Dec. 12, 1961 E. M. WILSON 3,012,460

MUSICAL INSTRUMENT

Filed June 25, 1958 3 Sheets-Sheet 1

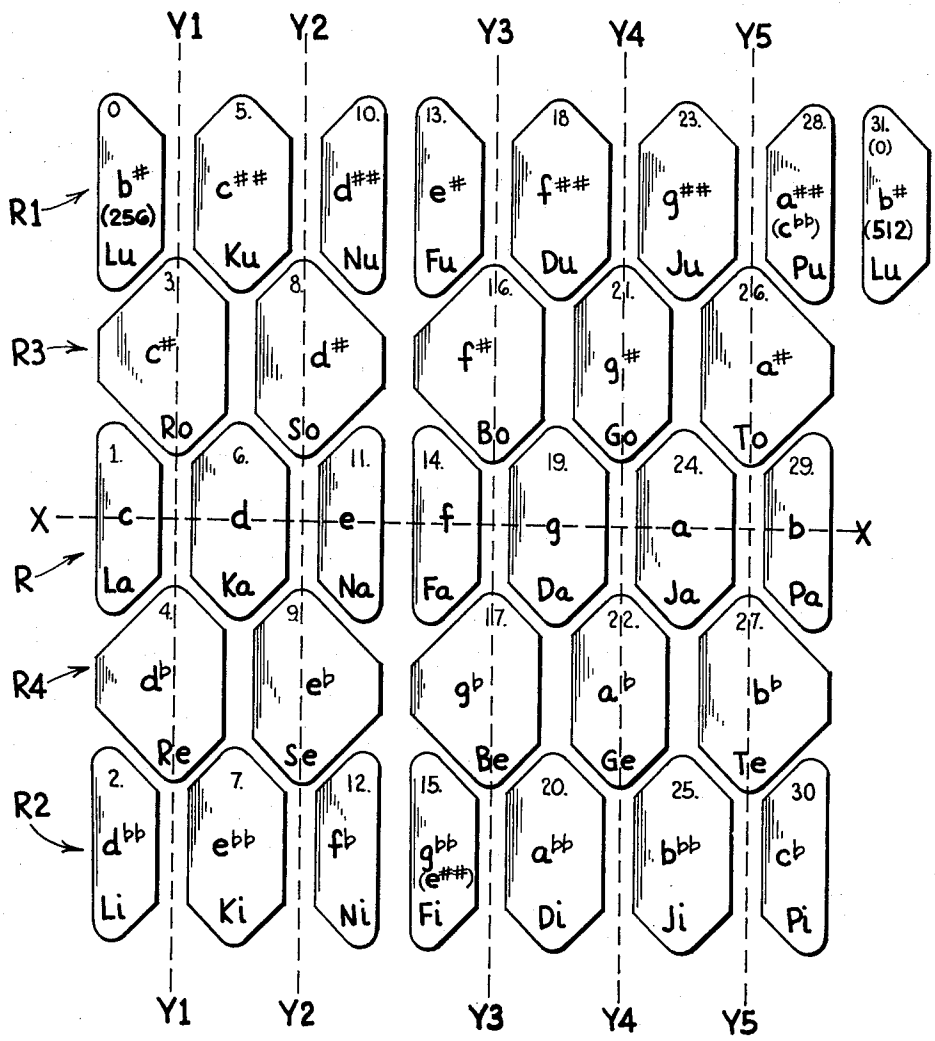


FIG. 1

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