May 9, 1950 M. J. LARSEN 2,506,723

ELECTRICAL GENERATION OF MUSICAL TONES

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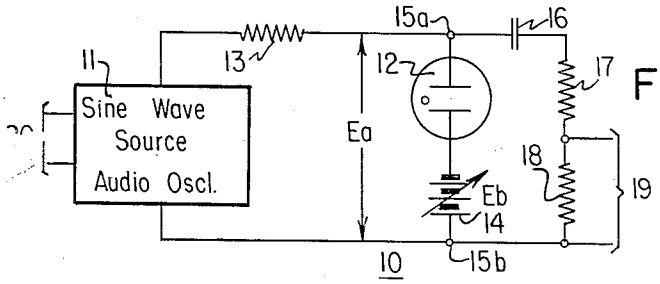


FIG. 1

FIG. 2a

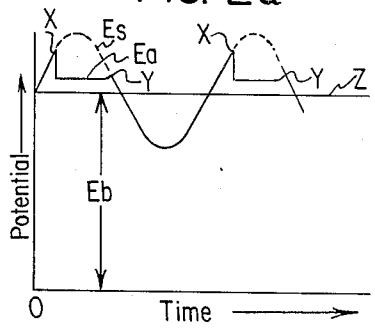


FIG. 2b

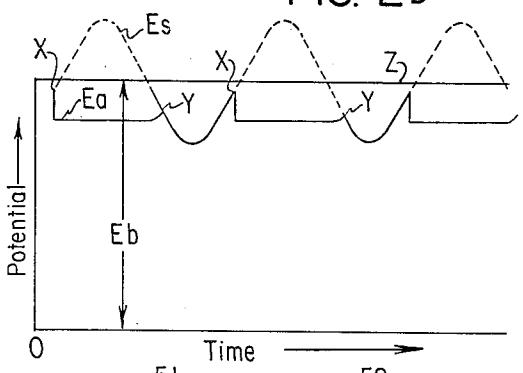
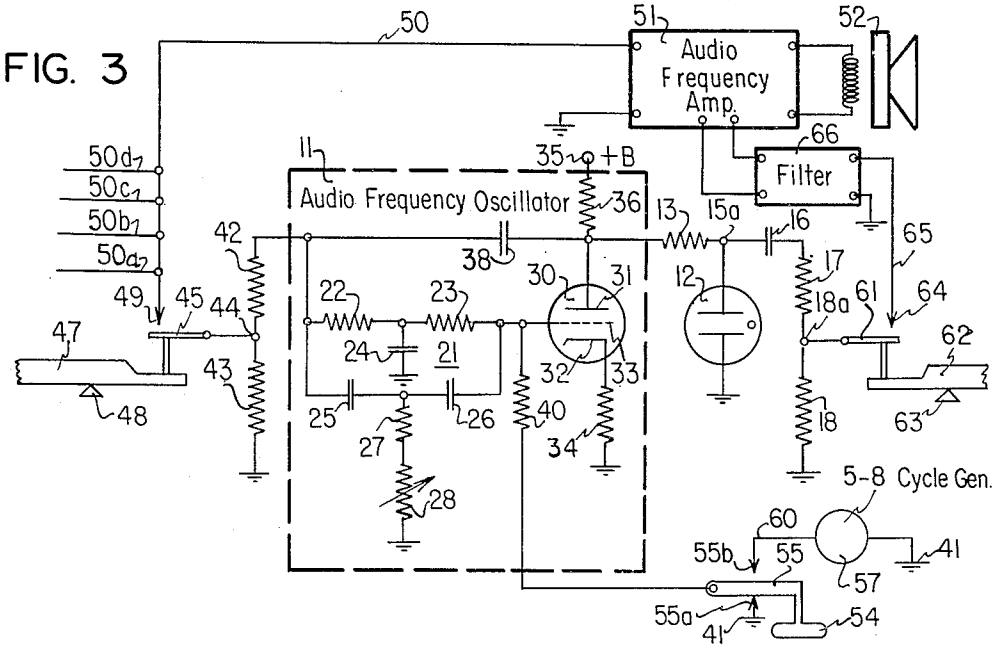


