HOW THE SUBBASSPROTOTON WORKS

If you are interested in what to do in the ProtoTon, please take a look at the other brochure **What to Do and Experience in the SubBassProtoTon**

Sie können die deutsche Fassung dieser Erläuterungen in der Broschüre Akustik — Wie die Töne entstehen lesen.

SUB	BASS	PROTO	TON
BELOW	LOW	FIRST	TONE

Johannes Goebel
1986 / 2016

HOW IT WORKS

There are two different kinds of pipes: one kind, which is long, and another kind, which is not narrow but round or cubical or oval. The two musical instruments that represent these two different sorts of pipes are the flute and the ocarina.

In the 19th century, quite a few scientists experimented with pipes, which were not long, but cubical or other shapes.

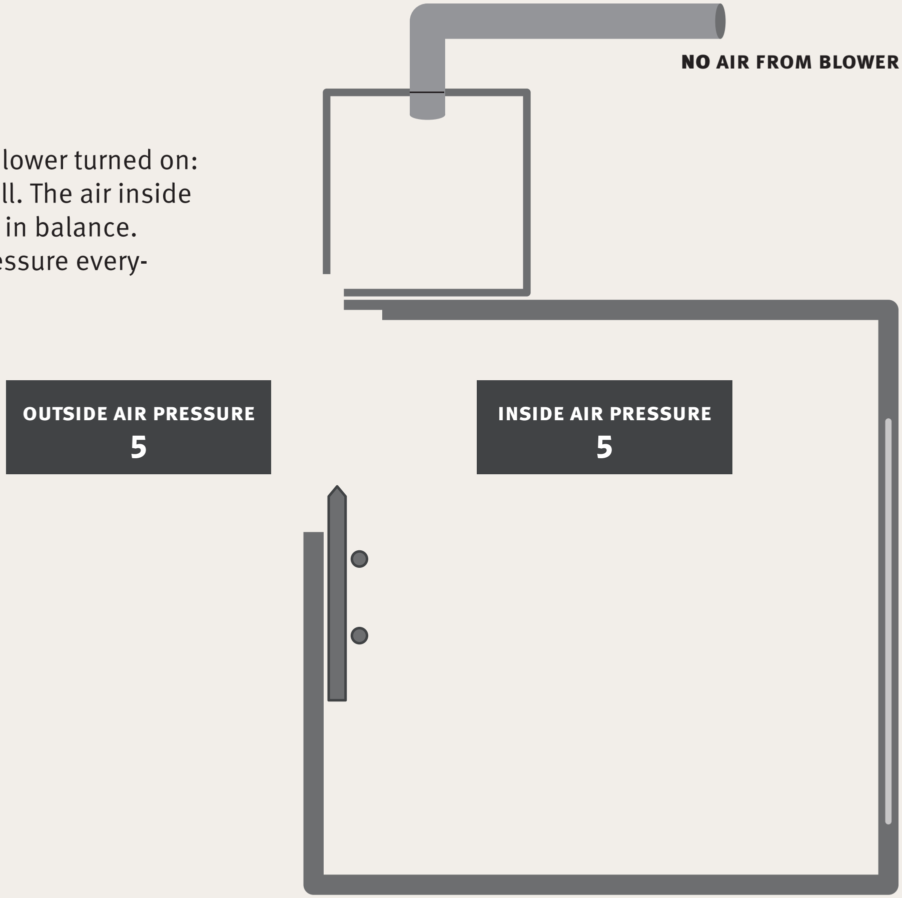
In the first half of the 20th century cubical pipes were used in some organs.

I wanted to build a pipe I could walk into, and where I could be inside the sound.

Pipes in different shapes, built around 1865 by Rudolph Koenig in Paris (Collection of Historical Scientific Instruments, Harvard University)

1

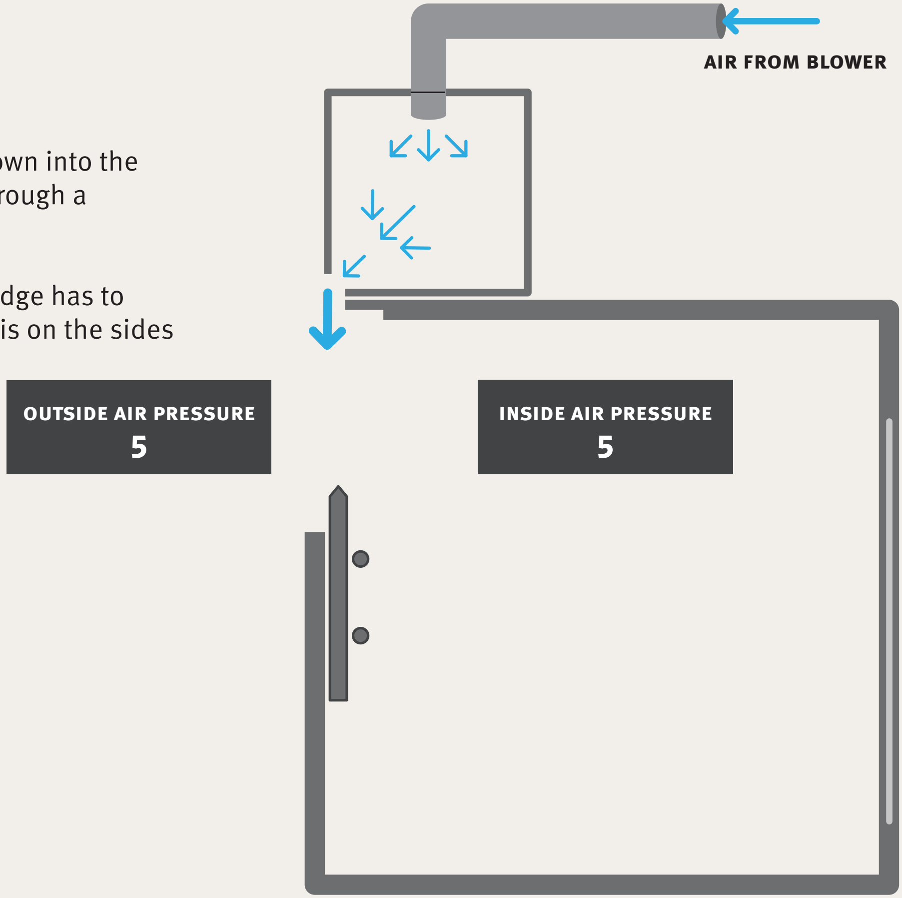
The ProtoTon without the wind blower turned on: Nothing moves, everything is still. The air inside the pipe and outside the pipe is in balance. There is the same level of air pressure every-where – say, “5.”



