

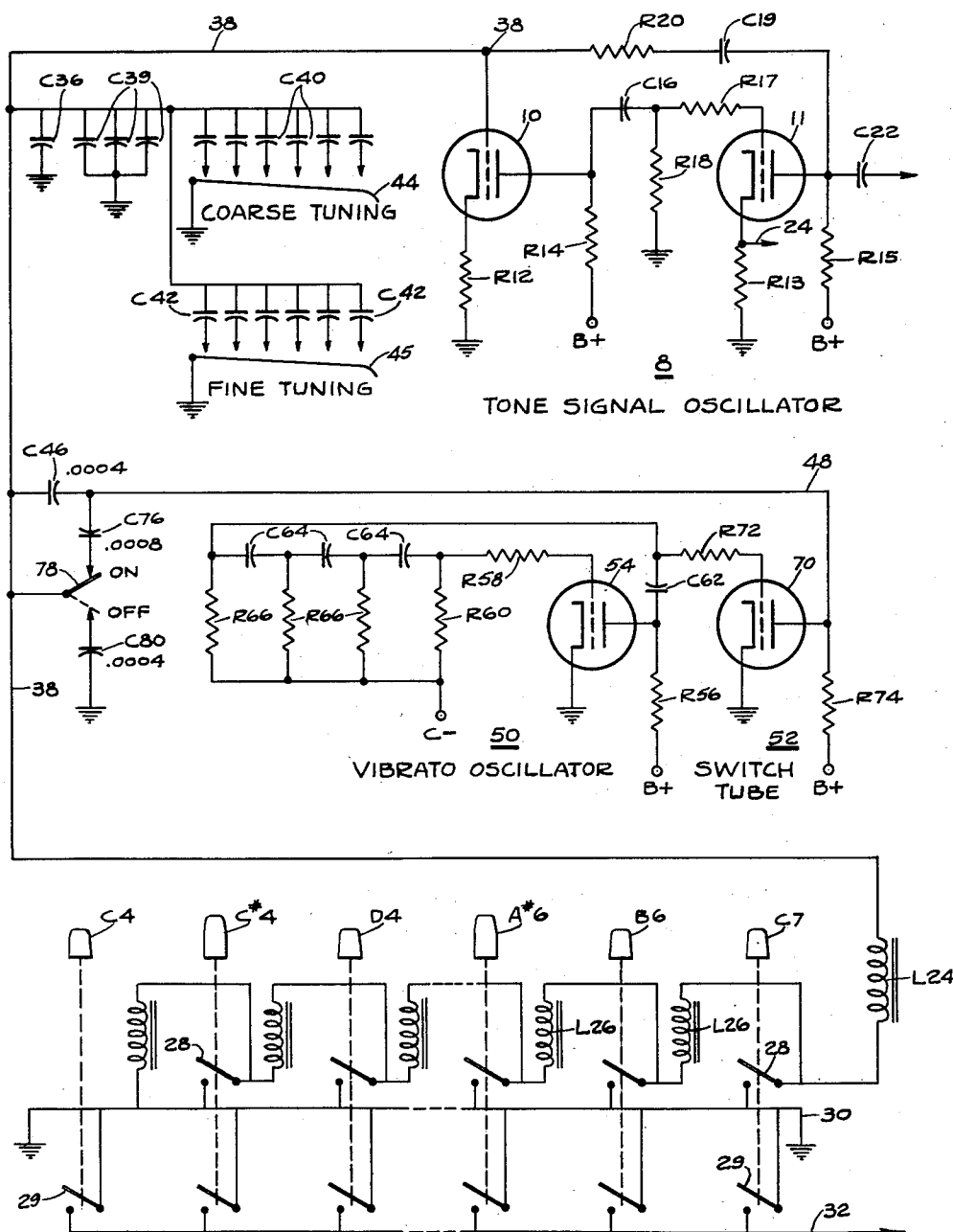
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J. M. HANERT

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VIBRATO APPARATUS FOR ELECTRICAL MUSICAL INSTRUMENTS

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Inventor
John M. Hanert
By *Benjamin F. Vesper*
Atty.

