

Aug. 11, 1959

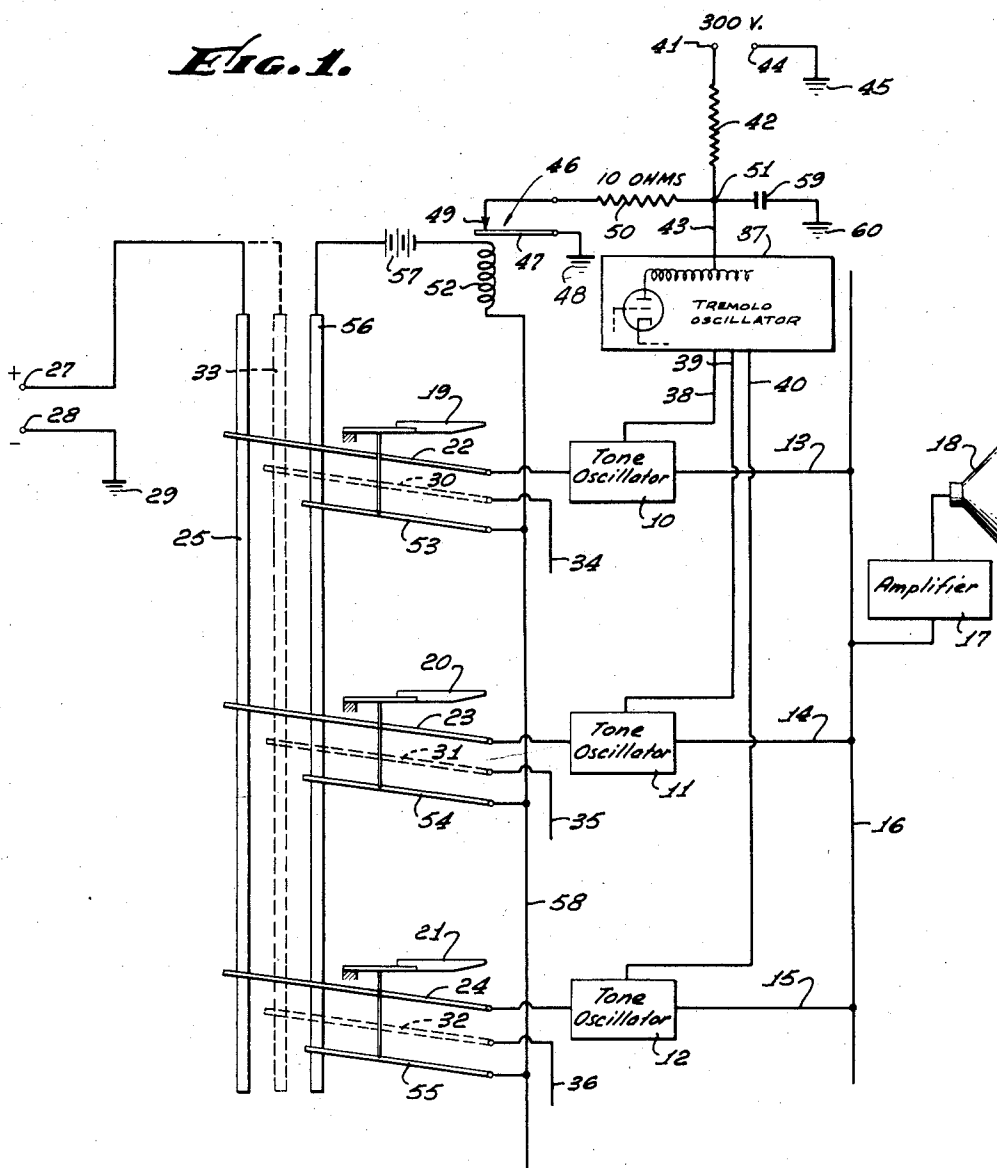
D. J. LESLIE

2,899,644

ELECTRONIC TREMOLO DEVICE

Filed March 12, 1956

6 Sheets-Sheet 1



INVENTOR.
DONALD J. LESLIE
BY *Flann and Flann*
ATTORNEYS.

Aug. 11, 1959

D. J. LESLIE

2,899,644

ELECTRONIC TREMOLO DEVICE

Filed March 12, 1956

6 Sheets-Sheet 2

FIG. 2.

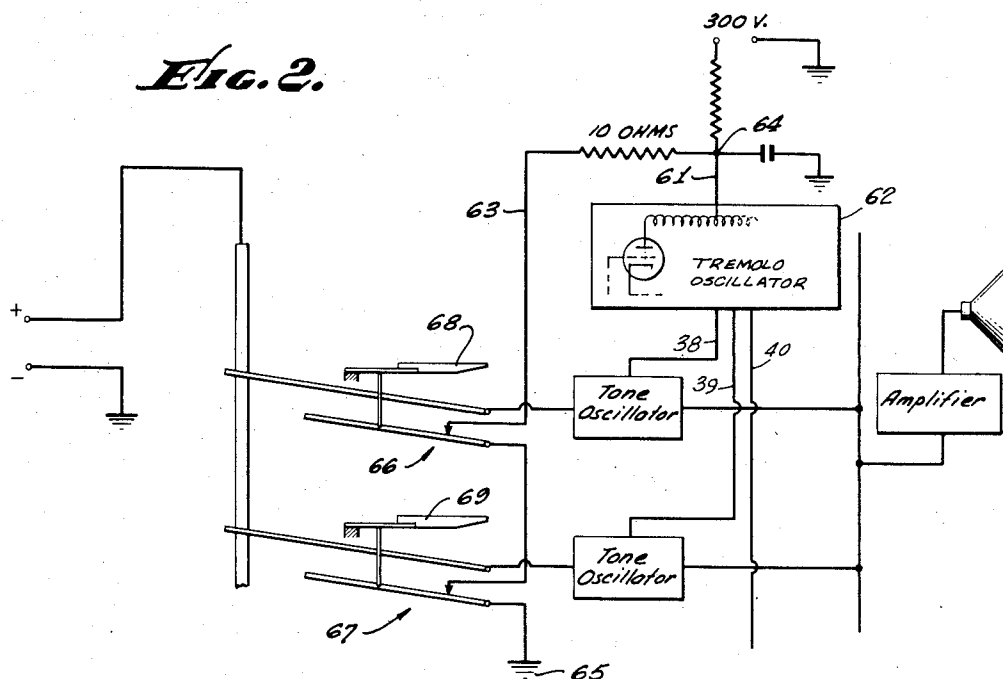
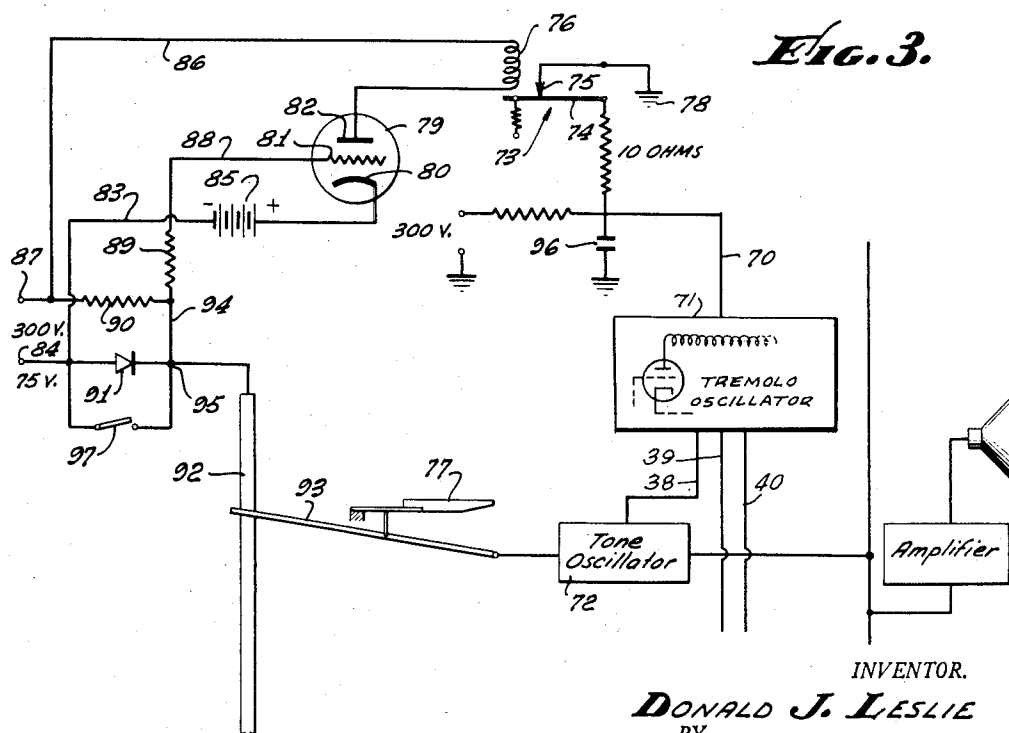


