ELECTRONIC MUSICAL INSTRUMENT OF JUST INTONATION

Filed May 28, 1965 10 Sheets-Sheet 1

Fig. 1.

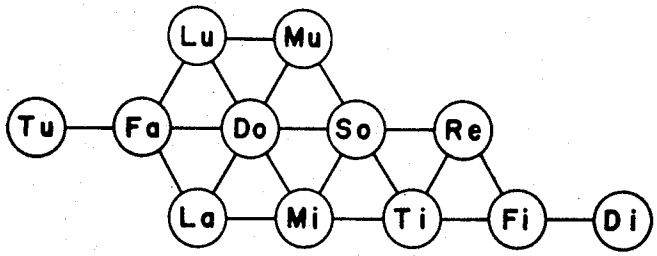


Fig. 2.

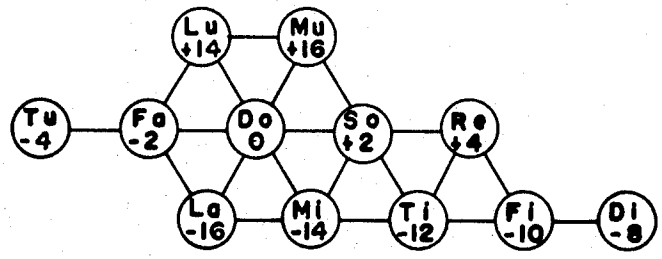


Fig. 3.

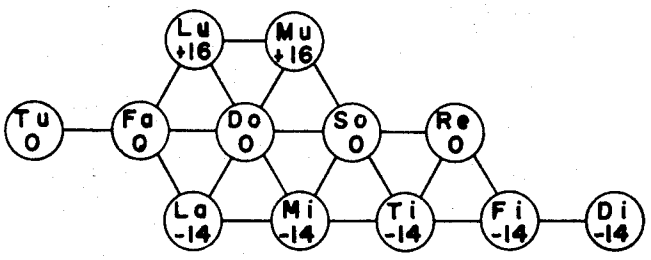
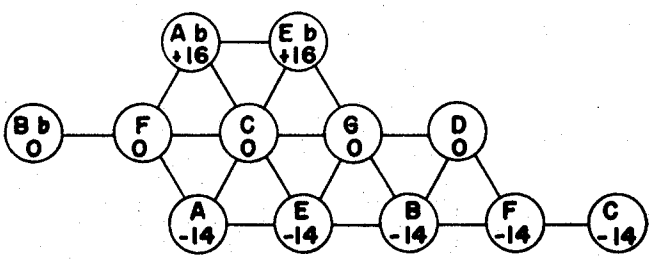

Lu +16
Mu +16
Tu 0
Fa 0
Do 0
So 0
Re 0
La -14
Mi -14
Ti -14
Fi -14
Di -14

Fig. 4.


Ab +16
Eb +16
Bb 0
F 0
C 0
G 0
D 0
A -14
E -14
B -14
F -14
C -14

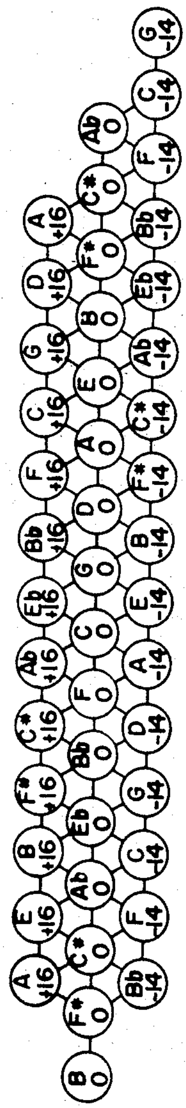


Fig. 5 (a).

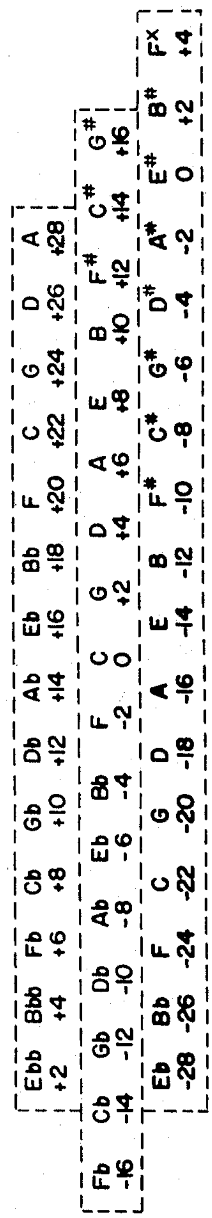


Fig. 5 (b).

Fig. 6 (a).

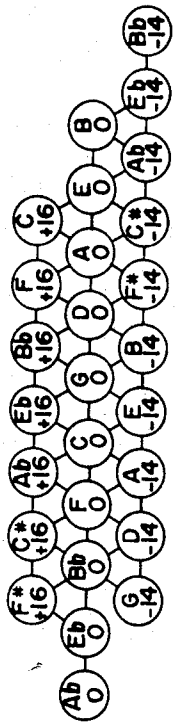

Ab 0
Eb 0
Bb 0
F 0
C 0
G 0
D 0
A 0
E 0
B 0
F# +16
C# +16
Ab +16
Eb +16
Bb +16
F +16
C +16
G -14
D -14
A -14
E -14
B -14
F# -14
C# -14
Ab -14
Eb -14
Bb -14

Fig. 6 (b).

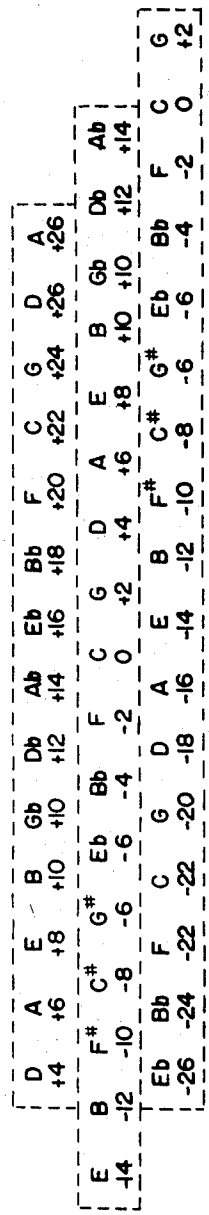
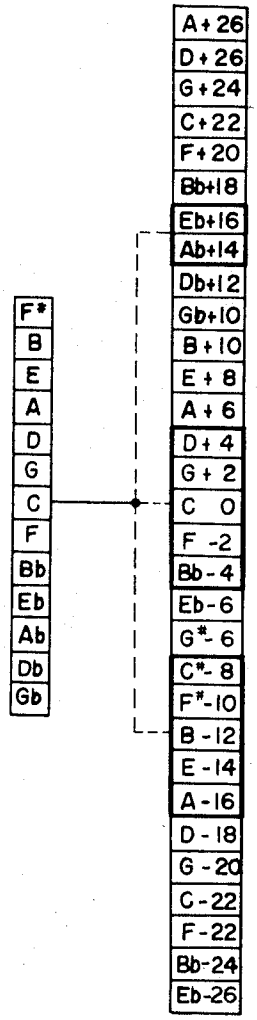

E -14
B -12
F# -10
C# -8
G# -6
Eb -6
Bb -4
F -2
C 0
G +2
D +4
A +6
E +8
B +10
Gb +10
Db +12
Ab +14
Eb +16
Bb +18
F +20
C +22
G +24
D +26
A +26
Eb -26
Bb -24
F -22
C -22
G -20
D -18
A -16
E -14
B -12
F# -10
C# -8
G# -6
Eb -6
Bb -4
F -2
C 0
G +2
D +4
A +6
E +8
B +10
Gb +10
Db +12
Ab +14

Fig. 6 (c).


