The present invention relates to electrical musical instruments, and, more particularly, to an electrical musical instrument of the type in which space discharge devices, such as thermionic tubes, glow-discharge tubes, or the like, are employed to produce electrical oscillations of musical frequencies.

The instruments of the described character may be generally divided into two groups, according to the number of musical oscillations which may be simultaneously produced. The term "polyphonic" instrument denotes instruments of the type in which a plurality of space discharge devices are provided, permitting the production of any desired number of oscillations of musical frequency at the same time, in response to depression of respective playing keys, while the term "monophonic" instrument is employed to denote instruments of the prior art in which one, or more, oscillation producing space discharge devices are employed in such circuit combinations as to produce only a single musical note at a time upon depression of any single playing key. It is acknowledged that instruments of the monophonic type have obvious musical limitations, in that they cannot produce harmonies or chords and can only carry a single voice or melody. As those skilled in the art know, with the exception of the piano, the harp, and the organ, practically all of the conventional musical instruments are of a generally monophonic character, although greatly restricted and largely transient, polyphonic effects may be produced by most string instruments. Therefore, a substantial field of musical literature is available for interpretation by means of monophonic instruments, particularly if these instruments are accompanied by other instruments of the conventional or electrical type.

With the development of the art of electrical musical instruments, it has been found increasingly desirable to provide an electrical musical instrument which is capable of producing two musical notes at the same time. An instrument of this type would have considerably less musical limitations than the instruments of the monophonic type and in addition to interpreting a great portion of existing musical literature and various pleasing and novel effects could be obtained thereby. For convenience, in the following, the term "duophonic" will be employed to denote an instrument of this type, capable of producing two musical notes at the same time from the same or common keyboard.

The simplest and most obvious way of obtaining a duophonic electrical instrument would be to combine a pair of monophonic instruments in a single case, each of said instruments having its own oscillation producing space discharge devices, sound producing means, and manually operative elements, such as keyboards, for controlling the pitch of the notes produced. Considerable practical difficulties are, however, encountered in carrying this concept into practice.

First of all, the duplication of all parts doubles the cost and the space requirements of the instrument. Another and even more serious disadvantage is that two playing manuals have to be provided, both of which have to be simultaneously operated by the player. This greatly increases the difficulty of playing as frequently the fingers of the same hand had to be playing on different manuals or keyboards, this obviously requiring such manual dexterity and training which, while available to a highly skilled organist, is beyond the skill of the average musician.

I have discovered that the outstanding problem may be solved in a remarkably simple manner with resultant musical advantages that have never before been attained.

It is an object of the present invention to provide an electrical musical instrument which avoids the foregoing difficulties and inconveniences, and which makes it possible to produce duophonic music by means of an extremely simple playing technique.

It is another object of the present invention to provide a duophonic electrical musical instrument in which a pair of monophonic electrical musical instruments are combined with a single playing manual or keyboard in such a manner that any two musical notes within the range of the two monophonic instruments may be produced simultaneously.

A further and important object of the present invention resides in the provision of an organization of parts, including an electrical network and a common keyboard, wherein upon simultaneous actuation of any two playing keys—one part of said electrical network automatically functions to produce audible sound of the pitch of the note associated with one of such keys, during similar production by another part of said network of audible sound of the pitch of the note associated with another key, thereby causing a simultaneous audible production of tones corresponding to the musical frequencies of notes associated with different playing keys of said common keyboard, substantially in the same manner.
as when two keys are simultaneously actuated in any well known instrument of the heretofore mentioned polyphonic type.

The invention also contemplates a duophonic musical instrument which is extremely simple in construction and easy to manufacture and operate and which may be readily manufactured and sold on a practical and commercial scale at a price which is only slightly higher than that of a monophonic musical instrument.

