

HOW TO BUILT A CRANK ORGAN

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NOTE ON THE TRANSLATION OF THIS DOCUMENT



At first, this document was written in French. We received several emails from France of course, but also from several foreign countries.

So, we think that it must be a bit frustrating to have information and not understand them. That's why we did the English translation.

English is not our native language. We did our best, but some errors probably still remain. Translation minor errors are not serious. But it is important to report errors that can lead to a misunderstanding.

In this case, do not hesitate to cut text with errors and paste the correction in an email. Then, we will update the document on line - thank you for your help.

Of course, your comments of any kind are welcome....

FOREWORD

Who has not been one day sensitive to the sound of a crank organ, apart from younger who prefer the sound "boom boom" distilled by MP3 players ?

So if you read this document, it means that you would like to turn the crank at the corner of the street.

To get to this stage, several solutions are available :

- Buy a beautiful brand new crank organ - the first prize for such an instrument is in the range of 4000 / 5000 euros - given the materials and the number of hours of work for professionals, the price is largely based.
- Buy a kit organ - See on the Internet.
- Bidding on a used crank organ on EBAY - The prices are not necessarily lower than for a new organ, and it's a lottery for its conditions.
- Or with a lot of luck finding a crank organ in the grandfather's attic.

If none of these solutions is yours, you have to roll up your sleeves and build yourself your own instrument.



Budget level, according to your possibilities appos wood and supplies (copper tubes and aluminum, plastic tubes, leather, etc.) you should get away for 300 to 400 euros.

The construction is not as complicated as it seems. You have to get help from those who know !

To do this, it is possible to participate in courses organized by crank organ builders. This is a good solution. Alternatively, you can search for practical information on the Internet. That's what we did.

There, we found the two french popes of the crank organ !



Both of them have been of great help to deal with all the little special points that punctuate the adventure.

Do not hesitate to browse their personal website (in French)

Pierre PENARD	http://pagesperso-orange.fr/orgue-de-barbarie
Jean-Pierre COSSARD.	http://pagesperso-orange.fr/jean-pierre.cossard/orgue/index.htm



Playing an instrument of your production provides incommensurable pleasure compared to a crank organ purchased commercially.

Conversely, if it takes 2 minutes to send a VISA CARD number, it takes many months or years to make his crank organ. So arm yourself with patience.

Tip : Do not go alone in the adventure. It is more motivating and nice not to be isolated. A friend and I have found the solution of "the combination of skills".

We both live in Quimper (Brittany - France), so it was really convenient to meet regularly.

Depending on the knowledge and tools of each of us, we split the various tasks to build each his instrument. Advantage : we can play in stereo ...



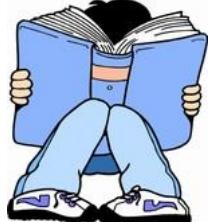
Jean-Claude for plans, calculations, wood cuttings, assembly, testing.



Jean-Marc for all very delicate machining (flutes - pressure rollers - etc)

Without being an expert for hand saw and wood chisel, you must have some manual skills, although it is always possible to get help for very special pieces.

The proper functioning of certain components is closely related to the precision of manufacture (flutes / valves unit).



Note 1 : We strongly recommend that you read entirely this document before starting. It would be sad to stop before the end due to lack of knowledge or tools.



Note 2 : Despite the care taken in writing this document, we can not be held responsible for any error or bad explanation that force you to manufacture a new part.



Note 3 : This document is 100 % free and cannot be sold for 2 reasons:

1 - it cost us nothing except time. If we had to calculate the number of hours, it would be very expensive ...

2 - This construction manual is largely based on information provided by Pierre PENARD and Jean-Pierre COSSARD. With these two people everything is free. With us too !



Note 4 : We have only one request !

Please, send us via email your comments of any kind about this construction manual.

Joint construction pictures, and of course instrument pictures when it is finished. Many thanks... (see email address on first page of this manual)

1 - WHAT ARE NOTES PLAYED BY THE INSTRUMENT ?

You will not find here a long section on music theory. Our knowledge in this area are equivalent to our ability to speak Serbo-Croat !

Note however that the crank organ described here is the "pneumatic" type and meets the standard "ERMAN".

Compared to a standard chromatic instrument (eg guitar, piano), a standard crank organ can only play 27 notes.



But thanks to a tip, two notes have been added, making 29 notes in all. (For very detailed explanation, see the personal website of Pierre PENARD)

Here are 29 notes that are generated by the flutes :

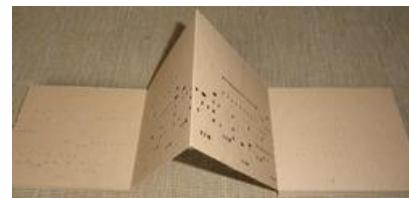
$C2 + D2 + F2 + G2 + A2 + C3 + D3 + E3 + F3 + F\#3 + G3 + G\#3 + A3 + A\#3 + B3 + C4 + C\#4 + D4 + D\#4 + E4 + F4 + F\#4 + G4 + G\#4 + A4 + A\#4 + B4 + C5 + D5.$

An instrument with 29 notes can therefore use the book provided for 27 notes since we found the same notes in the same places. With these 2 added notes, the music will be even better.

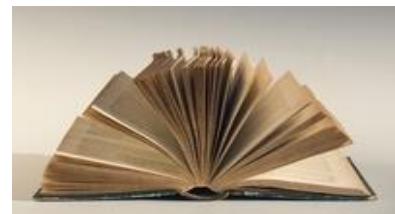
The limitation of the notes will affect the level of the arrangement of books. Indeed, for making books, starting from a MIDI file, you will have to make the file compatible with the possibilities of the instrument.

On remark : in this construction manual, we will talk about "a book"

Concerning crank organ world, a book is the music cardboard which is perforated all way long

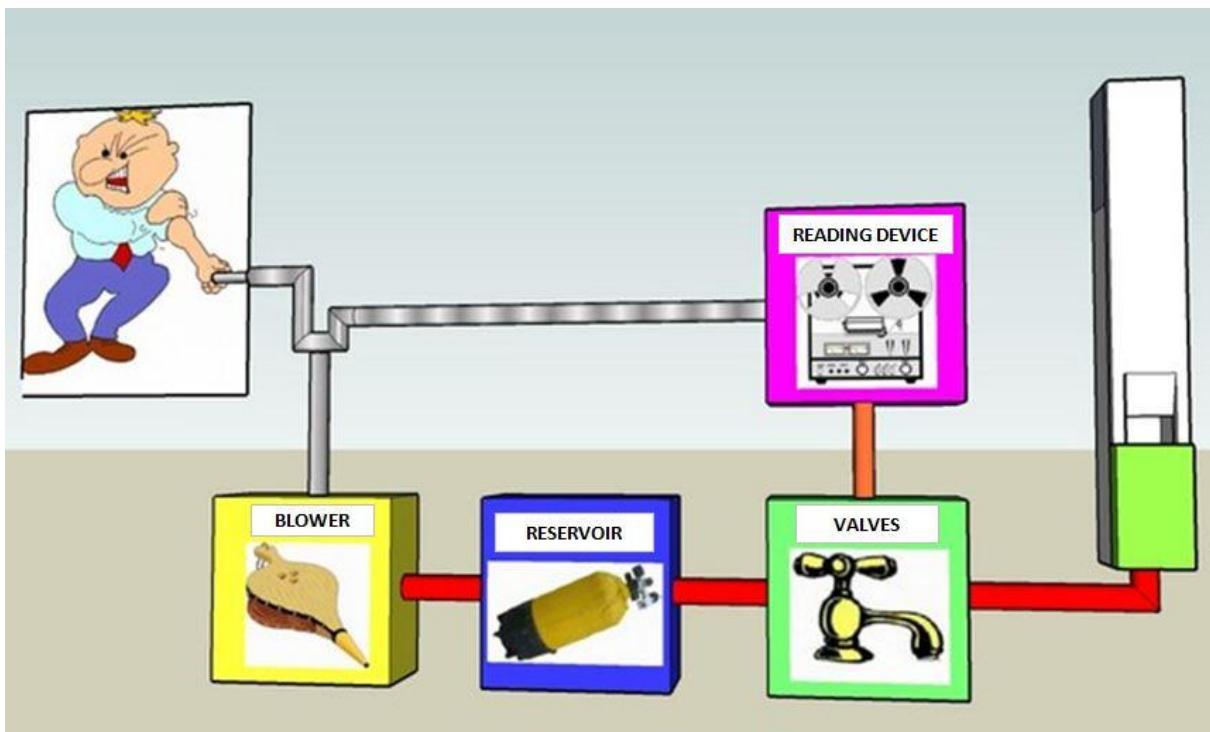


Do not make the confusion with a real book



2- HOW DOES A CRANK ORGAN WORK ?

In order to complete the construction of the instrument, it is best to understand its operating principle.



By turning the crank, it spends three different things :

1. Book scrolls above a reading system
2. It moves pallet up and down inside of a blower to generate air
3. Make your arm painful after a few hours

The air produced by the blower is stored under pressure in a reservoir. Then, air is sent to a valves unit, and also goes in reading system which explore perforated book during its scrolling.

Depending on the presence of holes in the book, the reading system sends opening and closing commands to the valves unit that allows or blocks the air toward the flutes.

Of course a full description of each component will be much more detailed in the document.

3 - DESCRIPTION ORDER

We did not want to participate in the deforestation of the Amazon forest, or Breton forest in our case, wasting too much wood. So it is best to think carefully about the different parts by drawing before machining. To do this, we had two software at our disposal :

- PPE Software (paper / pencil / eraser) - simple, economical, "bugs" very rarely, but a little "has-been"
- SKETCHUP software - simple enough to use, free and downloadable on the Net, so why not use it.

As we reported earlier, we built two crank organs. We can say that most of the components are the same. The main difference lies in the layout of flutes, which sometimes has a small impact on the manufacture of certain parts (eg flutes).

We will also see that alternatives solutions have also been taken into account between the two buildings. In this construction manual, the two organs will be named "Organ n° 1" and "Organ n° 2" (yes it's not very original, but it has the merit of simplicity.)

All specific information about the construction of the organ n° 2 will be denoted by blue characters.

Our choice of solutions can always be challenged by others people who have already built their crank organ, but this document is not for these people. Anyway, what is described here works !

Nothing prevents you to make a version "Organ n° 3" with a combination of the first two versions, and even an "Organ n° 4" version with brand new ideas.

Although it is possible to build the different elements in any order, it makes more sense to follow the procedure below :

- The flutes - it's more motivating if early enough you can hear them sing
- The blower - for testing the flutes in the best conditions
- The blower activation mechanism - essential, otherwise the blower would be unusable
- The book reading system - used to read information from the book to control the valves unit
- The valves unit - send the air in the flutes when necessary (or not to send when it will not be ...)
- The tuning of flutes and adjusting the valves unit
- The cabinet

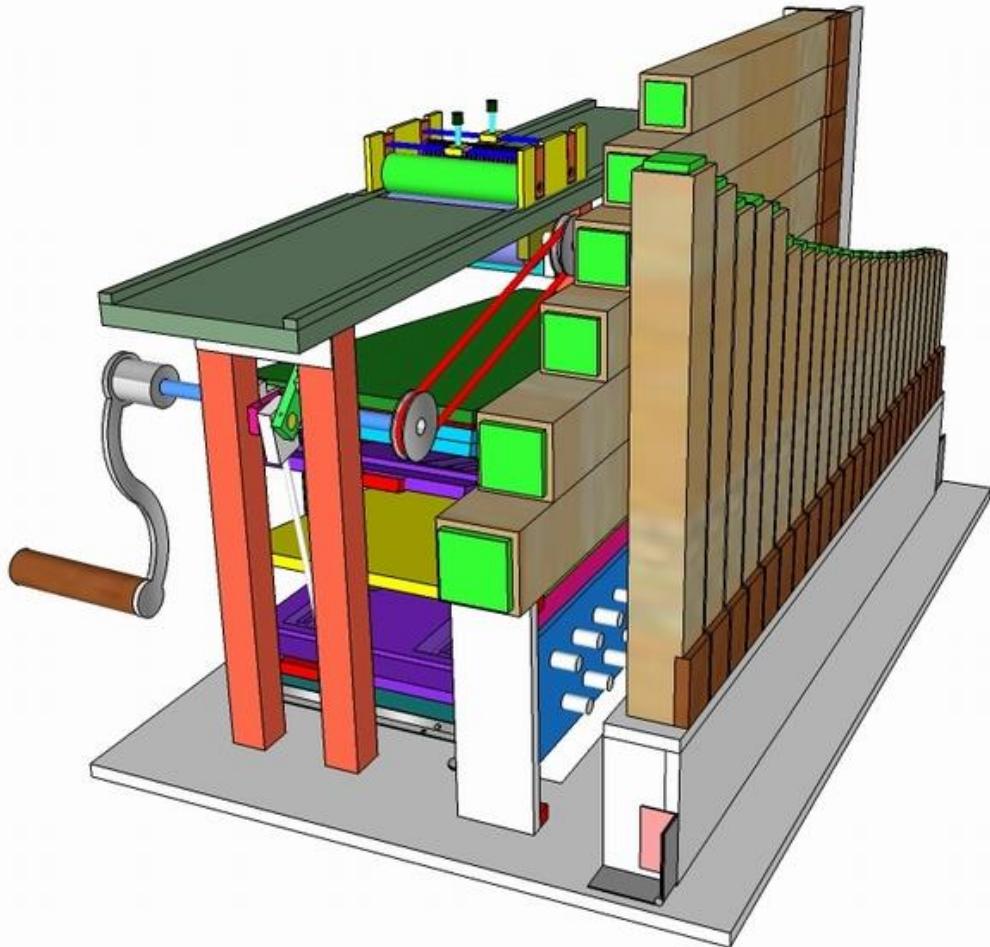
It is in this order that will address the different topics in this construction manual.

You must keep in mind not to make a too big and too heavy crank organ.

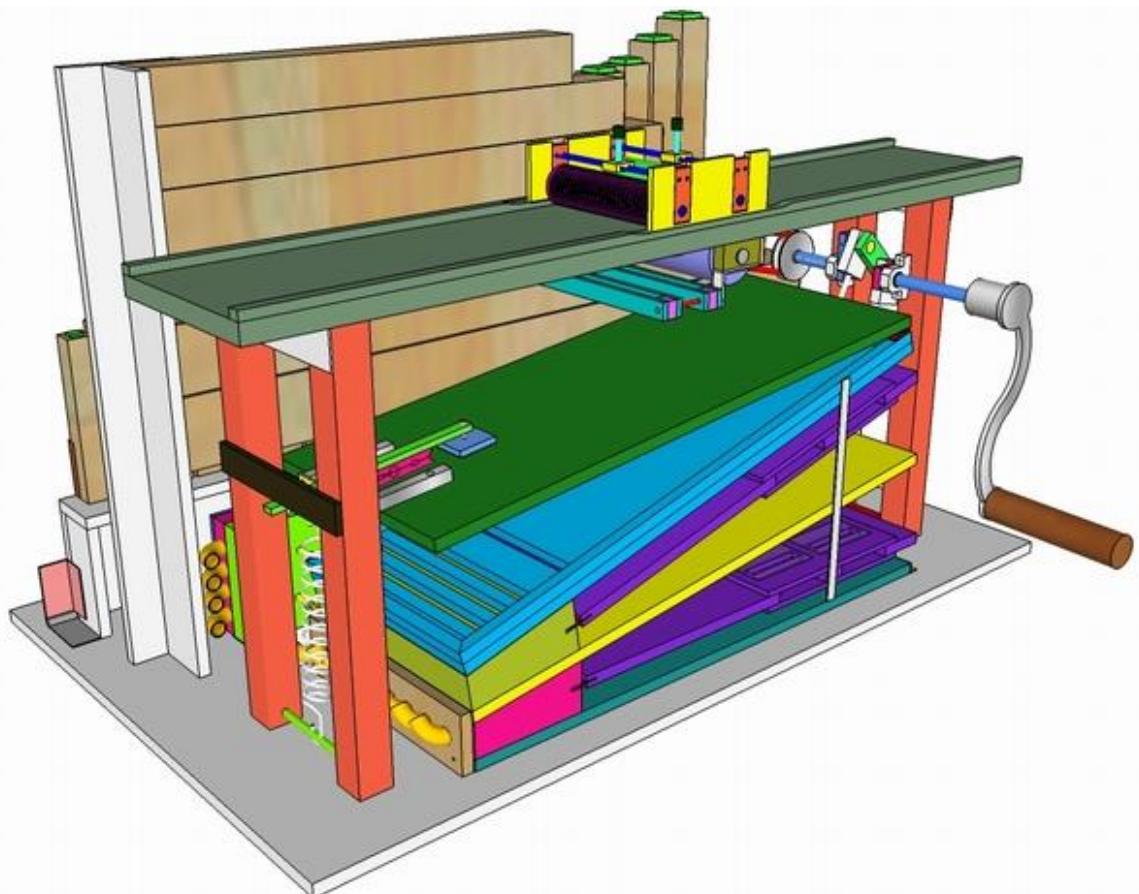
Check the size of your car trunk, otherwise you will have to invest in a suitable vehicle.



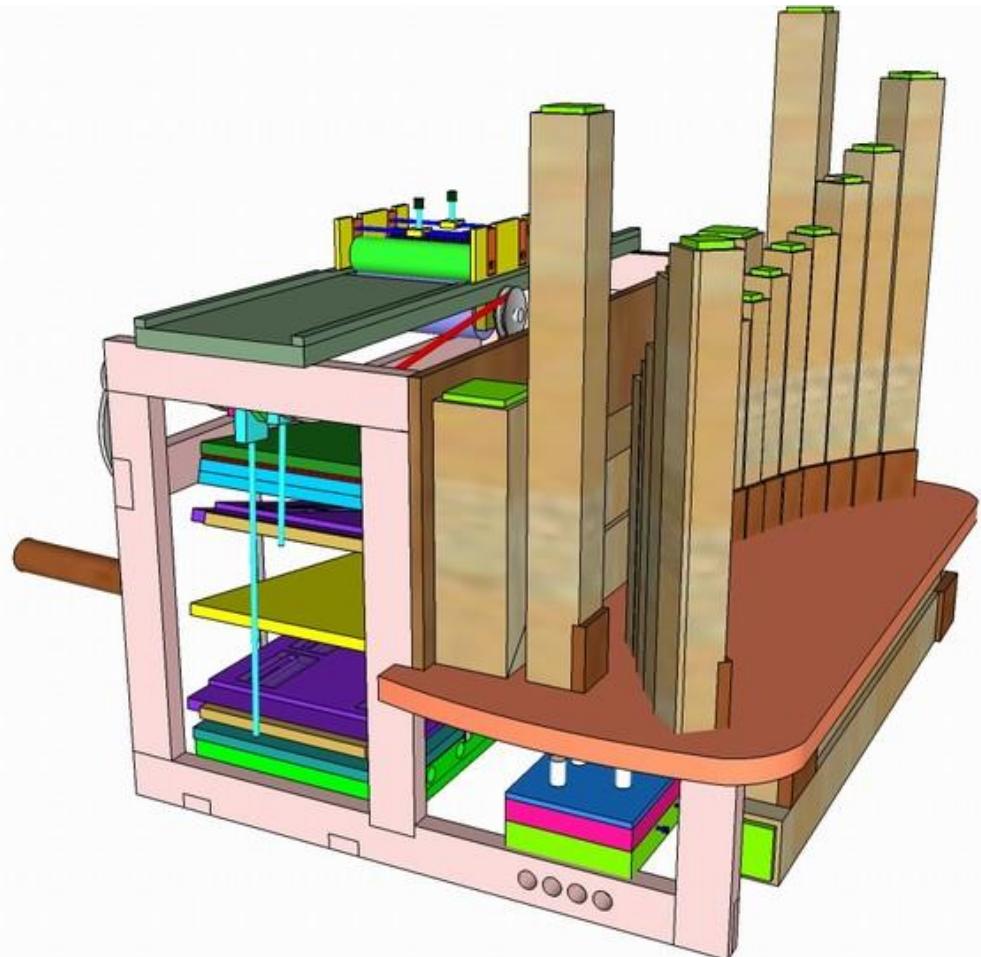
Here are sketches of the two crank organs :



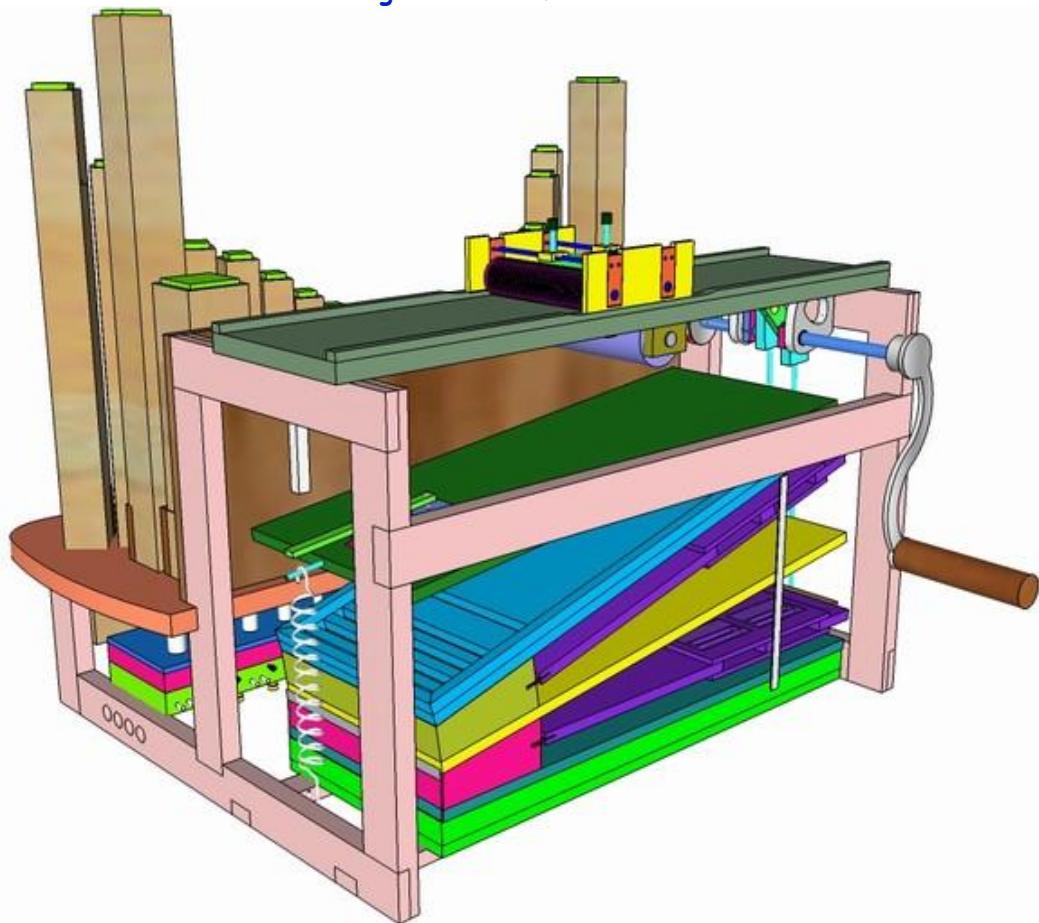
Organ n° 1 - Front view



Organ n° 1 - Rear view



Organ n° 2 - Front view



Organ n° 2 - Rear view

Here is the complete video for organ n° 1.

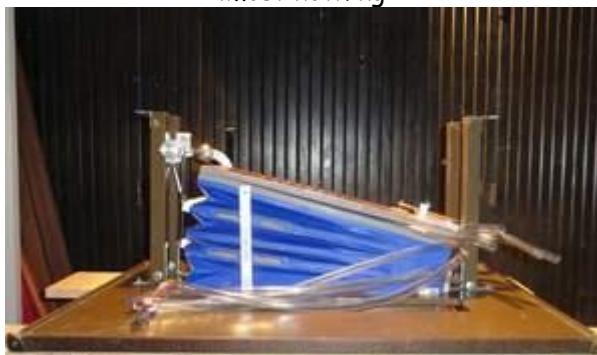
The same scenario applies to the organ n° 2.



Almost nothing



Blower implementation



Support pillars implementation



Keyframe implementation



Connecting the valves unit



Horizontal flutes implementation



Vertical flutes implementation



Cabinet implementation

Now, let's go for it !

4 - 1 - WORKING PRINCIPLE

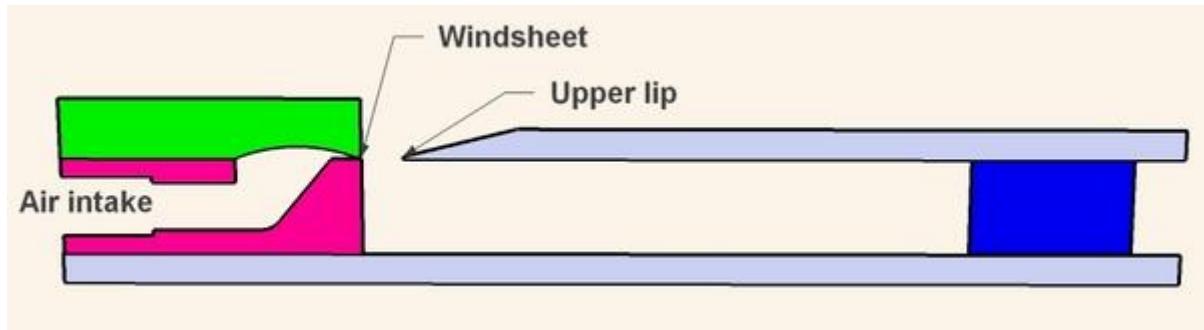
The working principle is identical to that of a recorder.

Aside from a recorder is not clogged, and has many holes to play different notes. In our case, there are no holes, so you have one flute by note.

In our crank organ, there will be 29 flutes. Dimensionally, they are all different from each other.



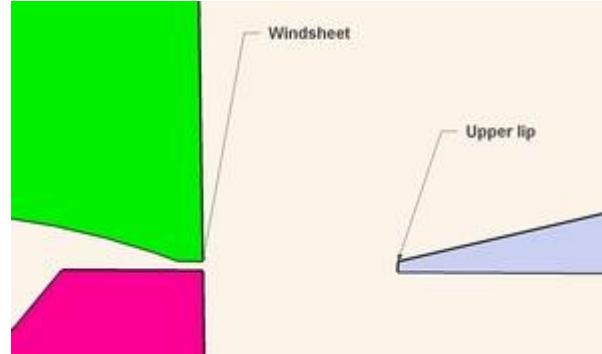
In the view below, the air enters through the left side, turns toward the top, goes out through the windsheet, and arrives just in front of the upper lip.



An important point to make it works :

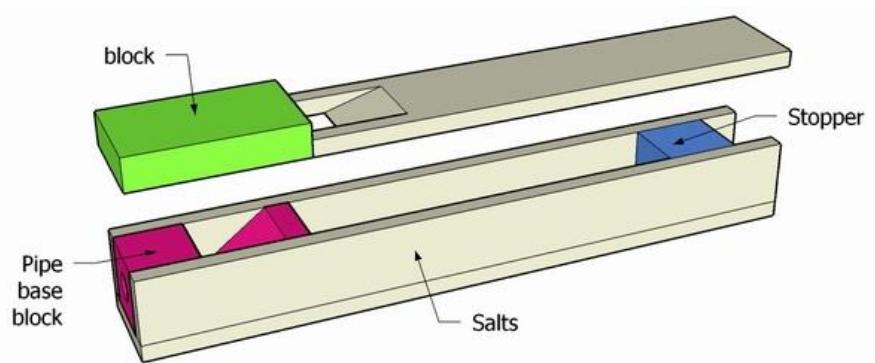
It is necessary that the thickness of the windsheet is equal to thickness of the upper lip.

In addition, it must have a perfect alignment between them.



A flute is made up of four main elements:

- a pipe base block
- a block
- a set of slats
- a stopper



How to calculate the dimensions of the flutes ?

Here are a preview of the Excel sheet :

Dimensions de tuyaux d'orgue bouchés, à section carrée														
Constantes de construction														
Position tuyau	Arrière	Avant												
<i>H pied</i>	0.060	0.050												
<i>H bouchon</i>	0.040	0.030												
<i>Epaisseur paroi</i>	0.006	0.005												
Paramètres			F (Hz)	c (m/s)	L/M(69)	M	N Ising	V air (m/s)	Pression (cm H ₂ O)					
440	343.32	18	18	2.50	47.000			13.806						
Dimensions			Note	N° MIDI	Fréq. (Hz)	Long. théor. (m)	Section int. (m)	E. lame d'air (mm)	Hauteur bouche (mm)	Longueur Accous. totale (m)	Section ext. (Lcl m)	Surf. paroi (Wa m)	Larg. face	Jeu tube
B	Si	47	123	1.390	0.030	0.60	24.0	0.665	0.765	0.042	0.000			
c	Do	48	131	1.312	0.029	0.60	23.1	0.627	0.727	0.041	0.098	0.04	1	
d	Ré	50	147	1.169	0.027	0.60	21.4	0.558	0.658	0.039	0.181	0.08	1	
f	Fa	53	175	0.983	0.024	0.50	18.0	0.468	0.568	0.036	0.246	0.12	1	
g	Sol	55	196	0.876	0.022	0.50	16.6	0.416	0.516	0.034	0.302	0.15	1	
a	La	57	220	0.780	0.020	0.50	15.4	0.370	0.470	0.032	0.349	0.18	1	
c'	Do	60	262	0.656	0.018	0.50	13.7	0.310	0.410	0.030	0.386	0.21	1	
													6	

For the full version, go to the site of Pierre PENARD.

In the lines that follow, we will give you a simplified version of this document which is limited to only the data necessary for the production of 29 flutes that we will now describe.

4 - 2 - THE SLATS

The best is to use beech. It is a wood that is easy to work is easy to sand.

This allows a good surface appearance both outside for a glance, and also inside to get a good sound.

Other wood species may also be suitable, such as pine.

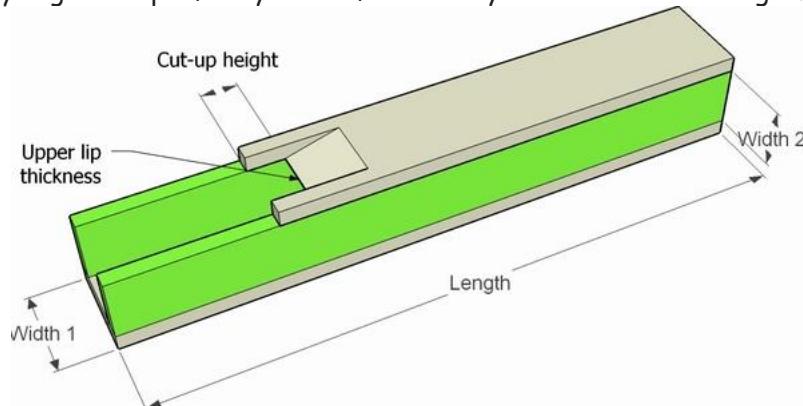
For each flute, there are 4 slats. First, it is easier to cut them all to the maximum length, even if one will be shorten later.

Beware, it is always easier to re-cut a flute than to make it longer.

That is why it is highly recommended to provide an extra length of 10 mm on each slat.



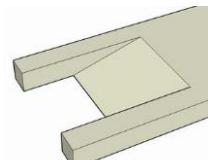
It is only after you get the perfectly tuned flute that you can reduce its length.



On the upper slat, there must be a bevel. At this stage, there are two solutions :



Solution n° 1 : bevel without edges



Solution n° 2 : bevel with edges

Of course the solution n° 1 is the easiest to achieve.

Solution n° 2 is the luxury version : this slat can be positioned against the block during the assembly operation of the flute.

Musically, the solution n° 2 is supposed to reduce the "tchack", which is an undesirable noise. But you must be very good music professional to notice this noise.

This is why we opted for the solution n° 2 with edges...

All slats have a thickness of 5 mm. This thickness is not critical musically, but inevitably has an impact in the dimensions of slats that are given in the dimension table below.

Note that the heights are not here increased by 10 mm (see above)

flute number	Note	Length	Width 1	Width 2	Cut-up height	Upper lip thickness	Slope
1	C 2	707	59	49	25	0.8	+/- 10°
2	D 2	639	55	45	24	0.8	+/- 10°
3	F 2	551	50	40	20	0.7	+/- 10°
4	G 2	501	47	37	19	0.7	+/- 10°
5	A 2	456	44	34	16	0.6	+/- 10°
6	C 3	397	41	31	15	0.6	+/- 10°
7	D 3	364	38	28	13	0.6	+/- 10°
8	E 3	334	36	26	12	0.6	+/- 10°
9	F 3	320	35	25	12	0.6	+/- 10°
10	F # 3	308	34	24	11	0.5	+/- 10°
11	G 3	296	33	23	10	0.5	+/- 10°
12	G # 3	264	33	23	10	0.5	+/- 10°
13	A 3	253	32	22	10	0.5	+/- 10°
14	A # 3	243	31	21	9	0.5	+/- 10°
15	B 3	234	30	20	9	0.5	+/- 10°
16	C 4	225	29	19	9	0.5	+/- 10°
17	C # 4	216	29	19	8	0.5	+/- 10°
18	D 4	208	28	18	8	0.5	+/- 10°
19	D # 4	201	27	17	8	0.5	+/- 10°
20	E 4	194	27	17	7	0.5	+/- 10°
21	F 4	187	26	16	7	0.5	+/- 10°
22	F # 4	181	25	15	6	0.4	+/- 10°
23	G 4	175	25	15	6	0.4	+/- 10°
24	G # 4	169	24	14	6	0.4	+/- 10°
25	A 4	164	24	14	6	0.4	+/- 10°
26	A # 4	159	23	13	5	0.4	+/- 10°
27	B 4	154	23	13	5	0.4	+/- 10°
28	C 5	150	22	12	5	0.4	+/- 10°
29	D 5	142	21	11	5	0.4	+/- 10°



Should you have slats in a different thickness of 5 mm, you would have of course to recalculate width slats which are given above.

Given the large number of slats, a table saw with a guide is very useful.

Among discounters DIY, it is not very expensive.

The accuracy of our table saw is not extreme, but enough for the intended application.



Table saw for the width



Hand saw cutting for the length



Sanding

How machined slats previously cut at their dimensions ?



Old time technique with wood chisel



Or with a milling machine

In our case, we did not find a wood chisel, and we had to do the job with a milling machine....

Here are some pictures of the making of the upper slat.



Clean end



Cut-up height



How to make a clean bevel



The front end of the bevel must keep a certain thickness equivalent to windsheet of the block.

We do not skimp. In the table given above, it is specified 0.80, it is 0.80, not 0.79 or 0.81 ...

Given the large number of slats, you must be quite methodical in their manufacture.

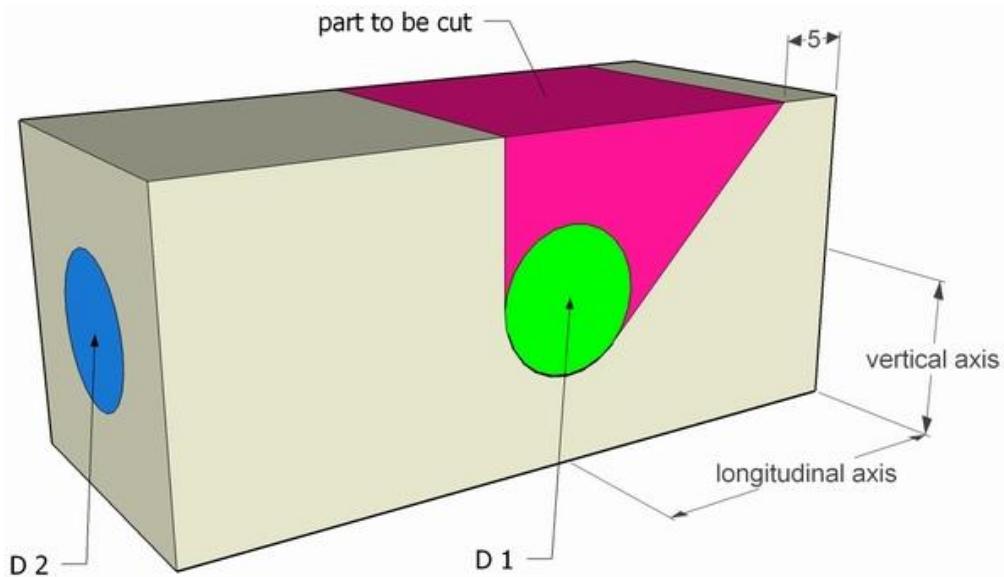
You must identify and group them as the form of fagots.



4 - 3 - THE PIPE BASE BLOCK

It is through this part at the base of the flute that will arrive the air coming from the blower (via the valves unit)

Pipe base blocks are carved in oak cleats.



Here is the "manual" method to take out the triangular part :

1. Drill a hole D 1 across the piece (see table below for position)
2. Give first shot of saw 90 °
3. Give a second shot of saw 135 °
4. Remove the triangular part
5. Sand surfaces with sandpaper.