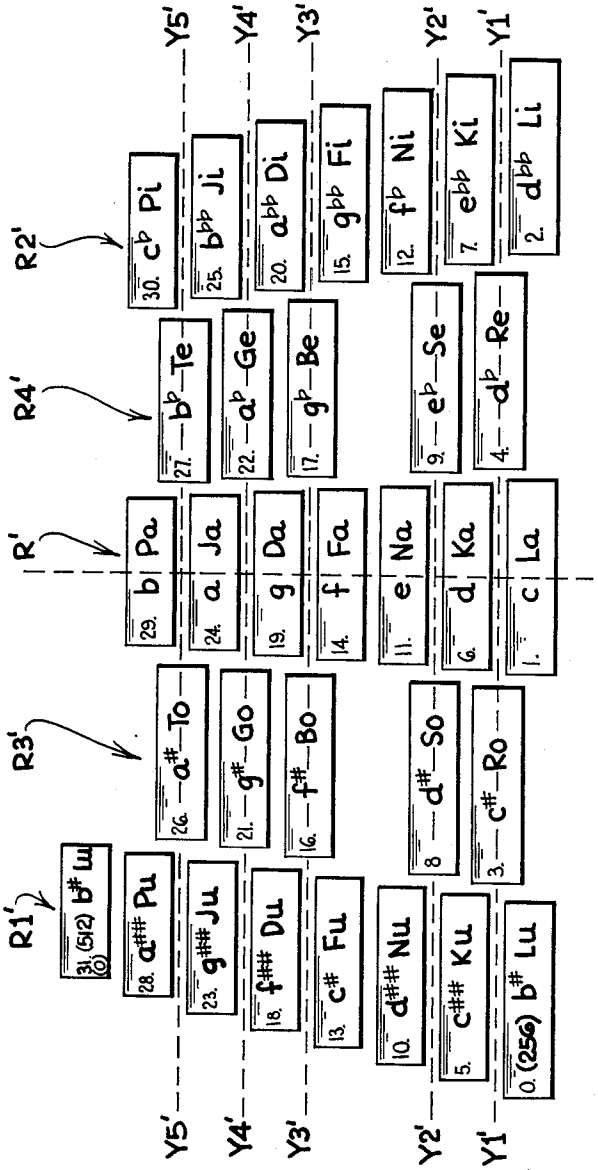


FIG. 2

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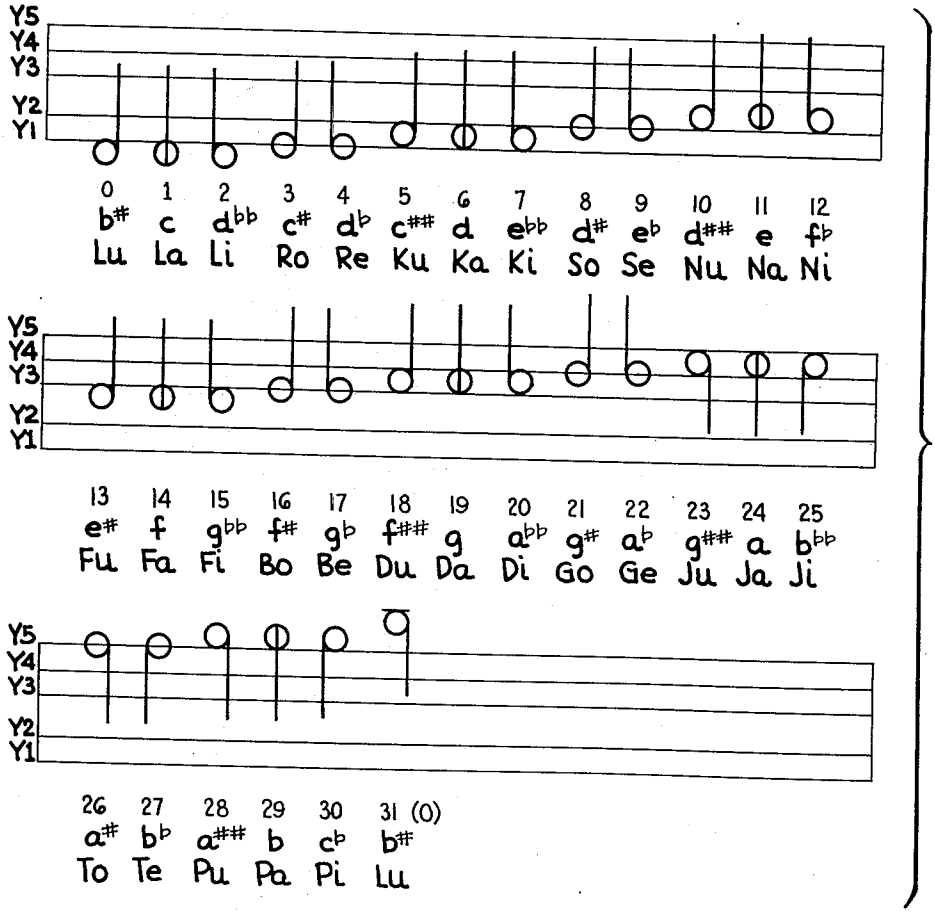