FIG. 3



INVENTOR.
Merwin J. Larsen

BY T. L. Bowes

Atty

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FIG. 4a

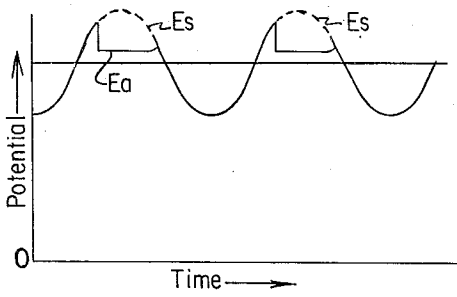


FIG. 4b

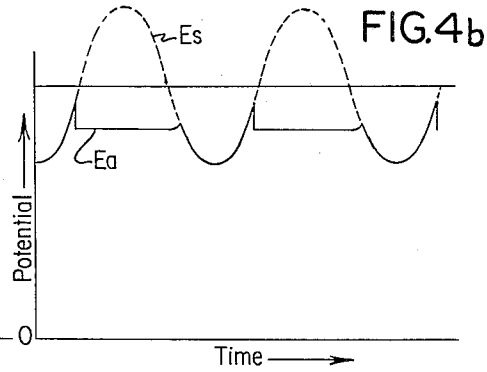


FIG. 5

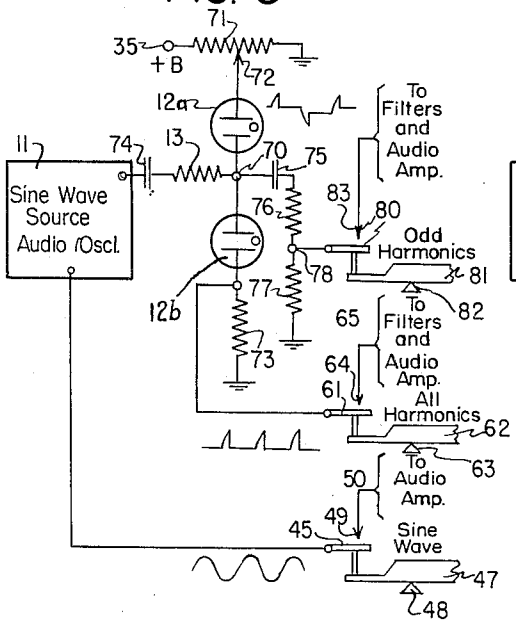


FIG. 7

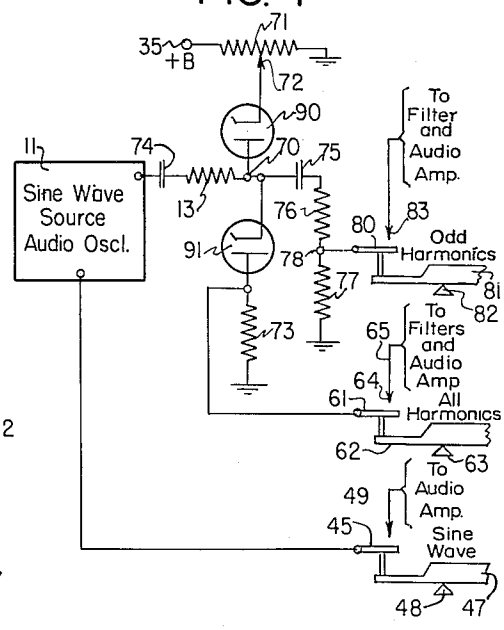
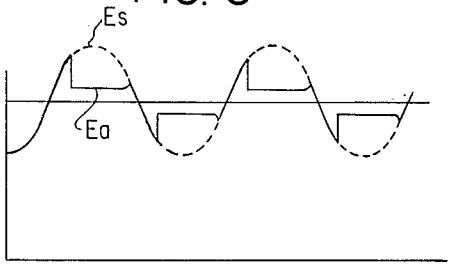


FIG. 6



INVENTOR.
Merwin J. Larsen

BY
J. L. Bowes

Atty.

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ELECTRICAL GENERATION OF MUSICAL TONES

Merwin J. Larsen, Villa Park, Ill., assignor to Stromberg-Carlson Company, a corporation of New York

Application December 31, 1947, Serial No. 795,060

8 Claims. (Cl. 84—1.19)

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The present invention relates to apparatus for the electrical generation of musical tones and more particularly to improvements in musical instruments of the type employing electrical oscillators of audible frequency for the production of musical notes.