2

The fan is turned on and air is blown into the wind chest – where it escapes through a narrow slit.

Important: The slider with the wedge has to be positioned to where the mark is on the sides of the slider.



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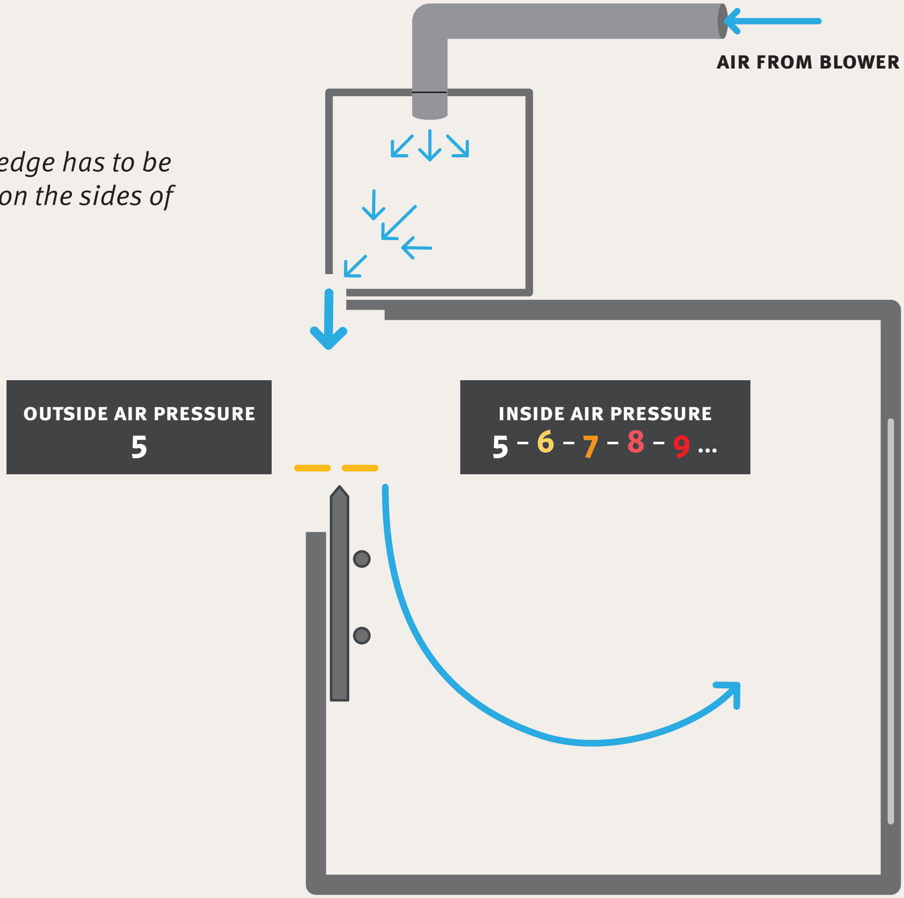
Important: *The slider with the wedge has to be positioned to where the mark is on the sides of the slider.*