A+26
D+26
G+24
C+22
F+20
Bb+18
Eb+16
Ab+14
Db+12
Gb+10
B+10
E+8
A+6
D+4
G+2
C 0
F -2
Bb-4
Eb-6
G*-6
C*-8
F*-10
B-12
E-14
A-16
D-18
G-20
C-22
F-22
Bb-24
Eb-26
F*
B
E
A
D
G
C
F
Bb
Eb
Ab
Db
Gb

ELECTRONIC MUSICAL INSTRUMENT OF JUST INTONATION

Filed May 28, 1965 10 Sheets-Sheet 6

Fig. 8 (a).

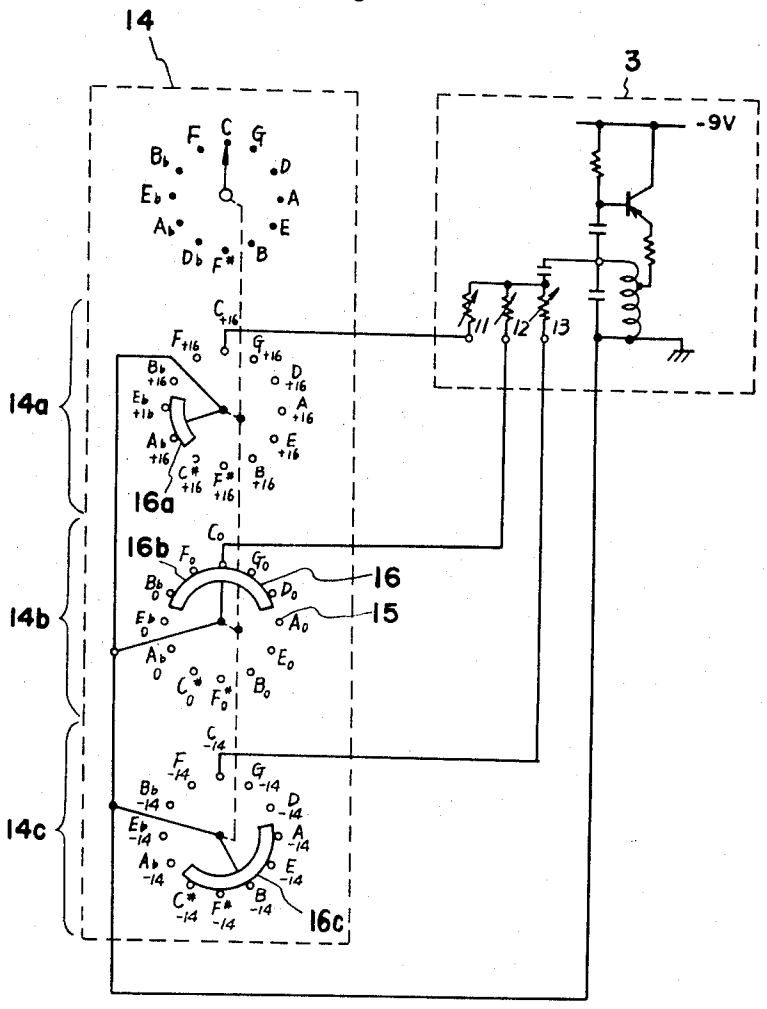


Fig. 8(b).

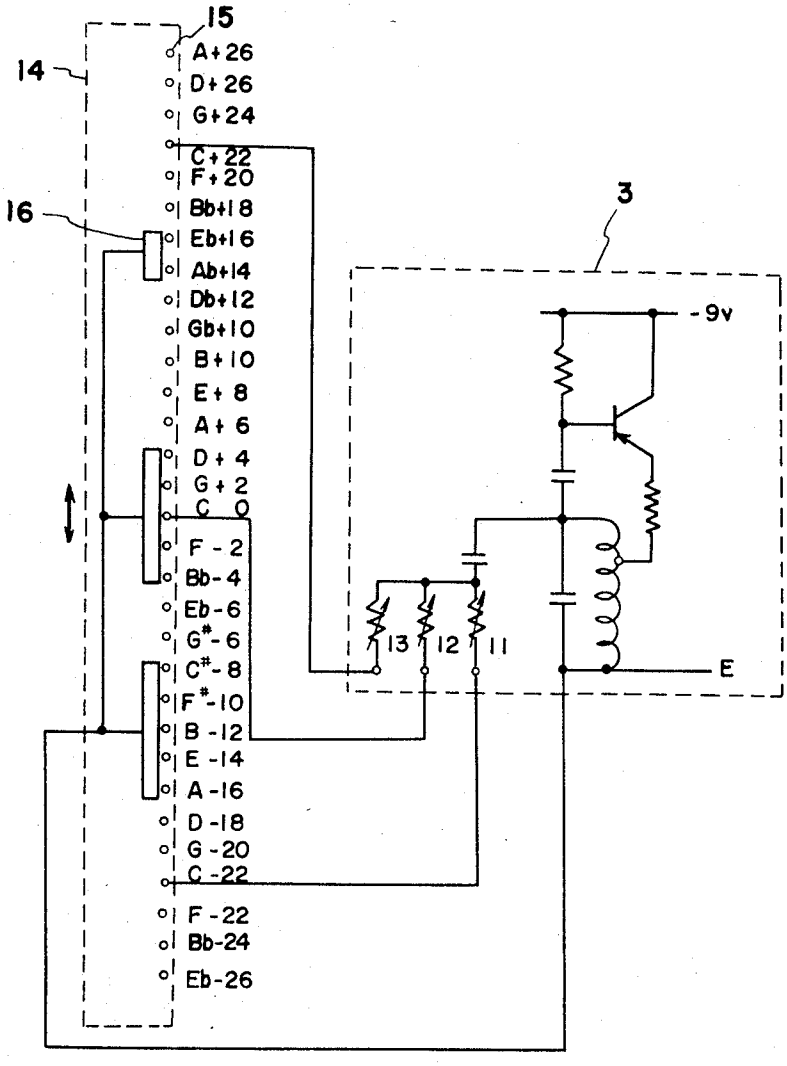

15
14
16
3
A+26
D+26
G+24
C+22
F+20
Bb+18
Eb+16
Ab+14
Db+12
Gb+10
B+10
E+8
A+6
D+4
G+2
C 0
F-2
Bb-4
Eb-6
G#-6
C#-8
F#-10
B-12
E-14
A-16
D-18
G-20
C-22
F-22
Bb-24
Eb-26
13
12
11
-9v
E

Fig. 7.

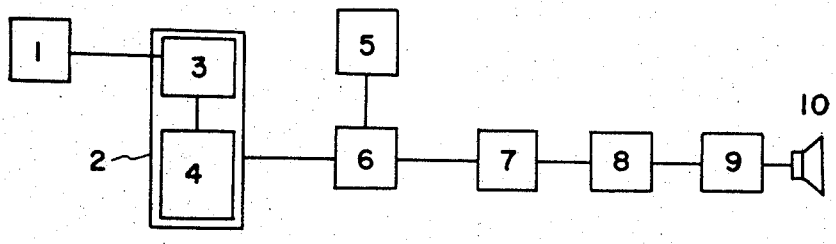


Fig. 9 (a).

