CIRCULAR SCALE ELECTRICAL MUSICAL INSTRUMENT

Filed June 23, 1950 2 Sheets-Sheet 1

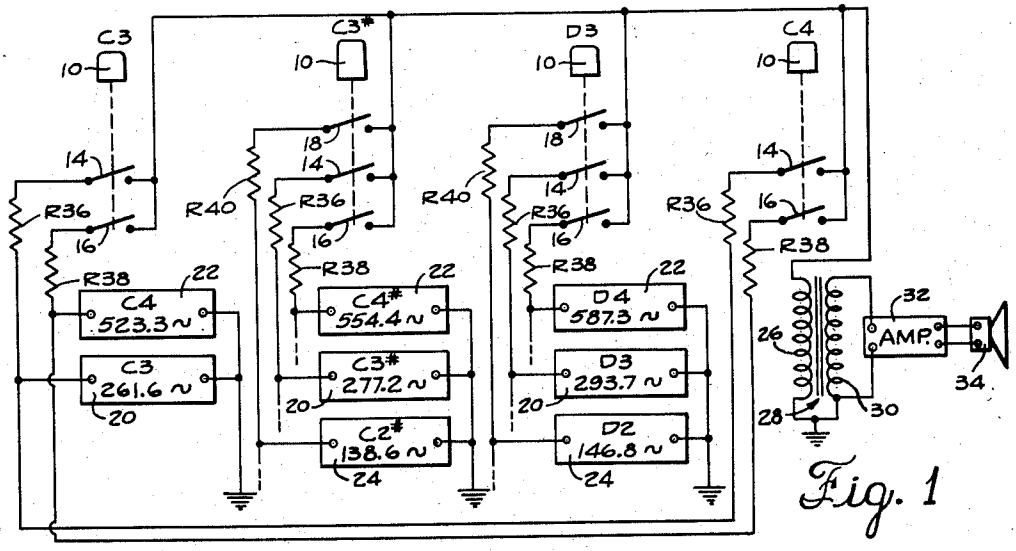


Fig. 1

KEY	VALUES OF RESISTORS CONNECTING KEY-OPERATED SWITCHES TO GENERATORS (OHMS)		
	LOW OCTAVE GENERATOR	MIDDLE OCTAVE GENERATOR	HIGH OCTAVE GENERATOR
C	——	39	39
C*	330	39	47
D	270	39	56
D*	220	39	68
E	180	39	82
F	150	39	100
F*	120	39	120
G	100	39	150
G*	82	39	180
A	68	39	220
A*	56	39	270
B	47	39	330

