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Fluidic Relaxation Oscillators for Microbubble Generation

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Abstract: Paper discusses low-frequency oscillators based on the unusual relaxation principle. In the fluidic version, the oscillator is suitable for supplying CO_2 to cultivated unicellular algae.

Introduction

There is a demand for fluidic oscillators making possible generation of sub-millimetre microbubbles in water – while simple, non-oscillated aerator air flows tend to generate bubbles larger by a decimal order of magnitude. Even with the oscillator the microbubble generation task is by no means easy. Initial development was misguided, being led to operation at very high frequencies by the idea of fragmentation of the larger bubbles. Found only recently [1] was the proper approach, requiring low frequency and return of newly generated microbubble into aerator exit channel for the rest of the period to protect it from growth by conjunctions. Standard fluidic oscillator designs are not suitable for the task and it is desirable to investigate new approaches.

Relaxation oscillators

One of the promising approaches is offered by oscillators based on the idea of initially storing the energy-carrying fluid and discharging it when the storage reaches a level at which the active element meets its load-switching level. Though by far not a direct analogy, the basic idea of this relaxation principle has been already developed in 1921 in the electronic oscillator of Pearson and Anson [2] – Fig.1. In fact, there is a little known Patent by Zalmanzon [3] who developed a fluidic version of relaxation oscillator (Fig. 2) in 1960. His design would not work at the low frequencies.

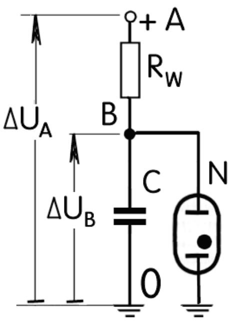

Fig. 1: (*Left*) The electronic relaxation oscillation phenomenon, discovered in 1921 by S. O. Pearson and H.S. Anson [2], is a periodic variation of the voltage ΔU_B across a capacitor C, the latter connected in parallel with neon bulb N. When charged through the working resistor R_w from the source of constant DC voltage ΔU_A, the voltage ΔU_B slowly increases until the breakdown value is reached at which the neon gas inside N ionises.

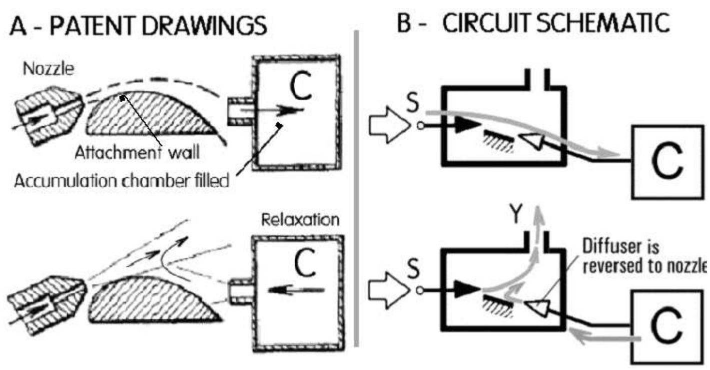

Fig. 2: (*Right*) Zalmanzon's 1960 fluidic relaxation-type oscillator [3]. The compressibility-type capacitance C is small (pressure grows rapidly with accumulated amount of air), making this oscillator suitable for high frequencies.