It is well-known that the timbre or tone quality of musical instruments depends upon the harmonic content of the wave form of the musical note produced. Some musical instruments such as the flute, the triangle and the like may produce tones having substantially sinusoidal wave forms. It is also well known that certain musical instruments are characterized by the absence or extreme weakness of certain harmonics and the predominance of others. Some musical instruments, for example, have strong odd harmonics such as the fundamental, third, fifth, etc. and weak even harmonics such as the second, fourth, sixth, etc. Musical instruments of the type often characterized by the term electronic organ, have been constructed so as to be able to imitate the characteristics of various other musical instruments having wave forms of the type referred to above. It is obvious therefore that such musical instruments must be able to produce tones varying from sinusoidal wave forms to those having complex wave forms. Known tone sources for use in electrical musical instruments produce wave forms which are either substantially sinusoidal or else wave forms which are rich in harmonics. If a sinusoidal wave form source only is available, it is necessary subsequently either to distort the sine wave or combine the outputs of various sine wave generators in order to arrive at a tone of complex wave form. On the other hand, if a complex wave form source only is used, such as relaxation oscillators, or multivibrators, then rather involved filtering is necessary in order to produce tones having a substantially sinusoidal wave form.

It is apparent therefore that to produce the desired tone quality, it is necessary to have tone sources which are capable of producing audible signals having wave forms varying all the way from a sine wave to a wave form of very complex harmonic structure. A plurality of different methods have been employed for accomplishing this result. One method which has been extensively employed comprises employing a plurality of generators for producing only substantially sinusoidal voltages of frequencies following the tempered scale. The complex wave form tones are then produced by bleeding various harmonics along the tempered scale from those generators whose frequencies exactly or sometimes approximately correspond to the harmonic orders desired and

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recombining them to produce the desired tones. Another method which has also been extensively used employs means for initially generating tones rich in harmonics and employing suitable filters for getting the desired pure tones without harmonics or the desired combinations of frequencies. A third method starts with sinusoidal voltages and produces complex wave forms by distorting techniques. The present invention is particularly concerned with this third method whereby a simple inexpensive multiple tone source can readily be provided.

It is an object of the present invention to provide a multiple tone source for a musical instrument which is exceedingly simple and inexpensive and very satisfactory in operation.

It is another object of the present invention to provide a tone source which provides a source of substantially pure tones as well as a source of tones rich in harmonics without the requirement of filtering means or other complicated means for recombining various frequencies to provide complex wave forms.

A still further object of the present invention is to provide a tone source for both pure tones and tones having complex wave forms with simple means for providing a vibrato output whenever desired.

Further objects and advantages of the present invention will become apparent as the following description proceeds, and the features of novelty which characterize the invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of the present invention reference may be had to the accompanying drawings in which:

Fig. 1 is a schematic circuit diagram to aid in understanding one feature of the present invention;

Figs. 2*a* and 2*b* are curve diagrams to aid in understanding the operation of the circuit of Fig. 1;

Fig. 3 is a schematic diagram of a multiple tone source embodying the present invention and employing the basic concept of Fig. 1;

Figs. 4*a* and 4*b* are curve diagrams similar to Figs. 2*a* and 2*b* to aid in understanding the operation of the multiple tone source of Fig. 3;

Fig. 5 is a circuit diagram similar to Fig. 3 illustrating a modification thereof;

Fig. 6 is a curve diagram to aid in understanding the operation of the multiple tone source of Fig. 5; and

Fig. 7 is a diagram similar to Fig. 5 illustrating still another modification of the present invention.

Because of its low cost the resistance-capacitance or R. C. type of audio oscillator has been found to be very well suited for a sine wave tone source. The so-called parallel-T oscillator which has recently been extensively employed is especially satisfactory since the frequency stability is very good and is more a function of component stability rather than a function of the voltage or tube characteristic. The basic theory underlying the so-called parallel-T type oscillator is disclosed in United States Letters Patent to Scott 2,173,427. Although a parallel-T type of oscillator has been illustrated in some of the figures of the drawings as the source of a signal of sinusoidal wave form, it should be understood that other forms of audio oscillators might equally well be employed and the illustrated embodiment is by way of example only.

Referring now to Fig. 1 of the drawings there is illustrated, partially in block diagram, a multiple tone source generally indicated at 10 including as a basic element thereof an audio oscillator 11 capable of acting as a sine-wave source. This sine-wave source 11 may be of the form disclosed in detail in Fig. 3 of the drawings or some other suitable audio frequency oscillator preferably of the resistance-capacitance or so-called "R. C." type.

