FUTUR MUSIQUE

#3

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Feedback: C100k
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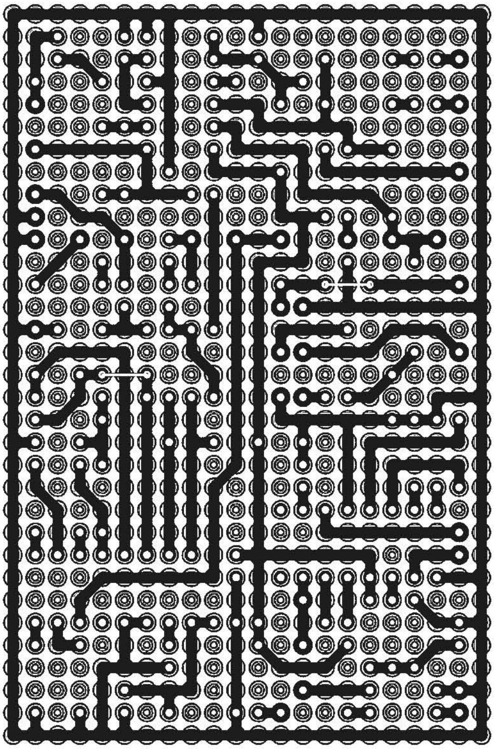
Switch 1: DPDT



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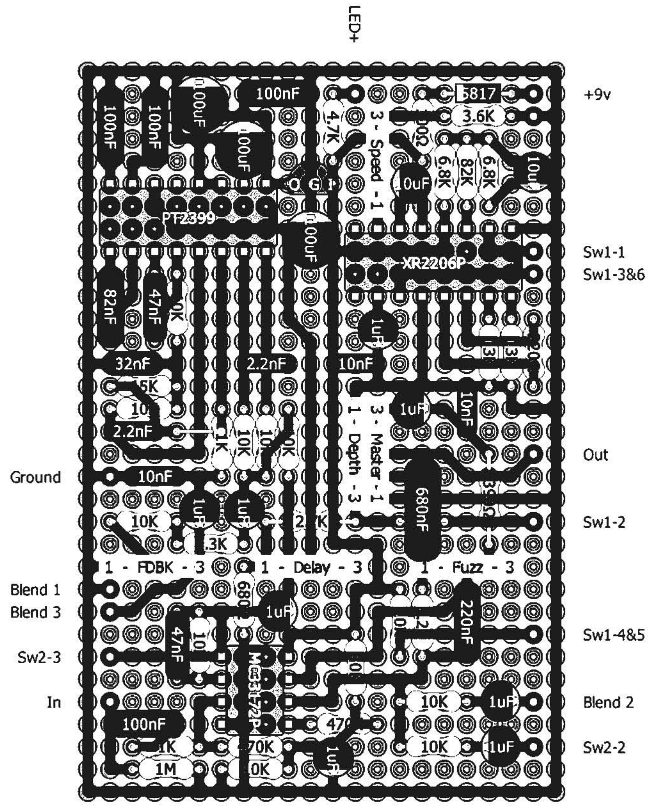

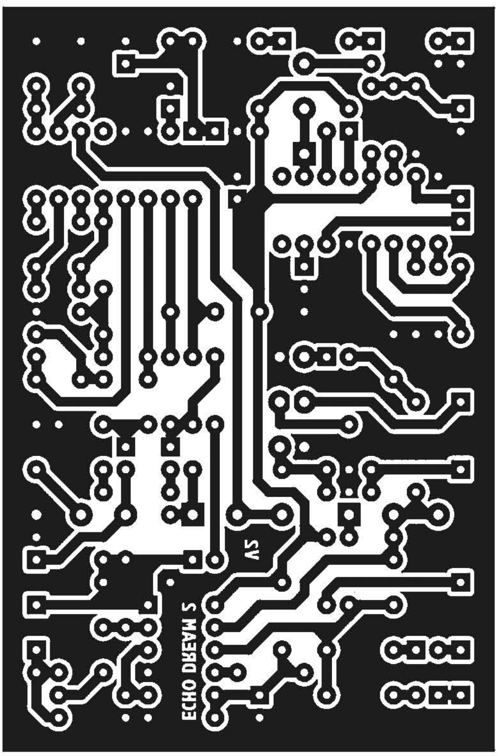

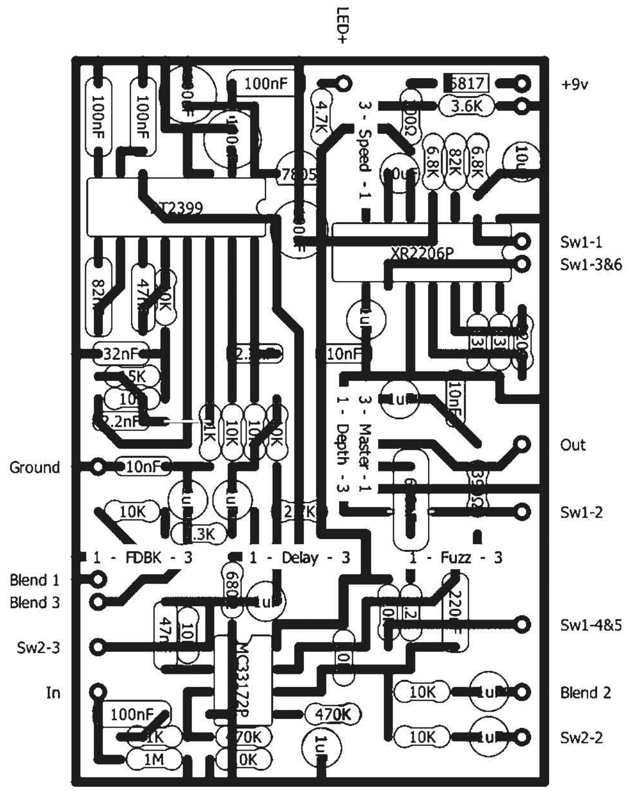

layout by storyboardist

FUTUR MUSIQUE #3

contents:

These pages contain practical and theoretical texts about the construction of various musical instruments. They are reprinted from websites and books. Some texts are shortened, because this zine can only have so many pages. On the last page you will find a bibliography of source material.

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de Fanfare voor Vooruitstrevende Volksmuziek in 2020
50 copies made
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3 Harmonica-related Digital Musical Instruments

We employ the term "Harmonica-related Digital Musical Instruments" to describe a set of digital musical instruments designed to resemble the acoustic harmonica because of the ways the musician uses to interact with it in a standard performance situation. These instruments take advantage of the performance repertoire of experienced harmonica players, so that the musician can use his/her own existing knowledge and motor skills and apply it to the electronic instrument. Therefore, the learning curve is less steep, and a higher musical expression can be achieved in a smaller amount of time.
Digital musical instruments (DMIs) are defined as musical instruments whose sound generation is carried out by a computer and controlled by a gestural controller or control surface, where the physical interaction takes place (Wanderley and Depalle 2004; Miranda and Wanderley 2006).

It is rare for a DMI to incorporate the rich interaction possibilities and feedback modalities of an acoustic counterpart. Most acoustic instruments have been developed and refined over centuries, which is why they cannot be directly compared to DMI prototypes. Furthermore, a DMI is not generally developed to replace the acoustic counterpart, but rather to add or extrapolate certain features, while others may become absent. This distinction is especially important since many people have false expectations about the capabilities of a DMI, either thinking of it as a pure limitation or a toy, or expecting science fiction. Even their expectations of a DMI's sound may be biased, perhaps since the advent of popular synthpop music in the 1970s.

The diatonic harmonica is a perfect candidate for augmentation, as well as instrument-like or instrument-inspired design. The instrument has unique interaction characteristics and playing techniques, but also many limitations that could be overcome with a DMI design. The diatonic harmonica is arguably the best-selling instrument in the world, which indicates that there must be a great community of harmonica players who could possibly be interested in a DMI design based on their instrument.

Although the acoustic harmonica is a huge commercial success, harmonica-related electronic instruments are not. None of the reviewed materials about the instruments have suggested that they were sold to the mass market. Two recent developments failed in an attempt to crowd fund the production of the instrument (DiCesare 2012; Read 2012), and many devices invented earlier are no longer produced.

In the following section, we will present a review of harmonica-related DMIs. Many different design decisions were made, such as mounting the blow hole on a slide versus having multiple blow holes, adding buttons to the instrument body, etc. With a better understanding of the interaction, we can adapt design principles, and thus significantly improve the acceptance of harmonica-like controllers in the community of harmonica expert performers.

The main sources of information were chosen to be patents, as they offer great insight to thoroughly developed ideas and ensure the originality of the presented device. As many developers do not seem to work within an academic institution, but intend to invent a commercial product, patents prove to be a richer source than academic publications.

Patent review

We reviewed a total of 17 patents claiming harmonica-related electronic instruments or related inventions. The time span of these patents reaches from 1949, when Ernest Robert Workman claimed the first design of an actual electronic harmonica, to 2013, when Wayne Read claimed the invention of the XHarp. The dates refer to the issue of the patent.

The patents were investigated for information about the layout and use of different sensors on the device, descriptions of the musical gestures associated with it, as well as feature extrapolations and other design-relevant information.
If additional information about the devices was found, e.g., in manuals or through personal communication with the developer, it has been indicated with a reference.
Patent claims are often very broad and do not tell us anything about the actual manufacturing of the device. It is not known how many of the harmonica-related DMIs were

actually produced commercially.

The depicted schemata were adapted from the patents.

3.1 Controller types

Harmonica-related digital musical instruments must be distinguished from electric harmonicas. Electric instruments amplify the acoustic signal of the instrument, whereas digital musical instruments produce computer-generated sound. Harmonica-related electronic instruments do not have any reeds that could produce sound directly, but rely on a sensor acquisition system that measures the musician's gestures. The input signals are then mapped to the synthesized sound.

Augmented musical instruments are real acoustic musical instruments, which have been modified by adding sensors that capture originally uncaptured musical gestures or physical properties of the instruments. While leaving the original sound production of the instrument intact, computer-generated sound is either additionally produced, or the instrument's sound is modified through a computer (Miranda and Wanderley 2006).
Sometimes, however, the distinction between augmented and electric musical instruments is not easy to make. There are border cases where the only dimension measured is almost identical to the resulting acoustic signal. One example would be the *Turboharp* developed by Antaki (2001), which implements an optical sensing technique to determine the vibration frequency of the reeds.

3.2 Musical gestures

3.2.1 Excitation gestures

An excitation gesture describes a gesture that is needed to generate the sound output of a DMI. It is the gesture, that "provides the energy that will eventually be present in the perceived phenomena" (Cadoz and Wanderley 2000). In the case of harmonica-related DMI, this is inherently blowing air into and/or drawing air out from one or more air channels.
In terms of the sophistication of the excitation gesture measurement technique, it can be differentiated between mere triggering based on a threshold or physical interaction, and continuous measuring allowing for control over the amplitude envelope of the sound output.

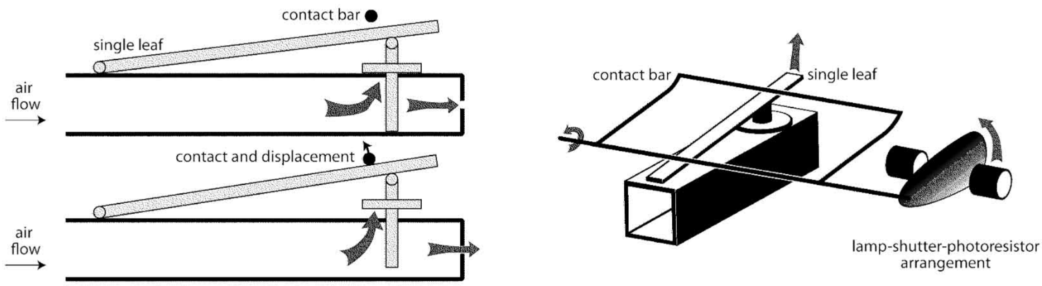
Seven patents were found to describe a device that is only capable of triggering a tone by establishing an electrical contact in a tone generation circuit. Twelve patents described a device capable of sensing air pressure continuously, so that the sensor signal can be used to modulate the resulting tone and create an amplitude envelope.
Two devices provided both a discrete note trigger by electrical contact, as well as a means of measuring air pressure (Hillairet, Lecadre, and Wallace 1970; Mölders 1980).

Workman (1949) proposed the design of a device with five air channels, containing a flexible metal bar projection bent with the air flow of blowing into or drawing from the respective hole of the instrument. This action brings it into electrical contact with a brush or terminal, establishing a closed circuit for sound production.
In a second proposition, Workman employs a permanently magnetised metallic ball held between two metallic tubes serving as contacts. Air pressure moves the ball to either one side or the other, bringing it into electrical contact.

Wilken (1965) proposed a design containing an air channel with a double cone attached in the centre by means of elastic rubber bands. The double cone, though not further specified, would move with the air flow in either the blowing or drawing direction, and be brought into contact with an electrical switch that turns on a tone generator.

Hillairet, Lecadre, and Wallace (1970) proposed a design, where a vertically-placed piston is driven upwards to displace a leaf mounted on the air channel. This leaf establishes a contact with a hinged bar situated above the air channel and across all air channels. The bar acts as a resistor, which makes it possible to infer the position of the contact point by measuring the voltage across a voltage divider, similarly to the functionality of a linear potentiometer. The downside to this measurement technique is that only the nearest piston contact of the hinged bar's anode side will be measured, as the circuit is closed with this contact. Any other contacts will not be recognized, which makes the instrument monophonic.

In order to give control not only over whether or not a tone is produced, but also over the amplitude envelope of the tone, the contact bar is hinged and can be rotated. After contact of the piston with the bar is established, the piston lifts up the bar, which results in rotational movement. A shutter plate displaying a transparent to opaque gradient is



(a) A graphic of the air channel profile.

(b) A graphic of the mechanism used to measure breath intensity.

Fig. 3.1 – The mechanism to measure air pressure and note position as presented in Hillairet, Lecadre, and Wallace (1970).

mounted at the hinge of the bar. A lamp and photo-resistor pair on either side of the shutter generate an analogue signal according to the transparency of the shutter plate. As the hinged bar is rotated, the shutter rotates along with it, swivelling the plate in front of the lamp and photo-resistor pair, and changing the resulting sensor signal.

French inventor Robert (1982) presented the *Clavier Electromechanique à Vent*; a device which enables the user to play an organ or piano by the use of a harmonica-like controller. The organ's keys are struck by the means of electromagnets each turned on or off by a mechanism in the controller's air channels. Inside each air channel, a piston is held in a neutral position by two springs. As the piston is pierced at its centre, it can be displaced by applying either positive or negative air pressure, i.e., blowing and drawing respectively. The piston comes into physical contact with two metal leaves, which closes an electrical circuit and turns on the electromagnet.

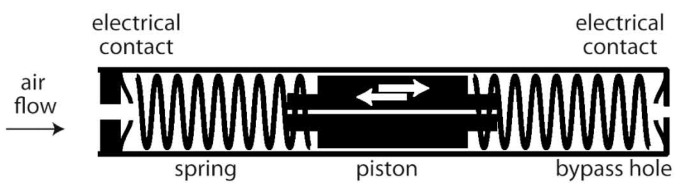


Fig. 3.2 – A simplified schematic of the air channel profile as presented in Robert (1982).

Arai (1984) propsed a design involving an elastic component that would be deformed with the air pressure inside the air channel. The elastic component is attached to the leaf of an industry-standard contact switch. Given a certain deformation, the contact is interrupted and a note onset is indicated. This solution improves the durability of the device by separating the electrical circuit from the air channel, protecting it from humidity.

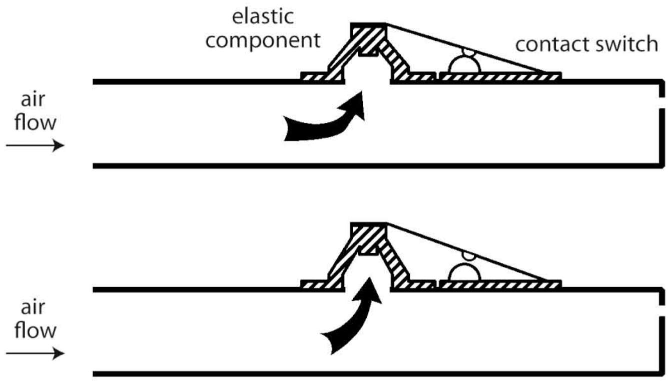


Fig. 3.3 – A simplified schematic of the air channel profile as presented in Arai (1984), embodiment alternative 1.

Kondo (1997) later proposed a similar measurement technique. It involves an elastic component whose deformation does not actuate a switch, but is measured with a displacement measurement system.

