Sept. 22, 1959 T. J. GEORGE 2,905,905

ELECTRICAL MUSICAL INSTRUMENT

Filed Feb. 1, 1954 2 Sheets-Sheet 1

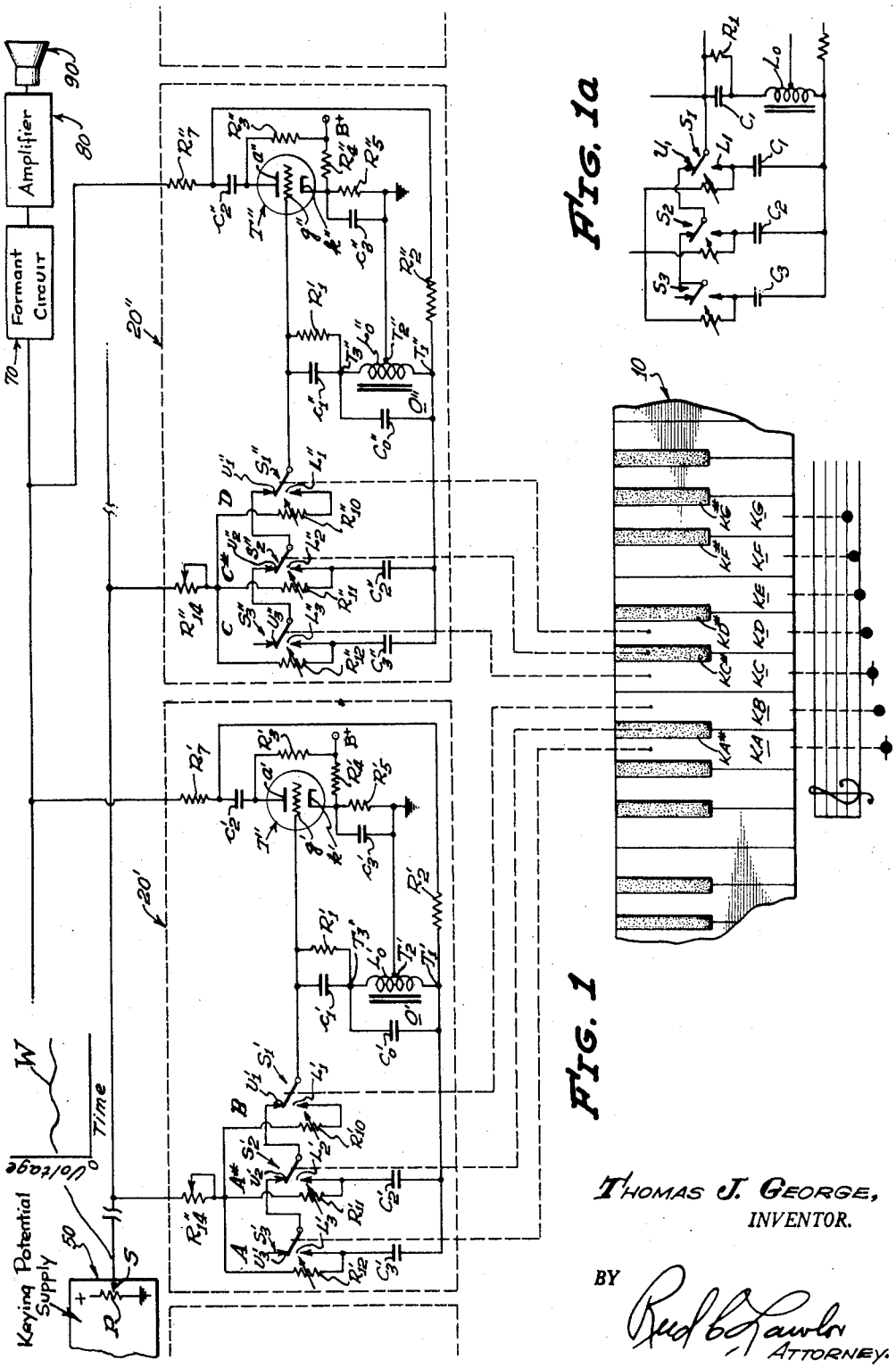

FIG. 1

FIG. 1a

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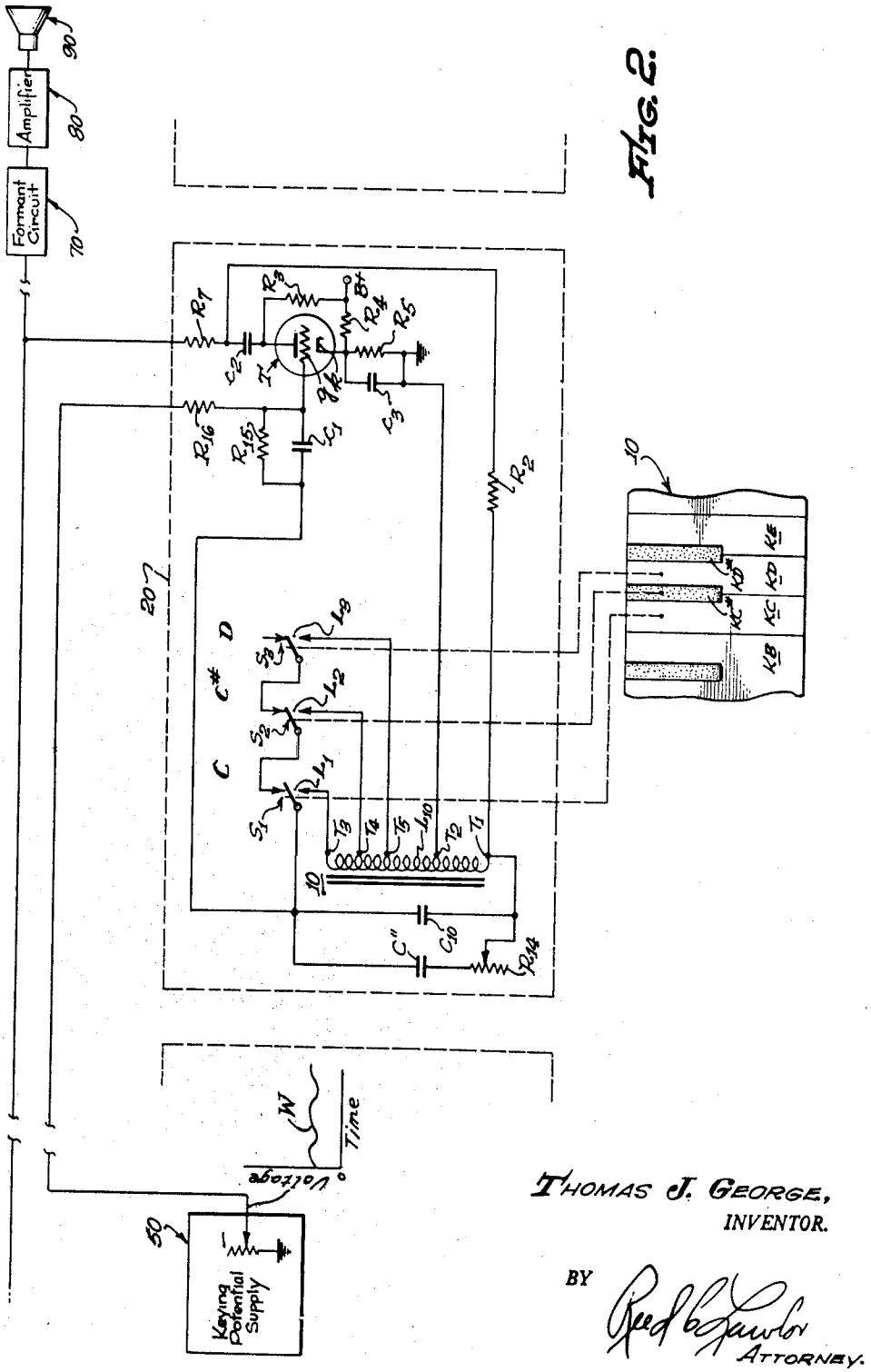

FIG. 2.