For the purpose of producing a tone having a complex wave form from the substantially sinusodial output of the oscillator 11 there is provided in accordance with the present invention a distorting circuit employing a small gas diode generally indicated at 12 which may for example comprise a 1/25 watt neon tube such as is available on the market under the type designation NE9. As illustrated one electrode of the gas diode 12 is connected to a terminal 15a which in turn is connected to one terminal of the sine-wave source 11 through a suitable current limiting resistor 13 for limiting the current which may flow through the gas diode 12 when it ionizes. The other electrode of the gas diode 12 is connected to the other terminal of the sine wave source 11 with a suitable adjustable source of direct current potential interposed in this circuit. This source of direct current potential is schematically designated by the battery 14 having its positive terminal designated as 15b. The sum of the battery potential and the potential appearing at the terminals of the oscillator 11, neglecting any voltage drop in the resistor 13, is therefore impressed across the diode terminals. When this voltage across the diode terminals exceeds the break down voltage of the diode, current will flow through the diode. Such diodes generally have a break down voltage which is substantially higher than the voltage when the diode is conducting current. A typical operating characteristic for a gas diode such as 12 might require 80 volts for break down or ionization following which the voltage drops to about 66 volts, rising slightly as the diode begins to deionize. The difference in voltage between the positive and negative peaks of the sine wave voltage output of the source 11 should preferably be several times greater than the difference in voltage across the diode for break down or ionization and when conducting full current, in order to compensate for operating differences from tube to tube.

The operating characteristics of the circuit of Fig. 1 will become apparent from the curve diagrams of Figs. 2a and 2b respectively. The voltage of the battery 14 is designated as E_b volts above the zero axis in both Figs. 2a and 2b and it is noted that the battery voltage is substantially greater in Fig. 2b than in Fig. 2a of the drawings. The sinusoidal voltage at the terminals of the audio oscillator or sine wave source 11 is the same in each of the Figs. 2a and 2b and is indicated by the dashed line curve E_s. The voltage across the terminals 15a and 15b in Fig. 1 of the drawings is represented by the solid line curves E_a in both Figs. 2a and 2b of the drawings. It will be understood that the differential voltages across the diode 12 have exactly the same wave forms as the curves E_a except that the zero axis is displaced by the amount E_b. If the horizontal lines Z in Figs. 2a and 2b were considered to be the reference axes or zero axes then the curves E_a with reference to the axes Z would truly represent the differential voltages across the gas diode 12 for the two situations represented by Figs. 2a and 2b of the drawings. An examination of the voltage curve E_a in Fig. 2a of the drawings indicates that the voltage across the diode 12 rises until ionization occurs at point X when a sudden drop in voltage occurs. The voltage remains substantially constant at this lower value until the gas diode 12 starts to deionize when a slight rise in voltage occurs. The point Y indicates the instant during each cycle that deionization occurs. From the point Y in Fig. 2a of the drawings to the successive point X the gas diode 12 is not conducting current and break down again occurs at X. By increasing the direct current bias voltage E_b in the manner shown in Fig. 2b of the drawings the gas diode 12 fires near the trough of the alternating current cycle as contrasted with Fig. 2a where the diode fires near the peak of the alternating current cycle. A harmonic analysis of the voltages represented by the curves E_a in Figs. 2a and 2b of the drawings indicates that a tone is produced which is rich in harmonics not unlike the output of a saw-tooth generator with the exception of the fundamental and second harmonic. It is evident that by varying the bias E_b of the battery 14 a variation of the wave form may be obtained, the curve E_a of Fig. 2a containing more fundamental and more second harmonic than the voltage E_a of Fig. 2b of the drawings.

For the purpose of obtaining a voltage having the complex wave form of the curves E_a of Figs. 2a and 2b, for example, a suitable circuit connected in parallel with the terminals 15a and 15b may be provided. As illustrated this parallel circuit comprises the capacitor 16, the resistor 17 and the resistor 18 all connected in series across the terminals 15a and 15b. This parallel circuit affords a convenient means of obtaining at the terminals 19 across the resistor 18 a suitable voltage having the wave form represented by typical curves E_a, such as are shown in Figs. 2a and 2b, the capacitor 16 preventing any direct current potential from reaching the terminals 19.

It will be apparent from the description thus far that by means of a simple and inexpensive gas diode a sine wave source of tone or signal may readily be converted to a dual tone source since the sine wave tone may be obtained across the terminals 20 of the oscillator 11 and the tone rich in harmonics may be obtained across the terminals 19.