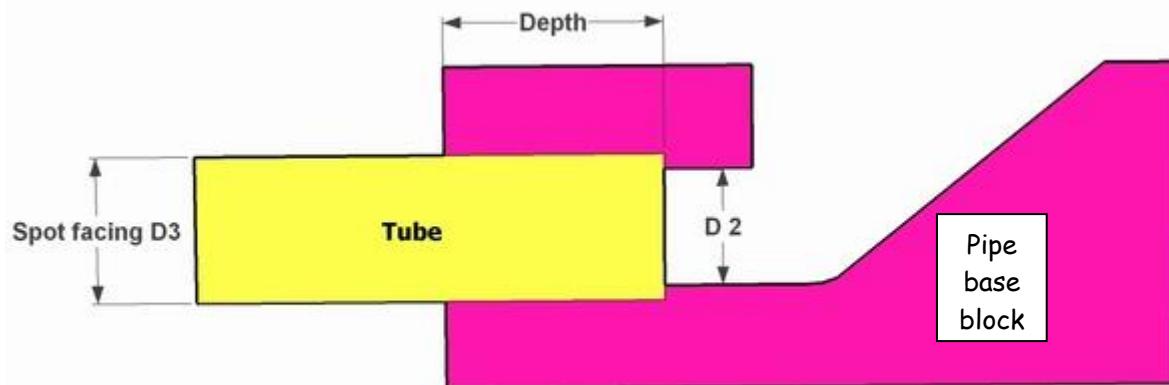
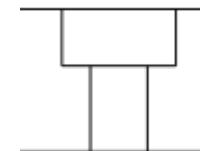


The hole at the base has the same diameter as the horizontal hole, so $D 1 = D 2$.

This hole will receive the tube that will maintain the flute on the table and will also be used to connect the flute to the valves unit.

For drilling end to receive the tip of the tube, it is advisable to make a "spot facing".

These are two concentric holes with 2 different diameters.



In a first step, the pipe base block is drilled in the end over its entire length with a diameter $D 2$.

Then with a countersink drill, two thirds of the length of the hole are drilled with diameter $D 3$ slightly larger than $D 2$. Therefore, the tube end abuts against the internal shoulder.

Moreover the inner diameter of the tube piece being equal to $D 2$, the hole surface is not reduced, resulting in a greater air inlet.

On the organ n° 1, for aesthetic and practical reasons, we chose to position 29 flutes on 2 separate rows. One row is vertical, and one row is horizontal.

For vertical row, pipe base block height is 50 mm, and for horizontal row, pipe base block height is 60 mm (this difference is not critical).

This is why, in the table below, there is change in height from the flute n° 7.

This can vary depending on the layout of your flutes (see next chapter)

Given the somewhat particular arrangement of flutes on the organ n° 2, some flutes will be modified by bringing the air on the back of the flute. We shall see this point later.

Here the table giving all dimensions for the manufacture of pipe base block :

Flute number	Pipe base block length	Pipe base block section	Drilling D1	Longitudinal axis drilling D1	Vertical axis drilling D1	Drilling D2	Drilling D3
1	60	49	14	39.2	24.3	14	16
2	60	45	14	37.4	22.5	14	16
3	60	40	12	33.6	20.1	12	14
4	60	37	12	32.1	18.6	12	14
5	60	34	12	30.7	17.2	12	14
6	60	31	10	27.4	15.3	10	12
7	50	28	10	26.3	14.2	10	12
8	50	26	10	25.2	13.1	10	12
9	50	25	10	24.7	12.6	10	12
10	50	24	10	24.2	12.2	10	12
11	50	23	10	23.8	11.7	10	12
12	50	23	10	23.3	11.3	10	12
13	50	22	8	21.5	10.8	8	10
14	50	21	8	21.1	10.4	8	10
15	50	20	8	20.7	10.0	8	10
16	50	19	8	20.3	9.7	8	10
17	50	19	8	19.9	9.3	8	10
18	50	18	8	19.6	8.9	8	10
19	50	17	8	19.3	8.6	8	10
20	50	17	8	18.9	8.3	8	10
21	50	16	8	18.6	8.0	8	10
22	50	15	8	18.3	7.7	8	10
23	50	15	8	18.0	7.4	8	10
24	50	14	6	16.3	7.1	6	8
25	50	14	6	16.1	6.8	6	8
26	50	13	6	15.8	6.6	6	8
27	50	13	6	15.6	6.3	6	8
28	50	12	6	15.3	6.1	6	8
29	50	11	6	14.9	5.6	6	8

Let's see far forward : Be aware that you will need to cut the stoppers that will be fitted into the flutes in order to tune them.

These stoppers are square sections, which in a first time, are the same as those of the pipe base blocks.

So why not take advantage to group the operations for making the same sizes for both pipe base blocks and stoppers.

The length of the stopper is equal to the length of the pipe base block divided by 2. Note that this length is not critical.

Flute number	Pipe base block and stopper section	Pipe base block length	Stopper length
1	49	60	30
2	45	60	30
3	40	60	30
4	37	60	30
5	34	60	30
6	31	60	30
7	28	50	25
8	26	50	25
9	25	50	25
10	24	50	25
11	23	50	25
12	23	50	25
13	22	50	25
14	21	50	25
15	20	50	25
16	19	50	25
17	19	50	25
18	18	50	25
19	17	50	25
20	17	50	25
21	16	50	25
22	15	50	25
23	15	50	25
24	14	50	25
25	14	50	25
26	13	50	25
27	13	50	25
28	12	50	25
29	11	50	25

Note that unlike the calculation flutes slats, pipe base blocks width and stopper width are independent of the thickness of the slats used in the manufacture of the flutes.

Now back to the milling machining. Here are some photos:





Whatever the way to manufacture these parts, hand saw or milling machine, you must sand the sides perfectly.

It is advisable to graphiter the inclined portion and the small flat part at the output.

This is to avoid the effects of moisture that raise the wood fibers, when we breathe into it for testing.

Just darken these surfaces with a pencil.



4 - 4 - THE AIR INLET TUBE



At the base of the pipe base blocks are inserted copper or aluminum tubes.

Their diameter must of course take in account the spot facing diameter made in the pipe base blocks (see previous explanations).

Concerning the length tubes, we're going to need tubes for 2 different uses, so it is better to provide right now the total length for all needs :

Where ?	Detailed calculation
At the base of flutes	<ul style="list-style-type: none"> Length in pipe base block = 2/3 of the remaining material after machining slope Length to cross the support table = 10 mm Length for connecting plastic tubes from the valves unit = 25mm
For output tubes of valves unit	<ul style="list-style-type: none"> Length inside the valves unit = 11 mm (to be confirmed according to your own valves unit) Length to go through the lid of the valves unit = 5 mm (to be confirmed depending on the thickness of your lid) Length for connecting plastic tubes leading to flutes = 25 mm

In summary, for all two positions, it takes at minimum :

Diameter of the tubes	Total lengths
16 mm	830 mm
14 mm	296 mm
12 mm	679mm
10 mm	1088 mm
8 mm	605 mm

To cut the tubes, nothing is more effective than a pipe cutter.

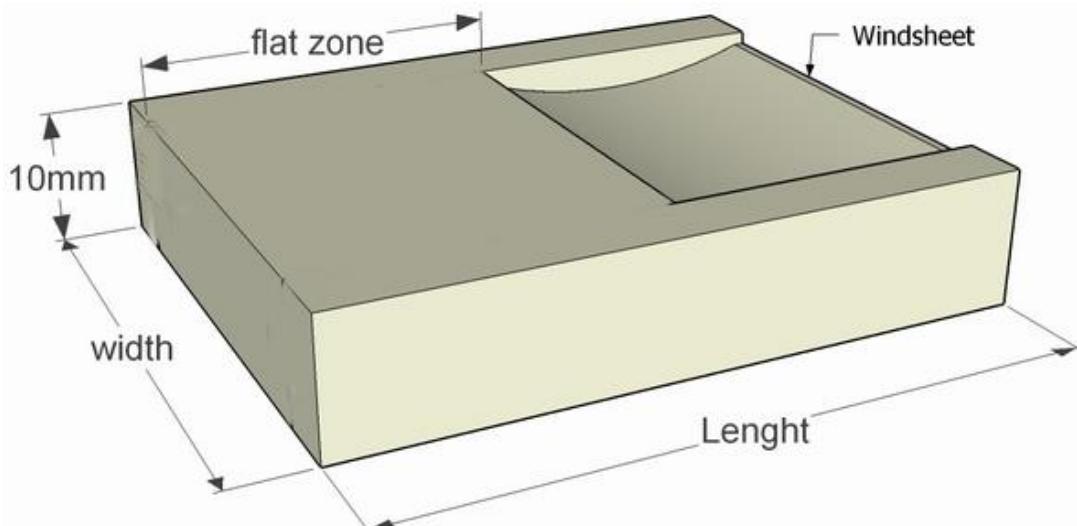


4 - 5 - THE BLOCK

This part is placed just above the pipe base block. It directs air coming from pipe base block toward the exit.

Blocks are cut into slats thicker than those used for the flutes. In this case, we use oak instead of beech.

Blocks are machined to have a curve on the inner face. A very slight reduction in height was made with lime to have what is called "windsheet".



The length of the plane area is not critical, and is more or less equal to the block length divided by two.

In fact, it depends on cutter diameter used during machining.

Depending on your possibilities, there are other ways which may be simpler to achieve a satisfactory result.

See the website of Pierre PENARD for details.

You must perfectly sand these parts.

Again, and for the same reasons as before, it is advisable to graphiter the machined zone.



The table below shows the different values for the manufacture of blocks for slats of 5 mm thickness.

Flute number	Block length	Block width	Windsheet height
1	60	59	0.8
2	60	55	0.8
3	60	50	0.7
4	60	47	0.7
5	60	44	0.6
6	60	41	0.6
7	50	38	0.6
8	50	36	0.6
9	50	35	0.6
10	50	34	0.5
11	50	33	0.5
12	50	33	0.5
13	50	32	0.5
14	50	31	0.5
15	50	30	0.5
16	50	29	0.5
17	50	29	0.5
18	50	28	0.5
19	50	27	0.5
20	50	27	0.5
21	50	26	0.5
22	50	25	0.4
23	50	25	0.4
24	50	24	0.4
25	50	24	0.4
26	50	23	0.4
27	50	23	0.4
28	50	22	0.4
29	50	21	0.4



The machining of the windsheet height is extremely important. If you are not precise, the flute will have very little chance to sing !

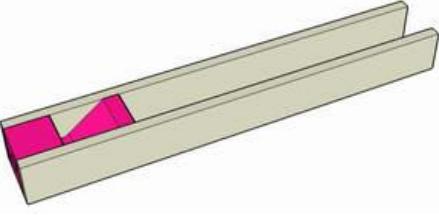
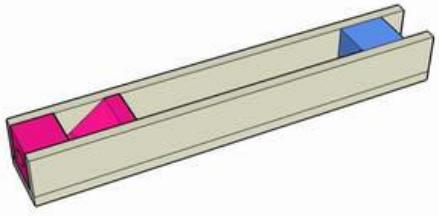
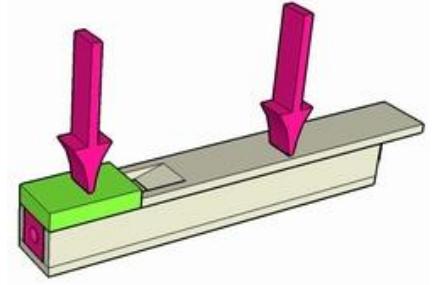
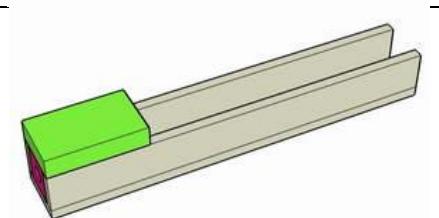
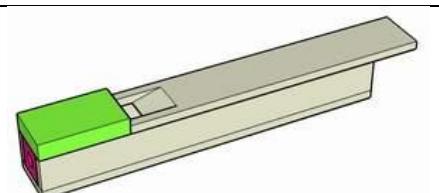
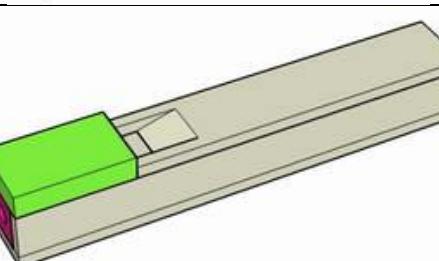
4 - 6 - HOW TO ASSEMBLE FLUTES

Attention : when it's glued and completely dry, it's almost impossible to turn back without making a mess on the flute.

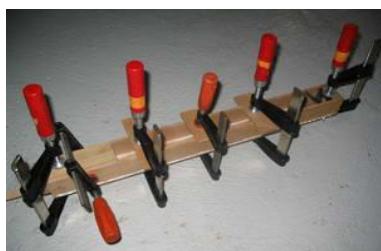
For bonding wood, nothing better than white vinyl adhesive.

After doing some tests on the first flutes, here is the process we think the best for assembling all components.



<p>1 Spread vinyl glue on the two large side faces of the pipe base block, and applying firmly the two side slats.</p> <p>Place all on a flat surface before tightening with a clamp. Be careful not to reverse the pipe base block....</p> <p>Once dry, use sandpaper to get all the pieces the same height</p>	
<p>2 Glue the previous assembly on its inferior face and applied the large slat. Temporally, the stopper can be used as a spacer.</p> <p>Be careful not to block the stopper by excess glue.</p>	
<p>3 Before gluing the block on the top, check the function of the flute in squeezing firmly the block and the upper slat.</p>	
<p>4 Glue the block with its little face right at the vertical of the pipe base block.</p> <p>Be careful not to reverse the block.</p> <p>Be careful not to leave excess glue at the windsheet.</p>	
<p>5 Apply upper slat by putting it up against the block.</p>	
<p>6 Wait for drying and cut the upper slat at the same level as the others.</p>	

For a better visual look, all vertical edges were broken with sandpaper.



At each step, it is advisable to quickly remove excess glue. This avoids a laborious further sanding.

Do not be stingy on the number of clamps.

4 - 7 - THE STOPPER



Small pieces of oak must be inserted at the end of each flute. They are called "Stopper"

Initially, you have to manufacture stoppers at the same time with the pipe base blocks. The section is the same, so it simplifies the operation.

The stopper must be able to slide in the flute to tune it.

It must have sufficient clearance for the sliding, but not too large to ensure the stopper sealing.

Again, there are two solutions for the dimensional setting of the section:

Solution n° 1 : precise adjustment - we do not recommend this solution that we had planned initially.

Besides the fact that it requires a fairly high accuracy in machining, this solution does not offer easy sliding to the stopper.

In addition, the wood is sensitive to variations in temperature and humidity, which causes jamming.

Solution n° 2 : Reduction of the stopper section with seal provided by a small piece of shammy skin.



Despite the fact that we are very sensitive to the conservation of the animal, we opted for this solution.

We have to reduce stopper section so that there is enough gap for the shammy skin.

It is estimated that a small reduction in thickness of a millimeter on each side of the stopper is enough.

Place the stopper on the skin

Cut the skin leaving an excess of about 5 mm.

The skin must be bonded to the stopper by a glue point (eg neoprene)

This avoids leaving the skin into the body of the flute when pulling the stopper outward.

During settings, the stopper may sink completely within the flute. So there must be a ring piton to pull out the stopper without having to break the flute.



When finishing the crank organ, we shall hide those nasty ring pitons.

You will see later that these ring pitons will have a second use. What suspense !

For easy hanging of non-visible ring pitons, we made a very simple tool. It is a bent metal rod.



The stopper must slide "hard", enough to be positioned in its right place.

It must not move alone when transporting the instrument.

Please note also that there is no air leakage at this level.

To locate leaks, we "invented" a very simple system.

Just approach a candle and watch the flame. So it must not wobble.



If you have been too generous on file strokes at reducing stoppers section, it is possible to reverse by surrounding their feet with adhesive tape.

There is another way to check if the stopper will not move alone. Simply sanding flute with an electric sander !!!!!

If the stopper is not properly adjusted, the vibrations of the sander will move it alone. It's magic !

Take time to identify each flute with its number and its note on its back.



To end the production of flutes, it is advisable to spray the inside faces with bomb varnish.

This improves the flow of air, thus musicality



The varnish does not cost much, but it is not a reason to spread a $\frac{1}{4}$ liter in each flute.



If you spray too much varnish, it may clog the windsheet.

If this happens (as it happened to us) it is possible to clear windsheet with a metallic ruler.



Prior to paint or varnish, flutes should be tested ...

4 - 8 - FLUTES TESTING

Although it is not recommended to blow into a flute for the test, it is difficult to resist. This has the bad effect of putting the moisture inside.

But it helps to have a quick idea on the fact that the flute "sings" or not.

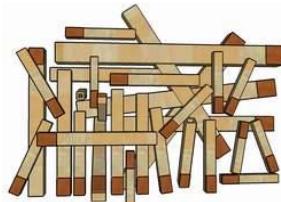
The perfect tuning of a flute can be done once connected to your own blower, and via your own valves unit. These two elements will be described later.



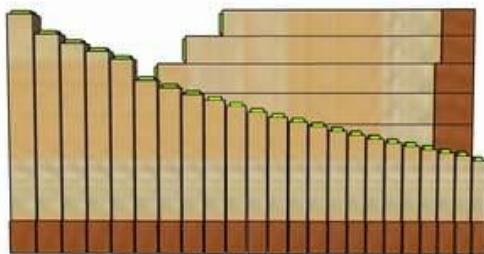
4 - 9 - FLUTES LAYOUT

After completing the flutes, you have the choice for their layout.

Keep still in mind that the layout will affect the overall volume of the instrument.

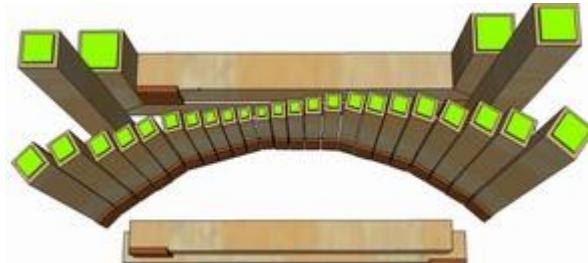


Here are two types of layouts we chose for our 2 organs :



Layout for organ n° 1

Flutes 1-6 horizontally on the rear
Flutes 7 to 29 vertically on the front



Layout for organ n° 2

Flutes 1 and 2 - 90° bended behind the arc
3 and 4 flutes horizontal before the arc
5 and 6 vertical flutes behind the arc
Flutes 7-29 arcuate

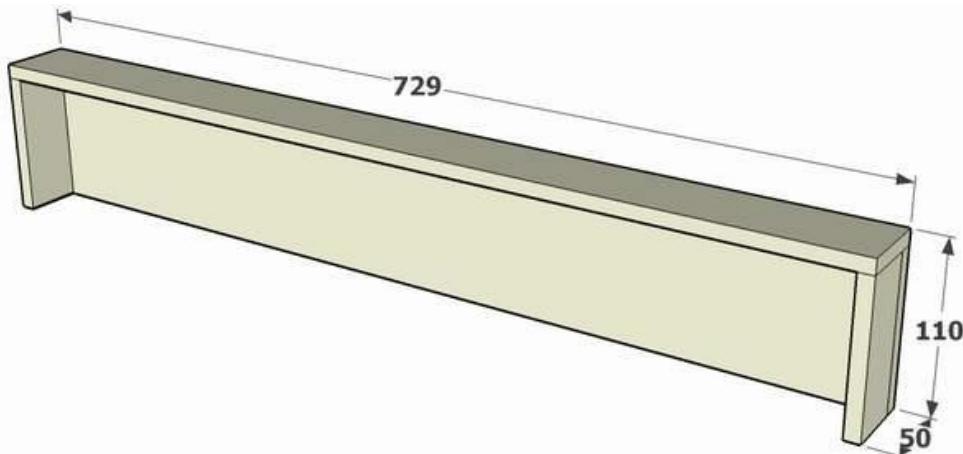
Here are the details for the layout of the organ n° 1 :

It uses two separate wooden board which are cut in plywood of 10 mm thickness. The flutes will be maintained in position by inserting their outlet air tube in the holes made in the two wooden board.

Dimensions the horizontal wooden board for flutes 7-29 :

- 655 mm for all flutes
- 66 mm for the spaces between flutes (2 mm between each flute)
- 30 mm for the two end areas (15 mm on each side)

This makes a horizontal support 729 mm width and 50 mm depth.



For flute position, you must make a more aesthetic than technical choice :

Align flutes on their front or on their back side ? It's up to you!

Despite all care you took in the manufacture of flutes and the drilling of the support, there is little chance that the flutes have a perfect alignment when positioned against each other.



In order to get a good verticality of each flute, it is necessary to make them solidarity by two wooden slats located on the back, so almost invisible.



Through a series of cardboard layers, you should get good verticality.

Then, you need to put a short screw to maintain in place the horizontal slat and the rear slats of flutes.

Insert the screw about 2/3 of the height of the flute and check that it does not enter in the area where the stopper slides. The fact of entering one screw inside the flute is not a problem because this is taken into account during the tuning operations.

We opted for an alignment of flutes on the front. So we inserted behind them cardboard layers in different numbers according the size of the flutes.



Initially, we set up two aluminum plates. Seen from the front, it's not beautiful !

So priority to wood

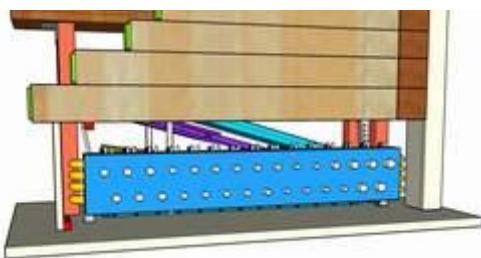
Do not glue the flutes on the support.

This would complicate disassembly if one day, we had to work on one of them.

To ensure proper mounting, we simply put a small screw which passes through the support from below.



Dimensions the vertical board for flutes 1-6 :



Let's go in the future to predict the location of the valves unit.

Effectively with flutes of the organ n° 1, it is planned to place the valves unit under the horizontal flutes. We must therefore raise all these flutes.

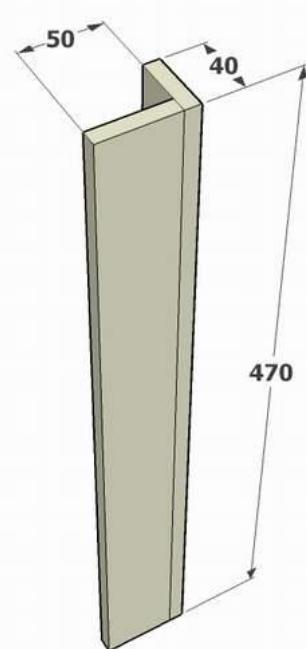
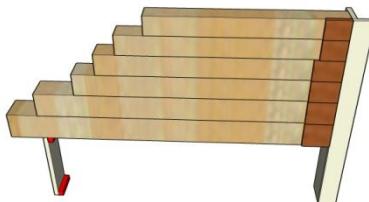
Unlike vertical flutes, horizontal flutes are not spaced from each other, but are stacked on each other.

Calculation of overall height:

- 296 mm for all flutes
- 174 mm to leave room for the valves unit

So we made a vertical support of 470 mm in length.

To keep the assembly on the opposite side of the vertical support, there must be a small board held in place by a wooden bracket.





For fixing the wooden bracket under the lower flute, you will definitely fall in the area where the stopper is. So it is best to stick the wooden bracket to the flute, thus avoiding the screws.

As we have done for vertical flutes, there must be a system in place to maintain firmly the horizontal flutes.

Considering the most important differences to compensate, we stuck together several unused slats.



Here is the result for the organ n° 1



(After tuning operations, ugly ring pitons will be hidden)

Here are the details for the layout of the organ n° 2 :

In this arrangement, it uses two angled flutes.

This reduces in great proportions the length of the flutes, and so therefore the total size of the instrument.



In the case of angled flutes, the effective length to be taken into account is that of the central axis.



To reduce the total volume even more, we may use angled flutes in several directions.

For the larger flutes (1-4), the input position of the connector tube has changed.

The entrance of the tube is no longer in the base of the flute, but at the rear.



For this organ n° 2, a single support is sufficient. It will be cut in a beautiful solid wood board because once finished, the support will be clearly visible.

At first, it is not easy to accurately determine the final dimensions of the support board.

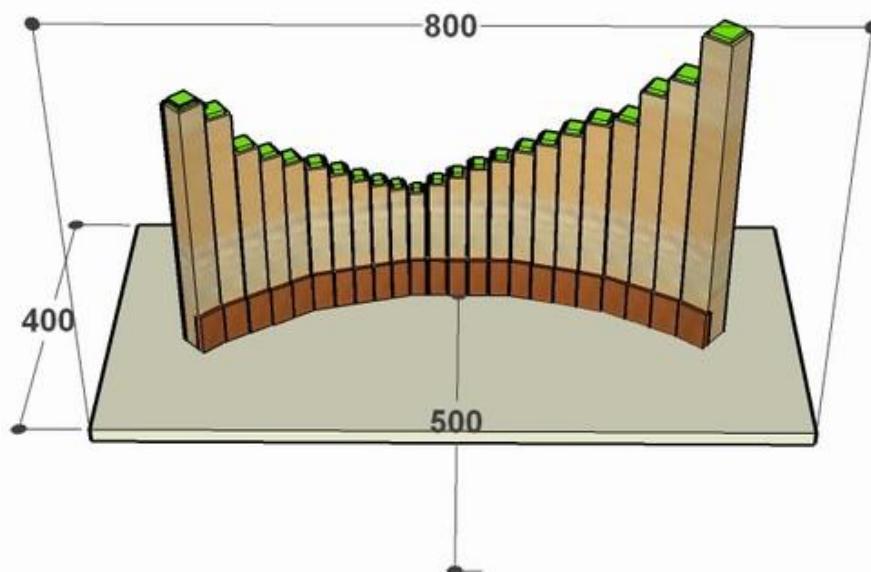
Indeed, contrary to what one might think, flute n° 29 is not necessarily placed in the center of the arc. This is explained by the different widths of flutes.

Here is a simple way to get the desired result.

Start on a larger board, say a board 800mm x 400mm. Using a string and a pin, trace a large arc of +/- 500 mm in diameter. Position yourself flutes on the bow to find the point of origin for the flute n° 29.

From that point of origin :

- Go to the right with the odd flutes (27/25/23/21/19/17/15/13/11/9/7)
- Go to the left with the pairs flutes (28/26/24/22/20/18/16/14/12/10/8)



Flutes 5 and 6 are fixed vertically on the support, a little behind the arcuate flutes.



As for the organ n° 1, each flute is held in place with a small screw, going through the support.



Flutes 3 and 4 are fixed under the support, and are held with brackets.



The air supply flutes 1 and 2 is done on the back

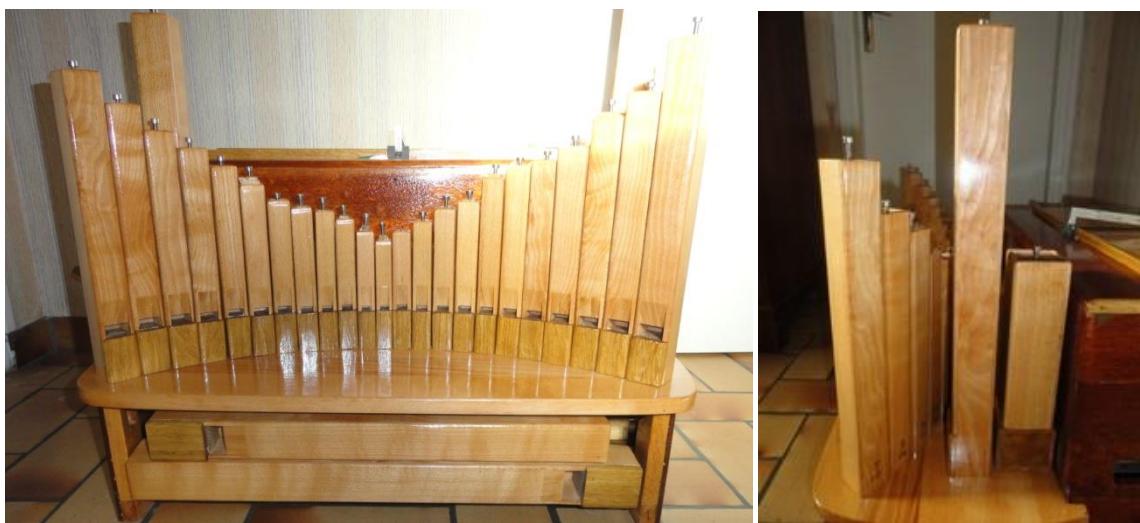


Once all the flutes in place, simply cut the support table to its right dimensions.

You can choose an very original shape.

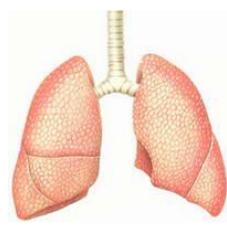


Here is the result for the organ n° 2



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 :

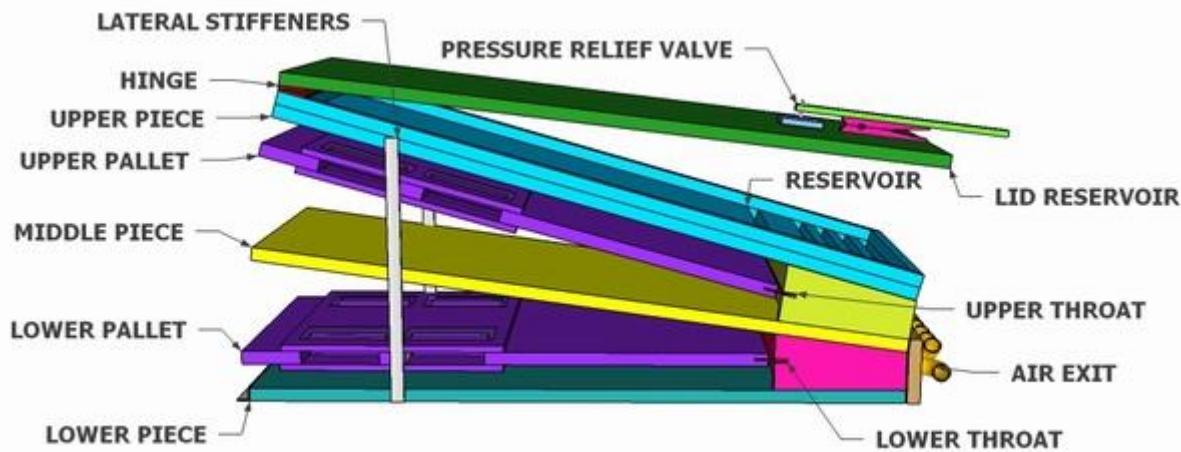


Photo of the blower half lined with skins (this allows you to see inside)

5 - 2 - WORKING PRINCIPLE

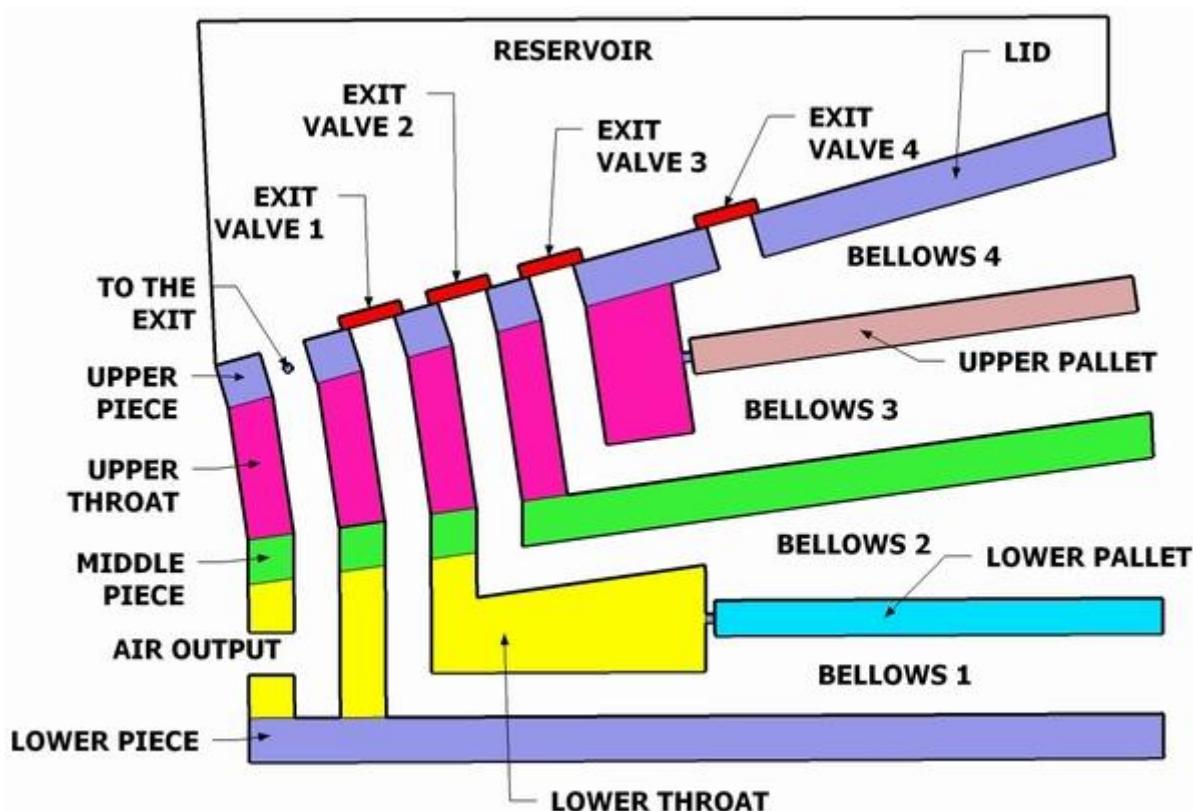
Before proceeding to the construction, it is helpful to understand the working principle.

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.

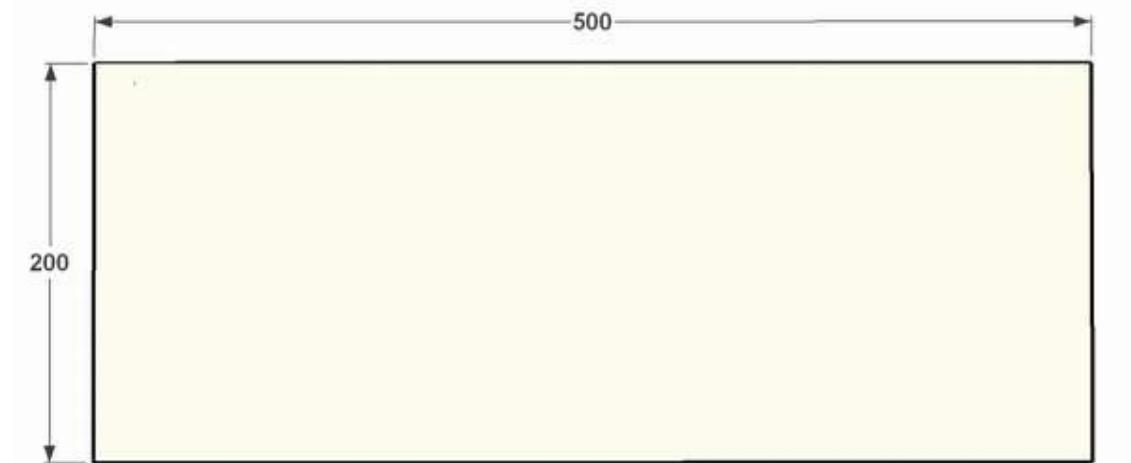


During manufacturing the blower, you must always remember caring assemblages and collages to eliminate any risk of air leaks. Besides the fact that they are sometimes difficult to locate, they are also often difficult to seal.

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.