FIG. 3.



INVENTOR.

DONALD J. LESLIE

BY

Flann and Flann

ATTORNEYS.

Aug. 11, 1959

D. J. LESLIE

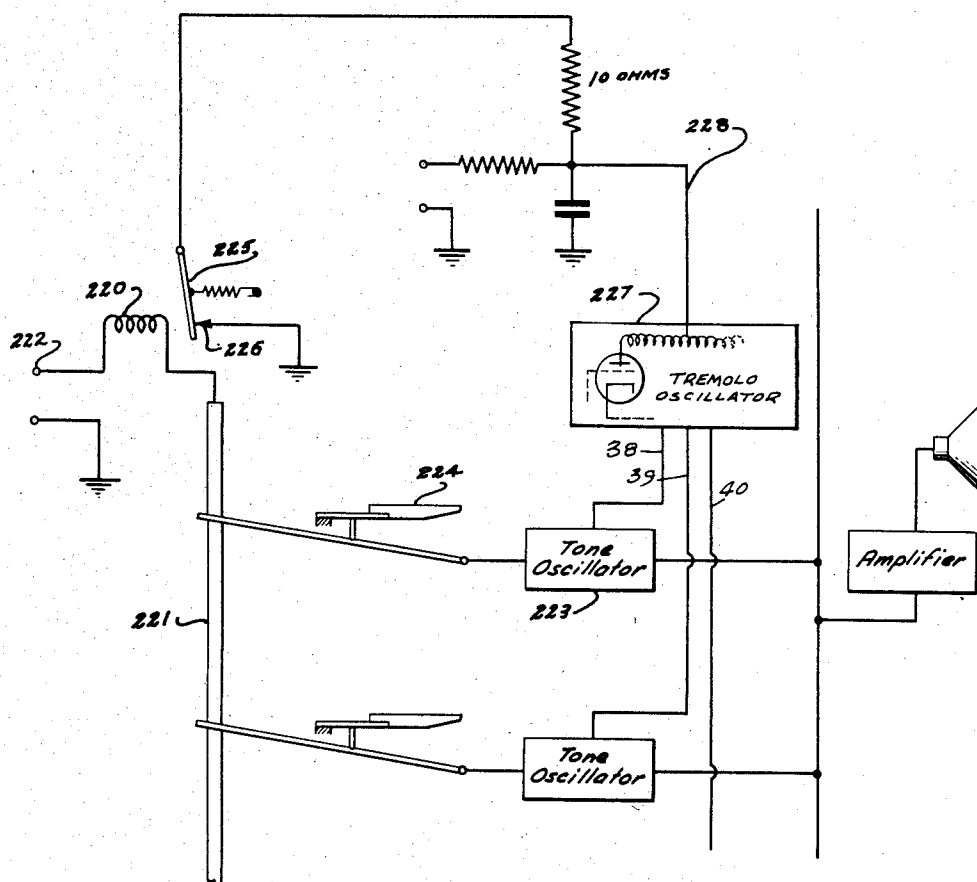
2,899,644

ELECTRONIC TREMOLO DEVICE

Filed March 12, 1956

6 Sheets-Sheet 3

Fig. 3a.



DONALD J. LESLIE
INVENTOR.

BY *Flaw and Flaw*

ATTORNEYS.