In Fig. 3 of the drawings there is illustrated schematically an application of the distorting circuit of Fig. 1 to a portion of the tone source of an electronic organ. The audio frequency oscillator is again generally designated by the refer-

ence numeral 11 and the corresponding parts of Fig. 3 are designated by the same reference numerals as in Fig. 1. The audio frequency oscillator 11 is illustrated as a parallel-T type oscillator which is a specific one of the bridge type of resistance-capacitance oscillators. As illustrated the oscillator 11 comprises a bridge circuit generally designated at 21 arranged in a so-called parallel-T with one T comprising the serially arranged resistors 22 and 23 and the capacitor 24 connected between the common terminal of the resistors 22 and 23 and ground. The other T circuit comprises the capacitors 25 and 26 connected in series with the common terminal of the capacitors connected to ground through resistors 27 and 28, one of which, i. e. resistor 28, is indicated as being adjustable to provide means for obtaining a fine frequency adjustment as for initially tuning the electronic organ. This parallel-T bridge type circuit is disclosed in the Scott Patent 2,173,427 referred to above. The audio frequency oscillator 11 further includes an electron discharge valve 30 specifically illustrated as a triode comprising an anode or plate 31, a cathode 32 and a control electrode or grid 33. The cathode 32 is grounded through a suitable cathode resistor 34 which provides the desired degeneration for improvement of the wave form, while the anode 31 is connected to a source of +B potential 35 through a suitable voltage dropping resistor 36. The bridge circuit 21 described above has one terminal, namely the terminal between the resistor 23 and the capacitor 26, connected to the control electrode 33 while the terminal between the resistor 22 and the capacitor 25 is connected to the plate 31 through a suitable direct current blocking capacitor 38. A suitable resistor 40 is also illustrated as normally connecting the control electrode 33 to ground as indicated at 41.

In order that a substantially pure sinusoidal potential may be obtained from the audio frequency oscillator 11 there is provided an output circuit comprising the resistors 42 and 43 connected in series and connected between ground and the plate 31 of the triode 30 preferably through the direct current blocking condenser 38 as illustrated. The sinusoidal output voltage may be obtained at the terminal 44 between the resistors 42 and 43. The resistor 42 preferably provides a very high resistance so as to prevent any frequency change of the oscillator 11 when an output potential is obtained as by keying or the like from the terminal 44.

Any suitable means for obtaining a sinusoidal potential from the terminal 44 may be provided. As illustrated the terminal 44 is connected to a suitable movable switch arm 45 adapted to be actuated by a key 47 pivotally mounted at 48. By depressing the finger engaging portion of the key 47 which may comprise the key of an electronic organ the switch 45 is moved into engagement with the stationary contact 49 connected by a suitable conductor 50 to an audio frequency amplifier 51 which in turn has its output connected to a signal reproduction device or loud speaker 52. It will be apparent therefore that the output of the audio frequency oscillator 11 may selectively be supplied to the amplifier 51 and loud speaker 52 to produce an audible tone of substantially sinusoidal frequency or in other words a pure tone. It will be understood that in an electronic organ a plurality of oscillators such as 11 each capable of producing a different frequency will be provided and by suitably keying these oscillators the common conductor 50 may be selectively connected to one or more of the oscillators such as 11. The conductors 50*a*, 50*b*, 50*c* and 50*d* are illustrated as representing branch conductors connecting the common line 50 with the various keying circuits of a plurality of oscillators such as 11.

It will be understood that other types of oscillators than the one illustrated may be employed equally well herein, the only requirements being that such an oscillator must have a safe margin of amplitude and a high degree of frequency stability.

By employing the parallel-T type oscillator described above a very desirable arrangement is provided for the injection of a low frequency signal to produce a frequency vibrato. As illustrated in the drawings a suitable key or stop 54 may be provided for controlling a two-position switch 55. Normally the switch 55 engages a contact 55*a* whereby the control electrode 33 is grounded through the grid resistor 40. Upon actuation of the key or stop, however, the switch 55 is moved into engagement with a normally open contact 55*b* so as to connect a low impedance low frequency source generally designated at 57 in series with the resistor 40 with one terminal of the generator 57 connected to ground, also designated by the reference numeral 41. Preferably the generator 57 is a five to eight cycle generator of sufficiently low impedance whereby keying of the switch 55 has no adverse effect. By the proper choice of the resistance value of the resistor 40 the frequency vibrato may be substantially free from amplitude modulation which is very desirable since it permits the gas diode 12 to operate steadily. It will be apparent that a single generator such as 57 may be employed for supplying the vibrato for all of the frequency oscillators such as 11 and consequently the conductor 60 connected to the other terminal of the generator 57 and the contact 55*b* may be common to all of the oscillators such as 11.