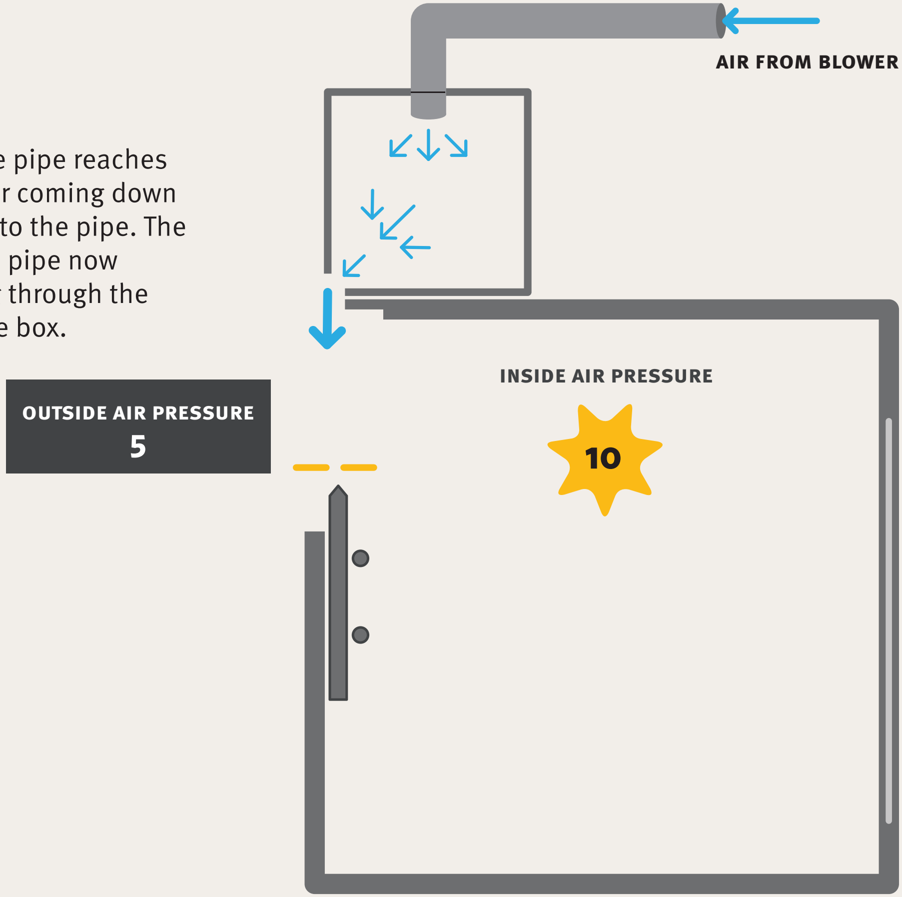
The air coming through the slit in the wind chest hits the wedge. Some of the air moves into the inside of the big cubical box – and the air pressure inside the box rises as more air follows the stream of air inside: 5 – 6 – 7 – 8 – 9 ...



4

When the air pressure inside the pipe reaches "10," it gets too strong for the air coming down from the slit, following the air into the pipe. The highly pressurized air inside the pipe now pushes the stream of air coming through the slit to the other side, outside the box.

The outside air pressure is not much influenced by the air moving out, since most likely the ProtoTon is placed in a very large space or outside, where the additional air does not make much of a difference to the general air pressure.



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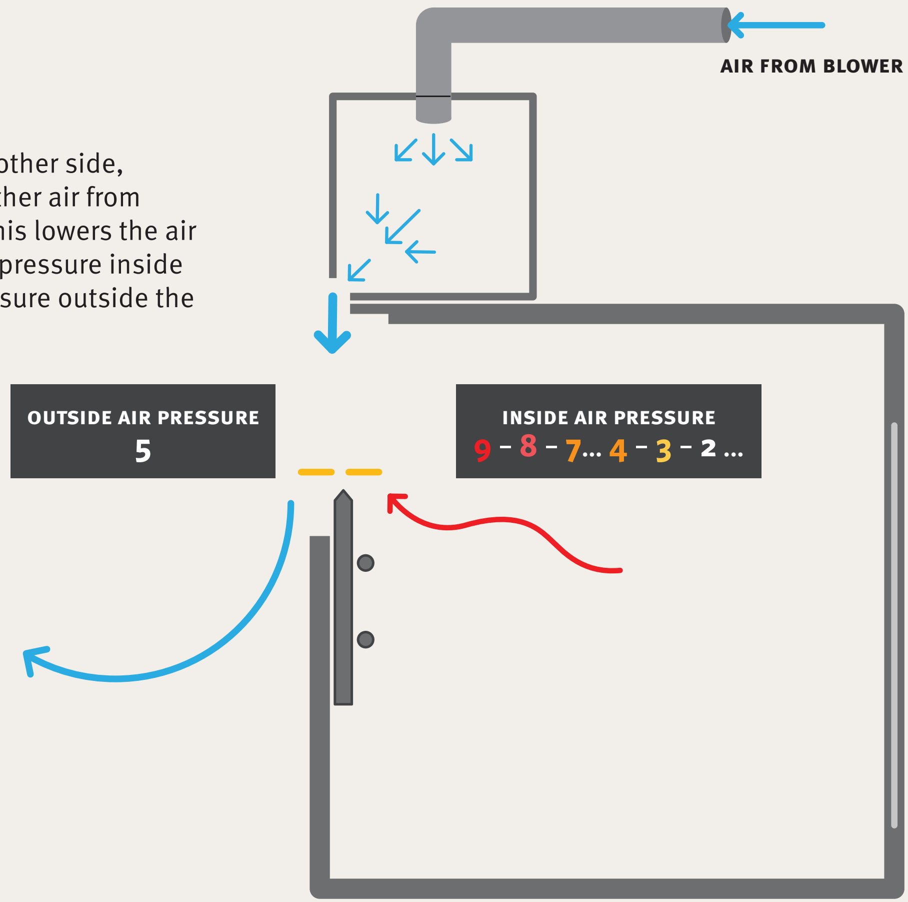
As the air is now moving to the other side, outside the box, it also sucks other air from inside the box to the outside. This lowers the air pressure inside the box. As the pressure inside the pipe gets below the air pressure outside the box, it goes down to 5, 4, 3, 2...



