

Helmholtz Resonance is killing me... by Brendan Power

Yes, I've got dem old lowdown Helmholtz Resonance Blues :-| WTF I hear you cry? Well, like most of you, I was only vaguely aware of this phenomenon until recently, but it's now become the bane of my life. First of all, what is it? Wikipedia, the fount of all 21st Century knowledge, states:

Helmholtz resonance is the phenomenon of air resonance in a cavity, such as when one blows across the top of an empty bottle. The name comes from a device created in the 1850s by Hermann von Helmholtz, the "Helmholtz resonator", which he, the author of the classic study of acoustic science, used to identify the various frequencies or musical pitches present in music and other complex sounds.

How does HR apply to harmonicas? Generally not much, but in certain circumstances, a lot! All harmonicas have cavities: the comb chambers between the reedplates. In addition our vocal tract is a cavity, and we use that all the time to shape tone and bend notes.

The harmonica is part of the free reed instrument family and, like all Western free reed instruments (accordion, concertina etc) is a late addition, born of ancient Asian origins. The Asian free reed instruments like the Sheng or Bawu almost invariably use

Helmholtz Resonance in a tuned chamber in association with a free reed, as an integral part of the sound. Long before old Hermann came along the Chinese had figured out a sophisticated way to couple the two kinds of sound generator together: the pitch of the free reed working with the pitch of its associated 'Helmholtz Resonator', normally a bamboo pipe cut to a precise length.

Asian free reeds are symmetric, which means they are in the middle of the reed slot (often cut from the same material) and sound on both 'in' and 'out' air directions. A strategically placed hole in the surrounding pipe is made such that the reed will not sound when the hole is open - it only sounds when the player closes the hole with his finger. The reed tone is enhanced and shaped by the pipe, which generally has a resonant frequency slightly above that of the free reed.

Harmonica and other Western free reeds are asymmetric: that is, mounted on one side of a reedplate above the reed slot, and will operate normally with air moving in just one direction; that's why we have separate blow and draw reeds. In harmonicas the comb cavities between which the reedplates sit are simply a means by which to channel the air to the individual reeds. The cavity normally has no special design beyond being roughly the size necessary to do its job.

HOWEVER... in the very high range of harmonicas, accordions etc it has been found that an inadvertent but significant coupling of reed pitch and chamber resonance starts to occur. The result is that high-pitched reeds will play flat and, in extreme circumstances, stop sounding altogether! Basically, the resonant frequency of the comb chamber is fighting the reed pitch in a very unhelpful way...

Harp tech guru Rick Epping once did a very clever test of this phenomenon. He sealed both sides of a Marine Band harmonica comb with thin boards to make a rudimentary pan pipe, and blew into each chamber to get its resonant frequency. He then put different pitch reedplates on the same size comb, and checked playability. Rick concluded that, especially in the very high range, it is important to make the resonant frequency of the comb chamber the same or slightly higher than the reed pitch, otherwise the reed will not play well.

That's why chromatic harmonicas generally have 'filled in' comb chambers at the high end, to reduce the volume and raise their resonant frequency. Customisers will generally reduce the chamber volume still further, as it has a genuinely positive effect. Rick has taken this chamber reduction to extremes with some of his harps, giving good playability in ridiculously high reeds that would

simply not sound at all with conventional comb chambers.

The reason I'm currently so obsessed with Helmholtz Resonance is because it's having a big unwanted effect on the keys I can offer in my new Twin-Harmonica System. Since I'm overlaying a new upper unit and mouthpiece/slider on top of two conventional harmonicas, I am inevitably increasing chamber length/volume. That is lowering the resonant frequency of the chamber between mouth and reeds, and the effects are horrendous! The reeds in hole 12 on a normal C chromatic will not play at all, on hole 11 they are down about two tones, hole 10 down about a tone, and hole 9 plays significantly flat.

So far the only 'solution' is to make these new instruments in medium to low keys, from a G chromatic down. However I would love to find a way to overcome this unwanted coupling effect on higher keys, and am discussing it via email with Rick and some scientific researchers in the field.

The more you examine it the more complex it seems, especially when you take into account the changing vocal tract of the player as well! I live in hope that there might be some trick to free the reeds from this cursed coupling. I'll keep you posted.

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