The gas diode or neon tube 12 is connected in substantially the same manner as in Fig. 1 of the drawings with the resistor 13 connected to the plate circuit of the triode 30. Instead of employing the biasing battery of Fig. 1 of the drawings, however, the terminal 15*a* connected to one electrode of the diode 12 is connected to the source of +B potential 35 through the serially arranged resistors 13 and 36. The source of potential 35 therefore provides the necessary bias for the gas diode 12 whose other electrode is connected to ground as shown. It will be apparent that by suitably adjusting the resistors 13 and 36 any desirable bias may be obtained such as was obtained by varying the voltage of battery 14 in Fig. 1 of the drawings.

The tone or signal of distorted wave form may also be keyed and, as illustrated in Fig. 3 of the drawings, the terminal 18*a* between the resistors 17 and 18 is connected to a suitable switch 61 which is controlled by a key 62 pivotally mounted at 63. The switch 61 includes a normally open contact 64 which is connected by a conductor 65 to suitable filters generally designated at 66 the output of which may, if desired, be connected to the audio amplifier 51 for audible reproduction by the loud speaker 52. It will be understood that conductor 65 may be a common circuit for the complex waves produced by the distorting circuits of other audio oscillators forming a part of an electronic organ. If desired the capacitance of capacitor 16 may be made small enough to partially suppress the fundamental component of

the audio frequency signal of complex wave form since this fundamental component is available for separate control at the terminal 44.

In Figs. 4a and 4b there are illustrated certain wave forms for understanding the operation of the distorting circuit of Fig. 3 of the drawings which curves are quite similar to the curves shown in Figs. 2a and 2b of the drawings. The curves E_s in both Figs. 4a and 4b indicate the sinusoidal voltage output of the audio oscillator 11, it being observed that a larger voltage is present in the curve of Fig. 4b which is obtained by increasing the potential of the +B source 35 as by adjusting the resistor 36. The curves E_a of Figs. 4a and 4b represent the potentials at the terminal 15a of the diode 12 which potential is displaced from the zero axis by the direct current biasing voltage of the source 35. This biasing voltage is indicated as also being of greater magnitude in Fig. 4b than in Fig. 4a.

It will be understood that various circuit arrangements and various circuit constants may be employed in connection with the arrangement of Fig. 3 of the drawings for example. In order, however, to illustrate the relative magnitudes of the principal elements of a typical circuit arrangement which has been found to satisfactorily embody the present invention the following approximate values of such elements together with other pertinent information are given for a particular device. It should be understood that these values are given by way of example only and not by way of limitation.

Gas diode 12	NE 9 (1/25 watt)
Resistor 13	4.7 megohms
Capacitor 16	has such a value of capacitance that its capacitive reactance at the oscillator frequency is 2.2 megohms.
Resistor 17	2.2 megohms
Resistor 18	0.1 megohm
Resistor 22	0.27 megohm
Resistor 23	0.27 megohm
Capacitor 24	capacitance in microfarads approximately equal to $1.8/f$ where f is the frequency in cycles
Capacitor 25	½ the capacitance of capacitor 24
Capacitor 26	½ the capacitance of capacitor 24
Resistor 27	18,000 ohms
Resistor 28	0 to 10,000 ohms
Electron discharge valve 30	6SL7 (½ of the 6SL7 to be used for one audio frequency oscillator 11 and the other half for a similar oscillator of a somewhat different frequency)
Resistor 34	3,900 ohms
Potential of +B source 35	200 volts
Resistor 36	0.27 megohm
Capacitor 38	ten times the capacitance of capacitor 24
Resistor 40	1 megohm
Resistor 42	2.2 megohms
Resistor 43	0.1 megohm
Frequency of generator 57	5 to 8 cycles