Fig. 2

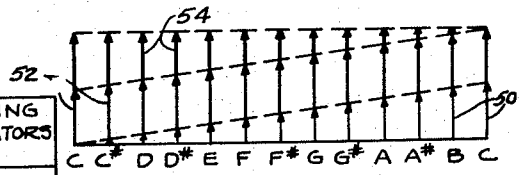


Fig. 3

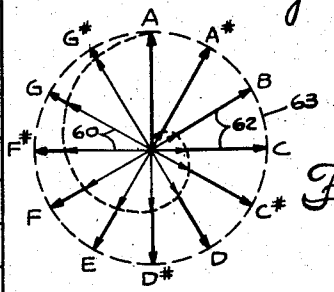


Fig. 4

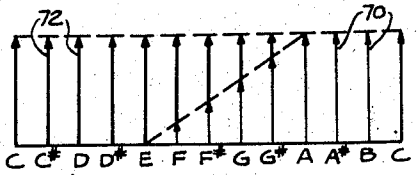


Fig. 5

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CIRCULAR SCALE ELECTRICAL MUSICAL INSTRUMENT

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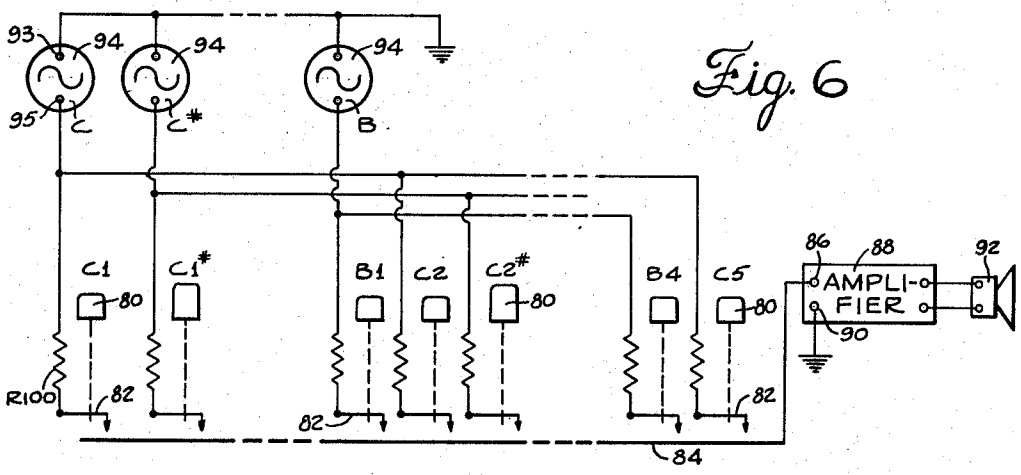


Fig. 6

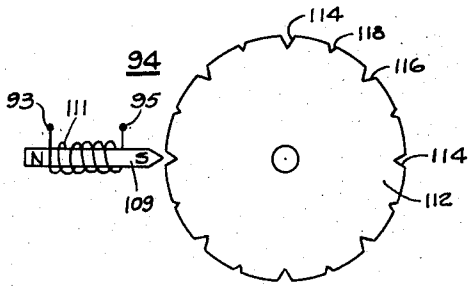


Fig. 7

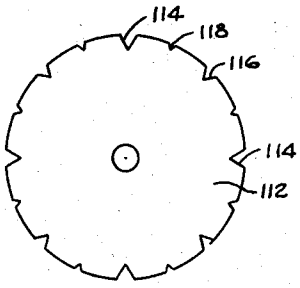


Fig. 8

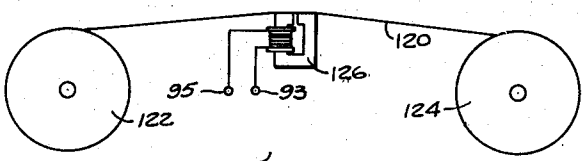


Fig. 9

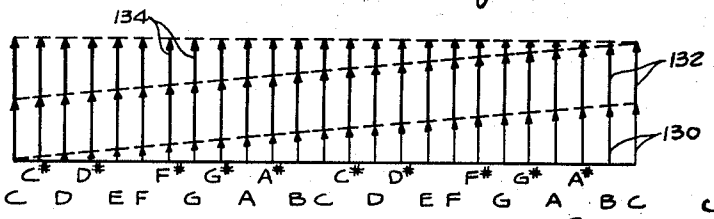


Fig. 10

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United States Patent Office 2,846,913 Patented Aug. 12, 1958

2,846,913

CIRCULAR SCALE ELECTRICAL MUSICAL INSTRUMENT

Laurens Hammond, Chicago, Ill., assignor to Hammond Organ Company, a corporation of Delaware

Application June 23, 1950, Serial No. 169,901

6 Claims. (Cl. 84—1.01)

My invention relates generally to electrical musical instruments and more particularly to a method and apparatus for producing a novel effect in the perception of the pitch of musical tones.

It is generally stated that the apparent pitch of a complex musical tone is determined by the pitch of the lowest frequency component of the tone. It is known that this is not strictly true. One known exception is that a complex musical tone having at least second and third harmonic components but no fundamental component is perceived by the listener as having the pitch of the absent fundamental.

I have discovered that a novel and very startling musical effect may be produced, for example, with a musical instrument adapted to provide musical tones that change in quality in a certain manner as the tones change in pitch. If the keys of an octave of such an instrument are depressed one after the other in a deliberate manner as in playing the chromatic musical scale, from low pitch to high pitch, each successive tone apparently has the pitch corresponding to the depressed key, and the series of tones apparently is that of the ascending chromatic scale. However, if after the twelfth tone of the octave has been played, the first is again sounded, the surprising fact is that the tone produced then seems to a listener to be of higher pitch than the twelfth tone.