Aug. 11, 1959

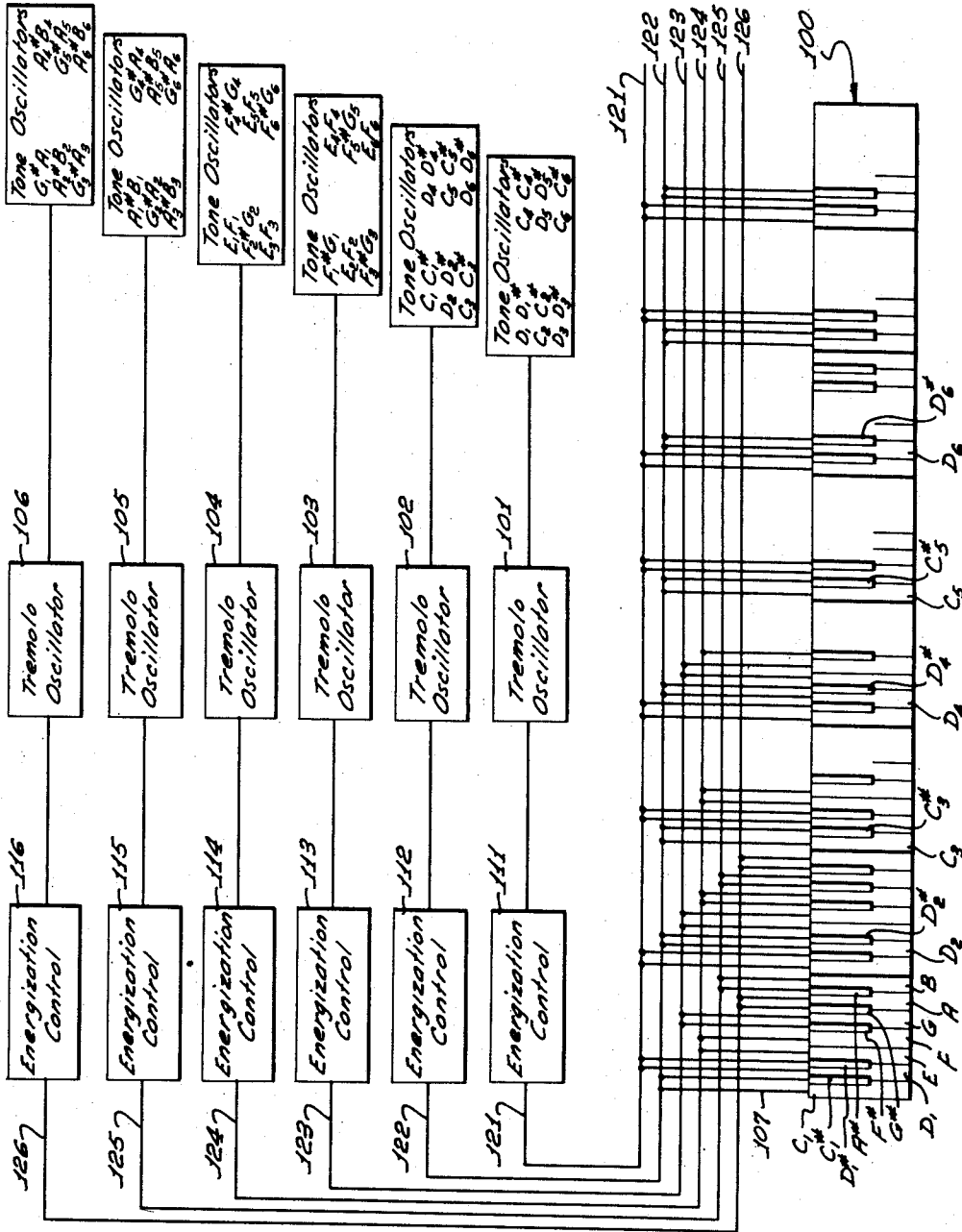
D. J. LESLIE

2,899,644

ELECTRONIC TREMOLO DEVICE

Filed March 12, 1956

6 Sheets-Sheet 4



Aug. 11, 1959

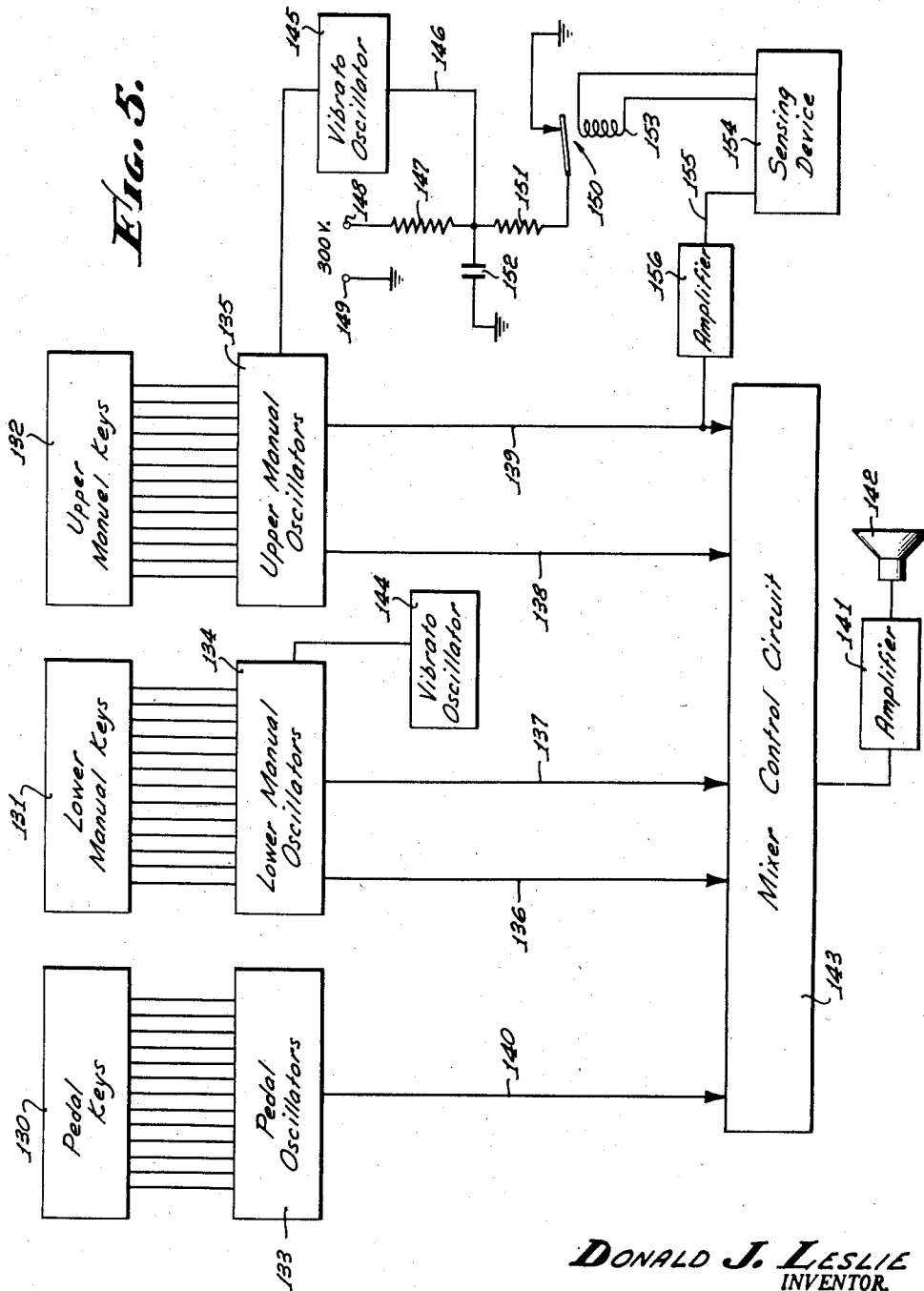
D. J. LESLIE

2,899,644

ELECTRONIC TREMOLO DEVICE

Filed March 12, 1956

6 Sheets-Sheet 5



DONALD J. LESLIE
INVENTOR.

BY *Flam and Flam*
ATTORNEYS.