As was mentioned above certain instruments, notably the woodwinds such as the clarinet, have strong odd harmonics and weak even harmonics. With the tone source illustrated in Fig. 3 of the drawings it is necessary to do a substantial amount of filtering to eliminate the even harmonics. In Fig. 5 of the drawings there is illustrated a modification of the present invention in which there is essentially provided a triple tone source which comprises a sine wave tone source, a complex wave tone source in which substantially only odd harmonics are present, and a complex wave form source in which substantially all harmonics are present. The corresponding parts of Fig. 5 are designated by the same reference numerals as in the preceding figures. It will be understood that the wave E_a such as is shown in Fig. 4b, for example, could not be used to produce a clarinet tone which contains substantially only odd harmonics, without resorting to cumbersome filtering. If, however, the wave E_a of Fig. 4b, for example, were distorted so both the positive and negative halves were alike the resulting wave would contain substantially only odd harmonics. This is accomplished by the circuit arrangement of Fig. 5 where two gas diodes are employed, designated as 12a and 12b respectively. The diodes are connected in series with the common terminal 70 corresponding to the terminal 15a in the preceding figures of the drawings. The other terminal of the diode 12a is connected to the source 35 of +B potential through a suitable potentiometer comprising the resistor 71 and the adjustable tap 72. The other terminal of the gas diode 12b is grounded through a suitable resistor 73. The potential of the +B source 35 must be sufficiently large to fire both diodes 12a and 12b alternately. The terminal 70 is connected to the sine wave source 11 through the current limiting resistor 13 and the blocking capacitor 74. The terminal 70 is also connected to ground through serially arranged blocking capacitor 75 and resistors 76 and 77. The resistors 76 and 77 are illustrated as having a common terminal 78 which provides a source of potential of complex wave form containing substantially only odd harmonics. By virtue of the capacitors 74 and 75 the common terminal 70 of the gas diodes 12a and 12b is maintained at an average direct current potential between ground and the positive potential of the source 35 whereupon a very symmetrical wave form is obtained.

In Fig. 6 of the drawings there is illustrated by the curve E_a the complex wave form obtainable which contains substantially only odd harmonics. The oscillator sine wave voltage E_s is also shown.

The potential obtainable at the terminal 78 may be supplied through a suitable switch 80 actuated by a key 81 pivotally mounted at 82. Switch 80 is illustrated as being engageable with a normally open contact 83 connected by means of a suitable conductor 84 to suitable filters and subsequently to the audio amplifier. With the arrangement disclosed in Fig. 5 of the drawings a very simple way of obtaining a pure sine wave, a wave rich in all harmonics, and a wave rich in odd harmonics only is provided. The three different wave forms are illustrated schematically in Fig. 5 adjacent the conductor wherein the particular wave form appears.

It should be understood that instead of gas diodes 12a and 12b ordinary diodes might equally well be employed and in Fig. 7 of the drawings

the identical circuit of Fig. 5 with the tubes 12a and 12b replaced by ordinary diodes designated by the reference numerals 90 and 91 respectively, is shown. As illustrated the anode of the diode 90 is connected to the terminal 70 while the cathode of the diode 91 is connected to the terminal 70. It will be understood that when the potentiometer comprising the resistor 71 and the variable tap 72 is employed the odd harmonic output can readily be controlled merely by changing the common bias. With this arrangement it is possible to tie keys 62 and 81 together or in other words eliminate one of the keys thereby making possible a keying system employing a minimum number of cantacts and yet retaining a degree of quality control.

In view of the detailed description included above the operation of the multiple-tone source arrangements described will be apparent to those skilled in the art and no further discussion thereof is included herewith.

While there have been described and illustrated what are at present considered to be the preferred embodiments of the present invention, it will be obvious to those skilled in the art that various changes and modifications can be made therein without departing from the spirit and scope of the present invention. It is aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the present invention.

What is desired to be secured by Letters Patent of the United States is:

1. In a musical instrument, an oscillation generator for developing an audible signal having a substantially sinusoidal wave form, means for developing a signal of adjustably complex wave form comprising a distorting circuit including a gas diode characterized by having a firing potential which is substantially higher than the potential for sustaining current flow through said diode, means for impressing the output of said oscillation generator across said diode, the variation in potential of the output of said oscillation generator exceeding the difference in voltage across said diode for firing said diode and for sustaining current flow therethrough, and means for applying a direct current bias across said diode, the value of said bias determining the wave form of said developed signal.

2. In a musical instrument, an oscillation generator for developing an audible signal having a substantially sinusoidal wave form, means for developing a signal of adjustably complex wave form comprising a distorting circuit including a gas diode characterized by having a firing potential which is substantially higher than the potential for sustaining current flow through said diode, means for impressing the output of said oscillation generator across said diode, the variation in potential of the output of said oscillation generator exceeding the difference in voltage across said diode for firing said diode and for sustaining current flow therethrough, means for applying a direct current bias across said diode, the value of said bias determining the wave form of said developed signal, and means for obtaining a potential of said determined complex wave form from across said diode.