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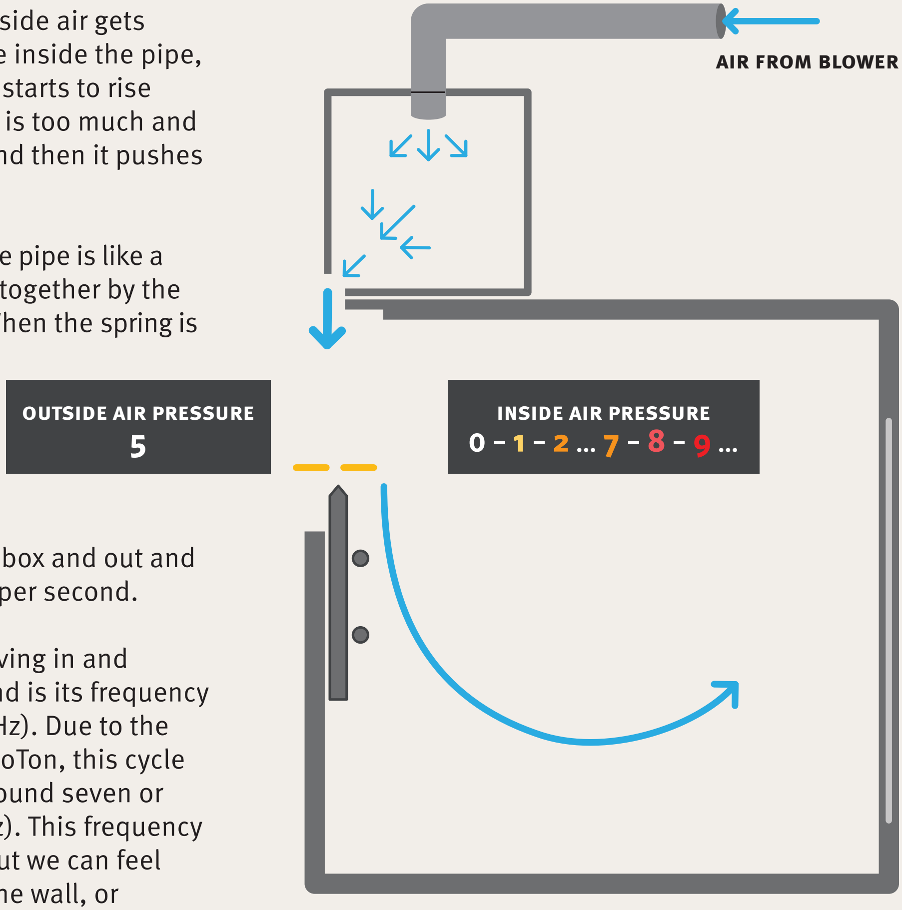
… and reaches “0.” Now the outside air gets pulled in by the weaker-pressure inside the pipe, and the pressure inside the box starts to rise again “5 – 6 – 7 – 8 …” – until it is too much and cannot be held inside the box and then it pushes out again.

One can imagine the air inside the pipe is like a large spring, which gets pushed together by the air coming in from the wedge. When the spring is compressed as much as possible, it expands and pushes the air out until again it has to move back and pulls the air in.



This cycle of air moving into the box and out and in again happens several times per second.

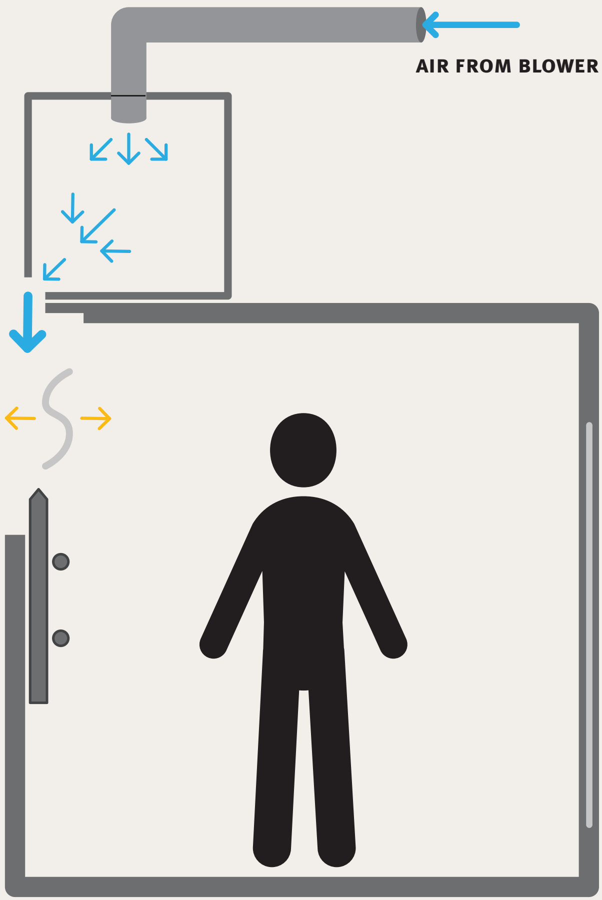
How often this one cycle of “moving in and moving out” happens in a second is its frequency (also called Hertz, abbreviated Hz). Due to the specific large volume of the ProtoTon, this cycle is quite slow and takes place around seven or eight times a second (about 8Hz). This frequency is too low for our ears to hear. But we can feel this frequency leaning against the wall, or holding our hands into the air stream, or holding a tissue into the air stream, which then flutters in and out at the speed of the changes in air pressure inside the pipe.

7

With the wedge set at the marked position, 7–8 Hz is the resonant frequency of the volume inside the box. It takes only the very little air coming from the organ blower to move the heavy walls of the box back and forth.

This frequency is too low for the human ear to perceive as pitch. One can hold a piece of paper or a handkerchief into the air at the wedge to see the frequency (an analog oscilloscope).

One can lean against a sidewall and feel the frequency with the whole body.