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VIBRATO APPARATUS FOR ELECTRICAL
MUSICAL INSTRUMENTSJohn M. Hanert, Park Ridge, Ill., assignor to
Hammond Instrument Company, Chicago, Ill.,
a corporation of Delaware

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My invention relates generally to electrical musical instruments and more particularly to improved means for introducing a vibrato effect by changing the frequency of oscillation of a tone signal producing or frequency controlling oscillator.

In prior musical instruments employing oscillators for the generation or control of the musical tone signal, various expedients have been adopted to introduce the vibrato effect. The most successful of these have consisted of a reed vibrating at a frequency of approximately 6 to 7 cycles per second, this reed being electromagnetically maintained in vibration and operating contacts to connect and disconnect in the resonant circuit of the oscillator a small inductance or capacitance, thus to vary the resonant frequency of the oscillator tuning circuit. Such vibratory reed mechanisms represent a substantial manufacturing cost and sometimes were noisy in operation and thus were not entirely satisfactory.

In general, the vibrato devices of the prior art which employed a vibrato oscillator used the output of this oscillator to vary the grid bias on the tone signal generating oscillator and this regulated in a tremulant. Furthermore, in such vibrato devices of the prior art it was not possible to apply the vibrato periodicity to an oscillator which was adapted to be tuned over a wide range of musical notes since the variation of the grid bias was effective to produce a true vibrato effect only throughout a limited frequency range.

It is therefore a primary object of my invention to provide an improved vibrato apparatus for electronic oscillators which may be manufactured at lost cost, which will impart a smooth true vibrato effect to a tone signal generating oscillator throughout a wide frequency range, and which is noiseless in operation.

Other objects will appear from the following description, reference being had to the accompanying drawing which is a schematic wiring diagram of the invention.

The circuit diagram shows a tone signal generating oscillator 8 comprising a pair of triodes 10 and 11 which have their cathodes respectively connected to ground through cathode biasing resistors R12 and R13. The plate of triode 10 is connected to a suitable operating potential source, indicated as a terminal B+, through a load resistor R14 while the plate of the triode 11 is connected to such source by a similar load resistor R15. The plate of the triode 10 is connected to the grid of triode 11 through a blocking capacitor C16 and a series grid resistor R17, the junction

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between C16 and R17 being connected to ground through a series grid resistor R18.

A feed back path from the plate of triode 11 to the grid of triode 10 is provided through a blocking capacitor C19 and resistor R20. The output signal is derived from the plate of the triode 11 through blocking capacitor C22, or by utilizing the voltage from across the cathode resistor R13 through a conductor 24, or both signals may be taken from the triode 11.

The frequency of oscillation of the oscillator 8 is determined by the resonant frequency of an inductance-capacitance mesh connected between ground and the grid of triode 10, to which a conductor 38 is connected. In the particular form of the invention shown herein, the inductance portion of this resonant circuit is provided by an inductance coil element L24 which may have any number of additional inductance coil elements L26 connected in series with it upon operation of playing keys such as C4 to C7. Each of these keys is mechanically connected to operate a pair of switches 28 and 29, the switches 28 being arranged to connect the junction between the inductance element L24 and the elements L26 to a grounded conductor 30. The switches 29, also operated by the playing keys, are adapted to ground a conductor 32, which, as is known in the art, is utilized to control the amplitude of the signal output by changing the grid bias on control tubes forming part of the amplifier and output system. The lowermost key C4 operates only a switch 29, since the inductance element L26 associated with this key has one terminal thereof permanently connected to ground. As more fully disclosed in my copending application Serial No. 51,409, filed September 27, 1948, the inductance elements L24 and L26 are separate coils which are arranged in space so as to secure a minimum of intercoupling effects. Each of these coils is wound upon a laminated core which may be adjusted to make slight changes in the inductances of the coils.

The capacitance of the resonant circuit is determined chiefly by a capacitor C36 which is connected between ground and the conductor 38 connected to the grid of tube triode 10. Capacitors C39 are of small value relative to C36 and are used initially to provide an accurately determined amount of capacity in parallel with the capacitor C36.

Coarse tuning capacitors C40 and fine tuning capacitors C42 may be connected in parallel with the capacitor C36 by operation of tuning control connectors 44 and 45 respectively, which are

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adapted successively to connect capacitors C40 and C42 to ground and thereby make it possible to tune the oscillator 8 to the desired frequency, to compensate for changes in the circuit due to changes in temperature and humidity, ageing of the capacitors, and other slight changes which may occur. These tuning capacitors may also be utilized to tune the oscillator 8 so that its frequency will accord with that of some other instrument such as a piano, with which the instrument, which includes the oscillator 8, is to be played.

