An Overview of Harry Partch's Construction of a 43-Tone Scale

Mike Winter

Many factors contributed to Harry Partch's construction of a 43-tone scale. His book, Genesis of a Music, goes into great detail about the evolution of just-intonation and monophony. Partch describes just intonation as "a system in which interval- and scale-building is based on the criterion of the ear and consequently a system and procedure limited to small number ratios" (Partch 71) and monophony as "an organization of musical materials based upon the faculty of the human ear to perceive all intervals and deduce all principles of musical relationships as an expansion from unity, as 1 is to 1" (Partch 71). Though this essay will primarily address the 43-tone scale construction, Genesis of a Music is the ultimate reference for not only scalar construction, but also the history of just intonation systems and the technical knowledge, such as the language of ratios and basic monophonic concepts, needed to understand Partch's system. An overview of all this material would result in a reiteration of everything Partch has clearly laid out in his book and would exceed the scope of this essay. It is assumed that the reader has a basic understanding of the concepts mentioned above.

Partch makes it clear that his interests stem from Pythagoras of Samos's work on his monochord (6th century B.C.), which can be regarded as "an expression of the overtone series, first perceived by Marin Mersenne" (17th century)(Partch 71). Partch's overview of the history of just-intonation systems is very useful for understanding the evolution of intonational systems that led up to his construction of the 43-tone scale.

Partch describes identity as "one of the correlatives, 'major' or 'minor,' in a tonality; one of the odd number ingredients, one or several or all of which act as a pole of tonality" (Partch 71). It is important to understand that a scale with a particular limit does not contain a ratio with a number or multiples of that number above the limit number. Consequently, it will not include any identities higher than the limit number. Most music throughout history does not reach beyond a 5-limit system. One of Partch's primary concerns was the use of an 11-limit system that would increase the number of

combinations possible for both otonality or utonality's identities. This produces a multitude of triads, tetrads, and pentads. An otonality is "a tonality expressed by the over numbers of ratios having a numerary nexus" (Partch 72), which is "the common number to all identities in the ratios of one tonality" (Partch 72). A utonality is a tonality "expressed by the under numbers of ratios having a numerary nexus" (Partch 75). The 5-limit system only contains one triad from the combination of the 1-3-5 identities and has few secondary tonalities, most of which are not complete through the five identities.

An 11-limit system would create 20 triads, 15 tetrads, and 6 pentads. In Genesis of a Music, Partch shows all of these on pages 123 – 124, but they can be calculated by exhausting all combinations of the numbers 1, 3, 5, 7, 9, and 11. Also, there would be 16 secondary tonalities; two of which are complete through their 11 identities, four of which are complete through their 9 identities, six of which have the 9 identities with the seven missing, and four of which are complete through their 5 identities (Partch 161).

An overview of these possibilities simply illustrates reasons why Partch had interest in using an 11-limit system. In fact, his use of an 11-limit system as opposed to a 13 or higher-limit system is quite arbitrary. He states, "From a scale standpoint this (i.e. the use of a 13-limit system) is not objectionable, and from a harmonic standpoint it is far from objectionable… The reason for resting at the limit of 11 is a purely personal and arbitrary one" (Partch 123). Now, with an understanding of both the arbitrary reason and the harmonic reasons of using an 11-limit system, we can move on to the details of how Partch arrived at a 43-tone scale.

The initial step is to calculate all non-multiple-number ratios of the 11-limit. To achieve this, one must understand three parameters for the calculations.

1) All ratios must contain a 1, 3, 5, 7, 9, or 11, which are all identities of the 11-limit.
2) A ratio cannot contain an identity beyond the 11-limit, which is represented by any odd number above 11.
3) All ratios should be less than 2/1.