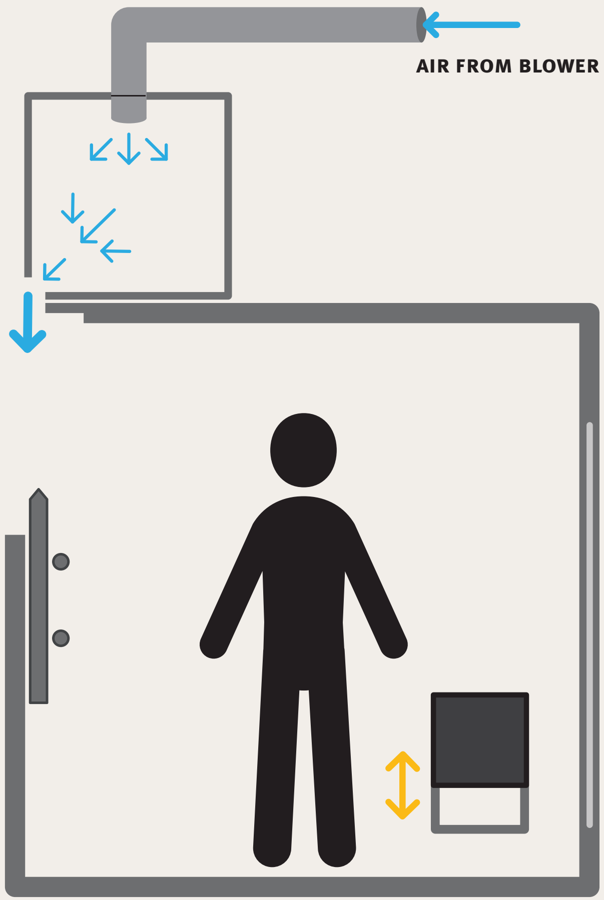
8

There is a slider towards the back of the one sidewall. One can slowly raise the slider. And when one leans against the wall, one feels that the speed gets faster, the frequency rises.

The reason for this is that the slider opens to the outside. This allows air to escape. The air inside the pipe cannot build up that much pressure any more and has an easier way to move back and forth. This results in a faster in-and-out movement of the air.

The resistance of the air inside the pipe is reduced. The “spring” is looser and can move faster.

When the slider is lowered, the speed gets slower again.



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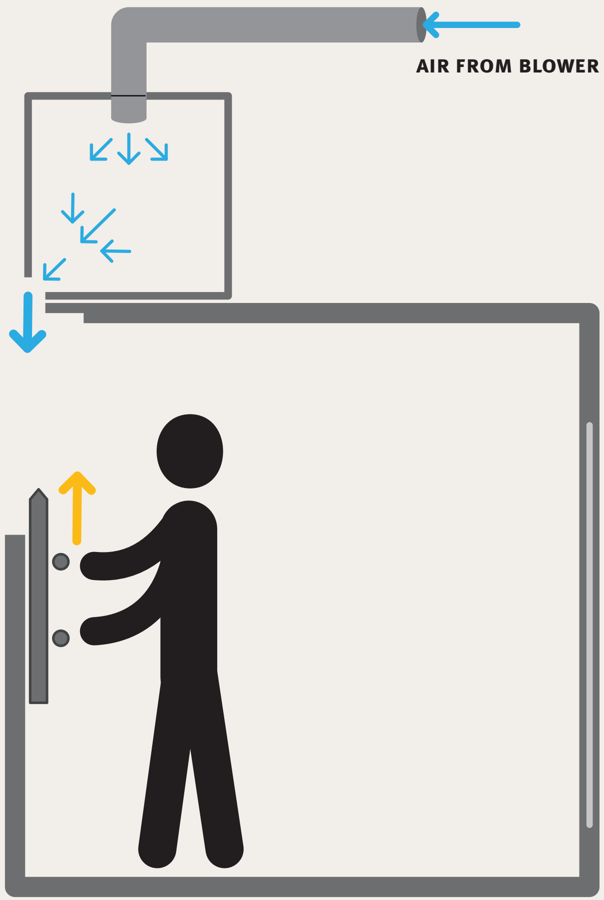
Moving the wedge higher, makes the pulses go faster. A rumble appears and then one perceives a smooth low tone. Now the ear perceives the air moving in and out as a continuous pitch. The lowest threshold of hearing tones has been passed.

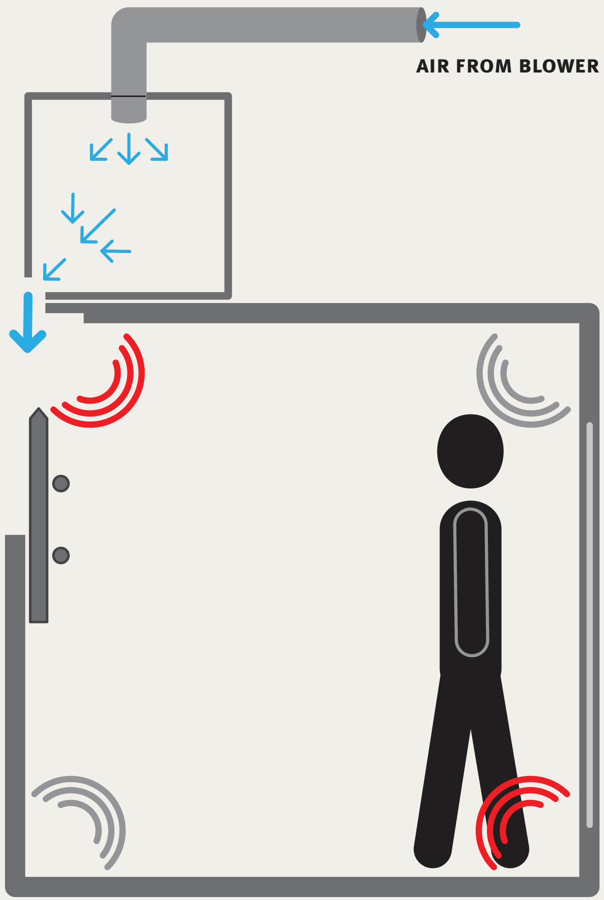
If you hold the paper in the air stream, the eyes will not be able to see movement clearly.