Aug. 11, 1959

D. J. LESLIE

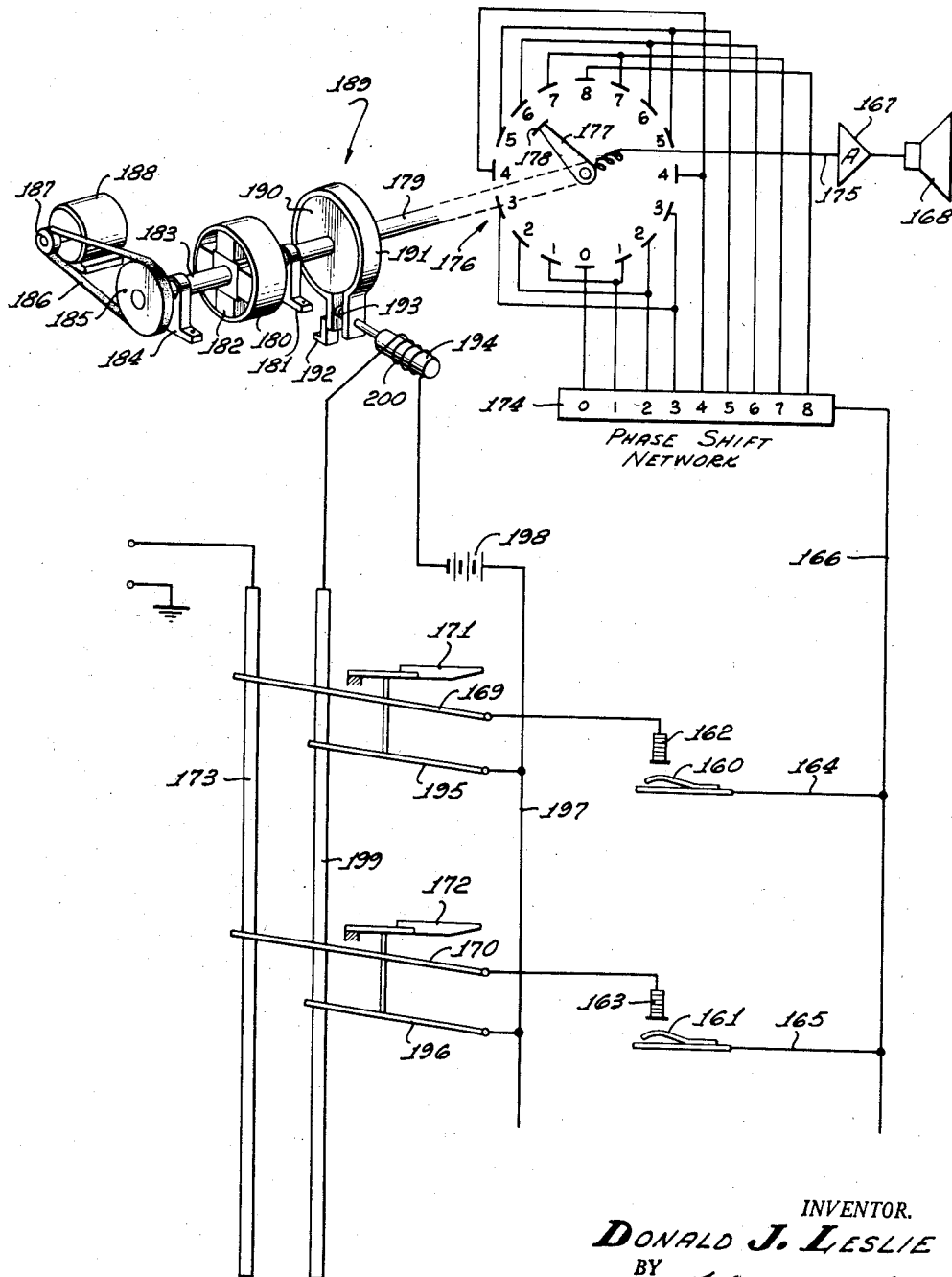
2,899,644

ELECTRONIC TREMOLO DEVICE

Filed March 12, 1956

6 Sheets-Sheet 6

Fig. 6.



INVENTOR.
DONALD J. LESLIE
BY *Flam and Flam*
ATTORNEYS.

1

2,899,644

ELECTRONIC TREMOLO DEVICE

Donald J. Leslie, Pasadena, Calif.

Application March 12, 1956, Serial No. 571,027

26 Claims. (Cl. 331—49)

2

This invention relates to electronic musical instruments and especially to apparatus for adding tremolo or vibrato to electrically created tones, such as vacuum tube oscillators, rotary magnetic or electrostatic generators, or vibrating reeds with associated pick-up arrangements.

In some instruments of this character it is common practice to use a tremolo device such as a vacuum tube oscillator or mechanically operated voltage variation means which periodically detunes a tone oscillator at a rate of from five to eight cycles per second in order to obtain the vibrato or tremolo effect. It is well known that a tone oscillator circuit may be arranged so that its frequency of output will be sensitive to one of the direct current voltages supplied to the oscillator, and the purpose of the vibrato oscillator or vibrato device is to supply a varying voltage at tremolo frequencies which, in turn, detunes the tone oscillator by the desired amount.

In other instruments fixed frequency generators are often employed, such as rotary generators using magnetic or electrostatic pick-up means or vibrating reeds with associated pick-ups. In this class of instruments a phase shifting network is often employed that will impart tremolo, and often vacuum tubes are used in the phase shifting network which may be controlled by direct current voltages pulsating at tremolo frequencies to cause varying amounts of phase shift to occur in the network. In this second class of instruments it is therefore possible to stop, start, and control tremolo effects by varying a direct current voltage from a suitable device.

Tremolo devices in the past have been operative to create tremolo throughout the duration of the tone produced by the instrument. However, it is apparent that techniques used by artists with violins or other instruments, for example, are materially different from constant tremolo. For example, a pitch may be started without tremolo and then tremolo may be gradually added in increased amounts and speed until a maximum is reached for a particular tone.

The primary object of this invention is to make it possible for such interpretive effects to be accomplished in electronic musical instruments of this character. This object is accomplished by novel circuits in which the tremolo oscillator or other tremolo producing device is energized or controlled to cause increasing amounts of tremolo after operation of a key corresponding to the tone desired to be produced.

Another object of this invention is to make it possible to incorporate such features in an electronic musical instrument without undue multiplication of parts.

Another object of this invention is to provide an inertia mechanism for operating a mechanical device for producing tremolo in which the inertia mechanism provides an increasing speed of tremolo in accordance with the existence of a tone.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of several embodiments of the invention. For this purpose, there are shown a few

forms in the drawings accompanying and forming part of the present specification. These forms will now be described in detail, illustrating the general principles of the invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a diagrammatic representation of an electronic organ incorporating the present invention; and

Figs. 2, 3, 3a, 4, 5 and 6 are, respectively, diagrammatic representations of an electric organ, each incorporating modified forms of the present invention.

In Fig. 1, there is disclosed a series of tone oscillators 10, 11 and 12, the outputs of which are connected through leads 13, 14 and 15 via a common connection 16 to an amplifier 17 and a loud speaker 18. Only three tone generators are shown. However, it will be understood that as many tone generators are provided as there are desired tones in the instrument.

The tone oscillators 10, 11 and 12 are placed in operation by manipulation of keys 19, 20 and 21 respectively associated with the tone oscillators. Each of these keys 19, 20 and 21 operates a circuit controlling arm 22, 23 and 24 to connect the tone oscillator to a source of current. On depression of the key 19, for example, the circuit controlling arm 22 engages a bus 25 connected to one terminal 27 cooperable with a current source. Another terminal 28, grounded as at 29, completes the connection pair.

The other arms 23 and 24, associated with the keys 20 and 21, may also be urged to engage the bus 25 which is utilized as a common connection for this purpose.

Depression of any one of the keys of the instrument accordingly places in operation the corresponding tone oscillator, and musical tones are produced.

Shown by way of example in Fig. 1 are supplemental circuit controlling arms 30, 31 and 32 associated with the respective keys 19, 20 and 21. These supplemental arms engage a second common bus 33, also connected to the source of current. By operation of a usual organ stop provided in the instrument, the bus 33 may be placed in operative position. Leads 34, 35 and 36, associated with the respective supplemental arms 30, 31 and 32 and cooperable with the bus 33, may establish connections to other tone oscillators corresponding to certain harmonics. Any number of supplemental arms may be associated with each key.

A tremolo oscillator 37 is coupled to all of the tone oscillators 10, 11 and 12, coupling circuits being indicated by the lines 38, 39 and 40. The tremolo oscillator creates a signal having a frequency of between five and eight cycles per second and periodically detunes the oscillators in order to create appropriate tremolo effect.

As thus far described, the apparatus is typical of many installations heretofore existing.

Plate voltage is supplied to the tremolo oscillators from a terminal 41 through a resistor 42 and a lead 43. A terminal 44, grounded as at 45, cooperates with the terminal 41 to complete the coupling pair.

Normally the tremolo oscillator 37 is ineffective to create a signal. This is accomplished by normally grounding the plate connection or lead 43. For this purpose, a normally closed relay operated switch 46 is provided. The movable arm 47 of the switch 46 is grounded as at 48. The contact 49, normally engaged by the arm 47, connects with the plate lead 43 through a small resistor 50, a connection point 51 being indicated at the plate lead 43. The function of the resistor will be described hereinafter. The resistance of the resistor 42 is many times as great as that of the resistor 50. As a specific example, the resistor 42 may have a resistance of 82,000

ohms, and the resistor 50 may have a resistance of about ten ohms. The connection point 51 and the anode of oscillator 37 are, accordingly, substantially at the potential of the ground connection 48 when the switch 46 is closed.