From smallest to largest these are ordered 1/1, 12/11, 11/10, 10/9, 8/7, 7/6, 6/5, 11/9, 5/4, 14/11, 9/7, 4/3, 11/8, 7/5, 10/7, 16/11, 3/2, 14/9, 11/7, 8/5, 18/11, 5/3, 12/7, 7/4, 16/9, 9/5, 20/11, 11/6, (2/1). On page 127 of Genesis of a Music, Partch lists all these ratios with a

cent deviation from the 1/1 and the ratios and cent deviations that represent all intervals in between. To calculate the ratio of the interval between any of the above ratios, one can multiply the larger ratio by the reciprocal of the smaller ratio. For example, the ratio for the interval between 12/11 and 11/10 can be calculated from 12/11 * 10/11 = 121/120. To illustrate the perceived distance of any given interval, one can calculate the cents by this equation; (1200 /(log 2)) * (log (frequency ratio)) = distance in cents. For example, the cent deviation of 121/120 = (1200 /(log 2)) * (log (121/120)) = approx. 14.4 cents. The scale one arrives at happens to be completely symmetrical and Partch proclaims, "The inevitable symmetry of the structure is apparent (Partch 135)."

When calculating the intervals between all of the ratios listed above, it becomes evident that there are wide gaps between some intervals. The intervals between the 1/1 and 12/11, and the 11/6 and 2/1 are the widest in the set. There are also gaps between the 7/6 and 6/5, the 9/7 and 4/3, the 4/3 and 11/8, the 16/11 and 3/2, the 3/2 and 14/9, and the 5/3 and 12/7 (Partch 131 – 132).

Though one could simply leave the gaps, Partch felt that a scalar construction should not have gaps and that the overall distribution should be somewhat uniform. Partch carefully fills the spaces listed above by implanting multiple-number ratios between these intervals. The use of multiple-number ratios "contribute(s) to further increase of new tonalities" (Partch 129). To determine the multiple-number ratios between an interval, one can multiply any of the identities of the limit and use the numerator or denominator to create an interval that lays in the space that one desires to fill. For example, to find a multiple-number ratio between the 1/1 and 12/11, one can take the 3rd multiple of the 5th identity, or vise-versa, which equals 15. If fifteen is the numerator, the only denominator in the 11-limit that would create a ratio within this space is 14, which gives a ratio of 15/14. If 15 is the denominator, then the only numerator that would function for our purpose is 16, making a ratio of 16/15. General principles that one can use to determine these pitches include:

1) No ratio can include a multiple of a prime number higher than 11.

2) Any multiple-number ratio will not contain a number below any of the numbers in the ratios bounding the space that one desires to fill.

3) The complement of a ratio that fills a gap on one side of the center axis of a scale will fill the complementary gap on the other side of the axis.

The third principle simply suggests that after determining how one might fill the spaces on one side of a scale's symmetrical axis, the complements of the determined ratios will fill the gaps on the other side of the symmetrical axis. If the numerator is even, the complement is the reciprocal ratio with the even number divided by 2. If the denominator is even, the complement is the reciprocal of the ratio with the even number multiplied by 2. For instance, the complement of 16/15 is 15/8, and the complement of 81/80 is 160/81. This maintains the symmetry of the scale because the interval between 1/1 and 16/15 is the same perceived distance as the interval between 15/8 and 2/1. Conversely, the perceived distance between 16/15 and 12/11 is the same as 11/6 and 15/8. Partch gives many of the possibilities of multiple-number ratios on page 131 of Genesis of a Music.

Because there are many multiple-number ratio possibilities, Partch explains that when subdividing intervals, "successive-number ratios are appropriated simply because they are the ratios of the smallest numbers available for the purpose (Partch 129)." For example, when the interval between the 7/6 and the 6/5 is divided by the 32/27, the intervals created between the 7/6 and 32/27 and the 32/27 and 6/5 are 64/63 and 81/80, respectively. He also suggests that "gaps should contain degrees spaced approximately as they are spaced in the sequence of the twenty-nine ratios shown previously, in which the smallest interval between degrees is 14.4 cent and the largest exactly 63 cents" (Partch131).

Partch suggests creating a feel of perpetual tonal ascent or descent as another factor in determining how to subdivide larger intervals that need multiple subdivisions like the gaps between the 1/1 and 12/11 and the 11/6 and 2/1. A tonal descent is achieved by successive-number ratios that get smaller (expressed with larger numbers) as they approach 1/1 and a tonal ascent is achieved by the complements of successive-number ratios that get smaller as they approach 2/1(Partch 129-131).