10

And as one moves the slider slowly up, all of a sudden – boom! – one hears a very loud sound. A standing wave has been established inside the pipe. This is not the volume of the cube being excited, but a wave that fits perfectly between the edges of the cube – from the top at the front, where the sound is created, to the bottom back corner.

This standing wave is very loud at those two locations – but soft at the bottom of the front and at the top of the back. One can experience that by moving the head and ears to those places.

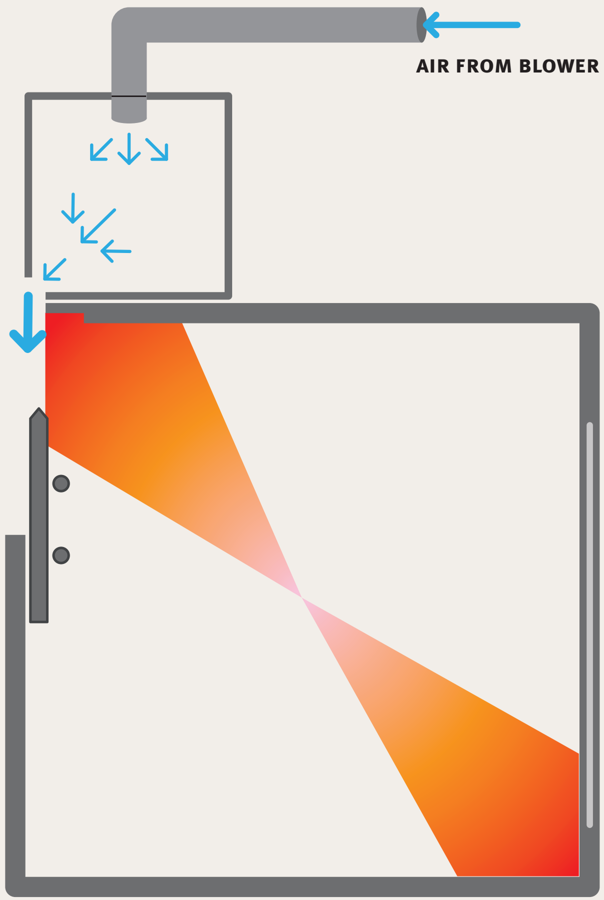


11

The standing wave fits perfectly in between the corners and does not seem to move. The two ends with the highest air pressure are at the ends of the standing wave and the place of the constantly lowest pressure is in the center. With our two ears, we can move along in this field between soft where the maximum pressure is low (soft for us) and to the corners where the air reaches very high pressure levels (loud for us).

You can wander through the pipe with your head high up or by kneeling down on the floor to get your ears down low. And you can move into the corners to explore where the sound wave is loud and soft. You can create a map of loud and soft locations in your mind.

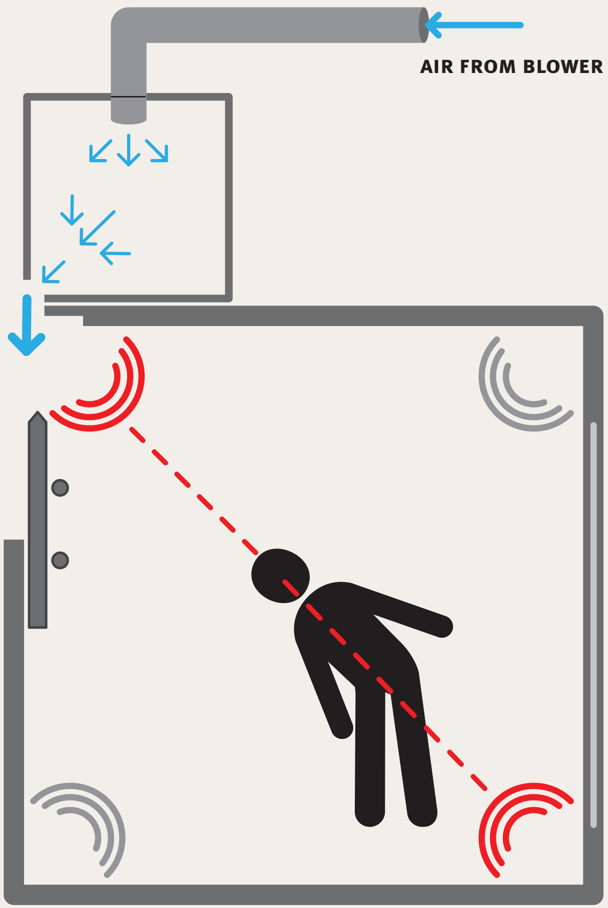
Because this standing wave is determined by a distance within the pipe, opening the slider in the sidewall does not change the sound. The slider in the sidewall only affects the lowest frequency, which in this pipe is the one you can only feel.



12

Move to the center of the pipe and align your left and right ear so they are on the diagonal from the wedge at the front where the sound was very loud to the bottom in the rear where it was loud as well.