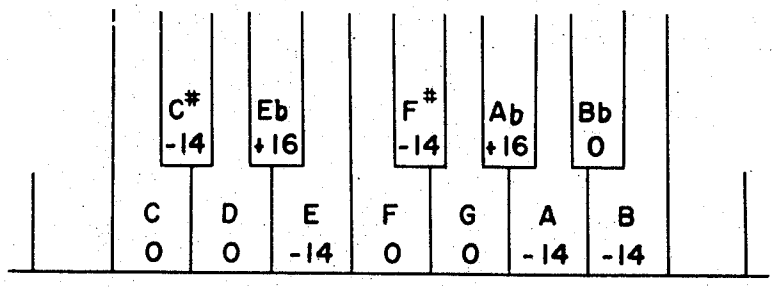
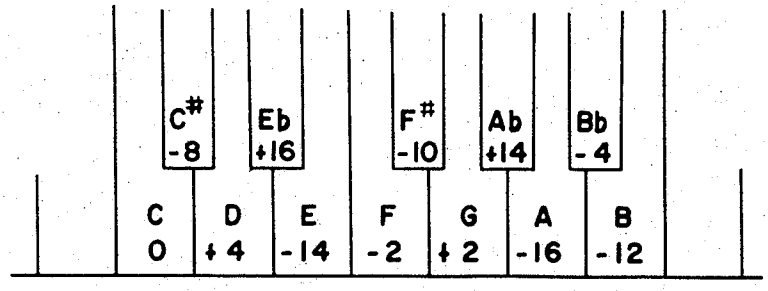


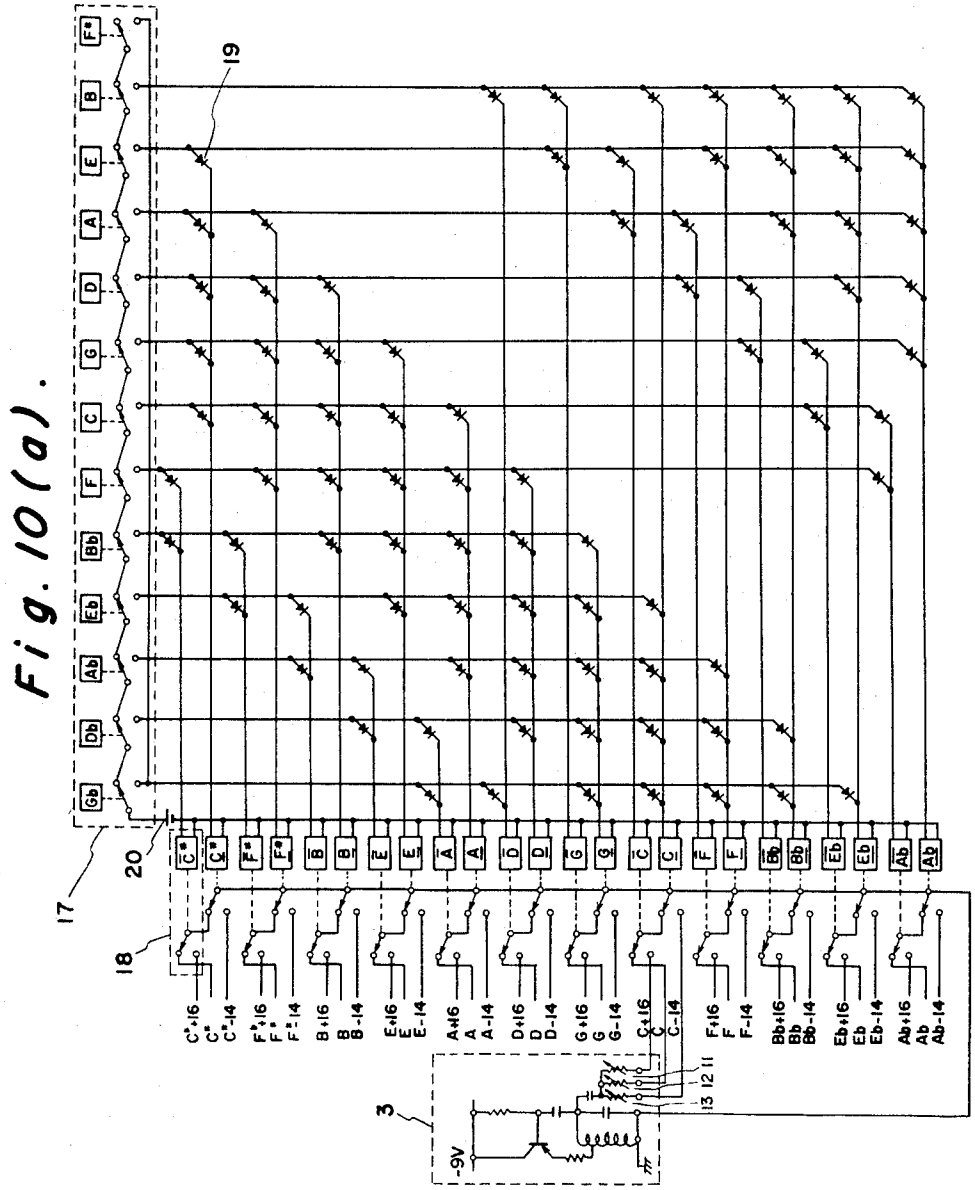
Fig. 9 (b).



ELECTRONIC MUSICAL INSTRUMENT OF JUST INTONATION

Filed May 28, 1965 10 Sheets-Sheet 9

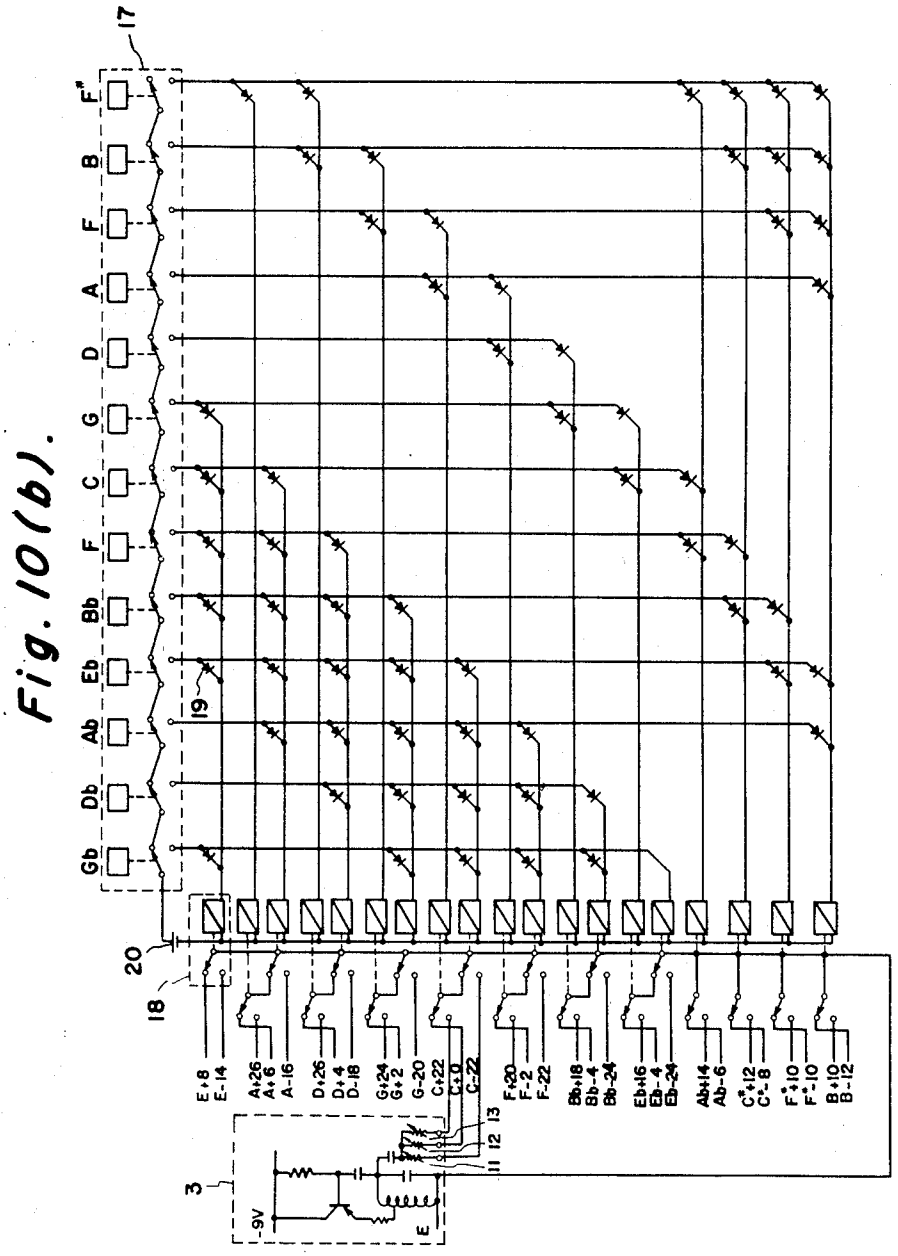
Fig. 10(a).