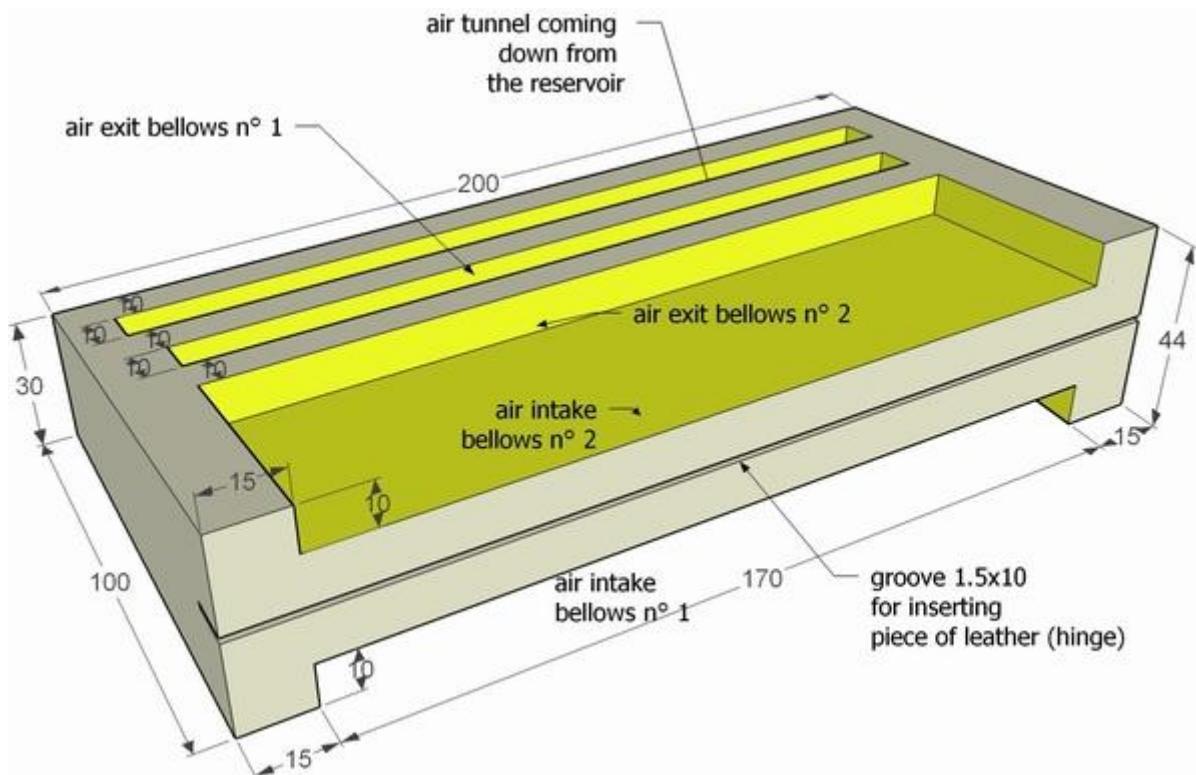
Very complex sketch of the bottom piece

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).

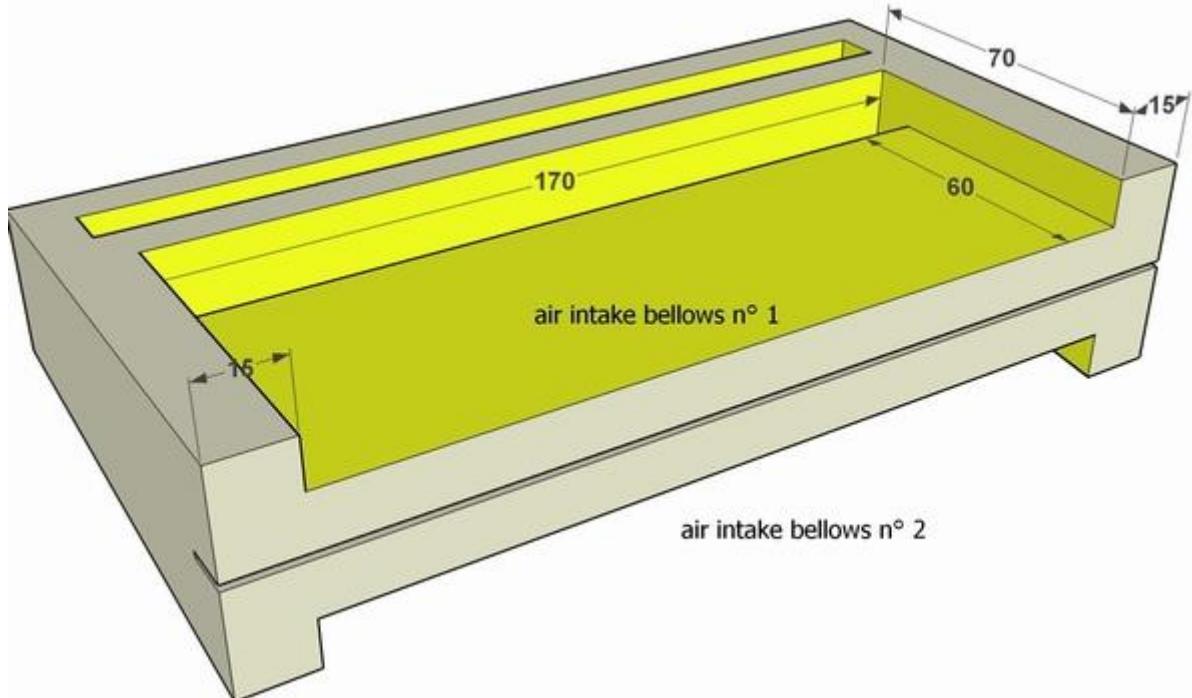
Note that machining on our sketches were drawn at right angles but in reality, they are made with rounded angles which is simpler.



Sketch of the lower throat - top view



Photo of the lower throat - top view



Sketch of the lower throat - view from below



Photo of the lower throat - view from below

5 - 5 - LEADING AIR FROM THE BLOWER TO THE VALVES UNIT

It's fine to produce air, it is also necessary to give it the possibility to go inside the valves unit and after to the flutes.

The connection is made with plastic tubes from the rear of the lower throat. Then, plastic tubes are connected on each other on the narrow sides of the valves unit.



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.

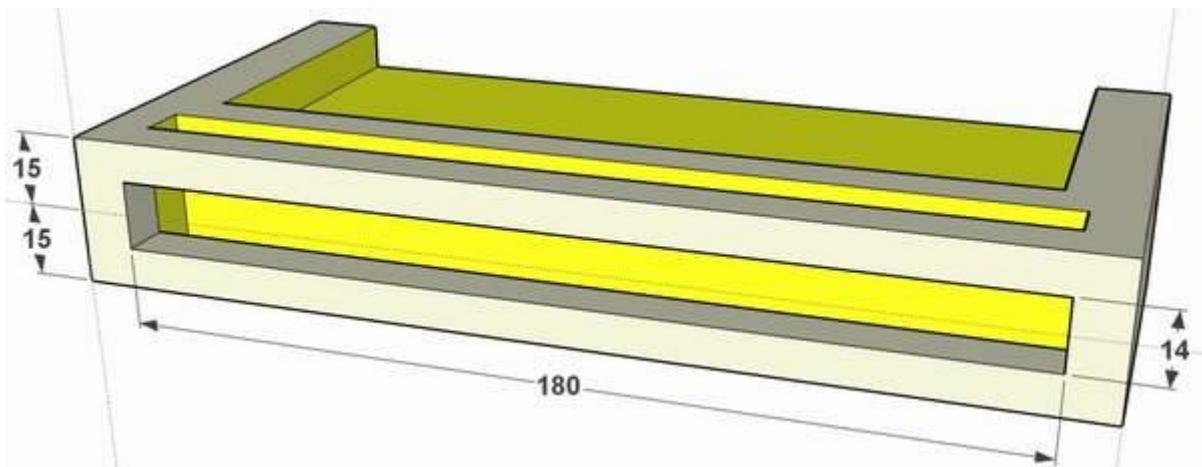
In fact, all we were able to make, it is a machine to bubble.

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.

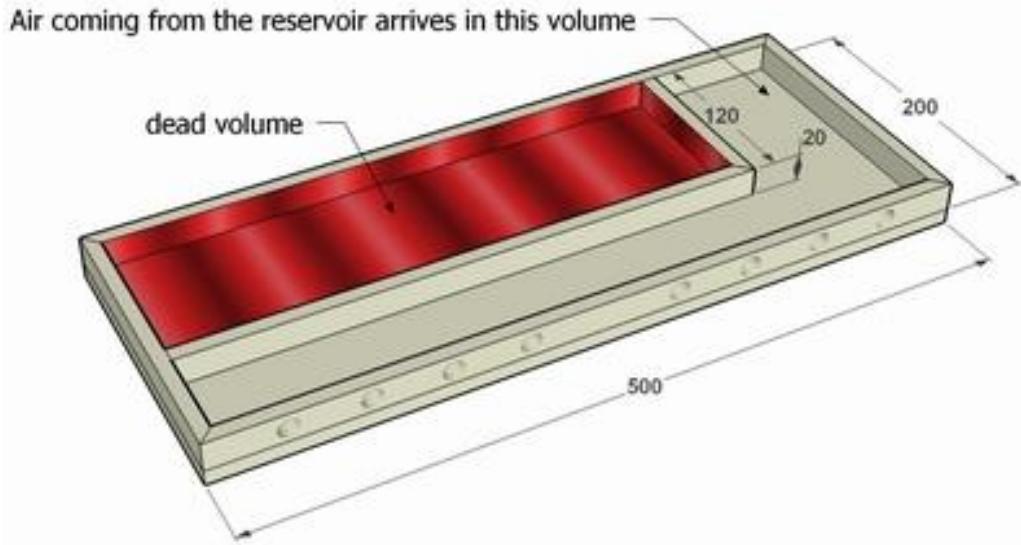
For organ n° 2, we have put under the blower an air tunnel with a "death" volume to avoid excessive air consumption, so we get rapid inflation of the reservoir at startup .

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.

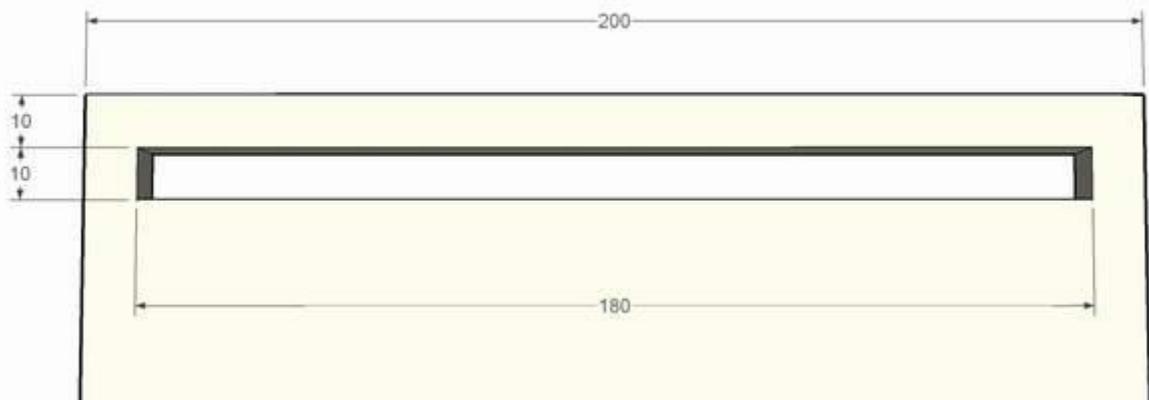


Sketch of the air tunnel for the organ n° 2



Photo of the air tunnel (during drying)

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.



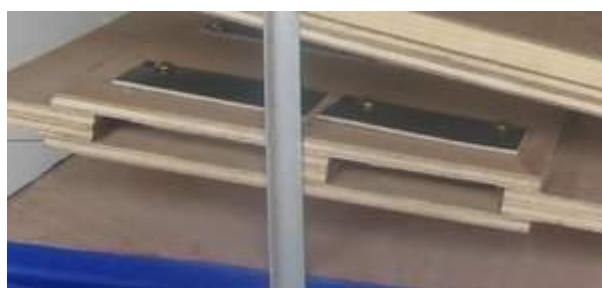
Sketch of the air tunnel lid for the organ n° 2



Photo 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)

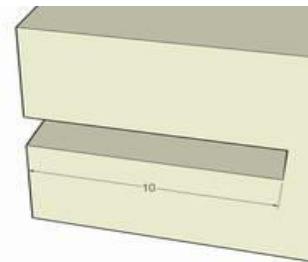


It takes a piece of plywood 400 x 200 mm thickness 10 mm for the pallet, and two pieces of plywood 165 x 200 mm, 5 mm thick, which are bonded to the pallet and that support the valves.

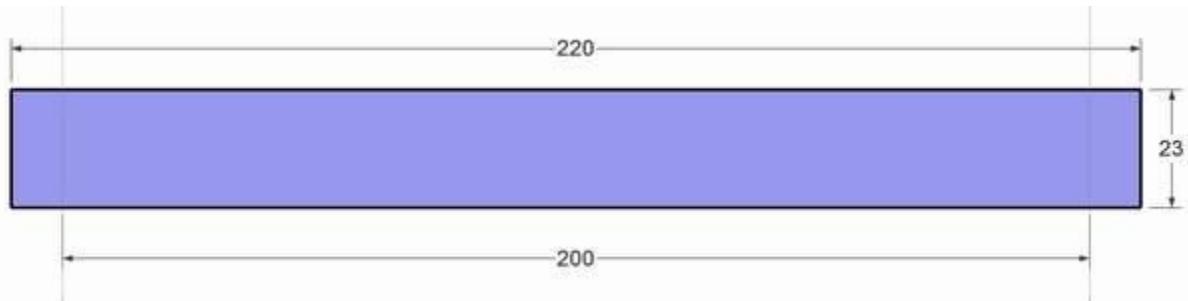
On the rear small edge of the pallet must be a groove to receive a leather strip acting as a hinge.

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.

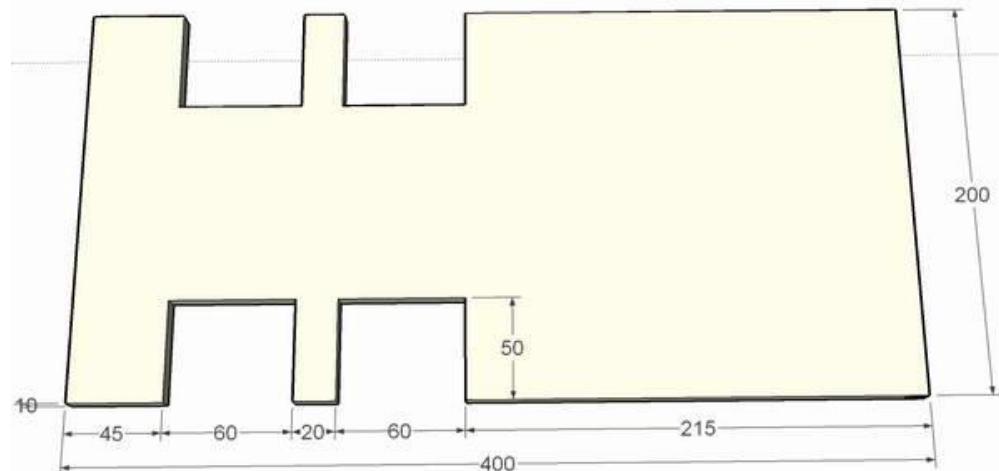
Before its introduction, the leather strip will be spread on both faces with vinyl glue.

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 !

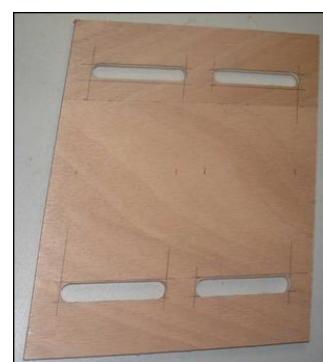
All year long they pollute your mailbox with their bogus invitations.
This is the time to visit them ...



Sketch of the lower pallet



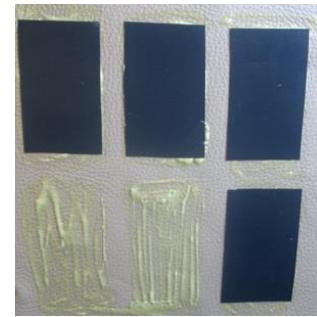
Main part



Valves support

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.

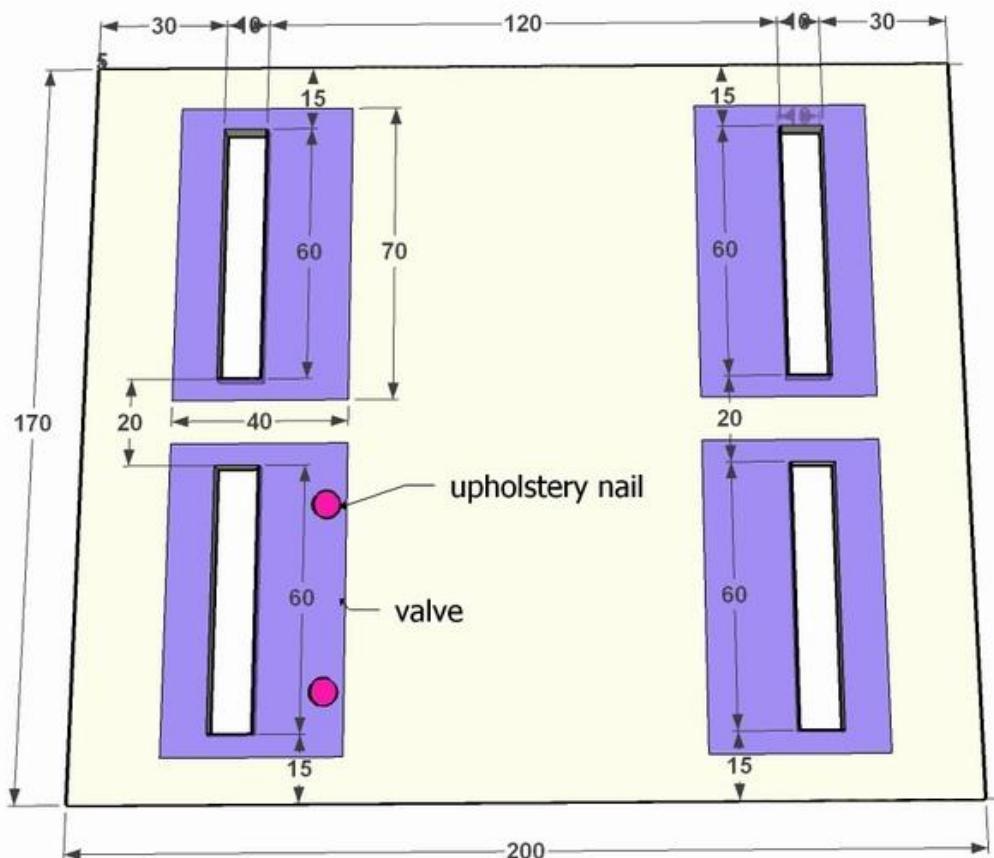
It is the smooth side of the leather which has to be glued against the plastic film and not the fluffy side. It will take 16 in all (8 for the lower pallet and 8 for the upper pallet)



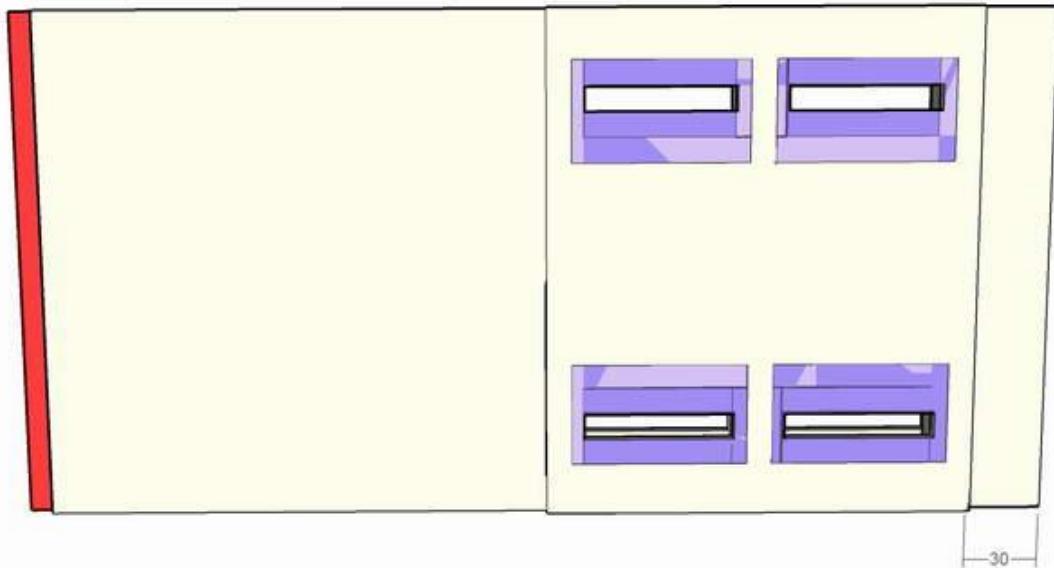
Leather fluffy side must be faced the pallet. The assembly is secured by two upholstery nails.



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



Sketch of the valves support



Sketch of complete lower pallet



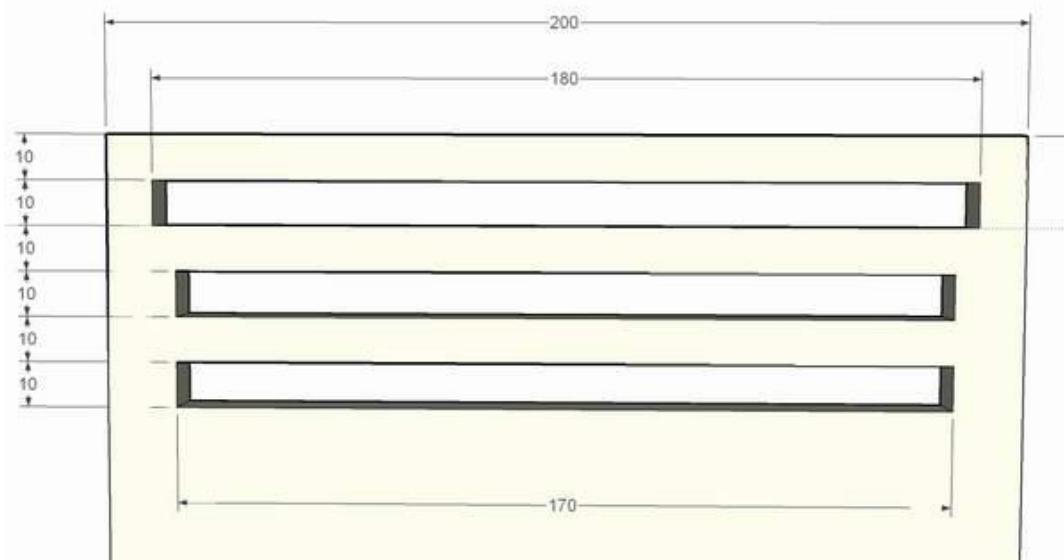
Lower pallet without valves



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



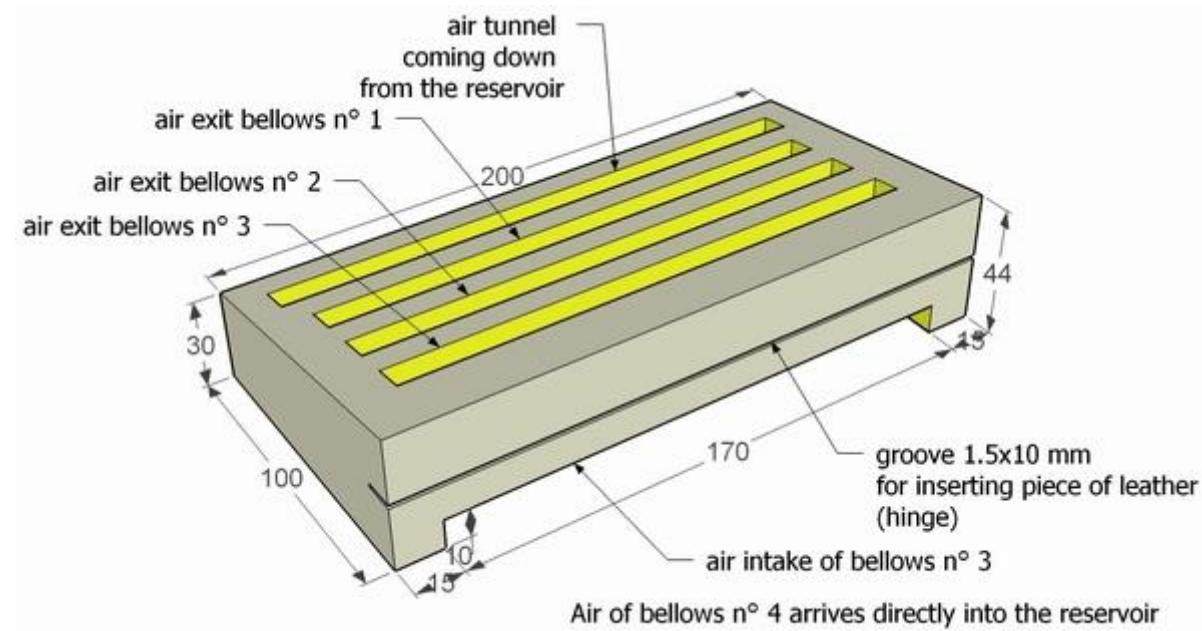
Photo of the middle piece

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

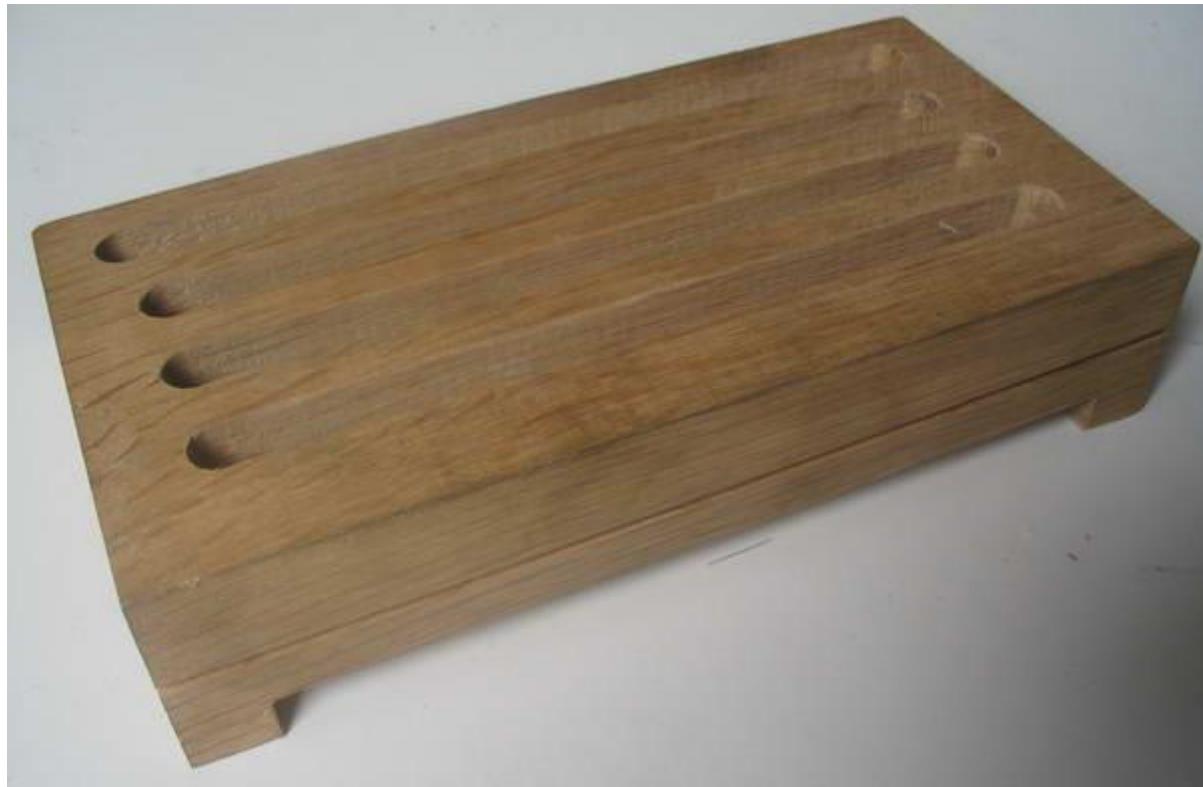
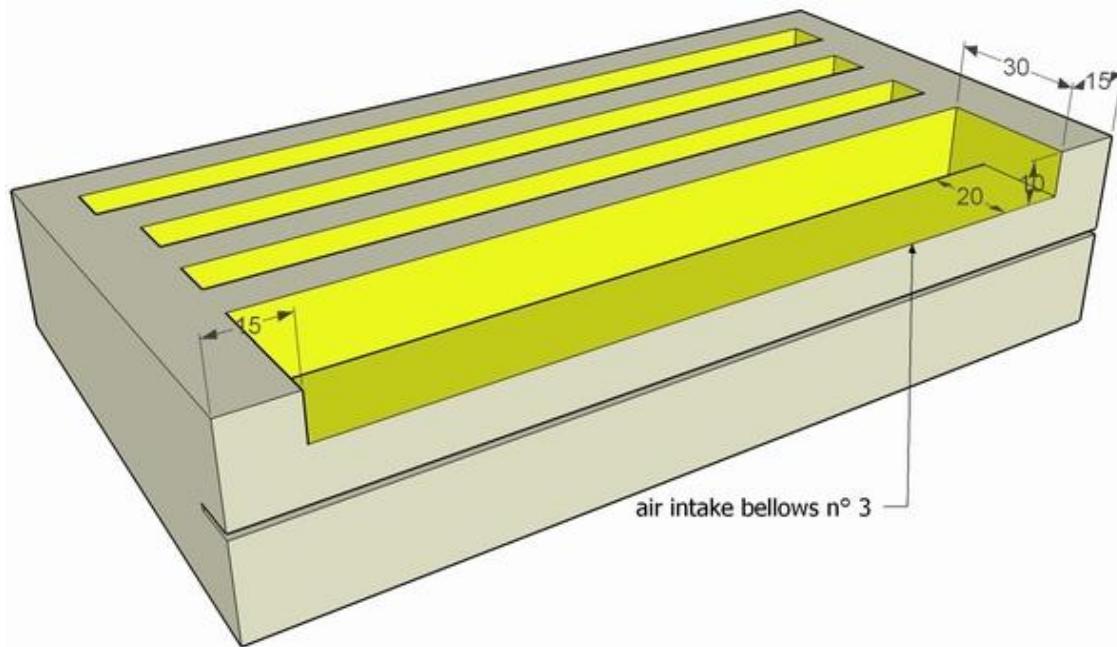


Photo of the upper throat - top view



Sketch of the upper throat - bottom view



Photo of the upper throat - bottom view

5 - 9 - THE UPPER PALLET

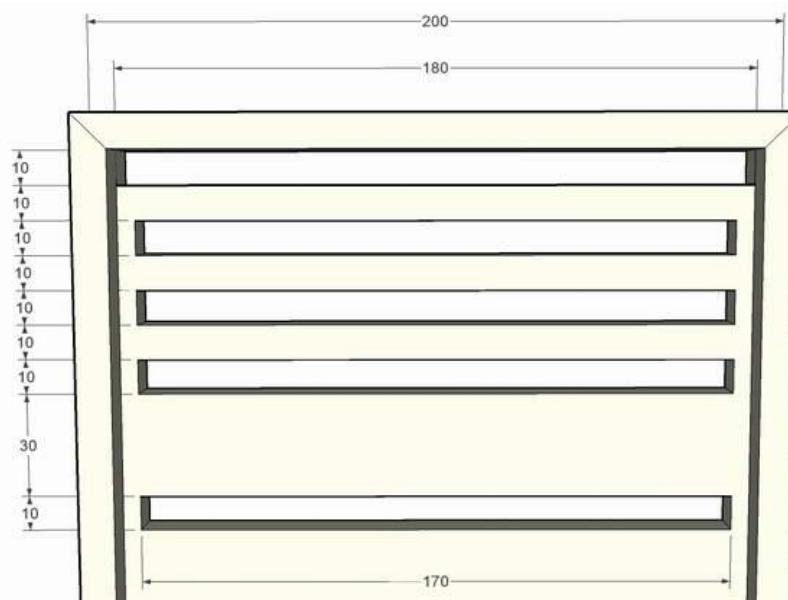
Exactly the same as the lower pallet - See description above.

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

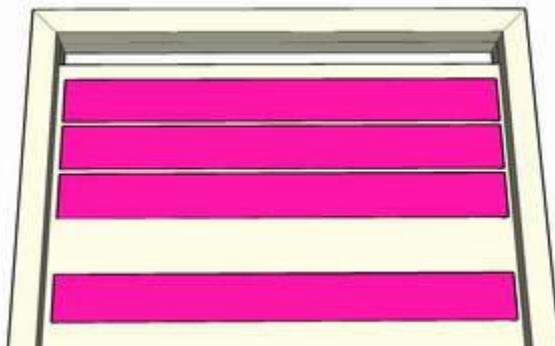


Photo of the upper piece (without valves)

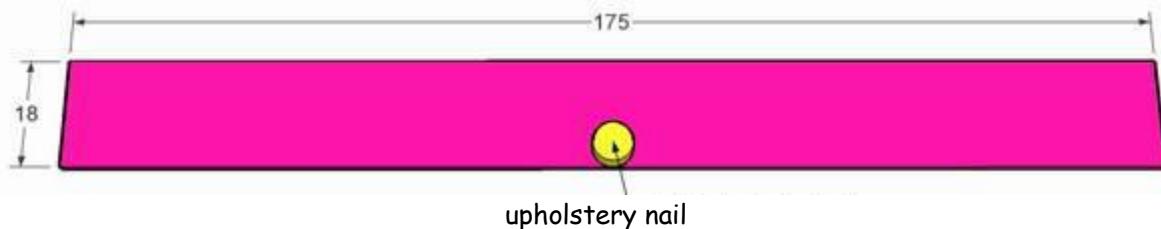
To prevent air from the reservoir to return where it came from, 4 valves must be positioned just above the apertures of the upper piece.

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.



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

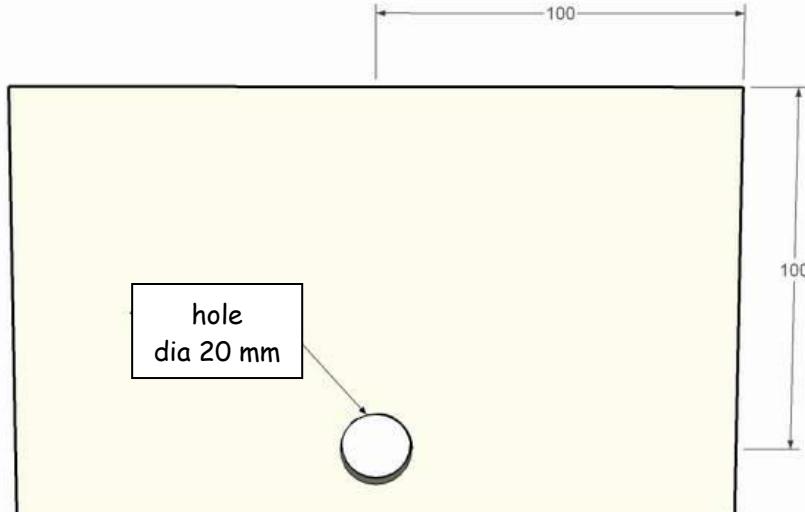
Therefore, both external parties will easily lift.



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

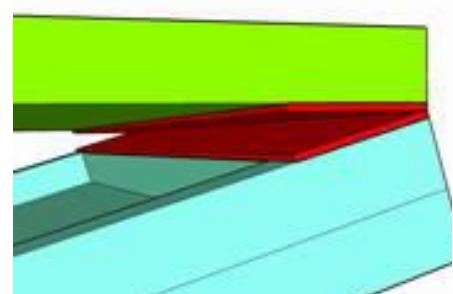


Photo of the reservoir lid

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.

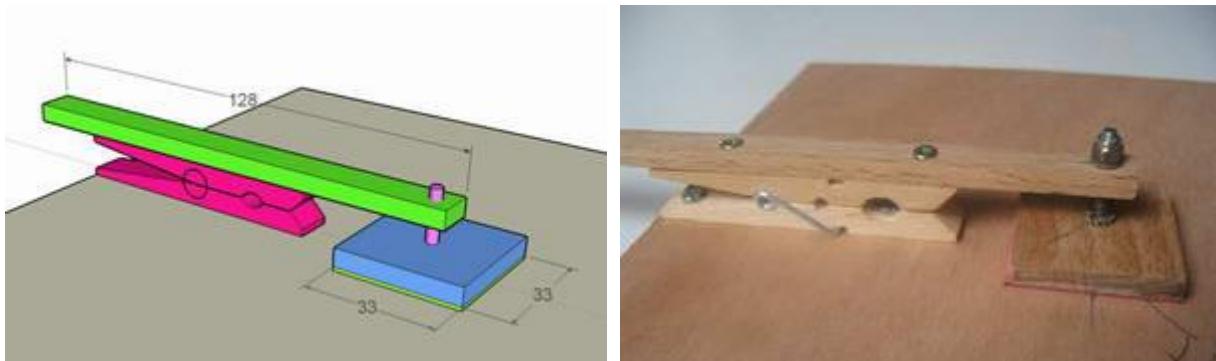
A spring mechanism controls the opening of a valve that is positioned just above the hole of 20 mm.