Other and further objects and advantages of the present invention will become apparent from the following description taken in conjunction with the accompanying drawings, in which

Fig. 1 illustrates a circuit diagram of a preferred embodiment of the present invention in which gaseous discharge tubes, such as, for example, glow-discharge tubes, neon tubes, and the like, are employed for producing electrical oscillations of musical frequencies; and

Fig. 2 depicts a similar circuit in which space discharge tubes of the thermionic type are employed for producing the electrical oscillation within the audible range which are ultimately converted into musical sounds.

Broadly stated, according to the principles of my invention, I provide a duophonic electrical musical instrument in which a pair of monophonic oscillators are incorporated. Each of these oscillators comprises one space discharge device electrically associated with electrical elements such as resistances, capacities, inductances of suitable value and with switching means for selectively connecting such elements of different value to the space discharge device. Generally speaking, the type of electrical elements employed and the method of their connection with the switching means varies with the type of oscillator which is employed. Thus, in gaseous discharge tube oscillators it is preferred to employ resistances and capacitors of appropriate value to tune the oscillator to the desired pitch, while in thermionic tube oscillators resistances and capacitors or inductances and capacitors of predetermined values may be employed to selectively tune the instrument to any note within the musical range of the instrument. It has been found desirable to maintain one of the said elements fixed, while the other one is adjustable in steps by means of the switching elements. For example, in the case of glow-discharge tube oscillators, a wide range of musical frequencies may be produced by connecting a capacity of determined value to the tube and by connecting resistances of different values to such capacity. The same result may be obtained by connecting a resistance of definite value to the tube and connecting the same in circuit with capacitors of different value. In the former case, the "keyed" element is the resistance in the other the capacity and to obtain the pitch of the oscillations produced, generally as many keyed elements are provided as there are musical intervals within the range of the instrument. It has been found that best results are obtained when the keyed element is provided in the form of a chain of elements connected in series of which one or more are rendered effective by actuation of a suitable switching key. The advantage of this arrangement is that when it happens that more than one switching element is actuated at the same time, only the switching element which is the lowest, (or highest) in the series becomes effective, connecting the chain up to that point with the oscillator tube while the tuning elements, resistors or capacitors, whichever the case may be, which are between the two actuated switching elements, are short circuited and have no effect on the tuning.

This characteristic of series-connected chains of resistors or capacitors of great importance and value in that even when more than one switching element is actuated at a time, always one of the two will be automatically selected to be effective for regulating the resulting frequency and at no time are non-harmonic notes, that is: not corresponding to any note of the tempered scale, produced. For example, when a chain of serially-connected resistors is used, the note actually produced will conform to the higher one of the two coordinated to the actuated pair of keys, while when a chain of serially-connected capacitors is used, the note actually produced upon actuation of two keys or switching elements will conform to the lower one of the two coordinated to the actuated pair of keys.

In the following the expressions "high-responsive" and "low-responsive" will be applied to the combination of a space discharge space with a network of tuning elements variable in steps by means of key-controlled switching elements when upon simultaneous actuation of any two keys, the higher or the lower of the two will respectively determine the frequency of the resulting oscillation.

In order to provide a duophonic electrical musical instrument, in accordance with the principles of the present invention, a "high-responsive" and a "low-responsive" monophonic oscillator with associated switching elements are coordinated to a common playing manual in such a manner that each key of the playing manual has two switching elements coordinated thereto, electrically associated with the respective monophonic oscillators. I have found that when in an instrument of the described character any two keys are depressed simultaneously, the two switching elements corresponding to the "high-responsive" oscillator will cause said oscillator to oscillate at the higher frequency of the two, while the two switching elements corresponding to the "low-responsive" oscillator will cause the said oscillator to oscillate at the lower frequency of the two. In other words, upon depression of any two keys, two frequencies will be produced, one oscillator automatically being assigned to the higher one of the two and the other being automatically assigned to the lower one of the two, as it will be explained more fully as the description proceeds. It will be readily understood by those skilled in the art that certain elements of the two monophonic oscillators may be in common in order to save space and material. These elements are, for example, the current supply system or power pack, the output circuit, the amplifier, and the sound producing means, and, of course, the playing manual, or keyboard. This not only results in considerable economy in parts and labor, but also greatly increases the stability of the oscillations produced because any change in the voltage of the current supply will substantially uniformly influence both monophonic oscillators.