When the switch 46 is opened, plate supply voltage is available to the tremolo oscillator 37 since the ground connection is interrupted. The switch 46 is opened whenever a key, such as 19, 20 or 21, is depressed. A relay coil 52 is provided for this purpose. Circuit controlling arms 53, 54 and 55, associated with each of the keys 19, 20 and 21, are effective upon depression of the corresponding key to complete an energization circuit for the relay 52 to open the switch 46. A common bus 56 is connected to one side of a battery 57. The other side of the battery 57 is connected to one terminal of the relay coil 52. The other terminal of the relay coil 52 connects with a common connection 58. Each of the circuit controlling arms 53, 54 and 55 is connected to the common connection 58 and is engageable with the bus 56. Should the key 19 be depressed, for example, corresponding to energization of the tone oscillator 10, an energization circuit for the relay coil 52 will be completed as follows: One side of the battery 57, common bus 56, circuit controlling arm 53, common connection 58, through the relay 52, through the other side of the battery 57. All of the circuit controlling arms 53, 54 and 55 engageable with the common bus 56 are in parallel relationship.

When the ground connection established by the switch 46 is interrupted, plate supply voltage is increased slowly. For this purpose, a capacitor 59 is provided that connects between a ground connection 60 and the connection point 51. The capacitor 59 opposes instantaneous build-up of voltage to the tremolo oscillator.

As the plate supply voltage to the tremolo oscillator 37 slowly builds up, the amplitude and speed of tremolo are correspondingly increased. The amplitude transient characteristics are achieved by making the capacity of the capacitor 59 approximately ten microfarads. The increasing speed of the tremolo is accomplished by the change of tuning of the tremolo oscillator due to the increasing vacuum tube plate current which gradually decreases the tuning inductance as the plate current increases through saturation effects. They key must be depressed for a certain length of time before maximum tremolo effect and speed are achieved. Appropriate interpretive effects are accordingly provided that correspond to interpretive effects often employed by artists.

The small resistor 50 prevents arcing when the switch 46 is again closed.

In the form shown in Fig. 2, the lead 61 to the tremolo oscillator 62 is normally grounded in a slightly different manner. A lead 63, connecting through the 10-ohm resistor to the connection point 64 and the tremolo plate lead 61, is connected to a ground connection 65 through serially inserted, normally closed switches 66, 67, etc. associated with respective keys 68, 69, etc. On depression of any of the keys, the ground connection at 65 is interrupted and plate supply voltage may be applied to the tremolo oscillator 62. The apparatus shown in Fig. 2 otherwise operates in a manner similar to that shown in Fig. 1.

In the form shown in Fig. 3, the plate lead 70 to the tremolo oscillator 71, coupled to the various tone generators 72, is normally grounded by a relay operated switch 73. The arm 74 of the switch 73 is resiliently biased so that it normally does not engage the contact 75 of the switch. A relay coil 76 is energized to close the switch except when a circuit is established to any of the tone generators 72. Accordingly, on operation of the key 77, for example, the relay coil 76 is deenergized and the ground connection 78 to the switch arm 74 and contact 75 is interrupted so that the tremolo oscillator 71 is supplied with plate voltage.

A circuit structure utilizing a vacuum tube 79 is re-

sponsive to the existence of current to any of the tone oscillators 72. The vacuum tube 79, which includes a cathode 80, a grid 81 and a plate 82, conducts current only when current is not supplied to any of the generators 72.

The coil 76 is in the plate circuit of the vacuum tube 79. An explanation of the operation of this vacuum tube operated relay is as follows:

A lead 83 connects the cathode 80 to a plus 75-volt tap 84 through a biasing battery 85 which furnishes the proper amount of grid bias voltage to cut off all plate current in tube 79 if there are no other external potentials applied between grid and cathode. A lead 86 into which the coil 76 is serially inserted connects the plate 82 to a 300-volt tap 87. A lead 88 from the grid 81 connects through serially joined resistors 89 and 90 to the 300-volt tap 87. The resistors 89 and 90 have resistance of about two megohms and one megohm respectively.

The oscillators 72 are energized from the 75-volt tap 84. A one-way conductor or rectifier 91 is inserted between a common bus 92 engaged by corresponding arms 93 associated with the various keys 77 and the tap 84 for purposes to be presently described.

A sensing connection 94 extends from between the resistors 89 and 90 in the grid circuit to a point 95 between the rectifier and bus bar 92 of the energization circuits for the tone oscillators. When the key 77 is in its off position, the sensing connection at 95 rises above 75 volts due to the connection of resistor 90 to the 300-volt tap. The value of voltage at 95 will be limited to below 300 volts due to the back resistance of the rectifier 91, as the resistor 90 and the back resistance of the rectifier 91 form a voltage divider between the 300-volt tap and the 75-volt tap. It is well known that the back resistance of a properly selected rectifier will be high compared to its forward resistance and, therefore, the voltage rise at point 95 will be definite and reliable when the arm 93 does not make contact with the bus 92.

With the connection 94 at a value higher than 75 volts, for instance 150 volts, the potential of the grid 81 is raised in a positive direction due to the connection of resistor 89 to the point 95. Since the grid will start to permit passage of current to the cathode when it reaches the same potential as the cathode, the value of the voltage at connection 88 will rise no higher than the cathode potential; also, because the resistor 89 has a high resistance value, the grid current will be limited to a low value. The net result of the tube operation is that the actual positive value at point 95 may vary over wide limits, but voltages above those necessary to bring the grid to the same potential as the cathode will appear as a voltage drop across the resistor 89 and, therefore, the operation of the tube 79 will not be critical to the voltage supplied at connection 94 as long as there is a minimum value available to bring the grid up to the cathode potential.

With the key 77 in its off position, therefore, the grid will conduct slightly and eliminate grid-cathode bias, causing plate current to flow through coil 76 which, in turn, will operate arm 74 to close contact 75 and ground the plate supply to the tremolo oscillator through ground 78 and the 10-ohm resistor.

When key 77 is operated, the rectifier 91 conducts through a very low forward resistance between the 75-volt tap and the point 95 because even one tone oscillator requires more current than can be supplied through resistor 90. This set of conditions then provides sensing conductor 94 with 75 volts and, under these conditions, the biasing battery will supply sufficient grid bias to prevent conduction of plate 82. Accordingly, the relay 73 is deenergized and the switch arm 74 moves away from the contact 75, ungrounding the plate supply lead 70 to the tremolo oscillator.

In all other respects the arrangement shown in Fig. 3 is similar to that shown in Fig. 1 or 2, the capacitor 96 controlling the build-up of voltage to the tremolo oscillator 71.

A manually operable switch 97 parallels the rectifier so that the sensing voltage point at 94 remains at 75 volts. Under these conditions, the bias battery 85 prevents plate current in tube 79, thereby allowing contact 75 to remain open so that tremolo is applied continuously whether key 77 is operated or not. The switch 97 accordingly achieves alternate modes of operation of the instrument.

In the form shown in Fig. 3, the apparatus senses the existence of operation of the tone oscillators 72 without draining power from the circuits for the tone oscillators. This is especially important where the tuning of the oscillators depends upon a well regulated voltage source. If the oscillators are of such character as to permit power drains from the circuits without altering the tuning of the oscillators, a simpler arrangement can be provided. Thus, in Fig. 3a a relay coil 220 is serially inserted between a common bus 221 and one of the terminals 222 of a terminal pair cooperable with a voltage source for operating the tone oscillators. As in the previous form, depression of any of the keys 224 serves to energize the corresponding oscillator 223. When any one of the oscillators is so energized, current passes through the coil 220 to move a relay switch arm 225 away from its contact 226. As in the previous form, movement of this arm causes ungrounding of a connection 228 leading to a tremolo or vibrato oscillators 227. Vibrato or tremolo is accordingly permitted to build up.