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2,905,905

ELECTRIC MUSICAL INSTRUMENT

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29 Claims. (Cl. 331—49)

This invention relates to electrical musical instruments and more particularly to improvements in electrical switching systems employed to generate various notes in such instruments.

In electrical musical instruments, such as electronic organs, a keyboard which is provided with a plurality of manually or pedally operated keys, is employed to operate switches that control circuits that generate electrical waves of various frequencies and these waves are reproduced acoustically to produce musical sounds. In certain types of such instruments, oscillators are employed to generate the sounds of the various notes. In certain electrical musical instruments the electrical tone generated by each oscillator includes not only a component of fundamental frequency that represents the pitch, but also overtones, or harmonics of the second order and higher. With instruments of this type, formant circuits are employed to modify the tones produced by the oscillators so as to simulate the sounds of various mechanical musical instruments. In some instruments a separate oscillator is controlled by each key.

In any electrical musical instrument employing a keyboard, it is necessary to provide a switch for each key. In some electrical musical instruments, the key switches employ many pairs of contacts that are connected to corresponding circuits which control the harmonic content, or spectrum, of sound produced when the respective keys are pressed. In others, one pair of contacts is employed to tune the oscillator and another pair to energize the oscillator. Such switches are frequently a source of trouble, due particularly to the failure of the contacts to close properly and thereby operate the circuits when the corresponding keys are pressed. Such failure of contacts often occurs because tarnish develops on the contact surfaces. This is especially true when the contacts are employed in low-voltage circuits. To overcome this difficulty, precious metals such as palladium and platinum have been used to minimize contact failure. This of course is very expensive especially when each key switch is of the multiple contact type.

Various systems have been proposed to eliminate the need to provide an individual oscillator having its own amplifying tube for each of the keys. For example, circuits have been devised which permit one oscillator to be employed to generate any one of two or more consecutive notes, as for example, C, C♯ and D. With such a system, only one of these notes can be played at a time even though more than one key is pressed. The fact that two of such notes can not be played simultaneously is not a serious limitation since it is rare that any two notes differing by only one or two semitones would be played in the same chord. In the past, the switching systems that have been employed with such a multiple-note oscillator have employed switches that utilized at least two pairs of switch contacts per switch, the pairs of contacts of each switch being closed simultaneously to create the musical note corresponding to each key, one pair of contacts being employed to tune the oscillator

to the desired frequency and the other pair being employed to energize the oscillator.

According to the present invention in its simplest form, a single pair of contacts operated by pressing each key is employed to tune the oscillator to a predetermined frequency and to simultaneously initiate oscillation. Furthermore, in accordance with this invention, a plurality of such switches that are operated by different keys are connected to tune and operate a common oscillator and the switches are so arranged that a frequency corresponding to only one of the keys is produced and is of the correct value, even though some other key associated with the same oscillator is pressed simultaneously. Also, in accordance with the present invention, the switch contacts are included in high voltage circuits, thereby permitting the employment of relatively inexpensive contact material such as silver. Also, in accordance with the present invention, as illustrated in the forms thereof that are described herein, the various switches corresponding to different keys in a group associated with a single oscillator are arranged to connect resonant circuit means, such as reactive elements, of different values, to an oscillator that contains other resonant circuit means, when the respective keys are pressed, in order to selectively tune the oscillator to a fundamental frequency of the value that corresponds to the note being played.

In the forms of the invention described herein in detail, the resonant circuit means associated with the respective switches are reactive, and upon operation of the switches, they are selectively connected in parallel with other reactive means that is permanently connected in the oscillator to effect the desired tuning. In one form of the invention, the resonant circuit means associated with the switches are capacitive while the resonant circuit means connected permanently in the oscillator includes an inductive element; in another form of the invention, they are inductive while the resonant circuit means connected permanently in the oscillator includes a capacitive element. As will become apparent hereinafter under some circumstances, all of the tuning for one note of a group of notes may be accomplished by means of a resonant circuit permanently connected to the oscillator amplifier, and this frequency may be altered by some of the switching keys to produce the other notes of the group. Also, under some conditions, no reactive element at all need be connected permanently to the amplifier of the oscillator.

In both forms of the invention, the oscillator includes an amplifier in the form of a triode that is inoperative when biased beyond cutoff and is operative when biased below cutoff, and the same contacts that are employed to determine the tuning of the oscillator also shift the bias to initiate the oscillation.

Accordingly, to understand the principles of the invention, reference is made to the following description and to the drawings, wherein like reference characters in the different figures indicate like elements and in which:

Fig. 1 is a wiring diagram of a portion of an electronic organ to which my invention is applied;

Fig. 1*a* is a fragmentary wiring diagram of an alternative form of the invention; and

Fig. 2 is a wiring diagram of an alternative form of oscillator.

General description

The electronic organ illustrated in Fig. 1 employs a manual keyboard **10**, a plurality of multiple-note oscillators **20**, a keying potential source **50**, a formant circuit **70**, a power amplifier **80**, and a loudspeaker **90**.

This electronic organ operates on the chromatic scale, each octave containing four groups of three notes each,

namely, the first group, A, A♯, B, the second group C, C♯, D, the third group D♯, E, F, and the fourth group F♯, G, G♯. The keys in each group are employed to control the generation of electric waves by a corresponding oscillator **20**. While the organ may contain three, or even five octaves, only two oscillators are shown.

For convenience in describing the invention, the superscripts ′, ″, etc., are employed to designate identical or corresponding parts of the circuits that are located in the respective oscillators **20**. However, the superscripts are sometimes omitted when the description applies equally to different groups of notes.

All of the oscillators **20** corresponding to the respective groups are of the same design except, however, that some of the components have different values as explained more fully hereinafter. The oscillator **20′** is operated by the keys KA, KA♯, and KB in the first group, while oscillator **20″** is operated by the keys KC, KC♯, and KD, in the second group, etc. Outputs from all the oscillators **20′**, **20″**, etc., are transmitted through the common formant circuit **70** to the power amplifier **80**, which supplies the loudspeaker **90** in which the various musical tones are audibly reproduced.

Though the oscillators **20** may be of other types, as shown here, they employ Hartley circuits that utilize amplifier tubes in the form of vacuum triodes T, hereinafter for simplicity merely called amplifiers. Three switches S_1, S_2, and S_3 are arranged in sequence in each oscillator **20** to tune and operate each oscillator **20** at a different frequency according to the key that is pressed. The first switch S_1 has a pair of normally-closed upper contacts U_1 and a pair of normally-open lower contacts L_1; the second switch S_2 has a pair of normally-closed upper contacts U_2 and a pair of normally-open lower contacts L_2; and the third switch S_3 has only a pair of normally-open lower contacts L_3. The designations upper and lower are employed here not to designate physical positions in the organ itself, but merely to assist in distinguishing between the pairs of contacts.

