

CANADA WIDE SCIENCE FAIR

From File Reports

Luke Regier is the winner of this year's Special Award from the Canadian Acoustics Association for his project "Blowing Down the Walls of Jericho - Construction and Testing of a Horn Speaker Cabinet."

Luke Regier, 13 yrs old, is now attending St. Monica's School in Barrie Ontario as a grade 8 student. He has been involved in science fair and enjoy Science and Math. In Grade 6 his project was calculating the velocity of a hockey slap-shot using sound recording. The project won the Junior gold medal at the Simcoe County Regional fair. Luke was too young to be considered for participation at the Canada wide fair that year, but it gave him a good slap-shot that Spring and he scored a game winning goal with it.

His other interests and activities include snowboarding, hockey, and piano (currently at the grade 6 level, Celebration Series). He participates in piano recitals, exams, and occasionally competitions and plans to teach piano. Last summer he completed Bronze Medallion in swimming and plan to work up to life-guard.

The science fair award was presented in the Junior



Physical Sciences Category, in which he also received Honorable Mention.

Luke Regier's full article is reproduced below.

BLOWING DOWN THE WALLS OF JERICO - CONSTRUCTION AND TESTING OF A HORN SPEAKER CABINET*

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Editor's Note: The submission by Steven Gasior was reformatted and edited to fit in to the Journal format.

1 INTRODUCTION

A Jericho Horn Speaker Cabinet (Jericho Cabinet) is a type of acoustic amplifier that has a number of chambers through which the sound travels. *The sound gets louder because of a process called resonation.* As sound waves travel through the horn, it gets in step with longer bass frequencies matching the full cycle of specific sound wave lengths in the widening chambers. *Vibrations in the cabinet walls match specific frequencies, amplifying them.* The Jericho Cabinet transforms sound to deeper tones lower in frequency. *This occurs because the sloping chamber walls of the Jericho only resonates certain frequencies; the higher frequencies are fewer as they get disrupted by the amplitude of the resonating frequency.* The Jericho Cabinet is not mass produced, and was constructed at home for testing from a design that appeared in the German engineering magazine "Klang and Ton" posted on a web site. The home made cabinet uses a store bought electrical speaker.

The performance characteristics of the Jericho speaker was evaluated through an experiment. The purpose of this

experiment was to construct, test, and explore the properties of a Jericho Cabinet, specifically:

- 1 - Does the Jericho cabinet resonate the bass sound frequencies?
- 2 - Differences in amplitude with 1 speaker against 2 in the Jericho Cabinet (Test 1).
- 3 - Energy use of a Jericho Cabinet with a 50 watt speaker, in comparison to a 200 watt bass amplifier speaker cabinet ? (Test 2).
- 4 - Explore the changes in the sound wave of a simple bass sample as it travels through the Jericho Cabinet (Test 3).

2 EXPERIMENTAL PROCEDURE

Build Jericho Cabinet using the specified dimensions and materials.

Test 1: wire 2 KOSS speakers into cabinet. Record the sound with microphone at 5 different locations, playing through 1 speaker and then 2 speakers.

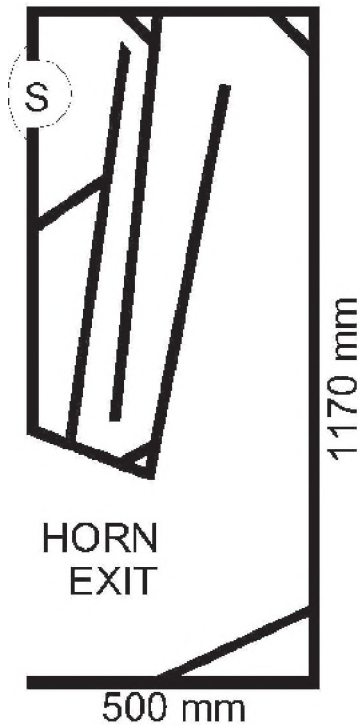


Figure 1. Jericho Speaker

Test 2: place microphone 5.0 m away from the Jericho Cabinet, and 5.0 m away from the Yorkville 200w Amplifier, recording sound at different volumes. Use UPM EM100™ energy meter to measure electrical power used by the Yorkville, then the Jericho Cabinet powered by smaller watt amplifiers, during each recording.