The player thus may play an ascending scale in the same octave repeatedly and it is perceived by the listeners as a progression of tones of uninterruptedly ascending pitch. This illusion is very powerful, so much so that a listener hearing it for the first time is utterly perplexed and "cannot believe his ears."

With an instrument embodying a variant of the invention, a person may play the ascending chromatic scale through two octaves of keys and find by comparing the last tone with the first that there is only one octave of pitch difference between the two although, as the scale was played, each successive tone was apparently a semitone higher than the preceding tone.

The effects of playing a descending scale, as might be expected, are similar, in reverse, to the effects produced by playing an ascending scale. Each tone is apparently of lower pitch than the preceding one, but the thirteenth tone of the descending scale seems to be of lower pitch than the first tone sounded.

Broadly speaking these results are obtained by changing the quality of the tone slightly with each semitone for some or all of the semitone intervals of an octave, by progressively increasing the intensity of a low frequency tone component while at the same time progressively decreasing the intensity of a high frequency tone component as the pitch increases. The two tone components may differ in pitch by one or more octaves.

Thus an object of this invention is to produce a novel, unexpected musical effect.

A further object is to provide apparatus for combining tone components to provide a series of tones for producing a novel scale effect whereby the tones sounded

in succession are perceived as a scale although the first and last notes of an octave have the same pitch.

A further object is to provide apparatus for producing a "circular scale" musical effect.

A further object is to provide apparatus for producing scale tones characterized in that the actual change in pitch over a given range is less than the apparent change.

A further object is to provide apparatus for producing accompaniment musical tones.

A further object is to provide apparatus for producing accompaniment tones for a multi-octave musical instrument having playing keys, the number of different tones being less than the number of keys.

Other objects and advantages of this invention will appear from the following description together with the drawings which disclose the details of illustrative embodiments of this invention in order that those skilled in the art may readily understand and practice its basic principles. A complete and concise statement of the patentable scope of this invention is set forth in the appended claims.

In the drawings, Figure 1 is a diagrammatic representation of an illustrative embodiment of this invention;

Figure 2 is a tabulation of illustrative resistance values of the resistors of Fig. 1;

Figures 3, 4 and 5 are diagrams illustrating the principles of this invention;

Figure 6 is a diagrammatic representation of a modified form of this invention;

Figures 7 and 8 illustrate tone wheel generators which may be employed as parts of the apparatus illustrated in Fig. 6;

Figure 9 illustrates a magnetic record reproducing mechanism which may form a part of the apparatus illustrated in Fig. 6; and

Figure 10 is a diagram illustrating the principles of this invention.

By "circular scale" as used in this application, is meant a progressive change in tone quality throughout the range of one or two octaves whereby the lowest tone within the range are complex tones comprising a relatively low strength unison tone and a relatively high strength octave tone while the highest pitched tone within the range consists of a relatively high strength complex unison tone and a relatively low strength octavely related complex tone, the intermediate tones within the range of an octave or two octaves being graded progressively between the lowest and highest tones.

Fig. 1 illustrates a musical instrument having thirteen keys **10**, the four typical keys **10** illustrated being the three lowest and the highest pitched keys **10**, designated as C3, C3#, D3 and C4.

Each key **10** has an operating connection with an individual middle octave switch **14**, with a high octave switch **16**, and, except for the C3 and C4 keys **10**, with a low octave switch **18**.

A rank of twelve middle octave generators or sources **20** are provided, three representatives of which are illustrated, for producing scale tone signals differing by semitone pitch intervals and extending over a musical octave beginning, for example, with the note C3, 261.6 cycles per second (C. P. S.), and progressing upward through C3# (277.2 C. P. S.), D3 (293.7 C. P. S.), and so forth.

Three high octave generators **22** are illustrated as representative of a rank of twelve such generators **22** provided for producing tone signals one octave higher in pitch than the signals produced by the correspondingly designated middle octave generators **20**. Thus the generators **22** respectively designated C4, C4# and D4 provide signals at 523.3 C. P. S., 554.4 C. P. S., and 587.3 C. P. S.