The keys KA, KA♯, KB, KC, KC♯, and KD, . . . are connected through suitable linkages or levers of conventional type to the corresponding switches S_3'', S_2', S_1', S_3'', S_2'', and S_1'', respectively, so that each of the switches is operated when the corresponding key is pressed and restores when the key is released. Sometimes hereinafter, when the description is equally applicable to any key, it is referred to simply by the symbol K. Likewise the symbols L and U are employed to refer to contacts of a typical switch S.

When no note is being played, all of the switches S_1', S_2', S_3', S_1'', S_2'', S_3'', etc., are in their normal, or restored positions in which the upper pairs of contacts U_1', U_2', U_1'', U_2'', etc., are closed, and the lower pairs of contacts L_1', L_2', L_3', L_1'', L_2'', L_3'', etc., are open. But when a note is to be played the corresponding key K is depressed thereby opening the normally-closed upper contact U and closing the normally-open lower contact L of the corresponding switch S.

Oscillator design and switching circuit

Each of the oscillators employs a triode and a tuned parallel-resonant circuit O that includes a capacitor C_0 and an inductor L_0. The inductor L_0 is provided with end terminals T_1 and T_3 and is divided into two parts by means of a grounded center tap T_2. One terminal T_3 of the inductor L_0 is connected to the grid *g* of the corresponding triode T through a blocking capacitor C_1 and also through a grid resistor R_1 that is connected in parallel with the capacitor C_1. The other terminal T_1 of each inductor L_0 is connected to the anode of the corresponding triode T through a feedback resistor R_2 and a blocking condenser c_2 in series with the feedback resistor R_2. Positive voltage from a suitable power supply having a negative point grounded is applied to the B+ terminal, this power being applied to the anode *a* through a shunt resistor R_3 and being applied to the cathode *k* through a potential dividing network including resistors R_4 and R_5. The latter resistor R_5 of the potential divider is connected between the cathode *k* and ground and is shunted by a by-pass condenser c_3. The output of each oscillator **20** appearing at the anode *a* is applied through the corresponding blocking condenser c_2 and a corresponding plate resistor R_7 to the input of the formant circuit **70**.

The values of the resistors R_3, R_4, and R_5, are so chosen that when no bias is applied to the triode T through any of the switches S_1, S_2, and S_3, the grid *g* is biased a few volts beyond cutoff. In this condition, the triode is inoperative and the oscillator does not oscillate.

The stationary members of the pairs of lower contacts L_2 and L_3 of the two switches S_2 and S_3 are connected through condensers C_2 and C_3 to the terminal T_1 of the oscillator circuit O remote from the connections to the grid *g*. The stationary members of the pairs of lower contacts L_1, L_2, and L_3 of all three switches are connected to the keying potential source **50** through individual isolation resistors R_{10}, R_{11}, and R_{12} respectively, and a common variable tuning resistor R_{14}.

The movable arm of the first switch S_1 is connected directly to the grid *g*. The movable arm of the second switch S_2 is connected to the stationary member of the upper pair of contacts U_1 of the first switch S_1, and the movable arm of the third switch S_3 is connected to the stationary member of the upper contact U_2 of the second switch S_2. Thus, when the switches are in their normal or restored condition, no voltage from the keying potential source **50** is supplied to the grid *g* and it is biased to cutoff. Also, in this normal or restored condition, the movable arm of the third switch S_3 is connected through the upper contacts of U_2 and U_1 of the second and first switches to the grid *g*.

It will be apparent that a capacitor C_1 could be connected between the stationary member of the lower pair of contacts L_1 of the first switch S_1 and the terminal T_1 in order to tune the oscillator to the desired frequency when contacts L_1 are closed. Furthermore, it will be noted that if such a capacitor C_1 is employed, the capacitor C_0 may be omitted as shown in Fig. 1*a*, provided only that the values of the capacitors C_1, C_2, C_3, are so chosen as to produce the desired tuning. However, considerable economy is effected by omitting condenser C_1, and employing the main tuning condenser C_0 as shown in Fig. 1.

Operation

The operation of a typical oscillator **20″** for generating the notes C, C♯, and D is described in detail below.

To play the note D, the corresponding key KD is depressed, thereby operating the corresponding first keying switch S_1'', opening the upper contacts U_1'' and closing the lower contacts L_1''. When the first switch S_1'' is thus operated, the second and third switches S_2'' and S_3'' are rendered inoperative, being totally disconnected from the grid *g′*. When the switch S_1'' is operated, a positive voltage from the keying potential source **50** is applied through a resistor R_{10}'' and the lower contacts L_1'', directly to the grid *g*. Also, when the grid circuit is thus energized the oscillator **20″** oscillates at a frequency determined primarily by the constants of the inductor L_0'' and the main tuning capacitor C_0''. When the key KD is released, the first switch S_1'' restores, opening lower contacts L_1'' and closing upper contacts U_1'', thereby biasing tube T beyond cutoff, de-energizing the oscillator and terminating the note D. At the same time the second and third switches S_2'' and S_3'' are prepared for operation by being connected again to the grid *g″*.

To play the note C♯, the corresponding key KC♯ is depressed, thus operating the second keying switch S_2'', opening the upper contacts U_2'' and closing the lower contacts L_2''. When the second switch S_2'' is

thus operated, the third switch S_3'' is rendered inoperative, being totally disconnected from the grid g''. Also, when the switch S_2'' is thus operated, the condenser C_2'' is effectively connected in parallel with the main tuning capacitor C_0'', thus altering the resonant frequency of the oscillator circuit O. At the same time, positive voltage is applied from the keying potential source **50** through the resistor R_{11}'' to the grid g''. As a result, the oscillator **20''** is tuned to the fundamental frequency of the note C♯ and oscillation is simultaneously initiated. When the key KC♯ is released, the switch S_2'' restores thereby terminating the generation of the C♯ note. At the same time the third switch is prepared for operation by being connected again to the grid g''.

To play the note C, the corresponding key KC is depressed, thus operating switch S_3'', closing the lower contact L_3''. When the switch S_3'' is thus operated, the capacitor C_3'' is connected in parallel with the main tuning condensers C_0, thus altering the resonant frequency of the oscillator circuit O. At the same time, positive voltage is applied from the keying potential source through the resistor R_{12}'' to the grid g''. As a result, the oscillator **20''** is tuned to the fundamental frequency of the note C and oscillation is simultaneously initiated. When the pressure on the key KC is released, the switch S_3'' restores, thereby terminating the generation of the C note.

In operation then, when any one of the keys KC, KC♯, or KD is depressed, the corresponding note C, C♯ or D is produced. It will be noted however, that if two of the keys are depressed simultaneously, only the sound corresponding to the higher pitch note is produced. Thus, if the key KD and either the key KC♯ or the key KC are depressed, the note D is played because the operation of the switch S_1'' disconnects the moving arms of the switches S_2'' and S_3'' from the grid g. Similarly, if the keys KC♯ and KC are both depressed, the note C♯ is played, because the operation of the switch S_2'' disconnects the moving arm of the switch S_3'' from the grid g''.