The systems heretofore described may be subject to a certain disadvantage. If one key is depressed and a second key is operated before the release of the first key, the tremolo oscillator is already in operation when the second key is depressed. The full tremolo effect on the second tone will then be immediate and coincidental with the tone itself. In order that the tremolo effects start to build up with the depression of each key, as many tremolo oscillators and control circuits could be provided as there are keys. However, such an arrangement would unduly multiply the equipment necessary.

In Fig. 4 there is diagrammatically illustrated a system wherein six tremolo oscillators 101, 102, 103, 104, 105 and 106 can be connected in a manner so as to approximate this result. Grounding devices or energization building controls 111, 112, 113, 114, 115 and 116 and six electrical channels 121, 122, 123, 124, 125 and 126 are associated, respectively with the tremolo oscillators. Leads from a keyboard 100 indicate that upon depression of the corresponding keys, certain connections are made to influence one of the tremolo oscillators. The lead 107 associated with C₁, for example, establishes an energization circuit in channel 122 to the tremolo oscillator 102.

Other keys cause energization of the tremolo oscillator 102, namely, C₁#, D₂, D₂#, C₃, C₃#, D₄, D₄#, C₅, C₅#, D₆ and D₆#, all as indicated by the leads between the channel 122 and the keyboard 100.

The segregation among the channels is as follows:

121	122	123	124	125	126	Octave
D D#	C C#	F# G	E F	A# B	G# A	1
C O#	D D#	E F	F# G	G# A	A# B	2
D D#	C C#	F# G	E F	A# B	G# A	3
C O#	D D#	E F	F# G	G# A	A# B	4
D D#	C C#	F# G	E F	A# B	G# A	5
C O#	D D#	E F	F# G	G# A	A# B	6

A segregation such as this is made in view of the probability of notes being consecutively sounded. For example, there is only a small probability that C₁ and D₂ will be simultaneously sounded or sounded in rapid succession. Accordingly, by virtue of this segregation, it is expected that during the course of playing the instrument, the respective tremolo oscillators will be for the most part controlled by the length of time that a particular key is operative. As an example, if D₁ and F₁# are sounded in sequence and F₁# is operative prior to the

time that D₁ is inoperative, the following operation will result: The tremolo oscillator 101 will be operative upon initial depression of the key corresponding to D₁ and the tremolo will increase in accordance with the time that the key D₁ is operative. The tremolo oscillator 103, operative to impose tremolo on F₁#, is not operative, D₁ being ineffective to operate that oscillator. When F₁# is operated, energization for tremolo oscillations will be increased from the time that F₁# is operated.

The energization controls may take the form shown in Fig. 1, 2 or 3.

In the form shown in Fig. 3, the sensing connection for the vacuum tube 79 is established at the common bus 92. It may be more convenient, especially in modifying existing electronic organ designs, to sense the existence of a tone at the output of the oscillators.

Fig. 5 diagrammatically illustrates a system of this character. The pedal switches 130, lower and upper manual switches 131 and 132 are illustrated by block diagrams. Pedal oscillators 133, operated by the pedal switches 130, are similarly illustrated. The blocks 134 and 135 indicate groups of oscillators respectively for the lower and upper manuals.

The lower and upper manual oscillators 134 and 135 are indicated as having two types of output for each tone. The lines 136 and 138 designate groups of flute-type output connections from the respective lower and upper manual oscillators 134 and 135. Lines 137 and 139 indicate groups of string-type output connections from the respective manual oscillators 134 and 135. A line 140 indicates output connections from the pedal oscillators 133. Impulses are then transmitted to an amplifier 141 and a speaker system 142 by the aid of a mixer circuit indicated by the block 143. Appropriate stop tablet controls may operate appropriate devices for selecting the impulses transmitted through the mixer circuit 143.

Vibrato oscillators 144 and 145 are associated with some of the oscillators in groups 134 and 135, as, for example, those oscillators producing string-type outputs. The build-up of vibrato oscillations produced by the vibrato oscillators 135 is controlled in a manner similar to that of Figs. 1, 2 and 3.

Plate voltage impressed across terminals 148 and 149 is conducted to the vibrato oscillator 145 serially through a high resistance 147 connected to the terminal 148 and a connection 146. The other terminal 149 is grounded. The arm of a relay 150 normally engages a grounded contact and grounds the plate connection 146, a resistor of small resistance 151 being serially associated with the arm of the relay 150 and the plate connection 146. Upon opening of the relay 150, the plate connection 146 is ungrounded and the voltage is permitted to build up as in the previous forms.

The relay 150 is controlled by a relay coil 153 in the output circuit of an electronic sensing device 154 which may incorporate a vacuum tube as in the form shown in Fig. 3. The electronic sensing device 154 causes energization or deenergization of the coil 153 in accordance with the existence or non-existence of an impulse at the output connections 139 corresponding to the string-type oscillations. This is diagrammatically illustrated by the connection 155.

An amplifier 156, serially inserted at the connection 155, provides appropriate signal strength for control of the device 154.

Upon the existence of string-type tones from the upper manual oscillators 135, the relay 153 is energized to unground the plate connection 146.

If desired, a plurality of vibrato oscillators in place of the single oscillators 145 may be provided associated with corresponding numbers of sensing devices 154 segregated in a manner described in connection with Fig. 4.

In Fig. 6 there is diagrammatically illustrated, for purposes of example, an electronic organ utilizing vibrating

reeds 160, 161, etc. for the purpose of producing impulses corresponding to the tones throughout the musical range of the instrument. The reeds, in a well known manner, are vibrated by a current of air. The length of the reeds 160, 161, etc. is carefully controlled to determine the appropriate fundamental frequencies. The reeds 160 and 161 are opposed to tone screw pick-ups 162 and 163 to which direct current voltage is selectively applied when it is desired that the reeds 160 and 161 be operative. Each reed 160 or 161 in cooperation with its respective pick-up 162 or 163 forms a capacitor, the capacity of which cyclically changes in accordance with the vibration of the reeds. This induces a flow of alternating current in connections 164 and 165 connected to the respective reeds 160 and 161.

A common connection 166 is coupled to an amplifier 167 and a speaker system 168 in a manner to be hereinafter described. Circuit controllers 169, 170, etc., respectively associated with keys, operate to polarize the respective tone screw pick-ups 162, 163, etc. For this purpose, the circuit controller arms 169, 170 cooperate with a common bus 173 to which a direct current potential is applied.

The common connection 166 cooperates with a phase shift network 174 that has various taps numbered 0, 1, 2, 3, 4, 5, 6, 7 and 8 representing, respectively, successively increasing amounts of phase shift with respect to the impulses as it appears at the common connection 166. The connection 175 to the amplifier is cyclically associated with the taps 0 to 8 in continuous sequence by the aid of a rotary scanner 176. The cyclically varying phase shift operates to impose vibrato effect in a well known manner. The taps of the phase shift network 174 respectively connect with condenser plates located circularly about the scanner 176. A revoluble arm 177, connected as by a brush to the amplifier connection 175, carries a condenser plate 178 that is moved into coupling relationship with the circularly arranged condenser plates to establish a coupling. Upon rotation of the arm 177, the amplifier connection 175 is effectively coupled in sequence to the taps 0, 1, 2, 3, 4, 5, 6, 7, 8, 7, 6, 5, 4, 3, 2, 1, 0, etc. The cyclical variation is achieved by providing two symmetrically arranged condenser plates connected to each of the taps 1, 2, 3, 4, 5, 6, and 7.

