Patent Application

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Scalable piano keyboard

Abstract

A scalable piano keyboard or synthesizer keyboard allows the user to vary the number of notes per octave, to apply new mathematical rules for tuning the piano, and to easily rearrange the notes on the keyboard. Instead of a repeating pattern of seven white keys in a front row separated by five *unevenly spaced* black keys in a back row, two rows of color-coded, evenly spaced keys are used. Every other front key extends to match every third key in the back row. The back row of keys are the traditional width while the front row of keys are 7/8 the traditional width or 3/2 the width of those in the back. The color pattern repeats every 8th key in the front row and every 4th key in the back row, with the result that harmonic notes have similar colors. Harmony is improved by tuning note n to a frequency proportional to n / w (linear tuning) or to w / n (reciprocal tuning) instead of 2 to the power n / w (traditional tuning), where w is width (traditionally 12), defined as the number of notes per doubling of frequency. The user can choose w for the front row and the width for the back row is then automatically 3 w / 2. The front row of keys divide an octave into halves, quarters, and eighths while the back row provides thirds, sixths, and twelvths. With linear tuning, the front row gives frequency ratios such as 3 / 2 and 5 / 4 while the back row gives ratios such as 4 / 3 and 5 / 3. The back row of keys can be tuned to the traditional 12 note scale. Or, the front row can be tuned to the traditional 7 notes A to G and the back row provides sharps and flats for all 7 instead of only 5. By choosing w equal to 4, 6, or 8 instead of 7, musical scales are in step with musical measures. By separating even-numbered notes to the right and odd-numbered notes to the left, or by grouping together the notes that were an octave apart, or by using smaller w (fewer notes per octave), even very small children can play nice chords by pressing the palms of their hands onto a new, scalable piano keyboard.

Invention of the Scalable Piano

Paul VanRaden

History of the Invention

Year / month	Idea
~ 250 BC	The first organ was invented by Ctesibius in Greece, but it had no keyboard and the pipes were played individually. Development continued among Arabs, primarily in Baghdad, until 757 AD, when an Arab organ was imported to France.
~ 900 AD	Organ keyboards were developed but had only one row with less than 10 keys. The keys were large and were played with a fist rather than with the fingers. A keyboard built in 1090 AD had 16 keys with the repeating letters A to G engraved into its keys. History books give no reason for the choice of <u>seven</u> notes per octave.
~ 1350	The back row of semi-tone keys was introduced. The color pattern on many early organs was reverse: the front keys were black and the back keys were white. History books give no reason for the *uneven pattern* of <u>five</u> semi-tone keys per octave.
~ 1450	Organ keys were reduced to their current width and length. The clavichord was developed and used a keyboard to play strings instead of pipes.
~ 1500	The harpsichord was developed in Italy. Its keyboard was copied from that of the clavichord and organ.
1709	Bartolomeo Cristofori of Florence, Italy invented the piano. The piano could play soft or loud by using a row of hammers instead of plucking the strings, but the keyboard was copied from the harpsichord, clavichord, and organ.

1824 Ludwig van Beethoven composed his ninth symphony in Vienna, Austria.

1970 Paul VanRaden took piano lessons at age ten for a year and played Beethoven's ninth symphony at a small recital in Forreston, IL, USA. Paul's teacher, Leroy Krum, told him that fancier arrangements of the ninth symphony exist which one person can't play because the notes needed are beyond the reach of the fingers. That was the beginning of my idea to re-tune the piano so that needed notes would be within reach.

1999 Angel VanRaden, Paul's one-year-old daughter, began playing the piano with the palms of her hands. Paul wondered why the two notes that sound the worst when played together are placed right beside each other. He noticed that the two pairs of *white keys that are not separated by a black key* (B,C and E,F) sound especially bad when played together. He could think of no reason why some pairs of white keys should be a *full step* apart (separated by black keys) and others only a *half step* apart. He concluded that the standard keyboard and the C scale with its pattern of two full steps, a half step, three full steps, and another half step between keys is not ideal but has been copied without thought since the dark ages.