Matsuzaki (1986) proposed an air channel sensor design involving an inclined elastic member with a magnet attached. The elastic member is bent by the force of the air flow, reducing the distance between the attached magnet and an electrical switch on the exterior of the air channel.
Matsuzaki (1986) is a development based on Arai (1984). Both inventions were affiliated with Casio Computer Co., Ltd. They both take advantage of elastic members to detect a threshold of air pressure. However, the original air channel layout of the acoustic harmonica cannot be maintained, as there is no way of including a mechanism for measuring both positive and negative air pressure in a single air channel. Therefore, both have proposed an air channel layout that introduces alternating blow and draw channels.

Ziegler (1989) invented the *Elektronische Mundaharmonika (EMH)*, which uses a differential air pressure sensor (0 to ±70 mBar) to measure the pressure that results from the air flow through the air channel. Differential air pressure sensors actually measure the deformation of a diaphragm inside the sensor housing, which separates the air channel's air from the surrounding atmosphere's air. The pressure difference can therefore be positive or

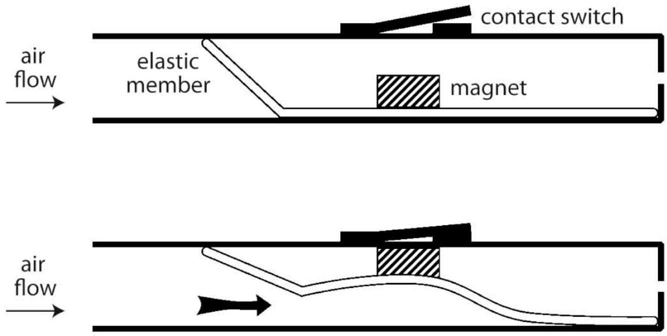


Fig. 3.4 – A graphic of the air channel profile as presented in Matsuzaki (1986).

negative, depending on the direction of the diaphragm's displacement. As the back opening of the air channel is relatively small in size, positive pressure is built up when blown and negative pressure is built up when air is drawn. The measurement setup is capable of distinguishing between both directions of air flow and the amount of pressure applied.
Similar to this air channel measurement setup, Whalen, Luther, and DiCesare (2011) and Read and Hebert (2013) have described their respective inventions *Jamboxx* and *XHarp* to make use of a differential air pressure sensor.

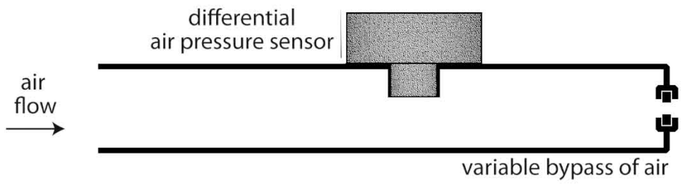
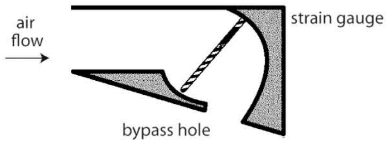


Fig. 3.5 – A graphic of the air channel profile as presented in Ziegler (1989).

Mölders (1980) proposed a *Mundharmonika* (ger.: mouth harmonica) that makes use of strain gauges to measure the air flow direction and pressure. A strain gauge is bond to a material strip in each air channel, which is bent in either direction when blowing into or drawing air from the hole. Using a Wheatstone bridge circuit, the resistance change caused by the deformation of the gauge can be measured. The resistance decreases with compression and increases with tension, so that both air flow directions can be distinguished. The amount of resistance change is then mapped to the amplitude of the sound.
Schille (1991) proposed an air channel sensing system design involving a strain gauge mounted perpendicular to the air stream inside the air channel. Similarly to the mea-

suring technique used in Mölders (1980), the air stream bends the strain gauge in one direction or the other, resulting in a resistance change that can be measured.



(a) A graphic of the air channel profile as presented in Mölders (1980).

(b) A graphic of the air channel profile as presented in Schille (1991).

Fig. 3.6 – Air channel sensor system designs involving strain gauges.

Wheaton (1993) employs two solid state pressure sensors mounted on the top inner side of the air channel, angled 45° to either direction of air flow. Solid-state pressure sensors do not have any moving parts, as a result of the application of piezo-resistive semiconductor technology. As the two sensors are mounted triangularly in opposite directions, blowing and drawing can be distinguished while the intensity of the air stream can be determined. As an additional excitation gesture sensor, Wheaton uses a microphone to pick up singing, humming, or other sound input, although he does not specify where it is to be found on the device.

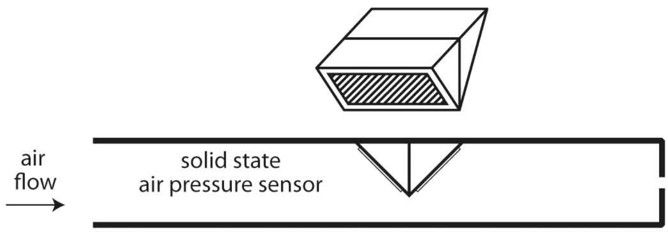


Fig. 3.7 – A graphic of the air channel profile as presented in Wheaton (1993).

There exist several other sensors capable of measuring air pressure and flow direction, which could be considered in the air channel sensor system design. Da Silva, Wanderley, and Scavone (2005) outlines the pros and cons of hot wire sensors and pressure sensors such as a Pitot tube for an application in the design of musical instruments.

3.2.1.1 Continuous control over signal amplitude

With respect to the control over the signal amplitude, two types of instrument interaction measurement could be determined:

1. **Simplified control**: The musician only has discrete control over note onset and offset (cf. Matsuzaki (1986) in Fig. 3.4).

2. **Complex control**: The musician has discrete control over note onset and offset and continuous control over amplitude of the sound. This can be made possible by

   - **Sensor-enabled complex control**: both note onset and control over amplitude are measured (cf. Hillairet, Lecadre, and Wallace (1970) in Fig. 3.1a)
   - **Hardware or software enabled mixed control**: a pressure sensor signal is gated by setting a threshold value in hardware or software (cf. *Millioniser* by Blobel, Muller, and Studer (1983) in Fig. 3.9b)

Arai (1984) claimed one embodiment of the invention as having control over the amplitude across all air channels. Therefore, both blowing and drawing air channels are connected and merged into a single airway (refer to Fig. 3.8). At its end, a pressure sensor is mounted in front of the opening to the atmospheric air.
The pressure sensor consists of a magnet and a surrounding coil. The magnet inside the coil is displaced with the air flow. This induces an electrical current into the coil, which can be measured, transformed, and mapped to the amplitude of the sound.
This approach simplifies the design and lowers the production cost of the device. However, without a proper closing of the individual air channels, air can flow out of the other holes, diminishing the effect of the air pressure on the pressure sensor. Given the particular design by Arai (1984) with alternating blow and draw air channels, closing is probably difficult to achieve.

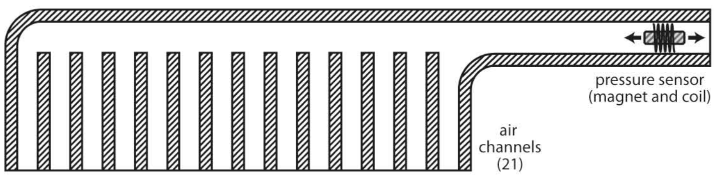


Fig. 3.8 – Arai (1984) proposed air pressure measurements across all air channels. The pressure sensor makes use of the electromotor force released by magnet displacement inside a coil.

3.2.1.2 Air flow resistance

Many inventors considered the implementation of an air flow resistance. The acoustic harmonica naturally provides a resistance to the air flow due to the inertia of the reed plates, so that the performer needs to make a certain effort to excite the system and produce a sound. Excitation effort is useful in two ways: on the one hand, an excitation gesture can the creation of computer music: “Form as pure freedom is empty: it has no motive. Effort is consciousness of our struggles with the matter of music, music without matter can not sound.”(Ryan 1992)

Ziegler (1989) introduced a system to limit the air flow manually by sliding a pierced bar whose holes can overlap the air channel openings, so that the hole diameter for each channel changes, depending on the position of the bar.

Blobel, Muller, and Studer (1983) described the air flow through the mouth piece of the device later called *Millioniser 2000* as being screw-adjustable (see Fig. 3.9b on page 31).

3.2.2 Selection gestures

Selection gestures are gestures used to change a setting or mode, or a note that is to be played. For example, a selection gesture on a keyboard would be to choose another sound, e.g., a harpsichord sound preset. Pressing a keyboard key also inherits a selection gesture, because the finger moves to a position so as to select a certain note. Then, pressing the key is an excitation gesture as well, as it produces sound output.

The same occurs when an acoustic harmonica is played. The note is selected by moving the mouth over to the corresponding air channel or channels and forming an embouchure. Then the air stream can be formed to excite the system and produce a sound.

3.2.2.1 Note selection

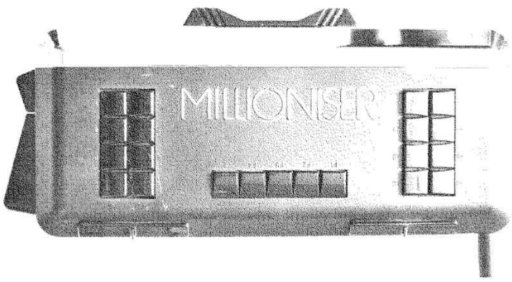
With harmonica-related DMIs, there are two types of devices with different approaches to the selection of notes. One approach is to provide a number of separate air channels, arranged just like those of an acoustic harmonica. The advantage of this is that harmonica players intuitively recognize the function of the channels, and can also jump to another note just like on an acoustic harmonica.

This is only true if the notes are accessible in the same way as on an acoustic harmonica. Several devices show an alternative note arrangement intrinsic to their design or the chosen tuning (cf. sec. 3.5 “Tunings”). If the air channel measurement setup is only able to measure the air pressure in one direction of the air flow, blowing and drawing gestures cannot be applied to the same hole and the note arrangement needs to be changed. Arai (1984), Matsuzaki (1986), and Li and Li (1990) propose a note selection arrangement of alternating blowing and drawing holes.

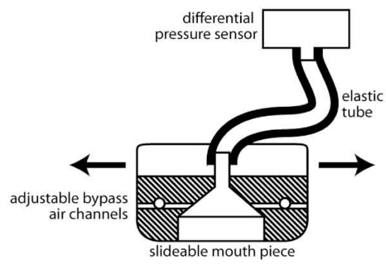
The other approach to note selection is to provide a mouth piece mounted on a slider. Sliding the mouth piece to a different position selects the note played when air is blown into or drawn from the mouth piece. One advantage of this approach is the lower cost of manufacturing the device, as it only needs one air channel measurement system as opposed to multiple separate measuring systems. Another advantage is the fact that the number of selectable notes can be chosen arbitrarily (if the slider's sensing resolution is continuous).

Thus, the device can emulate the note arrangement of, for example, a 10-hole diatonic harmonica as well as a 14-hole chromatic harmonica.
The arbitrariness of the number of selectable notes can also be seen as a disadvantage to this approach. The player has no visual, intuitive cue of where the notes are situated. Repeatability is an important key to the learnability of a DMI (Wanderley and Orio 2002). If the same gesture does not lead to the same resulting sound, the performer cannot adapt to the instrument or learn to play it. Therefore, one school of thought in DMI design advocates for the use of more fixed mappings over very loose and often changing ones (Cook 2001)[1](Hunt and Wanderley 2002).

Furthermore, performers rely only on proprioception and ego-location, not on tactile cues, in order to slide to the desired note's position.



(a) A photo of the *Millioniser 2000*, an example of a slide-based harmonica-related DMI.



(b) A schematic of the slideable mouthpiece.

Fig. 3.9 – The *Millioniser 2000*, a device presented in Blobel, Muller, and Studer (1983).

Developers have put much thought into these shortcomings, and proposed different solutions. Blobel, Muller, and Studer (1983) employ a sliding mechanism allowing the performer to feel bumps when sliding the mouth piece. The bumps are caused by equidistant notches, which add friction to the sliding head. This direct tactile feedback may help with the task of selecting the right note, but diminishes the advantage of an arbitrarily selectable note number if the desired number of notes are not the least common denominator of the number of bumps.
Whalen, Luther, and DiCesare (2011) accounted for this problem by employing a continuous slider, and attaching a replaceable strip of bumps right underneath the actual slider, so that the bumps can be felt by the lower lip (Jamboxx Music 2014a). Several bump strips with different spacings are provided with the instrument.

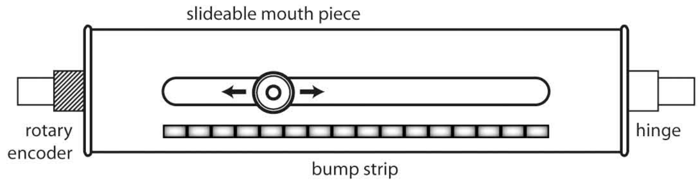


Fig. 3.10 – A schematic of the *Jamboxx* (Whalen, Luther, and DiCesare 2011).

Ziegler (1989) described a function of his *Elektronische Mundharmonika (EMH)* as transposing the harmonica base key during or in between performances. The leftmost and rightmost air channels are not used for excitation gestures, but serve as a sensor for a selection gesture.
By blowing a short air blast into the hole, the entire note arrangement is transposed either upwards or downwards. These air channels do not have a bypass opening for air to pass through, so air pressure quickly builds up in the channel when blown and enhances the gesture recognition. They also have a greater spacing from the adjacent air channels, so as to avoid being accidentally mistaken for sound generating air channels.

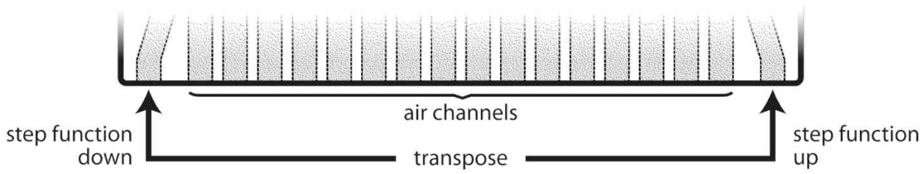


Fig. 3.17 – A schematic drawing showing the transpose function of the harmonica-related DMI as presented in Ziegler (1989).

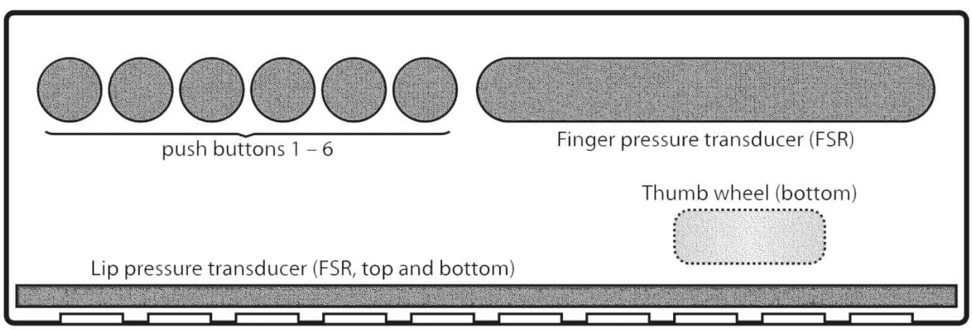


Fig. 3.18 – A schematic drawing showing the top side of the harmonica-related DMI as presented in Wheaton (1993).

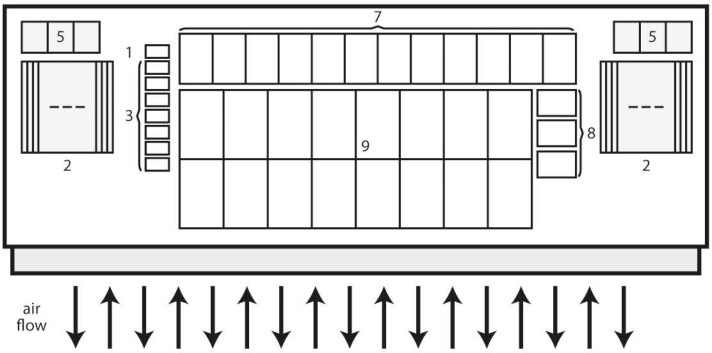


Fig. 3.14 – A top view schematic of the *electronic harmonica* by Arai (1984), second embodiment alternative. **1** on/off power switch **2** integrated piezo loud speakers **3** sound selection **5** chord mode switch **7** chord tonic keytone selector **8** effect switches (e.g., tremolo) **9** solar cell panel.