It is thus seen, that, although three switches associated with each oscillator are employed to produce three different notes, only one note can be produced at a time and the operation of more than one switch does not interfere with the correct and accurate production of that note. In spite of this, many or almost all chords that appear frequently in the usual musical composition can be played because it is seldom that chords employ notes that are only a tone or semitone apart. Even such chords as these may often be played if the close notes appear in groups of notes associated with different oscillators.

By employing a relatively high keying potential, such as a voltage of about 70 volts, across the contacts when open, low cost contacts, such as silver contacts, may be employed.

Frequency shift

In practice, the frequency of oscillation is determined primarily by the values of the inductor L_0 and the capacitor C_0, and to some small extent also upon the value of the voltage applied to the grid g. For this reason, if the keying potential source **50** consists only a regulated voltage supply, the frequencies of the sounds produced upon the closure of any of the keys have some predetermined fixed constant values.

But, if the keying potential source **50** includes some means to cause its output to vary, then when any key is depressed, the voltage applied to the grid g varies, thereby changing the frequency of the note produced. In practice, the voltage from the keying potential source may include a relatively large D.C. component and a relatively small A.C. component of 6 c.p.s. as indicated by the waveform W at the output of the keying potential source.

When such a source of such fluctuating voltage is employed, a vibrato effect is produced.

Furthermore, the frequencies of the signals generated when the various keys associated with the oscillator are depressed may be varied somewhat by moving the sliding contact of the potentiometer p.

Provision is made for adjusting the frequencies of the individual notes by employing variable resistors as isolation resistors R_{10}, R_{11}, and R_{12}.

Circuit constants

In order to select the values of the tuning capacitors C_0'', C_2'', and C_3'', so as to generate middle C and the neighboring notes C♯ and D, some suitable value of the inductor L_0'' is first chosen, and the sliding contact s is set in midposition or at some other intermediate position, on the potentiometer p. The value of the main tuning capacitor C_0'' is then so chosen that the frequency of oscillation of the oscillator **20''** under these conditions with the first switch S_1'' closed is 293.66 c.p.s., which is the fundamental frequency of note D. Next, the value of the capacitor C_2'' is so chosen that with the second switch S_2'' depressed, the oscillator oscillates at a frequency of 277.18 c.p.s., which is the fundamental frequency of note C♯. Then with only the third switch S_3'' depressed, the value of the capacitor C_3'' is so selected that a frequency of 261.63 c.p.s., which is the fundamental frequency of middle C, is generated by the oscillator.

When a 6J5 is employed as amplifier T and the value of the voltage supplied by the keying potential source **50** is 70 volts and the voltage applied to the B+ terminal is 150 volts, suitable values for the various components of the oscillator **20''** for generating the notes middle C, middle C♯, and middle D are as follows:

$c_1''=0.05\mu f.$
$c_2''=0.02\mu f.$
$c_3''=0.5\mu f.$
$C_0''=0.03\mu f.$
$C_2''=0.004\mu f.$
$C_3''=0.0072\mu f.$
$L_0''=10h.$
$p=1{,}000{,}000\omega$
$R_1''=500{,}000\omega$
$R_2''=56{,}000\omega$
$R_3''=100{,}000\omega$
$R_4''=15{,}000\omega$
$R_5''=2{,}200\omega$
$R_{10}''=500{,}000\omega$
$R_{11}''=500{,}000\omega$
$R_{12}''=500{,}000\omega$

In this application, the following abbreviations have been used:

c.p.s.=cycles per second
h=henries
$\mu f.$=microfarad
ω=ohms

Similarly, the circuit constants of the other oscillators are so chosen that notes of the correct pitches are obtained.

It will be noted that once the circuit constants have been chosen, the frequencies produced may be varied somewhat by manipulation of the moving contact in the potentiometer p. Furthermore, if desired, the resistors R_{10}, R_{11}, and R_{12} may be made variable so that the pitches of different notes produced by an oscillator may be varied somewhat as previously mentioned.

If desired, the amplifier tubes of various oscillators may be combined in a common envelope. Thus, instead of employing a 6J5 triode in each oscillator, a dual triode such as a 6SN7 may be employed for two oscillators. In this case it is apparent that it is only necessary to employ two dual triodes in the manufacture of the oscillators required to generate any note in an entire octave of the chromatic scale. Only twelve oscillators and hence only six dual triodes are required for a three-octave organ.

Tapped Transformer Type

In an alternative embodiment of the invention illustrated in Fig. 2, there is shown an arrangement in which the keying switches tune the oscillator to the desired frequencies by connecting different inductances in parallel with a main tuning capacitor, the value of the inductances being so chosen as to tune the oscillator to the desired frequencies. This oscillator is very similar to those described above in that the plate circuits and the cathode circuits are of the same form. However, the tuning elements and the grid circuits are different as explained more fully hereinafter.

In the oscillator of Fig. 2, a tuning condenser C_{10} and tapped inductor L_{10} are employed to tune the oscillator **20** to the various frequencies desired, upon the closure of the keying switches S_1, S_2, and S_3. In this case, however, though the switches S_1, S_2, and S_3 are of the same construction as those previously described, they are connected to the grid *g* through the grid leak capacitor c_1 and grid leak resistor R_1 and they are employed to generate the notes C, C♯, and D, respectively, instead of D, C♯ and C respectively, as in the former case. The tuning inductor L_{10} is provided with five terminals including end terminals T_1 and T_3, and taps T_2, T_4, and T_5. The tap T_2 which is near the center of the inductor L_{10} is connected to ground. The terminals T_3, T_4, and T_5 are connected to the stationary members of the lower contacts L_1, L_2, and L_3 of the switches S_1, S_2, and S_3, respectively.

The main tuning capacitor C_{10} is connected between the movable arm of the first switch S_1 and the terminal T_1. This condenser is shunted by a small trimmer condenser C_{11} and a variable resistor R_{14}.

With this arrangement when the key KC is depressed, the entire inductor L_{10} is connected across the condenser C_{10} and the switches S_2 and S_3 are rendered inoperative. When the key KC♯ is depressed, the portion of the inductor L_{10} between taps T_1 and T_4 is connected across the condenser C_{10}, and switch S_3 is rendered inoperative, and when the key KD is depressed, the portion of the inductor **40** between the terminals T_1 and T_5 is connected across the condenser C_{10}. In this oscillator, as in the oscillator previously described, even if more than one key is depressed, only one note is produced because when a switch is inoperate, it can not effect the connections to the grid *g* when the corresponding key is depressed.

In order that notes of desired fundamental frequencies may be produced, the value of the inductances connected across the capacitor C_{10} upon depression of the respective switches S_1, S_2, and S_3 are so chosen that the resonant circuit **10** thereby formed has the desired characteristic. Thus, for example, if the note C is produced by operation of a switch S_1 and the connection of the entire inductor L_{10} across the condenser C_{10}, then for operation of switches S_2 and S_3 to produce the notes C♯ and D respectively, the inductance of the portion of the inductor between the taps T_4 and T_1 should be 87.6%, and the inductance of the portion of the inductor between the taps T_5 and T_1 should be 73.8%, of the inductance of the entire inductor L_{10}.

The system of Fig. 2 has the advantage over that of Fig. 1 in that aging of the inductor or capacitor of any oscillator does not change the ratio of frequencies of the three tones that may be generated by that oscillator.