ELECTRONIC MUSICAL INSTRUMENT OF JUST INTONATION

Filed May 28, 1965 10 Sheets-Sheet 10

Fig. 10(b).



United States Patent Office 3,401,229 Patented Sept. 10, 1968

3,401,229

ELECTRONIC MUSICAL INSTRUMENT OF JUST INTONATION

Yoshikazu Kawabata and Maki Yamashita, Hamamatsu, Japan, assignors to Nihon Gakki Seizo Kabushiki Kaisha, Hamamatsu, Japan

Filed May 28, 1965, Ser. No. 459,765
Claims priority, application Japan, May 30, 1964, 39/30,391; Oct. 10, 1964, 39/57,908
13 Claims. (Cl. 84—1.04)

This invention relates to an electronic musical instrument of just intonation provided with an improved key selector and an improved arrangement of tones.

The musical scales are divided into a scale of just intonation and a scale of equal temperament from the viewpoint of accuracy of pitch. In view of the frequencies of tones, the scale of just intonation is what the musical scale should be. For this reason, there have been under way studies on the theory of musical scale of just intonation, and attempts have been made to manufacture several kinds of organs of just intonation. Musical instruments of just intonation that have heretofor been manufactured are capable of producing beautiful harmony of tones. Nevertheless, these musical instruments have had disadvantages in that the instruments of simple construction do not lend themselves to modulating tones and that those which are constructed with a view to making modulations possible are too complicated in construction to play. These disadvantages have set limits on the development of musical instruments of just intonation, so that they failed to become popular as musical instruments of practical use. Because of this, the musical instruments that have become popular are those of equal temperament which have the advantages of making modulations possible as well as of being simple in construction and easy to play, provided that more or less aberrations in tone are tolerated. Most of the musical instruments manufactured today are those of equal temperament.

It is an object of this invention to provide a musical instrument of just intonation of practical use which has a simple construction of twelve keys for each octave like conventional keyed musical instruments.

It is another object of this invention to provide a musical instrument of just intonation which, though constructed essentially for use in the scale of just intonation, can accommodate itself to the scale of equal temperament.

The invention will now be explained with reference to the drawings wherein:

FIGS. 1, 2, 3, and 4 are diagrams showing the arrangements of tones;

FIGS. 5(*a*), 5(*b*), 6(*a*), 6(*b*) and 6(*c*) are diagrams showing the arrangements of tones which are needed for the electronic musical instrument of just intonation provided by this invention;

FIG. 7 is a schematic diagram of an electronic musical instrument according to this invention;

FIG. 8(*a*) is a circuit diagram of one embodiment of this invention which relies on a rotary switch for selecting keys;

FIG. 8(*b*) is a circuit diagram of another embodiment of this invention which relies on a slide switch for selecting keys;

FIG. 9(*a*) is a diagram showing the tones for the key of C as arranged in a keyboard;

FIG. 9(*b*) is a diagram showing another set of tones for the key of C as arranged in a keyboard;

FIG. 10(*a*) is a circuit diagram of one embodiment of this invention which relies on push-buttons for selecting keys; and

FIG. 10(*b*) is a circuit diagram of an alternate embodiment of this invention which relies upon push-buttons for selecting keys.

FIG. 1 shows a combination of tones, which is a characterizing feature of this invention, in relation to twelve notes in one octave including stem notes ranging from prime note to major seventh note and the derivatives of these stem notes. The connections between tones as indicated by lines are: horizontally, perfect fifth above rightwardly and perfect fifth below leftwardly in the note-row of fifth; oblique rightwardly, minor third above upwardly to the right and minor third below downwardly to the left in the note-row of minor third; and oblique leftwardly, major third below upwardly to the left and major third above downwardly to the right in the note-row of major third. (Inversion, such for example as one between perfect fifth up and perfect fourth down, is considered to be nonexistant, so that the two notes are regarded as identical.) Consequently, the relation between tones as illustrated in FIG. 1 can be described as follows: in stem notes, perfect fifth note Sol and perfect fourth note Fa are set at perfect fifth above and perfect fifth below relative to prime note Do; second note Re is set at perfect fifth above relative to perfect fifth note Sol, and major sixth note La, major third note Mi and major seventh note Ti are set at major third above relative to perfect fourth note Fa, prime note Do and perfect fifth note Sol respectively; in derivatives, augmented fourth note Fi is set perfect fifth above relative to major seventh note Ti, augmented prime note Di is set perfect fifth above relative to augmented fourth note, minor sixth note Lu and minor third note Mu are set at minor third above relative to perfect fourth note Fa and prime note Do respectively, and minor seventh note Tu is set perfect fifth below relative to perfect fourth note Fa. In this arrangement, the three notes which are contiguous in a downward triangle form a major triad, while the three notes which are contiguous in an upward triangle form a minor triad.

When the twelve tones arranged in relation to one another as described hereinabove are considered from the point of view of producing chords, it will be seen that seven stem notes are used to produce chords of I, IV, V and V_7, and that derivatives form a combination with each other as follows: Fi and Di as leading notes for Sol and Re; Mu and Lu as a tone used for producing chords of I and IV respectively; and Tu as a tone used for producing a chord of I_7. This is the most useful combination of tones in both major and minor keys. It might be added that this arrangement of tones include chords of IV_b and V1 in addition to those chords which were described hereinabove, but they will be left out of consideration because they are secondary in importance.

FIG. 2 shows the combination of FIG. 1 with the intervals of perfect fifth, minor third and major third being converted into the intervals of just intonation. The figures under the tones refer to the amounts of abberation expressed in cents from the respective tones of equal temperament (this applies to other drawings as well). The validity of these figures is based on the fact that in just intonation perfect fifth is 702 cents, minor third is 316 cents and major third is 386 cents. According to the arrangement of tones shown in FIG. 2, the aforementioned chords are converted into perfect chords of just intonation (except for chords of 7, namely V_7 and I_7, which do not include natural 7th for reasons of scales), which form a correct scale as a scale of just intonation. If this note-row is followed in performance, however, the principal tones will deviate from the tones of equal temperament whenever a modulation is made. In view of the prevalence of equal temperament at present, this is not desirable.