The invention will now be explained more fully to those skilled in the art, reference being had to the accompanying drawings in which certain preferred embodiments of my invention are illustrated.

Referring now more particularly to Fig. 1 of
the drawings, the simplified circuit of a duophonic electrical musical instrument employing two-electrode gaseous discharge tubes is shown. Reference to the drawings reveals a monophasic gaseous discharge tube oscillator comprising a tube G-1 having two electrodes, connected in series with a condenser C and a source of direct current voltage B-1, through the primary winding of an output transformer T. A serially connected chain of resistances C-2 to C-10, connected in series, is connected at one end to the common point of tube G-1 and condenser C and has normally open, key-actuated switches or key contacts S-1, S-2 . . . S-5 between the other ends of the respective resistances and a common bus bar D-1 connected to the other plate of condenser C. Each switch is operatively connected with a key of the playing manual, switch S-1 being connected with key K-1, switch S-2 with key K-2, and so forth. It will be noted that upon depression of each key, a predetermined number of the serially connected resistances is connected across condenser C. Thus, upon depression of K-1, switch S-1 is closed and resistance R-1 will be connected across C, upon depression of K-2 both serially connected resistances R-1 and R-2 will be connected across condenser C, etc. As those skilled in the art know, in a circuit of the described character the electrical oscillations will be produced, the frequency of said oscillations being determined by the capacity and the resistance in the circuit, provided that the other factors having bearing on the frequency such as the break-down and extinction voltages of the tube G-1 and the voltage of current source B are maintained constant. By appropriate selection of C and of resistances R-1, R-2, etc., it is possible to produce frequencies corresponding to successive notes of the tempered scale. Preferably, resistances R-1, R-2, etc., are adjustable in order to facilitate tuning of the instrument to its proper pitch. It is also advantageous to provide capacitor C in the form of a variable condenser to adjust the general pitch of the device, experience having shown that varying the capacity of C has the effect of altering the frequency of the oscillations produced upon depression of any key by substantially the same amount without appreciably affecting the relative frequencies of the oscillations produced. This may be expressed in musical terminology, by stating that varying C transforms the musical frequencies produced into a different musical key or tonality without affecting the intervals between the various notes. While in Fig. 1 only five keys and resistances have been shown, obviously any desired number of such tuning elements may be employed in accordance with the extent of the desired musical range. Thus, in practical instruments it has been found desirable to use 21, or more, playing keys and associated resistances, covering the range of three octaves, or more.

A monophasic oscillator O-1 with its associated network of switches and resistances constitutes a monophasic electrical musical instrument and consequently at any time only one key has to be depressed, in playing an instrument of this type with the conventional playing technique familiar to players of keyboard instruments it is unavoidable that at times more than one key is depressed at the same time. This seems particularly the case in playing "legato" passages when in order to obtain a closely knitted sequence or flow of successive notes, the next key is depressed already before completely releasing the last. To determine the effect of this occurrence, let us assume that first key K-1 is depressed and then key K-3 is depressed before releasing K-1. The depression of K-1 will close switch S-1 and will connect resistance R-1 across condenser C. This will tune oscillator O-1 to its highest frequency in view of the fact that the lowest value of resistance will be connected into the circuit. Assuming that now key K-3 will be likewise depressed, this will close switch S-3 but will not change the amount of resistance connected across C, because resistances R-2 and R-3 between switches S-1 and S-3 are short-circuited by the corresponding portion of bus bar D-1. In other words, in oscillator O-1 when more than one switching key is depressed at the same time, the oscillator will be tuned to the highest of the frequencies corresponding to the depressed keys. In the terminology introduced in the foregoing, this may be expressed by stating that oscillator O-1 is a "high-responsive" monophasic oscillator. The oscillations produced by oscillator O-1 may be taken off through a transformer T and may be amplified by means of an amplifier A-1. The amplified output may be rendered audible by means of a translating device, such as a loud-speaker L-1.