In the oscillator of Fig. 2, an adjustable negative voltage from a keying potential source **50** is connected to the grid circuit through a potential dividing network including resistors R_{15} and R_{16} which may have values of 500,000 ω and 1,000,000 ω, respectively. When all the switches S_1, S_2, and S_3 are in their normal or restored conditions, the full voltage supplied from this source **50** is impressed upon the grid thereby biasing the tube T beyond cutoff. But when any of the switches S_1, S_2, or S_3, are closed, the grid *g* is connected through the grid leak capacitor c_1 and resistor R_{15} and through a portion of the inductor L_{10} to ground, thereby changing the bias on the grid to below cutoff and initiating the oscillation of the circuit.

It is thus seen that in this oscillator as in the foregoing, the operation of each key switch, both tunes the circuit and changes the bias simultaneously thereby initiating oscillation of the circuit at the desired frequency.

Conclusion

It is to be noted that in both types of oscillators described herein, the switches perform three functions. First of all, each of the switches, except the switch S_1 when capacitor C_1 is omitted in the first form of oscillator as shown in Fig. 1, connects a tuning element to a fixed tuned circuit or element to determine the frequency of oscillation. Secondly, the operation of each switch changes the bias in a grid circuit to initiate oscillation. And thirdly, each of the switches except the last in the sequence, acts to render each of the following switches in the sequence inoperative, so that if more than one key is depressed, nevertheless, only one note is produced. Furthermore, all of these functions are accomplished simultaneously in the most rudimentary fashion, namely one in which only one pair of contacts closes, and no more than one pair of contacts opens when any one switch is operated.

In the first form of the invention described above, the fixed tuning element may be in the form of an inductive reactance provided by the inductor L_0 or it may be in the form of a reactive impedance provided by the inductor L_0 and the capacitor C_0. In this case as described, the additional reactive elements are C_1, C_2 and C_3 that are connected in the circuit to change its tuning are in the form of capacitors. However, it is to be understood that at least from a theoretical standpoint they could be in the form of inductors. In the second form of the invention, however, the fixed tuning element is in the form of a capacitive reactance supplied by the capacitor C_{10} and the added tuning elements are in the form of inductive reactances provided by the various portions of the inductor L_{10} that are connected to the lower contacts of the key switches. It is to be noted that in the oscillators of this invention, a fixed tuning element or tuning circuit is permanently connected in the grid circuit and that the frequency of oscillation is altered by connecting a selected additional tuning element to the fixed or main tuning element when one of the key switches is depressed.

While only a limited number of forms of the invention have been described herein, it will be understood that the invention may be embodied in many other forms without departing from the underlying principles. It is therefore obvious that the invention is not limited to the forms described herein, but is capable of a wide variety of embodiments. Various changes which will now suggest themselves to those skilled in the art may be made in the form, details of construction, and arrangement and connection of the elements without departing from the invention. It is therefore to be understood that the invention encompasses all forms thereof that come within the scope within the appended claims.

The invention claimed is:

1. In an electrical musical instrument: an oscillator including an amplifier connected between coupled input and output circuits, said amplifier being inoperative when biased beyond cutoff but operative when biased below cutoff; means for normally biasing said amplifier beyond cutoff; a plurality of sequentially arranged resonant circuit means, each being adapted to tune said oscillator to a different frequency when connected thereto; a plurality of corresponding sequentially arranged normally restored key switches; a plurality of corresponding sequentially arranged keys, each being connected to operate the corresponding key switch when said each key is pressed and to restore the corresponding key switch when said each key is released; means controlled by the operation of each

key switch except the last in the sequence for rendering inoperative the remaining key switches following said key in the sequence; means controlled by the operation of each operative key switch for connecting the corresponding resonant circuit means to the oscillator; and means controlled by the operation of each operative key switch for changing the bias on said oscillator from beyond cutoff to below cutoff.

2. In an electrical musical instrument: an oscillator including an amplifier connected between coupled input and output circuits, said amplifier being inoperative when biased beyond cutoff but operative when biased below cutoff; means for normally biasing said amplifier beyond cutoff; a potential source; a plurality of sequentially arranged resonant circuit means, each being adapted to tune said oscillator to a different frequency when connected thereto; a plurality of corresponding sequentially arranged normally restored key switches, each including a pair of normally-closed contacts and a pair of normally-open contacts, a plurality of corresponding sequentially arranged keys, each being connected to operate the corresponding key switch when said each key is depressed and to restore the corresponding key switch when said each key is released; the normally closed contacts of each key switch except the last in the sequence being so connected that upon operation of each key switch the remaining key switches following said each key in the sequence are rendered inoperative; and the normally open contacts of each operative key switch being so connected to the respective resonant circuit means and to said potential source that upon operation it connects the corresponding resonant circuit means to the oscillator and changes the bias on said oscillator from beyond cutoff to below cutoff.

3. In an electrical musical instrument: an oscillator including an amplifier connected between coupled input and output circuits, said amplifier being inoperative when biased beyond cutoff btu being operative when biased below cutoff; means for normally biasing said amplifier beyond cutoff; a resonant circuit connected to said input circuit; a resonant circuit means that is normally disconnected from said input circuit; first switching means adapted when operated to bias said amplifier below cutoff and when restored to bias said amplifier beyond cutoff; second switching means adapted, when operated while said first switching means is restored, to connect said resonant circuit means to said resonant circuit and to simultaneously bias said amplifier below cutoff and when restored to disconnect said resonant circuit means from said resonant circuit and to simultaneously bias said amplifier beyond cutoff; first means including a first key for selectively operating and restoring said first switching means whereby oscillation of said oscillator is initiated and discontinued at one fundamental frequency; and second means including a second key for selectively operating and restoring said second switching means whereby when said first switching means is restored, oscillation of said oscillator is initiated and terminated at a different fundamental frequency.

4. In an electrical musical instrument: an oscillator including an amplifier connected between coupled input and output circuits, said amplifier being inoperative when biased beyond cutoff but operative when biased below cutoff; means for normally biasing said amplifier beyond cutoff; a first resonant circuit means connected to said input circuit; second and third resonant circuit means that are normally disconnected from said input circuit, said latter means having different values and being adapted when connected to said input circuit to tune said oscillator to different fundamental frequencies; first switching means adapted when operated to connect said second resonant circuit means to said first resonant circuit means and to simultaneously bias said amplifier below cutoff and when restored to disconnect said first and second resonant circuit parts and to simultaneously bias said amplifier beyond cutoff; second switching means adapted when operated, while said first switching means is restored, to connect said third resonant circuit means to said first resonant circuit means and to simultaneously bias said amplifier below cutoff and when restored to disconnect said first and third resonant circuit means and to simultaneously bias said amplifier beyond cutoff; first means including a first key for operating and then restoring said first switching means, whereby oscillation of said oscillator is initiated at one fundamental frequency and then discontinued; and second means including a second key for operating and restoring said second switching means, whereby when said first switching means is restored, oscillation of said oscillator is initiated at a different fundamental frequency and then discontinued.