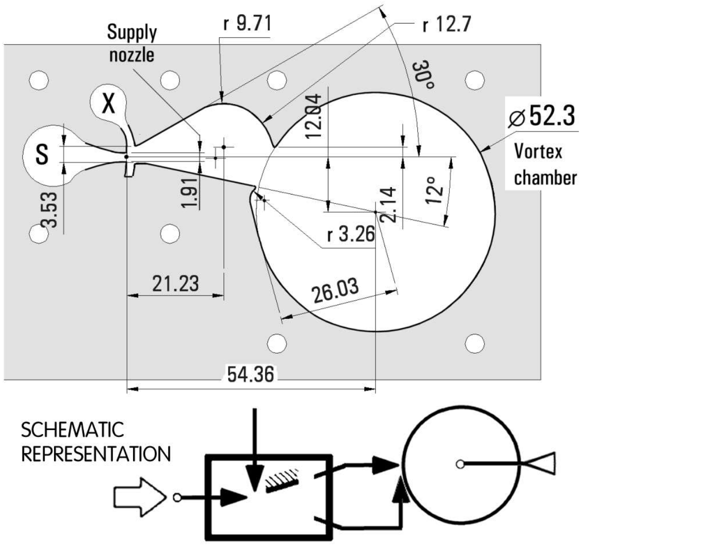

Fig. 3: (*Above*) Author's relaxation type fluidic oscillator. Essential novelty is the charged accumulating element replaced by the vortex-type restrictor, with the time delay effect caused by the spin-up (and spin-down) period in the vortex chamber. Presence of the control terminal X in this picture is misleading: it was simply open to atmosphere.

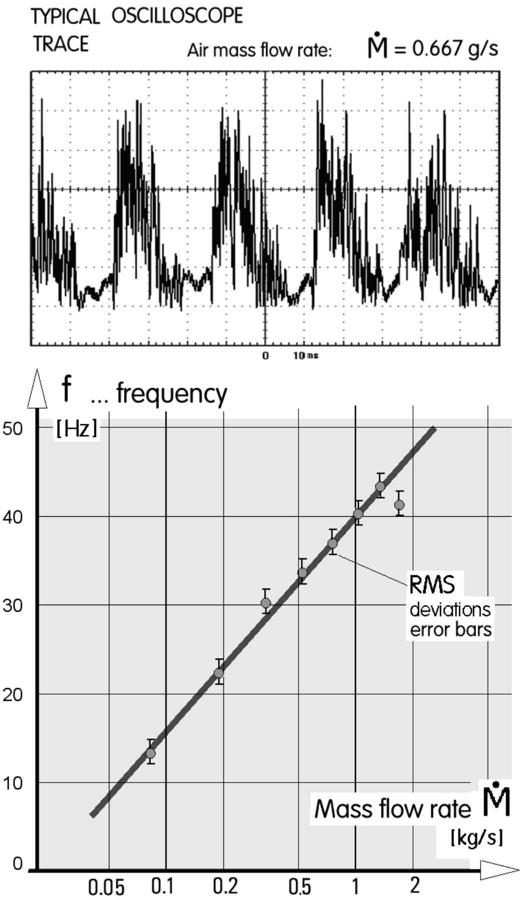

Fig. 4: (*Right*) Measured performance results.

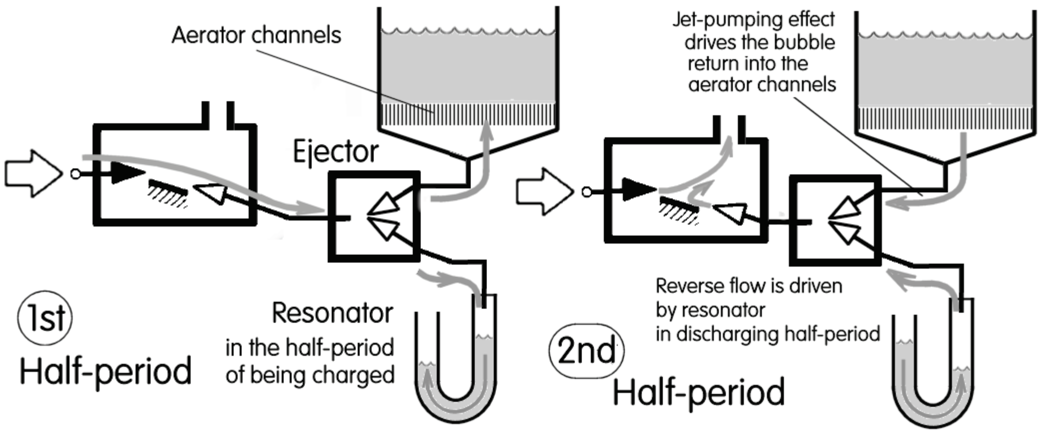

Fig. 5: Another author's relaxation oscillator with the jet pump ("Ejector") that generates the flow reversal using the energy temporarily stored in the resonator (here in the form of U-tube). The dominant low natural frequency of the resonator also suppresses the high-frequency noise.

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