FIG. 3

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MUSICAL INSTRUMENT

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5 Claims. (Cl. 84—423)

This invention generally relates to musical instruments and more particularly concerns an improved diatonic scale designed to bring about more subtle and consonant distinctions of intonation.

Although the present invention will be described primarily from the standpoint of its application to pianos and xylophones, it will be appreciated that the invention may be embodied in other music producing mechanisms, e.g., pipe organs, electric organs, reed organs, accordions, vibraphones, marimbas, orchestra bells, glockenspiels, celestes, chimes, and the like.

The subject of just intonation has been dealt with over a long period of years. It is recognized that the present day piano or xylophone, for example, with its limited number of notes is not constructed to produce chromatic harmony except to an approximated degree. For example, in the major scale of C, the interval C–D is not the same kind of whole tone as the interval D–E, but differs as 8:9 from 9:10.

Various efforts have been made to devise various keyboard arrangements and divisions of the octave in order to more closely approximate just intonation; however, difficulties have been encountered in designing a manually convenient and feasible system of arranging a configuration of greater number of keys to still enable facile playing of the instrument and correspondingly setting forth a system of notation for symbolic representation thereof. A most important problem has been to establish a division of the octave which will approach just intonation and yet which will not bring about the heretofore mentioned physical difficulties in playing the instrument or in establishing a suitable system of notation.

It is, therefore, an object of the present invention to provide a tonal division of the octave which more closely approximates just intonation than is feasible with present keyed or digital type instruments.

Another object of the present invention is to provide an improved keyboard configuration corresponding with a division of the octave which wields more harmonic and consonant tones.

Another object of the present invention is to provide an improved keyboard configuration and corresponding division of the octave which in its overall sense more closely approximates the most consonant odd harmonics.

Another object of the present invention is to provide a versatile tonal division of the octave which will enable scales of 5, 7, 12, and 19 tones to be derived therefrom.

A still further object of the present invention is to provide a division of the octave which will permit a composer a greater and higher level of freedom and discrimination in his selection of tonal material.

These and other objects and advantages of the present invention are generally attained by providing a thirty-one tone equal temperament division of the octave and a corresponding keyboard configuration and system of notation.

A better understanding of the present invention will be had by reference to the drawings showing merely illustrative schematic embodiments of the invention, and in which:

FIGURE 1 is a schematic configuration of one octave of a piano keyboard employing a thirty-one tonal division of the octave according to the present invention;

FIGURE 2 is a schematic configuration for a xylophone embodying the thirty-one tone equal temperament division of the octave according to the present invention; and,

FIGURE 3 is a musical scale indicating a preferred system of notation corresponding with the thirty-one tone equal temperament octave of the present invention.

In order to appreciate the full significance of a thirty-one tone equal temperament division of the octave, the most pleasing harmonic division of the octave must first be established. Thus, in Table I there is set forth an harmonic division of the octave based on the first seven odd harmonics being reduced to the same octave.