Oscillator O-2 is similar in its circuit to oscillator O-1 with the difference, however, that only one resistance is provided and the tuning range within the gamut of the instrument is obtained by means of a chain of serially connected condensers. Oscillator O-2 comprises a gaseous discharge tube G-2 connected in series with a resistance R and with the source of direct current B through the primary winding of transformer T, the source of current and the output transformer being in common with oscillator O-1. A chain of serially connected condensers C-8, C-4, C-1 is connected at one end to the common point of resistance R and tube G-2. Switching keys or key contacts S-10, S-9 . . . S-5 are connected between each common point between successive condensers and common bus bar D-2 whereby any desired number of serially connected condensers may be connected across resistance R in accordance with the switch operated. Thus, it will be noted that when key contact S-10 is actuated, condenser C-5 will be connected across resistance R which will cause oscillations of musical frequency to be produced by gaseous discharge tube oscillator O-2. When key contact S-5 is actuated, condensers C-8 and C-4 in series with each other will be connected across resistance R and an oscillation of higher frequency will be produced due to the fact that the resultant capacity of two condensers connected in series is lower than that of any one of the individual condensers. By means of suitable selection of the capacities and of the resistance and of the other constants in the circuit, it is possible to obtain that the frequency of the oscillations produced by oscillator O-2 upon actuation of the various key contacts corresponds to the frequencies of the successive notes of the tempered scale. To facilitate such "tuning" of the oscillator, condensers C-1 to C-5 and also resistance R, may be made adjustable. By adjusting condensers C-1 to C-5, the proper tuning of the oscillator may be readily accomplished and each note may be readily brought into the proper and desired pitch of the tempered scale while by adjusting R, the general pitch of the oscillator may be adjusted without appreciably changing the relative intervals between the vari-
ous notes. Of course, in a commercial instrument a relatively large number of condensers and key contacts is used, such as, for instance 37, corresponding to the range of three octaves. It is worth noting that in an oscillator of the described character in which a chain of serially connected condensers is employed, upon actuation of more than one key contact at the same time, always the frequency corresponding to the lowest actuated key contact will be produced. This will be readily understood from contemplation of the circuit of oscillator O-2 in Fig. 1. Assuming that key contact S-10 is closed, condenser C-8 alone will be connected across resistance R, tuning the oscillator to the lowest frequency of its range. When now key contact S-8 is likewise closed, serially connected condensers C-3, C-4 and C-5 will be all connected across resistance R through bus bar D-2. However, the portion of the chain between contacts S-8 and S-10, that is condensers C-3 and C-4, will be short-circuited through the said contacts and the said bus bar and will have no effect on the frequency of the oscillations produced, such frequency being determined only by the capacity of C-5. In other words, in case more than one key contact is closed at the same time, the frequency of the oscillations produced is determined by the key contact corresponding to the lowest frequency between the key contacts actuated, or reverting to the special terminology introduced in the foregoing, an oscillator, such as O-2, employing a condenser chain in series connection is a "low-responsive" monophonic oscillator.

The oscillations produced by means of oscillator O-2 are withdrawn through transformer T which is in common with oscillator O-1. These oscillations, together with the oscillations produced by means of oscillator O-1 are amplified by amplifiers A-1 and are converted into musical sounds by means of translating device or loudspeaker L-1.