A rank of eleven low octave generators **24** are provided, two typical generators **24** being illustrated, for producing tone signals one octave lower in pitch than the signals from the corresponding middle octave generators **20**. Thus the generators **24** respectively designated C2# and D2 produce signals at 138.6 C. P. S. and 146.8 C. P. S. No generator **24** of the pitch C2 is provided.

One output terminal of each of the generators **20**, **22**, **24** is grounded. One terminal of each of the switches **14**, **16**, **18** is connected with one end of a low impedance primary winding **26** of a transformer **28**, the other end of the winding **26** being grounded. The secondary winding **30** of the transformer **28** is connected with the input of an amplifier or output system **32**. One end of the secondary **30** is grounded. The output of the amplifier **32** is connected with a speaker or translator **34**.

The other terminal of each middle octave switch **14** is connected through an individual resistor **R36** with the ungrounded terminal of the middle octave generator **20** having the same pitch designation. Thus, the C note switch **14** is connected with the generator **20** designated C3, the C# note switch **14** with the C3# generator **20**, the D switch **14** with the D3 generator **20**, and so forth. The switches **14** and resistors **R36** may be regarded as parts of the respective generators **20**.

In like manner, each of the high octave switches **16** is connected by an individual resistor **R38** with the high octave generator **22** having the same pitch designation. Thus the C switch **16** is connected with the C4 generator **22**, the C# switch **16**, with the C4# generator **22**, and so forth.

Each of the low octave switches **18** is connected through an individual resistor **R40** with the corresponding low octave generator **24**, the C# switch **18** being connected with the C2# generator **18**, and so on.

The resistors **R36**, **R38**, **R40** regulate the amplitudes of the output signals from the generators **20**, **22**, **24**. The values of **R36**, **R38** and **R40** should be large compared with the impedance of the transformer primary **26** and with the internal impedances of the generators **20**, **22**, **24**. As indicated in Fig. 2, all the middle octave resistors **R36** may have the same value, such as 39 ohms. The values of the high octave resistors **R38** are graded, roughly in a geometric series, between a value such as 39 ohms for the C notes and 330 ohms for the B notes. The low octave resistors **R40** are graded geometrically between values such as 330 ohms for the C# notes and 47 ohms for the B notes.

Illustrative values of **R36**, **R38** and **R40** are given in order that those skilled in the art may more readily grasp the fundamental principles of this invention. It will be understood that many other appropriate values may be employed.

If the C3 key **10** is depressed, the associated switches **14** and **16** are closed and the C3 and C4 generators **20** and **22** are connected through **R36** and **R38** respectively to the primary **26** of the transformer **28** and thence to the output system **32**. Thus the tones C3 at 261.6 C. P. S. and C4 at 523.3 C. P. S. are sounded simultaneously. Since, as shown in Fig. 2, **R36** and **R38** have the same values for this key **10**, the tones have equal intensities, and an octave coupler effect is produced. The apparent pitch is that of the lower frequency C3 component.

If the C3 key **10** is released and the C3# key **10** depressed, the generators **20** (C3#), **22** (C4#) and **24** (C2#) are connected with the output system **32** through **R36**, **R38** and **R40** respectively and the three generators are concurrently sounded to produce a tone comprising three octavely related components. As seen in Fig. 2, the middle octave (C3#) component has the same amplitude as before since the values of all of the resistors **R36** are the same, but the high octave component (C4#) has a slightly smaller amplitude than before because the value of **R38** is about 20 percent greater. The amplitude of the low octave component (C2#) is very small because of the relatively high value of **R40**. In fact, the amplitude of the low octave component is so small that the apparent pitch of the composite tone is that of the middle octave (C3#) component and the apparent pitch thus is higher than that of the preceding tone.

If the C3# key **10** is released and the D3 key **10** depressed, a tone comprising middle octave (D3), high octave (D4) and low octave (D2) components is sounded. It may be seen in Fig. 2 that the intensity of the low octave component is slightly greater than before because of the smaller value of **R40**, and the intensity of the high octave component is decreased slightly because of the greater value of **R38** while the intensity of the middle octave component remains the same as before. Since all three of the components have increased in pitch from the previous tone the apparent over-all pitch of the tone is increased also.