TABLE I

Harmonic division of octave

No.	Ratio	Fraction Octave $\log_2$
1	16/8	1.0000
15	15/8	.9069
7	14/8	.8074
13	13/8	.7004
3	12/8	.5850
11	11/8	.4594
5	10/8	.3219
9	9/8	.1699
1	8/8	.0000

Referring to Table I, the number of the harmonic is shown in the left hand column; the pitch ratio is shown in the center column; and, the absolute number or fractional division of the octave is shown in the right hand column. The fraction of the octave is found by taking the numerical representation of the ratio in the center column and establishing its logarithm to the base 2 in order to attain a fractional representation from zero to one. As heretofore mentioned, one of the objects of the present invention is to obtain an equal temperament division of the octave which will as closely as possible approximate the harmonic division set forth in Table I.

In present day conventional keyboard instruments, a twelve tone equal temperament division of the octave is employed. Thus, in Table II, there is shown a basis for comparing the degree of discord between the notes of the present day twelve tone equal temperament octave relative to the harmonic division of the octave as set forth in Table I. It will be noted in Table II, and particularly the right hand column thereof, entitled "Fraction of octave $\log_2$" that only four of the harmonics set forth in Table I are even approximated by the present day scale. Of course, the octaves are perfect; however, the fifteenth harmonic is .0097 sharp, the third harmonic is .0017 flat, the fifth harmonic is .0014 sharp, and the ninth is .0033 flat. The eleventh, thirteenth, and seventh harmonics are not even approximated in the twelve tone equal temperament division of the octave.

TABLE II

12-tone equal temperament

No.	Note	Fraction Octave $\log_2$
12	c	1.0000 (oct.)
11	b	.9166 (15)
10	$a\sharp\ b\flat$	.8333
9	a	.7500
8	$g\sharp\ a\flat$	.6666
7	g	.5833 (3)
6	$f\sharp\ g\flat$	.5000
5	f	.4166
4	e	.3333 (5)
3	$d\sharp\ e\flat$	.2500
2	d	.1666 (9)
1	$c\sharp\ d\flat$	.0833
0	c	.0000 (oct.)

In the thirty-one tone equal temperament division of

the octave according to applicant's invention, every harmonic as set forth in Table I, is relatively closely approximated. Thus, referring to Table III, it is seen that the octaves are perfect. Reading downwardly in Table III, the fifteenth harmonic is .0037 flat; the seventh is .0009 flat; the thirteenth is .0093 sharp; the third is .0044 flat; the eleventh is .0078 flat; the fifth is .0007 sharp; and, the ninth is .0086 flat. Thus, all the harmonic intervals of Table I are approximated in the thirty-one tone equal temperament scale as set forth in Table III more accurately than even the fifth harmonic is approximated in the twelve tone equal temperament scale as set forth in Table II.

TABLE III

31-tone equal temperament

No.	Fraction Octave Log_2
31	1.0000 (oct.)
30	.9677
29	.9355
28	.9032 (15)
27	.8710
26	.8387
25	.8065 (7)
24	.7742
23	.7419
22	.7097 (13)
21	.6774
20	.6452
19	.6129
18	.5806 (3)
17	.5484
16	.5161
15	.4839
14	.4516 (11)
13	.4194
12	.3871
11	.3549
10	.3226 (5)
9	.2903
8	.2581
7	.2258
6	.1935
5	.1613 (9)
4	.1290
3	.0968
2	.0645
1	.0323
0	.0000 (oct.)

It is evident from a comparison of the above tables that the thirty-one tone equal temperament octave will result in a much closer approximation to just intonation than is feasible or possible with the twelve tone equal temperament scale. Furthermore, it is evident that a thirty-one tone scale has a versatility not even closely approximated by the twelve tone scale. By superimposing the "thirty-one tone fifth" thirty-one times, each of the thirty-one degrees is derived and a cycle of fifths is completed on the original tone. As a consequence, free modulation of any potential scale to each of the thirty-one degrees is possible. Furthermore, it is apparent that the scales of five, seven, twelve, and nineteen tones may be derived by superimposition of the "thirty-one tone fifth." These facts follow from the correspondence of the "thirty-one tone fifth" (.5806 oct.) to the "mean tone fifth" (.5805 oct.) used successfully for centuries in Europe as a system for deriving musical scales by superimposition of the mean tone fifth.