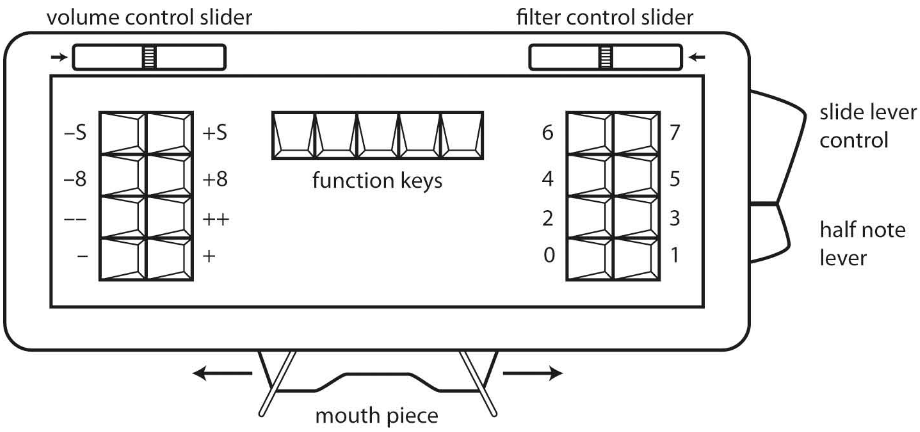


Fig. 3.12 – A top view schematic of the *Millioniser 2000*, showing the layout of the various buttons and switches (Blobel, Muller, and Studer 1983).

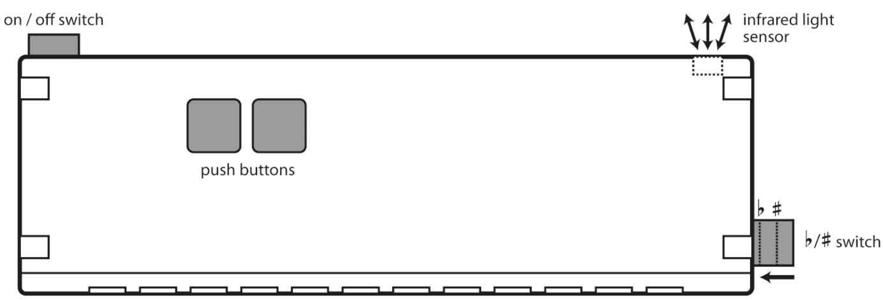
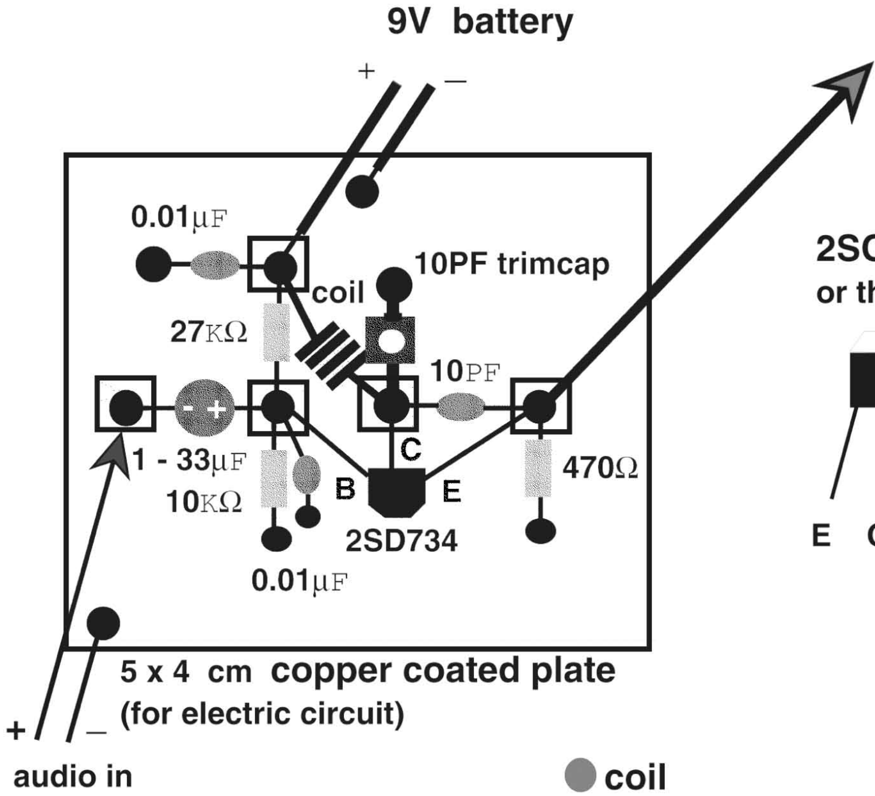
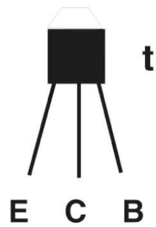


Fig. 3.20 – A schematic drawing showing the top surface of the *Electronic Chromatic Harmonica (ECH)* as presented in Schille (1991).

Making the simplest FM Transmitter



2SC2001, 2SD734
or the compatible



- **coil**

  4 turns by 0.8 mm enameled wire

- **How to solder:**
  Solder every part
  at the shortest distance.

● **: direct to the ground**

: insulated from
the ground by a
small square of the
plate (5 x 5 mm)

- **registers**

  470 Ω (yellow-violet-brown)
  10K Ω (brown-black-orange)
  27K Ω (red-violet-orange)

- **capacitors**

  10 PF
  0.01 µF (103)
  1 - 33 µF

- **trimcap 10PF**

more info.: http://anarchy.translocal.jp/radio/micro/howtotx.html

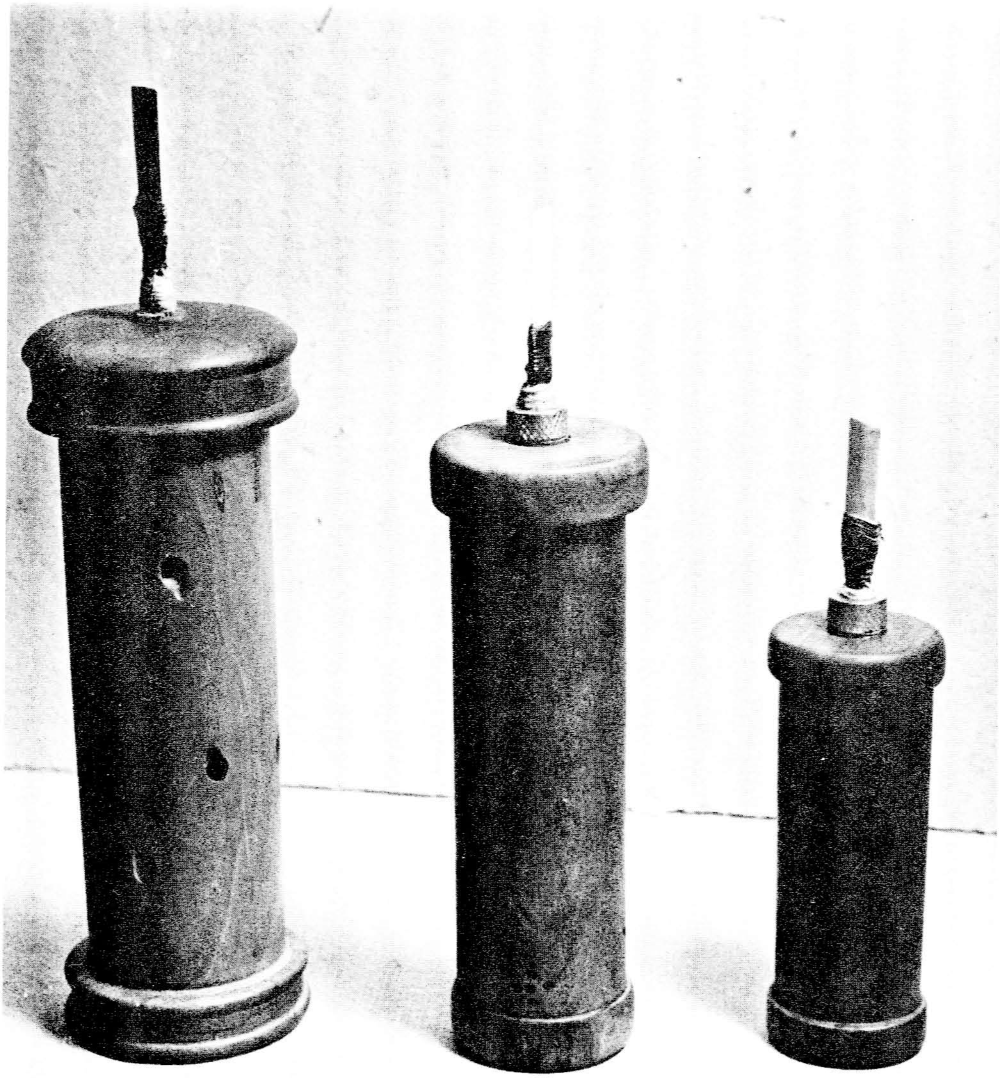


FIGURE 26. A family of racketts.

8 Racketts

The racketts or sausage bassoons were a family of instruments introduced late in the sixteenth century and already superseded by bassoons at the end of the seventeenth century. The concept of achieving a long-bored, bass instrument by interconnecting several short tubes within a single block of wood is theoretically sound, and being able to carry in one's pocket an instrument that will descend as low in pitch as a modern bassoon is still a very attractive idea. What doomed the rackett was probably not so much its quiet sound that blends well with recorders and krumhorns but rather its intractable fingering pattern. Some racketts had as many as sixteen holes to be controlled so that some holes were covered by the palms of the hands and the middle joints of the fingers. The sequence of uncovering holes to produce a scale appears from the outside of the instrument to follow a random pattern and, worse, is not the same from member to member of the rackett family. The family as described by Praetorius consisted of four sizes: cant, tenor-alto, bass, and great bass. The two instruments for which dimensions are given here (table 8.1) correspond roughly to the cant and tenor-alto, although in the interests of simplicity the number of finger holes has been reduced so that their ranges are not so wide as those in the racketts described by Praetorius. The cant covers the range from F to g and the tenor-alto from C to e, while Praetorius' instruments had a range of a twelfth.

Since the bores are all cylindrical and relatively short, they can be made with the drill press by laying out the work carefully and drilling from both ends; or the boring can be done in the lathe with a shell auger if a four-jaw chuck is used so that the piece can be set off-center to drill the six outside holes. When the bores have been made, the outside is turned down to be concentric with the center bore, and the interconnecting passages are chiseled away between the bores. The end caps are turned so that the bottom one fits tightly and the top one is easily removable. Before gluing on the bottom end cap, I like to glue a piece of stiff paper or cambric to the bottom with contact cement to make sure that no leaks between neighboring bores exist where they should not. The arrangement I have devised for fastening the top cap is, of course, not traditional, but it is important to have the top cap easily removable to permit evaporation of moisture after playing, and it is also essential to avoid the slightest trace of air leakage between bores. Other arrangements that I have seen or tried fail to satisfy both of these requirements. The $\frac{1}{8}$-in. brass pipe nipple is fastened to the center bore by cutting a thread in the wood with an ordinary pipe tap. The nut that screws down on the cap must be made by drilling, knurling, and tapping a short length of brass rod. The pad of soft leather that fits into the cap should be well greased and will then make a tight seal when the nut is tightened.

The diamond-shaped arrangement for the four holes at the end of the bore was common but not universal in these instruments. In the diagrams (fig. 27)* the finger holes are indicated where they enter the bore, but it is advisable to drill some of them at an angle to make them more easily reached.

The brass pipe nipple should be drilled out so that its bore is nearly that of the main bore and the top end should be reamed with a tapered reamer to give a better seat for the reed staple. The reed is made of plastic in the same way as described for krumhorns (chap. 7). For the smaller rackett a reed of the same size as that for the tenor krumhorn may be used. For the tenor-alto it could be slightly larger.

*fig. 27 is to be found in the centerfold of this magazine

TABLE 8.1
Rackett Hole Dimensions

See figure 27 for hole locations.

Cant		Tenor-Alto	
Hole Designation	Diameter (mm.)	Hole Designation	Diameter (mm.)
G	2.0	E	2.5
F-sharp	2.0	D	2.5
F	2.0	C	2.5
E	3.0	B	2.5
D	2.5	A	2.0
C	2.0	G	2.0
B	2.0	F-sharp	2.0
A	2.0	F	2.0
G	2.0	E	1.5
F (4 holes)	2.0	D	2.0
		C (5 holes)	2.0

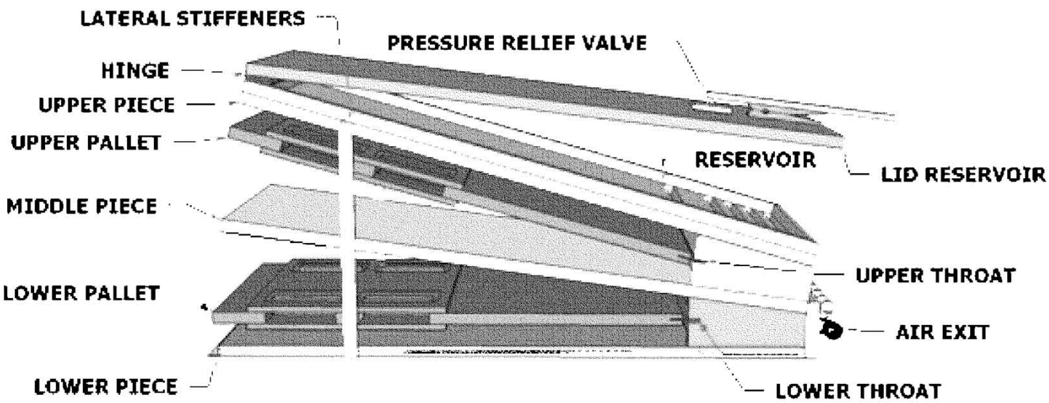
5 – 1 – DEVICE PRESENTATION

The blower is the lung of the instrument and it is probably with the valves unit, one of the most delicate parts to achieve.

On its design, and its good construction depends the correct volume of air needed to make the flutes sing. Asthmatic blower would not produce enough air to feed flutes particularly if many of them would be forced to sing together.

Initially, the organ builder Robert HOPP had the idea of such a blower with superimposed bellows accompanied by a reservoir. Pierre PENARD was inspired in its buildings, and Jean-Pierre COSSARD has made the plans.

In our turn, we made this sketch showing in detail the different parts :



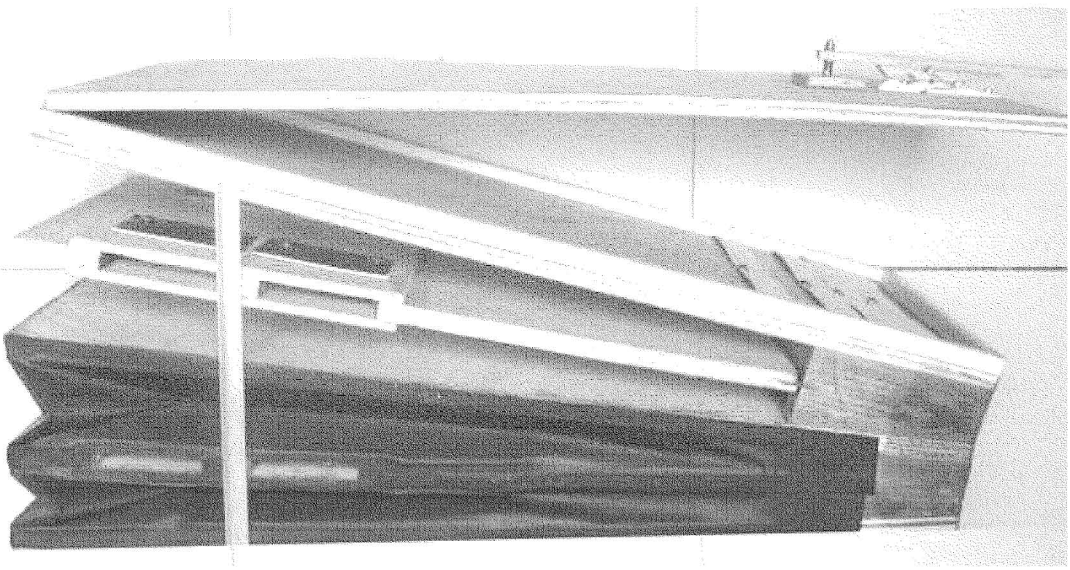


Photo of the blower half lined with skins (this allows you to see inside)

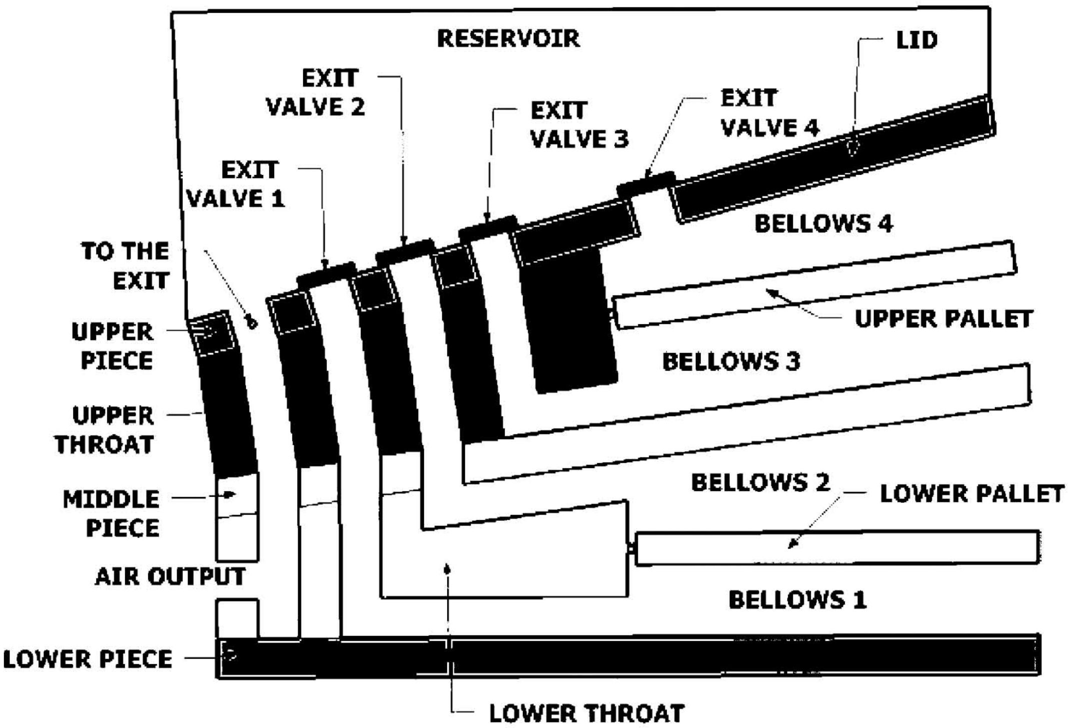
5 - 2 – WORKING PRINCIPLE

Before proceeding to the construction, it is helpful to understand the working principle.