In the circuit constituting Fig. 1 of the drawing, a "high-responsive," serially-connected resistance-tuned monophonic oscillator O-1 is combined with a "low-responsive" serially-connected condenser-tuned monophonic oscillator O-2, both oscillators being supplied from a current source in common and feeding their output into a common amplifier and translating device. As it will be readily observed in Fig. 1, key contacts S-1 to S-5 cause production of oscillations of different pitch by step by step decreasing frequencies of the tempered scale, same as closure of contacts S-8 to S-10, associated with oscillator O-2. In view of the fact that the longer the chain of resistances R-1 to R-5, the higher the resultant resistance is, and, on the other hand, the longer the chain of serially-connected condensers, the lower the resultant capacity is, oscillators O-1 and O-2 and their respective key contacts are coordinated in reverse relative sequence. Thus, key contact S-1 is directly superposed upon key contact S-2, key contact S-2 is directly superposed upon key contact S-3, etc. In other words, key contacts of oscillators O-1 and O-2 are superposed upon each other in such an arrangement that contacts corresponding to the same frequencies are superposed upon each other and may be actuated by the depression of the corresponding key of the playing manual. This is indicated by means of the dotted lines connecting key contacts S-1 and S-4, S-4 and S-7 which may be closed simultaneously by depression of keys K-4 and K-2, respectively. This mechanical connection may be readily ac-

completed by mounting corresponding key contact sets directly underneath of the same key of the playing manual, as those skilled in the art will understand without any detailed explanation.

From the foregoing description, the operation of my duophonic electrical musical instrument will be readily understood. When two keys of the playing manual, or keyboard, are simultaneously depressed, two pairs of key contacts will be simultaneously closed, two of these contacts being in the circuit of O-1 and two of these contacts in the circuit of O-2. In view of the fact that oscillator O-1 with its chain of serially connected resistances is a "high-responsive" monophonic oscillator and oscillator O-2 with its chain of serially connected condensers is a "low-responsive" monophonic oscillator, oscillator O-1 will be tuned to the frequency corresponding to the higher one of the depressed keys, while oscillator O-2 will be tuned to the frequency corresponding to the lower one of the depressed keys. Thus, upon depression of any two keys of the playing manual, the higher one of the two will be automatically assigned to oscillator O-1 and the lower one will be automatically assigned to oscillator O-2. The two oscillations simultaneously produced may be amplified by amplifier A-1, which is inductively coupled with both oscillators, and may be rendered audible by means of translating device L-1 which is likewise in common for both oscillators. Of course, it is quite possible to provide separate outputs, means, amplifiers and translating means for both oscillators but in most cases this is not necessary, nor desirable.

While generally the same musical range is assigned to both oscillators so that upon depression of any single playing key both oscillators are tuned to the same note of the tempered scale, in some cases further musically valuable results may be obtained by so adjusting the general pitch of the two oscillators that there is a definite and constant interval therebetween. This interval may be that of an octave, a fifth, a third, etc., and may be readily obtained by proper adjustment of condenser C in oscillator O-1 and of resistance R in oscillator O-2. In this case the depression of any single key of the playing manual will cause the production of two notes which are separated from each other by the constant interval separating the general pitch of both oscillators, while upon depression of any two keys of the playing manual two notes will be heard which will be separated from each other by the interval between the two playing keys plus or minus the difference between the general pitch of the two oscillators.

When at any time more than two keys are simultaneously depressed in my duophonic electrical, only the highest and the lowest will be effective in determining the pitch of the two simultaneous heard notes while the intermediate keys will have no effect on the tuning of the instrument.