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

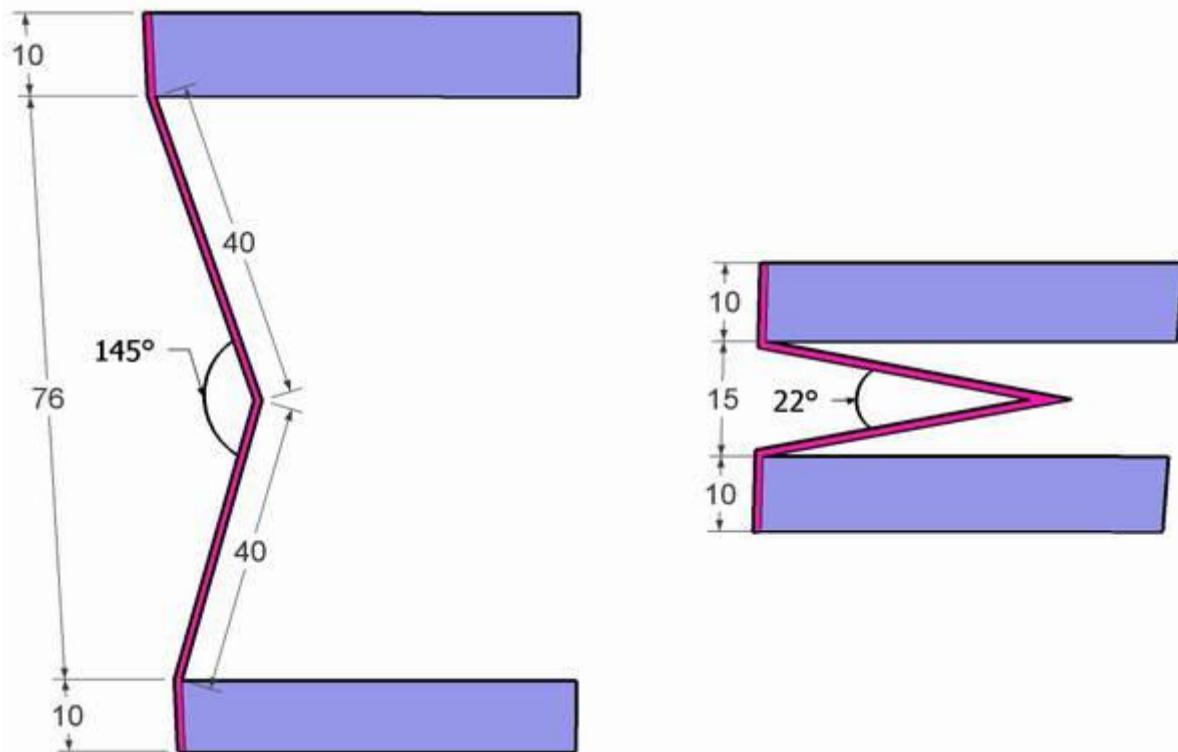
You have to line in the 4 bellows of the blower, but also the reservoir.

Let's start with the explanations for the bellows.

Warning : 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.



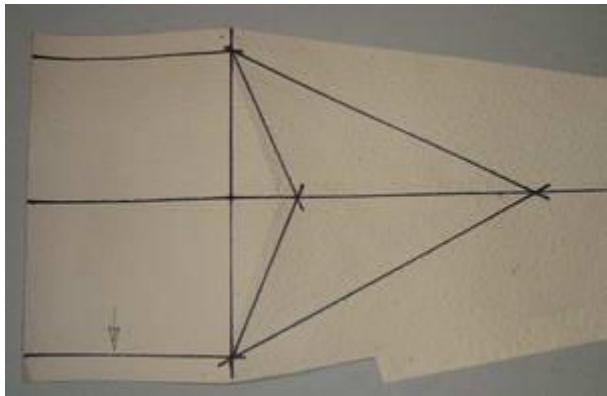
The above dimensions are those of bellows skin and not for the reservoir skin.

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 .

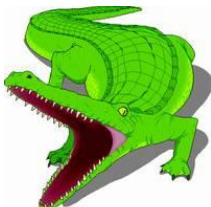
Before pinning up the pattern on the bellows you must insist on paper folds to make it fold where it should be.





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 m² (depending on creature size)

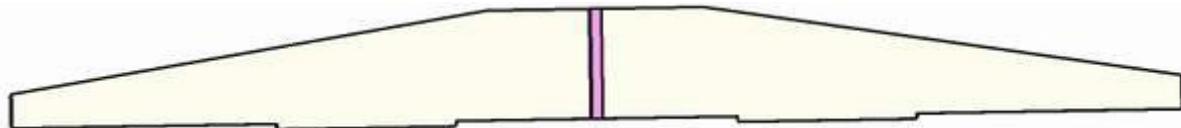
But beware : perfectly rectangular lambs are not numerous, so that the entire surface is not exploitable.

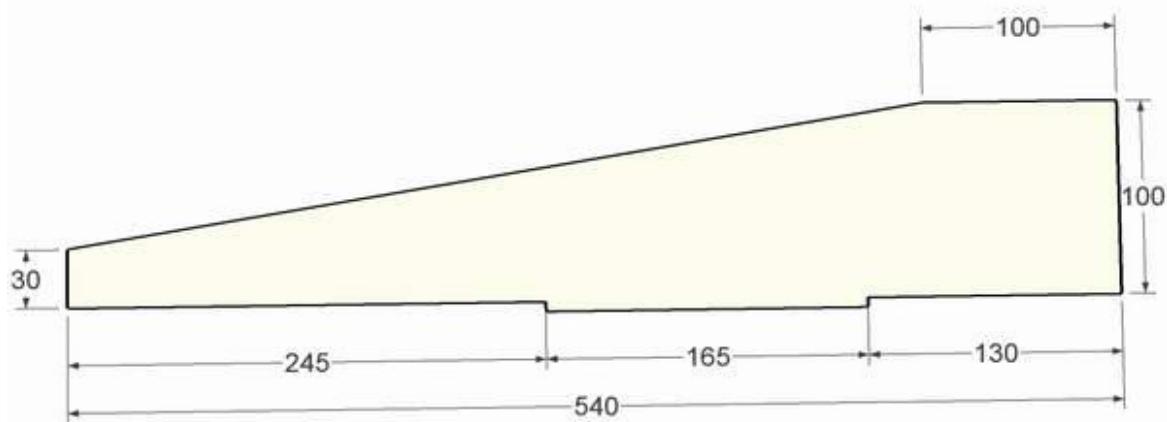
So you have to supply 2 skins.



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.

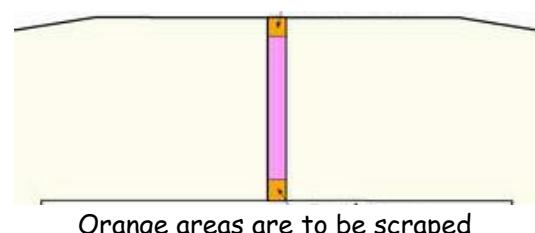
Different skins will overlap on the edge of the pallet, and also at the connection end to end of two half skins.

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 $\frac{1}{2}$ skins, skin of the strip has its fluffy side against the two halves glued-skins. Its smooth side will be applied to pallets.

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 cardboard are called "stiffeners"

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

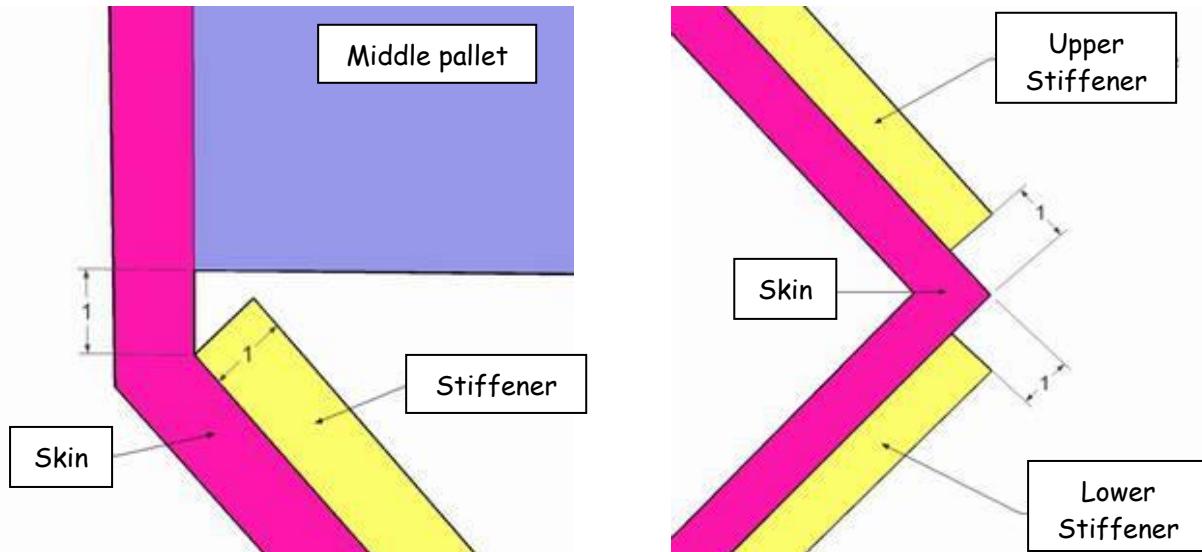
These internal reinforcements must be very firmly glued to vinyl glue (white glue for wood).



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

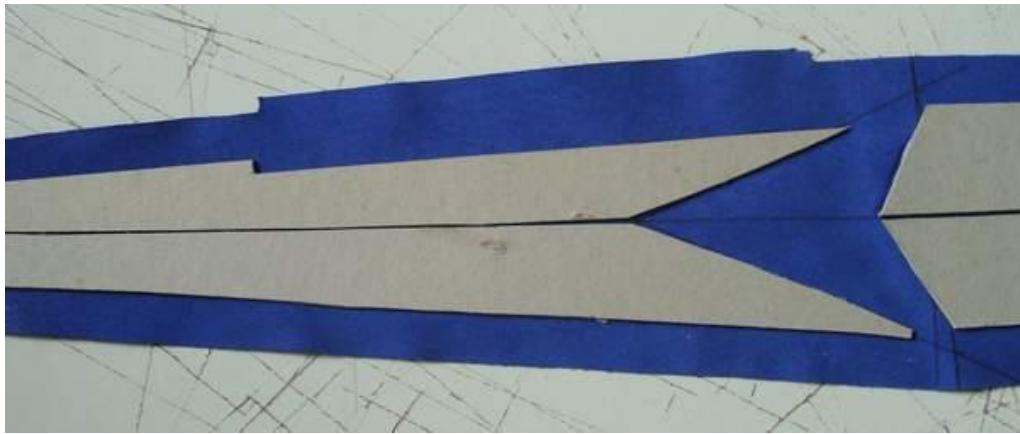


The space between the outer edge of the stiffener and the pallet is of the order of 1 mm, which is equivalent to the thickness of the stiffener

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

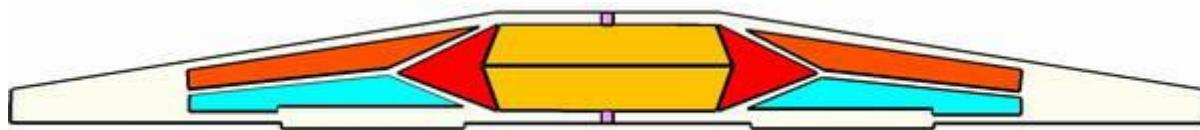
To determine the dimensions of the stiffeners and their location, it is advisable to draw on skins lines bounding surfaces theoretically intended to receive the stiffeners.

Then reserving a small margin of 1 to 2 mm.



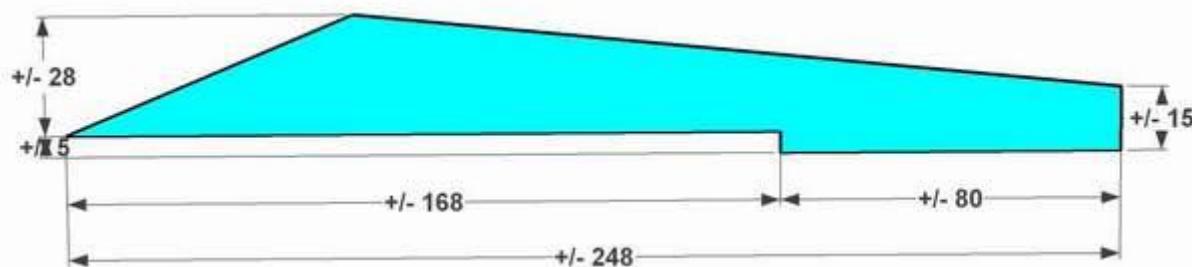
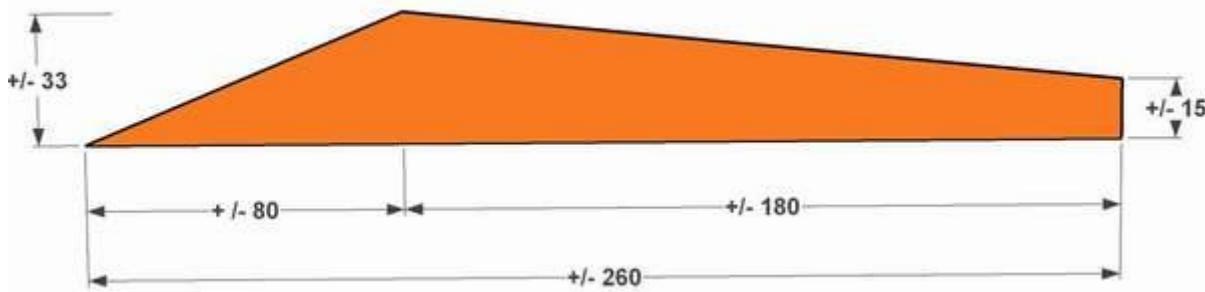
When it folds and unfolds easily and properly, we are on the right way. It is then necessary cut all stiffeners with same dimensions (except those of the reservoir).

Here the positioning of the various stiffeners .Two of them cover the junction between the two leather strips connected end to end (in yellow on this sketch)



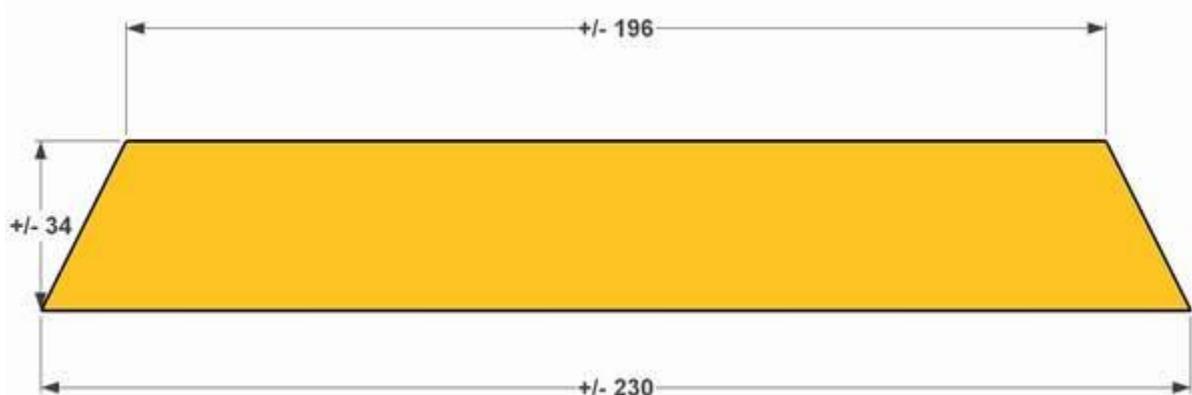
Once the 4 lateral sides and 2 front sides in place, there must exist two sectors not covered by stiffener. Above, they appear in red.

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

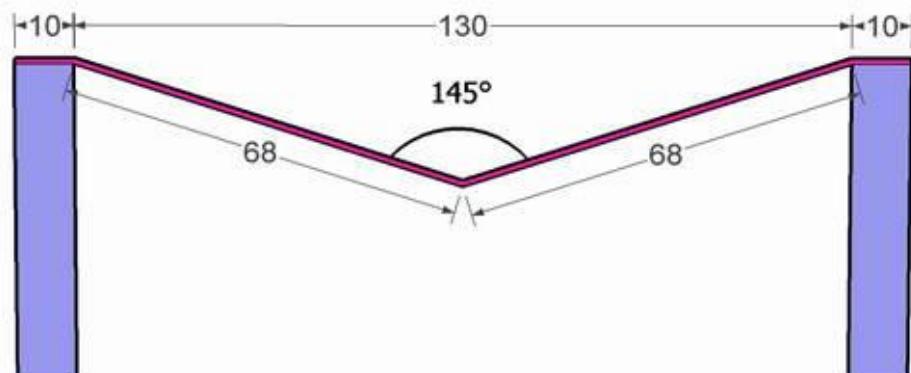
5 - 15 - RESERVOIR LINING

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

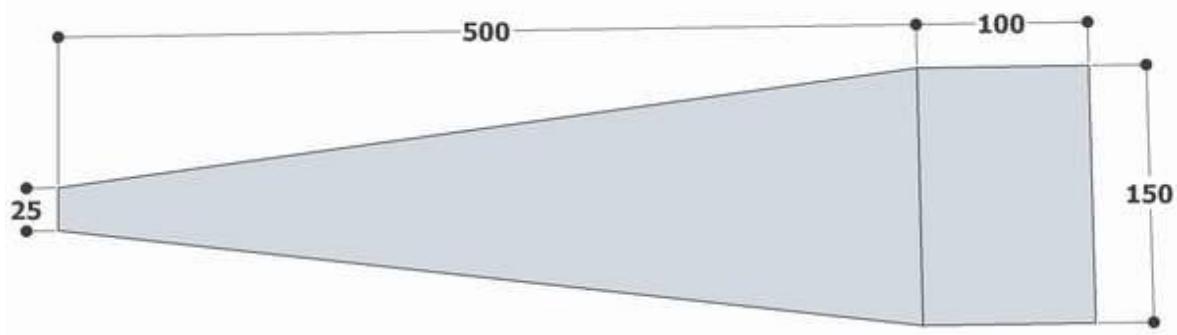
That is an estimate of the maximum skin :

$$10 + 68 + 68 + 10 = 156 \text{ mm.}$$

rounded to 160 mm



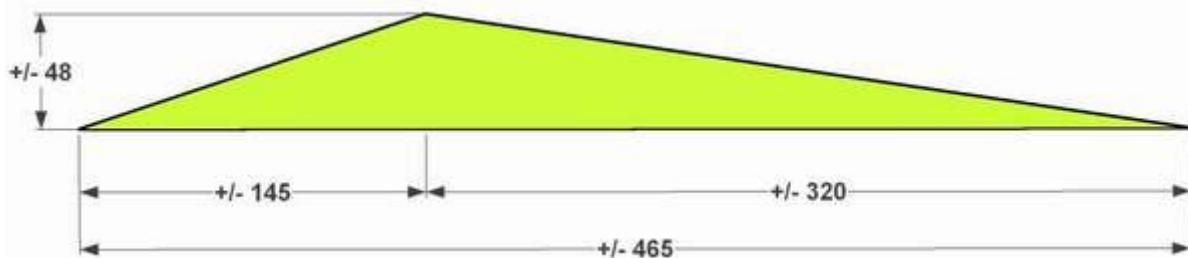
See below an estimate of skin size to line half of the reservoir.



5 - 16 - RESERVOIR STIFFENERS

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

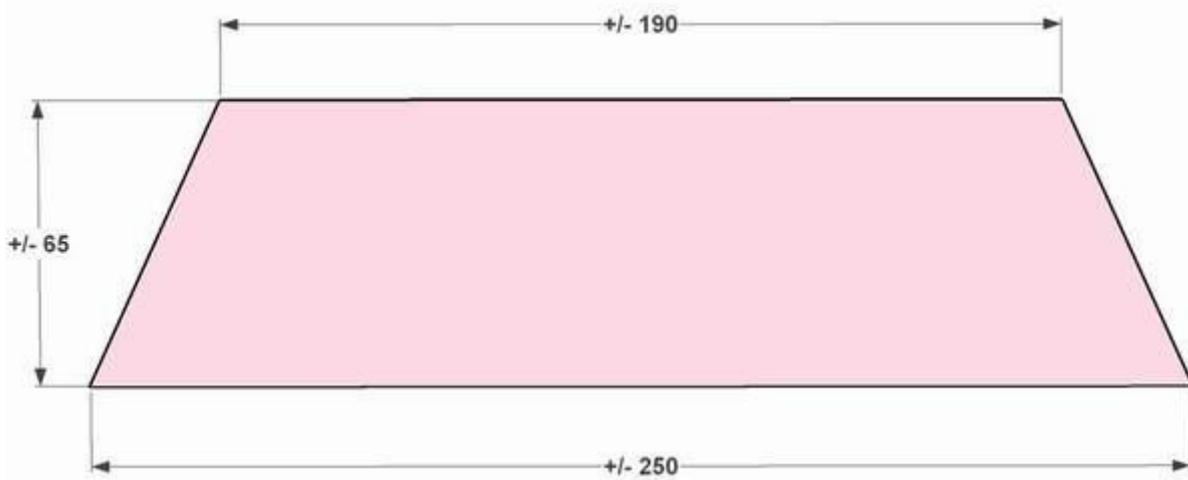
Dimensions are always given for guidance only and are to be validated according to your reservoir.



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.

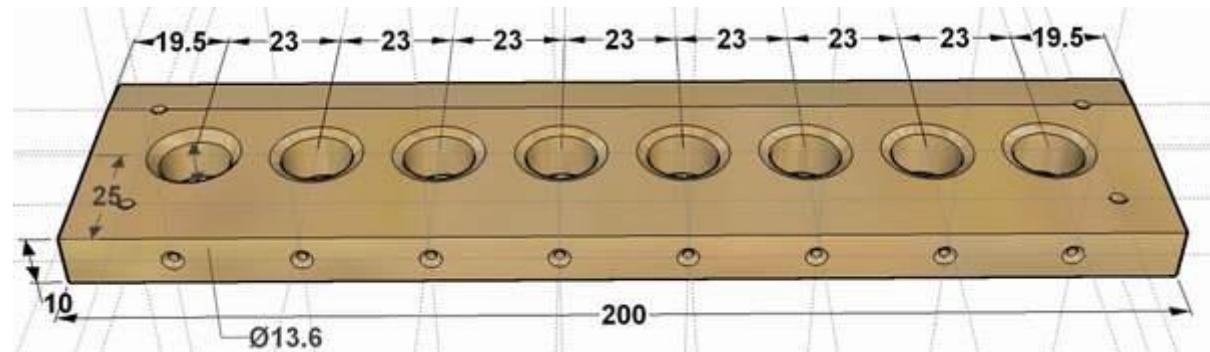


5 - 18 - CONNECTION BETWEEN BLOWER AND VALVES UNIT

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.

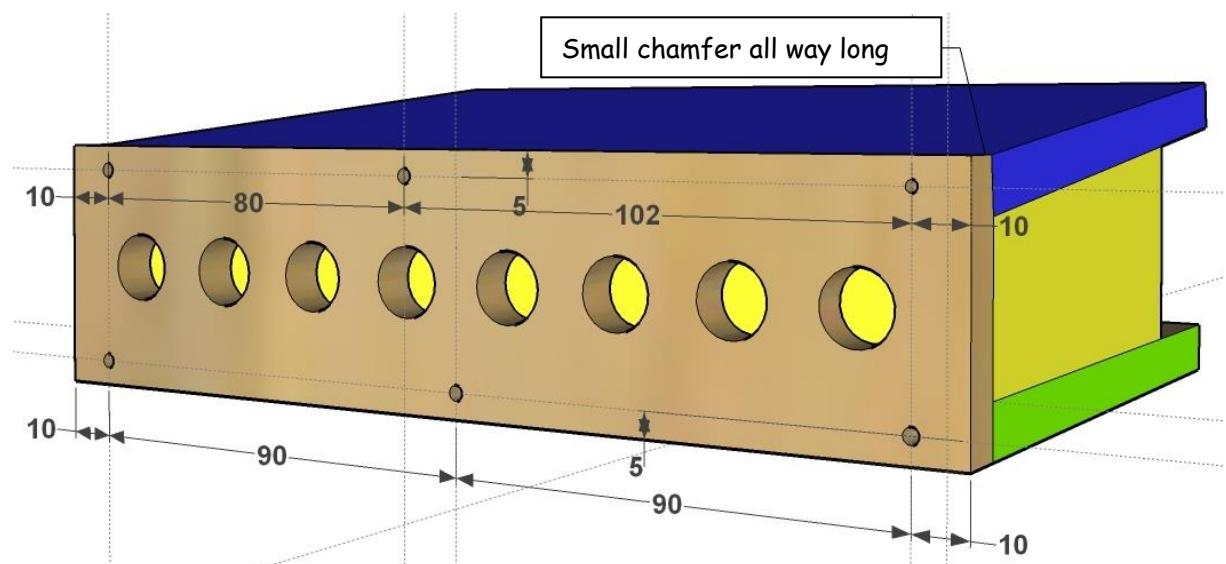


On one face of the cleat, we make a small circular chamfer on exit holes of 13.6 mm, just enough to deposit a silicon seal once copper elbows have been fitted.

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.

For information, we attempted an alternative, with a connecting plate cut in epoxy printed circuit. But it could not stand the heat of the torch .



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.

This structure will be described in Chapter 6-4.

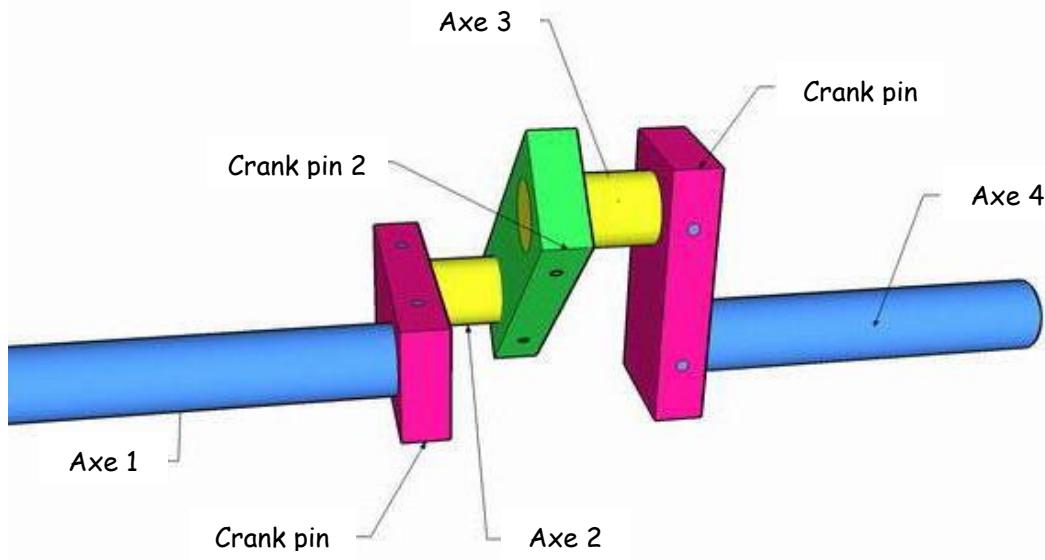


Apart the test phase that may take you backward, we can consider that your blower is complete and you can proceed to the next step.

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

6 - 1 - THE CRANKSHAFT

This part, controlled by the crank, is used to activate the two connecting rods which in turn will activate the pallets.



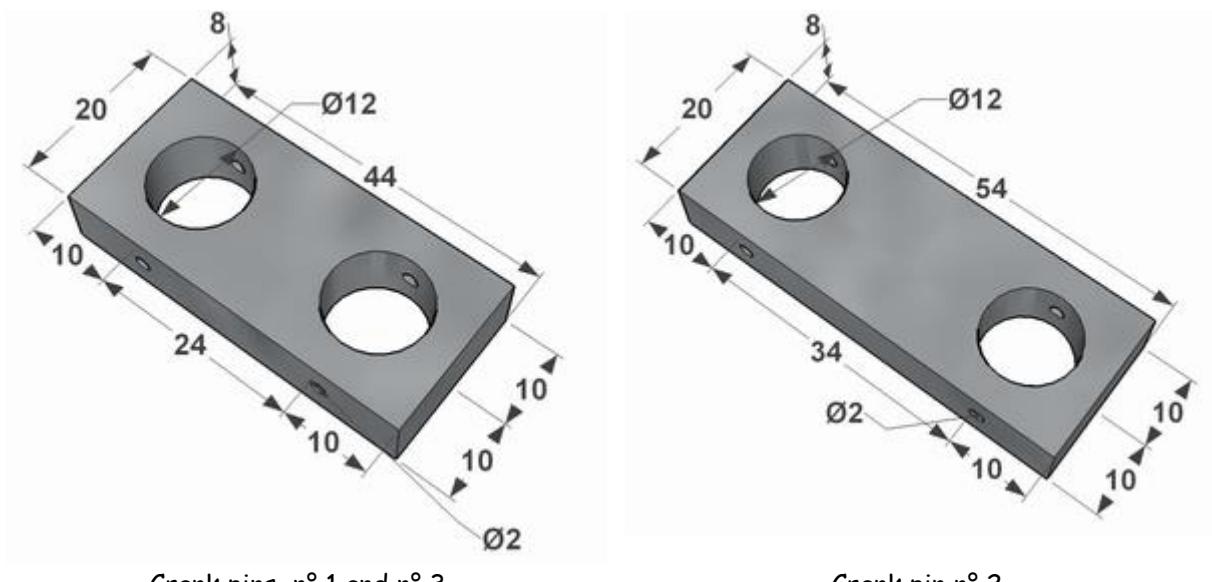
The crankshaft movement is from + 22 mm - 22 mm.

The space between two crankpins is of 13 mm. They are offset by 45 °.



The crankshaft is not an easy piece to manufacture, and requires extreme precision, which if it is neglected, make the crankshaft not working properly, or even not at all. The crank could be hard to turn. Be careful not to catch tendinitis each time you play.

To achieve a good result, two axis 1 and 4 must be in perfect alignment, and you must scrupulously respect the dimensions of the crank pin 2. We realized the crank pins in aluminum.





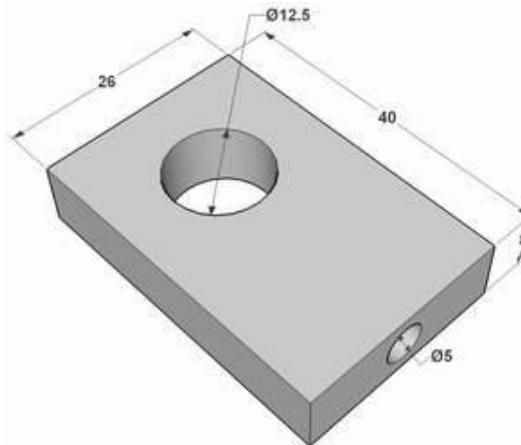
The dimension of 34 mm between the two holes on the crank pin n° 2 is critical, otherwise the crankshaft cannot rotate. This dimension must be equal to the dimension 24 mm of the crankpin n° 1 multiplied by 1.414 = 33,936 mm (rounded to 34 mm)

You need two Rilsan bearings for connecting rods.

The texture of Rilsan ensures good rotation.

Without this material, you can use hard wood.

Rods will be attached to the base (M6 threaded)



You also need 4 axis diameter 12 mm.



The length of the axis n° 1 (the one receiving the handle) is difficult to determine at the beginning because it also affects the ability to remove the organ cabinet from above.

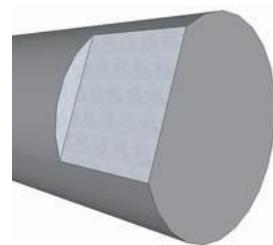
If the axis is too long, it will be impossible to remove the cabinet. If the axis is too short, the crank cannot be fixed. So it is better initially to take some margin over its length.

The length of the axis n° 4 (the one receiving the pulley) is also somewhat difficult to define. It depends on the type of the pulley (gear ratio). So too, you had better to take a little longer and recut afterwards.

Axis length :

- axis n° 1 = length 150 mm (then adjusting)
- axis n° 2 and n° 3 = length 31 mm
- axis n° 4 = length 100 mm (then adjusting)

On axis n° 1 and n° 4, must be a light meal lime for perfect clamping solidarity fixing screws of the crank and pulley.



Implementation of "MECANINDUS" pines.

Between the crankshaft and the hammer, there is only very little space to put your fingers ...





Photo of the full crankshaft

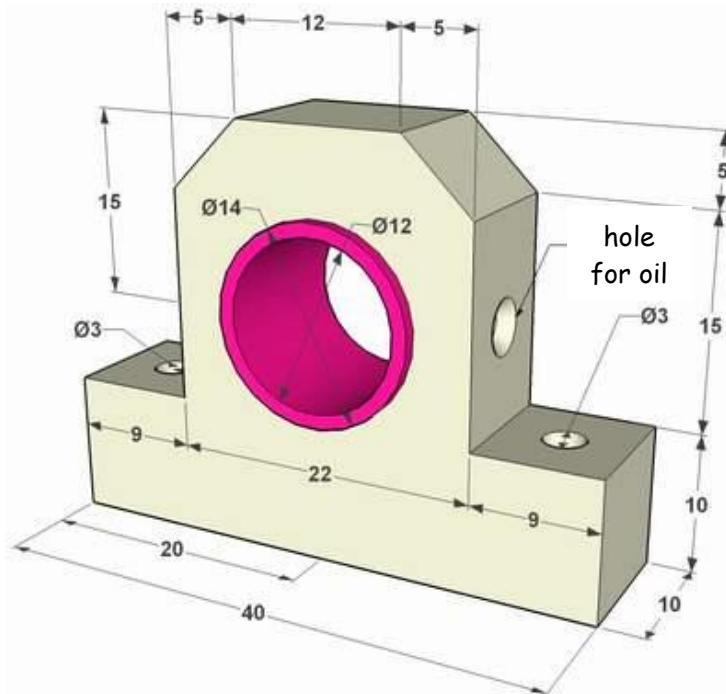
6 - 2 -CRANKSHAFT BEARINGS

It takes a couple of bearings for fixing and rotating the crankshaft.

We fell in luxury by cutting an aluminum block and inserting in force a bronze ring. The durability of the instrument, in this case is estimated at 5 ... centuries.

Depending on your options, you can use oak. In this case, the life of the instrument is limited to only two centuries. It's up to you !

Both bearings will be firmly fixed on the support pillars that support the keyframe. The description of the support pillars will be made later.



A small countersunk hole on the top of each bearing, makes it easy to insert a few drops of oil in it.



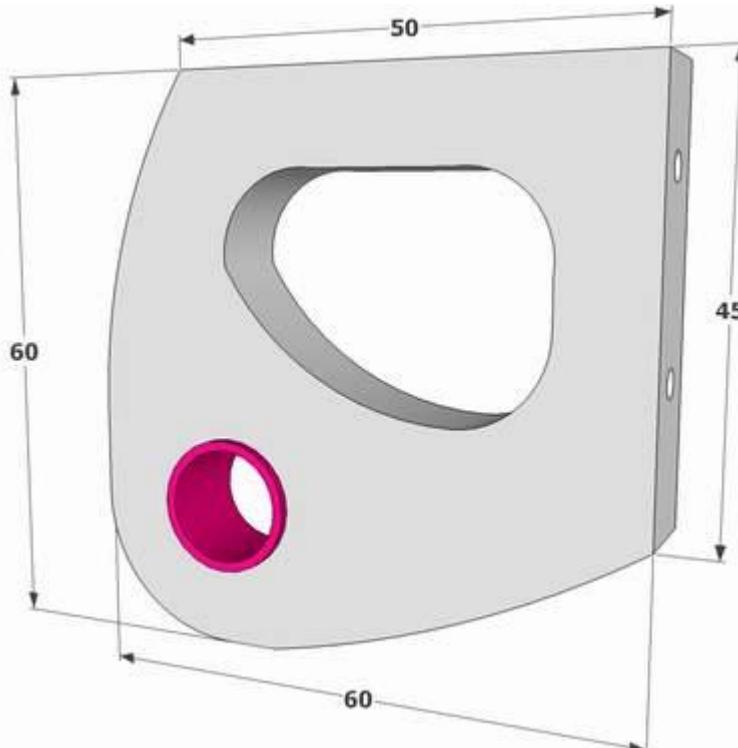
This will reduce friction and reduce noise

The shape of the above bearing has been chosen for the organ n° 1.

For the organ n° 2, bearings have a slightly different shape in order to simultaneously hold the crankshaft and support the keyframe.

The central part is recessed to gain some weight.

This type of bearings will require holes in the keyframe.



View the complete crankshaft and bearings on the organ n° 2.



Visible screw heads on the keyframe (they can be hidden with wood filler paste).

6 - 3 - THE CRANK

For the first tests, you can use a very basic crank.

A simple cleat 20x20, a piece of threaded rod as a handle, and a screw which abuts on the axis of the crankshaft will do the job.

Rudimentary but effective !



But it is still preferable to manufacture right now a more ergonomic and aesthetic model.

You can use a wheel sewing machine (search on flea market)





The wheel sewing machine was sandblasted and lacquered. This looks great, but with a drawback, namely a weight of 4 kg which will force on the bearings.