As the remaining keys **10** of the scale are successively depressed, in ascending order, the proportionate intensity of the low octave component progressively increases while the intensity of the high octave component progressively decreases. These progressive changes in intensity are clearly illustrated by the diagram of Fig. 3 in which the lowest arrows **50**, drawn with light lines, represent the intensities of the low frequency component, the middle arrows **52**, drawn with medium weight lines, represent the intensities of the middle octave component and the upper arrows **54**, drawn with heavy lines, represent the intensities of the high octave component. As shown in Fig. 3, when the note B3 is reached the intensity of the low octave component is nearly as great as the intensity of the middle octave component while the intensity of the high octave component is reduced to a very small value. The apparent pitch of this tone is that of the low octave component and is actually a semitone lower than the apparent pitch of the C3 tone which was first sounded. If the C4 key **10** is depressed the tone sounded is the same as that produced by the depression of the C3 key **10** but the tone seems to be higher in pitch than the preceding tone in the scale. With an instrument such as this the pitch of the tones seems to change in the normal manner from note to note as a scale is played, but the pitch of the last scale tone is the same as that of the first. Such a scale may aptly be termed a "circular scale."

In Fig. 1 the components connected to the output by operation of a given key **10**, taken together, may be regarded as a single source of a complex octave coupler type signal. For example, one such complex source comprises the components connected with the D3 key **10**, including the D3 generator **20** and the associated resistor **R36** and switch **14** which contribute the middle octave or fundamental signal component, the D2 generator **24** and the associated resistor **R40** and switch **18** which contribute the low octave or suboctave coupler component, and the D4 generator and the associated resistor **R38** and switch **16** which furnish the high octave or octave coupler component. The middle arrows **52** in the diagram of Fig. 3 may be regarded as indicating the percentage magnitude of the fundamental component, the lower arrows **50** the percentage magnitude of suboctave coupler, and the upper arrows **54** the percentage magnitude of the octave coupler. The fundamental component has the same percentage amplitude for all the tones of the scale but the suboctave coupler effect increases progressively from tone to tone in ascending order and the octave coupler effect decreases progressively from tone to tone.

The principles of this invention may be applied in many different ways to provide a considerable variety of apparatus capable of producing different but basically similar musical results. Fig. 4 illustrates one such variation. A polar diagram is shown in which the arrows **60** originating at the origin or center of the diagram represent the intensities of a low octave or suboctave tone component and the outer arrows **62** terminating at a

circular envelope line **63** represent the intensities of a high octave or fundamental tone component. The two components may differ in pitch by a single octave. The diagram illustrates how the components may be combined to produce a circular scale effect. The tone A comprises the fundamental component only. A small amount of the suboctave component is introduced into the tone A♯ to produce a suboctave coupler effect and the fundamental component is reduced slightly so that the total amplitude remains constant. The magnitude of the suboctave coupler effect increases progressively through the tones B, C, C♯, D, D♯, E, F, F♯, G and G♯ while the magnitude of the fundamental component progressively decreases, as indicated by the diagram. For tones such as F♯, G and G♯ the intensity of the suboctave coupler component is considerably greater than that of the fundamental component, and the suboctave component tends to dominate the tone and to determine the apparent or subjective pitch. The tone G♯ has a lower subjective pitch then the tone A because the suboctave component which dominates the tone G♯ is one semitone lower in pitch than the fundamental component which dominates the tone A.

With the aid of the disclosure herein, those skilled in the art will readily be able to devise an apparatus for producing a scale of tones having the qualities illustrated in Fig. 4. For example the apparatus of Fig. 1 may readily be modified to provide such a scale of tones by omitting the generators **24**, the resistors **R40** and the switches **18** and by changing the values of the resistors **R36** and **R38**. The generators **22** may be utilized to furnish the fundamental components and the generators **20**, to furnish the suboctave coupler components. A generator **20** is not required to produce the tone A since a generator **22** produces the fundamental component which comprises the entire tone.