When subdividing a gap, Partch chooses multiple-number ratios and their complements. This creates important identities in secondary tonalities, intervals with successive-multiple-number ratios, uniformly spaces the scale, and leads to tonal ascents and descents. To divide the gap between 1/1 and 12/11, he uses the intervals of 81/80,

33/32, 21/20, and 16/15. The compliments, 160/81, 64/63, 40/21, 15/8, respectively, divide the gap between the 11/6 and 2/1. He divides the intervals between the 7/6 and 6/5, the 9/7 and 4/3, the 4/3 and 11/8 with 32/27, 21/16, and 27/20, respectively. The complements of these last three ratios, 27/16, 32/21, and 40/27, respectively, divide the gaps between the 5/3 and 12/7, the 3/2 and 14/9, and the 16/11 and 3/2, respectively. These divisions are laid out on pages 131 and 132 of Genesis of a Music. Though he could have used other options, it is evident that he deliberated very hard and exhausted many possibilities before arriving at his final 43-tone scale.

By examining the above calculations, we have followed Partch's path to this 43-tone scale represented by the following list of frequency ratios:

> 1/1, 81/80, 33/32, 21/20, 16/15, 12/11, 11/10, 10/9, 9/8, 8/7, 7/6, 32/27, 6/5, 11/9, 5/4, 14/11, 9/7, 21/16, 4/3, 27/20, 11/8, 7/5, 10/7, 16/11, 40/27, 3/2, 32/21, 14/9, 11/7, 8/5, 18/11, 5/3, 27/16, 12/7, 7/4, 16/9, 9/5, 20/11, 11/6, 15/8, 40/21, 64/33, 160/81, and (2/1).

Partch has documented the scale with the intervals produced between each tone and the subsequent cent deviations on page 133.

Now, with an understanding of how Partch calculated his 43-tone scale, one may better see the multitude of possibilities it creates. In Genesis of a Music, Partch states, "The major contribution of Monophony as an intonational system is its realization of a subtle and acoustically precise interrelation of tonalities, all stemming or expanding from unity, 1/1. This interrelation is not capable of manifold modulations to 'dominants' or to any of the other common scale degrees; it is not capable of parallel transpositions of intricate musical structures; it does not present any tone as any specific tonality identity. Conversely, it is capable of both ordinary and hitherto unheard modulations to the natural limits imposed by Just Intonation and the arbitrary limit of 11; it is capable of an expanded sense of tonality, from Identities 1-3-5 to Identities 1-3-5-7-9-11; it is capable of great variety in that expanded sense; it does offer twenty-eight possible tonalities, more than are inherent in Equal Temperament, and therefore a greater total of tonality identities, or assumable senses, than does Equal Temperament" (Partch 158).

Although, Partch's system does not present a "cycle" because "no multiple of an interval will go into another interval" (Partch 135), a composer still has a plethora of

tonal possibilities. It is helpful to understand that most music, especially tonal, is reflective of the natural harmonic series. When a scale is tempered, we abstract ourselves from that particular natural phenomenon. No doubt, a vast array of repertoire has exploited the benefits of Equal Temperament in a successful and positive way, but it is the natural process of musical evolution to explore different musical possibilities. The quantization of an infinite amount of pitch possibilities to a series of 12 pitches can be quite limiting. Therefore, it appears natural that a composer would seek an alternative. Partch's system is closely connected to theories that have been in existence for thousands of years, but it is the rejection of musical theories shortly prior to his time and a strong sense for a particular type of natural harmony that inspired his work. Presumably, there will be continued developments in intonational systems for as long as music is being created. It is the responsibility of musicians to attempt to learn the principles of many different methodologies, instead of only one system. Then, other intonational systems can be exploited to the extent of 12-tone Equal Temperament.

Bibliography:

Partch, Harry. Genesis of a Music. New York: Da Capo Press, 1974.