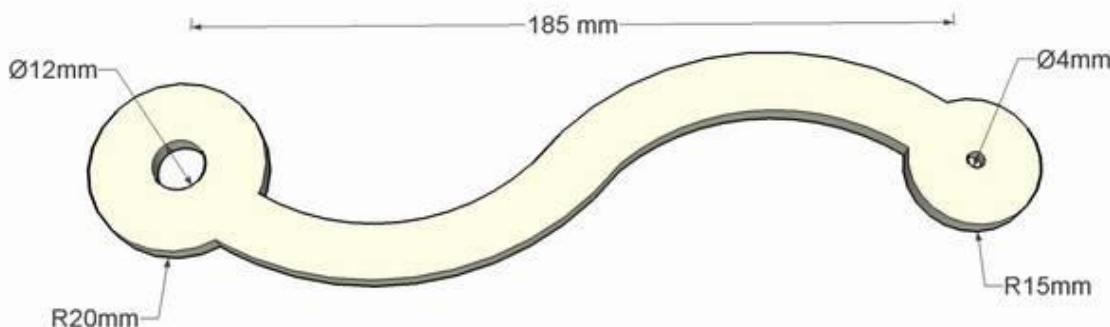
You can keep only one part
The weight falls to 200 grams.



Disadvantage: cast iron is very brittle in this case.

So life time has been only a few days!

If wandering on flea market is not your cup of tea, you can make your own handle. First, you must make a sketch on paper or with a drawing program (SketchUp for example).



Once the shape perfectly defined, you have to go to manufacturing.

Here are 3 steps for a simple crank cut in a aluminum piece 5 mm thick.



Tracing the form
on the aluminum plate



Rough cut
with a jigsaw



Finish Lime

Here is the result for the organ n° 1





For organ n° 2, we chose another method of manufacture, namely a steel rod heated with a torch, and distorted S-shaped

Whatever its form, we must build a system to ensure perfect adhesion of the crank on crankshaft axis. Being dismantled is essential to be able to remove the cabinet organ, and for easy transport (going through a narrow door)

The system we found consists of 2 parts:

1 - A cap crankcase drain, wherein one has a hole corresponding to the diameter of the crankshaft axis (diameter 12 in this case).

A small hole is made of 3.3 mm on one side and is tapped for M4 screws.

This piece will always remain in place on the axis of the crankshaft.



2 - A "connector" metal ring.

For the organ n° 1



For the organ n° 2



- a hole of 17.5 mm and 20 mm threaded corresponding to the diameter of the cap crankcase drain
- At 120 ° apart, 3 small holes 1.6 mm diameter and threaded M2 for mounting screws that pass through the flat of the crank.
- a hole of 17.5 mm threaded M20 corresponding to the diameter of the cap crankcase drain.

For organ n° 1, an extension of 40 mm is added to the connector metal ring described above.

To remove the handle, simply place the handle in a horizontal position and type one single shoot very hard to rotate counterclockwise.

In this case, we use the phenomenon of kinetic energy. For this to work, the belt must be in place.



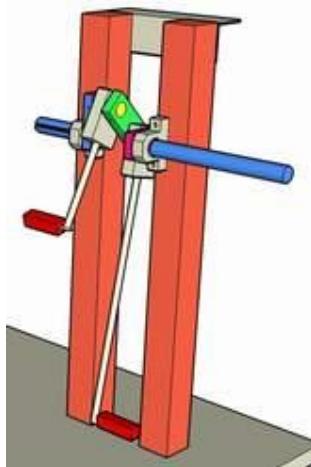
If however the crank does not disassemble as expected, it is possible to block the belt on the pulley through an opening in the cabinet.



6 - 4 - THE SUPPORT STRUCTURE

For organ n° 1, we used pine cleat section 28x28 mm. There are 4 vertical pieces that act as support pillars.

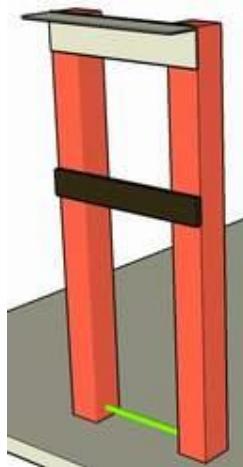
Two support pillars on crank side



These support pillars will maintain :

- the keyframe through a large aluminum bracket.
- the crankshaft via 2 bearings

Two support pillars on opposite crank side



These support pillars will maintain :

- the keyframe through a large aluminum bracket.
- a abutment slat for pressure relief valve lever.
- a threaded rod to hang the large reservoir pressurizing spring (see explanation below)

It is imperative that the 4 support pillars are of exactly the same height.

This will facilitate the realization of the cabinet that will cover the organ.

In our case, support pillars height is 340 mm. The fixing of support pillars on the floor of the organ is made using aluminum brackets.

During initial tests, we started with small aluminum brackets 20x20.

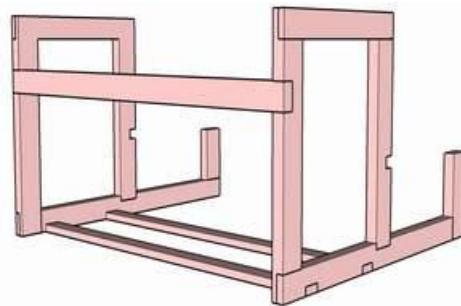
This is not a good choice, because the support structure will oscillate to the rhythm of turns of the crank, with the next major downside :

In this case, it is the support structure that will absorb some of the energy produced by the pallets, which do not fully fulfill their function, namely the production of air - The result = low efficiency of the blower.

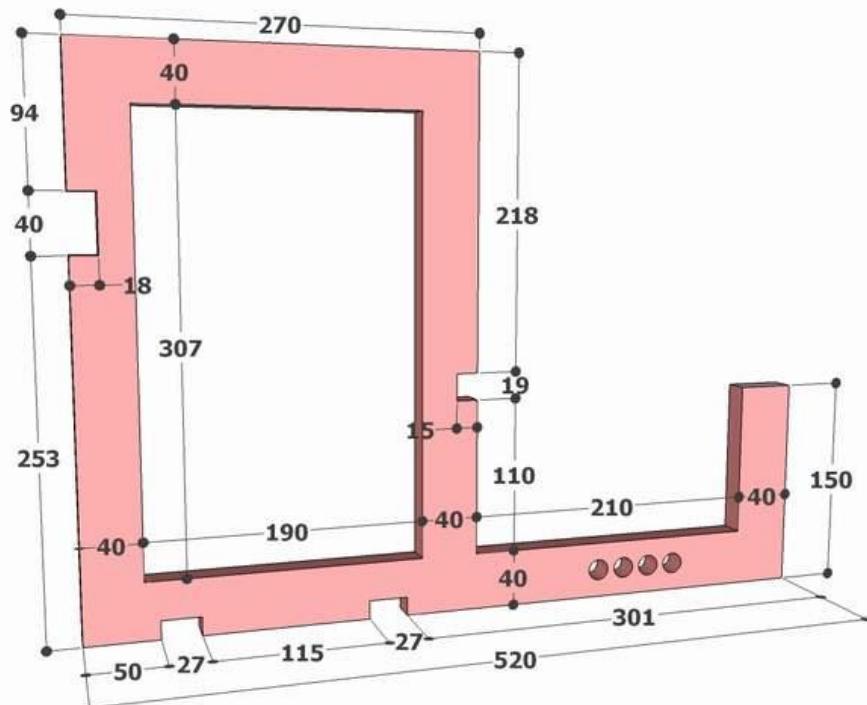
So to avoid this, it is necessary to maintain the support structure firmly in place with heavy iron brackets firmly fixed to both the organ base and support pillars.



For organ n° 2, we use a more elaborate system, which holds in place the blower, the keyframe, and support table for flutes.



All joints are made by "half-timber" to improve rigidity.



The dimensions of notches are to be adapted to the section of the cleats which connect the two vertical frames.

4 holes are made in the lower cleat to make way for plastic tubes connecting the blower to the valves unit.

6 - 5 - FIXING THE CRANKSHAFT

It's not as simple as it seems. If you screw the 2 crankshaft bearings without any precaution, there is little chance that it rotates very freely. In fact the distance and the parallelism between the two support legs are of importance on good axis rotation.

The easiest way is to proceed as described here :

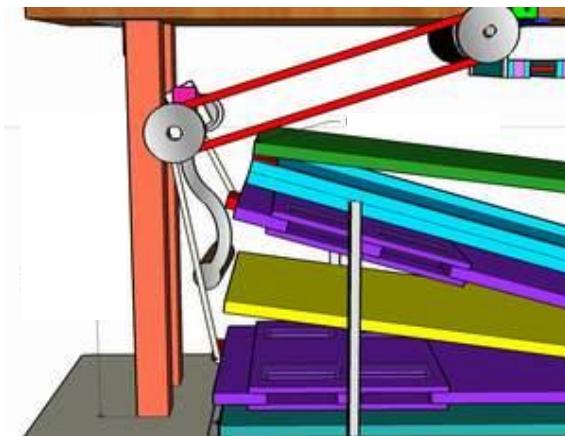
- First, make two holes at support pillars base, to insert a piece of threaded rod with 4 washers and 4 nuts.
- Join support pillars tops by a small wooden crossbar screw on top.
- Keep support pillars quite parallel and tight the nuts.



Furthermore, we'll have to carefully calculate the height at which will be the axis of the crankshaft.

In order to avoid belt chaffing on the top of the reservoir lid, it is necessary that crankshaft is high enough.

It also depends on the pulley diameter.



So, when the height of crankshaft is correctly calculated, you have to fix bearings crankshaft as follows :

- Secure the assembly "crankshaft and bearings" on the inner edge of the support pillars, with a single screw on each side, not two.
- Turn the crank, the two support pillars will thus find their ideal position - adjust the nuts and tighten them.
- Still cranking, so that the two bearings find their ideal position and add the two missing screws.
- Once the two support pillars connected to the base by brackets, it is possible to remove the threaded rod.



6 - 6 - THE RODS

Two rods are connected at one end to the crankshaft and the other to the fastening system on the pallets. Their function is to transmit the motion from the crankshaft to the two pallets.

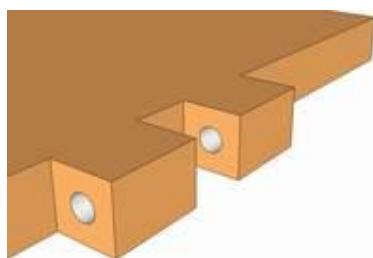
To determine the precise length of the rods, proceed by positioning initially the pallets in the lower position and upper position to determine the middle position.

Do the same for the crankshaft bearings.

The distance between the two middle positions should correspond to the length of the rod. The rods are then drilled on their ends and threaded to receive a threaded M5 diameter rod.

This operation has to be made twice insofar as the two rods are of different length. The connecting rods are screwed into the crankshaft bearings Rilsan.

There are several ways to achieve these links: threaded rods, wooden cleats, etc.



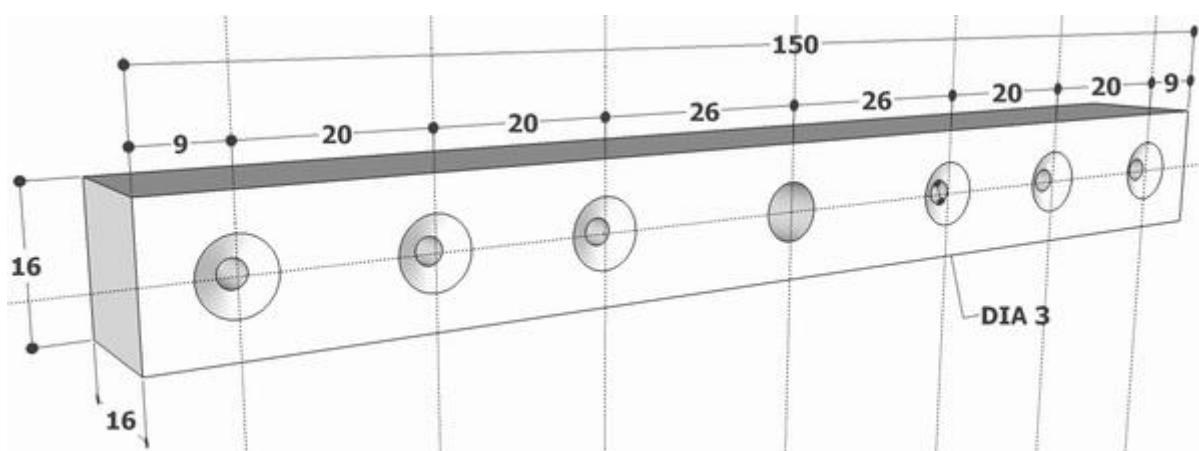
Fixing rods on the lower end is possible by cutting a special form on the pallets, but it's not a very good solution since it complicates the implementation of skin.

We focused our choice on a very simple mechanism, namely the rods used to hold open the trunk of a car.



This system usually has a ball bearing which allows a perfect rotation in several axis, and absorbs small misalignments.

It will be necessary to make two attachments pieces to hold up the ball bearing.



These two attachments pieces are set firmly on each of the pallets by means of long screws with small diameter

Do not forget to drill hole to prevent pallets bursting.



Before the establishment of the links, it is advisable to place some grease on the ball bearing.

This will reduce friction and reduce noise.



Here is the result



Before giving the first turns of crank for the first time, it is necessary that the pressure relief valve on reservoir lid works perfectly.

6 - 7 - ACTIVATING SYSTEM FOR THE RESERVOIR PRESSURE RELIEF VALVE

Sure, you are eager to test your lovely blower, but before that, you must put in place a system that will allow the blower to deflate at the appropriate time, just before the reservoir explodes under the effect of a too high air pressure!

First, place low enough a slat and hold in place with two clamps.

If needed move up or down the slat as long as a good effect on the pressure relief valve reservoir is reach. Once the right position is determined, set firmly slat on the two support pillars using 2 screws.



What happens if the slat is too high?



The skin will go to the outside, with a thud.

In this case, you must move down the slat.



After several tests, we determine the maximum height is 90 mm.

Of course, this can vary on your own blower.



If after having lowered the slat, skins still go outwards, this is probably due to the release of one or more stiffeners !

We can easily validate this terrible diagnosis by tapping gently on the skin where it is thought that the stiffener is not bonded anymore.

If the skin is soft, it is a sign that the stiffener has gone away.

So we have to proceed a open-heart surgery on blower.



Here in detail the progress of the operation.

	
Block the reservoir lid in upper position by inserting any bulky object (here an electric screwdriver)	Use a cutter with a brand new blade serve to separate the skin from the reservoir lid
	
Next, an injection of vinyl glue on the faulty stiffener	Slightly pressed maintaining the reservoir lid in the lower position
	
Place the blower on the side by inserting a piece of wood to prevent the bulging sides to abut against the table	Carefully spread vinyl glue on the skin
	
Apply pressure with a heavy object: here UHF cavity vacuum tube 2 C 39 - but if you do not this part a bit special, one or two kilos of sugar will do. (73 de F6FYN)	Successful operation With any luck it will leave a slight scar

Postoperative visit is essential to check if there are no leaks.

If the use of the candle is valid for detecting leaks on a vertical plane, the system is not suitable for detecting leaks in a horizontal plane. It was therefore necessary to find a simple and effective way.

Just drop a little cocaine, or flour on the part where the skin was reattached.

By operating the crank, the powder will be seen clearly enough to fly away where there are leaks.



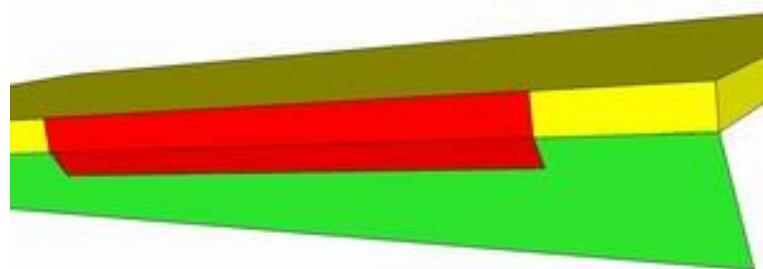
Just then put some silicone seal on sensitive places.



As your organ is getting old, and for some unexplained reason, skin folds could no longer find their perfect place between pallets.

If the stiffeners are not loosened, here's a tip to remedy without having to peel off the skin.

Just stick a small strip of skin above the faulty area (glued to the white glue)



6 - 8 - HOW TO GET PRESSION INSIDE THE RESERVOIR



To go from the reservoir to the flutes, it is a long way to go for air !

It has to go through the apertures of throats, through the connecting plastic pipes to the valves unit, through the valves unit by itself, through connecting pipes flutes.

It is essential that the air in the reservoir is always under sufficient pressure.

Therefore constant pressure on the reservoir lid is needed.

Here is our solution :

It's a good coil spring that will do the trick. The hardest part is finding the right spring size.

For your information, our spring is 90 mm long, 14 mm outer diameter, with wire 13 / 10

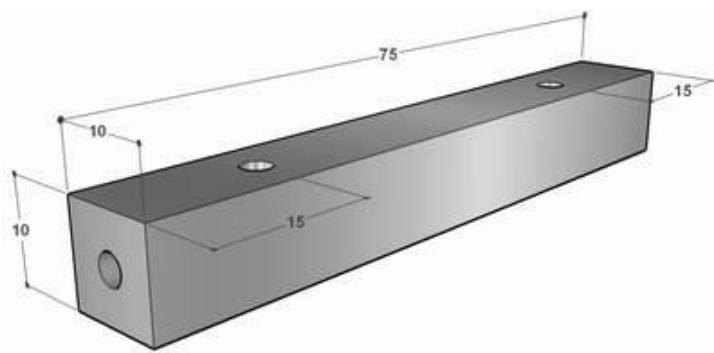
The pulling force of the spring is of paramount importance, in that it determines the level of pressure needed to power the flutes.

We will develop this subject later.

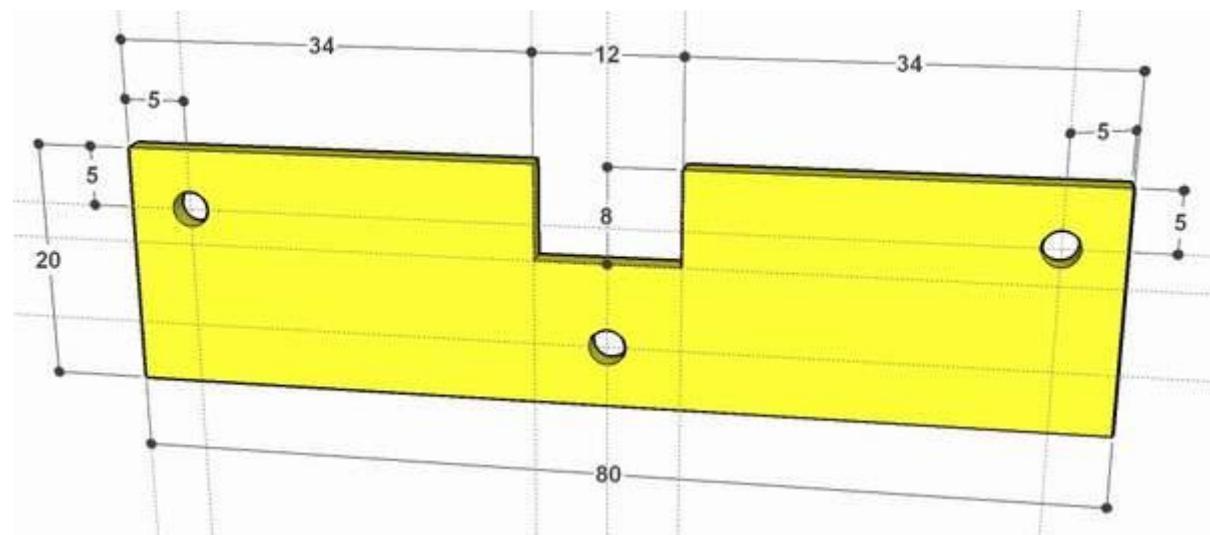


At the bottom, the spring is held by a threaded rod which is inserted into the lower part of the support pillars.

For the traction takes place symmetrically, two small aluminum sections 10x10 were firmly attached on the reservoir lid at each side of the pressure relief valve system.



An aluminum plate of 2 mm thick connects these two sections of aluminum. In the center, there is a notch to give space for pressure relief valve lever. The spring is fastened at the center. Ensure that you can easily detach the spring without special tools.



Whatever the pressurizing method used, it must reach a given pressure. This brings us to the next chapter ...

6 - 9 - BLOWER TEST - EPISODE 2

Give your first turns of crank and see the reservoir to inflate. A great moment of happiness !

In the best case, the reservoir must be filled in one turn of handle. Then if we stop turning, it slowly empties within 4 or 5 seconds.

A crucial point : the blower should produce air at a pressure of 12-13 cm water column.

This data is very important because it came into account in the calculation of the dimensions of flutes.





The air pressure is confirmed with an "air pressure controller"

It's a simple piece of transparent plastic pipe in which we put a little water or mead (Breton drink that makes you walk backwards). The diameter of the pipe has no importance.

Hold the pipe in place with small fasteners commonly used to hold in place electrical cable.

The form that is given to the pipe is extremely important. It is imperative to linearly side by side, parallel and vertical 2 sections of the same pipe.



We connect the air pressure controller to one output of the blower, of course taking the precaution of having clogged all the others.

Just for info, here is the photo of our first air pressure controller.

That's all that we should not do : There is only one section and not two.

The pressure thus measured is highly dependent on the position of the plastic pipe which is used.

Therefore reading is unreliable and therefore not usable.

How to use your device ?



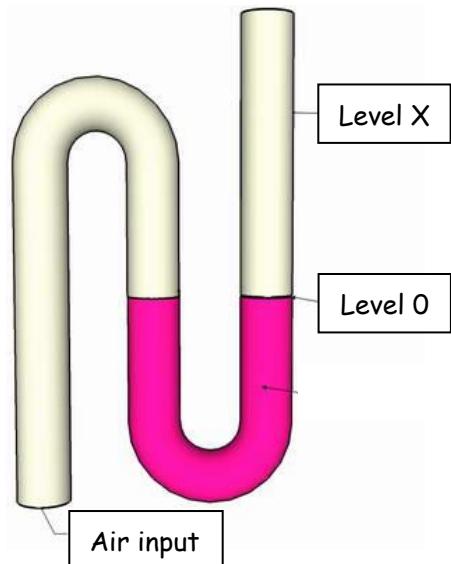
State without presence of air	State with presence of air
Using a funnel, fill the tube with liquid to a height of about 15 cm. For better readability, you can color the liquid with grenadine or Ricard. Avoid the inclusion of air bubbles.	Then turn the handle and measure the height in centimeters between the lower position and the upper position of the liquid.



Here's a mistake not to do (we did it) for the measurement of pressure :

On this sketch the measure to take into account is not the one between Level 0 and Level X.

In this case you get a pressure equal to double the actual pressure.



When handling the air pressure controller, be careful not to introduce water into the blower.



If you do not get the minimum pressure of 12 cm to 14 cm, it means that your spring is too low.

In this case, you can put a stronger spring or two springs.



One leak in collages of skin may also explain the lack of pressure.

To locate leaks, just approach a candle and watch the flame so that it does not wobble. **Be careful not to burn the skin**

If, conversely, you get a much higher pressure (at first, we got 23 cm) you must implement a weaker spring.

It is true that "who can do more can do less." But excessive pressure will make the reservoir harder to inflate. This affects on the crank which is harder to turn.



For proper operation, the right level of pressure is not enough. It is imperative that it is almost constant and does not change according the rhythm of turns of the crank. If this is the case, it is likely that one or more valves of the blower does not work correctly.

However, it can be assumed a very slight variation of pressure drop that occurs when the opening of the pressure relief valve that is located on the reservoir lid.

In fact, the pressure changes all the time depending on the position of the reservoir lid.

But that does not matter. In fact, it is random and it is also related to the number of flutes sing at the same time.

We will also see a little loss of pressure when will have inserted valves unit between the blower and the air pressure controller.

So the couple "sufficient pressure" and "constant pressure" is unavoidable.

Once obtained a good operation, you will certainly be tempted to replace the air pressure controller by your flutes, just to hear them sing other than blowing into it, which will be recalled, is not recommended.



So if you notice any abnormal sound, it may be that there is still some water in the plastic tube.

A single drop can cause a particular sound.

To understand the system that will be used to scroll the book and to read its information, it is necessary to know characteristics of the book itself.



7 - 1 - BOOK CHARACTERISTICS

The theoretical width of a book is 130 mm.

In reality, there is a slight tolerance +/- 1 mm.

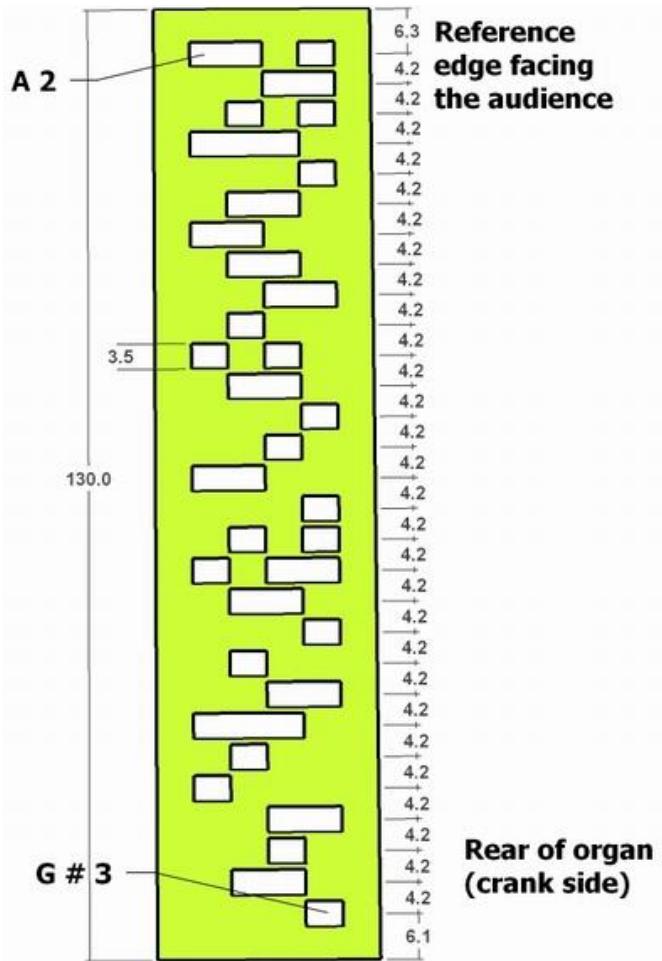
On the keyframe, it is defined a "reference edge" which is the edge facing the audience.

When scrolling the book, the right hand drives the crank, and the left hand keeps the book in abutment against the reference edge.

From this reference edge, the axis of the first perforation will be set at 6.3 mm.

This is what is called the heel.

This first perforation is the lowest note namely A2.



Note that in reality, a book has fewer perforations as close together than in the example above.

The space between two perforations is 4.2 mm. Each perforation is 3.5 mm wide. The length of perforation is proportional to the length of the note to be played.

Unlike the gap of 6.3 mm between the reference edge and the axis of the first perforation, the gap between the opposite edge and the axis of the last perforation is only 6.1 mm.

The book is folded in accordion, and the length of the base is 160 mm. This will affect for the two shelves located on each side of the cabinet.

Books are sometimes slightly sanded on the face opposite the reference edge. This allows a smooth surface on which it is possible to write the name of the song.



Note that the book is the ancestor of our current CD.

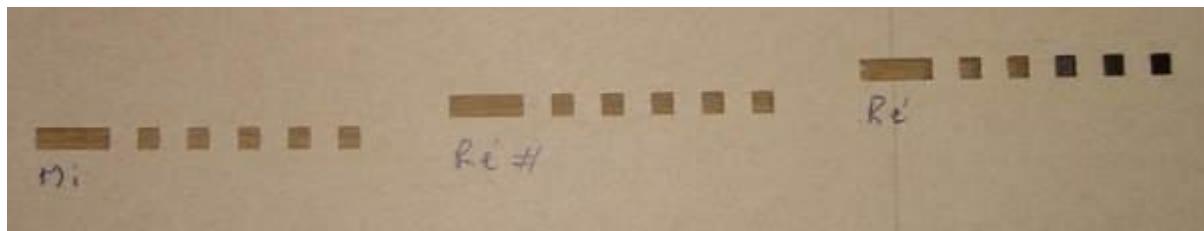
Both operate on the binary system "all or nothing"

You will need a "test book" for two reasons:

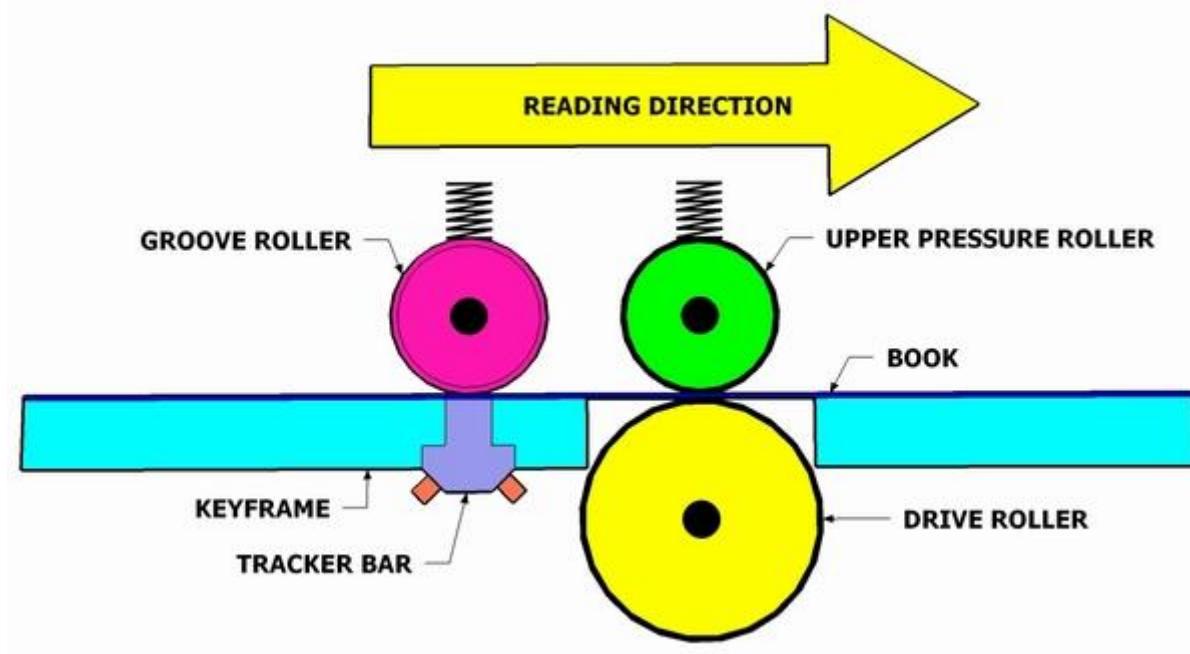
- Validating the keyframe width
- Testing notes

How to get this specific book ?

- You can make it - it is not the easiest - you'll see it in Chapter 11 of this document
- You can order it from books manufacturers, either professional or amateur.



7 - 2 - DRIVING BOOK SYSTEM PRINCIPLE



Using a belt and a set of pulleys, the crank will rotate the drive roller located below the keyframe.



The upper pressure roller will apply constant pressure on the book.

Book will scroll above of one reading system which is called "tracker bar." It is at this level that information will be sent to the valves unit.

To have a good reading, it is necessary that the book is properly applied against the tracker bar during scrolling, especially at the folds, not to hear undesirable noise.



To ensure right pressure on the book, it will appeal to a pressure system that will push downward continuously on the book.

Let us now see in detail the different parts.

7 - 3 - THE TRACKER BAR



This is the reading system which gets information from the book.

It will be connected to the valves unit through a set of plastic tubes.

Our organ is based on the principle of **pneumatic reading**.

For your information, there is another completely different process which is called **mechanical reading**.

With **mechanical reading**, we use sensors that will operate the valves. This system is very responsive, but it is more aggressive on the books, which in this case must have a special surface treatment to harden, thereby improving their longevity.

Let's go back to our tracker bar : its holes are of course in relation to the holes of the book.

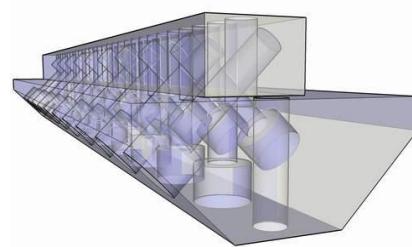
This very special part is machined in an aluminum block length 136 mm x 26 mm x 19 mm.

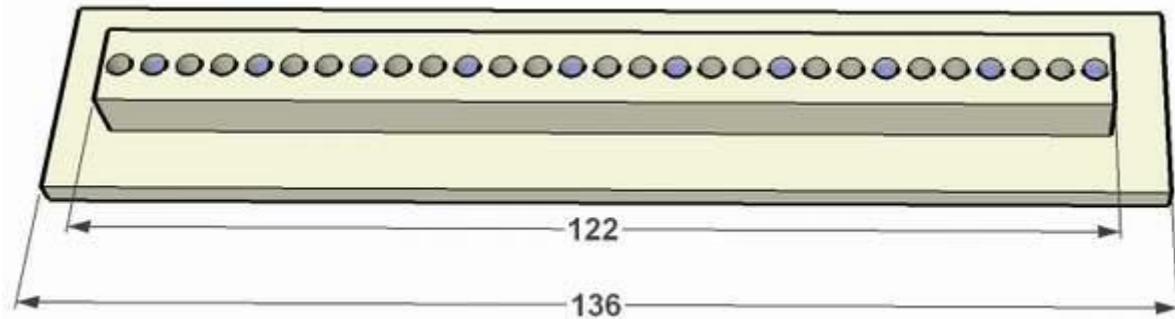
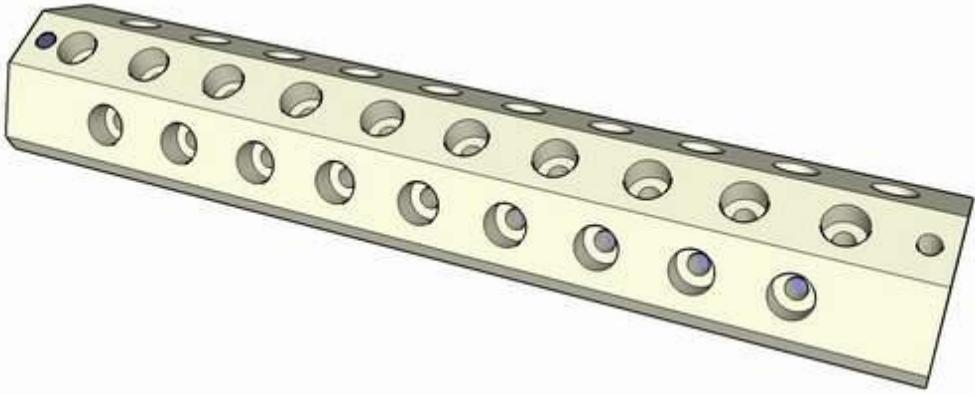
You can also use a hard wood block, or better yet a Rilsan block. This is the type of materials used for making cutting boards in the kitchen. Its slippery texture will promote the travel of the book.

Where it gets complicated a little bit, is that at the base of the piece, given the holes too close together, it is not possible to simply connect on the same plane all plastic tubes with a diameter too important.

This requires that the outputs of each hole are alternately made on 3 sides.

- One the top, the hole n° 1 comes out on the pan tilted to the left
- On the top, the hole n° 2 comes out on the bottom
- One the top, the hole n° 3 comes out on the pan tilted to the right
- And so on until the hole n° 29





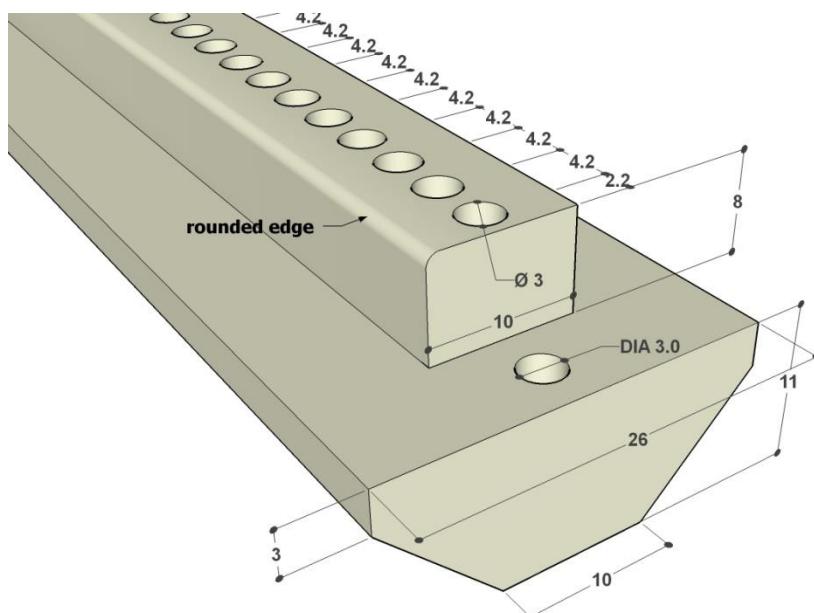
The upper part of this piece is intended to pass through the keyframe.

Therefore, the board used for this purpose rests in one part which ensures a good rigidity and flatness.