5. In an electrical musical instrument: an oscillator including an amplifier connected between coupled input and output circuits, said amplifier being inoperative when biased beyond cutoff but operative when biased below cutoff; means for normally biasing said amplifier beyond cutoff; first and second resonant circuit means that are normally disconnected from said input circuit, said resonant circuit means being adapted when connected to said input circuit to tune said oscillator to different fundamental frequencies; first switching means adapted when operated to connect said first resonant circuit means to said input circuit and to simultaneously bias said amplifier below cutoff and when restored to disconnect said first resonant circuit means and to simultaneously bias said amplifier beyond cutoff; second switching means adapted when operated, while said first switching means is restored, to simultaneously connect said second resonant circuit means to said input circuit and to simultaneously bias said amplifier below cutoff and when restored to disconnect said second resonant circuit means from said input and to simultaneously bias said amplifier beyond cutoff; first means including a first key for operating and then restoring said first switching means, whereby oscillation of said oscillator is initiated at one fundamental frequency and then discontinued; and second means including a second key for operating and then restoring said second switching means, whereby when said first switching means is restored, oscillation of said oscillator is initiated at a different fundamental frequency and then discontinued.

6. In an electrical musical instrument: an oscillator including an amplifier connected between coupled input and output circuits, said amplifier being inoperative when biased beyond cutoff but operative when biased below cutoff; means for normally biasing said amplifier beyond cutoff; first resonant circuit means connected to said input circuit; second and third resonant circuit means that are normally disconnected from said input circuit; first switching means adapted when operated to bias said amplifier below cutoff and when restored to bias said amplifier beyond cutoff; second switching means adapted when operated while said first switching means is restored, to connect said second resonant circuit means to said first resonant circuit means in said input circuit and to simultaneously bias said amplifier below cutoff and when restored to disconnect said first and second resonant circuit means and to simultaneously bias said amplifier beyond cutoff, third switching means adapted when operated, while said first and second switching means are restored, to connect said third resonant circuit means to said first resonant circuit means and to simultaneously bias said amplifier below cutoff and when restored to disconnect said first and third resonant circuit means and to simultaneously bias said amplifier beyond cutoff; first means including a first key for operating and then restoring said first switching means whereby oscillation of said oscillator is initiated at one fundamental frequency and then discontinued; second means including a second key for operating and then restoring said second switching means only when said first switch-

ing means is restored, whereby oscillation of said oscillator is initiated at a second fundamental frequency and then discontinued; and third means including a third key for operating and then restoring said third switching means only when said first and second switching means are restored, whereby oscillation of said oscillator is initiated at a third fundamental frequency and then discontinued.

7. In an electronic organ, a plurality of shared-note oscillators, each of which is adapted to selectively produce signals forming a sequence of notes of a musical scale, each oscillator having a predetermined quiescent output state, each of said oscillators comprising a first key-operated frequency control means for selectively changing the output state of said oscillator from said quiescent state to a first predetermined state of oscillation, a second key-operated frequency control means for selectively changing the output state of said oscillator from said quiescent state to a second predetermined state of oscillation, and a third key-operated frequency control means for selectively changing the output state of said oscillator from said quiescent state to a third predetermined output state, each of said first, second and third frequency control means including circuit means for predetermining the output frequency of said oscillator, whereby said first, second and third states of oscillation are characterized by three different output frequencies respectively, means interconnecting said first, second and third frequency control means of each oscillator in an interlocked circuit whereby operation of said first frequency control means renders said second and third frequency control means inactive, and operation of said second frequency control means renders said third frequency control means inactive, and bias means selectively coupled to each of said oscillators through said first, second and third frequency control means whereby operation of any of said frequency control means simultaneously predetermines the frequency of the output and alters the bias of said oscillator to cause said oscillator to oscillate at one of said predetermined frequencies.

8. In an electronic musical instrument, a plurality of shared-note oscillators adapted to apply to a common output a sequence of notes of a musical scale, successive notes of said scale being spaced a half tone apart; each of said oscillators being adapted to oscillate at a frequency of any one of a corresponding group of no more than three consecutive notes, each oscillator having a predetermined quiescent state in which no signal is applied to said output; each oscillator comprising a plurality of sequentially arranged individually operable frequency control means, each of said frequency control means being normally active, and each of said frequency control means except the last having a normally closed circuit control means and a normally open circuit control means; circuit means including said normally closed circuit control means of each oscillator, said circuit means being opened by the operation of each frequency control means except the last in the sequency for rendering inactive the remaining frequency control means following said each frequency control means in the sequence; means controlled by closure of each said normally open circuit control means when active for tuning the corresponding oscillator to a predetermined frequency corresponding to said each frequency control means irrespective of whether any of the inactive frequency control means is operated, and bias means coupled to a preselected circuit control means of each of said frequency control means whereby closure of each of said normally open circuit control means simultaneously tunes said oscillator to a corresponding predetermined frequency and changes the interconnection of said bias means to said oscillator so that said oscillator produces an output at said predetermined frequency.

9. In an electronic organ, a plurality of shared-note oscillators adapted to apply to a common output circuit a sequence of notes of a musical scale consisting of at least one octave, successive notes of said scale being spaced a half tone apart; each of said oscillators being adapted to oscillate at a frequency of any one of a corresponding group of no more than three consecutive notes, each oscillator having a predetermined state in which no signal is applied to said output; each oscillator comprising a plurality of sequentially arranged frequency control means, each said frequency control means being normally active, each of said frequency control means except the last having a normally closed circuit control means and a normally open circuit control means; means for operating each of the frequency control means individually; circuit means including said normally closed circuit control means of each oscillator, said circuit means being opened by the operation of each frequency control means except the last in the sequence for rendering inactive the remaining frequency control means following said each frequency control means in the sequence; and means controlled by closure of each said normally open circuit control means when active for tuning the corresponding oscillator to a predetermined frequency corresponding to said each frequency control means irrespecive of whether any of the inactive frequency control means is operated, whereby said oscillator applies a signal at said predetermined frequency to said output circuit.

10. In an electronic organ, a plurality of shared-note oscillators adapted to apply to a common output signals forming a sequence of notes consisting of at least one octave of a musical scale, successive notes of said scale being spaced a half tone apart; each oscillator having a predetermined state in which no signal is applied to said output and each of said oscillators being adapted to oscillate at a frequency of any one of a corresponding group of only three consecutive notes separated by half-tone intervals, independently of the oscillation of any of the other oscillators, each of said oscillators comprising a first frequency control means including a normally open first circuit control means and a normally closed second circuit control means, a second frequency control means including a normally open third circuit control means and a normally closed fourth circuit control means, and a third frequency control means including a normally open fifth circuit control means; means including a first note key for operating said first frequency control means to close said first circuit control means and to open said second circuit control means, means including a second note key for operating said second frequency control means to close said third circuit control means and to open said fourth circuit control means, means including a third note key for operating said third frequency control means to close said fifth circuit control means; first means controlled by closure of said first circuit control means for causing said oscillator to oscillate at a frequency of a first note of said corresponding group of notes irrespective of whether said third or fifth circuit control means is closed and to apply a signal at the frequency of said first note to said common output; second means controlled by closure of said third circuit control means for causing said oscillator to oscillate at a frequency of a second note of said corresponding group of notes provided said second circuit control means is closed but irrespective of whether said fifth circuit control means is closed and to apply a signal at the frequency of said second note to said common output; and third means controlled by closure of said fifth circuit control means for causing said oscillator to oscillate at a frequency of a third note of said group of notes provided said second and fourth circuit control means are both closed and to apply a signal at the frequency of said third note to said common output; the characteristics of said first, second and third means of the oscillators being such that the successive groups of notes produced by the oscillators are separated by half-tone intervals.