In order that the thirty-one tone equal temperament scale division of the octave, according to the present invention, may be practical, it is, of course, essential that it be capable of being embodied in a keyboard arranged for convenient playing and furthermore that it be susceptible of being transposed by a system of notation into printed music. Towards this end, a description of FIGURES 1, 2, and 3 follows.

Referring now to FIGURE 1, there is shown a schematic configuration of an octave for a piano or similar keyboard instrument. The octave contains a central row of digitals R, each of which intersects the transverse dotted line X—X. Spaced from the central row R on either side thereof is a row of digitals R1 consisting of seven keys, and a row of digitals R2 consisting of seven keys. Interposed between the row of keys R and R1 is a row of five keys R3; similarly, interposed between the row of keys R and R2 is a row of five keys R4.

It will be noted that the keys forming the row R3 are positioned relative to the keys forming the row R in the same manner that the conventional black keys of the present day keyboard, for example, are positioned relative to the white keys in a particular octave. Conversely, the row of keys R4 are positioned relative to the row of keys R in similar but opposing relationship.

It will further be noted that the keys in row R3 and R4 intersect the respective dotted vertical lines Y1—Y1, Y2—Y2, Y3—Y3, Y4—Y4, and Y5—Y5. It is also seen from reference to FIGURE 1 that the keys in rows R1 and R2 are spaced on either side of the transverse line X—X and in between the respective spaced vertical dotted lines Y1—Y1, Y2—Y2, Y3—Y3, Y4—Y4, and Y5—Y5. A better understanding of the spacing of the keys with respect to the transverse dotted line X—X and the five vertical dotted Y lines will be appreciated when FIGURE 3 is hereafter described.

By placing the notes as indicated by the identification symbols thereon in FIGURE 1, a very convenient and systematic arrangement of the keys is obtained from the standpoint of learning the new keyboard arrangement relative to present day configurations. Thus, the first note, designated as $b\sharp$, is positioned in the upper left hand corner (as viewed in FIGURE 1) and the last note (No. 30) in the lower right hand corner with the numbered notes running consecutively downwardly beginning from the left hand corner. Furthermore, the various sharps and flats are positioned on either side of the center line X—X in systematic arrangement to the conventional keys, as set forth on the center line X—X.

The particular means of identifying the notes by "Lu, La, Li," for example, merely illustrates a convenient manner to use the vowels as a means of denoting musical sounds for the notes. Of course, other types of musical symbols could be employed.

FIGURE 2 merely represents a variation of FIGURE 1 for application of the schematic configuration of the thirty-one tone octave as applied to a xylophone type instrument. Thus, by rotating the keyboard of FIGURE 1 counter clockwise ninety degrees, the keyboard of FIGURE 2 is approximated except for the particular shape of the digitals employed. In this regard, the truncated end portions of the digitals in FIGURE 1 enables closer arrangement of the notes for convenience in finger manipulation. However, in the arrangement for the xylophone or similar instrument, as shown by FIGURE 2, where the notes need not fall within a finger span, a different shape for the individual digitals may be employed.

In FIGURE 2, the row R1′ corresponds to the row R1 of FIGURE 1; the row R3′ corresponds to the row R3 of FIGURE 1; and a similar relationship exists with the rows R′, R4′, R2′ and the dotted lines Y1′—Y1′, Y2′—Y2′, Y3′—Y3′, Y4′—Y4′, and Y5′—Y5′ of FIGURE 2 with respect to the analogous rows of FIGURE 1.

FIGURE 3 illustrates a preferred system of notation for transposing the printed music to the keyboard arrangement of FIGURE 1, for example. Thus, the lines Y1—Y1, Y2—Y2, Y3—Y3, Y4—Y4, and Y5—Y5 of FIGURE 1 correspond to the same lines identified in FIGURE 3. The transverse line X—X of FIGURE 1 and its position relative to the keys shown in FIGURE 1 is denoted, respectively, by the position of the stem of the note in FIGURE 3 with respect to the circular portion (base) thereof.