On top of the tracker bar there is a ramp of 29 non-emerging holes diameter 3 mm and a pitch of 4.2 mm.

The first hole is located at 2.2 mm from the edge.

As we have conceived this part, a milling machine is essential for its production.



Whatever the outputs distribution on the tracker bar, ensure that the oblique holes do not open into their length on the middle tracker bar flat surface. If so, some flutes could sing constantly.



29 brass (or other metal) tips of 6 mm diameter will be inserted into the tracker bar.



On these tips, we will connect firmly 29 plastic tubes leading to the valves unit.

These tips will be inserted and glued with a strong glue.

- Diameter of the spot facing = 6 mm (or equal to the tip diameter)
- Spot facing depth = 4 mm

You will also need 29 tips for connecting pipes on the valves unit.



Tracker bar - top view



Tracker bar - bottom view



To prevent the book folds abut against tracker bar, the first front external edge is slightly rounded with a file and sandpaper.

During the operation, it is advisable to clog all holes of the tracker bar to avoid aluminum dust to get inside.

Phase control of the tracker bar is essential. Indeed, it may have defaults :

- Blind hole
- Opening hole too much
- Air path partially or completely obscured by glue



Simply connect a plastic tube : blow in it and clog the corresponding hole.

The air must pass 100% or be blocked 100% completely.

The most perceptive of you will have noticed that tracker bar pictures that is presented above does not fully correspond to the description we made.

In fact, it is only once the piece was completed that we realized the outputs were too close to each other.

If plastic tubes fit together properly, it is not easy to put a clamp around to secure them.

There will be just enough room to round a thin copper wire .

We'll see that later.



On the organ n° 2, the section the tracker bar profil is different, but there is still very little space between the pipes.

7 - 4 - THE DRIVE ROLLER AND THE PULLEYS



This is a very smooth couple insofar as the diameter of the drive roller determines the diameter of the pulleys.

So we will deal with both subjects simultaneously.

Let's start with the drive roller.



This is the roll situated below the keyframe.

It will be brought into rotation by means of set "crank / crankshaft / belt / pulley".



The roller is coated with a rubber sleeve to prevent slippage on the book.

Question: Does the diameter of the roller matter ?

Answer: Yes and no !

YES, insofar as it determines the running length of the book each time the roller turns once.

NO, because it can be compensated by a adequate transmission ratio.



You should know that in the first turn of the crank, the belt is not yet perfect tense. This has the effect that the distance traveled by the book during the first round is less than the distance traveled in the following rounds.

This raises the question : What is the proper speed of rotation of the crank ?

This is a topic that seems to be debate in the small world of crank organ builders !

Some advocate "the famous revolution per second." In this, it is necessary to have a mark to turn at this specific rate.

For others, the speed seems to be irrelevant, assuming that after some time, we totally forget the rhythm of crank turns, and we primarily focus on what is heard.



In fact, the right speed, this is the one for you ! Neither too slow to be subject to variations and not too fast to avoid getting sore arm.

This is the basis on which we started :

We used a PVC tube section 50 mm in diameter.



To keep the center in the middle of PVC tube, we must realize two disks. These two disks and axis are glued and force-fitted into the tube.

Material	PVC tube
Roller length (without axis)	130 mm
Outside roller diameter WITHOUT rubber coating	50 mm
Outside roller diameter WITH rubber coating	50,5 mm
Axis length on the pulley side	40 mm
Axis length opposite pulley side	10 mm
Axis diameter	8 mm
Disk diameter	45 mm
Disk thickness	10 mm

A flat surface will be done with a lime on the axis side pulley so that the locking screw perfectly fulfills its role



The operation consists of covering PVC tube with rubber sleeve may seem easy.

In reality, it's a hassle.

After a fierce battle with rubber sleeve and PVC tube, a solution was finally found.



It consists in introducing into the rubber sleeve some dishwashing liquid. By forcing a little on the PVC tube, it comes into the rubber sleeve.



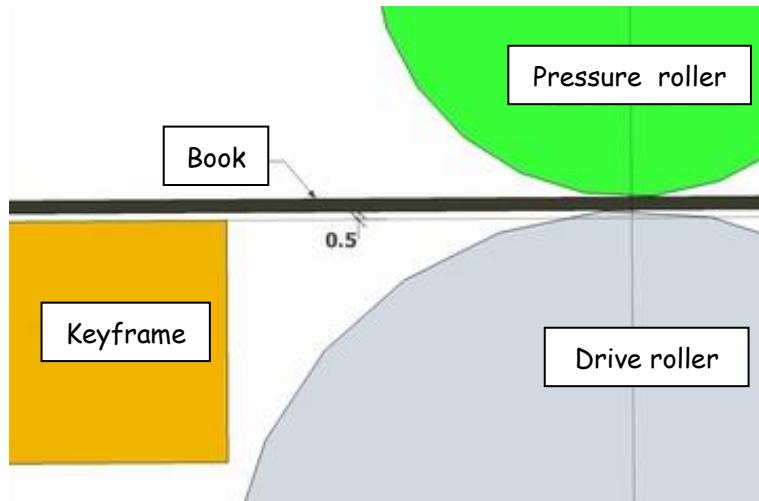
There are other kinds of sleeves lubricated latex, but they are too thin, so for another use

To firmly hold that big roller in place, it uses two Rilsan bearings.



On the bearings, the positioning of the hole which receives the roller axis at a great importance because it determines how much the drive roller exceed or do not exceed from keyframe top.

In order to prevent slippage of the book, it is recommended that the top of the drive roller is 0.5 mm above the keyframe.



The elevation also helps avoid the parasitic friction of the book against the keyframe.

This case happened to us during the transition from the first books, so we found blockages in scrolling.

Looking more closely, we saw black marks just upstream and downstream of the drive roller and also near the tracker bar.



Another question discussed at the manufacturers :

Do we need to give a certain angle to the drive roller relative perpendicular to the travel path of the book ?

There are several opinions on this point !

Pros...	<p>System that encourages the book to stay as close to the reference edge. In this case, it is necessary to do the same on the pressure roller which be positioned above.</p> <p>If you opt for this solution, it is necessary that the angle is minimized.</p> <p>Some manufacturers have even added on the roller drive a pivot system to find the optimum orientation.</p>
Cons....	<p>That force on the board, and sometimes over long bridges without perforations, the book can crease.</p> <p>This prohibits the use of too low grammage book or even paper.</p>

To sum up, taking care of the mechanical design of the bearings, and the book should go straight!

THE PULLEYS

Due to large diameter of the drive roller, we made two pulleys of different sizes to have an appropriate gear ratio.

We have made aluminum but you can use hard wood.



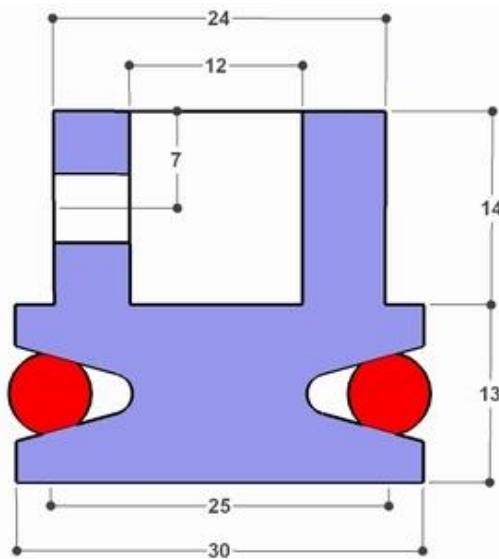
The groove is machined according to the diameter of the belt that you can find (5-6 mm)

Pulley on the crankshaft :

To avoid having a diameter of pulley too large on the drive roller, the transmission ratio requires us to have a fairly small pulley on the crankshaft axis.

This is what explains its rather special form.

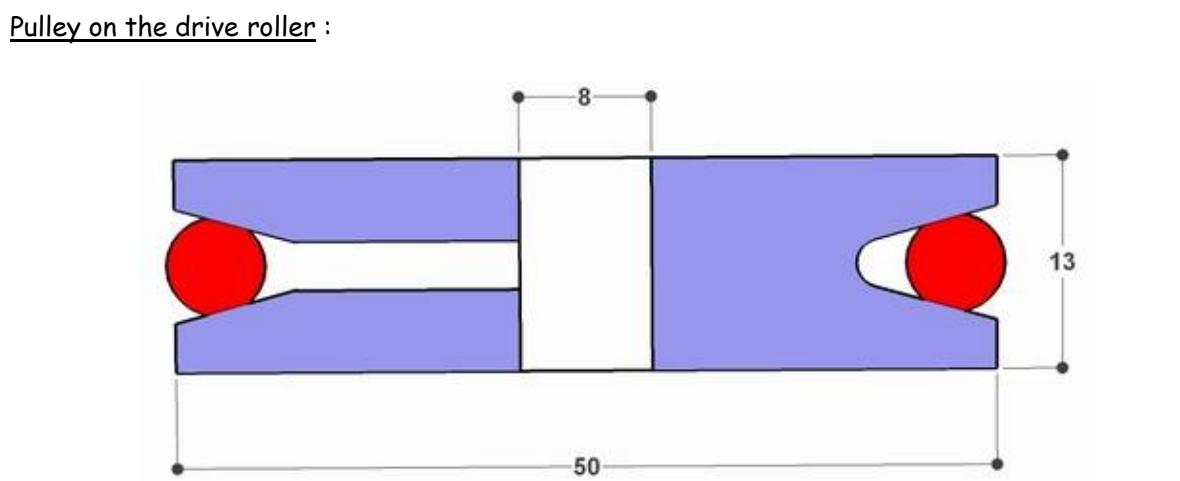
Note that the dimensions of the pulley are not critical, insofar as it is going to act on the transmission ratio by acting solely on the pulley which is fixed to the drive roller.



To fix the pulley integral on crankshaft axis, you must drill a 3.3 mm hole and tapped for M4 screw.

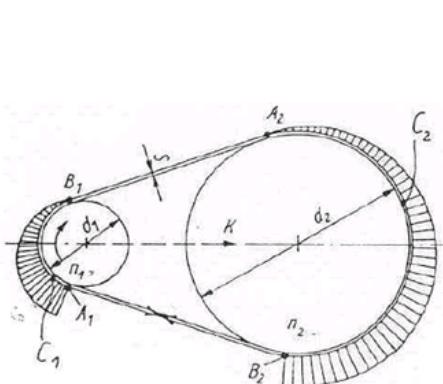


The length of the shaft should be adapted to ensure that the belt is in perfect alignment of the other pulley.



For the calculation of the transmission ratio, in theory, you should take into account not the outside diameter pulleys, but the distance between the two axis of the belt.

Also, be aware that the subject of the belt drive is much more complicated than it seems. For proof, just go on the net to discover the level of complexity.



$$a = \text{entraxe [mm]}$$

$$\text{L'entraxe minimum } a_{\min} \text{ doit être} > \frac{(d_{w_1} + d_{w_2})}{2}$$

$$\text{L'angle :}$$

$$\beta = \arcsin\left(\frac{d_{w_2} - d_{w_1}}{2.a}\right)$$

$$\text{Le nouvel entraxe :}$$

$$a_{\text{calculé}} = \left[L_{\text{disponible}} - \left[\frac{\pi(d_{w_1} + d_{w_2})}{2} + \frac{\pi.\beta}{180}(d_{w_2} - d_{w_1}) \right] \right] \cdot \frac{1}{2.\cos\beta}$$

In reality, we have to face a slip phenomenon of the belt during its rotation. Are also included in the calculation, the groove profil, the belt length, the belt diameter, the tangential velocity, the center distance, and the captain's age...

Knowing that the error is quite small, we will not consider these parameters. If indeed speed does not suit you, simply remanufacture a new pulley.

A small hole is made in the thickness to accommodate a small special "needle screw type"



- Diameter M4
- Length +/- 10 mm
- hexagon socket cap head

It is convenient to mark the location of the screw.



7 - 5 - THE BELT

The belt should lead the drive roller beneath the keyframe. There are belt sold by the meter and heat sealable. It is found in very specialized hardware.

How thermo-welding the belt?

- Estimate the length of the belt
- Cut with a sharp cutter ensuring to have two flat surfaces
- Heat a soldering iron
- Apply belt sides on the soldering iron
- Maintain pressure face to face
- Cut the small ridge that formed



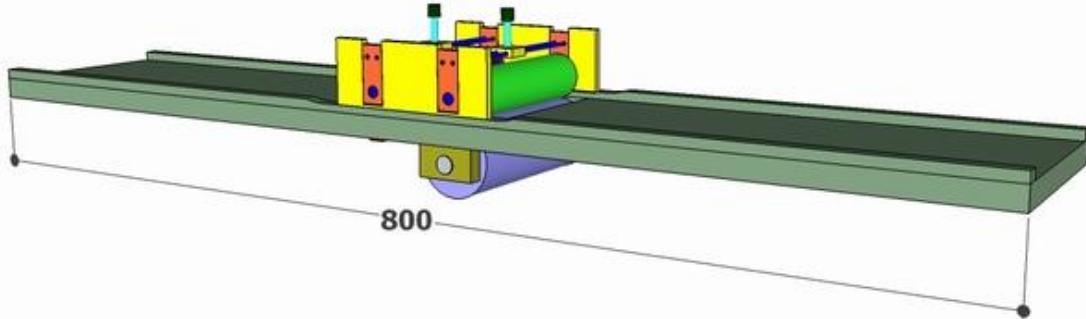
Theoretically, the belt should have a very good life. But you can take the precaution of making a relief belt which will be left in reserve within the organ.

It will be welcome when you will break your belt during a performance in front of 15,000 people...

7 - 6 - THE KEYFRAME

Now that you have completed the tracker bar and the drive roller, you can tackle to keyframe that is simply a board of 800 mm x 151 mm and thickness 15 mm.

Why 800 mm in length? The path length is related to the overall length of the cabinet that will dress the instrument. At this stage of manufacture, the cabinet overall length is estimated at 800 mm.



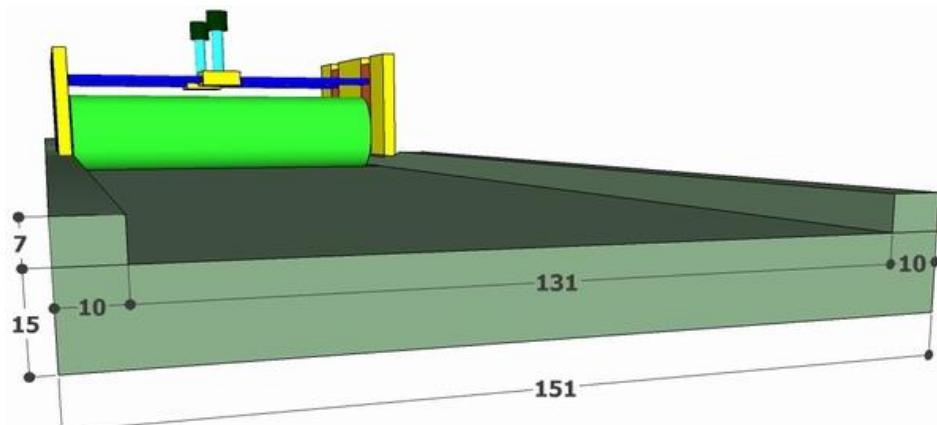
In order to lift off the cabinet from the organ n° 1 the overall length of the keyframe must be equal to the external dimension of the box minus 2 layers of the cabinet thickness ($800 - X - X$).

When in doubt, it better to provide a little longer.

FYI, here are the final overall dimensions of the two keyframes :

For organ n° 1 = 766 mm and organ n° 2 = 608 mm

Why 151 mm width ? The width of the path is equal to the width of the book namely 130 mm + 1 mm margin. The keyframe overall width is equal to the width of the path + the width of the two small cleats on the border of the path, or in our case $131 + 10 + 10 = 151$ mm.



Why 15mm thick ? The thickness is not critical. However, it must ensure a good rigidity of the assembly once apertures will be made in the center.

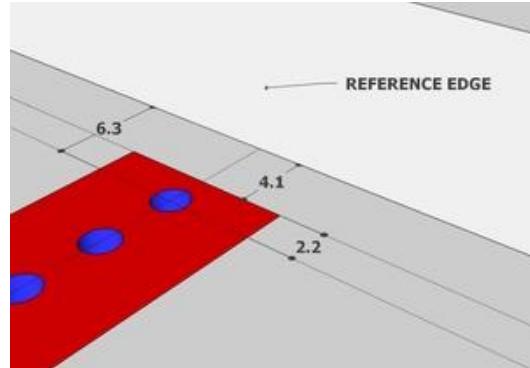


It will be more convenient to glue and screw the lateral cleats after the router operations (apertures for tracker bar and drive roller)

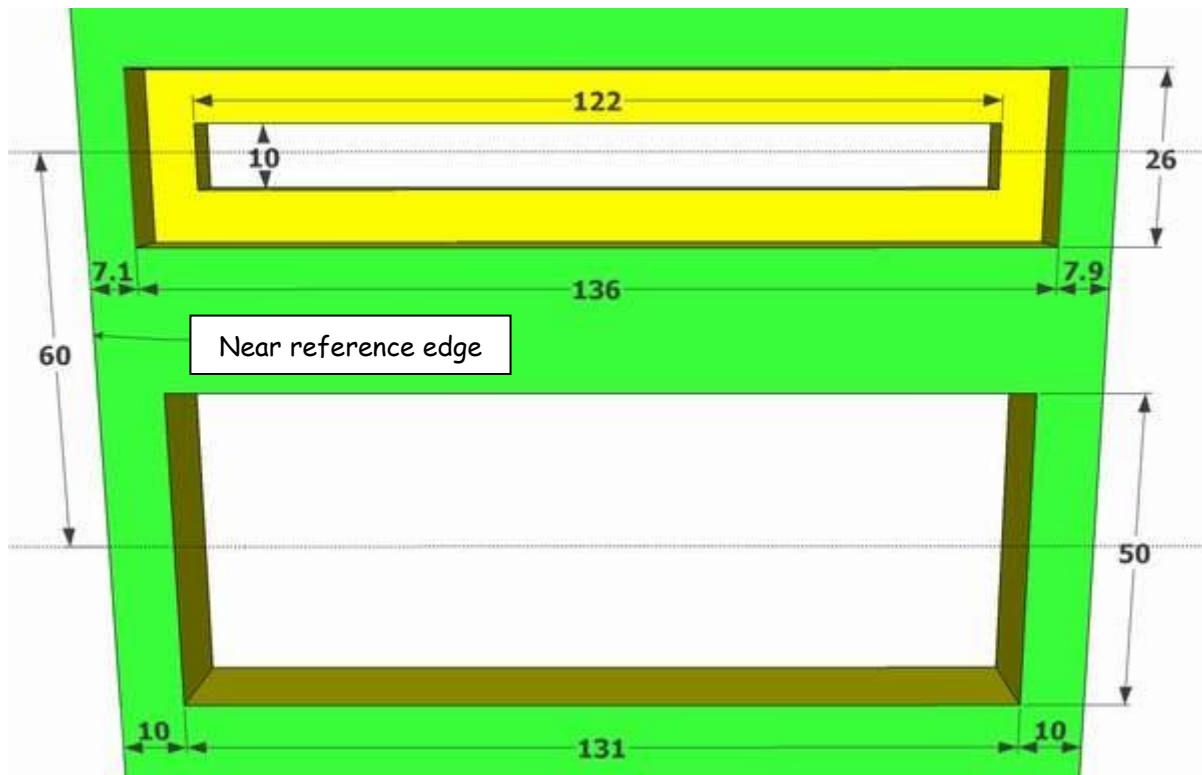
The positioning of the tracker bar is extremely important.

It is necessary that the axis of the first hole is located exactly at 6.3 mm from the reference edge.

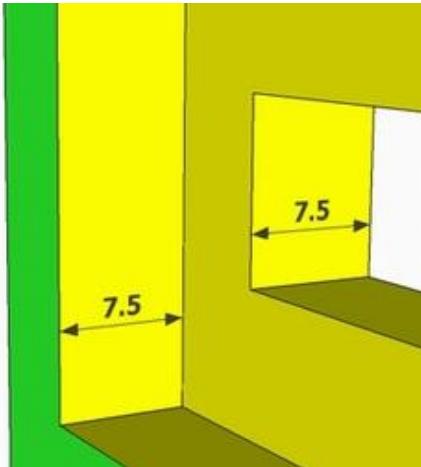
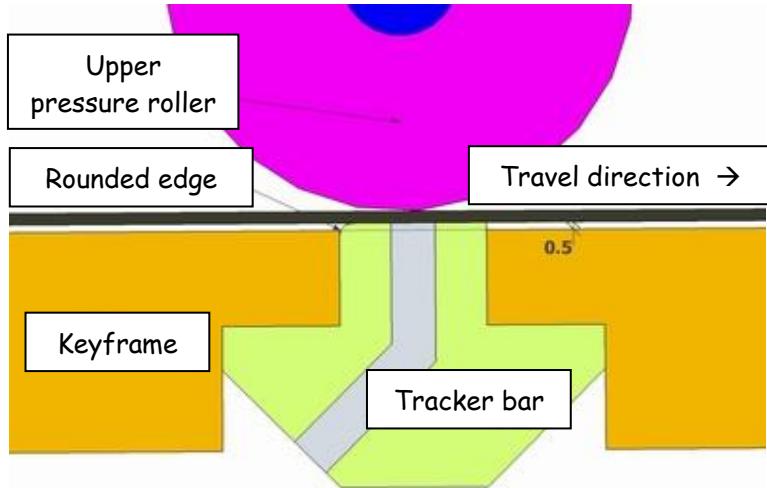
The reference edge is the inner face of the cleat bordering the keyframe.



Here are apertures dimensions (here for a drive roller diameter 50.50 mm)



As we have done for the drive roller, the top of the tracker bar is raised 0.5 mm from the keyframe.



Depths of the aperture for the tracker bar
The 7.5 mm corresponds to the upper part of the tracker bar (8 mm) minus the elevation (0.5 mm)



Unless you are the king of the wood chisel,
this is done at the router

7 - 7 - FIXING LATERAL CLEATS AND TRACKER BAR

Now that the router operations are carried out, you must securely fasten the two lateral cleats which line the keyframe.

Attention : before screwing the two cleats, it is strongly advised to check precisely if the test book scrolls freely.

First keep the two cleats with clamps.

It is only after the book scrolls freely that we can permanently fix the cleats for good.



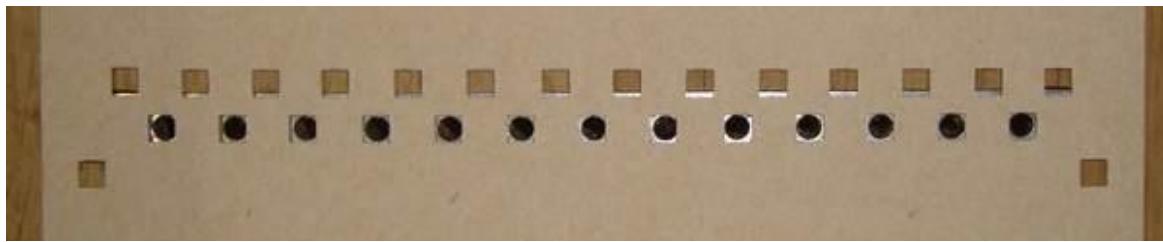
It is important that the book travels freely. Any friction will cause blockages.

If this is the case, use a wood chisel on the cleat at the opposite of the reference edge.

Next, you will insert the tracker bar in the aperture provided for this purpose.

At the beginning of the test book, there are 3 rows of regularly spaced holes in the entire width.

The book holes are staggered to ensure better stability. For the same reason, the two outermost holes are in a row separately.



Then you must validate that the tracker bar holes are perfectly vertical with holes of the book.

If this is not the case, you must review the position of the tracker bar, by making it translate in the right direction by extending the aperture with a lime.



7 - 8 - THE UPPER PRESSURE ROLLER

This is the roller located above the keyframe. This roller is not driven by the belt and rotates freely.

To keep the center in the mid PVC tube, we must realize two disks.



These two discs and axis are glued and force-fitted. A step of 1 mm is machined at each end to reduce friction.

Characteristics of upper pressure roller	
Material	PVC
Roller length (without axis)	130 mm
Usable roller length (without steps and axis)	128 mm
Outside diameter of the roller	32 mm
Axis length	4 mm
Axis diameter	8 mm

Contrary to what one might think, it is not necessary to coat the roller with a rubber sleeve.

It may well remain smooth, which makes it easier to clean because after a few hundred books, the roller will be covered with black grime stains that are dust accumulation found on book surface.

7 - 9 - HOW TO PRESS DOWN THE BOOK ON THE TRACKER BAR

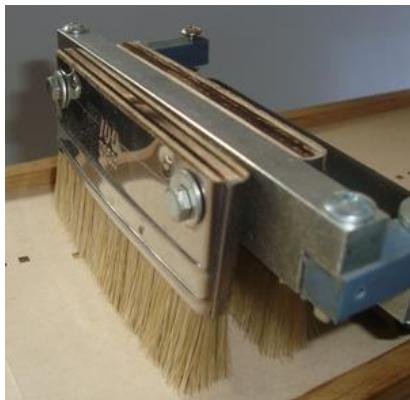
Before describing the perfect system to apply good pressure of the book on the tracker bar, let's see systems we tested previously without success.



Solution n° 1 : Setting up a small plate of plastic with lower edge covered by foam.

The system doesn't push enough on the book and is not elastic enough to absorb the folds.

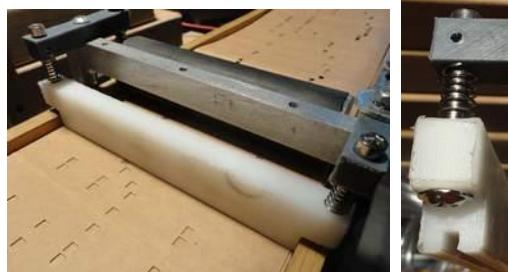
In addition, the slightly rubbery texture of the foam does not favor the scrolling of the book, and tends to slow it down.



Solution n° 2 : Two large brushes push down on the book, but they are not wide enough to push on the entire width.

So with this system the ends of the book are not perfectly flat against the keyframe.

Consequence : flute n° 5 and flute n° 12 sing continuously.



Solution n° 3 : A piece of Rilsan pushes down on the book. An inside longitudinal groove allows air to escape.

This slippery material promotes easy scrolling on the book. However, the book folds have a little trouble to pass without generating spurious sounds.

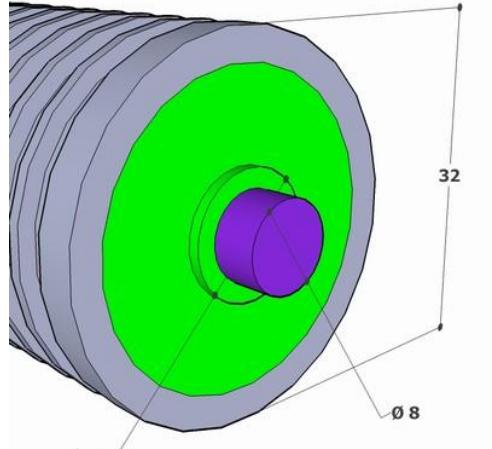
None of these three systems would have been successful.

Finally, we used a grooved aluminum pressure roller.

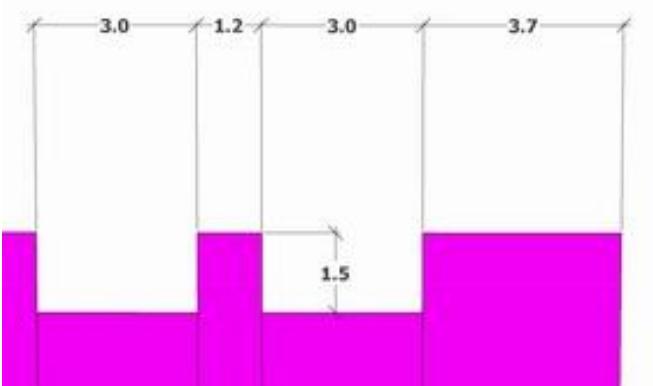
A step of 1 mm is machined at each end to reduce friction.



Characteristics of grooved aluminium pressure roller	
Material	Alu
Roller length (without axis)	130 mm
Usable roller length (without steps and axis)	128 mm
Outside diameter of the roller	32 mm (or idem pressure roller outside diameter)
Axis length	4 mm
Axis diameter	8 mm



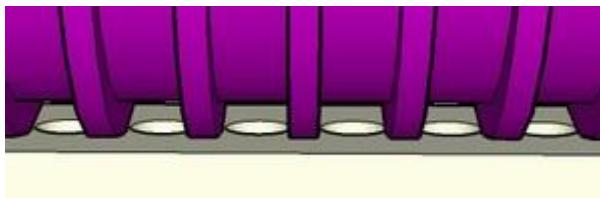
The fact that the diameter of the grooved roller is identical to that of the pressure roller simplifies manufacturing bearings insofar as they will be identical.



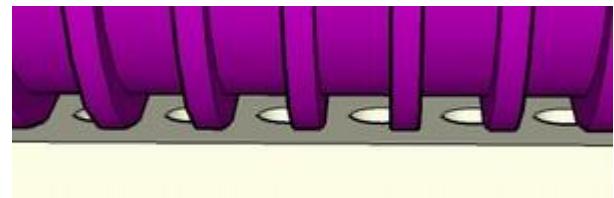
Groove width is equal to the diameter of tracker bar drilling (3 mm).

The pitch is 4.2 mm.

The depth of the grooves is 1.5 mm, but this dimension is not critical.

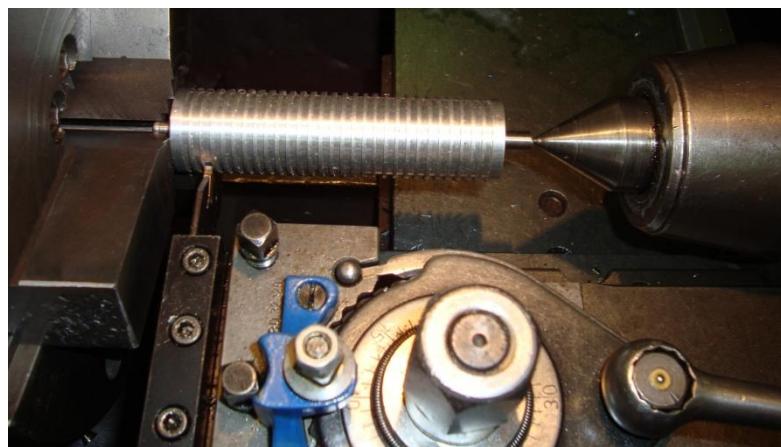


Ideally, it is preferable that the grooves of this roller are just above holes of the tracker bar.



But in practice, a shift can be accepted, in that the air always finds its way out.

Certainly a turn machine is essential for the production of this unusual piece.



7 - 10 - HOW TO PRESS DOWN THE GROOVED ROLLER ON THE BOOK

In theory, it is very simple : just applying the "sufficient pressure" on the book !

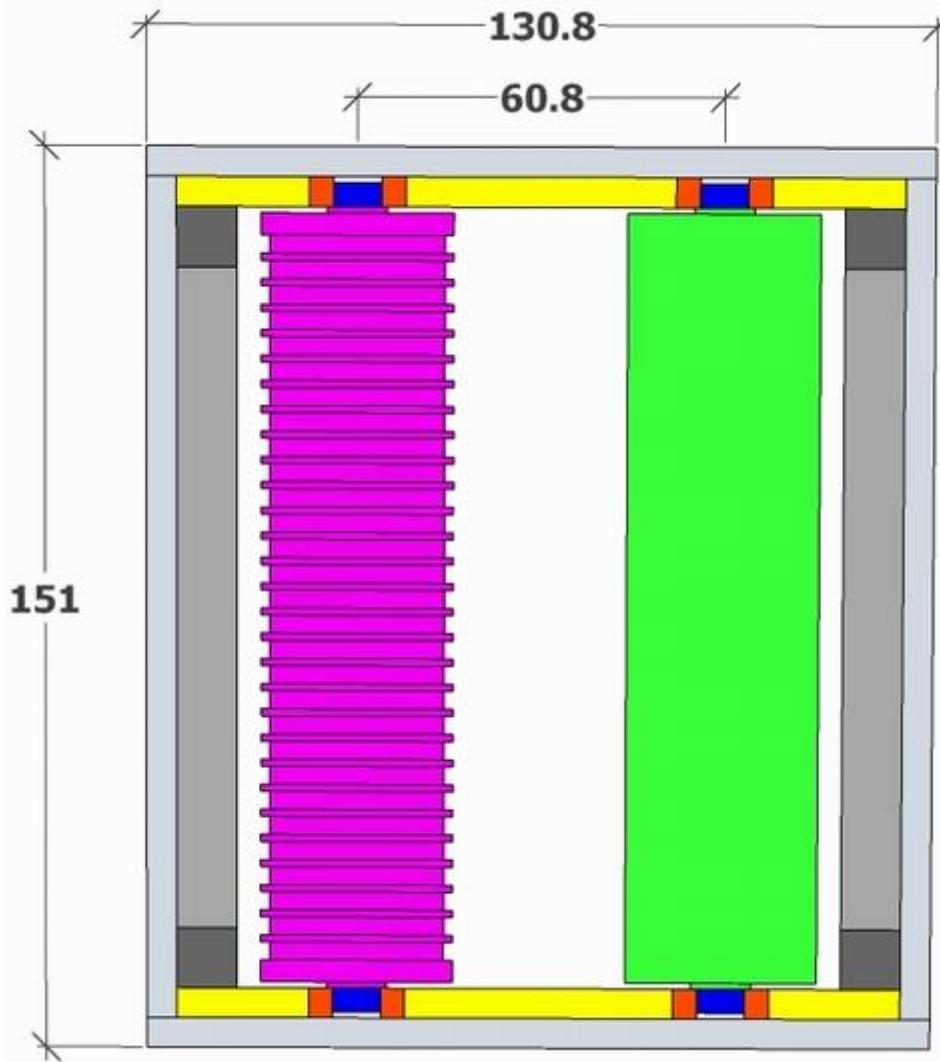
The difficulty is to estimate the famous "sufficient pressure".

Erratic operation of the system means that your organ :

- Will not sing at all (stuck book)
- Will make flutes singing whereas they should not (no enough pressure)
- Produce noise especially during the book folds passage

All ingenious mechanisms previously described have been put in the trash, to make way for a multifunction rollers box :

- Maintaining the rollers in place with a perfect guidance
- Applying an adjustable and independent pressure to adapt to the different book thickness
- Blocking book during tuning operation
- Cover the entire mechanical

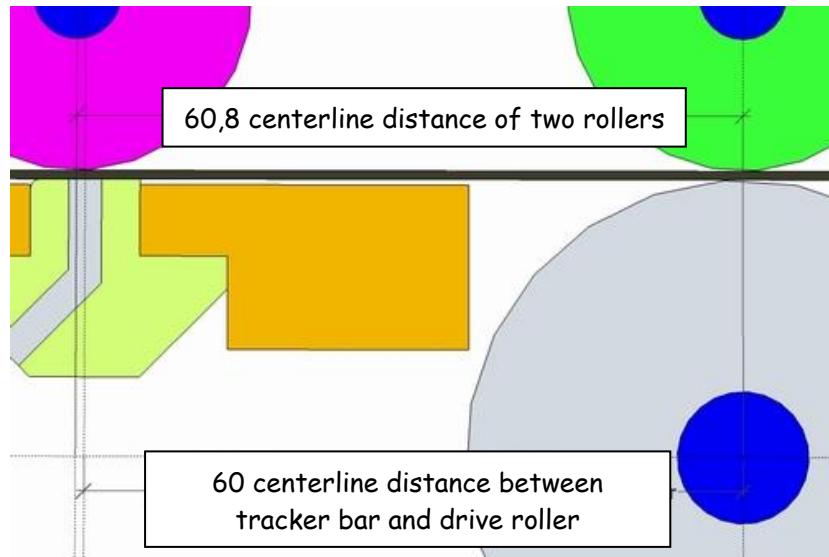


With this system you can easily adjust the precise position of the grooved roller above the tracker bar. Logic would suggest that this grooved roller would be positioned perfectly aligned with tracker bar holes.

NO ! It is preferable that the central axis of the grooved roller is slightly offset from the tracker bar axis.

The correct position is when the grooved roller axis falls on the first half of tracker bar holes..