FIG. 3 is a diagram in which the intervals of perfect fifth shown in FIG. 2 are converted into the intervals of equal temperament, with the major third chord being of the interval of just intonation from the root, so that the present instrument can accommodate itself to equal temperament. In this case, the tones of perfect fifth show a deviation of 2 cents, but this error is negligible. According to this arrangement, the major third note which is the weakest point in the chords of equal temperament has an interval of just intonation, so that this combination of tones can be considered to be a scale of just intonation.

FIG. 4 is a diagram showing in the key of C the relation disclosed in FIG. 3. What has been described with reference to FIG. 1 will now be described with reference to this figure. Ten tones, with the exception of F♯ and C♯, are used to form chords of C, F, G, C_7, G_7, C_m and F_m, while the two tones of F♯ and C♯ constitute leading notes of G and D, respectively. It will be appreciated that this is the most advantageous arrangement of tones for performance in the key of C (C major and C minor).

FIG. 5(*a*) is a diagram showing an arrangement of tones in which the tones shown in FIG. 4 are enlarged to the right and left so that the principles described hereinabove may be applied to twelve keys ranging from D♭ to F♯ (the same tone with different denominations is expressed in either of the denominations). The tones arranged in relation to one another as shown in FIG. 3 are used for each key.

It will be understood from considering FIG. 5(*a*) that there are a total of thirty-six tones, each note having three kinds of tones including a tone identical with the tone of equal temperament, a tone which is 16 cents higher than the tone of equal temperament and a tone which is 14 cents lower than the tone of equal temperament (these tones will hereinafter be referred to as 0 cent tone, +16 cent tone and −14 cent tone respectively). If the scope of keys used is narrowed, the number of tones required will naturally be reduced. Limiting the number of keys to the six keys ranging from B to A will result in only twenty-seven tones being sufficient to answer the purpose. Stated differently, FIG. 6(*a*) satisfies the relation shown in FIG. 3 with respect to the aforementioned six keys.

It will be understood from the foregoing description that according to the present invention three kinds of tones are provided, 0 cent tones, +16 cent tones and −14 cent tones, with 0 cent tones being used for prime note, second note, perfect fourth note, perfect fifth note and minor seventh note, +16 cent tones being used for minor third note and minor sixth note and −14 cent tones being used for augmented fourth note, major sixth note and major seventh note as twelve tones in each octave for each key selected. There are twelve keys provided for each octave, so that these tones can be produced by using corresponding keys of the keyboard of an electronic musical instrument which facilitates switching of tones.

FIG. 5(*b*) shows a combination of notes which represents an enlargement in scope of the original combination and enables the application of what has been described to thirteen keys ranging from the key of G♭ to the key of F♯. For each key, the notes related to one another in the same manner as in FIG. 2 are used. In FIG. 5(*b*), the comparison of seven notes ranging from E♭ to A♭ on the left side of the upper row with the seven notes from D to G♯ on the right side of the middle row and of the ten notes ranging from F♭ to G on the left side of the middle row with the notes on the right side of the lower row shows that there is a difference of 2 cents between them. Since the provision of all those notes which vary from one another by only 2 cents is uneconomical and the difference of 2 cents is negligible from the viewpoint of producing harmonious tones, it would be advantageous to provide either of these tonal combinations for common use.

FIG. 6(*b*) represents a diagrammatic representation of a redrawn form of FIG. 5(*b*), in which either one of the notes having a difference of only 2 cents has been dropped in favor of producing chords and A at the right end of upper row and E♭, B♭ and F located leftwardly on the lower row have been modified for the convenience of producing chords. In this case, there leaves something to be desired with respect to the four chords of B, B_m, A♭ and $A♭_m$, but the errors are negligible from the point of view of the chords of just intonation.

FIG. 6(*c*) is a diagram showing the three note-rows of FIG. 6(*b*) redrawn in one note-row of fifth. In this note-row of fifth, tones are spaced apart from one another an interval which is 2 cents greater than are the notes of equal temperament, with the exception of four intervals where the difference is 0 cent (namely the same as in equal temperament). It is evident that this is due to the amendment made as described hereinabove. These irregularities are caused by the attempt to meet two requirements which are contradictory to one another: one is that the intervals between two notes are 2 cents greater than the intervals of tones in equal temperament and the other is that there is an aberration of 22 cents between the notes of same denomination which are twelve tones apart from one another. Assigning +1 cent twice instead of establishing zero cent once as irregularities of expanding 22/12 cents instead of 2 cents for each tone by distributing the difference in equal instalments can make note-rows equal to each other. The slight aberration in tone which is involved in both cases does no harm to the intrinsic value of the chords of just intonation.

When the tonal combination of FIG. 2 is applied to the note-row of fifth shown in FIG. 6(*c*), a combination of twelve notes consisting of a key note; the next, the second, the eighth and the ninth notes upwardly in the note-row of fifth; and the next, the second, the fifth, the sixth, the seventh, the eighth and the ninth notes downwardly in the note-row of fifth can be obtained for each key. The provision of aforementioned combination in the note-row of fifth constitutes a characterizing feature of this invention. The combination shown in FIG. 6(*c*) is a variation on this combination of notes which is used for the key of C. Thus, it will be seen that corresponding variations can be made on the combination of notes for each key.

In view of the foregoing description, it will be understood that two or three tones having a difference of 22 cents (20 cents in some cases because of aforementioned amendment) should be provided for each note of same denomination, with one of them being used at the same time. In the foregoing description, reference was made to the application of the principles of this invention to thirteen keys ranging from G♭ to F♯. If the scope of application is altered, it will naturally follow that the notes provided on the note-row of fifth are altered accordingly. This invention resides in the application of the principles for providing a musical instrument of just intonation as described above to electronic musical instruments.

Embodiments of the invention will be explained. FIG. 7 is a schematic diagram of one embodiment of this invention which is an elecrtonic musical instrument having tone generators of the frequency division system. A key selector **1** is a device whereby a combination of tones according to this invention are selected for each key. The key selector **1** actuates a master oscillator **3** in the tone generator **2** and determines the frequency of the tone to be uttered. The tone of the frequency divider is determined accordingly, and the tone is uttered, as in the case of conventional electronical musical instruments, through key switch **6** actuated by the manipulation of keyboard **5**, tone filter **7**, expression control **8**, amplifier **9** and speaker **10**. What distinguishes the electronic musical instrument of this system from electronic musical

instruments of the conventional type lies in the relation between key selector and master oscillators, there being no difference in other parts between the two systems. Accordingly, the description of this system will be confined to the relation between the key selector and the master oscillators in the interest of brevity.

