# Model Builder's Guide
# To Understanding Veljko Milkovic's
# "Two-stage Mechanical Oscillator"

The following description is a set of guidelines for model builders who wish to replicate a working model of Veljko Milkovic's "Two-stage Mechanical Oscillator".
http://www.veljkomilkovic.com/OscilacijeEng.html

For a theoretical description of what the machine does, and why, please read:
http://www.veljkomilkovic.com/Images/Opinion_Dr_Peter_Lindemann.PDF

**Understanding the Mechanism**

The first part of this machine is a "simple machine" called a lever and fulcrum. It functions as a balance beam resting on a low-friction bearing system, with one fixed weight on either side of the beam. This part of the machine is oriented in the horizontal plane, and can rock up and down within a limited range. This limited horizontal movement is best defined by physical "stops" and limited to less than 15 degrees of rotation. Likewise, this movement is best "damped" by adding springs on both the top and bottom of the beam to constantly center the beam at the mid-point of its movement, and to return energy to it when the beam approaches the extremes of its movement range. This creates a mechanical oscillator that has mass, inertia, and an inherent frequency of oscillation based on its physical constants. This is the first of two oscillators in the system.

The second component of the machine is a weighted pendulum. One of the fixed weights is replaced with a weighted pendulum of equal mass hanging from the beam on one side. Ideally, it should be attached to the balance beam by a low-friction bearing mount whose position can be adjusted along the length of the beam. This weighted pendulum defines a second oscillatory system in the vertical plane, and is free to swing back and forth within a defined range. The swing of the pendulum is "undamped", and left able to swing completely free in the gravitational field for no less than 90 degrees of rotation, and up to 180 degrees of rotation. The weighted pendulum defines a second mechanical oscillator that has mass, inertia, and an inherent frequency based on its physical constants.

The combining of these two, separate mechanical oscillators into a single system becomes a "Two-stage Mechanical Oscillator". When properly tuned, this machine can function as a Mechanical Amplifier.

**Specific Set of Plans**

This document does not function as a specific set of plans for building a model, simply because there are so many different variations the home model builder may wish to explore. Whatever design is used, the model must be built so that the frame can withstand all of the physical forces that appear in the machine, without bending. It must be stiff and firmly mounted to an immovable base. Each movement, including the pivoting of the balance beam, and the swinging of the pendulum, should be secured in high quality bearings, to minimize frictional losses during operation.

Also, the linkage of the power take-off from the beam should be light weight, and strong enough to convey the energy to the output load. The weight of this output linkage must be taken into account in the over-all balance of the horizontal beam system.

**Necessary Adjustments**

For these two mechanical oscillators to function together harmoniously, their oscillatory characteristics must be synchronized. In order to facilitate this tuning process, Veljko recommends that various aspects of the machine be built so that they are adjustable. These include:

1) The position of the "fixed" weight on the balance beam should be adjustable horizontally.
2) The position of the bearing block holding the pendulum should be adjustable horizontally.
3) The position of the weight on the pendulum rod should be adjustable vertically.
4) The tension of the springs that damp the movement of the horizontal beam should be adjustable.

When tuned properly, the oscillations of both systems act together to produce "harmonic re-enforcement" of the energy stored in the combined oscillatory system, and very large force amplifications are possible. When left untuned, or improperly tuned, the oscillations of the two systems cause "beat frequencies" against one another, and the force amplification is dissipated in "parasitic oscillations." Therefore, the machine can only function as a Mechanical Amplifier when it is built well AND tuned properly.

**Specific Tuning Procedures**

The first set of adjustments is to make sure that the beam is balanced in its resting position. This is accomplished by moving the fixed weight or the pendulum bearing block along the balance beam as necessary, so that the beam rests perpendicular to the floor, without the damping springs in place. After the balance position is found, the damping springs may be installed.

The second set of adjustments is made to synchronize the oscillatory periods of the two oscillators. The oscillation period of the beam can be adjusted by changing the spring tension. In general, the stiffer the spring tension, the faster the oscillation will be. The oscillation period of the pendulum can be adjusted by sliding the weight up and down the pendulum rod. In general, the higher up the rod the weight of the pendulum is, the faster the oscillation will be. The goal is to tune both of these oscillations so that the beam oscillates at exactly twice the frequency of the pendulum swing.

There are numerous other subtleties to the tuning process, but this will get model builders pointed in the right direction.

Good luck,

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