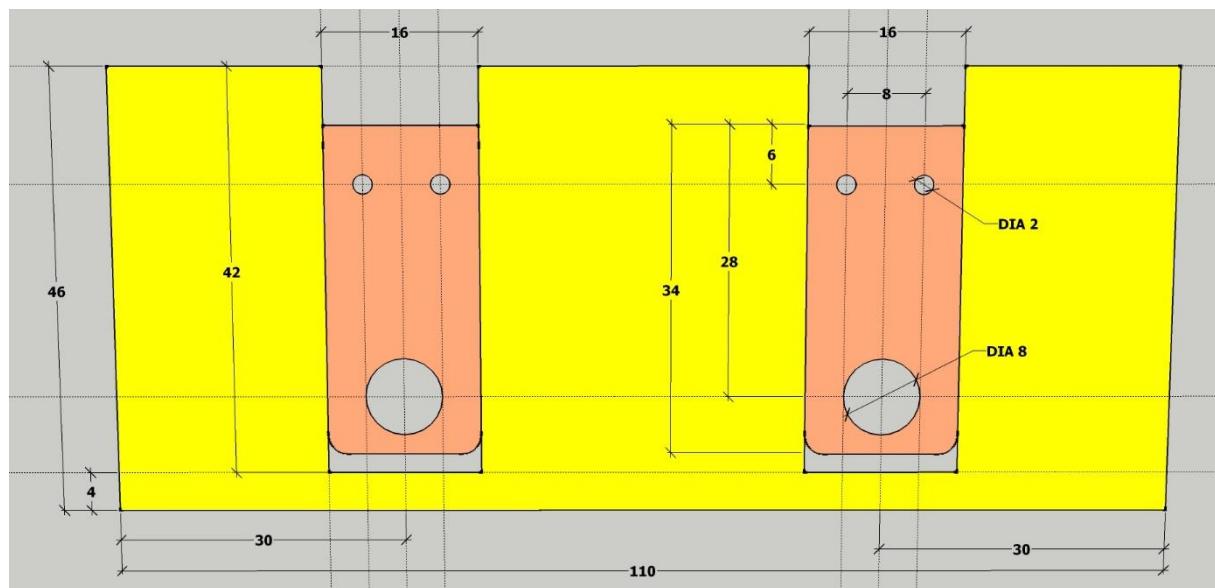
With this precaution, we avoid air leakage of the concave folds, and bad noise.



In our case, we have drilled the tracker bar with holes 3 mm in diameter. The axis of the half hole therefore falls to 0.75 mm (3 mm /2 /2). This dimension can be rounded to 0.8 mm.

The axis of the two rollers (grooved roller + pressure roller) are received in 4 bearings which slide vertically in 4 notches made in two opposites sides of the box.

The 4 bearings can be made in Rilsan or even hard wood.



To exert a constant pressure of both rollers on the book, we used a pair of 2 mm piano wire.

Piano wires are held in place by being inserted in small holes in the bearings.



In this way, we can adjust independently and without any disassembly pressure on each roller.

Being able to adjust the pressure on the rollers is very convenient because during flute testing operation, if you release completely the pressure on the pressure roller, the book doesn't scroll any longer.

- Release pressure on the pressure roller (not the grooved roller)
- Apply strong pressure on the grooved roller
- On the test book, choose the note to be tuned, and place the hole right above tracking bar hole
- Turn the crank (the book is steady)
- Adjusting the position of the stopper in the flute
- The same process has to be done for the 28 other flutes
- At the end, we reapply the correct pressure on the pressure roller

For the production of the box, carefully carry the components for a good vertical sliding of the two rollers.



4 movable bearings in Rilsan



2 guides for movable bearings. Wood has been chosen to be easily glued on the box side also in wood



During box assembly, ensure a perfect squareness to allow rollers to turn freely.



Reinforcements are placed in the 4 corners. They will in addition receive the screws for fixing the box lid.

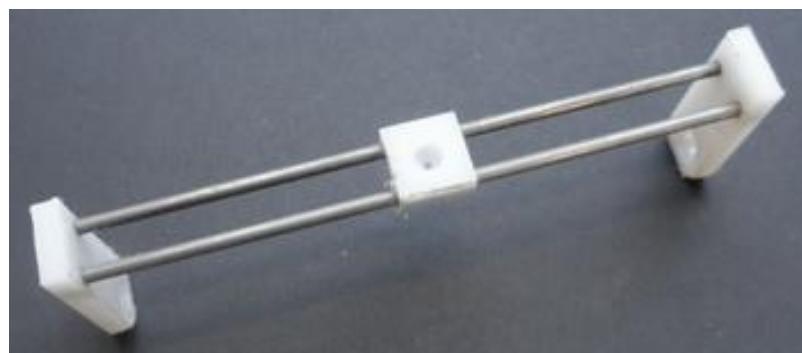
4 springs will cut out the piano wire of 2 mm.



Initially, we used 3 mm diameter piano wire. This is too much, because in this case, the pressure system works almost "all or nothing". In this case the book is blocked.

The piano wires of a pair are joined in their middle by a small junction piece of hard plastic.

On the top of this piece will be based a screw to set the pressure from the box lid.



The two adjustment screws pass through the box lid. It is not easy to pierce the box lid just vertically above the center of the junction piece.



To get a good precision we drilled a hole of two millimeters which is just enough to point the location.



Then with a simple nail, go through the junction piece and make a mark on the box inner face.



To center the tip of the screw, make a blind hole of 5.5 mm (2 mm depth)



The outer face of the lid is drilled to 4 mm and is threaded for a screw M5.



A little bit of paraffin facilitates sliding mobile bearings



In order the adjustment screws are always found at the vertical of junction pieces, it is advisable to mark the good lid position.



First, it is easier to validate the correct operation of the box if we can clearly see the rollers which is not possible when lid is in place. A screw holder is temporarily set up.

For now, the box cannot perfectly apply on the keyframe due to the presence of two cleats on the borders.

It is possible to completely cutting the cleats at the point where they face the rollers box. In this case, the keyframe would be weakened because of the lack of material.

So it is better to reduce to the router parties in conflict.



Reduction of the box on its 2 sides



Later on, metal screw heads were cut to make room for two more aesthetic wooden knobs.

Brass pieces covers mask fixing screws.



Slight reduction of 2 cleats



Here is the result



Before setting up the hinges, align the box so that the axis of the grooved roller is slightly upstream of the tracker bar axis (see explanation in previous chapter)



2 mini hinges on the rear of the box



A latch is set on the front panel to ensure a good pressure.

8 - 1 - WORKING PRINCIPLE

If the blower acts as the instrument lung, valves unit can be seen as the brain of the organ, because valves unit must understand information which come from the tracker bar, then it will take the decision to block or allow the air to the flutes.

The valves unit is a set of pneumatic valves, which are equivalent to 29 taps,



The control is done by air pressure or air depression according to the holes in the book.

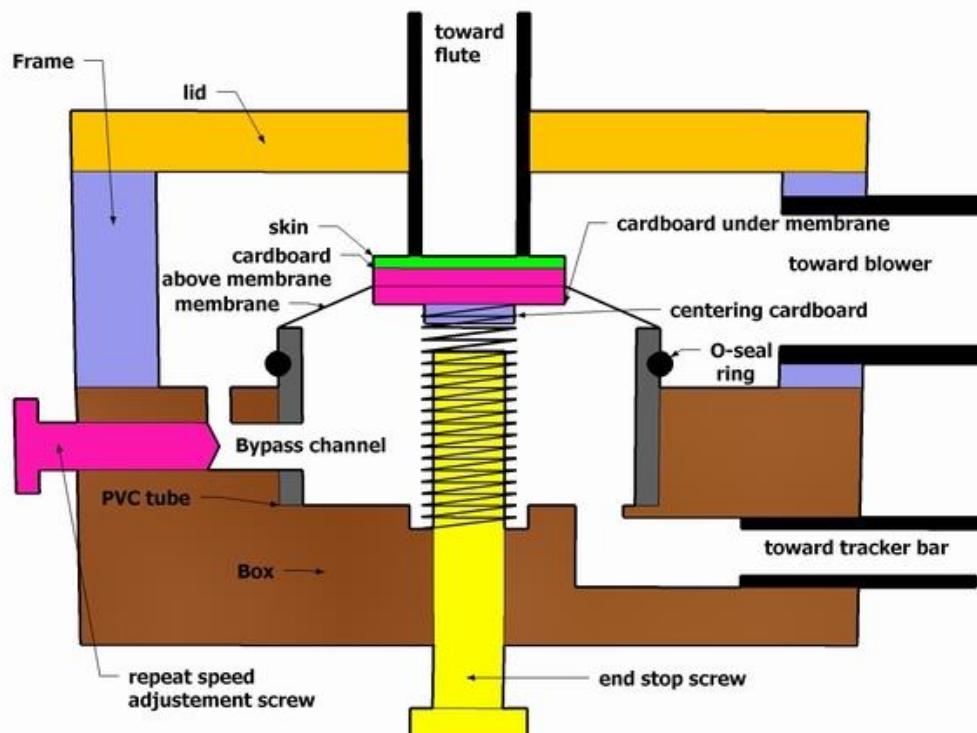
Each valve can only have two states :

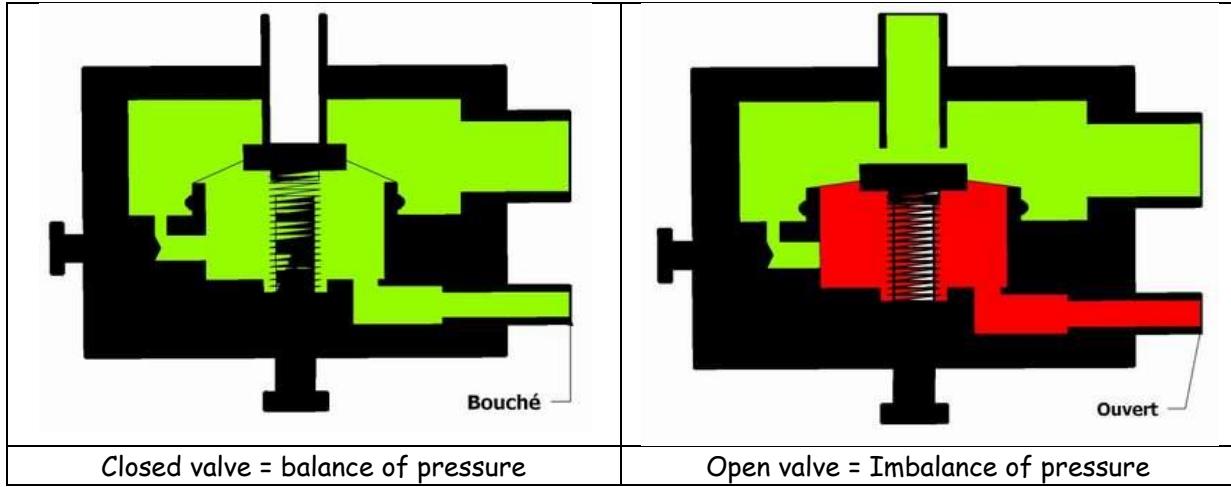
- 1 - Closed valve : the air from the blower is blocked and does not reach the flute
- 2 - Open valve : the air from the blower is not blocked and reaches the flute

What does control the state of the valve ? In the normal state, the air from the blower is introduced in the main part of the valves unit, but also in the lower part via a bypass channel.

If the hole on the upper face of the tracker bar is clogged by the book, there is balance, and due to the presence of the spring, the valve (made of cardboard and skin washers) obstructs the entrance of the tube which goes to flute that plays the sound. In this case, the air does not arrive on flute rendering it mute.

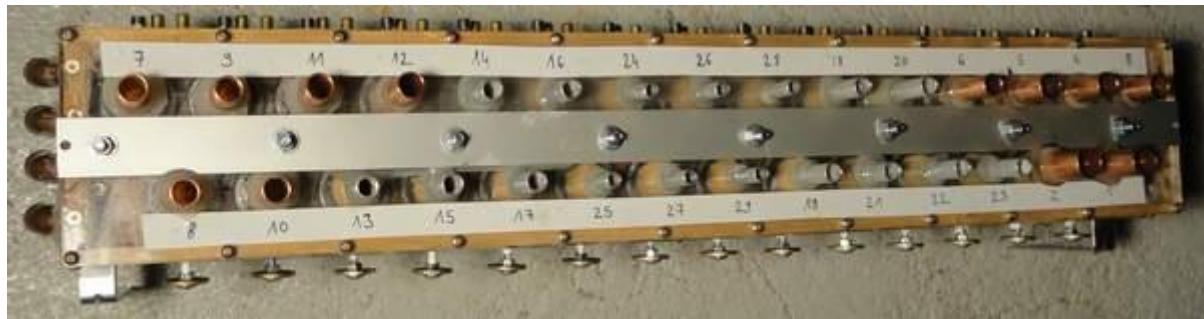
If, conversely, the hole on the upper face of the tracker bar is not clogged by the book, there will be a vacuum in the plastic tube that connects the tracker bar to the wind chamber of the valve. This depression will release the stress on the valve, leaving an air passage to reach the flute and let it sing.





It is the German organ builder Robert HOPP who is behind this principle of valves, which was used in churches organs in Germany.

This is a picture of the finished box !



A beautiful piece of 2.4kg. But before you get there, you have to be persistent

8 - 2 - MAKING A TESTING VALVES UNIT



We have a friend who tests ejection seats on helicopters.

He does insist on the necessity to test any mechanical system !

At first, we had only a sketch of principle and no accurate drawings with dimensions.

That the reason we took the precaution of going through the stage of a mini-box test before going further with the whole box.

This allowed us to validate the valves dimensions, the spring strength, and the proper functioning of the whole.



The use of a Plexiglas lid gives advantage to visualize the movement of the valve, thus validating its perfect operation. For against, use of plexiglass has a drawback which is to be fragile.

In fact, it is when drilling for output tubes valves, and when tightening the mounting screw that there is risk of cracks.

We made a small box with 4 sizes of different outputs to suit all output tubes flutes.

Begin by testing a first valve. Just plug two plastic tubes :

- one on the air inlet of the wind chamber (from the blower)
- on the air supply of the tracker bar

It must of course also connect a flute, which is on our photo is connected directly to the mini-box. Then send air into the first tube.

If the air inlet tube of the tracker bar is clogged with finger, the air pressure in the valve is equal through the bypass channel. Thanks to the spring, the membrane remains in UP position, and the air does not come out to the pipe that will be connected to the flute. In this case, the flute is silent.



If the air inlet tube of the tracker bar is left in the open air, there is a depression in the lower part of the wind chamber. So the membrane goes in DOWN position, and the air can reach the plastic tube that will be connected to the flute. In this case, the flute sings.



You must follow the same process for each valves of the test box, although normally, if it works for one, it should also work for others.

Once full operation is validated, should throw the mini-box test in the bin ?



Certainly not ! it will be reused for educational purposes to explain the functioning of the crank organ.

Actually you will see that a lot people want to know and understand how a crank organ works.

While it is relatively easy to explain how the blower works, it is more complicated for the valves unit.

So it becomes much easier to explain with the object in his hands.

So we sawed into two parts. One for each of us.

Only one membrane is positioned to see the inside wind chamber.

A simple plastic whistle will do the job (no need to make a 30st flute)

The box is fully operational, simply blow into it



8 - 3 - MAKING THE WHOLE VALVES UNIT

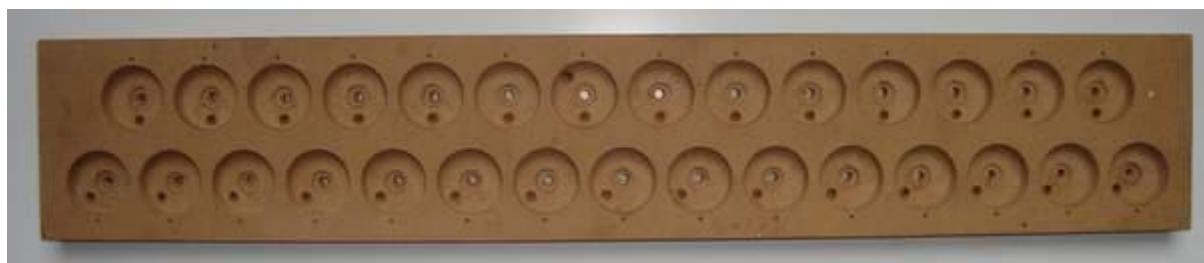
The box is carved from a block of MDF (medium density fiber).

This material has an advantage and a disadvantage.

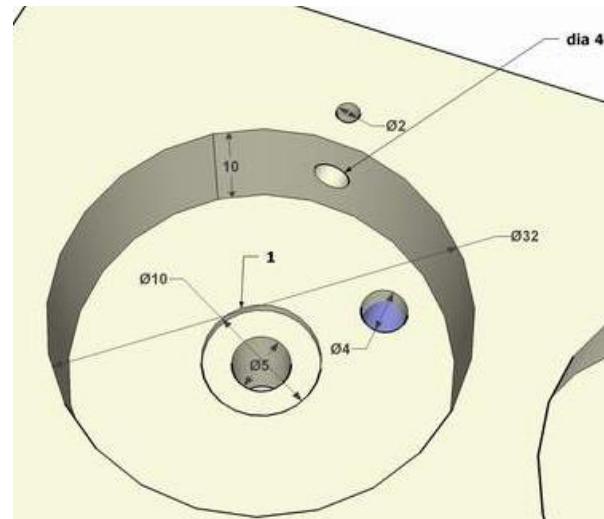
- Advantage = it machines easily
- Disadvantage = it is porous, leading to air leaks. It will therefore be taken into account with a particular treatment

The valves unit has 203 holes or machining, so it will be similar to a nice piece of Swiss cheese.

Dimensions of the lower part : length 592 mm X 100 mm wide X 22 mm thick

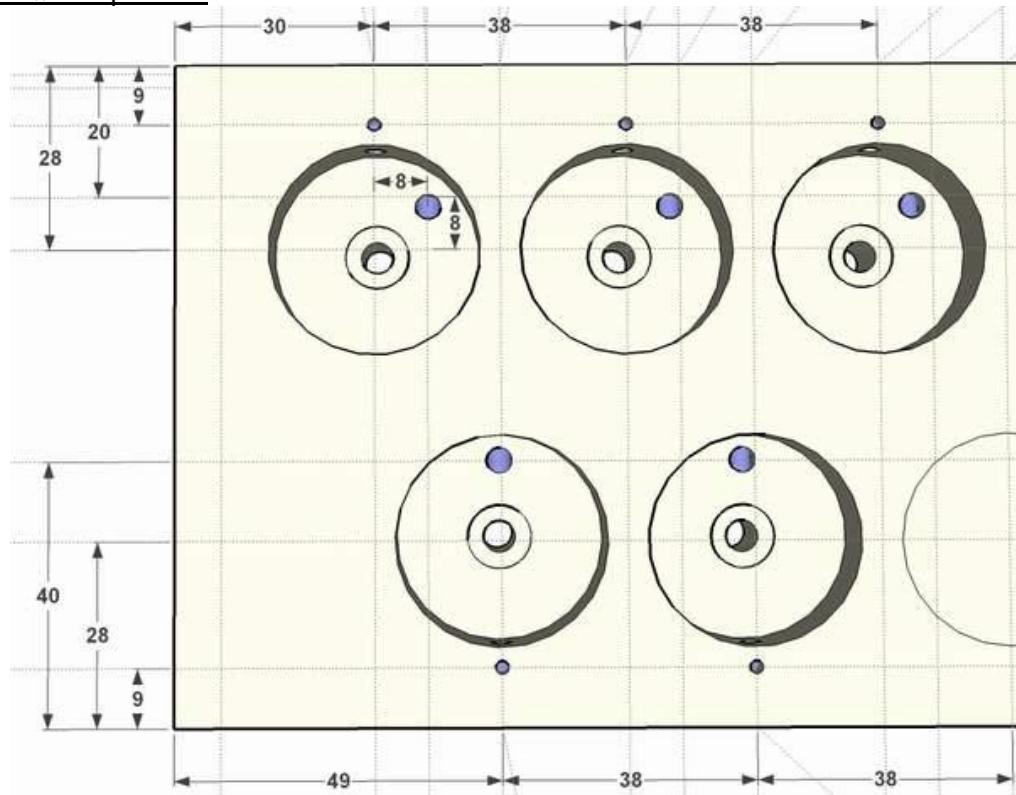


Wind chambers characteristics



- Wind chamber diameter 32 mm
- Wind chamber depth 10 mm
- Vertical hole centered 5 mm threaded screw M 6 (setting the stop screw)
- Milling dia 10mm 1 mm deep (centering spring)
- Eccentric vertical hole dia 4 mm and a depth of 8 mm (air intake of the tracker bar)
- Horizontal hole dia 3.3, threaded to screw M 4 (repeat speed adjustment screw)
- Vertical hole dia 2mm (bypass channel between inside and outside of the wind chamber)

Wind chambers position



Let's start with the holes for end top adjustment screw valve, taking the following precautions :

To be sure that the output holes towards the flutes located on the lid are perfectly aligned with valves located in the valves unit, it is advisable to use the technique of counter-drilling.

So, drill the two pieces (box and lid) simultaneously.

In fact, it is advisable to drill completely the box from side to side, but only to point the position on the lid. **Warning plexiglass is fragile**



On organ n° 2, we used a wooden lid.

Whatever its material (Plexiglas or wood), the dimensions of the lid will be of course identical to those of the valves unit.





To be sure to replace easily the lid on the box, it is advisable to mark a reference arrow.

This avoids turning the lid in all direction to find the right position.

Then, we go to the machining operations of the box :



For wind chambers, a milling machine will be once again welcome

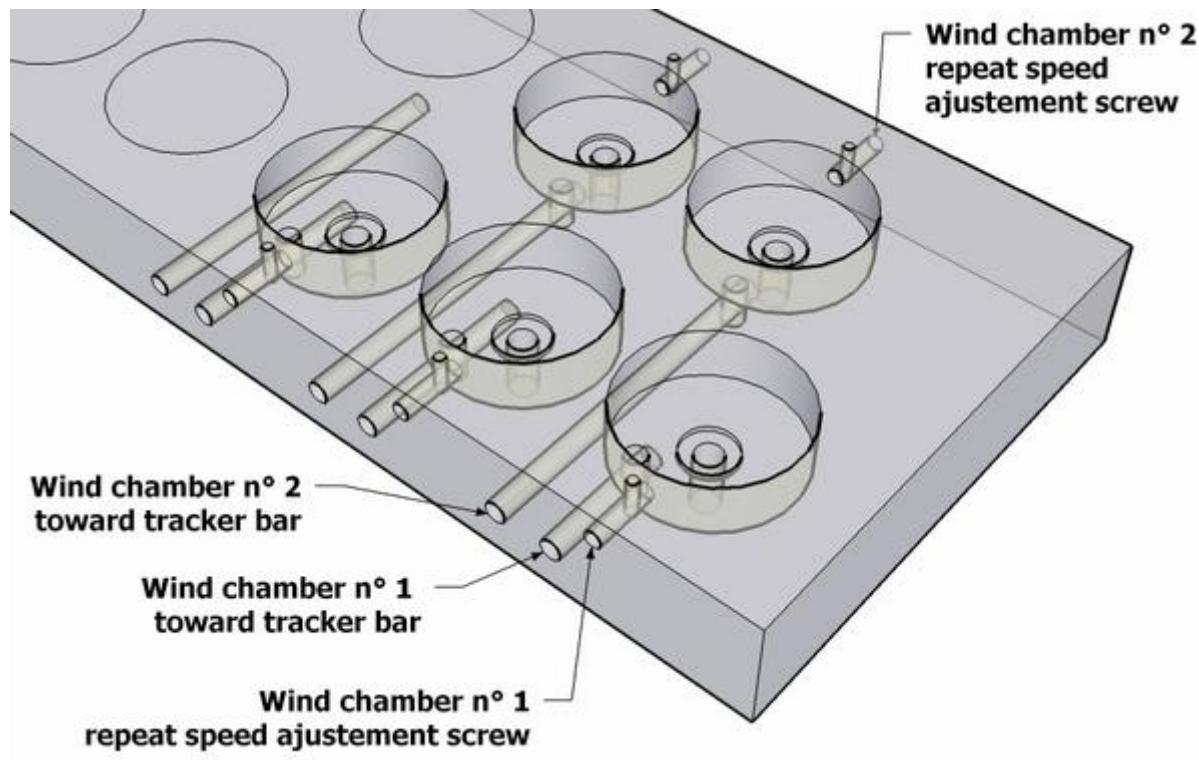


Thread for screw valves



If you have no milling machine at your disposal, you can use flat drill to make large hole for chambers

Explanations of the holes on box edges :





Holes on the upper side

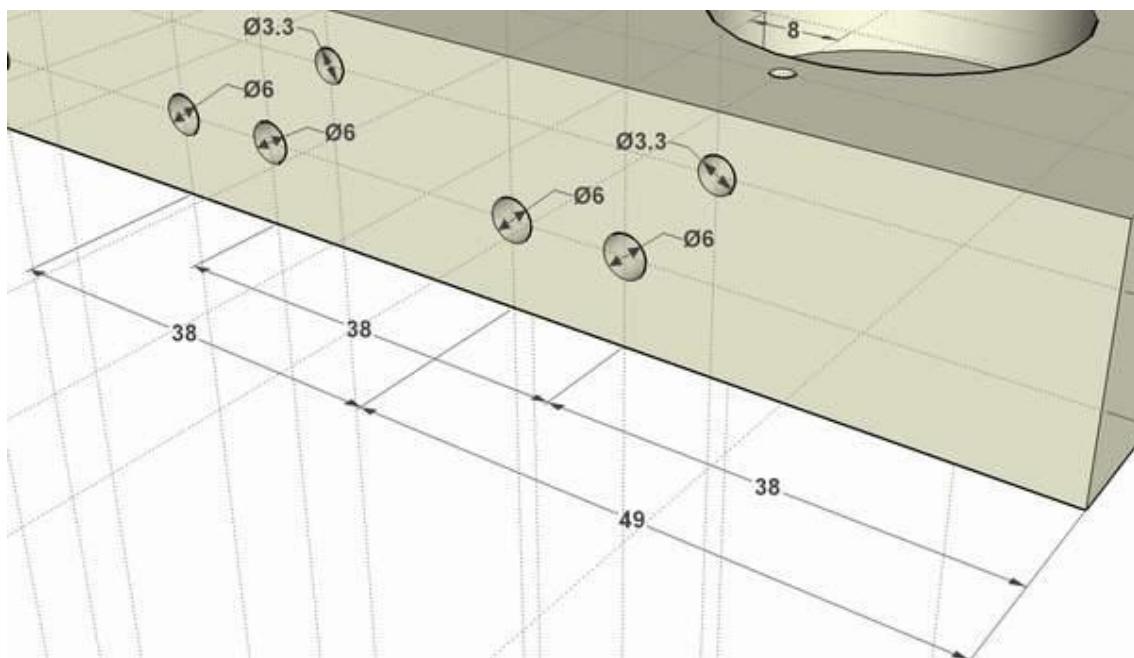
Small holes = repeat speed adjustment screw
Large holes = toward tracker bar



Holes on the lower side

Small holes = repeat speed adjustment screw

Holes positions on the side



Box surface treatment :

After completing all drilling and machining, you must sand the box everywhere, including in the inside of wind chambers to remove medium (MDF) lint.



The medium (MDF) is a porous material.

So, you must apply two coats of varnish. Without this precaution, there may be a risk of air communication between two wind chambers, so two notes would sing simultaneously while only one should.

It will brush all parts, focusing primarily on the inner parts.



If you have been a little too generous on the amount of varnish, it is possible that varnish clogs the bypass channel.

Simply insert a small drill to clear the bypass channel.



8 - 4 - THE VALVES

As we explained before, valves have the function to control the passage of air from the blower to the flutes. So these are a major part that require special attention,

For the flexible membrane, purists will advise you to cut small discs from pig intestine, or horse ! The characteristics of this skin would be ideal for the intended use.

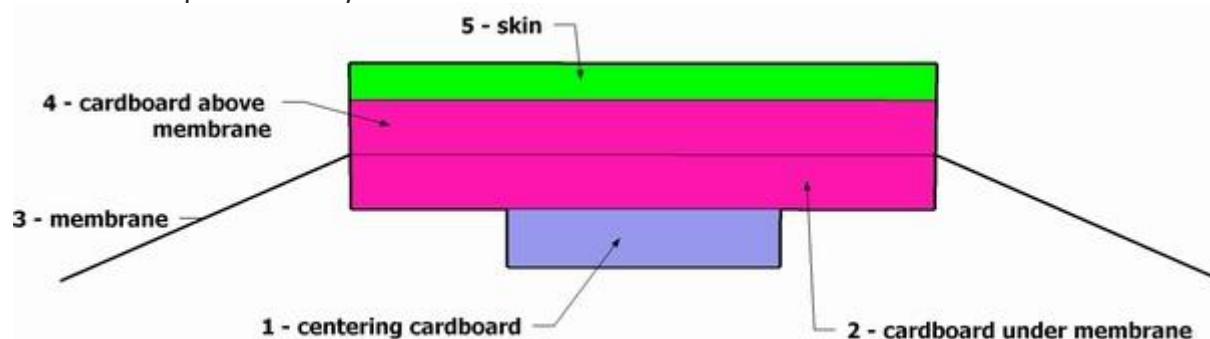
Initially, we followed this solution.

But cleaning pig intestines do not specifically set your taste and the odor during drying easily attracts flies So we went to Plan B.

Plan B is simply to use plastic bag film readily available in your big food store. In addition, it is for free.



A valve is composed of 5 layers :



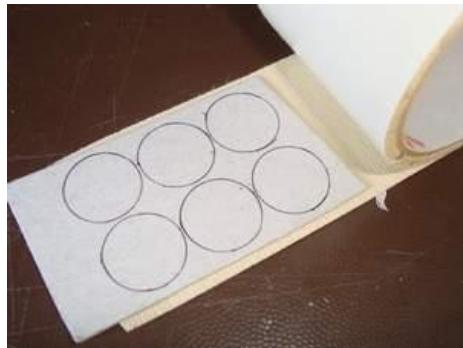
Layer	Description	How to glue ?	What is it for ?
1	A first ring of diameter 8 mm cut into a cardboard of 1.3 mm thick.		Allows centering of the pressurizing spring
2	A second ring 20 mm cut from a cardboard 1.3mm thick.	This ring is adhered to the previous with ordinary glue	Allows the stop of the pressurizing spring
3	A flexible membrane and very fine (plastic bag in food store)	This membrane is adhered to the previous washer by a piece of double sided tape.	Allows the assembly to be secured to the PVC tube
4	A third ring 20 mm diameter cut into the cardboard of 1.3 mm thick.	This ring is adhered to the membrane by a piece of double sided tape	Receives skin
5	A fourth ring of 20 mm diameter cut from in leather skin of 1.3 mm thick.	This ring is adhered to the previous ring by a piece of double sided tape	Allows plugging the outlet pipe of the valves unit

Knowing that some valves could be damaged during their introduction, we advice to make more valves than needed.

The cuts can be made with a cutting punch.

If you have the opportunity, choose a short cutting punch. So you can squeeze it in a vise.

It is easier and less noisy than with a conventional punch and a hammer.



The plastic film for the membrane is convenient and cheap, but it nevertheless has a small disadvantage in that it is difficult to stick it on the valve unit. Anyway, if you can stick it, it becomes impossible to get it off in case of trouble.

Despite multiple adhesive testing, we have not found the good one.

That's why we used to 29 sections of grey PVC tubing outside diameter 32 mm

In all cases, it is quite laborious.

It is therefore advantageous to cut sandwiches (cardboard + double-sided tape + skin).



Warning : if like we did, you opt for recycling tube, beware of choosing tubes having the perfect same inner diameter. Depending on their origin, you can find different thickness. This will impact upon the establishment of the valves using a specific tool which will be adapted to the inner diameter of the tube.



Each section is 15 mm height. We performed a round small groove 1 mm depth and 3 mm from an edge.

Valves are held in place with a simple O-ring seal.

The end of the tube must be perfectly sanded to prevent the film is injured.

Advantage of this solution : the valve is repositioned if it goes wrong.

8 - 5 - THE VALVES SPRINGS

The springs are used to maintain a slight pressure of skin discs against the output tubes.

We need 29 very soft springs of 8 mm outer diameter and 20 mm height uncompressed (20 mm = 1 mm to enter the milling at the bottom of wind chamber + 15 mm for spring height + 4 mm PVC pipe exceeded)

It is not easy to find them in your DIY store.....



So we will manufacture them with piano wire 4/10. Compliance with this diameter ensures perfect operation.



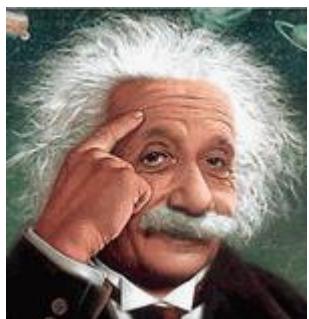
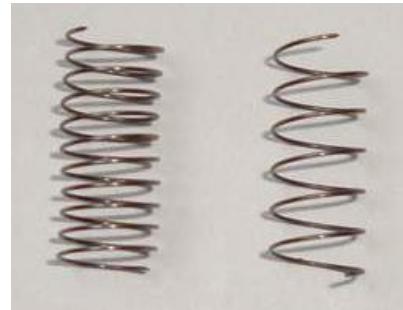
At the beginning, we started with a very rudimentary system for making springs :

- A long threaded rod 8 mm diameter, drilled across to insert the tip of the piano wire
- Blocking the rod between two pieces of wood clamped in the jaws of a vise.
- Turn the wrench
- We get a long spring which has to be cut at the required length.

This system has a disadvantage insofar as the springs thus manufactured are not all identical.

There is no constant in diameter, and the number of turns is also variable.

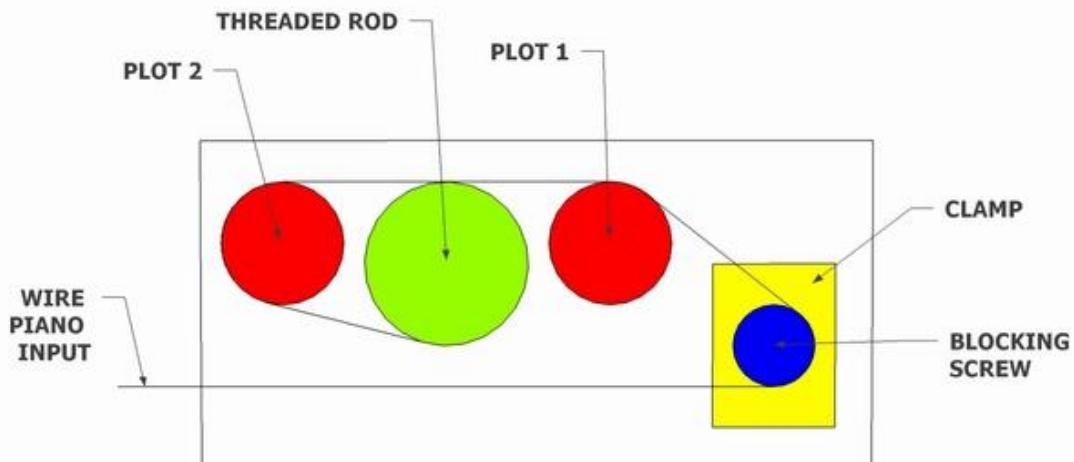
For the same overall length, the left spring is more flexible and better suited than the right one.



Our engineering department has therefore focused on the subject and concluded that it was because at first, the piano wire is wrapped into a coil, and we have to stretch it beforehand.

Then our prototypes department has considered a machine to slightly stretch the piano wire before winding on the threaded rod.

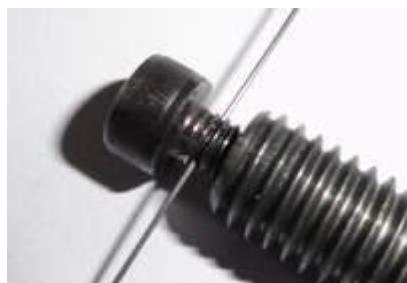
Here is the result :



Travel of the piano wire :

- The piano wire is firmly clamped between the support and a Rilsan clamp
- Then it turn around the screw which tighten the Rilsan clamp
- It bends a little on the plot n° 1
- It makes a U-turn on the plot n° 2
- It is wounded on the threaded rod

The dimensions of the device are not critical.



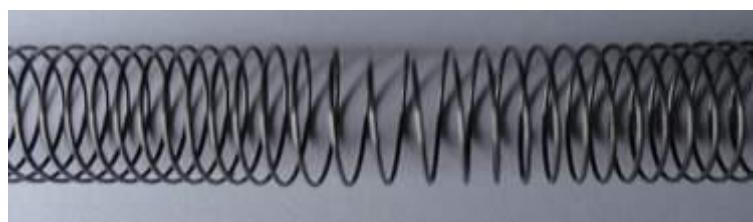
To be perfectly driven around the threaded rod, piano wire must be strongly attached.

This is why the threaded rod is drilled and tapped to M3. A screw with a small transversal hole allows to bind the piano wire.



During the rotation of the threaded rod, either with a wrench or an electric screwdriver, don't release the effort.

Otherwise, the wire is not perfectly tight, and we get springs with uneven spacing between the turns, so with different characteristics.



One point : the more you tighten the rilsan clamp, smaller will be the diameter spring

Make a first test on a small length.

To cut all the springs at the same length we have invented a system whose complexity is inversely proportional to its ease of use.

It's a simple piece of paper with two pencil lines spaced 20 mm. Simply place over the spring, and cut to the right place.



How long piano wire do you need ?

- Approximate length of one turn = diameter x 3.14 = $8 \times 3.14 = 25$ mm
- Length for a spring = number of turns x length of one turns = $14 \times 25 = 35$ cm
- total length springs = $35 \times 29 = 10.20$ m.