This is the same as the bellows used to fan the flames of fire, except that our blower produces more air because it does not have only one volume of production but four.

The air enters through the 8 air intake on the lower and upper pallets. Then we used two blocks of wood called the "throats" whose various machining will serve to channel the different airflow.

Here is a sketch intended to explain the flow of air.



Through two throats, the air produced in the bellows is raised in the reservoir on the top of the blower.

The air is temporarily stored in the reservoir and leaves as air requirements needed to make the flutes sing.

The pressure is kept constant in the reservoir with a spring which pulls the lid down.

Unable to go down via the same path due to the presence of 4 valves, air has only one exit door downwards to the plastic tubes that will lead to the valves unit.

Air pressure must be constant.

The flow rate is obtained by using 4 bellows which operate two by two in turn.

Their movement is out of phase by 180 ° with a crankshaft, which is itself driven by a crank.

This set of bellows 4 is called the blower. Pressure, which we know the necessary level, is measured quite easily. We shall see later !

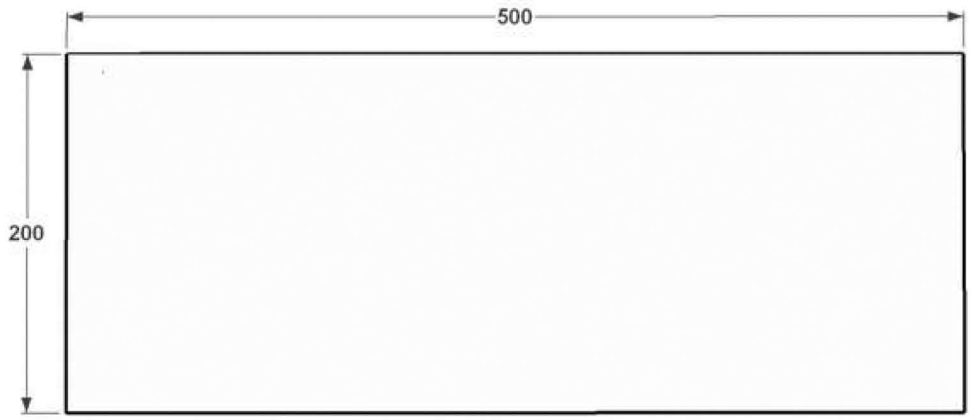
In the following lines, the blower will be fully described from the bottom to the top.

During manufacturing the blower, you must always remember caring assemblages and collages to eliminate any risk of air leaks. Besides the fact that they are sometimes difficult to locate, they are also often difficult to seal.

5 - 3 – THE BOTTOM PIECE (only for organ n° 1)

This piece is the basis for the entire blower.

It takes a piece of plywood 500 x 200 mm thickness 10 mm.



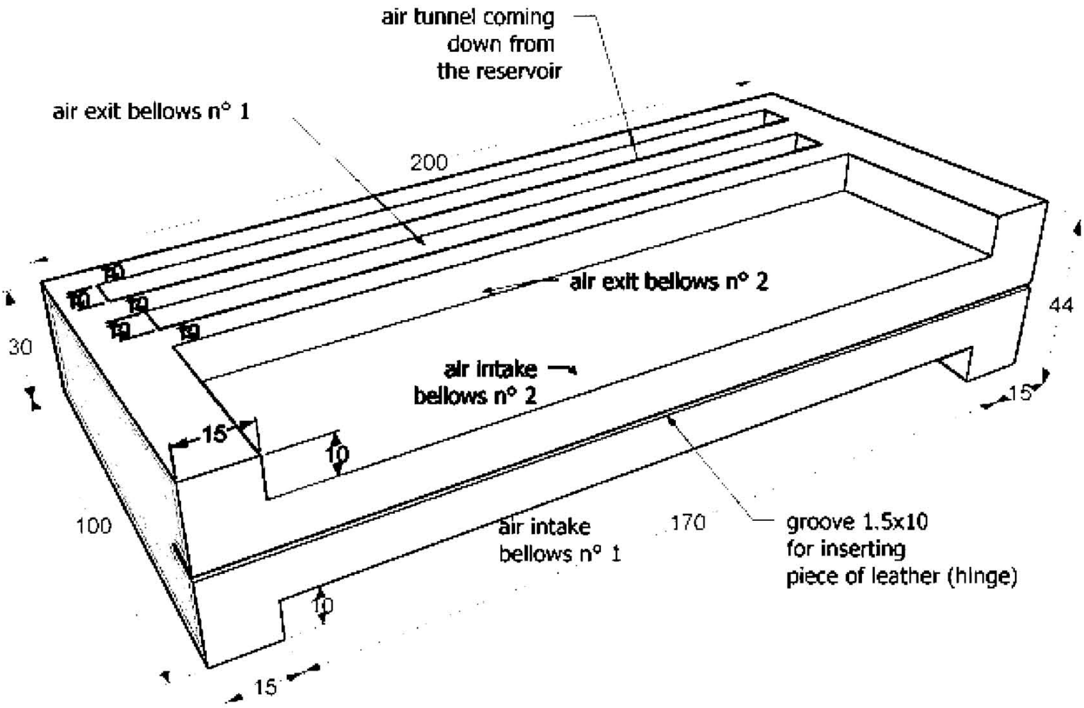
Very complex sketch of the bottom piece

5 - 4 – THE LOWER THROAT

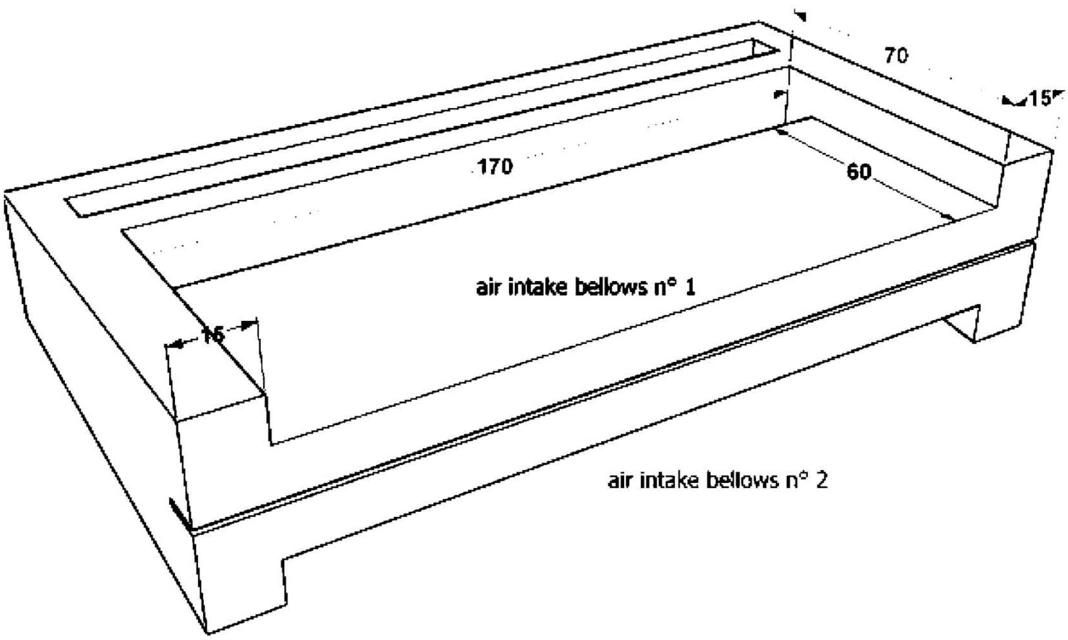
This is the name of the piece of wood which is used to lead air from the 2 lower bellows to the reservoir. Machining also allows to go down all the air from the reservoir to the valves unit. An oak block will be perfect.

Certainly with a milling machine or a router, it is easier to do than with wood chisel (provided you know how to use the machine).

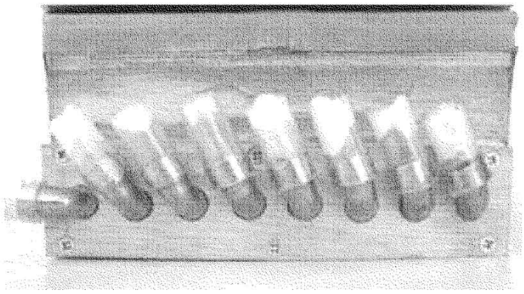
Note that machining on our sketches were drawn at right angles but in reality, they are made with rounded angles which is simpler.



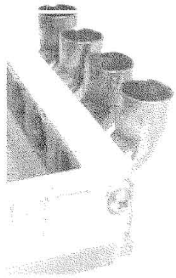
Sketch of the lower throat - top view



Sketch of the lower throat - view from below

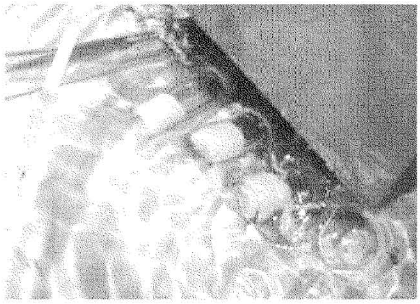


Air outlet at the rear of the blower
(on the lower throat).



Air inlet on both other sides
of the valves unit

Wanting to keep the possibility of dismantling the set, we had forcibly inserted plastic tubes **in the copper elbows**. This solution unfortunately **fails to air leak test.**



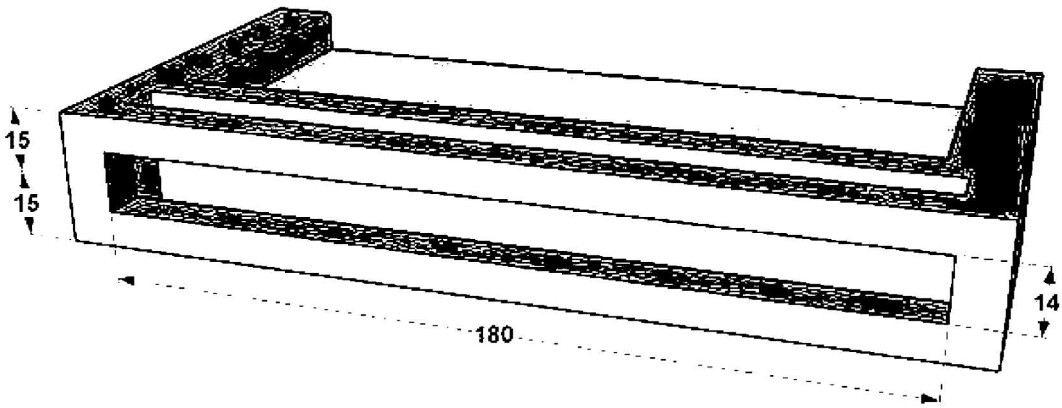
To confirm where air leaks were located, we dived vertically the rear of the valves unit in a container filled with water.

In fact, all we were able to make, it is a machine to bubble.

That's good, but it's not really the goal.

"Good solution" is still to dispose of copper elbows on the blower and the valves unit, but instead of inserting plastic tubes in the copper elbows, plastics pipes must be put **around the copper elbows.**

For now, let's just make a rectangular aperture at the back of the lower throat.



By doing this, do not force like a crazy guy on the drill, because there is a risk of going through the inner wall of the throat.

We will see at the end of this chapter, how secure connections for connecting plastic pipes.

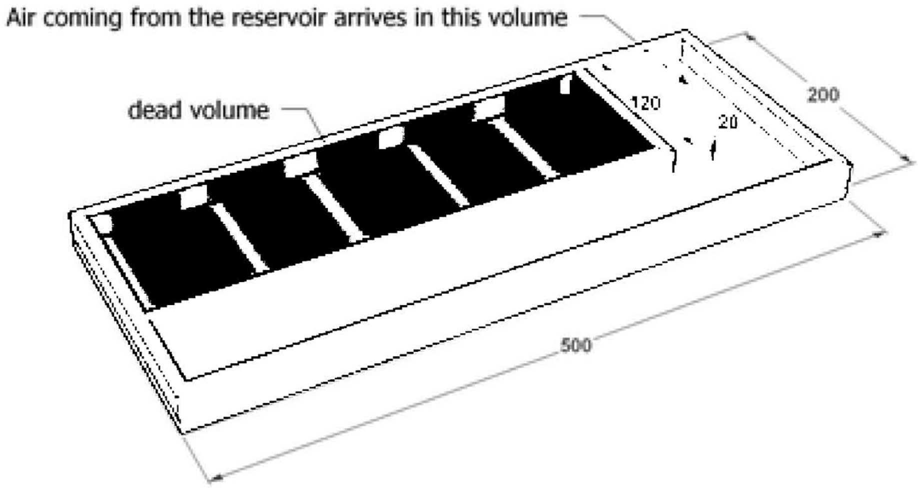
For organ n° 2, we have put under the blower an air tunnel with a "death" volume to avoid excessive air consumption, so we get rapid inflation of the reservoir at startup .

The bottom piece of the air tunnel is plywood of 10 mm and measuring 500 x 200 mm (same as bottom piece of the organ n° 1)

The cleats for the perimeter and interior partitions are section 10x20 mm.

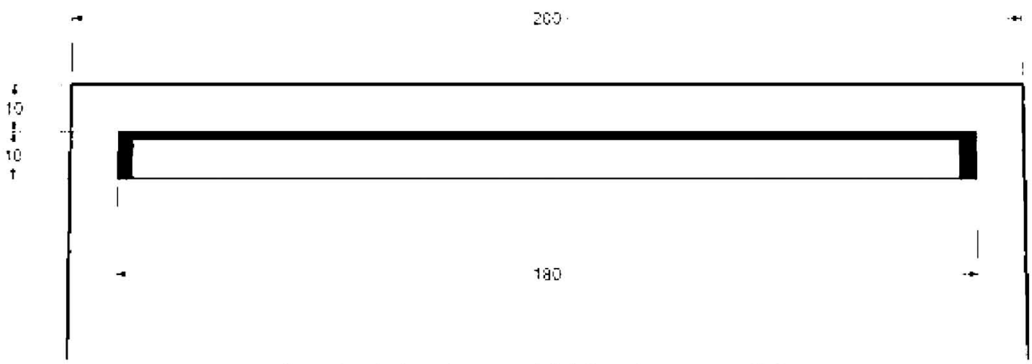
On one of the great cleats, there are 8 holes for the outputs to the valves unit.

During assembly, do not be stingy on vinyl adhesive to ensure perfect sealing of the cavity.



Sketch of the air tunnel for the organ n° 2

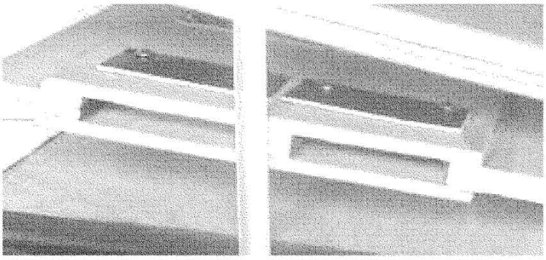
To allow air coming from the lower below to enter the air tunnel, you have to make a rectangular aperture 180 x 10 mm on the lower lid. The bottom piece is also used as the air tunnel lid.



