Vibraphone Project

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Abstract

This document describes the building of an electromechanical vibraphone.

1 Introduction

2 Pipes

2.1 Materials

We use copper pipes as vibrating elements. The main reasons being copper is simple to work with, easily found in local stores and cheap.


2.2 Computing pipe length

The length depends on 3 factors:

- the required frequency,
- the vibrating element shape,
- the sound propagation speed in the medium.

According to [wiki_acous_reson], the formula for a cylinder is:

$$\boxed{f = \frac{nv}{2(l+0.8d)}}$$

where:

- f the frequency in hz,
- n an integer (1, 2, 3 ...),
- v the speed of sound in medium in ms^{-1},
- l the length in $meters$,
- d the cylinder diameter in $meters$.

However, we found an apparently better formula in [tamhigh_xylo] which accounts for the pipe radius of gyration. The nth transveral frequency is given by:

$$\boxed{f_n = \frac{\pi v k}{8l^2} m^2}$$

where:

- f_n the frequency in hz,
- v the speed of sound in medium in ms^{-1},
- k the gyration of radius,
- l the length in $meters$,
- m a value such that:
  - $m = 3.0112$ when $n = 1$,
  - $m = 5$ when $n = 2$,
  - $m = 7$ when $n = 3$,
  - $m = 2(n + 1)$ otherwise.

For a tube, the radius of gyration is:

$$\boxed{k = \frac{1}{2}\sqrt{R^2 + r^2}}$$

where:

- R the outter radius in $meters$.
- r the inner radius in $meters$,

Note this is equivalent to:

$$\boxed{k = \frac{1}{4}\sqrt{D^2 + d^2}}$$

where:

- D the outter diameter in $meters$.
- d the inner diameter in $meters$,

The copper sound propagation speed is:

$$\boxed{3700 ms^{-1}}$$

Since we want the whole device small, we keep the pipe as short as possible. However, we want to build it using relatively inaccurate drilling and cutting tools. Thus, we ended up choosing the 8th frequency mode (ie. the DO note frequency is 2093 hz), which results in the following table:

frequency (hz)	*length (m)*	*first node (m)*	*second node (m)*
2093.000000	0.141960	0.031799	0.110161
2349.313067	0.133993	0.030014	0.103978
2637.014757	0.126472	0.028330	0.098142
2793.819815	0.122872	0.027523	0.095349
3135.956712	0.115976	0.025979	0.089997
3519.992394	0.109466	0.024520	0.084946
3951.057873	0.103322	0.023144	0.080178
4186.010000	0.100381	0.022485	0.077896

2.3 Cutting the pipes

The easiest and most accurate way to cut the pipe is by using a pipe cutter:

pipe cutter

We found experimentally that we must add roughly 1.5mm to the previously computed length. This is due to the transversal holes and the vibration effects when the pipe is finally mounted. By the way, it is always better to have a longuer pipe, since we can reduce it with a lime for tuning until it reaches the correct frequency.

2.4 Drilling the pipes

TODO

2.5 Checking the frequence

TODO

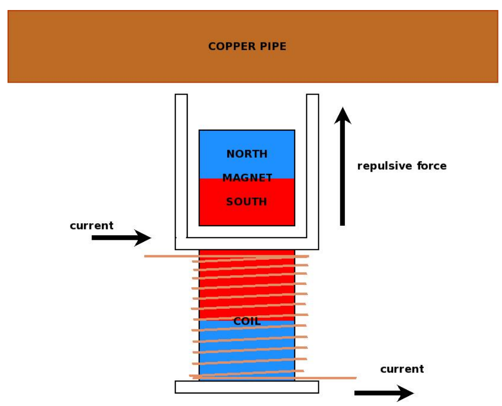
- video of xanalyzer -rate 16000
- recording audio files

3 Striking elements

3.1 Concept

To vibrate, the pipes need to be struck by a mass. An intuitive solution is to use a slug driven by a small DC motor. However, having one such element by pipe is too complicated and not cheap enough for our design, since motors can be hard to find.

Another solution is to use the magnetic field produced by a current flowing through a solenoid to lift a mass, acting as the slug. In our design, we use the magnetic field of a permanent magnet as a repulsive force. This is described in the following picture:



magnetic field used to lift a permanant magnet

4 Assembling

4.1 Drilling the base

Drill the pipe transversal holes before drilling the base holes. Once this is done, mark the base to prepare the drilling. It helps correcting small errors made while percing he pipe holes.

4.2 Mounting the pipes

5 Bill of materials

reference	*reseller*	*description*	*quantity*	*price (euros)*
copper pipe				

6 Related projects

- http://www.robovibes.com/home
- http://www.logosfoundation.org/instrum_gwr/vibi.html
- http://www.nerdkits.com/videos/robotic_xylophone

7 References

- wiki_acous_reson: http://en.wikipedia.org/wiki/Acoustic_resonance
- tamhigh_xylo: staff.tamhigh.org/lapp/xylophone.pdf