11. In an electrical musical instrument: an oscillator

having an amplifier that is normally biased beyond cutoff; a first tuning means including normally open first control means and normally closed second control means; a second tuning means including normally open third control means; means including a first key for operating said first tuning means to close said first control means and to open said second control means; means including a second key for operating said second tuning means to close said third control means; biasing means connectable to said amplifier through either said first or said third control means when closed to bias said amplifier below cutoff; said first tuning means including means for causing said oscillator to oscillate at one predetermined frequency when said first control means is closed irrespective of whether said third control means is closed; and said second tuning means including means connected to said oscillator through said second control means when closed but not through said first control means when closed for causing said oscillator to oscillate at a second predetermined frequency.

12. In an electrical musical instrument: an oscillator that is normally biased beyond cutoff; a first switch including a normally open first pair of contacts and a normally closed second pair of contacts; a second switch including a normally open third pair of contacts; means including a first key for operating said first switch to close said first pair of contacts and to open said second pair of contacts; means including a second key for operating said second switch to close said third pair of contacts; means controlled by operation of either key for biasing said oscillator below cutoff; means including a first impedance means connected to said amplifier when said first pair of contacts is closed for causing said oscillator to oscillate at one predetermined frequency irrespective of whether said third pair of contacts is closed; and means including a second impedance means connected to said oscillator through said second pair of contacts when closed but not through said first pair of contacts when closed for causing said oscillator to oscillate at a second predetermined frequency.

13. In an electrical musical instrument: an oscillator including an amplifying device having a cathode element, an anode element, and a control element; voltage supply means having first and second terminals that are respectively positive and negative relative to one another, the first terminal being connected to apply a positive voltage to said anode element; means including a resistor connected between said cathode element and said second terminal for applying a further positive voltage to said cathode element; a first switch including a normally open first circuit control means and a normally closed second circuit control means; a second switch including a normally open third circuit control means, bias control potential supply means having one end connected to said second terminal and having the other end connectable to said second terminal through resistor means either through said first pair of contacts when closed or through said third pair of contacts when closed to bias said amplifying device below cutoff; first resonant frequency determining means, a first key for operating said first switch to close said first pair of contacts and to open said second pair of contacts whereby said oscillator oscillates at one predetermined frequency in accordance with a characteristic of said first resonant frequency determining means when said first key is operated irrespective of whether said second key is operated; second resonant frequency determining means; and means including a second key for operating said second switch to close said third pair of contacts whereby said oscillator oscillates at a second predetermined frequency in accordance with a characteristic of said second resonant frequency determining means if said first switch is not operated.

14. In an electrical musical instrument: an oscillator having an amplifier that is normally biased beyond cutoff; a first tuning means including a normally open first control means and a normally closed second control means; a second tuning means including a normally open third control means and a normally closed fourth control means; a third tuning means including a normally open fifth control means; means including a first key for operating said first tuning means to close said first control means and to open said second control means; means including a second key for operating said second tuning means to close said third control means and to open said fourth control means; means including a third key for operating said third tunnig means to close said fifth control means; biasing means connectable to said amplifier through either said first, third, or fifth control means when closed to bias said amplifier below cutoff; means for causing said oscillator to oscillate at a first predetermined frequency when said first control means is closed irrespective to whether third or fifth control means is closed; means for causing said oscillator to oscillate at a second predetermined frequency when said third control means is closed provided said second control means is closed but irrespective of whether said fifth control means is closed; and means for causing said oscillator to oscillate at a third predetermined frequency when said fifth control means is closed provided said second and fourth control means are both closed.

15. In an electrical musical instrument: an oscillator having an amplifier and a first impedance means connected therein, said oscillator being operative only when said amplifier is biased below cutoff and being normally biased beyond cutoff; a first switch including first and second stationary contacts and a movable contact arm; a second switch including first and second contacts, one of which is stationary and the other of which is movable, said first movable contact arm being connected to said first impedance means, said second stationary contact being connected to one of the contacts of said second switch, said first movable contact arm and said second stationary contact of said first switch being normally closed, said contacts of said second switch being normally open; a second impedance means connected to one of the contacts of said second switch, said oscillator being tuned to different frequencies according to whether or not said second impedance means is connected to said first impedance means; a first bias means for normally biasing said amplifier beyond cutoff; a second bias means; a first resistor connected between said second bias means and said first contact of said first switch; a second resistor connected between said second bias means and the contact of said second switch that is not connected to said second contact; and means including two keys for operating the respective switches to alter a connection between said second bias means and said oscillator whereby when either key is operated the bias on said amplifier is changed from beyond cutoff to below cutoff and said oscillator oscillates at one predetermined frequency when said first switch is closed irrespective of whether said second switch is closed and at a different predetermined frequency when only said second switch is closed.

16. In an electrical musical instrument: an oscillator including an amplifying device having a cathode element, and anode element, and a control element; voltage supply means having first and second terminals that are respectively positive and negative relative to one another, the first terminal being connected to apply a high positive voltage to said anode element; means including a resistor connected between said cathode element and said second terminal for applying a low positive voltage to said cathode element; a first circuit means connected in one path between said second terminal and said control element; a first normally restored tuning means including a first normally open control means having a pair of control terminals, one of said control terminals being connected to a point between said first resonant circuit means and said control element; a second normally restored tuning means including a second normally open

control means having a pair of control terminals; a second circuit means connected in another path between said second terminal of said voltage supply means and one of the control terminals of said second tuning means; bias control potential supply means having one end connected to said voltage supply means and having the other end normally connected to said tuning means, whereby when both said tuning means are restored said oscillator is biased beyond cutoff, and whereby when one of said tuning means is operated said oscillator is biased below cutoff; means including a first key for operating said first tuning means to close said first control means thereby to initiate oscillation of said oscillator at one frequency; and means including a second key for operating said second tuning means thereby to initiate oscillation of said oscillator at a different frequency, said second circuit means being connected to said first circuit means when one of said control means is closed but not when only the other control means is closed, whereby said oscillator oscillates at one predetermined frequency when only a certain one of said tuning means is operated and at another predetermined frequency when the other of said tuning means is operated regardless of whether said certain tuning means is operated.

17. In an electrical musical instrument: an oscillator including an amplifier that is inoperative when biased beyond cutoff and is operative when biased below cutoff; means for normally biasing said amplifier beyond cutoff; a plurality of normally active sequentially arranged frequency control means, each said frequency control means being normally restored; means for operating each of the frequency control means individually; means controlled by the operation of each frequency control means except the last in the sequence for rendering inactive the remaining frequency control means following said each frequency control means in the sequence; and means also controlled by operation of each frequency control means when active for changing the bias on said amplifier from beyond cutoff to below cutoff and for tuning the oscillator to a predetermined frequency corresponding to said each frequency control means irrespective of whether any of the inactive frequency control means is operated.

18. In an electrical musical instrument: an oscillator that is inoperative when biased beyond cutoff and is operative when biased below cutoff; first bias means for normally biasing said oscillator beyond cutoff; a plurality of normally active sequentially arranged switches, each switch being normally restored, each switch having a corresponding pair of normally open contacts; means for operating each of the switches individually; means controlled by the operation of each switch except the last in the sequence for rendering inactive the remaining switches following said each switch in the sequence; and circuit means completed by the closure of the pair of contacts of an active switch when operated, said circuit means including second bias means for changing the bias on said oscillator from beyond cutoff to below cutoff, said circuit means further including means for tuning the oscillator to a predetermined frequency corresponding to said each switch irrespective of whether any of the inactive switches is operated.