Sketch of the air tunnel lid for the organ n° 2

5 - 6 – THE LOWER PALLET

It is a set of several pieces for producing an air compression. It takes two identical sets (lower pallet and upper pallet)

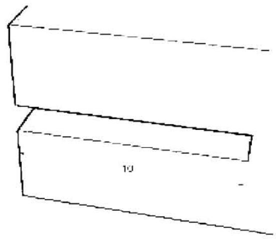


It takes a piece of plywood 400 x 200 mm thickness 10 mm for the pallet, and two pieces of plywood 165 x 200 mm, 5 mm thick, which are bonded to the pallet and that support the valves.

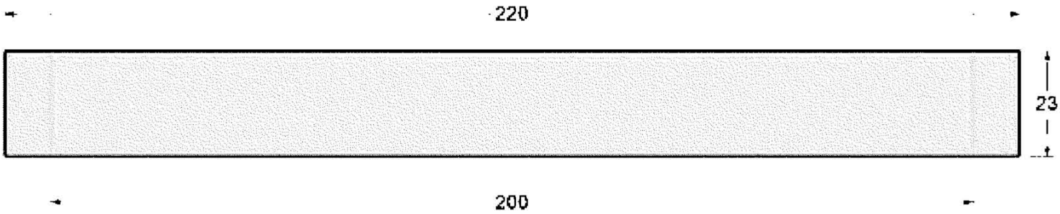
On the rear small edge of the pallet must be a groove to receive a leather strip acting as a hinge.

The depth of the groove is 10 mm.

The height of the groove must be slightly greater than the thickness of the leather strip to allow its easy insertion.



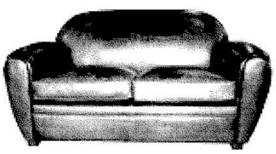
The hinge of the pallet is composed of a single strip of thick leather, of the order of 1.5 to 2 mm, the width is 23 mm (10 mm to fit into each groove + 1 gap of 3 mm between the pallet and the throat).



At first, the length of the strip is 220 mm. Then the strip is cut to the exact width of the pallet and the throat.

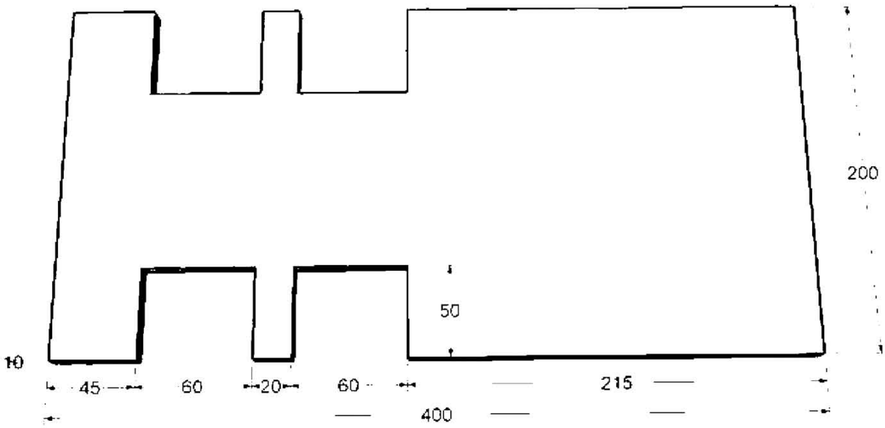
Before its introduction, the leather strip will be spread on both faces with vinyl glue.

When inserting leather strip in the pallet groove and the throat groove, you must ensure that an excess glue will not disturbed movement.



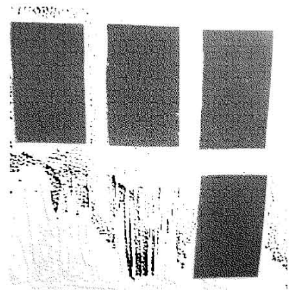
Where to find cheap leather : the easiest way is to go to salons dealers !

All year long they pollute your mailbox with their bogus invitations. This is the time to visit them ...



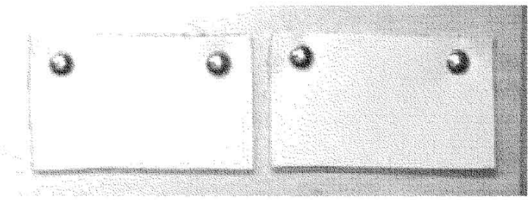
Sketch of the lower pallet

The internal valves must not leak. They consist of a small piece of leather 1 mm thick and 40x70 mm dimensions. which is bonded to the neoprene on a plastic film 2 / 10 thick.

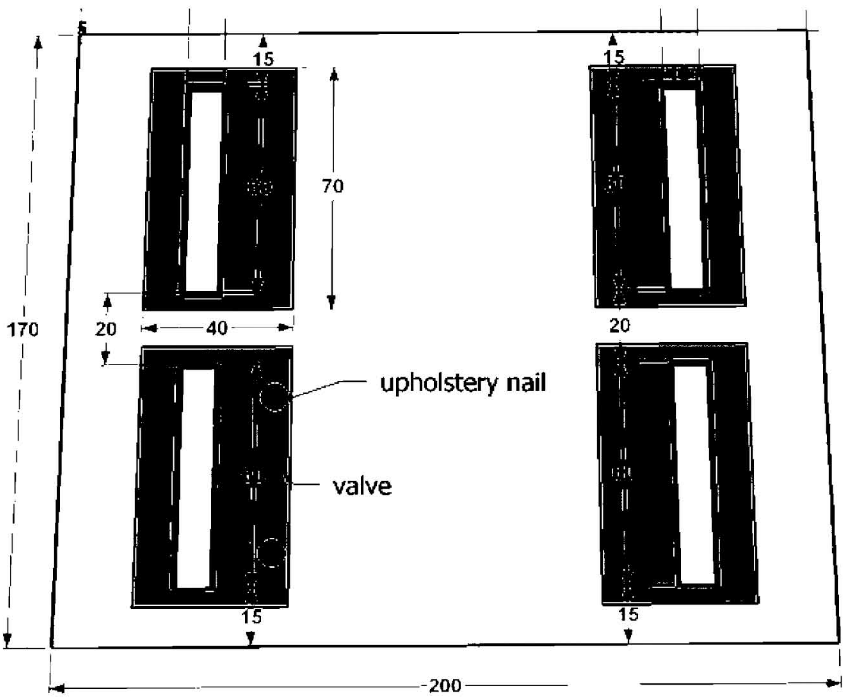


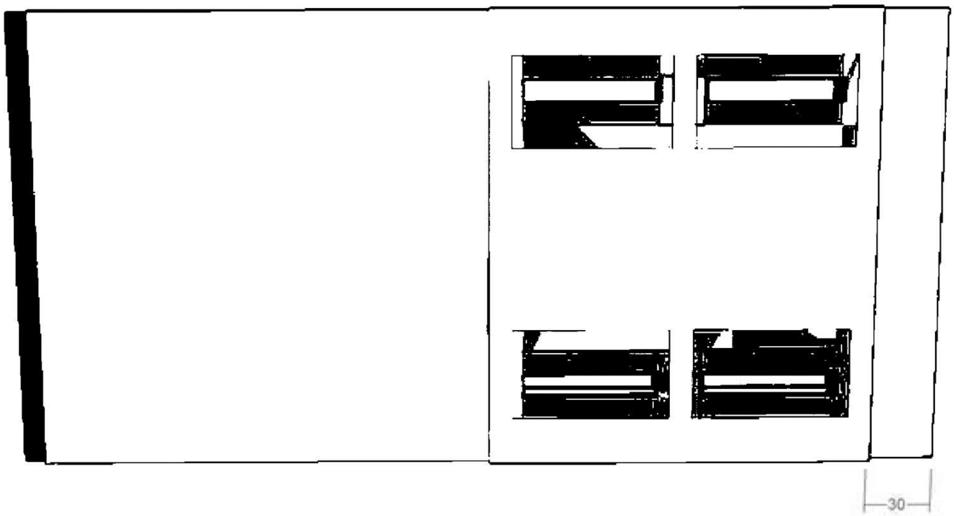
It is the smooth side of the leather which has to be glued against the plastic film and not the fluffy side. It will take 16 in all (8 for the lower pallet and 8 for the upper pallet)

Leather fluffy side must be faced the pallet. The assembly is secured by two upholstery nails.

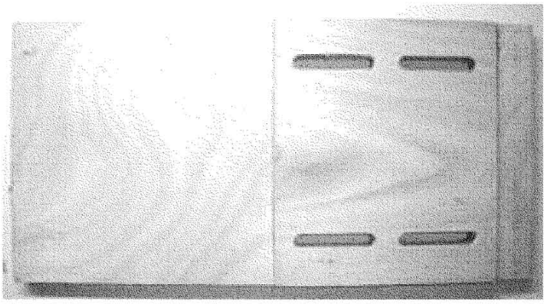


To prevent the valve from curling, beforehand it is advisable to make slightly bigger holes in the valves, with a big nail.

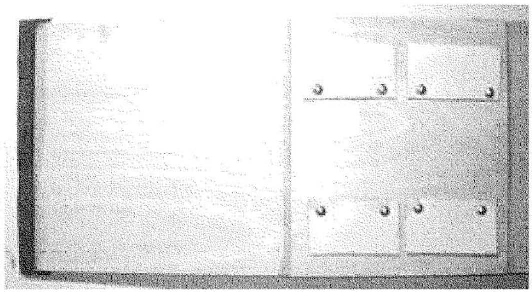




Sketch of complete lower pallet



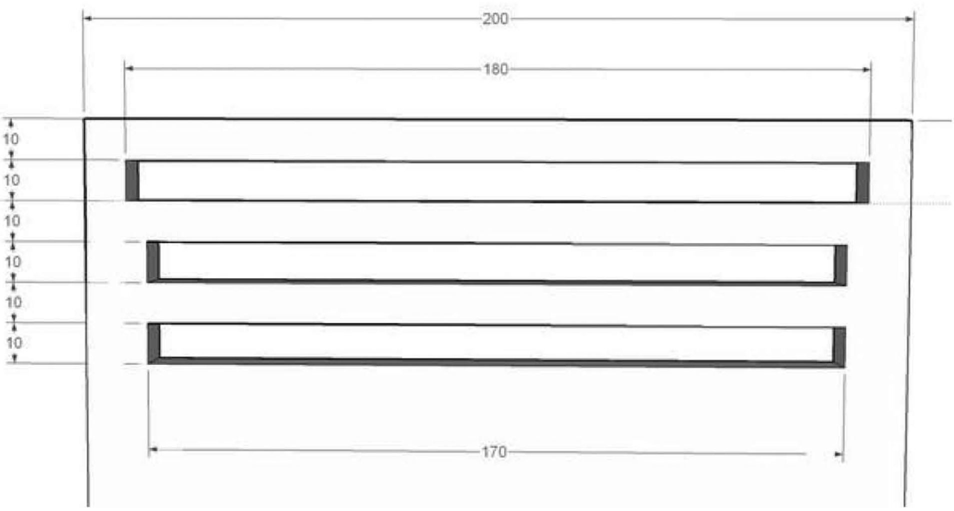
Lower pallet without valves



Lower pallet with valves

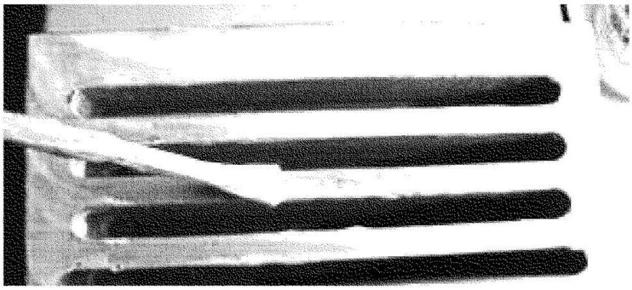
5 - 7 – THE MIDDLE PIECE

It takes a piece of plywood 500 x 200 mm thickness 10 mm. Three rectangular apertures of unequal size are formed.



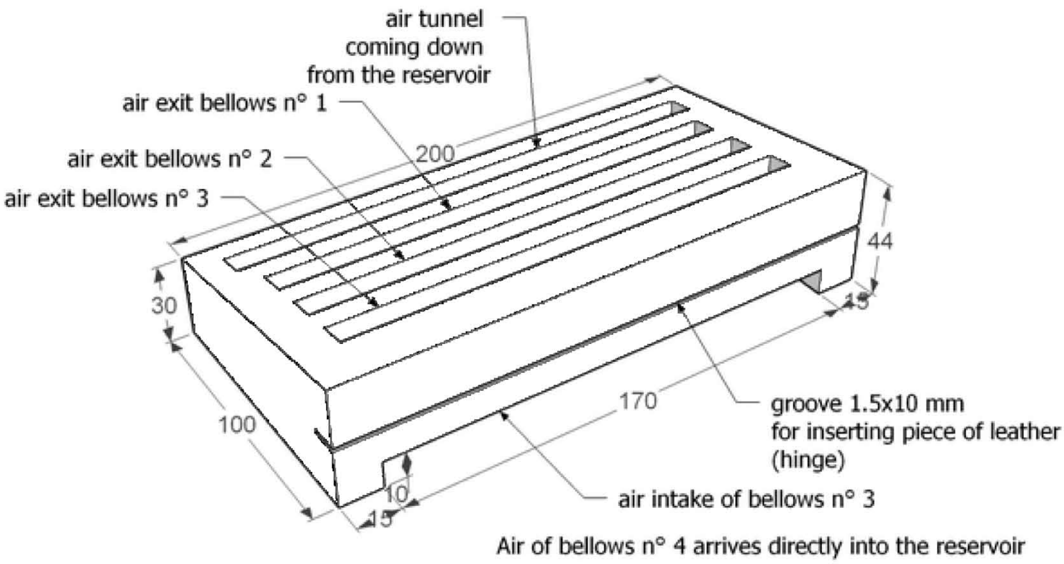
Sketch of the middle piece

As for the lower throat, all sides must be thoroughly coated with glue to prevent air leaks.

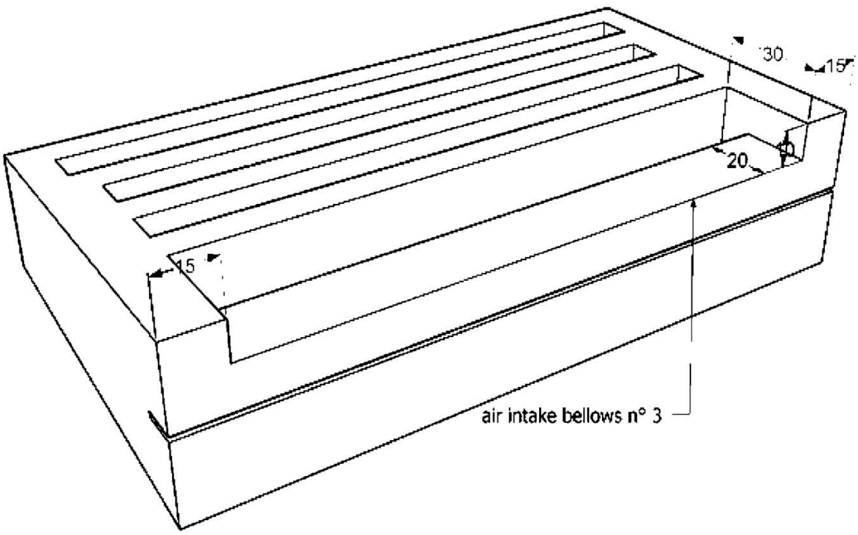


5 – 8 – THE UPPER THROAT

It allows to lead air from the two upper bellows to the reservoir. Machining also allows air to go down from the reservoir to the exit.



Sketch of the upper throat - top view



Sketch of the upper throat - bottom view

5 – 9 – THE UPPER PALLET

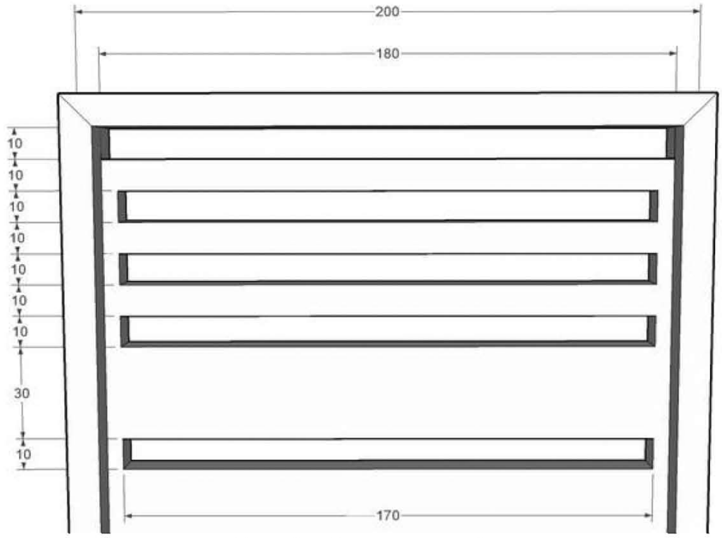
Exactly the same as the lower pallet - See description above.