3. In a musical instrument, an oscillation generator for developing an audible signal having a substantially sinusoidal wave form, means for developing a signal of adjustably complex wave form comprising a distorting circuit including

a gas diode characterized by having a firing potential which is substantially higher than the potential for sustaining current flow through said diode, means for impressing the output of said oscillation generator across said diode, the variation in potential of the output of said oscillation generator exceeding the difference in voltage across said diode for firing said diode and for sustaining current flow therethrough, and for applying an adjustable direct current bias across said diode, the value of said bias determining the wave form of said developed signal, and means comprising a serially arranged capacitor and resistor connected across said diode whereby a potential of said determined complex wave form may be obtained across said resistor.

4. In a device for producing musical tones including tones of sinusoidal wave form and tones of adjustably complex wave form, the combination of a source of alternating potential of audio frequency having a substantially sinusoidal wave form; means for distorting said potential of audio frequency comprising an electron discharge valve of the type requiring a substantially greater potential across its terminals to initiate ionization than to maintain ionization once such ionization has occurred, the sinusoidal wave form output of said source having a variation in potential exceeding the difference in potential across said valve between that existing at the instant of ionization and that for maintaining ionization; means for connecting said valve across said source; and means for impressing a direct current potential across said valve of sufficient magnitude so that the sum of said audio frequency potential of sinusoidal wave form and said direct current potential equals the ionization potential of said valve at some point during each cycle of said audio frequency potential whereby the potential across said valve comprises an audio frequency potential rich in harmonics, the magnitude of said direct current potential determining the wave form of said developed audio frequency potential.

5. In a device for producing musical tones including tones of sinusoidal wave form and tones of adjustably complex wave form, the combination of a source of alternating potential of audio frequency having a substantially sinusoidal wave form; means for distorting said potential of audio frequency comprising a gas diode of the type requiring a substantially greater potential across its terminals to initiate ionization than to maintain ionization once such ionization has occurred, the sinusoidal wave form output of such source having a variation in potential exceeding the difference in potential across said diode between that existing at the instant of ionization and that for maintaining ionization; means for connecting said diode across said source; and means for impressing a direct current potential across said diode of sufficient magnitude so that the sum of said audio frequency potential of sinusoidal wave form and said direct current potential equals the ionization potential of said valve at some point during each cycle of said audio frequency potential whereby the potential across said valve comprises an audio frequency potential rich in harmonics, the magnitude of said direct current potential determining the wave form of said developed audio frequency potential; and a circuit associated with said diode for providing a means of extracting a potential having a wave form rich in harmonics.

6. In a musical instrument, a resistance-ca-

pacitance oscillator capable of producing a potential of sinusoidal wave form comprising an electron discharge valve including at least three electrodes one of which is a control electrode, a parallel-T network connected across two of said electrodes, a resistor connected between said control electrode and ground, means for producing a frequency vibrato comprising a low frequency low impedance source connected in series with said resistor, and a distorting circuit comprising a gas diode connected to said oscillator for providing a source of potential of audio frequency and of complex wave form.

7. In a musical instrument, an oscillation generator for developing a first audible signal having a substantially sinusoidal wave form, means for developing two additional signals of complex wave form one containing both odd and even harmonics and the other containing substantially only odd harmonics, comprising a distorting circuit including a pair of gas diodes each characterized by having a firing potential which is substantially higher than the potential for sustaining current flow therethrough, means for connecting one terminal of each of said diodes to a common terminal, means for connecting the other terminal of one of said diodes to a source of direct current potential, means for connecting the other terminal of said other diode to ground, means for connecting said oscillation generator across said other diode, the variation in potential of the output of said oscillation generator exceeding the difference in voltage at said common terminal required for firing each of said diodes, a circuit connected to said common terminal for supplying a potential of complex wave form containing substantially only odd harmonics, and means connected to said other terminal of said other diode for supplying a potential of complex wave form rich in both odd and even harmonics.

8. In a musical instrument, an oscillation generator for developing a first audible signal having a substantially sinusoidal wave form, means for developing two additional signals of complex wave form one containing both odd and even harmonics and the other containing only odd harmonics comprising a distorting circuit including a pair of diodes each characterized by having a firing potential which is substantially higher than the potential for sustaining current flow therethrough, means for connecting the anode of one diode and the cathode of the other diode to a common terminal, means for connecting the cathode of said one diode to a source of adjustable direct current potential, means for connecting the anode of said other diode to ground, means for connecting said oscillation generator across said other diode, the variation in potential of the output of said oscillation generator exceeding the difference in voltage at said common terminal required for firing each of said diodes, a circuit connected to said common terminal for supplying a potential of complex wave form containing substantially only odd harmonics, and means connected to the anode of said other diode for supplying a potential of complex wave form rich in both odd and even harmonics.

MERWIN J. LARSEN.

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