The arm 177 is mounted upon a shaft 179 and carries at one end a cylindrical shell 180. A bearing 181 supports the shaft near the shell 180. A magnetic device 182, supported upon a shaft 183 aligned with but separate from the shaft 179, is continuously rotated. The magnetic device 182 fits with slight clearance into the shell 180 and tends to rotate the shell 180. The shaft 183 is supported by a bearing 184. A pulley wheel 185 is engaged by a belt 186 which, in turn, cooperates with a pulley 187 mounted upon a shaft of a motor 188.

The shaft 179, upon which the scanner arm 177 is mounted, is normally restrained from the rotation by the aid of a brake structure 189. The brake includes a wheel 190, mounted upon the shaft 179, and a friction band 191, one end of which is mounted upon a stationary bracket 192. The other end of the band 191 is normally urged into wrapping relationship with the wheel 190 by the aid of a spring 193, accordingly preventing rotation of the shaft 179 and the arm 177. Under this condition, there is no change in phase relationship between the amplifier connection 175 and the common connection 166, the arm 177 being stationary, and no vibrato is added.

The band 191 is released by a solenoid 194 that is energized upon depression of any of the keys 171, 172, etc. For this purpose, supplemental circuit controlling arms 195, 196, etc. are respectively associated with the keys 171 and 172. Each of the circuit controlling arms 195 connects with a common connection 197 that is connected to one side of a battery 198. The arms 195, 196, etc. are engageable with a common bus 199 that con-

nects through the solenoid coil 200 to the opposite side of the battery 198. Thus, upon depression of any of the keys, an energization circuit is completed for the solenoid 194, and the brake band 191 is removed to releasing position. The shell 180 is thus free to rotate and the shaft 179 comes up to speed.

Conveniently, the wheel 190 forms an inertia element so that the rate that the speed of the shaft 179 increases is limited. Accordingly, upon release of the band 191, as by operation of any of the keys, the speed of rotation of the scanner arm 177 increases slowly and the rate of change of phase shift correspondingly increases. Vibrato oscillations accordingly build up in speed in accordance with the time interval of operation of the keys 171, 172, etc. When the key is released, an energization circuit for the solenoid 194 is interrupted and causes the band 193 to engage the wheel 190 quickly to cause a cessation in the rotation of the shaft 179.

It is obvious that many modifications, so far as adaptations of the systems described herein are concerned, may be made without departing from the broader aspects of this invention.

Vibrato and tremolo are recognized as producing similar effects. In fact, the terms are often used interchangeably by musicians. So far as the present invention is concerned, it will readily be appreciated that the controls and circuits may be used either for tremolo or vibrato systems or for combined systems. Since no term generic to tremolo and vibrato is known, the term "vibrato," so far as used in the appended claims, will be understood as meaning tremolo or vibrato or both.

The inventor claims:

1. In an electrical musical instrument utilizing a tone oscillator and a playing key depressible for causing the tone oscillator to be effective: a vibrato oscillator having an anode and a source of potential connected to the anode; a circuit coupling the oscillators for affecting the output tone of the tone oscillator by aid of the vibrato oscillator; and circuit means operable upon depression of the playing key for modifying the potential of the anode for causing the vibrato oscillator to become increasingly active.

2. In a musical instrument: an electrical tone generator; selective means for controlling the output of impulses by the tone generator; a vibrato device increasingly operative only upon operation of the controlling means; and means for limiting the rate at which the output of the device increases after initial operation thereof.

3. In a musical instrument: means for producing an electrical impulse corresponding to a tone; means for controlling the output of impulses by the tone producing means; means for increasingly adding vibrato to the impulse and operative only upon output of impulses by the tone producing means; and means for limiting the build-up of the vibrato produced by said vibrato adding means.

4. In a musical instrument: means for producing an electrical impulse corresponding to a musical tone; selective means controlling the output of impulses by the impulse producing means; electrically energizable means for producing vibrato in amounts dependent upon the extent of energization thereof; an energization circuit for the vibrato producing means; means cooperable with the energization circuit for normally determining a minimum energization of said vibrato producing means; means operative upon the existence of output from the impulse producing means for interrupting operation of said minimum energization determining means; and time delay means for limiting the rate of increasing energization of the vibrato producing means after operation of said minimum energization determining means is interrupted.

5. In a musical instrument: a vibrato oscillator; an energization circuit for the vibrato oscillator; a relay operated switch normally preventing energization of the vibrato oscillator and operable to permit energization of said vibrato oscillator; a series of tone oscillators; con-

trollers selectively operative to cause the tone oscillators to be effective; a coupling between the vibrato oscillator and at least some of the tone oscillators; circuit means effective upon operation of any one of at least some of the controllers for operating the relay operated switch; and time delay means controlling the rate of increase of energization of the vibrato oscillator.

6. In a musical instrument: a vibrato producing device; means providing an energization circuit for the vibrato device; a series of means for producing electrical impulses corresponding to musical tones; controllers for the impulse producing means; means for causing the vibrato device to add vibrato to the impulses; a series of switches associated with the controllers and closed only when the controllers are in inoperative position; connection means connecting the switches in series and determining a circuit relationship only when all of the switches are closed to prevent energization of the vibrato device; and time delay means controlling the rate of increase of energization of the vibrato device.

7. In a musical instrument: means for producing electrical impulses corresponding to musical tones; a vibrato producing device; an energization circuit for the vibrato device; a relay operated switch normally preventing energization of the vibrato device and operable to permit energization of the vibrato device; means for causing the vibrato device to add vibrato to the impulses; a control device having an input circuit and output circuit, the output circuit including relay means for operating said switch, the input circuit including means dependent upon the output of impulses by any one of the impulse producing means; and time delay means controlling the rate of increase of energization of the vibrato device.

8. In a musical instrument: tone oscillators; a vibrato oscillator; an energization circuit for the vibrato oscillator; a relay operated switch normally preventing energization of the vibrato oscillator and operable to permit energization of the vibrato oscillator; couplings between the vibrato oscillator and at least some of the tone oscillators; a control device having an input circuit and output circuit, the output circuit including relay means for operating said switch, the input circuit including means responsive to the operation of any one of at least some of the tone oscillators; and time delay means controlling the rate of increase of energization of the vibrato oscillator.

9. In a musical instrument: means for producing electrical impulses corresponding to musical tones; an energization control circuit for said means, including a unidirectional conductor and circuit controllers; a vibrato device; means for causing the vibrato device to add vibrato to the impulses; an electronic device having an input circuit and an output circuit, the output circuit including means for permitting and preventing energization of said vibrato device in accordance with the condition of operation of said electronic device; means biasing the input circuit for one mode of operation of the electronic device in which energization of said vibrato device is prevented; a sensing connection between the input circuit and one side of said conductor; the circuit controllers, when operative, causing a flow of current through the conductor to impose a different biasing voltage on said input circuit to cause another mode of operation of said device in which energization of said vibrato device is permitted; and time delay means controlling the rate of increase of energization of the vibrato device.

10. In an electrical musical instrument: a series of tone oscillators; a series of circuit controllers for the tone oscillators; electrically common means cooperable with the circuit controllers and connected through a unidirectional conductor with a first source of direct current; a vibrato oscillator coupled to at least some of the tone oscillators; a switch; an energization circuit for the vibrato oscillator and dependent upon the switch being in one position; an electronic device having a pair of

electrodes and a control electrode; an output circuit between the pair of electrodes, and including means for moving the switch; a circuit for the control electrode connected to a second source of direct current at a potential higher than that of said first source to determine a mode of operation of said output circuit in which said switch is in said one position; a sensing connection connected to the control electrode and to the common means, and operable upon conduction through said conductor to connect said first source to said control electrode to determine a mode of operation of said output circuit in which said switch is in another position; and time delay means for limiting the rate of increase of energization of said vibrato oscillator.