5 - 10 – THE UPPER PIECE

This piece serves both as the lid of the upper below, and as the floor of the reservoir. It takes a piece of plywood 500 x 200 mm thickness 10 mm.

A small cleat 10x10 mm is positioned around the perimeter of the piece. The cleats avoid the reservoir lid to block valves when they have to be open.

Five unequal size apertures are realized. The four lights allow valves do not rub against the side cleats.

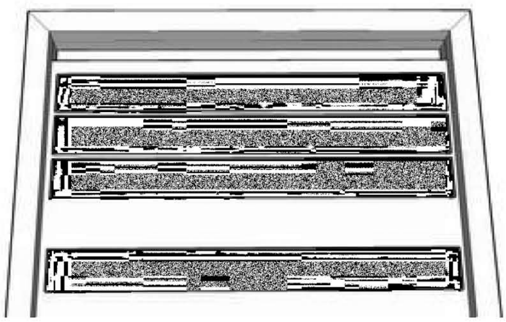


Sketch of the upper piece

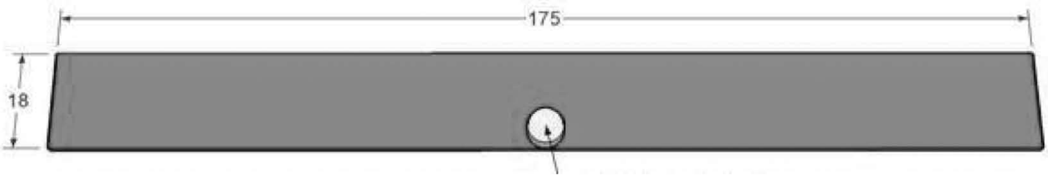
To prevent air from the reservoir to return where it came from, 4 valves must be positioned just above the apertures of the upper piece.

Do not put a valve on the aperture close to the upper border !

You have to guess the reason ...



As for the lower and upper pallets, these valves are a stack made of a 175x18 mm leather strip adhered to the neoprene on a plastic film 2 / 10 thick.



upholstery nail

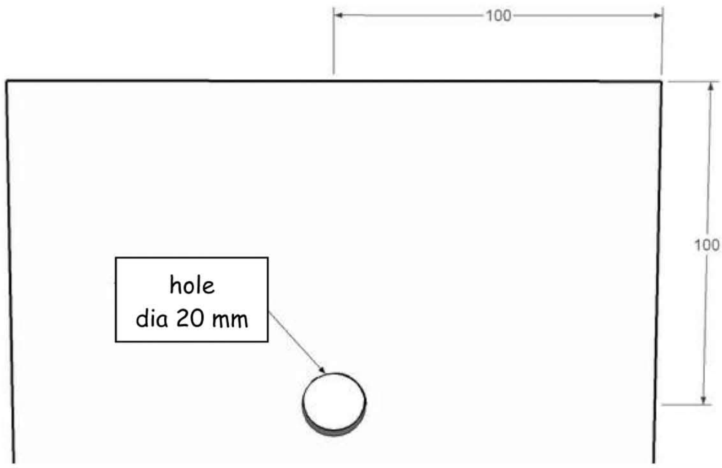
To allow good mobility of valves, just attach them with a single upholstery nail inserted into the middle of their great side.

Therefore, both external parties will easily lift.

5 - 11 – THE RESERVOIR LID

It closes the reservoir. The lid is pierced with a hole of 20 mm diameter which allows air to escape in case of deletion. The shutter mechanism will be described later.

It takes a piece of plywood 500 x 200 mm thickness 10 mm.

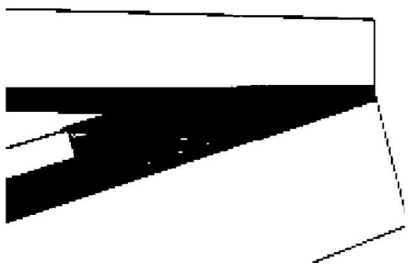


Sketch of the reservoir lid

This lid will be fixed to the upper piece with a leather strip acting as a hinge

The leather should be 1-2 mm thick.

Before gluing, let the leather strip folded on itself in a vice all night to mark folding.



5 - 12 – THE PRESSURE RELIEF VALVE

If the blower produces more air than consume flutes, the reservoir could explode.

Therefore you need to install a pressure relief valve like in a pressure cooker.

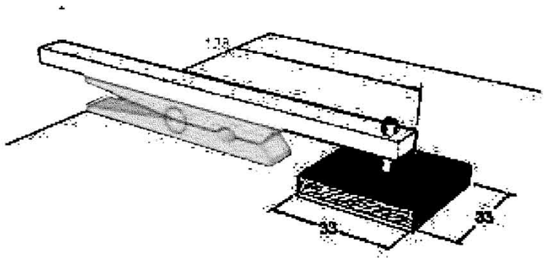
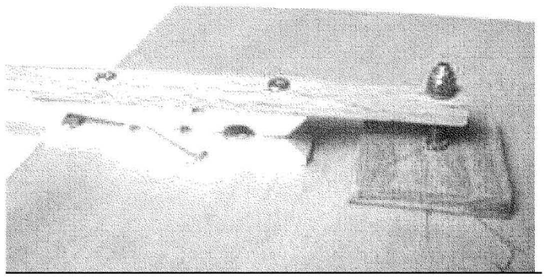
A spring mechanism controls the opening of a valve that is positioned just above the hole of 20 mm.

Instead of building this spring mechanism, we appealed to an existing object of great ingenuity, of formidable simplicity, and very cheap.

Timber clothespin meets these criteria. Simply screw on the reservoir lid, and screw a strip of wood on top that will make a lever.

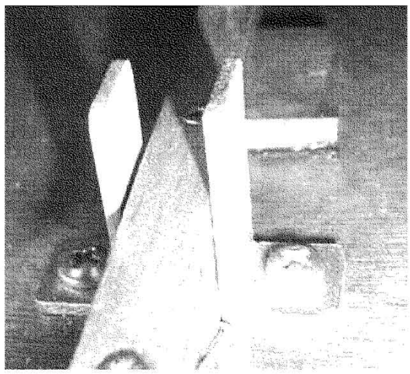
At the optimum position of the reservoir lid, the lever will come into abutment against a slat secured to the pillars which support the keyframe.

This valve consists of a beech wood plate cut in the falls of the flutes, and is lined by a thin layer of leather, also cut in the skin drops that will be used to fill the bellows.

Sketch and photo of the pressure relief valve

To prevent lateral displacement of the moving part, it is good to have two small lateral guides carved into a piece of aluminum.

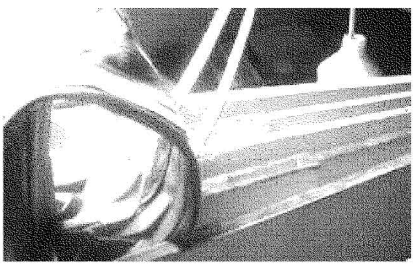


5 - 13 – BELLOWS LINING

This is where it gets a little hot !

Why ? The dimensions of the plywood parts are easy to determine, and it is quite rare to crash them during cutting. Even if it was the case, it is easy and not very expensive to repeat.

Regarding the leather is different. Due to the movements of the pallets (lower and upper), the leather pieces have variable geometry and you have to think before getting out the scissors.



Moreover, the price of skins is not the same as plywood.

If you fail to take precautions that follow, you expose yourself to having to repeat several times.

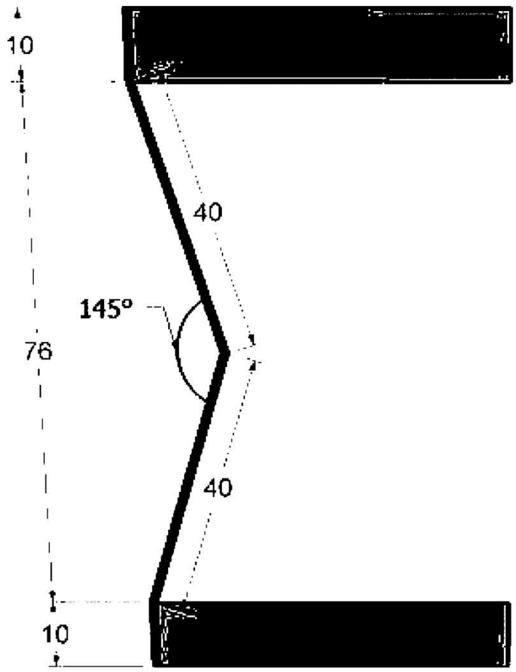
Souvenir photo ....

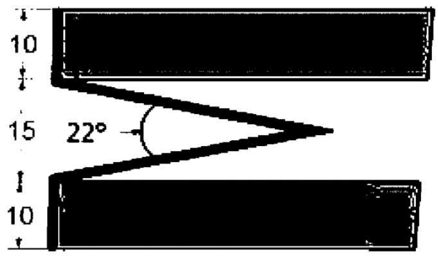
You have to line in the 4 bellows of the blower, but also the reservoir.

Let's start with the explanations for the bellows.

<u>Warning</u> : In open extreme position the skins must not be straight. It is necessary that the skin retains an angle of about 145 ° so that, when the pallet is moving, the skin "knows" where it should go, namely inwardly and not outwardly of the bellow.

See below the two angles formed by the skin of one bellow in the two end positions of the pallet.





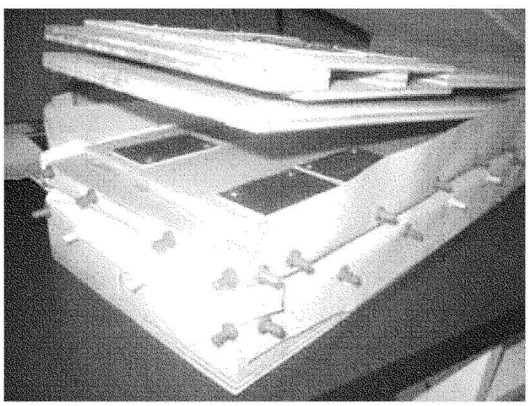
We reassure you ! There is no need extreme precision to the angle formed by the skin. The values shown above are there to give an order of magnitude.

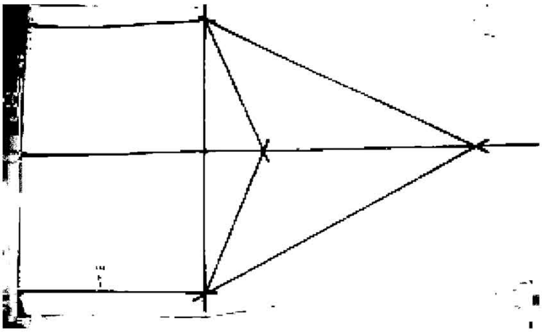
The above dimensions are those of bellows skin and not for the reservoir skin.

In fact before cutting into the skin, it must be tested by cutting a rigid pattern. Thick wallpaper is very suitable for this use.

Another important point : You must take into account the maximum deflection of the pallet according to your crankshaft .

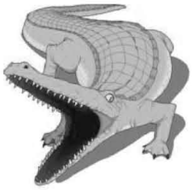
Before pinning up the pattern on the bellows you must insist on paper folds to make it fold where it should be.





Once the correct operation validated, mark with a pen clearly the folding lines.

This will be useful later to duplicate these lines on leather skins.



The crocodile skin is not recommended for blower manufacture.

It prefers the lamb : a thickness of 0.5 to 0.7 mm makes it very flexible.

The skin must be completely air-proof.

Of course the color does not matter. In our case, there are two colors due to two separate supplies due to a second command (after cutting error ....)

See on the Internet to find a skin provider

Estimate of the necessary surfaces :

- Bellows sides = 8 pieces of 100 mm x 600 mm
- Reservoir sides = 2 pieces of 160 mm x 600 mm

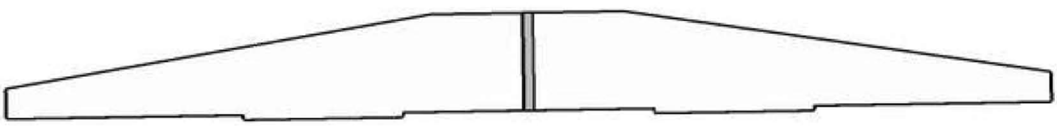
This should be a total area of about 0.60 square meter. Comprehensive lambskin is about 0.40 to 0.60 m^2 (depending on creature size)

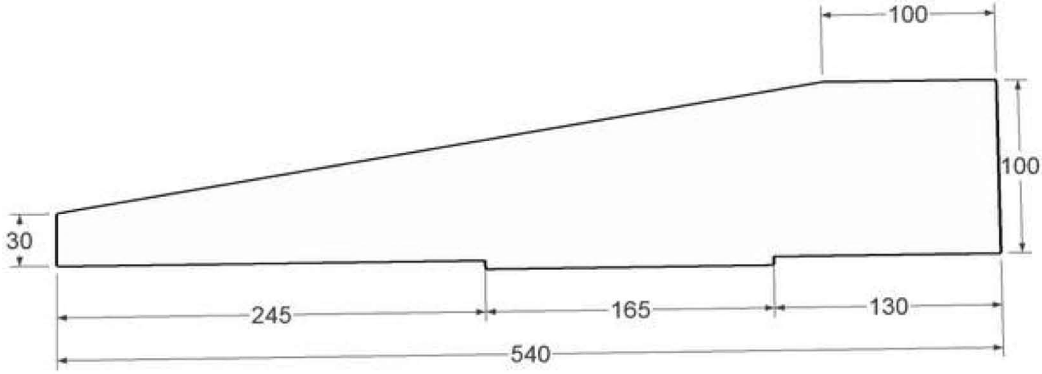
But beware : perfectly rectangular lambs are not numerous, so that the entire surface is not exploitable.

So you have to supply 2 skins.

On average, a lamb skin is about 1000 mm in its greatest length.

The maximum length required is of the order of 540 mm. It is therefore not possible to obtain a piece integrally. A bellow skin is actually made of two skins laid end to end, the joint will be covered by a skin strip of 10x100 mm.





Estimate of size skin to line one half bellow

Why we mention "estimate size". In fact, the actual dimensions of the skin are highly dependent on the accuracy (or lack precision) of your pallets.

Do not cut all the pieces once. It is recommended to cut just enough to line one bellow, and check before going further.

You will save time using a template to optimize cuts.

Knowing that there are 8 skins cutting, it is advisable to prune a template whose dimensions correspond exactly to the pattern.

A carton of 2 mm thick perfectly will do the trick.

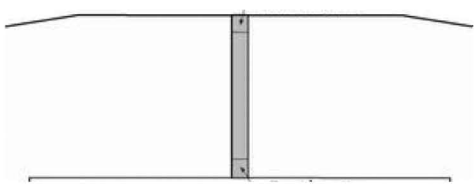
Skin has two faces : a fluffy face and a smooth face. For perfect adhesion to the pallets, the fluffy side must be glued. Vinyl glue (easy adhesive white wood) is fully indicated in this case.

Different skins will overlap on the edge of the pallet, and also at the connection end to end of two half skins.

It seems difficult to make a good collage between fluffy side of a skin and the smooth side of another skin. We tried different types of glue but when tearing a bit, none of them was good enough.

Here's a tip : before applying a skin on the other, it is necessary with emery cloth scratching the smooth side of the lower skin. Thus, one obtains two fluffy sides, and with vinyl glue it will become virtually inseparable.

For the end to end of the two ½ skins, skin of the strip has its fluffy side against the two halves glued-skins. Its smooth side will be applied to pallets.

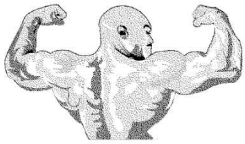


Orange areas are to be scraped

Considering what has been said above, it is advisable to scrape the two small areas of 1 cm at the ends of the strip for a perfect adhesion on wood.

During glue drying, you must apply strong pressure on the joints. Otherwise, this may cause leaks that are difficult to locate.