Test 3: drill holes into the side of the Jericho cabinet and record the sound in each chamber.

Graph and compare results from all three tests. An algorithm was used to determine the frequency of graphed waves by counting the number of intersections on the y axis.

3 RESULTS AND DISCUSSION

3.1 Construction and Testing

The Jericho Cabinet took 8 hours to build at a cost of approximately \$165 including the speaker. The wood

thickness in the website diagram was found to be incorrect. The thickness specified was 21 mm, but was actually 19 mm, a standard product thickness, found by adding up the overall dimensions. The finished speaker cabinet produced a clear, smooth tone at low to mid volumes; however, at high volumes it was observed that the speaker mounting rattled. The mounting bracket was of light plastic construction with a poor seal to the face of the cabinet. It was observed that the sound software records volumes as $1 \pm$ decibels of sound pressure (dBsp). A formula is used to convert to decibels. The recordings were conducted either at suitable distance from the amplified speakers, or at low volumes.

3.2 Test Results

Test 1: There was a noticeable increase in Amplitude (volume dB) using 2 KOSS 3-watt speakers (Ks-3) compared to 1 Ks-3 at locations 1 and 2 (Figure 2).

The observed amplitudes at Location 2 were greater than the respective amplitudes observed at location 1, and much lower in frequency. Recordings at locations 3, 4, 5: were lower in volume dB, and the frequencies started to average out.

Test 2: The power use of various amplifiers to generated volume using the Jericho Cabinet was compared and the results are shown in Figure 3. Connected to the 30 watt Fender Amplifier (Fn-30), the Jericho used less electrical power at low volumes as a Yorkville 200 watt (Yk-200), illustrating it can be more energy efficient compared to high-watt mass-produced amplifiers. The Fn-30 did not have enough power to match the volume produced by the Yk-200. The test was repeated connecting the Jericho Cabinet to a 50 watt Marshall AVT Head Amplifier (Mr-50). The Mr-50 was able to produce higher volumes of sound than the Fn-30, but did not display better efficiency in power usage compared to either the Fn-30 or the Yk-200. It was observed volume output is directly related to power input and that electrical speakers are very efficient devices, using little energy. The Yk-200 could produce the most volume having the most power, and was as energy efficient at higher volumes.

Test 3: The sound wave frequency changed as the sound traveled through the Jericho Cabinet (See Figure 4). There

Figure 2 - RESULTS OF EXPERIMENT 1 - COMPARING 1 AGAINST 2 SPEAKERS

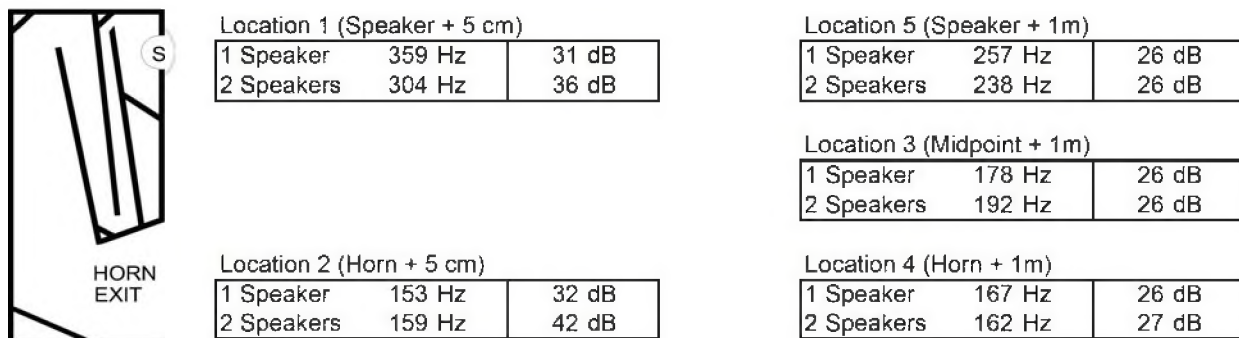
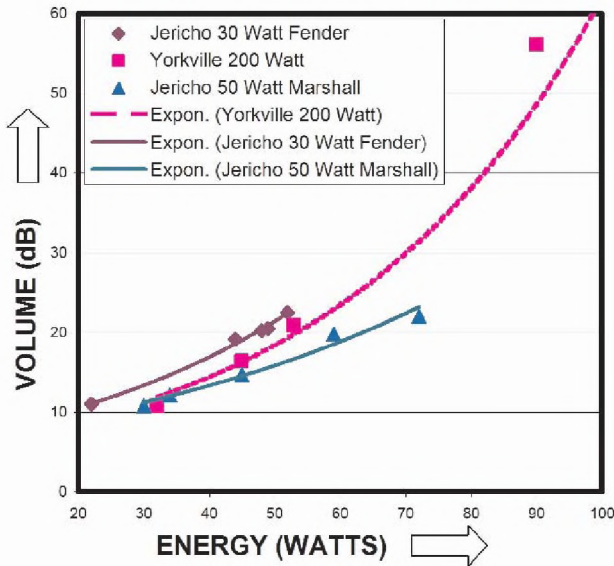