FIG. 8(*a*) is a diagram showing the relation between the key selector and master oscillator in the embodiment of FIG. 5(*a*). A rotary switch **14** is used as a key selector in this embodiment. In FIG. 8(*a*) there is illustrated a connection between one master oscillator (for tones of C) out of twelve master oscillators. It must be noted that other master oscillators are also connected to the corresponding contacts **15**. The rotary switch **14** is of a 3-pole 12-position type, the circuits **14***a*, **14***b* and **14***c* being adapted to switch those into +16 cent tones, 0 cent tones and −14 cent tones respectively. The fixed contacts **15** are connected to corresponding master oscillators 3 in the order of the note-row of fifth, while the movable contacts **16***a*, **16***b* and **16***c* are connected to the grounds of master oscillators. The master oscillator **3** is provided with tuning variable resistors **11**, **12** and **13** inserted in the resonance circuit thereof which are aranged such that they generate +16 cent tones, 0 cent tones and −14 cent tones, respectively, when grounded. FIG. 8(*a*) shows a rotary switch **14** set at the key of C, with twelve master oscillators having tones of C, C♯—14, D, E♭+16, E—14, F, F♯—14, G, A♭+16, A—14, B♭ and B—14 (unit in cents). It will be understood that the arrangement makes it possible to carry out performance in each octave in the tones shown in the keyboard of FIG. 9(*a*). The selection of the key of C by means of rotary switch 14 makes each note ready for uttering a tone suited to the key of C according to this invention, so that it is possible to carry out performance in the key of C of just intonation though there are only twelve keys for each octave just like in a conventional musical instrument. The same is true of selecting other keys; once a key is selected, the notes are arranged in the scale of just intonation in the key selected.

FIG. 8(*b*) is a diagram in explanation of the relation between the key selector and master oscillator in the embodiment of FIGS. 5(*b*), 6(*b*) and 6(*c*). This figure shows the connection between one master oscillator **3** (for C in this instance) out of the twelve master oscillators and the key selecting slide switch **14**. The slide switch **14** has thirty-one fixed contacts **15**, and slide contacts **16** which are adapted to keep contact with twelve contacts comprising two contacts, five contacts skipping five and five contacts skipping two commencing from the top as seen in the figure. The fixed contacts **15** are connected to oscillators **3** corresponding in position to the notes in the note-row of fifth as seen from the top in FIG. 6(*c*), with slide contacts being connected to the ground of the master oscillator. The master oscillator **3** (for C in this case) has tuning variable resistors **11**, **12** and **13** inserted in the resonance circuit thereof which are arranged such that they generate three tones (C—22, C and C+22 in this case) when grounded. The notes of the same denomination which require only two series of pitch (e.g., B) may have only two variable resistors instead of three. FIG. 8(*b*) shows a case in which the slide switch is set at the key of C with twelve master oscillators generating the twelve tones of C, C♯—8, E♭+16, F—2, F♯—10, F+2, A♭+14, A—16, B♭—4, and B—12. It will be appreciated that this arrangement make performance possible in the notes shown on the keyboard of FIG. 9(*b*) in each octave. The selection of the key of C by means of the sliding switch makes each note ready for uttering a tone suited to the key of C according to this invention, so that it is possible to carry out performance in the key of C of just intonation although there are only twelve keys for each octave just like a conventional musical instrument. The same is true of selecting other keys; once a key is selected, the notes are arranged in the scale of just intonation in the key selected.

FIG. 10(*a*) shows the relation between the key selector **1** and master oscillator **3** of another embodiment of this invention corresponding to FIG. 5(*a*) which has a key selector comprising push-buttons of the lock-and-release type **17** and a plurality of relays **18** connected with one another by a pluraliiy of diodes **19**, with the push-buttons being used to select a key. The contacts of the relays and the contacts of the push-buttons in the figure are all shown in rest positions. Each of the relays **18** is provided with a transfer contact for one circuit, and there are two corresponding relays for the tones of the same denomination, two break contact circuits of said relays being connected in series with one another and normally connected to a variable resistor **12** corresponding to a 0 cent tone and the ground of a master oscillator **3**, respectively. The other NO contacts are connected to variable resistors **11** and **13** corresponding to a +16 cent tone and a −14 cent tone, respectively. In this figure, there is illustrated one master oscillator **3** (tones of C) connected to tone generators, but other master oscillators are also connected through the key selector to tone generators indicated by tonal denominations, the figures being in cents.

Assuming that a push-button for C has been pushed in operation, seven relays C♯, F♯, B, E, A, E♭ and A♭ are actuated by power from the following power source **20**, so that the notes are set C♯—14, F♯—14, B—14, E—14, A—14, D, G, C, F, B♭, E♭+16, and A♭+16 in accordance with FIG. 10(*a*). If these notes are redrawn in regular order in a keyboard, the keyboard shown in FIG. 9(*a*) is obtained. Pushing another key-button results in the same process being gone through, the tones being set in the scale of just intonation in the particular key selected. The method shown in FIG. 10(*a*) offers an advantage over the method illustrated in FIG. 8(*a*) in that a desired key can be selected at a stroke, bypassing the intermediate keys, thereby facilitating performance of music.

It will be understood from the foregoing description that the electronic musical instrument of just intonation according to this invention comprises tone generators arranged in an orderly manner in 0 cent tones, +16 cent tones and −14 cent tones, so that an arrangement of tones for key selection is simplified. This facilitates designing and manufacture of the musical instruments. The arrangement of twelve notes in each octave makes specialized techniques for performance unnecessary, enabling the performance of music in just intonation with beautiful harmony of tones.

The key selector provided by this invention makes it possible to determine at a stroke the combination of tones for the key selected. This makes modulations possible during performance. The fact that the note-row is based on equal temperament accommodates this musical instrument to equal temperament. These are some of the advantages which make the musical instrument of this invention an excellent musical instrument.

FIG. 10(*b*) shows the embodiment illustrated in FIG. 8(*b*) as modified to include a key selector comprising push-buttons of the lock-and-release type **17** and a plurality of relays **18** connected with one another by a plurality of diodes **19** instead of a key selector relying on a slide switch. That is, FIG. 10(*b*) shows the relation between the key selector and the master oscillators. The contacts of the relays and the contacts of push-buttons in the figure are all shown in rest positions. Each of the relays **18** is provided with a transfer contact for one circuit. The transfer contacts of two relays are connected in series for a master oscillator **3** having three tones for the note of the same denomination, and normally a variable resistor **12** corresponding to the middle tone is connected to the ground of the master oscillator **3** and the remainder of the actuating contacts are connected to variable resistors **11** and **13** corresponding to higher and lower tones, respectively. For a master oscillator

having two tones for the note of the same denomination, one relay is used to switch from one tone to the other. Normally, however, a variable resistor corresponding to the tone more frequently used is connected to the earth E of the master oscillator. The positions of contacts and the notes corresponding thereto are illustrated in the figure.

Assuming that a push-button for C has been pushed in operation, four relays including a relay of E, a relay on the lower side of A, a relay on the upper side of B♭ and a relay of A♭ are actuated by power from the power source **20**, so that the notes are set at E—14, A—16, D+4, G+2, C, F—2, B♭—4, E♭+16, A♭+14, C♯—8, F♯—10 and B—10 in accordance with FIG. 10(*b*). If these notes are redrawn in regular order on a keyboard, the keyboard shown in FIG. 5(*b*) is obtained. Pushing another key-button results in the same process being gone through, the tones being set in the scale of just intonation in the particular key selected.

The method shown in FIG. 10(*b*) offers an advantage over the method illustrated in FIG. 8(*b*) in that a desired key can be selected at a stroke, bypassing the intermediate keys, thereby facilitating performance of music.

It will be understood from the foregoing description that the electronic musical instrument of just intonation according to this invention comprises tone generators arranged in an orderly manner and simple arrangements of the tones for key selection. This facilitates designing and production of the musical instruments. The arrangement of twelve notes in each octave makes specialized techniques for performance unnecessary, enabling the performance of music in just intonation with beautiful harmony of tones.