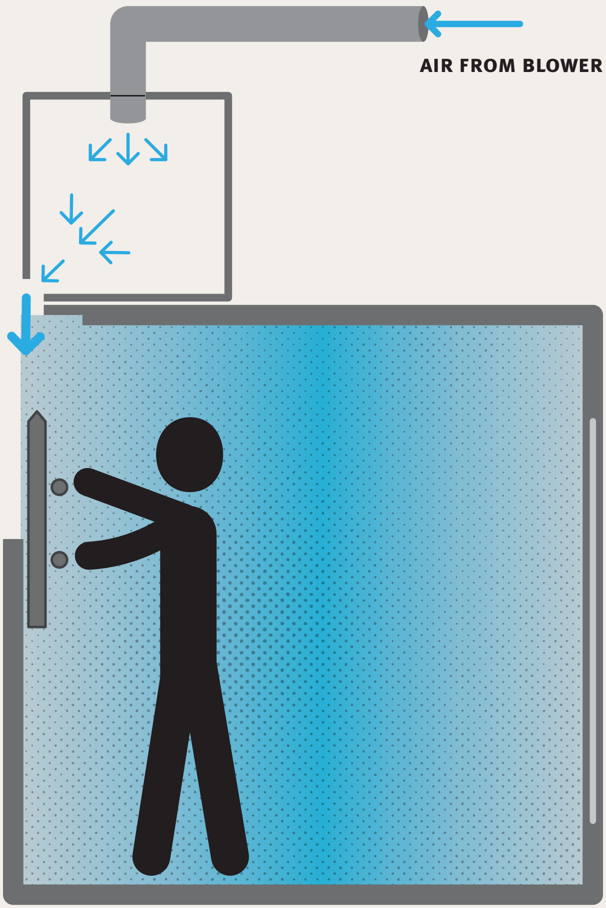
When you find the sweet spot, the sound will be perceived to be right in the middle of your head. When you move your head on the imagined diagonal a little left and right, the sound you hear will also move to the left and right. You have found the so-called node of a standing wave!



13

There are several other standing waves in the pipe, which fit perfectly between two walls or edges of the pipe. By moving the wedge slowly higher they can be evoked.

Leaving the wedge in such a position, one can again wander through the pipe and find the loud and soft locations of that wave.



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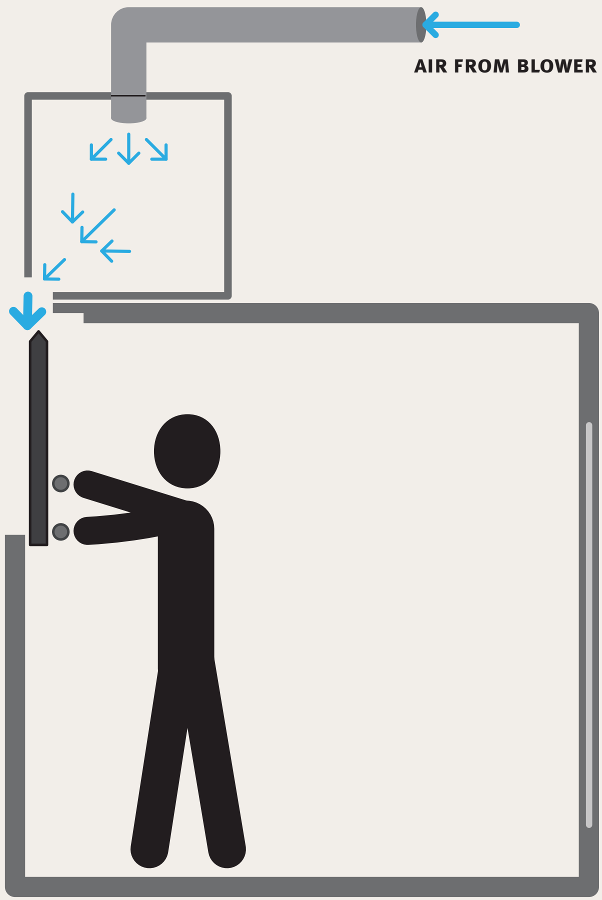
When the wedge is moved further up, almost up to the gap where the air comes through, different whistling sounds and noises are occurring – like the air howling around the corner of a house.

The sounds now only depend on the air hitting the wedge – independent of the volume of the pipe (which is responsible for the lowest frequency) and independent of the dimensions inside the cube (which are responsible for the standing waves).



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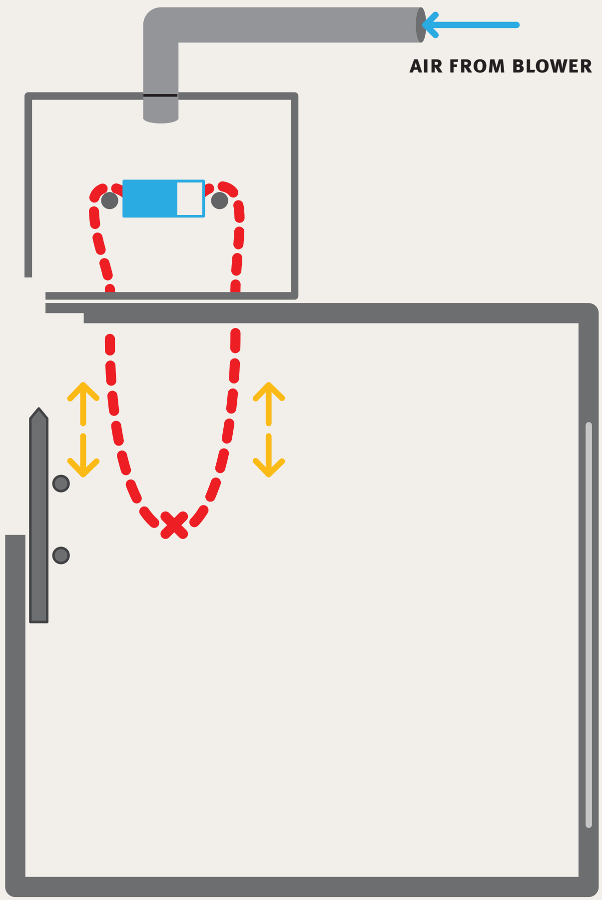
There is still one tool that allows us to change the sounds of the box: The rope hanging from the ceiling to the left of the wedge.