Figure 3 - ENERGY vs VOLUME



is a noticeable and measurable lower frequency produced in each chamber. From location 0 (Speaker), to location 4 (horn exit) the average frequency changed from 287 Hz to 88 Hz, a decrease of 199 Hz.

3.3 Discussion

The most striking observation noted during the process of building the Jericho cabinet was its shape. Starting from the top where the sound from the speaker enters, the cabinet gets larger in size. This enlarging pattern continues through the fourth chamber at the base of the cabinet, making a horn shape. This is how the Jericho cabinet resonates bass sounds. The distance the sound travels is 3.37m, taking approximately 0.01 seconds at the speed of sound of 344 m/s. This is approximately the wavelength of the frequencies produced by the speaker, meaning the sound exiting the horn lags the sound of the speaker by 1 or 2 wavelengths.

It was observed that there was a slight increase in amplitude between having 1 and 2 speakers in the Jericho (Test 1). This is because with 2 speakers, the small additional amount of power used to drive the 2nd speaker doubles the vibration of air. The two sources of sound in the speaker compartment also provide some resonance where the waves combine from both speakers.

The Yorkville 200 watt amplifier speaker produced better power to volume ratio at higher volumes because larger speakers can move larger quantities of air. It was discovered that the Marshall design technology uses a Tube system, producing heat as well as sound, causing it to use more energy.

4. Conclusions

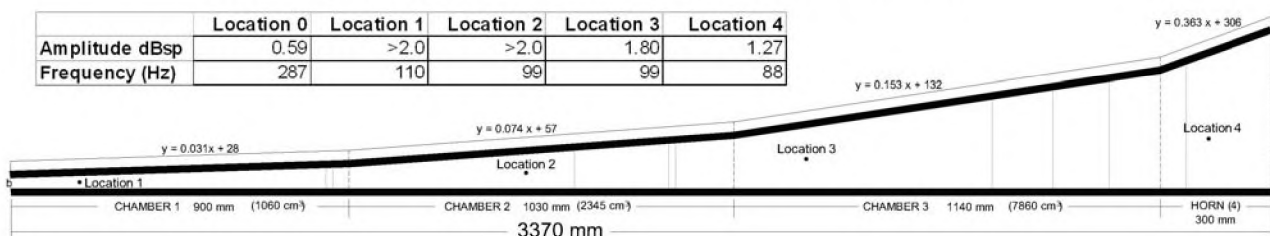
- i. The speaker could be bolted directly to the face of the cabinet, rather than using a mounting bracket to reduce rattling.
- ii. The Jericho Horn Speaker Cabinet resonates the bass frequencies of sound
- iii. Speaker Cabinets can provide higher amplitudes with the same of amount of power by using two speakers instead of one.
- iv. At low volumes, the 50 watt speaker Jericho Cabinet took less power to give it the same volume compared to the Yorkville 200 watt speaker.
- v. The Jericho Cabinet changes sound traveling through it to lower frequency and higher amplitude waves.

Fewer speaker cabinets are needed as the Jericho Cabinet provides a source of bass sound. There is a stereo effect caused by time lag between the bass frequency and the originating source of sound at the speaker, and separation between the speaker and horn. This was a practical science project that can be enjoyed for many years.

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**Figure 4 DIAGRAM AND RESULTS TEST 3
PROFILE OF HORN & CHANGE IN SOUND THROUGH CHAMBERS**



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