19. A musical instrument as defined in claim 11 in which said biasing means comprises a source of biasing potential, a first adjustable resistor providing the connection between said biasing source and said first control means, and a second adjustable resistor providing the connection between said biasing source and said second control means.

20. A musical instrument as defined in claim 19 in which each of said tuning means comprises a different condenser.

21. In an electrical musical instrument, a shared-note oscillator including an amplifier that is normally biased to a quiescent state; first tuning means including first control means and a first condenser for causing said oscillator to oscillate at a first predetermined audio frequency when said first control means is operated; second tuning means including second control means and a second condenser for causing said oscillator to oscillate at a second predetermined audio frequency when said second control means is operated; first and second adjustable resistors connected to said first and second control means; and a source of bias potential connected to said amplifier through said first resistor by said first control means when operated and through said second resistor by said second control means when operated for changing the bias on said amplifier to bias said amplifier to an oscillatory condition the bias potentials applied to said implifier when either of said control means is operated being independently adjustable.

22. In an electrical musical instrument: a plurality of oscillators that are tunable to different audio frequencies, each oscillator comprising an amplifying device that is normally biased to a quiescent state; a common source of bias voltage for said oscillators; and control means for selectively biasing each said amplifying device to change it from a quiescent state to an oscillatory state and to tune each oscillator to a predetermined audio frequency, said control means comprising a normally open key-operated switching means for each oscillator for changing the bias of each said oscillator to an oscillatory state, tuning means including a parallel resonant circuit comprising an inductive element and a capacitive element connected to tune each said oscillator to a different predetermined audio frequency only when said switching means is operated, and a separate adjustable resistance means connected to said bias source and to each of said oscillators, whereby the operating biases on said oscillators may be independently adjusted.

23. In an electrical musical instrument: a plurality of oscillators that are tunable to different audio frequencies, each oscillator comprising an amplifying device having a cathode element, an anode element, and a control element, each said amplifying device normally being biased to a quiescent state; means connected to said elements of each amplifying device for rendering each said oscillator operative to oscillate when said each amplifying device is biased to an oscillatory state, said means including a separate inductive element connected between the cathode element and the control element of each said amplifying device; a common source of bias voltage for said oscillators; and control means for selectively changing the bias on each said amplifying device to change it from a quiescent state to an oscillating condition and to tune each said oscillator to a predetermined frequency, said control means comprising a normally open key-operated switching means for each oscillator, each switching means having two terminals, one of said terminals being connected to the control element of each oscillator, tuning means including a condenser connected between each said other terminal and the cathode element of said each oscillator, and a separate adjustable resistance means connected between said bias source and said other terminal of each said switching means, whereby the operating biases on said oscillators may be independently adjusted.

24. In an electronic organ, a plurality of shared-note oscillators adapted to apply notes of a musical scale to a common output circuit, each of said oscillators being adapted to oscillate at a frequency of any one of a corresponding group of notes, each oscillator comprising means for establishing a predetermined state in which no oscillating signal is applied to said output circuit, any two of the notes produced by each oscillator rarely occurring simultaneously in musical compositions, the notes produced by the oscillators forming a sequence of notes of a musical scale consisting of at least one octave, successive notes of said scale being spaced a half tone apart, each oscillator comprising a plurality of sequentially ar-

ranged frequency control means, each said frequency control means being normally active, each of said frequency controy means except the last having a normally closed circuit control means and a normally open circuit control means; means for operating each of the frequency control means individually; circuit means including said normally closed circuit control means of each oscillator, said circuit means being opened by the operation of each frequency control means except the last in the sequence for rendering inactive the remaining frequency control means following said each frequency control means in the sequence; and means including tuning means controlled by closure of each said normally open circuit control means when active for tuning the corresponding oscillator to a predetermined frequency corresponding to said each frequency control means irrespective of whether any of the inactive frequency control means is operated and for altering the state of said oscillator to an oscillating state in which a signal of said predetermined frequency is applied to said output circuit.

25. In a musical instrument, oscillating means normally biased to a quiescent state, a keying potential supply providing a keying voltage characterized by a relatively large direct current component and a relatively small alternating current component of low frequency, a plurality of note producing means including key-operated switching means for applying said keying voltage to said oscillating means to variable bias said oscillating means to an oscillatory condition whereby a selected note of vibrato character is produced upon operation of the corresponding note producing means.

26. In a musical instrument as defined in claim 11 in which said amplifier comprises an amplifying device having a cathode element, an anode element, and a control element, the combination therewith of means including a resistor connected to said control element and to one of said other elements to provide a conductive path from said control element irrespective of whether said control means are opened or closed.

27. In an electrical musical instrument, a shared-note oscillator including an amplifier that is normally biased to a non-oscillatory condition; first tuning means including first control means and a first condenser for causing said oscillator to oscillate at a first predetermined audio frequency when said first control means is operated; second tuning means including second control means and a second condenser for causing said oscillator to oscillate at a second predetermined audio frequency when said second control means is operated; first and second adjustable resistors connected to said first and second control means; and a source of bias potential connected to said amplifier through said first resistor by said first control means when operated and through said second resistor by said second control means when operated for biasing said amplifier to an oscillatory condition whereby the bias potentials applied to said amplifier when either of said control means is operated is independently adjustable.

28. In an electrical musical instrument; a plurality of oscillators that are tunable to different audio frequencies, each oscillator comprising an amplifying device that is normally biased to a non-oscillating condition; a common source of bias voltage for said oscillators; and control means for selectively biasing each said amplifying device to change it from a non-oscillating condition to an oscillating condition and to tune each oscillator to a predetermined frequency of oscillation, said control means comprising a normally open key-operated switching means for each oscillator for changing the bias of each said oscillator to an oscillating condition, tuning means including a parallel resonant circuit comprising an inductive element and a capacitive element connected to tune each said oscillator to a different predetermined audio frequency of oscillation only when said switching means is operated, and a separate adjustable resistance means connected to said bias source and to each of said oscillators, whereby the operating biases on said oscillators may be independently adjusted.

29. In an electrical musical instrument: a plurality of oscillators that are tunable to different audio frequencies, each oscillator comprising an amplifying device having a cathode element, an anode element, and a control element, each said amplifying device normally being biased to a non-oscillating condition; means connected to said elements of each amplifying device for rendering each said oscillator operative to oscillate when said each amplifying device is biased to an oscillating condition, said means including a separate inductive element connected between the cathode element and the control element of each said amplifying device; a common source of bias voltage for said oscillators; and control means for selectively biasing each said amplifying device to change it from a non-oscillating condition to an oscillating condition and to tune each said oscillator to a predetermined audio frequency of oscillation, said control means comprising a normally open key-operated switching means for each oscillator, each switching means having two terminals, one of said terminals being connected to the control element of each oscillator, tuning means including a condenser connected between each said other terminal and the cathode element of said each oscillator, and a separate adjustable resistance means connected between said bias source and said other terminal of each said switching means, whereby the operating biases on said oscillators may be independently adjusted.

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