Fig. 2 illustrates a modified embodiment of the principles of the present invention into a duophonic electrical musical instrument in which the duophonic instrument is employed for producing the electrical oscillations of musical frequencies. The circuit depicted in Fig. 2 will be found to be much similar to that shown in Fig. 1 in that a "high-responsive" and a "low-responsive" monophonic musical instrument is combined into a single instrument with a common playing manual or keyboard. The "high-responsive" mono-
phonic oscillator O-3 essentially comprises a three-electrode thermionic tube E-f. A source of direct current potential, such as a battery B-2 through a voltage divider P-4 applies a negative potential value to the cathode of the tube and a positive potential to the plate of the tube through a portion of inductance I-1, the other portion of said inductance being connected at its outer end through a condenser C-11 to the grid. A chain of serially connected resistances R-4 to R-16 is connected between the grid of the tube and a point or adjustable negative potential through a plurality of key contacts or switches S-11 to S-15 arranged between common points of adjoining resistances and bus bar D-3 in connection with the voltage divider P-4, so that upon depression of any one of the playing keys K-6 to K-16 of the playing manual or keyboard, a selected number of resistances will be connected between the grid and the point of negative potential on the voltage divider.

As those skilled in the art know, in a circuit of the described character audio-frequency oscillations are set up upon depression of any one of playing keys K-6 to K-16, the frequency of such oscillations being substantially determined by the time constant characteristic of condenser C-11 discharging through one or more of resistors R-4 to R-16. In view of the fact that those skilled in the art are familiar with the operation of an oscillatory circuit of the described character, no detailed description of the oscillatory action of the circuit will be necessary. It will be sufficient to state that the circuit employs a thermionic vacuum tube in combination with a feedback element closely coupling the plate-cathode circuit through a condenser to the grid. The condenser is electrically connected through the feedback means with the cathode and in a closed circuit relation through the cathode with the resistor included in the grid-cathode circuit. The condenser alternately receives a charge and discharges the accumulated charge through the resistor and as a result of the plate-cathode circuit to the grid, rapidly accumulates a charge sufficient to bias the grid beyond the cutoff potential. Thus, the period of the condenser discharge substantially determines the frequency of the oscillations produced, it being, of course, necessary to properly pole the feedback means and to properly adjust the supply potential at the grid. In oscillator O-3, the frequency of the oscillations produced is determined inter alia by the number of resistances R-4 to R-16 connected in series with each other and between the grid of the tube E-1 and voltage divider P-1, in accordance with the action of one of switches S-11 to S-18. Preferably, a much larger number of serially connected resistances is employed according to the range of the oscillator desired, and the values of the resistances are so selected that upon actuation of successive switching keys, the oscillator will be turned to successive notes of the tempered scale. It is advantageous to make condenser C-11 adjustable in order to be able to adjust the general pitch of the oscillator without appreciably changing the relative intervals between the various notes.

The output of oscillator O-3 is derived through a condenser C-12 and a resistance R-11 which are connected in series with a potentiometer or volume control P-2 between the plate and the cathode of tube E-1. The oscillations are amplified by means of an amplifier A-2 and are converted into sound by means of translating device L-2.

Oscillator O-4 is practically identical with oscillator O-3 described in the foregoing and comprises thermionic tube E-2, feed-back means I-3, voltage divider P-3 and source of direct current B-3, electrically associated with each other in the same way as the corresponding elements in oscillator O-3. The only difference resides in the arrangement of a chain of serially connected condensers C-5 to C-10 having switches S-16 to S-20 connected between the common points of the condensers and a common bus bar D-4 whereby a varying number of condensers may be connected between the outer end of feedback coil I-3 and the grid of the tube. An adjustable resistance R-12 is connected between the grid of tube E-2 and a point of negative potential on voltage divider P-3. The frequency of the electrical oscillations produced in this oscillator O-4 is essentially determined by the amount of capacity and resistance connected in the circuit by means of switches S-16 to S-20. While in Fig. 3 a chain of five serially connected condensers is shown, in actual practice a much greater number of condensers is used such as shown in Fig. 4 in accordance with the musical range contemplated, the individual condensers being so selected as to successively tune the oscillator to the consecutive notes of the tempered scale within the desired range. By adjusting resistance R-15 it is possible to adjust the general pitch of the oscillator without changing the intervals between the successive notes. From the foregoing description it is clear that oscillator O-4 is a “low-responsive” monophonic oscillator, that is upon closing more than one switching key at the same time, the oscillator will be tuned to the frequency corresponding to the lowest one of closed switches.

