Sound, Timbre and Noise

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This text is written to the best of my knowledge. It is how I understood music theory by researching the internet. But I am not a music professor, so this text can contain errors. Please forgive me if you find any errors.

1. Theory

1.1 Noise and Sound

In wind instruments, by blowing continuously the same note, a stable waveform is created in the instrument itself, which is responsible for the sound. This stable waveform in turn consists of several stable standing sinusoidal waves:

- The desired note (first harmonic, fundamental frequency)

  The sine whose frequency is as high as the waveform itself is called the fundamental.

- The overtones (other harmonics, partial tones)

  Since the frequency of every other stable sinusoidal wave in a wind instrument is integer-related to this fundamental, these sinuses are called harmonics (the overtones).

When you stop blowing in a wind instrument the created wave is not stable anymore and dies out. In string instruments and music boxes you have the same effect since the movement, after plucking, slowly dies out. The created wave is not stable.

https://en.wikipedia.org/wiki/Waveform

https://en.wikipedia.org/wiki/Standing_wave

https://en.wikipedia.org/wiki/Acoustics

In reality, every instrument will also create (stable) sinusoidal waves whose frequency does NOT relate to the desired note according to an integer. This is avoided as much as possible by the instrument maker since the difference between “noise” and “nice sound” for your ears can simplistically be defined as.

Nice Sound = all stable sinusoidal waves that are related to each other by an integer to the desired note (first harmonic) All the nice sounds are composed of overtones that have a high, mid or low frequency

Noise = all stable sinusoidal waves that are NOT related to each other by an integer.

(PS for simplicity I forget here that in some circumstances not integral related sinusoidal waves can sound good when played together…. Think of chords https://en.wikipedia.org/wiki/Chord_(music))

1.2 Amplification of Sound

The generated sound (+noise) of a struck thine/tooth from a music comb is so weak that amplification is always needed. The movement of a thine doesn't create a lot of vibration in the air around it so you will not hear it with your ears (or only very weak). The air vibration needs to be strong enough to move your eardrum..

https://en.wikipedia.org/wiki/Eardrum#:~:text=In%20the%20anatomy%20of%20humans,ear%20from%20the%20middle%20ear

To the best of my knowledge there are three ways to do that (without electrical amplification)

I. By Means of a Sound Box/Resonator Box

A mouth harmonica does not have a sound board (see below). All its amplification comes from a sound box (this is the mouth cavity). The vibrating reed causes the air to vibrate in your mouth and creates a waveform in the air. The continuous reed vibrations increase the air vibrations in power right until the wave becomes unstable in the sound box and the energy (that is accumulated in the air which vibrates more and more violently) "bursts" (continuously) out of the sound box hole. (When you whistle/sing a tune the sound box hole is also your mouth.)

II. By Means of a Sound Board

This is the wooden plate/table on which your music box brass/aluminum bedplate is screwed on. By choosing the correct length and width of this plate you can optimize this part. Ideally the generated sound makes the sound board vibrate as well.

The air vibration is now increased (by the moving thine/tooth and sound board working together) and forces the other walls of the music box to vibrate as well. At that moment all the walls of your music box (or sound box, see above…) begin to act as sound boards as well. (when you sing a tune this amplifying effect is not present. Your mouth does not have resonating, wooden walls)

III. Sympathetic Vibration (see 1.1)

Apparently you do not have this effect in a mouth harmonica, so I highly suspect you also do not have this in a music box. But on a piano, which is a string instrument, you can observe an effect that is called sympathetic vibration.

Experiment description

First, press down (lightly, so as to not play a sound) the C5, G5 and C6 keys on the piano and keep holding them down. Then strike and release the C4 key. You will hear the C5, G5, and C6 notes play This is because when you strike the C4 key, you are exciting the string with its fundamental (261 Hz) as well as a large number of integer harmonics (n=2 is the octave at C5, n=3 is the octave-plus-fifth at G5, and n=4 is two octaves at C6) in that single string all at the same time.

Sympathetic resonance causes the fundamentals of the C5, G5, and C6 strings to vibrate since those frequencies are present in the sound of the C4 note, even though those notes/keys were not struck.

https://en.wikipedia.org/wiki/Sympathetic_resonance

1.3 The Timbre of your Musical Instrument

When you blow/suck air in a harmonica this causes the reed to start vibrating in a stable waveform. On the link of the Seydel mouth harmonica webpage you can see that this stable waveform consists of both “nice sound”- and “noise”-waves. The “nice sound”-waves are all integers of 3.49 (the frequency of desired note): 6.98; 10.47; 13.96;…

Unfortunately the vibrating reed also creates noise-wave frequencies. These are not desired and usually small (the not integer ones)

https://www.seydel1847.de/epages/Seydel1847.sf/en_US/?ViewObjectID=18740&Currency=EUR

To evenly amplify the stable waveform (which consists of nice sound and noise waves) of the reed or thine in a music box, the body should be able to vibrate/resonate at every possible frequency that this waveform consists of.

In reality, this is never the case and the body of the instrument prefers certain frequencies that it can more easily vibrate with than others (e.g. natural frequencies). A dramatic example of this is the shattering of a glass by a human voice by sympathetic vibration. The glass body begins to vibrate to the sung note until it bursts. If the singer would sing another note (frequency) nothing would happen to the glass body. The glass body does not want to vibrate with those.

https://www.youtube.com/watch?v=CdUoFIZSuX0

https://en.wikipedia.org/wiki/Mechanical_resonance

The frequencies where the body can easily co-"vibrate" with will be amplified (louder) compared to the frequencies that the body cannot easily sympathize with. In this way, the body of the instrument/music box has a very important influence on the final timbre of the sound

- Which overtones of the struck tone are amplified? which are not?
- Which noise waves are amplified?
- Which additional noise waves are created by the vibration of the body? Just as the striking of the thine creates sound waves. The vibration of the body creates additional sound waves (existing of nice sound and noise waves) as well…

1.4 Which Materials Are Used?

The body of an instrument is typically made of three possible materials: plastic, wood or metal.

Plastic is considered dead material that has little or no influence on the final timbre. After all, it does not vibrate. This is why many speakers are made of plastic. (The speaker material is not intended to affect the timbre of the sound reproduction.)

Metal from the music comb provides the “first timbre coloring” of the sound. After all, this is a highly resonant material. It determines which sound waves are created by striking the tine. Just like a guitar (where you have the choice out of many different strings: steel, nylon, catgut…) The choice of steel is a very important factor.

Wood is mostly used for the sound box. You can find more information here:

http://acousticguitar.com/a-tonewood-primer-how-to-pick-the-right-materials-for-your-optimal-sound/