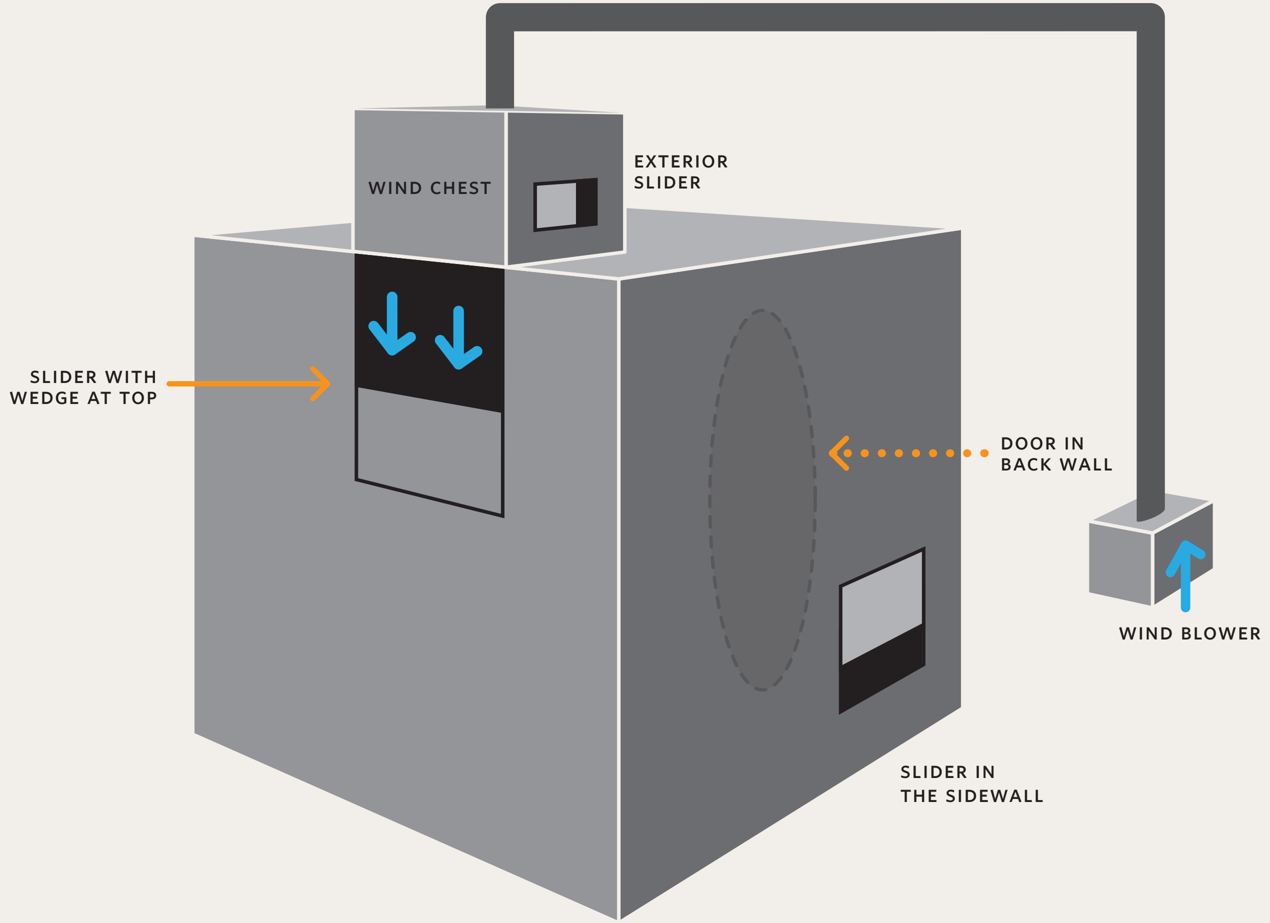
When pulling on the rope, a slider on the outside of the wind chest moves back and forth. When opening, it allows air to escape out of the wind chest and, as a result, less air gets to the wedge.

When the wedge is left in one position and we use the rope to change the amount of air that reaches the wedge, this has the same effect as moving the wedge up and down. It makes the pitch or the noises and whistles go up and down.

This indicates that the pressure, velocity, and volume of the air are important factors in the creation of vibrations.

This is a good way of tuning for the standing waves once the big slider is in a good, but not yet perfect, position. And it is also a great way to play with the noises when the slider is all the way up.




WIND CHEST
EXTERIOR
SLIDER
SLIDER WITH
WEDGE AT TOP
DOOR IN
BACK WALL
WIND BLOWER
SLIDER IN
THE SIDEWALL