The output of oscillator O-4 may be withdrawn by means of any suitable coupling device such as the capacity-resistance coupling means shown in Fig. 2 comprising condenser C-13 and resistance R-15 which are in series with volume control potentiometer P-2 and connected between the plate and the cathode of the tube E-2. The output of musical frequency is amplified by means of amplifier A-3 and is converted into musical sound by means of translating device L-2.

In view of the foregoing detailed description, the operation of my modified duophonic electrical musical instrument will be readily understood by those skilled in the art. Switches S-11 to S-18 of oscillator O-3 and switches S-16 to S-30 of oscillator O-4 are so arranged in pairs that switches of the two oscillators corresponding in coordinated frequencies are simultaneously actuated by depression of a single key of the playing manual. This may be readily accomplished, for example, by mounting the said pairs of switches in superposed position below the same playing key as this is indicated in Fig. 2 by means of dotted lines. Thus, depression of key K-6 will simultaneously close switches S-11 and S-16; depression of key K-7 will simultaneously close switches S-12 and S-17, etc. In view of the fact that oscillator O-3 is a “high-responsive” monophonic oscillator and oscillator O-4 is a “low-responsive” monophonic oscillator, upon depression of any key playing
are converted into musical sounds by means of translating means L-3 and L-4, respectively. The general pitch of oscillators O-3 and O-4 may be adjusted by means of variable condenser C-11 and variable resistance R-12, respectively. In the simplest case the general pitch of both oscillators may be the same, or, if desired, any appropriate musical interval may be provided between their general pitch, such as that of an octave, fifth, third, etc. The volume of the two oscillators may be adjusted individually by means of volume control potentiometers P-2 and P-4, respectively, which may be combined in a single, collectively adjusted unit, if desired.

Although the present invention has been described in connection with a few preferred embodiments thereof, variations and modifications may be resorted to by those skilled in the art without departing from the principles of the present invention. Thus, various refinements may be applied to the monophonic oscillators to produce wave forms of modified shape and thereby simulate the tone quality of different instruments or to obtain tone color or timbres of novel and musically useful type, to incorporate tremolo, percussion, and the like effects. While the monophonic oscillators disclosed comprise only a single space discharge device, the invention is also applicable to oscillators of the type in which a plurality of space discharge devices tuned to harmonically related frequencies is employed to produce a single musical note of the tempered scale at a time.

Instead of a chain of series-connected resistances, a tapped inductance may be employed with equal, or similar, results, particularly in the circuit disclosed in Fig. 2. I consider all of these variations and modifications as within the true spirit and scope of the present invention, as disclosed in the foregoing description and defined by the appended claims.

I claim:

1. A diaphonic electrical musical instrument comprising in combination a pair of electronic oscillators tunable in steps to frequencies within a musical range; each of said oscillators including two different space discharge devices, a series of tuning elements, and a plurality of switches for selectively connecting portions of said series into oscillation-producing relation with said space discharge device; said tuning elements and their associated switches being so connected in circuit that upon actuation of more than one switch at a time the oscillators are tuned to frequency respectively corresponding to the highest and to the lowest of the actuated switches; a playing manual for operating said switches in pairs appertaining to different oscillators; and sound producing means responsive to the output of said oscillators.

2. An electronic musical instrument of the twin melody type which comprises in combination a pair of electronic oscillators tunable in steps to frequencies corresponding to successive notes of the tempered scale within a desired range; each of said oscillators including a space discharge device, a series of tuning elements, and a plurality of switches for selectively connecting portions of said series into oscillation-producing relation with said space discharge device; said tuning elements and their associated switches being so connected in circuit that upon actuation of a plurality of switches at a time the oscillators are tuned to a frequency respectively corresponding to the highest and the lowest of the actuated switches; a playing manual for operating said switches in pairs appertaining to different oscillators; sound producing means responsive to the output of said oscillators; and individual means for adjusting the general pitch and the amplitude of the oscillations produced by each oscillator.