What is claimed is:

1. An electronic musical instrument of just intonation comprising a plurality of tone generators, means connected to each of said generators for producing tones which are sixteen cents higher with respect to their corresponding tones of equal temperament, means connected to each of said generators for producing tones which are fourteen cents lower with respect to their corresponding tones of equal temperament, musical key selector means, said tone generators being electrically connected to said key selector means, said key selector means being arranged to select a series of twelve notes in a single octave for each key selected including a prime note, a second note, a perfect fourth note, a perfect fifth note, a minor seventh note, a minor third note, a minor sixth note, an augmented prime note, a major third note, an augmented fourth note, a major sixth note and a major seventh note.

2. An electronic musical instrument of just intonation comprising twelve tone generators, means connected to each of said generators for producing tones which are sixteen cents higher with respect to their corresponding tones of equal temperament, means connected to each of said generators for producing tones which are substantially identical with respect to their corresponding tones of equal temperament, means connected to each of said generators for producing tones which are fourteen cents lower with respect to their corresponding tones of equal temperament, musical key selector means, said tone generators being electrically connected to said key selector means, said key selector means being arranged to select a series of twelve notes in a single octave for each key selected including a prime note, a second note, a perfect fourth note, a perfect fifth note, a minor seventh note, a minor third note, a minor sixth note, an augmented prime note, a major third note, an augmented fourth note, a major sixth note and a major seventh note, the first five notes of said series having tones identical with respect to their corresponding tones of equal temperament, the sixth and seventh notes of said series having tones which are sixteen cents higher with respect to their corresponding tones of equal temperament, and the remainder of the notes of said series having tones which are fourteen cents lower with respect to their corresponding tones of equal temperament, and means for playing each of said twelve notes.

3. An electronic musical instrument of just intonation comprising switching means for musical key selection, twelve master oscillators, three circuits controlled by said switching means, one of said circuits having two movable contacts for switching tones sixteen cents higher with respect to their corresponding tones of equal temperament, the second of said circuits having five movable contacts for switching tones identical with respect to their corresponding tones of equal temperament, and the third of said circuits having five movable contacts for switching tones fourteen cents lower with respect to their corresponding tones of equal temperament.

4. An electronic musical instrument of just intonation comprising switching means for musical key selection, said switching means being of a three-pole twelve position type, twelve master oscillators, three circuits controlled by said switching means, one of said circuits having two movable contacts for switching tones 16 cents higher with respect to their corresponding tones of equal temperament, the second of said circuits having five movable contacts for switching tones identical with respect to their corresponding tones of equal temperament, and the third of said circuits having five movable contacts for switching tones fourteen cents lower with respect to their corresponding tones of equal temperament, twelve fixed contacts for each circuit, each of said twelve master oscillators being provided with three tuning variable resistors, and said resistors being connected to said fixed contacts, respectively.

5. An electronic musical instrument of just intonation comprising a rotary switch for musical key selection, said rotary switch being of a three pole twelve position type, twelve master oscillators, three circuits controlled by said switch, one of said circuits having two movable contacts corresponding to a minor third note and a minor sixth note for each key and each note being sixteen cents higher with respect to its corresponding tone of equal temperament, the second of said circuits having five movable contacts corresponding to a prime note, a second note, a perfect fourth note, a perfect fifth note, and a minor seventh note for each key and each note being identical with respect to its tone of equal temperament, and the third of said circuits having five movable contacts corresponding to an augmented prime note, a major third note, an augmented fourth note, a major sixth note, and a major seventh note for each key and each note being fourteen cents lower with respect to its corresponding tone of equal temperament, each of said circuits having twelve fixed contacts engageable with said movable contacts, each of said twelve master oscillators being provided with three tuning variable resistors, said resistors being connected to said fixed contacts, respectively.

6. An electronic musical instrument of just intonation comprising a plurality of master oscillators, each of said oscillators being provided with a first resistor for producing tones which are sixteen cents higher with respect to their corresponding tones of equal temperament, each of said oscillators being provided with a second resistor for producing tones which are substantially identical with respect to their corresponding tones of equal temperament, each of said oscillators being provided with a third resistor for producing tones which are fourteen cents lower with respect to their corresponding tones of equal temperament, a key selector including a plurality of lock-and-release push-buttons, one being provided for each musical key selection, a plurality of relays, said relays being connected to said resistors respectively, a plurality of diodes interconnecting said relays and said

push-buttons, whereby actuation of any one of said push-buttons actuates a selection of said relays selecting a series of twelve notes in a single octave for the key selected including a prime note, a second note, a perfect fourth note, a perfect fifth note, a minor seventh note, a minor third note, a minor sixth note, an augmented prime note, a major third note, an augmented fourth note, a major sixth note and a major seventh note, the first five notes of said series having tones identical with respect to their corresponding tones of equal temperament, the sixth and seventh notes of said series having tones which are sixteen cents higher with respect to their corresponding tones of equal temperament, and the remainer of the notes of said series having tones which are fourteen cents lower with respect to their corresponding tones of equal temperament.

7. An electronic musical instrument of just intonation comprising a plurality of master oscillators, first resistor means connected to each of said oscillators for producing tones which are sixteen cents higher with respect to their corresponding tones of equal temperament, second resistor means connected to each of said oscillators for producing tones substantially equal to their corresponding tones of equal temperament, third resistor means connected to each of said oscillators for producing tones which are fourteen cents lower with respect to their corresponding tones of equal temperament, a key selector including a plurality of push-buttons, one being provided for each musical key selection, a plurality of relays, fixed contacts for said relays connected to each of said resistors respectively, diode means interconnecting said push-buttons and said relays respectively, each of said relays being provided with a transfer contact for one circuit, two corresponding relays being provided for the tones of the same denomination, two of said transfer contacts of said two corresponding relays being normally connected in series one to the other and normally connected to said second resistor means for each tone of the same denomination, whereby actuation of any one of said push-buttons actuates a selection of said relays selecting a series of twelve notes in a single octave for the selected key including a prime note, second note, a perfect fourth note, a perfect fifth note, a minor seventh note, a minor third note, a minor sixth note, an augmented prime note, and a major third note, an augmented fourth note, a major sixth note and a major seventh note, the first five notes of said series having tones identical with respect to their corresponding tones of equal temperament, the sixth and seventh notes of said series having tones which are sixteen cents higher with respect to their corresponding tones of equal temperament, and the remainder of the notes of said series having tones which are fourteen cents lower with respect to their corresponding tones of equal temperament.

8. An electronic musical instrument of just intonation comprising a plurality of tone generators, said generators being arranged to produce notes having intervals between notes in the note row of fifth from zero to two cents greater with respect to their corresponding tones of equal temperament and intervals between notes of the same denomination spaced apart one from the other by twelve tones being from twenty to twenty-two cents greater than their corresponding tones of equal temperament; musical key selector means, means connecting said generators to said key selector means, said key selector means being arranged to select a series of twelve notes in a single octave for each key selected including a key note, the next note above said key note, the second note above said key note, the eighth note above said key note, the ninth note above said key note, the next note below said key note, the second note below said key note, the fifth note below said key note, the sixth note below said key note, the seventh note below said key note, the eighth note below said key note, and the ninth note below said key note as expressed on the note-row of fifth.

