How to produce MMM (multimode, spatially uniform, overall) sonic and ultrasonic agitation of arbitrary shaped, solid objects of any size.

Usually complex geometry objects have number of resonant modes. Every resonant mode (presented as typical piezoelectric impedance) can be characterized as dualistic, electromechanically coupled resonator, meaning that that for each resonant mode, two resonators are mutually coupled (and have different resonant frequencies). One of mentioned resonators has typical series, and the other has parallel resonance equivalent electric circuit, which are mutually presentable as dual electric circuits. In other words, here we describe typical piezoelectric impedance of certain resonant structure.

Complex geometric structure of certain arbitrary shaped object usually has number of such resonant modes with pairs of series and parallel resonances (all of them having different resonant frequencies).

We can selectively excite (or resonate) every one of series or parallel resonant frequency, and it is also possible to operate the same resonator in the frequency zone between two neighbors, series and parallel resonances.

This method is here specified, as MMM agitation. It is mostly and best applicable for arbitrary shaped solid bodies, with complex or complicated geometry, since for applying MMM we need to have number of resonant frequencies. We also need such situation in order to be able to excite all resonant modes at once (using MMM concept and AMMM ultrasonic generators).

Let us specifically describe three of mentioned operating, resonant modes including MMM resonant operating regime.

1. If we operate certain mechanical system on its series resonance frequency this will be some kind of current resonance, meaning that electric impedance of such circuit is minimal, and resonant operating (or load) current is maximal, while load voltage tends to be minimal. Mechanical resonator operating that way is producing high oscillating, mechanical force, and low oscillating velocity, meaning producing high oscillating pressure and low oscillating amplitude (or displacement). We can say that this is dominant force source (output force or pressure is always high and output velocity or displacement is always low). Such resonators are good for delivering ultrasonic energy to high-density materials, like metals and some liquids, or to high acoustic impedance materials.

2. If we operate certain mechanical system on its parallel resonance frequency this will be some kind of voltage resonance, meaning that electric impedance of such circuit is maximal, and resonant operating (or load) voltage is maximal, while load current tends to be minimal. Mechanical resonator operating that way is producing high oscillating, mechanical velocity, and low oscillating force, also meaning producing high oscillating amplitude, and low oscillating force (or pressure). We can say that this is dominant velocity source (output velocity, or amplitude is always high, and output force or pressure is always low). Such resonators are good for delivering ultrasonic energy to low density materials like gases and some liquids, or to low acoustic impedance materials.

3. All other, compromising, mixed resonant situations can be covered when operating between series and parallel resonance, meaning between dominant force and dominant velocity resonant

frequencies. In other words, we can operate in the frequency interval between two, mutually dual electromechanical resonator circuits.

4. Let us now imagine that certain complex structure, or solid body, has number of resonant modes (as described under 1, 2 and 3). When using convenient network impedance or spectrum analyzer, we can experimentally find (by testing and by visual selection) in which frequency zone is the concentration of highest or strongest resonant modes. For instance, this will be certain frequency interval $\Delta f = f_2 - f_1$, between frequencies f_1 and f_2, with several of resonant-circuit dual pairs inside. If we now apply ultrasonic power supply (or generator) able to produce sweeping frequency output between frequencies f_1 and f_2, we will periodically excite all of (by Δf captured) force and velocity resonant modes, including mixed operating modes within each of series and parallel resonant frequency pairs. By giving sweeping repetition rate (how many times frequency sweeping will be applied per time unit), we can select certain dynamic regime of such complex and mixed resonant driving, and this way we will be able to produce and excite big number of higher and lower frequency harmonics that are outside of selected frequency interval Δf. Practically, we will excite, synchronously and periodically, all of possible and significant resonant modes of certain arbitrary shaped, solid object, producing very wide frequency spectrum (as much wide as mechanical properties and structure of solid object under such excitation will allow). Practically, this will be spatially uniform, sonic and ultrasonic, wideband excitation, without creating typical standing waves, or here named as MMM operating regime. MMM stands for Multifrequency, Multimode, Modulated Sonic and Ultrasonic Generator; EP 1 238 715 A.

The consequences or possible applications of described MMM excitation are that using MMM resonant regimes, we can realize residual stress relief, descaling, algae and biofilm removal, fluid flow optimization, liquids atomizing etc.