3. An electronic musical instrument of the twin melody type which comprises in combination a pair of relaxation oscillators tunable in steps to frequencies corresponding to notes of a musical scale; each of said oscillators including a glow-discharge tube having only two electrodes, a tapped tuning element, and a plurality of switches for selectively connecting taps of said element into oscillation-producing relation with said tube; the tapped tuning elements and their associated switches being so connected in circuit that upon simultaneous actuation of a plurality of switches the oscillators are tuned to a frequency respectively corresponding to the highest and to the lowest of the actuated switches; a playing manual for operating said switches in pairs appertaining to different oscillators; and sound producing means responsive to the output of said oscillators.

4. An electronic musical instrument of the twin melody type which comprises in combination a pair of relaxation oscillators tunable in steps to frequencies corresponding to notes of a musical scale; one of said oscillators including a glow-discharge tube, a tapped tuning element, and a plurality of switches for selectively connecting taps of said element resistance in oscillation-producing relation with said tube; the other of said oscillators including a glow-discharge tube, a tapped capacitor element, and a second plurality of switches for selectively connecting taps of said capacitor element in oscillation-producing relation with said last-named tube; the taps of said resistance and of said capacitor element and their associated switches being so connected in circuit that upon simultaneous actuation of a plurality of switches the oscillators are tuned to a frequency respectively corresponding to the highest and to the lowest of the actuated switches; a playing manual in common for both oscillators for operating said switches in pairs appertaining to different oscillators; and sound producing means responsive to the output of said oscillators.

5. An electronic musical instrument of the twin melody type which comprises in combination a pair of relaxation oscillators; one of said oscillators including a two-electrode glow-discharge tube, a plurality of series connected condensers, and a plurality of switches for selectively connecting a determined number of said condensers in oscillation-producing relation with said tube; the other of said oscillators including a two-electrode glow-discharge tube, a plurality of series connected condensers, and a second plurality of switches for selectively connecting a determined number of said condensers in oscillation-producing relation with said last-named tube; a playing manual in common for both oscillators for operating said switches in pairs appertaining to different oscillators; and sound producing means responsive to the output of said oscillators.

6. An electronic musical instrument of the twin melody type which comprises in combination a pair of oscillators; each of said oscillators being independently tunable in steps to frequencies corresponding to successive notes of the tempered scale and including a space discharge device hav-
ing at least a cathode, a grid and an anode, a series of tuning elements, and a plurality of switches for connecting a determined number of said tuning elements in oscillation-producing relation with said space discharge device; said tuning elements and their associated switches being so connected in circuit that upon actuation of a plurality of switches at a time the oscillators are tuned to a frequency respectively corresponding to the highest and to the lowest of the actuated switches; a playing manual for operating said switches in pairs appertaining to different oscillators; and sound producing means responsive to the output of said oscillators.

7. An electrical musical instrument comprising in combination a pair of oscillators individually tunable in steps to frequencies corresponding to successive notes of the tempered scale and of the type in which audio-frequency oscillations are maintained by the time constant characteristics of a condenser discharging through a resistance; each of said oscillators including a multi-electrode thermionic tube, a series of tuning elements, and a plurality of switches for selectively connecting a determined number of said tuning elements in oscillation-producing relation with said tube; said tuning elements and their associated switches being so connected in circuit that upon actuation of a plurality of switches at the same time the oscillators are tuned to a frequency respectively corresponding to the highest one and to the lowest one of the actuated switches; a playing manual for operating said switches in pairs appertaining to different oscillators; and sound producing means responsive to the output of said oscillators.

NICHOLAS LANGER.