Aug. 1999 Paul began research on mathematical formulas for tuning the piano and purchased a Technics KN-5000 keyboard with tunable keys for $4,189.50 from Jordan Kitts Music in Annapolis, MD so that he could hear the results of his theories.

Aug. 1999 Paul showed the piano salesman, Jamal Orr, how to get eight even steps on the log 2 frequency scale on the piano's white keys (plus F#) and six even steps on the black keys (plus C). He also showed the salesman a drawing of a new scalable piano in which every fourth key in the front row lined up with every third key in the back row (Figure 1). Instead of just black and white keys, shades of grey were used to highlite every other and every fourth note between octaves so that notes that sound alike would look alike. A few months later, daughter Angel helped Daddy by scribbling all over Figure 1 while Daddy was programming his keyboard.

Sept. 1999	The 8-note and 6-note log 2 tuning was demonstrated to Paul's coworkers at the USDA Agriculture Research Service in Beltsville, MD. One coworker, Suzanne Hubbard, complained that the keys were no longer all in order from low to high. Paul's response was "It's not my fault that the keyboard has two black keys, and then an empty space, and then three more black keys, and then another empty space." He showed his drawing of a scalable piano (Figure 1) to Ed Lewis and a few other coworkers.
Nov. 1999	The eight even steps and the six even steps on the log 2 scale did not include the standard note G which provides very nice harmony for C. Paul calculated that note G is halfway between the C below it and the C above it on the frequency scale, not the log 2 scale. The relative frequencies of C, G, and the next C are 1, 1.5, and 2. Thus, evenly spaced notes on the frequency scale give better harmony than evenly spaced notes on the log 2 scale (Figure 2). If the piano were tuned with even steps on the frequency instead of log 2 scale, relative frequencies would increase from 1 to 2 to 3 to 4 instead of 1 to 2 to 4 to 8 across the keyboard. Paul then developed new theories of harmony including intersecting linear harmony, parallel harmony, and negative notes (anti-sound). He tested the new types of harmony on his keyboard and liked what he heard. Beethoven's ninth symphony sounded better when played with linear tuning than with standard tuning.
Dec. 1999	Reciprocal tuning using the formula w / n instead of n / w, where n is the note number and w is width or number of notes per octave, was discovered by Paul. These formulas seemed simpler and better than standard piano tuning, which is based on relative frequencies of 2 to the power (n / w), with w set to 12. The KN-5000 also allowed the user to set w to 24 or 48 instead of 12, but the uneven pattern of black keys prevented the use of any w smaller than 12.
Dec. 1999	A letter explaining log 2, linear, and reciprocal piano tuning (Letter 1) was sent to Technics / Matsushita Corporation in Secaucus, NJ. Tables of note frequencies, a program to compute these, and a diskette containing songs and scales with new or standard tuning were included. These ideas on tuning were provided free of charge

because Paul believed that simple math was not patentable and because he hoped that the company would provide these new tuning options on its standard keyboards and thereby help create demand for a scalable keyboard. Few people will listen to new music theories, but many will listen to new music.

Dec. 31 1999 — The new keyboard's physical structure (Figure 3) was drawn by Paul while he watched the new millennium celebrations on New Year's Eve. He finished the drawing at about 1 am January 1, 2000.

Jan. 2000 — A color coding system for piano keys was developed so that keys which sound similar (for example, one octave apart) would look similar (Figure 4). With *unevenly spaced* keys, the pattern of black keys helped users to locate similar notes. With evenly spaced keys, color coding provides a similar visual aid. Paul drew raised *bumps* on the front and/or back of every other, every fourth, or every eighth key to help users easily locate notes by sight and *feel* (Figure 5).

Jan. 2000 — Rearrangements of the notes onto the piano keyboard were developed such that the notes which sound best together would be located on keys that are side by side. For example, even numbered notes could be separated to the right and odd numbered notes to the left, or all A notes placed together, B notes together, etc. This would allow the user to play many more harmonious notes that previously were out of reach of the fingers.

Mar. 2000 — Improved music notation was developed by Paul. Colored lines on white paper match exactly with the colored piano keys (Figure 6).

Feb. 2002 — Paul placed this patent application and this document on his web site.