5 - 14 – BELLOWS STIFFENERS

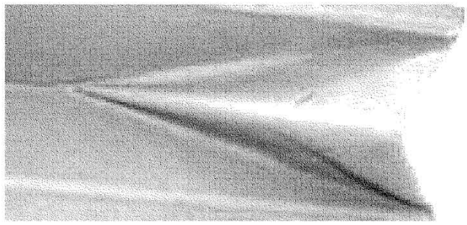


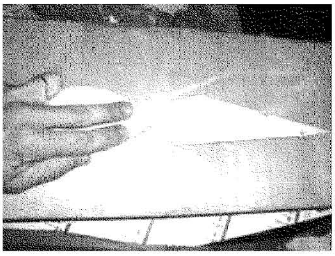
Before lining bellows, it is essential to strengthen the leather pieces.

To "tell" the skins to bend properly where it is needed, (inward the blower) it is necessary to double parts with reinforcements cardboard 1 mm thick. These pieces of cardboad are called "stiffeners"

The stiffeners are bonded to the inner faces of the skins and will therefore not be visible from the outside.

These internal reinforcements must be very firmly glued to vinyl glue (white glue for wood).

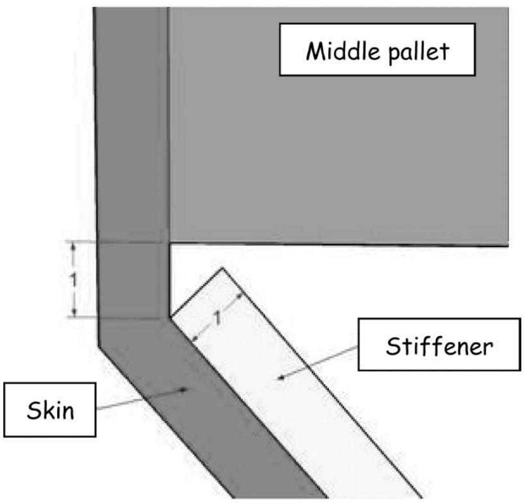




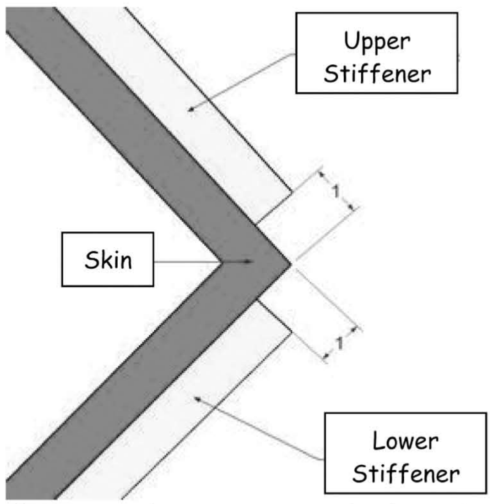
If you are using glossy cardboard, of the type used to print large calendars, finishing film will prevent the glue go deeply into the fibers of the cardboard.

You will have previously lightly sand the surface with sandpaper.

Otherwise, peeling of the stiffeners is very possible. We made the experience ....



The space between the outer edge of the stiffener and the pallet is of the order of 1 mm, which is equivalent to the thickness of the stiffener



The space between two side by side stiffeners is of the order of 2 millimeters.

To determine the dimensions of the stiffeners and their location, it is advisable to draw on skins lines bounding surfaces theoretically intended to receive the stiffeners.

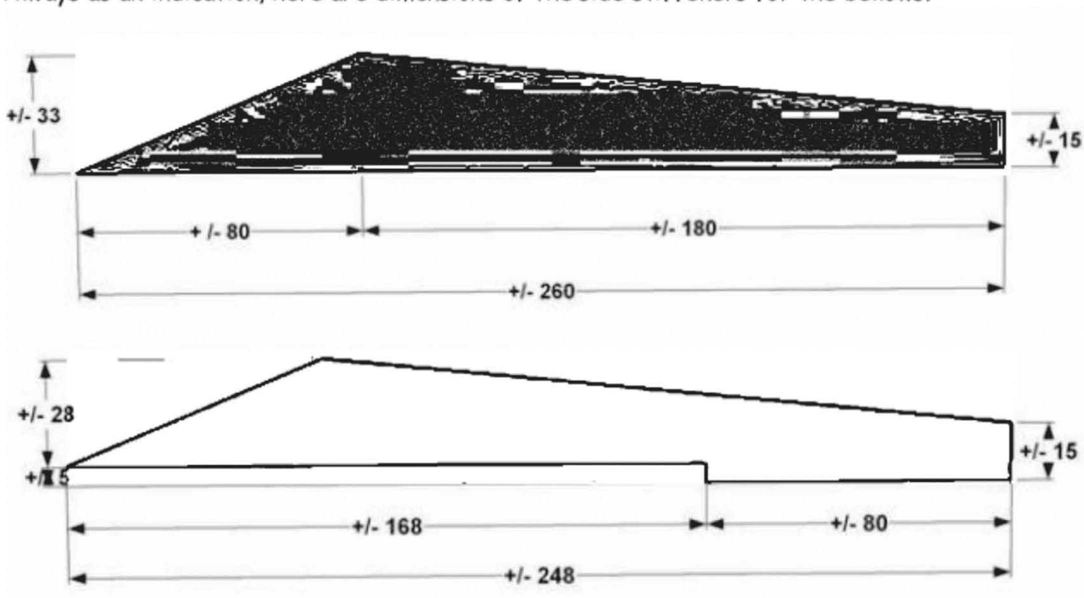
Then reserving a small margin of 1 to 2 mm.

When it folds and unfolds easily and properly, we are on the right way. It is then necessary cut all stiffeners with same dimensions (except those of the reservoir).

Here the positioning of the various stiffeners .Two of them cover the junction between the two leather strips connected end to end

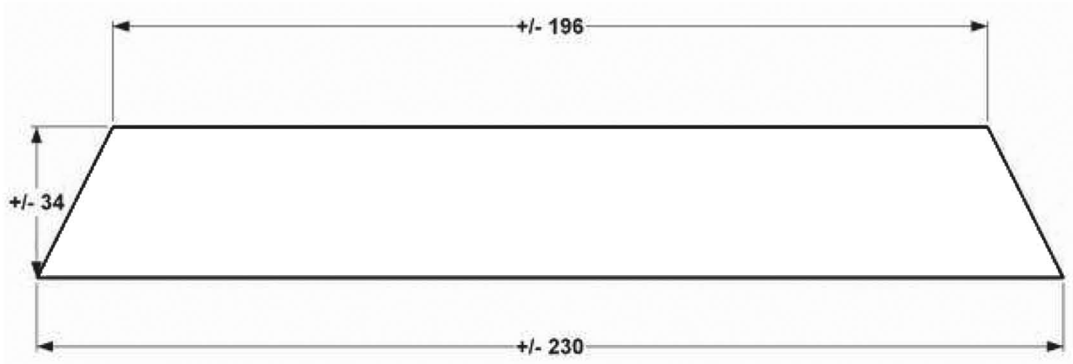
Once the 4 lateral sides and 2 front sides in place, there must exist two sectors not covered by stiffener. Above, they appear in red.

Always as an indication, here are dimensions of the side stiffeners for the bellows.



Sketch of lateral stiffeners for bellows

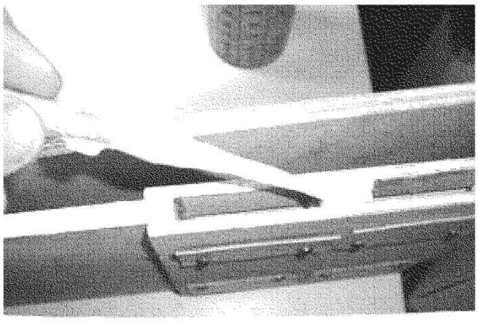
(there are two different cutouts to accommodate the extra thickness of the pallets where the valve holder are located)



Dimensions of the front stiffeners for the bellows.

Once stiffeners perfectly glued on skins, stick skins all over the bellows structure.

Do not make the operation at once : Take your time, sticking the skin on the front of the bellow and wait for drying before gluing the skin on the bellows sides.



Meticulous operation with left hand
(the right hand holds the camera ...)

Apply a weight on the skin during drying

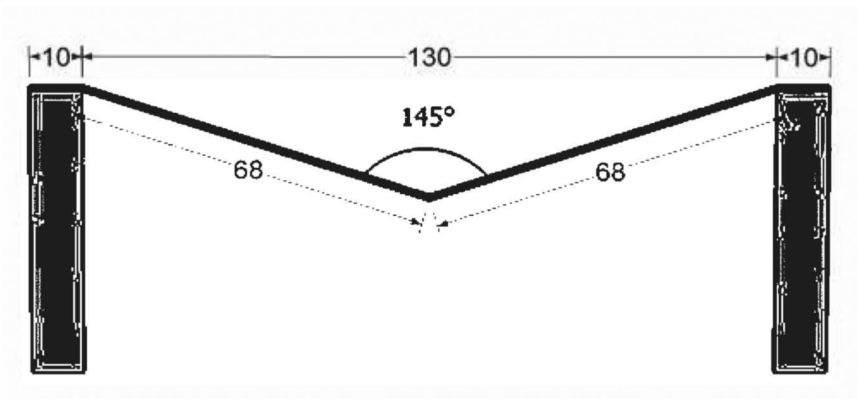
5 - 15 – RESERVOIR LINING

Everything that was explained for lining bellows remains valid for the reservoir, with the exception of dimensions that are slightly larger.

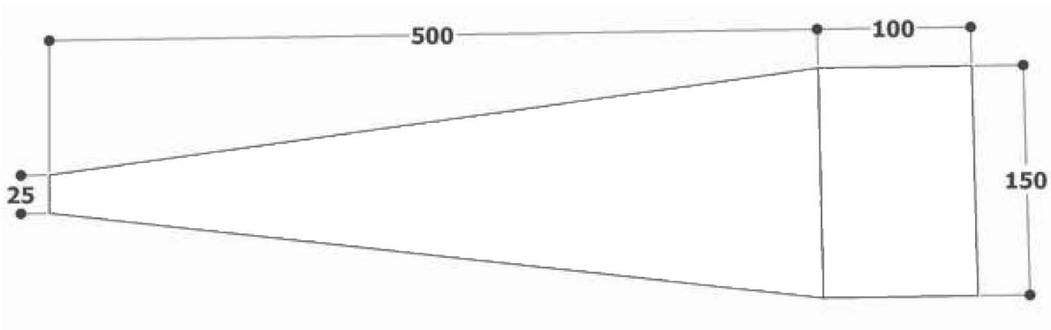
That is an estimate of the maximum skin :

10 + 68 + 68 + 10 = 156 mm.

rounded to 160 mm



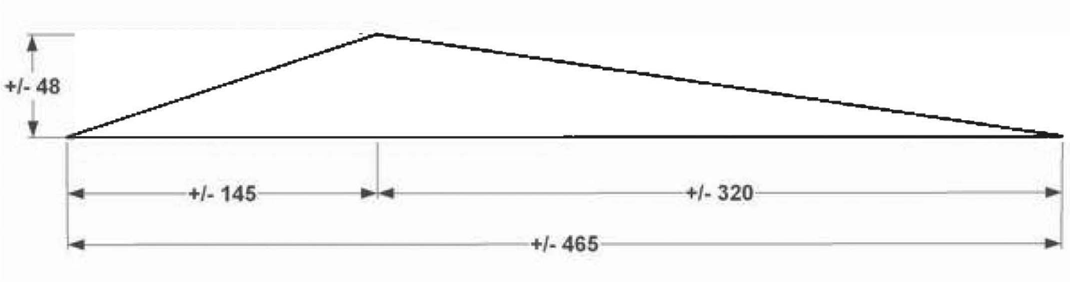
See below an estimate of skin size to line half of the reservoir.



5 - 16 – RESERVOIR STIFFENERS

If the stiffeners are indispensable for bellows, they are even more so for the reservoir where the pressure is stronger.

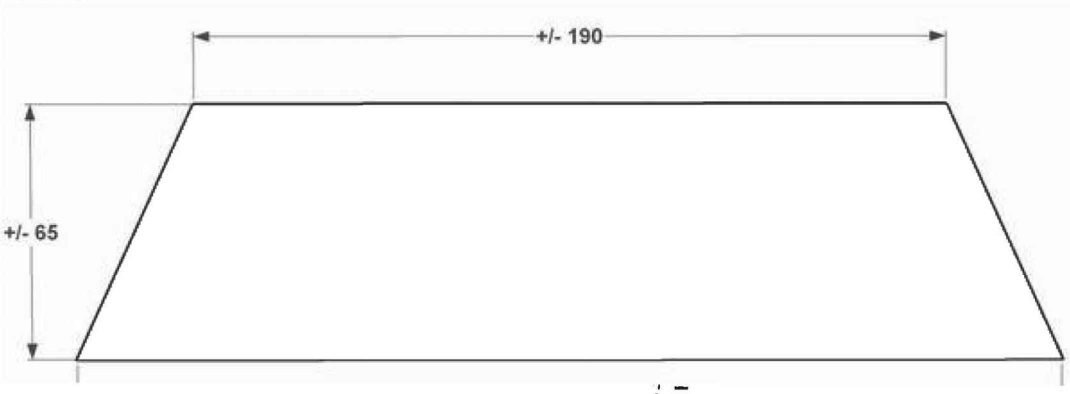
Dimensions are always given for guidance only and are to be valided according to your reservoir.



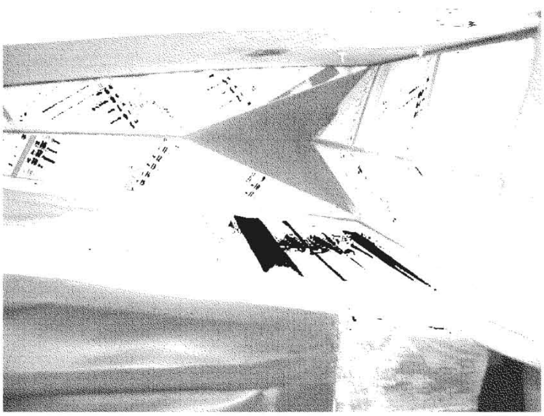
For stiffeners of reservoir, it is advisable to use cardboard 2 mm thick.

Cardboard calendars is perfect for this use. But be careful not to cut a stiffener on February - it would be shorter than the others !

As before, the dimensions are always given for guidance only and are validated according to your reservoir.



Two stiffeners for front side reservoir

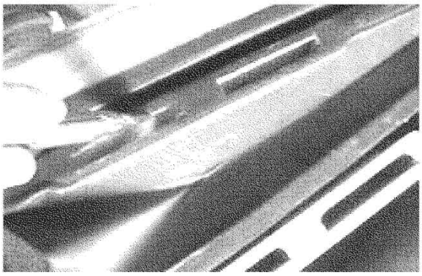


We take the photo just before closing the reservoir.

This clearly shows the shape and function of the stiffeners.

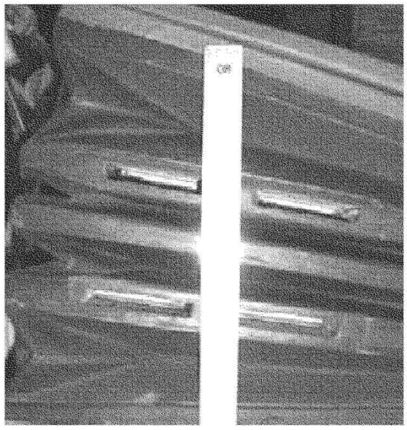
If the photo is out of focus, there will be little opportunity to do it again afterwards.

5 - 17 – AIR INTAKES AND SIDE REINFORCEMENT



Wait until the glue is well dry, and remove small skin area to allow air to get into the bellows.

Use a cutter with a new blade for a clean cut.



The blower will be subject to fairly significant efforts during operation.

There must be external side reinforcements connected on 3 steady pieces (lower/middle/upper).

These reinforcements are simply made of a flat aluminum profil.

Use long screws of small diameter and provide spacers 2 mm thick at 3 fixing points, so that the pallets will not rub against the reinforcements.

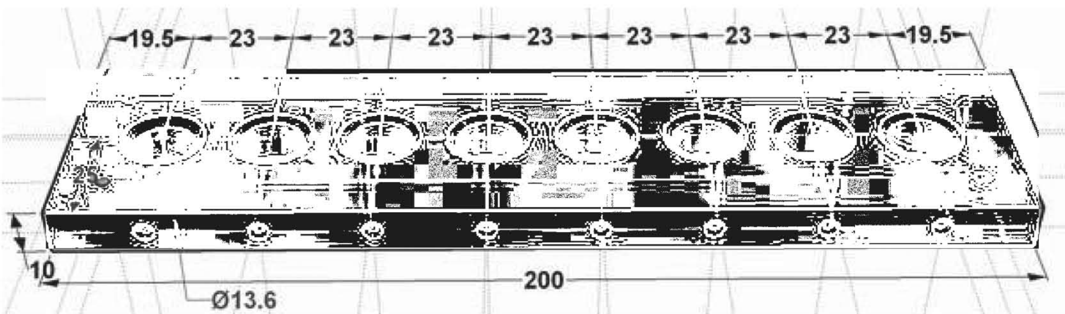
It is best to pre-drill the plywood to prevent it from bursting.

