact between the switch finger 28 and switch arm 34 will be broken very shortly after it is made, and therefore, as long as the key is held depressed, the positive or less negative bias on the grid GV73 will drift logarithmically toward the negative extinction potential as the condenser C5 becomes discharged through the resistor R5, and as the potential of the biasing potential source BVc becomes effective upon the grid GV73. As a result, with the key L73 held down, the inten-

sity envelope of the note sounded will resemble that of a piano note or the note of a picked or plucked string, in that it will have very rapid attack, and gradual logarithmic decay. Upon release of the key, it will be returned to normal position under the influence of its spring 26, and again complete a circuit with the contact 30, thereby shunting the condenser C5 and resistor R5, and causing the extinction biasing potential of the source BVc immediately to be impressed upon the grid GV73, thus cutting off the operation of the tube and terminating the sounding of the note. The completion of the circuit upon the engagement of the switch arm 28 with the contact 30, will thus act in a manner similar to the dampers of a piano which engage the strings immediately upon release of the keys, and cause the strings to cease vibrating.

By proper selection of the values of the condenser C5, resistor R5 and potential sources Bd and BVc, the rate of decay of the note may be predetermined to simulate that of the piano note or the notes of other similar instruments employing picked or plucked strings as the sound producing means.

The tube V73 not only serves to control the intensity envelope of the note, but also acts as a distorter tube to change the shape of the wave produced by the oscillator including the tube T73. This function of the tube V73 and its associated circuit is fully pointed out in my prior Patent No. 2,038,892 dated April 7, 1936, and my aforesaid Patent No. 2,083,246. Assuming the signal produced by the oscillator and impressed upon the grid GV73 is a sine wave, the value of the potential source Bd may be so chosen that when its potential is impressed upon the grid GV73, only the positive peaks of the signal wave will be effective to render the tube V73 conducting. As more fully described in my aforesaid patent, this will result in the introduction by the tube V73 of a series of higher harmonics which will greatly enhance the quality of the tone produced by the instrument. As the potential of the grid GV73 drifts negatively toward cutoff potential (as the condenser C5 discharges), the shape of the wave form of the signal transmitted by the tube GV73 will also change, thereby producing a change in the degree of harmonic development as the tone decays.

In an instrument of the piano type, there will, of course, be 88 oscillators (76 if the master oscillators are used to supply the twelve highest frequencies) similar to that comprising the tube T73, and in the drawing two additional oscillators comprising tubes T61 and tubes T49 are shown, these oscillators generating frequencies for the notes 61 and 49 of 880 and 440 cycles respectively. The elements of these oscillators may be identical with those of the oscillator previously described, except that there may be changes in the values of the elements of the circuits. It will therefore be unnecessary to describe them in detail. Similar reference characters have, however, been applied to the corresponding parts.

The frequency of the oscillator comprising the tube T61 is stabilized by the signal produced by the oscillator T73. This stabilizing signal is transmitted from the terminal 14 through a conductor 42 which is connected to the grid circuit of the tube T61 in the same manner that the master oscillator 10 is connected to the grid circuit of the tube T73. Similarly, the oscillator comprising the tube T61 impresses a frequency stabilizing signal upon the grid circuit of the tube T49 through a conductor 44, and the oscillator comprising the tube T49 supplies a stabilizing signal to the grid circuit of the tube for the oscillator for note No. 37 (not shown) through a conductor 46. In this way, a plurality of oscillators may be tied together so that their frequencies will be stabilized and controlled by the master oscillator. The oscillators which are illustrated bear octave relationship to each other. As pointed out in my aforesaid Patent No. 2,083,246 the relationship between the oscillators may be of any other harmonic relationship. The plates PV61 and PV49 are connected through blocking condensers C4 and resistors R7, to a terminal 48 by a conductor 50. Thus the outputs of all the repeater control tubes are connected in parallel to supply their signals to the amplifier 22.

From this it will be apparent that by tuning the master oscillator the series of oscillators controlled thereby will be correspondingly tuned, and similarly, if the frequency of oscillation of the master oscillator is periodically shifted through a small range at a vibrato periodicity, the frequencies of the series of oscillators controlled thereby will be shifted proportionately, and the notes produced will thus give a very desirable vibrato effect.

While I have disclosed but a single embodiment of my invention it will be apparent to those skilled in the art that numerous changes may be made without departure from the basic principles thereof. I therefore desire by the following claims to include within the scope of my invention all such constructions whereby substantially the same results may be obtained by substantially the same or equivalent means.

I claim:

1. In an electrical musical instrument, the combination of a plurality of generators of electrical impulses of the frequencies of the musical scale, an output circuit including an amplifying and electro-acoustic translating means, and means for selectively controlling the transmission of impulses from said generators to said output circuit, said means comprising a multi-electrode thermionic tube for each of said generators, said tube having a control grid normally receiving impulses from its associated generator, means for biasing said control grid beyond extinction potential, a selectively operable key, a condenser associated with said grid biasing means, means operated by said key during the downward stroke thereof to increase the charge on said condenser to cause the grid bias on said tube to decrease upon depression of said key, and a resistor connected to said condenser gradually to decrease the charge thereof during the interval that said key is held depressed.

2. In an electrical musical instrument, the combination of a plurality of generators of electrical impulses of the frequencies of the musical scale, an output circuit including an amplifying and electro-acoustic translating means, and means for selectively controlling the transmission of impulses from said generators to said output circuit, said means comprising a multi-electrode thermionic tube for each of said generators, said tube having a control grid normally receiving impulses from its associated generator, means for biasing said control grid beyond extinction potential, a selectively operable key, a switch closed only during the down stroke of said key, and a circuit associated with said switch to decrease the grid bias on said tube.

3. In an electrical musical instrument, the combination of a plurality of generators of electrical impulses of fundamental frequencies of the notes of the musical scale, a multi-electrode thermionic control tube for each of said generators and having a control electrode continuously receiving impulses from its associated generator, means for normally biasing said tube beyond cut-off to render said tube non-conducting, and selectively operable means to change the effective bias on said tube, said means comprising; a depressible key, means operated during initial portion only of the downward stroke of said key to render said biasing means ineffective and to render said tube conducting, and a condenser and resistance network for rendering said biasing means gradually more effective during the remainder of the down-stroke of said key and during the up-stroke of the key.

4. In an electrical musical instrument, the combination of a plurality of sources of electrical impulses of the frequencies of the musical scale, a plurality of multi-electrode thermionic repeater control tubes each having a control grid, circuits for impressing impulses from said sources upon the grids of said tubes respectively, a negative potential source connected normally to bias the grid negatively beyond extinction potential, and means associated with each of said tubes to change the effective grid potential thereof, said means comprising a selectively operable depressible key, a positive potential source, a resistor and condenser connected in parallel between said negative potential source and said grid, a switch temporarily closed by said key during only the initial portion of the down-stroke of the key, a circuit in parallel with said resistor and condenser and including said switch and said positive potential source, a second switch closed only when said key is in normal inoperative position, and a negligible impedance circuit including said second switch and shunting said condenser and resistor when said second switch is closed.

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