The diagram of Fig. 4 has been drawn in polar form in order to illustrate the aptness of the name "circular scale" and to show that the change in tone quality from tone to tone is so gradual that the tones may be sounded in succession without unusual discontinuities in pitch. If the tones are sounded in ascending order beginning with any of the tones, they are perceived as a regularly ascending scale although there is no net change in pitch over a complete octave of tones.

Fig. 5 shows another illustrative application of the fundamental principles of this invention. The scheme of the diagram is similar to that of Fig. 3, the lower arrows **70**, drawn with light lines, representing the amplitudes of a suboctave tone component and the upper arrows **72**, drawn with heavy lines, representing the amplitudes of a fundamental tone component. As shown, the circularization of the scale is accomplished through a range of only four tones rather than a complete octave. The tones C, C♯, D, D♯ and E consist entirely of the fundamental component. If they are successively sounded the first five tones of an orthodox chromatic scale are heard. The tones F, F♯, G and G♯ comprise both the fundamental and suboctave components, the suboctave component furnishing about 10 percent of the intensity of the tone F, 25 percent of the intensity of the tone F♯, 50 percent of the intensity of the tone G and 75 percent of the intensity of the tone G♯. The remaining tones A, A♯ and B consist entirely of the suboctave component. If the twelve tones are sounded in succession there is a slight change of quality between the tones E and F, but the change is so small that it is hardly perceptible and the pitch seems to rise a normal semitone between the two tones. Likewise there is a change in quality between the F and F♯ tones, but the change from 10 percent to 25 percent suboctave coupler effect is so slight as to be hardly perceptible and the illusion of increasing pitch is preserved. The same is true of the changes in quality between the tone F♯ and G, G and G♯, and G♯ and A. Although the actual pitch of the tone A is lower than that of the tone E, a powerful illusion of increasing pitch is produced if the tones E through A are successively sounded because the change from the fundamental range to the suboctave range is accomplished so gradually.

Fig. 6 illustrates how the circular scale principle may be applied to provide accompaniment tones for a multi-octave keyboard type electrical musical instrument. It will be apparent to those skilled in the art that a circular scale instrument is not well adapted to play solo melody parts in which large intervals of pitch change are encountered because the circular scale illusion depends upon the successive sounding of adjacent tones as in playing a chromatic or diatonic scale. However, a circular scale instrument may be employed as an accompaniment section of an instrument which also comprises a solo section. Both the solo section and the accompaniment section may be operated by a single keyboard, or separate keyboards may be employed. Only the accompaniment section of such an instrument is shown in Fig. 6 and the solo section may be of any desired construction.

The seven playing keys **80** illustrated in Fig. 6 represent the keys of a four octave instrument. Each of the keys **80** has an operating connection with a switch **82**. One terminal of each of the switches **82** is connected by means of a collector bus-bar **84** to an input terminal **86** of an amplifier or output system **88** having a low-impedance input, and the other input terminal **90** of the amplifier is grounded. The output of the amplifier **88** is connected to a speaker or other output device **92**. Twelve generating systems or sources **94** are provided to produce tones corresponding with the twelve musical notes of an octave. Three representative generators **94** designated C, C# and B are illustrated.

One output terminal **93** of each generator is grounded. Each of the switches **82** is connected through an individual resistor **R100** to the ungrounded terminal **95** of one of the generators **94**, all of the C switches **82** being connected to the C generator **94**, all of the C# switches **82** to the C# generator **94**, and so forth. By this connection a plurality of octaves of keys may be served by a single octave of generators.

The generators **94** are designed to provide tones having different tone qualities so that the circular scale effect is produced when the keys **80** are successively depressed. For example, each generator **94** may comprise a plurality of oscillators, somewhat as illustrated in Fig. 1, adjusted to produce high, low and middle octave components in the proportions suggested in Fig. 3, the amplitude of the low octave component increasing and the amplitude of the high octave component decreasing as an ascending scale is played. Alternately, each generator **94** may comprise oscillators to produce fundamental and suboctave components in the proportions indicated either in Fig. 4 or in Fig. 5.