A capacitor C46 is connected between the conductor 38 and a conductor 48, and a vibrato oscillator 50 and electronic switch 52 are provided effectively alternatively to connect the conductor 48 to a point of fixed potential and disconnect it therefrom.

The vibrato oscillator 50 comprises a triode 54 the cathode of which is connected to ground and the plate of which is connected to a B+ terminal through a load resistor R56. The control grid of the triode 54 is connected to a negative biasing potential source, indicated as a terminal C-, through a series grid resistor R58 and a grid return resistor R60. A 180 degree phase shift, at approximately 6 cycles per second, is provided through a network comprising a capacitor C62, which also serves as a blocking capacitor, and a series of capacitors C64. The junctions between these capacitors C62 and C64 are connected to the C- terminal through resistors R66. Capacitors C62 and C64, together with the resistors R56 and R60, constitute a phase shifting mesh which, as previously indicated, will shift the signal appearing on the grid relative to that on the plate by approximately 180 degrees, thereby causing sustained oscillation, inasmuch as the gain of the system provided by triode 54 is more than unity.

The output signal on the plate of the triode 54 is also impressed upon the grid of a triode switch tube 70 through a filtering series grid resistor R72. Since the output of the vibrato oscillator is of generally rectangular wave shape it is desirable to provide the resistor R72 to prevent driving the grid of the tube 70 more positive than the cathode and also to filter the high frequencies from the output wave to cause it to have more rounded corners. The plate of switch tube triode 70 is connected to the B+ terminal through a relatively high value plate resistor R74.

The conductor 48 may be connected to the conductor 38 through a vibrato capacitor C76 by moving a switch 78 to its full line position when the full extent of the vibrato is desired. When it is desired to have a vibrato of limited extent the switch 78 is moved to its dotted line position, in which a compensating capacitor C80 is connected between conductor 38 and ground.

Since the output of the vibrato oscillator 50 is alternately positive and negative throughout substantially equal portions of the cycle, the grid of switch tube triode 70 will be negative approximately half of the vibrato cycle and will be positive during the remaining half, the degree of positiveness of the grid being limited by the resistor R72. The use of a plate resistor R74 of impedance high relative to the circuit impedance of the tuning mesh prevents the capacitors C46 and C76 from having any appreciable effect in the resonant circuit of the oscillator 8 when the triode 70 is cut off due to the presence of a negative signal on its control grid. When a positive signal appears upon the grid of switch tube

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70 its impedance becomes negligible and it has substantially the effect of connecting conductor 48 to ground. Thus, under these circumstances the capacitors C46 and C76 are substantially fully effective in the resonant circuit of the tone signal oscillator, and cause the frequency of the latter to be lowered approximately one-half semi-tone.

It is to be noted that when the grid of the triode 70 is driven in a positive direction conduction does not occur instantaneously because of the curvature of the grid-voltage plate current characteristic, and due to the fact that the input wave does not have infinitely steep slopes. It may also be noted that the characteristics of the triode 70, including its plate resistance do not play a substantial role in the production of the vibrato effect. When the triode 70 is conducting its impedance is very low relative to the circuit impedance of the tuning mesh and variations in the tube impedance thus have substantially no effect. Likewise, neither the exact cutoff point of the tube 70, nor its gain factor, are of importance, because the voltage supplied by the oscillator 50 is of such great magnitude that the triode 70 is in the circuit one-half of the time and substantially out of the circuit during the remainder of the cycle, and changes in the exact cutoff point would not alter this half and half ratio factor.

It will be understood that the vibrato oscillator 50 may be of any suitable type in which the output wave is positive during approximately half its cycle and negative during the remaining portion of its cycle. Such oscillator devices as multivibrators and the like may be substituted for the phase shift oscillator shown. Likewise, the tone signal oscillator 8 may be of any suitable type employing a resonant tuning mesh for determining its oscillation frequency. It will be understood, however, that the circuit arrangement shown, in which the oscillator is tuned by key controlled switches which change the amount of inductance of the circuit, is preferred at present because the oscillator may then be tuned throughout a wider range, and the minor changes in the resonant frequency of the circuit, as are required for the vibrato, may be obtained by coupling additional capacitors in and out of the tuning circuit in parallel with the inductance thereof.