5 - 18 – CONNECTION BETWEEN BLOWER AND VALVES UNIT

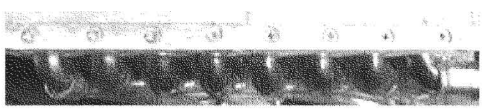
As we predicted during the manufacture of the lower throat, the air will pass through plastic tubes .

On the organ n° 1 we opted for the following solution :

To securely firmly copper elbows, simply insert them into a cleat oak or other hard wood in which 8 holes 13.6 mm have been made.



8 small holes will also be made on the underside of the cleat.



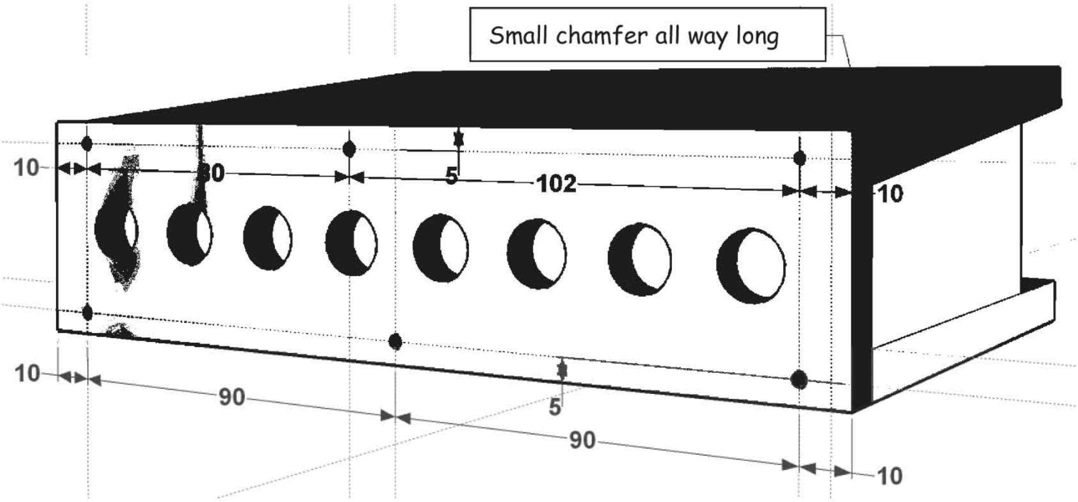
8 small screws will be inserted them, and will enter copper elbows on 1 or 2 millimeters, preventing rotation on themselves.

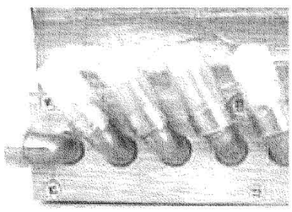
On one face of the cleat, we make a small circular chamfer on exit holes of 13.6 mm, just enough to deposit a silicon seal once copper elbows have been fitted.

The cleat must come apply perfectly to the rear surface of the throat.

Given the slightly trapezoidal shape of the throat, faces of the bottom piece and middle piece are not perfectly parallel.

It is therefore necessary to perform over the entire upper width of the cleat a small chamfer 10 mm height.





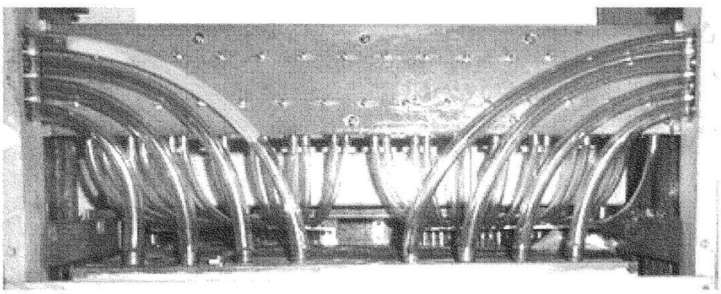
Provide also 6 holes for fixing screws. One of these holes is asymmetric to take in account the position at 45° of one of the copper elbows.

Coat the cleat inside face with silicone, and apply it firmly to the blower, then secure by 6 screws.

The copper elbows are "female / female" for tube diameter 12 mm.

24 copper elbows are needed.

On the blower of the organ n° 2, plastic tubes will be connected directly to small copper sections inserted and glued into the air tunnel.



We will see later how to connect plastic tubes to the valves unit.

5 - 19 – BLOWER TEST - 1st episode (there will of course episode 2)

Whatever the solution you chose (organ n° 1 or organ n° 2), you have to test the blower.

As long as the pressure relief valve and the control stop have not been placed on the reservoir lid, you must avoid moving pallets. Otherwise, the pressure may cause the separation of the leather.

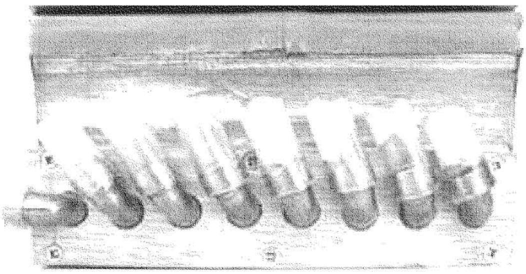
It is difficult to resist the temptation to immediately test the blower, by manually operating the pallets, just to check if the reservoir inflates.

So, if you do, and the reservoir does not inflate ! Why ? And then your brain starts to heat...

- Are throats in the right direction ?
- Are the valves are not too rigid ?
- Is excess glue would not prevent the proper operation of the valves ?

No, it may be that the reason is simple :

It seems obvious that the blower test can only be done if the air outlet holes of blower are clogged.



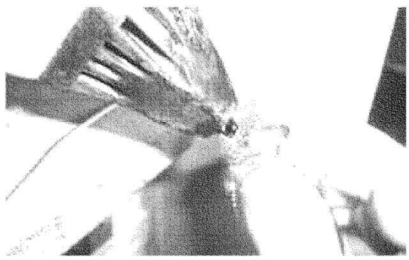
How temporarily clog these exit holes ?

Do not use adhesive tape : it is hassle to put on, and to take off.

In addition, it is difficult to have no leakage.

The solution is to make 8 small caps made of plastic tubes, one end is clogged with the glue gun.

Drying the glue in horizontal position, to prevent it flows inside the tube.



Do not stick plastic tubes on the copper elbows. The interlocking must remain removable.

To facilitate insertion of plastic tubes on the copper elbows without exerting too much effort, it is advisable to dive the ends in a bowl of boiling water to soften it.

The pipe will fit the copper elbow diameter by thermoforming.

The operation is also possible using a heat gun.

After 8 caps in place, check if there is no mini leaks where the copper elbows are inserted into the cleat at the rear of the blower.

Get out the candle that had served to test the flutes. The flame should not wobble.

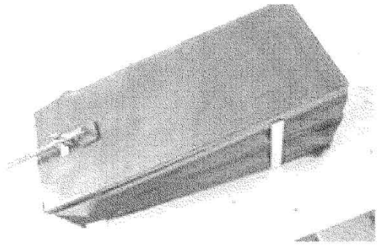
Although once the organ is enclosed inside its cabinet, the blower is not visible, it is still advisable to give 2 coats of varnish.

The day when you present the organ to a curious spectator, it will make more "professional".

Make sure you do not put varnish on pressure relief valve skin.

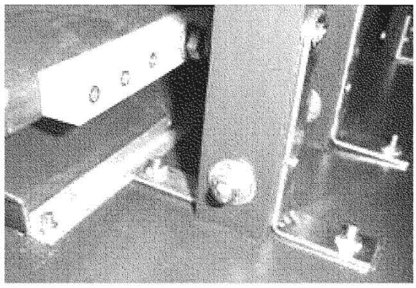
For organ n° 1, the blower was based in the middle of a board martyrdom.

It is only once all components will have found their ideal place we will calculate the precise dimensions of the organ base.



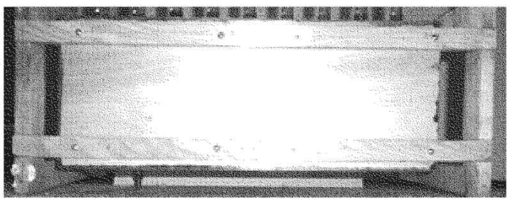
Fixing the blower is simply using aluminum 10x10 mm brackets.

Two small 30 mm bracket on blower lateral sides



A large 200 mm bracket crankshaft side.

For organ n° 2, the bellows secured on two cleats themselves secured to a structure which also serves to support the keyframe and the flutes support table.



Apart the test phase that may take you backward, we can consider that your blower is complete

We warned you at the beginning of this chapter by saying that the blower was difficult to achieve.

<u>SOURCES:</u>

BOOKS:
Trevor Robinson - The amateur wind instrument-maker, 1973

PDF's:
Julian Vogels - Harmonica-inspired digital musical instrument design based on an existing gestural performance repertoire.
"260510348_Vogels_Julian_Schulich School of Music_thesis.pdf

Jean-Claude Germain & Jean-Marc Gueguen - HOW TO BUILT (sic) A CRANK ORGAN (also available in a preferable version in French COMMENT CONSTRUIRE SON ORGUE DE BARBARIE)
"organ construction manual.pdf"/"cahier orgue.pdf"

WEBSITES:
tagboardeffects.blogspot.com

anarchy.translocal.jp/radio/micro/howtotx.html

COVER IMAGES:
Guust Flater #6

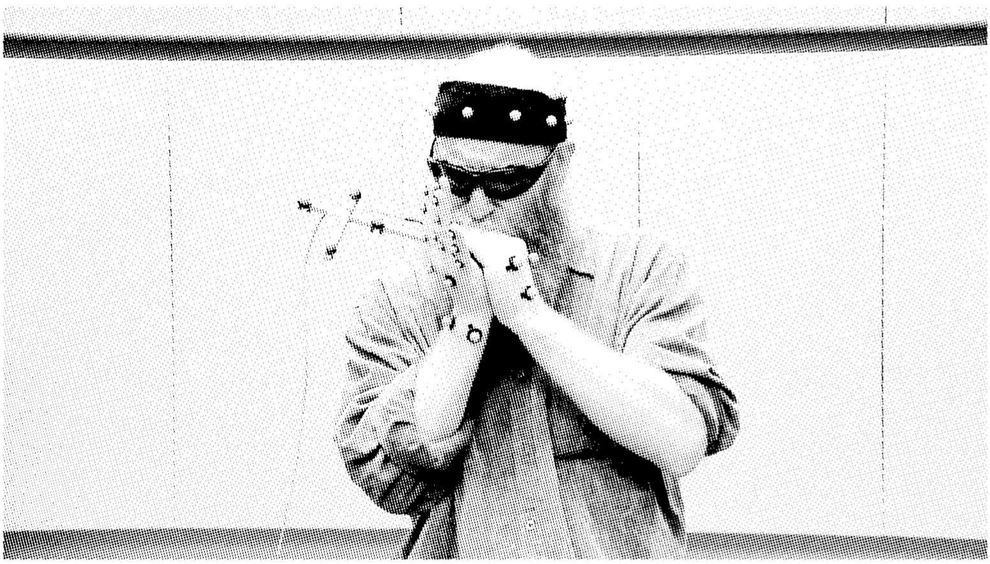
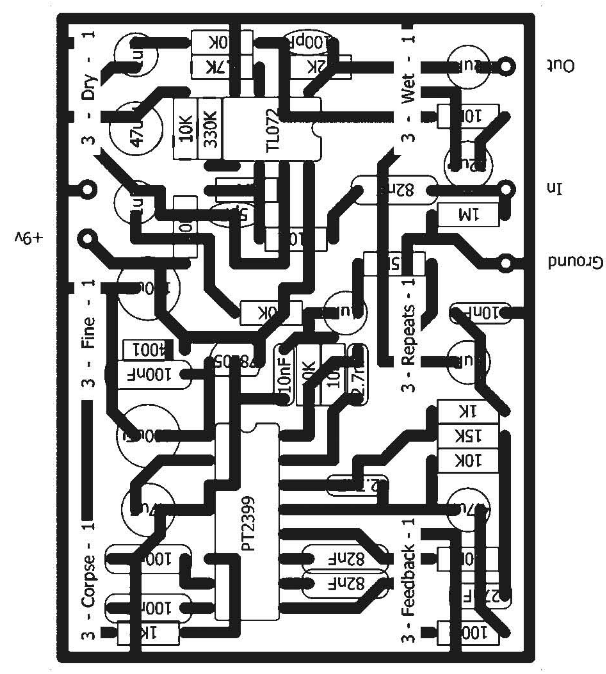
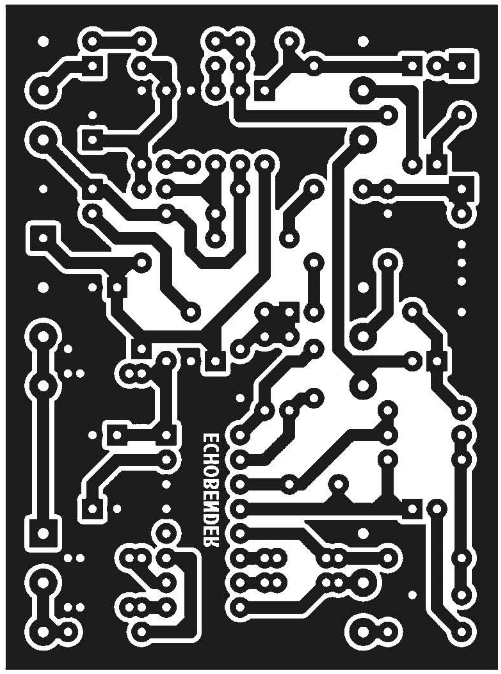


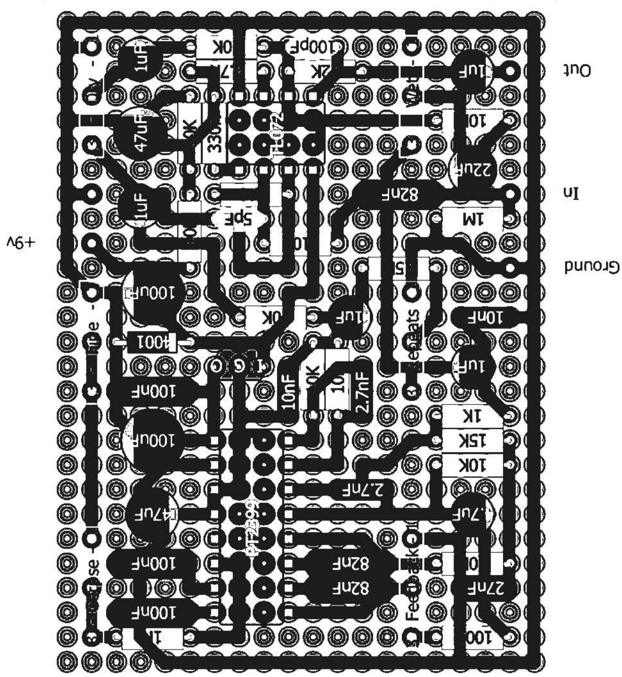
Fig. 4.1 – John is playing the modified harmonica, with markers attached to his hands and wearing a marker head band.

pt2399 delay circuits 2 : ECHOBENDER

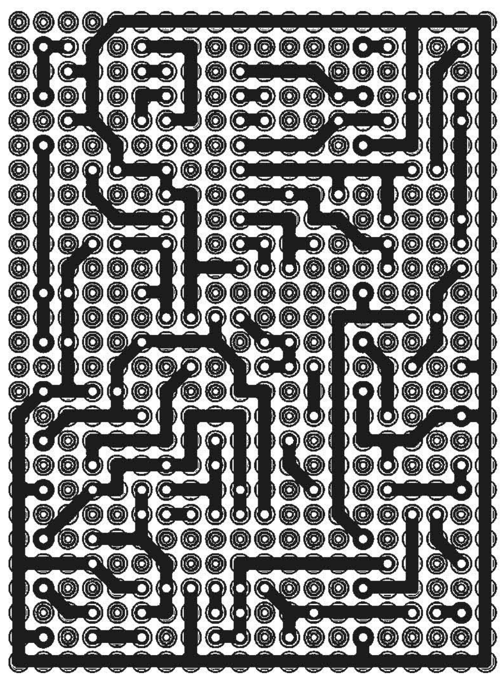




layout by storyboardist



Underside (reversed)



Dry: B100k
Wet: B100k

Fine: B10k
Repeats: B100k

Corpse: B500k
Feedback: B5k

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digital instuments

pt2399 delay designs

simple fm transmitter

how to make a
crank organ blower

and

rackett-construction plans