With the above in mind, it will be noted that all the keys in the row R of FIGURE 1 are centered across the line X—X, and similarly in FIGURE 3, these same keys include a note with the stem extending through the center of the circular portion (base). Furthermore, it will be noted that the note "*d*," for example, is positioned be-

tween the vertical lines Y1—Y1 and Y2—Y2 of FIGURE 1, and similarly this note is positioned between the horizontal lines Y1—Y1 and Y2—Y2 in FIGURE 3. In the event a particular note is located on a vertical line, for example, D♭ on the line Y1—Y1 of FIGURE 1, it is similarly located on the line Y1—Y1 of FIGURE 3. Also, if a note, for example, C♯, is located above the line X—X of FIGURE 1, it will have its stem on the right hand side as viewed in FIGURE 3; on the other hand, if it is located below the line X—X (E♭♭, for example), it will have its stem on the left side of the circular portion. Thus, a very systematic arrangement is established for readily transposing the notes to the particular keyboard of the instrument being used.

It will also be evident from viewing FIGURE 3 that each octave will have its notes located in identical scale positions as the corresponding notes of every other octave of the insrument embodying 31-tone equal temperament. Thus, the notational positions are repeated in each octave in contra-distinction to the twelve tone equal temperament system in which all the notes of the keyboard must be memorized.

It will be appreciated that many modifications and changes may be made in the keyboard designations, the shapes of the keys, the arrangements of the respective rows of keys, and the system of notation. However, it will be evident from the foregoing that the present invention not only contemplates a thirty-one tone even temperament division of the octave bringing about more refined and pleasing music but the present invention also sets forth a physical arrangement of the keyboard and system of notation which is both practical and simple to learn and apply.

What is claimed is:

1. A keyboard consisting of at least one octave characterized by thirty-one different tones of equal temperament, said octave comprising: seven digitals in parallel alignment to define a central row of given overall length extending in one given direction and being designed to effect progressive diatonic tones constituting an octave; seven digitals in parallel alignment to define a first row spaced from and within said given length on one side of said central row and being designed to effect corresponding progressive diatonic tones constituting an octave, said first row also extending in said one given direction; seven digitals in parallel alignment to define a second row spaced from and within said given length on the other side of said central row and being designed to effect corresponding progressive diatonic tones constituting an octave, said second row also extending in said one given direction; said digitals of said central, first, and second rows being aligned, respectively, in a direction perpendicular to said given direction to define seven rows of three digitals each, each of said three digitals in each of said seven rows, respectively, being designed successively to effect a tone one-thirty first of an octave apart; five digitals in parallel alignment defining a third row and designed to effect corresponding interdigitated semi-tones, said third row being interposed in said given length between said central row and said first row and extending in said one given direction; and five digitals in parallel alignment defining a fourth row and designed to effect corresponding interdigitated semi-tones, said fourth row being interposed in said given length between said central row and said second row and extending in said one given direction; said digitals of said fourth and fifth rows being aligned, respectively, in a direction perpendicular to said given direction to define five rows of two digitals each, each of said two digitals in each of said five rows being designed to effect a tone one-thirty first of an octave apart.

2. A keyboard according to claim 1 in which said third row and said fourth row are each of a lesser overall length than said given length.

3. A keyboard according to claim 1 in which said third and said fourth row, respectively, have the digitals thereof positioned in relationship to the digitals of said central row in a configuration equivalent to the relationship of the black notes to the white notes of the conventional keyboard arrangement.

4. A keyboard according to claim 1 in which said central row, said first row, and said second row have the respective digitals thereof positioned so as to form seven parallel columns of three digitals each extending in a direction perpendicular to said central row.

5. A keyboard according to claim 4 in which said third row and said fourth row have the respective digitals thereof positioned so as to form five parallel columns of two digitals each extending in a direction perpendicular to said central row.

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