9. An electronic musical instrument of just intonation comprising a plurality of tone generators, a portion of said generators being provided with three tuning variable resistors connected in the resonance circuit thereof arranged for generating three tones for notes of the same denomination, the remainder of said generators having two tuning variable resistors inserted in the resonance circuit thereof arranged for generating two tones for the notes of the same denomination, collectively said tone generators being arranged to produce notes having intervals therebetween in the note-row of fifth from zero to two cents greater with respect to their corresponding tones of equal temperament and the intervals between notes of the same denomination spaced apart one from the other by twelve tones being from twenty to twenty-two cents greater than the corresponding tones of equal temperament; a musical key selector, electrical means interconnecting said generators to said key selector, said key selector being arranged to select a series of twelve notes in a single octave for each key selected including a key note, the next note above said key note, a second note above said key note, an eighth note above said key note, a ninth note above said key note, a next note below said key note, a second note below said key note, a fifth note below said key note, a sixth note below said key note, a seventh note below said key note, an eighth note below said key note, and a ninth note below said key note as expressed on the note-row of fifth; twelve keys arranged in a keyboard for emitting said twelve notes as twelve tones for one octave.

10. An electronic musical instrument of just intonation comprising twelve master oscillators, one being provided for each key selection, a key selecting slide switch, said slide switch having thirty-one fixed contacts and twelve sliding contacts spaced from top to bottom including two contacts five contacts spaced the distance equivalent to five contacts below said two contacts, and five additional contacts spaced the distance equivalent to two contacts below said five contacts, said fixed contacts being connected to said oscillators corresponding in position to notes in the note-row of fifth, said slide contacts being connected to the ground of said master oscillator respectively, seven of said master oscillators having three tunable variable resistors inserted in the resonance circuit thereof arranged for generating three tones for a single note of the same denomination respectively, five of said oscillators having two tuning variable resistors inserted in the resonance circuit thereof arranged for generating two tones for two notes of the same denomination respectively.

11. An electronic musical instrument of just intonation comprising a plurality of master oscillators seven of said oscillators having three tones for a single note of the same denomination, and five of said oscillators having two tones for a single note of the same denomination, a key selector including a plurality of push-buttons, one being provided for each musical key selection, a plurality of relays, said relays being connected to said oscillators respectively, means interconnecting said relays and said push-buttons respectively, whereby actuation of any one of said push-buttons actuates a selection of said relays selecting a series of twelve notes in a single octave for each key selected including a key note, the next note above said key note, the second note above said key note, the eighth note above said key note, the ninth note above said key note, the next note below said key note, the second note below said key note, the fifth note below said key note, the sixth note below said key note, the seventh note below said key note, the eighth note below said key note, and the ninth note below said key note as expressed on the note-row of fifth.

12. An electronic musical instrument of just intonation comprising a plurality of master oscillators seven of said oscillators having three tone producing means for a single note of the same denomination, and five of said oscillators having two tone producing means for a single note of

the same denomination, said oscillators being arranged to produce notes having intervals therebetween in the note-row of fifth from zero to two cents greater with respect to their corresponding tones of equal temperament and intervals between notes of the same denominations spaced apart one from the other by twelve tones being from twenty to twenty-two cents greater than corresponding tones of equal temperament, a key selector including a plurality of push-buttons, one being provided for each musical key selection, a plurality of relays, said relays being connected to said oscillators respectively, means interconnecting said relays and said push buttons respectively, each of said relays being provided with a transfer contact for one circuit, two corresponding relays being provided for the notes of the same denomination having three tones, one corresponding relay being provided for the notes of the same denomination having two tones, two of said transfer contacts of said two corresponding relays being normally connected in series one to the other and normally connected to one of said corresponding tone producing means, the one transfer contact of said one corresponding relay normally being connected to one of said corresponding tone producing means, whereby actuation of any one of said push buttons actuates a selection of said relays selecting a series of 12 notes from said tone producing oscillators and resistors, said 12 notes being of substantially just intonation in a single octave for the key selected.

13. An electronic musical instrument of just intonation comprising a first relay having fixed contacts corresponding to the notes E+8 cents and E—14 cents, a transfer contact for said first relay normally connected to the E+8 cents contact, a second relay having fixed contacts corresponding to the notes A+26 cents and A+6 cents, a transfer contact for said second relay normally connected to the A+6 cents contact, a third relay having fixed contacts corresponding to the notes A+6 cents and A—16 cents, a transfer contact for said third relay normally connected to the A+6 cents contact, a fourth relay having fixed contacts corresponding to the notes D+26 cents and D+4 cents, a transfer contact for said fourth relay normally connected to the D+4 cents contact, a fifth relay having fixed contacts corresponding to D+4 cents and D—18 cents, a transfer contact for said fifth relay normally connected to the D+4 cents contact, a sixth relay having fixed contacts G+24 cents and G+2 cents, a transfer contact for said sixth relay normally connected to the E+2 cents contact, a seventh relay having fixed contacts corresponding to the notes G+2 cents and G—20 cents, a transfer contact for said seventh relay normally connected to the G+2 cents contact, an eighth relay having fixed contacts corresponding to the notes C+22 cents and C+zero cents, a transfer contact for said eighth relay normally connected to the C+zero cents contact, a ninth relay having fixed contacts corresponding to the notes C+zero cents and C—22 cents, a transfer contact for said ninth relay normally connected to the C+zero cents contacts, a tenth relay having fixed contacts corresponding to the notes F+20 cents and F—2 cents, a transfer contact for said tenth relay normally connected to the F—2 cents contact, an eleventh relay having fixed contacts corresponding to the notes F—2 cents and F—22 cents, a transfer contact for said eleventh relay normally connected to the F—2 cents contact, a twelfth relay having fixed contacts corresponding to the notes B♭+18 cents and B♭—4 cents, a transfer contact for said twelfth relay normally connected to said B♭—4 cents contact, a thirteenth relay having fixed contacts corresponding to B♭—4 cents and B♭—24 cents, a transfer contact for said thirteenth relay normally connected to the B♭—4 cents contact, a fourteenth relay having fixed contacts normally corresponding to the notes E♭+16 cents and E♭—4 cents, a transfer contact for said fourteenth relay normally connected to the E♭—4 cents contact, a fifteenth relay having fixed contacts corresponding to the note E♭—4 cents and E♭—24 cents, a transfer contact for said fifteenth relay normally connected to the E♭—4 cents contact, a sixteenth relay having fixed contacts corresponding to the notes A♭+14 cents and A♭—6 cents, a transfer contact for said sixteenth relay normally connected to the A♭—6 cents contact, a seventeenth relay having fixed contacts corresponding to the notes C♯+12 cents and C♯—8 cents, a transfer contact for said seventeenth relay normally connected to the C♯—8 cents contact, an eighteenth relay having fixed contacts corresponding to the notes F♯+10 cents and F♯—10 cents, a transfer contact for said eighteenth relay normally connected to the F♯—10 cents contact, a nineteenth relay having fixed contacts corresponding to the notes B+10 cents and B—12 cents, the transfer contact for said nineteenth relay normally connected to said B—12 cents contact, a plurality of master oscillators, said oscillators having a plurality of variable resistors, said oscillators and said resistors being connected to said relays respectively and being arranged to produce tones corresponding to said notes, a key selector including a plurality of push-buttons, one being provided for each musical key selection, a plurality of diodes interconnecting said relays and said push-buttons, whereby actuation of any one of said push-buttons actuates a selection of said relays selecting a series of 12 notes from said tone producing oscillators and resistors, said 12 notes being of substantially just intonation in a single octave for the key selected.

No references cited.

JOHN S. HEYMAN, *Primary Examiner.*