11. In an electrical musical instrument: a series of tone oscillators; a series of circuit controllers for the tone oscillators; electrically common means cooperable with the circuit controllers and connected through a unidirectional conductor with a first source of direct current; a vibrato oscillator coupled to at least some of the tone oscillators; a switch; an energization circuit for the vibrato oscillator and dependent upon the switch being in one position; an electronic device having a pair of electrodes and a control electrode; an output circuit between the pair of electrodes, and including means for moving the switch; a circuit for the control electrode connected to a second source of direct current at a potential higher than that of said first source to determine a mode of operation of said output circuit in which said switch is in said one position; a sensing connection connected to the control electrode and to the common means, and operable upon conduction through said conductor to connect said first source to said control electrode to determine a mode of operation of said output circuit in which said switch is in another position; time delay means for limiting the rate of increase of energization of said vibrato oscillator; and means for selectively shunting said unidirectional conductor in order continuously to connect said first source to said control electrode.

12. In a musical instrument: a plurality of means for producing electrical impulses corresponding to musical tones; selective means controlling the output of impulses by said impulse producing means; a series of vibrato devices; means for causing the vibrato devices to impose vibrato on the impulses created by separate groups of impulse producing means respectively; means responsive to output of impulses from any of said impulse producing means for energizing the corresponding vibrato device; and time delay means for determining a slow rate of increasing energization of the vibrato device.

13. In a musical instrument: a plurality of means for producing electrical impulses corresponding to musical tones; selective means controlling the output of impulses by said impulse producing means; a series of vibrato devices; means for causing the vibrato devices to impose vibrato on the impulses produced respectively by groups of impulse producing means; means initiated upon the existence of output of impulses from said impulse producing means for energizing that vibrato device associated with the group in which said impulse producing means is included; and time delay means for limiting the rate at which the energization of each vibrato device increases.

14. In a musical instrument: a plurality of tone oscillators; a set of vibrato oscillators, each coupled to a group of tone oscillators; means initiated upon effective operation of a tone oscillator for energizing that vibrato oscillator coupled to the group in which said tone oscillator is included; and time delay means for determining a slow rate of increasing energization of each vibrato oscillator, the tone generators being so grouped that successive operation of tones in any one group is unlikely in a musical composition.

15. In a musical instrument: a series of electrical tone generators creating impulses corresponding to musical notes in a plurality of octaves; playing keys controlling

the output of impulses by the generators; a set of six vibrato devices, each operable to impose vibrato on impulses of a group of tone generators, each group including generators for two tones in each octave; means initiated upon effective operation of a tone generator in any one group for causing operation of the corresponding vibrato device; and time delay means for limiting the rate at which the output of each vibrato device increases.

16. In a musical instrument: a series of electrical tone generators creating impulses corresponding to musical notes in a plurality of octaves; playing keys controlling the output of impulses by the generators; a set of six vibrato devices, each operable to impose vibrato on impulses of a group of tone generators, each group including generators for two consecutive half tones in alternate octaves and next consecutive two half tones in the other octaves; means initiated upon operation of a tone generator in any one group for causing operation of the corresponding vibrato device; and time delay means for limiting the rate at which the output of each vibrato device increases.

17. In a musical instrument: a vibrato oscillator having a plate circuit including an inductance element, the reactance of which decreases upon an increase in plate current; means supplying plate energization for the vibrato oscillator; means for producing an electrical impulse corresponding to a musical tone; means for causing the vibrato oscillator to superimpose vibrato oscillations on the electrical impulse; means cooperable with the plate current supplying means for normally determining minimum plate current for the vibrato oscillator; means responsive to the operation of said impulse producing means for interrupting operation of said minimum plate current determining means to permit build-up of plate energization; and time delay means for limiting the rate of increasing plate energization of the vibrato oscillator after interruption of said minimum plate current determining means.

18. In a musical instrument: means for producing electrical impulses corresponding to musical tones; a vibrato producing device; an energization circuit for the vibrato device; means including a relay operated switch normally preventing energization of the vibrato device; means for causing the vibrato device to add vibrato to the impulses; means sensing the existence of an impulse for determining the position of said switch; and time delay means controlling the rate of increase of energization of the vibrato device.

19. In a musical instrument: means for producing electrical impulses corresponding to musical tones; selective means for controlling the output of impulses from said impulse producing means; rotary means operable to produce vibrato in amounts corresponding to the speed of said rotary means; means normally preventing rotation of said rotary means; means for initiating rotation of said rotary means upon the existence of an output impulse; and means limiting the rate of increase of rotation of said rotary means.

20. In a musical instrument: means for producing electrical impulses corresponding to musical tones; selective means for controlling the output of impulses from said impulse producing means; a rotary device operable to produce vibrato in amounts corresponding to the speed of said rotary means; a brake normally preventing rotation of the rotary device; a slipping clutch for connecting the rotary device to a drive; and means for releasing the brake only upon the existence of an output impulse; the inertia of the rotary device determining a slow rate of increase of rotation of said rotary device.

21. In a musical instrument: means for producing

electrical impulses corresponding to musical tones; selective means for controlling the output of impulses from said impulse producing means; a rotary device operable to produce vibrato in amounts corresponding to the speed of said rotary means; a first magnetic clutch element carried by the rotary device; a second magnetic clutch element adapted to be continuously rotated and in operative relationship with the first magnetic clutch element; an inertia member carried by the rotary device; a band cooperable with the inertia member for holding the rotary device against rotation; resilient means urging the band into engagement with the inertia member; electromagnetic means for releasing the band; and means operative upon the existence of an output impulse for energizing the electromagnetic means.

22. In a musical instrument: means for producing a tone corresponding to a musical note; a key movable to one position for operating said means; and means for producing vibrato in increasing amounts dependent upon the period that the key is in said one position.

23. In a musical instrument: means for producing electrical impulses corresponding to musical tones; an operating circuit for said impulse producing means; selectively operable key means for controlling the output of impulses; a relay coil in circuit relationship with said operating circuit; electrically operated means for producing vibrato; means for initiating operation of said vibrato producing means only upon energization of said relay coil; and means limiting the rate of increase of vibrato after operation of said vibrato producing means is initiated.

24. In an electrical musical instrument: a series of tone oscillators; selectively operated control circuits for the tone oscillators for determining the tones produced by the instrument; means for adding vibrato; means responsive to tone producing operation of a control circuit for initiating operation of the vibrato means; and means determining a limited rate of increase of vibrato produced by said vibrato means after initiation of the operation of said vibrato means.

25. In an electrical musical instrument: a series of tone oscillators; selectively operated control circuits for the oscillators for determining the tones produced by the instrument; means for adding vibrato; means controlling the operation of the vibrato means, including a circuit controller movable in response to tone producing operation of a control circuit, for limiting the rate at which the output of the vibrato means increases upon operation of said one control circuit.

26. In an electrical musical instrument: a series of tone oscillators; energization circuits for the tone oscillators; selectively operated control circuits for the oscillators for determining the tones produced by the instrument; common means for adding vibrato; an operating circuit for initiation of the operation of the vibrato means, including a circuit controller that must be in one position for operation of the vibrato means; a common electromagnetic coil in circuit relationship with said control circuits for moving said circuit controller to said one position only in response to tone producing operation of any one of the control circuits; and means determining a limited rate of increasing output by said vibrato means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,245,354	Mroz	June 10, 1941
2,401,372	Rienstra	June 4, 1946
2,486,208	Rienstra	Oct. 25, 1949
2,768,551	Chick	Oct. 30, 1956