Figs. 7 and 8 illustrate another modified construction of the generators **94**. According to this modification the generators are of the type shown in the patent to Laurens Hammond, No. 1,956,350 entitled Electrical Musical Instrument, including magnetically permeable tone or phonic wheels which rotate adjacent permanent magnets **109** having pickup coils **111**. Figs. 7 and 8 illustrate such tone wheels which are adapted to produce circular scale tones.

Each of the generators **94** may include a tone wheel **112** such as that illustrated in Fig. 8. Sixteen notches or undulations **114**, **116** and **118** are equally spaced around the periphery of the tone wheel **112**. The notches **114**, having azimuths of 0°, 90°, 180° and 270°, are of variable depth; the four notches **116**, having azimuths of 45°, 135°, 225° and 315°, are of an intermediate or medium depth such as $\frac{3}{32}$ inch and the remaining notches are of small depth such as $\frac{3}{64}$ inch. In the tone wheel **112** forming a part of the C generator **94** the notches **114** have the same depth as the notches **116**. This particular

tone wheel is illustrated in Fig. 7. In the tone wheel **112** forming a part of the B generator **94** the notches **114** have a depth such as ⅛ inch which is considerably greater than the depth of the notches **116**. The notches **114** in the tone wheel **112** for intermediate note generators **94** are graded in depth between these extremes, the notches **114** becoming progressively deeper for the higher pitched notes. Thus the notches **114** in the C# phonic wheel **112** are slightly deeper than those in the C tone wheel **112**, the notches **114** in the D tone wheel **112** are slightly deeper than those in the C# tone wheel **112**, and so forth.

The phonic wheels **112** are rotated at different speeds to produce differently pitched signals. The speed of the phonic wheel **112** forming a part of the C generator **94** is the lowest and the speed of the phonic wheel forming a part of the B generator **94** is the highest.

When the notches **114** are the same depth as the notches **116**, as illustrated in Fig. 7, the tone wheel generator **94** produces a tone signal having fundamental and octave components, the fundamental component being due primarily to the deeper notches **114** and **116** and the octave component being due primarily to the shallower notches **118**. When the notches **114** are deeper than the notches **116** the tone wheel generator produces a tone signal having a suboctave component (with its harmonics) in addition to the fundamental and octave components (with their respective harmonics). The suboctave component becomes greater and greater relative to the fundamental and octave components when the notches **114** are made deeper and deeper than the notches **116**. Thus the tone produced upon depression of the C1 key **80** has fundamental and octave components of approximately equal intensities. The tone produced by the depression of the C1# key **80**, has a small suboctave component, but the suboctave coupler effect is so slight that the C1# tone is heard as having a higher pitch than the C1 tone. As an ascending scale is played the suboctave component gradually dominates the tones so that the B1 tone is heard as having the pitch of the suboctave component. The C2 tone, which has the same pitch and quality as the C1 tone, then has a higher apparent pitch than the B1 tone. The same circular scale is repeated if the succeeding octaves of keys **80** are successively depressed.

The provision of an accompaniment section employing the circular scale principle effects a substantial reduction in the number of accompaniment generators required for a multioctave instrument. Accompaniment chords and simple counter-melodies may be played with the circular scale accompaniment section with pleasing musical results. In addition, the circular scale effect may be utilized to produce novel melodic and accompaniment effects which are impossible with a conventional musical instrument.

The simultaneous depression of more than one octavely related key **80** produces additive effects because of the provision of an individual decoupling resistor **R100** for each key switch **82**. Thus, if the C1 key **80** is depressed, closing the C1 switch **82**, a tone signal from the C generator **94** is transmitted through the C1 resistor **R100** to the output system **88**. Simultaneous depression of the C2 key **80**, closing the C2 switch **82**, provides an additional path through the C2 resistor **R100** from the C generator **94** to the output system, and the C tone is sounded with additional intensity.