While I have shown and described a preferred embodiment 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 inductance capacitance resonant circuit the resonant frequency of which determines the frequency of an electrical tone signal generator, the combination of an oscillator operating at a vibrato frequency, a triode, a current limiting coupling connection between the output of the oscillator and the input of the triode, the response characteristics of the triode to input voltages being such that the negative and positive voltage peaks produced by the vibrato frequency

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oscillator are much greater respectively than the levels necessary to cut off the triode and cause grid current therein, a capacitor, and means including the cathode circuit of said triode for effectively coupling said capacitor in said resonant circuit whenever the triode is rendered conductive during the positive swing of the output of the oscillator.

2. In combination, a musical tone frequency generating oscillator having a tuning circuit including a first capacitor the capacitance of which is a factor in determining the frequency of oscillation of the oscillator, said first capacitor having one plate thereof connected to a terminal of fixed direct current potential, a source of alternating current of vibrato frequency, a multi-electrode discharge device having a control grid connected to said source and having its cathode connected to the fixed potential terminal, a high value resistor connecting the anode of the device to a source of plate potential, a second capacitor of value such that when connected in parallel with the first capacitor the frequency of operation of the tone frequency generating oscillator will change by approximately three per cent, and means including the anode and cathode of the electron discharge device to connect the second capacitor in parallel with the first capacitor whenever the electron discharge device is rendered conductive.

3. In combination, a tone frequency generating oscillator having a tuning circuit including a first impedance the value of which is a factor in determining the frequency of oscillation of the oscillator, a second oscillator operating at a vibrato frequency, an electron discharge device coupled to the output of the second oscillator, the electron discharge device having voltage response characteristics and the second oscillator having voltage producing characteristics such that the electron discharge device is cut off during substantially all of each negative half cycle of the output signal of the second oscillator and draws grid current during substantially all of each positive half cycle of said output signal, a second tuning impedance, and a circuit including a part of the output circuit of said electron discharge device for connecting the second impedance effectively in parallel with the first impedance whenever the device is rendered conductive by the output signal of the second oscillator.

4. In combination, a tone frequency generating oscillator having a tuning circuit including a first capacitor the value of which is a factor in determining the frequency of oscillation of the oscillator, a second oscillator operating at a vibrato frequency, an electron discharge device coupled to the output of the second oscillator, the voltage producing characteristics of the sec-

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ond oscillator and the voltage response characteristics of the electron discharge device being such that the electron discharge device is greatly overdriven by the second oscillator with the result that the electron discharge device alternately is completely non-conductive and virtually completely conductive, a second capacitor, and a circuit including a part of the output circuit of said electron discharge device for connecting the second capacitor effectively in parallel with the first capacitor whenever the device is rendered conductive by the output signal of the second oscillator.

5. In combination, a tone frequency generating oscillator having a tuning circuit including an impedance the value of which is a factor in determining the frequency of oscillation of the oscillator, a multi-electrode electron discharge device having means associated therewith for providing alternate complete non-conduction and virtually complete conduction between a pair of its electrodes at a vibrato rate, a coupling between one of said pair of electrodes and a terminal of fixed direct current potential, and a coupling between said impedance and the other of said pair of electrodes, whereby the alternation of conduction and non-conduction between said pair of electrodes will change the effectiveness of said impedance in the oscillator tuning circuit and change the frequency of oscillation of the oscillator at a vibrato rate.

6. In combination, a tone frequency generating oscillator having a tuning circuit including a first impedance the value of which is a factor in determining the frequency of oscillation of the oscillator, an electrical source of a vibrato frequency, an electron discharge device coupled to the output of the source, the source being constructed to produce a voltage greatly exceeding the voltage handling characteristics of the electron discharge device so that the latter is alternately driven completely non-conductive and substantially completely conductive a second tuning impedance, and a circuit including a part of the output circuit of said electron discharge device for connecting the second impedance effectively in parallel with the first impedance whenever the device is rendered conductive by the output signal of the vibrato frequency source.

JOHN M. HANERT.

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