Fig. 9 illustrates another modified form of the generators **94** of Fig. 6. According to this modification each generator may comprise a record **120**, which is illustrated as a magnetic wire, together with apparatus adapted to reproduce the signals recorded upon the record **120**. Such apparatus may include a supply spool **122**, a take-up spool **124** and a pick-up or transducing element **126** having output terminals **93** and **95** corresponding with the similarly designated output terminals of the generators **94** in Fig. 6. Any of the many well-known types of records and reproducing apparatus may be employed. Each of the records **120** may be impressed with a tone signal having octavely related components proportioned according to the principles of this invention. High, low and middle octave tone components may be combined according to the arrangement illustrated in Fig. 3 or, if desired, fundamental and suboctave components may be combined according to either of the arrangements illustrated in Figs. 4 or 5, for example.

The tone signal components for recording upon the record **120** may be derived from any desired sources.

Fig. 10 illustrates a further application of the principles of this invention in which the pitch changes one octave over a two octave range of notes. In the diagram, the lower arrows **130**, drawn with light weight lines, represent the amplitudes of a suboctave component, the middle arrows **132**, drawn with medium weight lines, represent the intensities of a fundamental tone component and the upper arrows **134**, drawn with heavy lines, represent the intensities of an octave tone component. The lowest tone C comprises fundamental and octave components having approximately equal amplitudes. A small amount of the suboctave component is introduced into the next tone C# and the amplitude of the octave component is correspondingly reduced so that the total amplitude remains unchanged. The amplitude of the suboctave component becomes greater and the amplitude of the octave component correspondingly smaller with each successive tone taken in ascending order through two octaves until with the twenty-fifth tone C the octave component is zero and the suboctave component is approximately equal to the fundamental component. Comparison demonstrates that there is only one octave difference in apparent pitch between the highest and the lowest C tones although the scale seems to ascend through a full two octaves of tones because of the very gradual introduction of the suboctave component. No unusual discontinuities in pitch or tone quality are heard as a scale is played.

It will be apparent to those skilled in the art that the principles of this invention may be applied advantageously to produce a starting circular scale effect. Moreover, by utilizing the principles of this invention a multi-octave musical instrument may be produced having only a single octave of accompaniment tone sources. This arrangement has the considerable advantages of simplicity and economy.

In some of the accompanying claims designation of the keys is by number, merely for clarity of definition of the invention, the numbers themselves being only of relative significance.

While I have disclosed this invention by describing and explaining certain illustrative embodiments, it will be understood by those skilled in the art that the principles of this invention may be applied in many alternative and equivalent ways to provide structures which may differ in their details from those of the illustrative embodiments described herein. Therefore, I wish to include within the scope of the appended claims such modifications and variations.

I claim:

1. An electrical musical instrument for playing a circular scale; comprising a plurality of scale tone signal sources including individual phonic wheels having a plurality of equally spaced notches, said notches being alternately deep and shallow, an output system coupled with said sources, and a plurality of playing keys connected with said sources for sounding said sources individually, said sources including a group of sources comprising phonic wheels having said deep notches which are alternately very deep and less deep, said very deep notches of the sources of said group in ascending order being progressively deeper and deeper.

2. In an electrical musical instrument having an output system including an electroacoustic translating means,

the combination of a plurality of playing keys, a plurality of sources of electrical musical tone signals of pitches corresponding to successive semitone intervals of the tempered musical scale, and means operable by the keys to cause substantially different tone quality signals to be transmitted from the sources to the output system, the quality of the tone signals being characterized by having sub-octave partials of progressively increasing amplitude as an ascending chromatic or diatonic scale is played.

3. The combination set forth in claim 2 in which the quality of the tone signals is additionally characterized by having unison partials of progressively decreasing amplitude as an ascending chromatic or diatonic scale is played.

4. The combination set forth in claim 2 in which the quality of the tone signals is additionally characterized by having unison partials of substantially constant amplitude, and by having octave partials of progressively decreasing amplitude as an ascending chromatic or diatonic scale is played.

5. The combination set forth in claim 4 which includes a series of at least twenty-five successive semitone keys and in which the quality of the tone signal transmitted to the output system upon playing of the twenty-fifth key is substantially the same as that transmitted to the output system upon playing the first key, but is apparently one octave higher in pitch.

6. The combination set forth in claim 2 which includes a series of at least thirteen successive semitone keys and in which the quality of the tone signal transmitted to the output system upon playing of the thirteenth key is substantially the same as that transmitted to the output sysem upon playing the first key.

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