Knowing that there is little chance that you can easily find the piano wire from your local hardware store, you will have ordering on the net.

No luck, the most common packaging is 10 ml. Therefore, you have to order two rollers 10 ml. Any way, you will have some loss especially in the early rounds.

The spring force must be such that the membrane does its full course under a pressure between 15 and 20 g ...

It is the weight of 2 pieces of 2 euros (2×8.5 g = 17 g).



Sorry if you live in a country with different currency.

It should not only focus attention on the upper limit of the range, ie the weight of 20 grams.

Indeed, one might think that if the valve is more sensitive, so if it reacts with a weight of less than 15 grams, the result will be better. Well no !

In this case, the valve will change state too easily, being very responsive to the slightest molecule of air that could occur in the circuit that connects the tracker bar to the valves unit.

So better is to use piano wire 4/10.



The method of measurement with 2-euro coins (or equivalent) may sound empirical and imprecise. Nay ! If you do not follow this method you will have valves that refuse to function normally.

8 - 6 - IMPLEMENTATION OF ELEMENTS ON THE VALVES UNIT

29 PVC pipe sections are fitted by force into the valves unit.

This is where you will realize that the diameter of PVC pipes could not be perfectly constant.

It is true that a sink drain does not require great accuracy.

First, ensuring that the tube section is straight before tightening all in the vice. Then tighten slowly.



The valves unit has previously been drilled 29 holes for the passage of air used for setting the repeat speed adjustment screw. So you must repeat the operation to cross the PVC tubes.

Drill straight to avoid damaging the threads.

Tips for pipe connections from the tracker bar

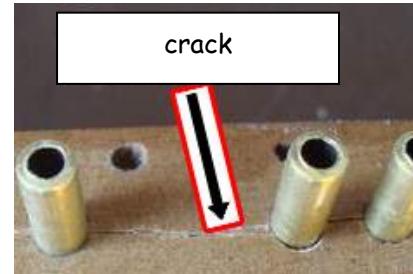
Before hitting hard on the tips to make them enter the valves unit, confirm that their diameter fits with the hole diameter.



Otherwise the box can crack.

Again we have tested for you ...

In this case, you must seal the crack with glue and put a small screws to make compact package.



Repeat speed adjustment setting



Like a machine gun, the valves will be subject to repetition of movements if the same note is played repeatedly.

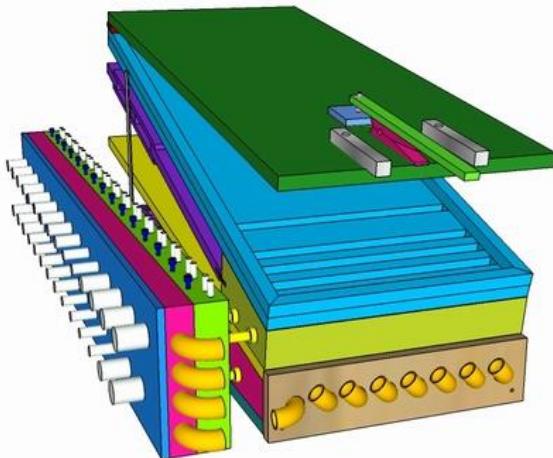
This screw will help to set the repeat speed adjustment, so the ability of the instrument to successively and distinctly play the same notes close together.

Dimensions 4x20 screws - Guess how much it takes?



For organ n°1, we opted for vertically positioning the valves unit. This is the position which we thought was the best.

- Air arrives from the blower by the ends
- The air outlets are going well in the direction of the flutes
- Air arrivals from tracker bar are from above
- The stop adjustment screws are accessible between the box and the blower
- The repeat speed adjustment screws are accessible from the top and from the bottom.



Having opted for the vertical position of the box makes that 14 screws of repeat speed adjustment are not found very accessible.

We must find a system to easily turn the repeat speed adjustment screw located below the box.

You can make special screws by using coins.

Once drilled and tapped, screw is locked with a nut.



Depending on the density of the medium you have used for the box, it is possible that there is some slack in the thread.

If this is the case, it must wrap each screw with some teflon tape used in plumbing.



For organ n° 1, the valves unit will be held in place by strong rigid brackets.

A small wooden block will be placed below the box to prevent the overhang.

Repeat speed adjustment screws located under the box are not very easy to access.

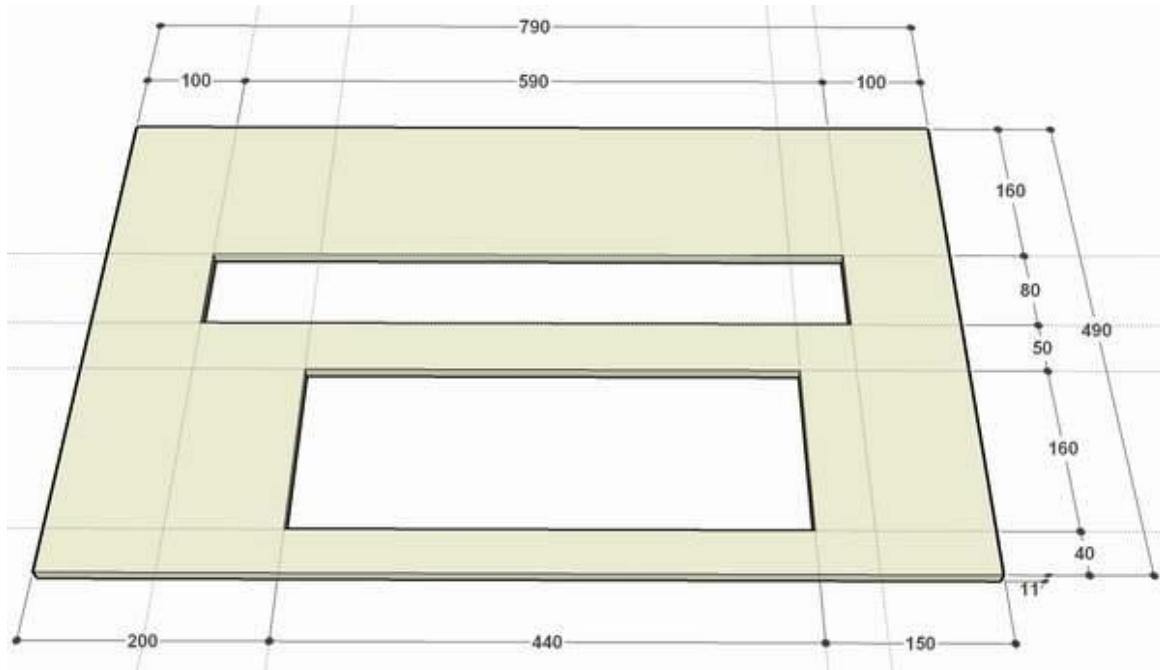
Before attaching the valves unit, it is essential to make a large aperture with a jigsaw on the base.

As the jigsaw is ready, make another aperture under the blower.

In this case, the goal is to gain a little weight.

We advice to make an accurate drawing before sawing.





For the organ n° 1, for easy access to repeat speed adjustment screws located on the upper side of the box, it's simple.

It will suffice to make a special long screwdriver handle, with an end of a hexagonal key connected to a long rod through a sleeve bonded.

Initially, screw to ensure that the end of all the screw arrives at the vertical of the small hole, which opens into the valves unit.

As for the setting of the stop screw valve, the precise adjustment of the repetition screw will be done later. The explanations will be given in Chapter 9.

For organ n° 2, the position of the valves unit is different, and we used another fixing system.

It uses two wooden pieces which provide the connection between the valves unit and the support structure.

In this case, repeat speed adjustment screws are easily accessible from each sides.



The stop screw valve



This screw will allow to adjust the amount of air that will free by the valve. This will affect the sound level generated by the flutes.

For organ n° 1, it's not always easy to have access to all the screws.

But normally when they are set at the beginning, we no longer need to touch them

For organ n° 2, all screws are accessible through the aperture cut in the base.

The valves

Once the valves are in place, the assembly is quite fragile. So we suggest you complete the valves unit after spending the following steps :

- hole of the valve unit lid for the seat tube and the mounting holes
- construction of the frame all around the valve unit
- making the gasket
- test pressure

8 - 7 - DRILLING OF THE VALVES UNIT LID



Excess lengths of plastic tubes between valves unit and flutes are to be avoided for not great lengths intertwined.

By contrast contrary to what one might think, the length of plastic tube has no influence on the flow and air pressure which arrive in flutes.

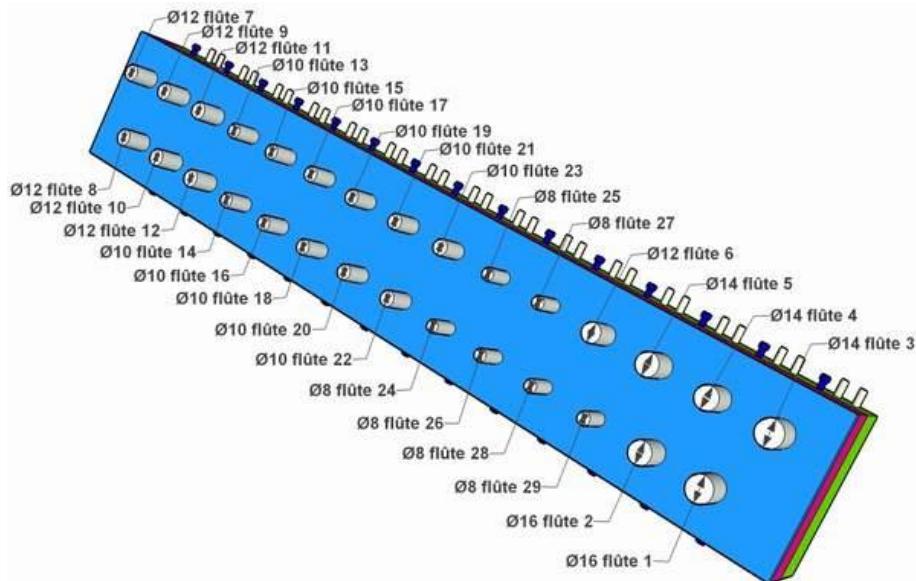
For proof, simply connect a flute after ten meters of plastic tube, and blowing into it, you will hear the flute sing as if it were connected to the shortest.

However, it would be totally illogical to connect the flute located rightmost on the output of the leftmost valves unit.

To optimize lengths, you must of course take into account the physical layout of 29 flutes. Approach the flutes sets close to valves unit.

It remains to be defined for each plastic tube the most appropriate way. Note on the lid, the hole diameter to drill and the flute number.

Here is the identification of outputs corresponding to the organ n° 1. This is not necessarily the flutes layout you have chosen. So it's a sketch to be customized according to your instrument.



Then drill the lid for 29 output tubes.

It is necessary that the lid is securely fastened during drilling operations.

To avoid errors during subsequent connections, and thus facilitate the delicate phase adjustment that will come, it is strongly recommended to identify the various inputs and outputs, as well as the adjustment screw number.



Marking the arrival of the tracker bar
and adjusting screws (repetition speed)

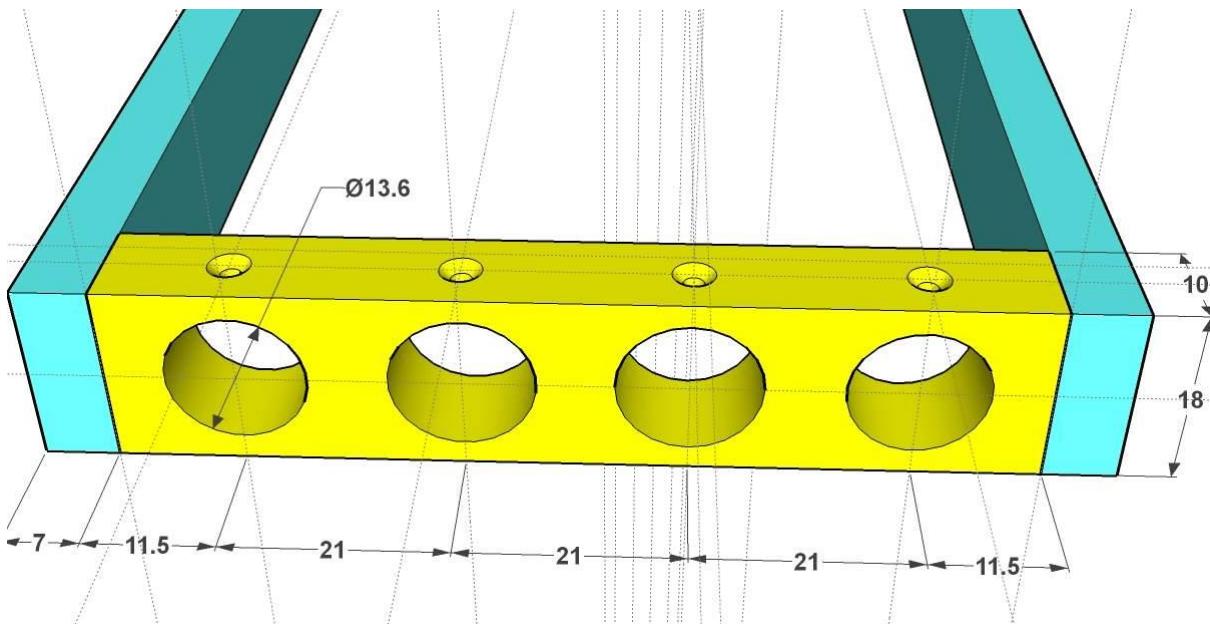


Marking of outputs to the flutes

8 - 8 - THE FRAME

We must now make a wooden frame that will take place between the valves unit and its lid. This frame takes a simple form of 4 wooden cleats.

- 2 long cleats section 18 x 7 mm and length 592 mm (equivalent to the length of the valves unit)
- 2 short cleats section 18x10 mm and length 86 mm. The larger thickness of 10 mm allows a better fixation of copper elbows that will be inserted in it.



On each small cleat located at the end, you must drill four holes diameter 13.6 which corresponds to the diameter of the copper elbows (or hole 13 mm + round rasp)

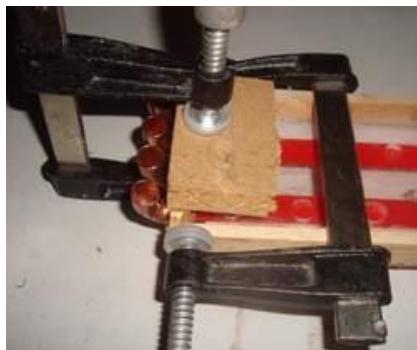
As we have done on the cleat that connects copper elbows to the blower you must :



Make small countersunk holes on top to put a short screw to secure copper elbows.



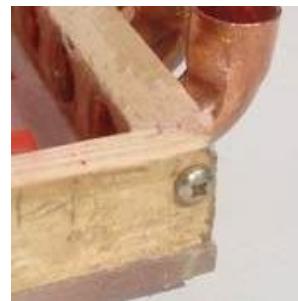
Chamfering the rear of the big holes to put a few drops of silicone ..



Plastic tubes will have unwanted strong efforts on the frame.

Hence, you must insert a small screw on each side of the frame.

To prevent air leakage between the frame and the lid, there must be a silicone seal around the perimeter frame.



Then the lid is applied heavily, placing above your old PLAY BOY magazines collection, and when it's dry, you put small screws through the lid.

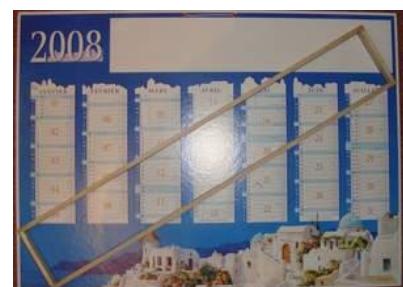
8 - 9 - THE GASKET AND FIXING THE LID

It must be a perfect link between the valves unit and its lid. So you have to make a gasket.

For organ n° 1, we opted for a gasket made of cardboard.

Its dimensions are naturally adapted to those of the frame.

Given its great length, it will be cut obliquely in a calendar.



A simple cardboard gasket is not enough to compensate all unevenness between the valves unit and the frame. In fact, we must make a sandwich of three layers (foam + cardboard + foam)

The foam is the one that is used under the floating floorboards.

- Cut cardboard in one unique piece
- Cover both sides with double-sided tape
- Apply on both sides a foam layer
- Carefully cut with a sharp cutter



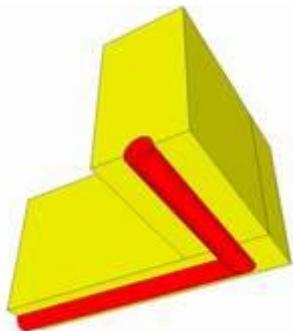
To center the frame and its lid on the valves unit, four plots are positioned at each corner. They are made of a spacer and a screw.

So the total set (lid + frame + gasket) will automatically find its right place.



When tightening the frame, the gasket could move sometimes with a slight decrease inward the valves unit.

In extreme cases, it can clog the bypass channel. To avoid this, just put a few nails, in order to keep it its place.



For organ n° 2, we opted for another solution, which requires a milling machine.

A small cylindrical groove was machined all around the frame and of course all around the valves unit.

Just buy a great length of O-ring, paste it to ends, and insert it into the groove

It is imperative that the valve unit and the set "lid + gasket + frame" are well attached.

A screw in each corner is not enough to ensure perfect adhesion.



We drilled the lid with several holes aligned along its longitudinal median axis.



Before drilling anywhere, make sure that the holes for fastening the lid are not made at the vertical of holes allow air access in the valves in the bottom row.

For securing the lid, using simple wood screws is not recommended for the following reason :

Given the many manipulations on the valves, there is a good chance that you will have to screw and unscrew the screws several times. The medium MDF has not a very hard structure. So, it will not bear several operations.



Here is the solution we chose for the organ n° 1 :

- Pre-drill the valves unit to the diameter of 4 mm
- Establish long screw 5x60 (no need to thread - in the medium, it goes in easily)



As we mentioned in the chapter about the test of the valves unit, the Plexiglas lid is prone to cracks when tightening the mounting screws.

Indeed, it is difficult to dose the effort to prevent damage. On the organ n° 1, the Plexiglas plate 5 mm thick was broken in two pieces. Then, we had to cut a new one.



To avoid cracks, it is strongly recommended to put a flat aluminum slat 25 mm wide to spread the load when tightening the nuts.

It will take a few notches with the half-round file to make room for the larger tubes.



To compress the gasket, you must tighten the nuts hard enough. This must be done gradually passing from one nut to another to avoid breaking the lid.



For organ n° 2, we have set up links screws that are used to connect the furniture together

Once the lid tightly screwed, ensure that the valves unit is waterproof, so no loss of air.

Before making the pressure measurement, of course you have to clog the holes on the lid and also the small tubes which receive plastic tubes coming from the tracker bar.



Occultation of holes on the lid
by scotch tape.



Occultation tubes with caps
(plastic pipe + glue gun)

Once all holes are clogged, air is introduced in one of the input box. The other 7 inputs must be of course clogged.

Logically the valves unit is opposite to the crank. So if you have not a good friend to turn the crank, the mission is tricky.

So, it is possible to blow directly into the valves unit via a plastic pipe.



In this case, in addition to test the valves unit with a higher air pressure, it also facilitates the search for air leaks, in so far as the valves unit can be positioned in any direction in order to get the candle closer, or to drop cocaine on it.



Approximate location of the leak by using a candle



To locate the mini leaks very precisely, you can sprinkle some cocaine, and look for mini eruptions .

Once your valves unit will have passed the test pressure "air from the mouth," you need to make a second test with the valves unit connected to the blower.

As we have already mentioned in a previous chapter, you should know that the insertion of the valves unit will cause a loss in the air circuit. This loss is in the order of a centimeter pressure.

If there is more, this is not normal. This is a sign that there is an air leak in the valves unit, or in the blower.

8 - 10 - VALVES IMPLEMENTATION

Let's go now to the delicate process of implementing the valves.

In the rest position, it is imperative that all valves are at the same height.

In a first step, adjusting the top adjustment screw to ensure that its end comes back to roughly one centimeter below the upper section of PVC pipe, in order not to hinder the introduction of the valve.



The screws will be set later during adjustment of the valves unit. This will be discussed in Chapter 9.



For the implementation of the valves on the PVC tube, you will need a third hand.

It takes two hands to hold the PVC film and another one to set up the O-ring seal.

Actually, the operation remains delicate with some risks :



Valve not horizontal



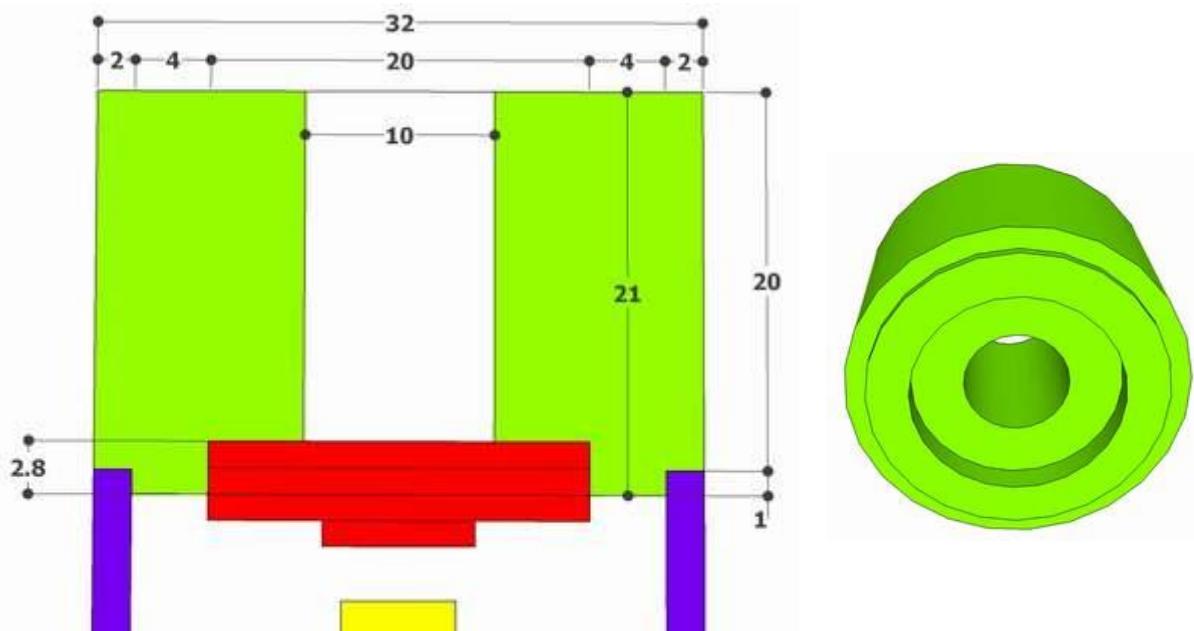
Eccentric position



Unstretched valve

In the worst situation you can also have an unstretched valve, not horizontal, and with an eccentric position. **BINGO !**

To do a good job, you must first invest some time in making a centering tool, with the following shape :



The dimension of 1mm is important, because it will affect the position of the membrane once the centering tool is removed.

We got the tool from a Rilsan block, but it can be made also in aluminum.

The tool will cap the PVC pipe section to deposit the membrane the best way possible.

Here is the methodology successfully tested:

- Insert a spring around the screw inside the wind chamber (yes it seems evident, but do not forget...)
- wrapping an O-ring seal at the base of the centering tool
- inserting a membrane in the tool
- positioning the tool vertically into abutment against the section of the PVC tube
- applying pressure to the tool and at the same time transfer the O-ring seal downwards.





Then remove gently the centering tool, leaving the membrane in place with a pen which traverses the tool.

Check that the membrane goes down well under the weight of two 2-euro coins (or equivalent)



Here we must emphasize on the extreme need for a perfect functioning of each valve. Do not accept a valve that does not react well to the test of euro coins (or equivalent)

The time you invest in this phase will largely pay for itself when you set up the output tube. If all membranes are correctly positioned, it will be possible to place output tube positioned at the same height.

After each membrane in place, it is necessary to carefully cut the film with a cutter, especially close to the bypass channel.



By tapping gently on the membrane, you must see it moving quickly. If its movements are slow with some inertia, it is a sign that the internal wind chamber does not communicate with the outside. In other words, this means that the bypass channel is clogged by varnish.

8 - 11 - OUTPUT TUBES TOWARD FLUTES

To ensure perfect air lock function, the top of membrane must come against a tube perfectly plane.

To manufacture these output tubes, you can use copper or aluminum tubes (or both of them depending on the diameter available).



The end of the tube should be perfectly prepared for a perfect seating of the membrane.

The slightest burr can cause an air leak.

A turn machine will be welcome.

You have to accurately determine the length of the output tubes inside the box. In the rest position, the skin disc must abut against the tube, neither too much nor too little.

- In the first case, the movement of skin disk is insufficient, and does not leave enough space for the air circulation.
- In the second case, the air would pass all the time, making flute sing continuously.

We must also take into account the aging of the skin, which will over time settle a little. Given these points, it is estimated that the optimum course of the skin disk is 1 mm.

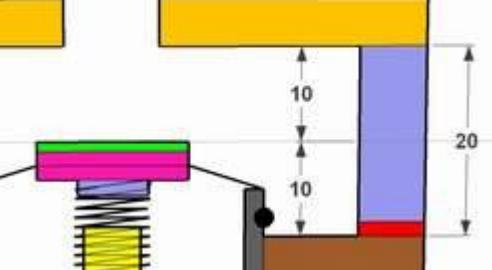
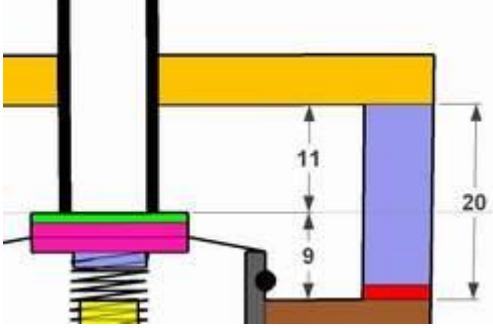
How to calculate the height of the tubes under the inner face of the lid ?

First, measure the distance between the top of skin disk and the upper face of valves unit.

This is done using 2 metallic rulers.

Here we get 10 mm



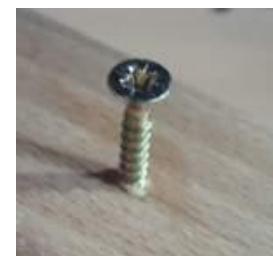
 <p>Calculation of height above the skin disk in the absence of the output tube. The frame and the gasket measure 20 mm. So, 10 mm remains between the top of the skin disk and the internal face of the lid.</p>	 <p>In order to get the disk skin course of 1 mm simply increase of 1 mm the space between the top of the skin disk and the internal face of the lid. ($10 \text{ mm} + 1 \text{ mm} = 11 \text{ mm}$)</p>
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This calculation has to be confirmed physically on the valves unit.

Before gluing all output tubes, check the calculation by making one test on only one valve..

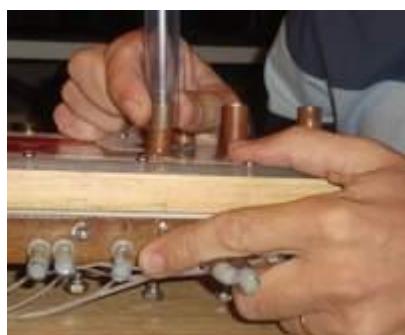
The valve operation control is made by connecting a medium sized flute.

Do not forget to plug temporarily by a screw the small hole in the back of the flute, which was previously done to keep it in vertical position.



Inserting a tube so that it abuts against the skin disk by exerting a slight pressure on the tube.

Having chosen a Plexiglas lid on the organ n° 1 makes possible the operation.



At first, move down slowly the tube until no longer song comes out from the flute..

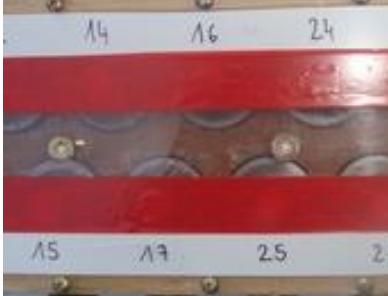
Of course the small tube that goes to the tracker bar is clogged with finger.

When the flute becomes mute, you take off your finger from the small tube. Then, you must hear the flute sing.

The above picture suggests that you need 3 hands: one to hold the output tube, one to clog the air inlet, and yet another to turn the crank...

This is where you will realize that the idea of small plastic tubes clogged with glue gun are very convenient. Count the number of times you'll have to put them on and take them off, and you will be convinced that the system is very useful.

If the flute does not sing, there may be several reasons :

<p>The flute does not sing at all, even if you blow directly into it.</p> <p>You must review its production.</p> <p>It is also possible that the cap is not in place or not airproof.</p>	
<p>The stop screw prevents the valve to go down. Having opted for a Plexiglas lid allows to visualize non-movement of the valve.</p> <p>In this case, screw down the screw.</p>	
<p>The other 28 holes are not clogged.</p> <p>You have to clog them temporarily with scotch tape.</p> <p>Attention : on the largest holes, one scotch tape strip could be not wide enough.</p>	
<p>28 tips that go to the tracker bar are not clogged.</p> <p>Check that all the metal tubes are clogged with small plastic tubes clogged the glue gun.</p>	

Once that is correct for the first valve, then just bond the first output tube.

At the time of bonding, be sure to get perfect verticality of the output tube.

Bonding the output tubes with a glue gun does not give good results on a Plexiglas lid. In addition it makes ugly blocks.

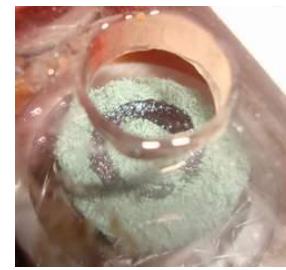
We must use bi-components glue quick setting (eg : Araldite). The mixture usage time is 4 minutes, so do not prepare too much at once.





When bonding the output tubes, we had another good bad idea. To increase tightness, we set the glue inside the hole in the lid.

In fact, when inserting the output tube, this has the bad effect of applying a beautiful print of glue on the skin disc.



So it is better to deposit a bead of glue only on the portion where the tube is in contact with the lid. After insertion of the tube, a pretty circular bead will form automatically.

The bead of glue will act as gasket around the output.

Before removing the plastic tube of the output tube, be patient and wait until the glue is dry. Otherwise, there is a risk to change the position of the output tube.



At first, bond the output tube only on the outer surface of the lid. Choose an output tube located at one corner of the valves unit.



Repeat this operation for 3 remaining output tubes also located near the corners of the valves unit.

You'll have a baseline for the development of the other 25 tubes, as follows:

- Remove the lid
- Check the length of the output tubes under the lid. If everything is normal, the size is the same for the 4 tubes (11 mm in our case)
- Cut a 560x80 mm wooden board so that it easily fits inside the lid.
- Place the lid over the board. it must be perfectly parallel.
- Slide in 25 output tubes with glue and apply them against the board
- Don't glue the tubes on the inner face of the lid
- Allow to dry



Caution : the position of the output tubes is of course related to the pressure applied to the lid when tightening screws or nuts.

Let's be pessimistic and consider the fact that one or more valves do not work properly.



After having repaired valves, which ensures that you will apply the same clamping force than the first time when reassembling the lid ?

That is a good question !

On the organ ° 2, we opted for a method of fastening the lid which ensures a constant clamping through O-ring seal. Just tighten and that's it !

On the organ n° 1, with the sandwich "foam / cardboard / foam" the risk is real.

We found a solution (of course ...)

- Before taking off the lid, measure with a caliper the overall thickness of the box (box + compressed gasket + frame + lid) It is 47.5 mm in our case
- From this value, subtract the thickness of the lower part of the valves unit so 22 mm, and the thickness of lid is 5 mm in our case.
- Cut aluminum tubes spacers 20.5 mm (47.5 - 22-5)



Open the valves unit and insert tubes spacers on the screw 5x60.

Then, when you will tighten the bolts, the lid is always be at the same height, as needed.

Once the lid is in place, we go for a final check of air leaks of the valves unit, and the proper functioning of each valve.

We advise you to make these controls in 2 steps :

Concerning the gasket :

Before making the pressure measurement, of course you have to clog the holes of the lid and also the small tubes that come out of from the valves unit to the tracker bar.

Connect the air pressure controller to one output and make the measurement.



In the end, we can still accept the loss of a pressure of one centimeter. This is almost inevitable.

Hence the need to start with 13/14 cm.

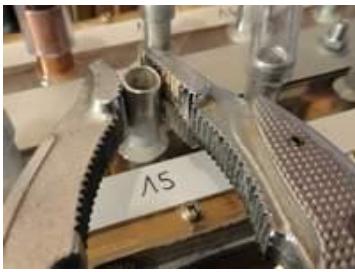
One centimeter was already lost with the valves unit without the output tubes. It subsequently falls into another centimeter with output tubes. Bottom line = 11/12 cm. That should be enough.

Concerning the valves :

Test each valve one after the other by removing the plug, and replacing it with a test flute.

Check that when you obstruct the air intake from the tracker bar, you do not hear any sound as small it may be.





If you hear a sound, you must go down very slightly the seat tube.

To take off one output tube without damaging it, the simplest seems to squeeze him softly in a vise clamp.

When you are sure that the 29 valves are working perfectly, you must take off the lid, hope for one last time, and paste all output tubes on the inner face of the lid.

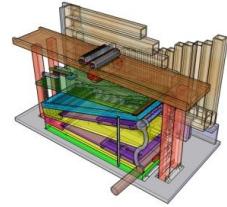
This will prevent the output tubes come off when connecting the plastic tubes to the flutes.



8 - 12 - CONNECTION BETWEEN BLOWER AND VALVES UNIT

You must first define the distance between the blower and valves unit, then estimate the length of plastic tubes.

Even if we took care to draw each item to scale, and if they are virtually positioned on the drawing board, it is still advisable to physically validate the location of various components.



Indeed, we must consider :

- To provide enough room for plastic tubes including their radius of curvature.
- The need to be able to place a wrench in order to adjust the screws on the valves unit.

The various components already manufactured have been positioned a little empirically on the board martyrdom.

For organ n° 1, the horizontal flutes are placed above the valves unit, and the vertical flutes are of course placed in the foreground.

As previously stated at the beginning of this document in the chapter flutes, you must provide sufficient space between the two rows of flutes.

This can be checked by playing one rear flute continuously and gently approaching a board in front of it, until the tone will drop slightly. This is where is the limit.

Pierre PENARD advocates a space between two rows equivalent to twice the height of the gap of the greatest flute ie 25 mm for the flute n° 1, giving 50 mm.



In this case, we are at 52 mm ...



We must also ensure that the 8 plastic tubes coming out of the blower make their way without taking up too much space.

To keep them together, you can use a pair of brackets.



Connecting plastic tubes on each side of the valves unit

For organ n° 2, the connection system is very similar in principle.

Coming out from the blower, the 8 tubes separate into two directions to reach the air intakes on either side of the valves unit.



8 - 13 - CONNECTION BETWEEN VALVES UNIT AND TRACKER BAR

You need plastic tubes inner diameter of 6 mm
(or matched to your tips)



A length of ten meters is sufficient.



According to this correspondence table, match the output number of tracker bar with the entry number of the valves unit.

Pay attention not to invert plastic tubes.

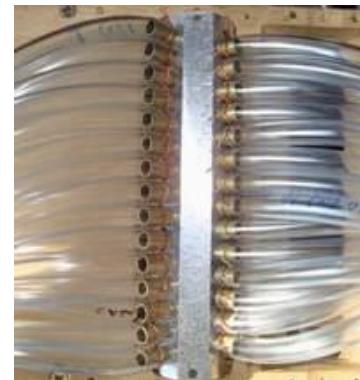
In bold red, there are 2 notes in addition of the 27 notes of "Erman" standard.

That the reason why the order doesn't seem logic.

	Output number on the tracker bar (from reference edge)	Notes	Flute number (via valves unit)
1	A 2	5	
2	C 2	1	
3	D 2	2	
4	F 2	3	
5	G 2	4	
6	C 3	6	
7	D 3	7	
8	E 3	8	
9	F 3	9	
10	F # 3	10	
11	G 3	11	
12	A 3	13	
13	A # 3	14	
14	B 3	15	
15	C 4	16	
16	C # 4	17	
17	D 4	18	
18	D # 4	19	
19	E 4	20	
20	F 4	21	
21	F # 4	22	
22	G 4	23	
23	G # 4	24	
24	A 4	25	
25	A # 4	26	
26	B 4	27	
27	C 5	28	
28	D 5	29	
29	G # 3	12	

To avoid stiff neck by connecting plastic tubes from the bottom of the tracker bar, you can turn on itself the keyframe. It is much more convenient.

Take care that the plastic tubes will not come off. We must secure with clamps electrician (or in our case small copper wire because we did not have enough room)



Here's another locking system of tubes that we have seen in a builder friend (tracker bar carved from a block of oak)

If you can find the perfect plastic pipe diameter, it is possible that the plastic pipe is maintained in place by itself.

The slight overlap ensure their blocking.

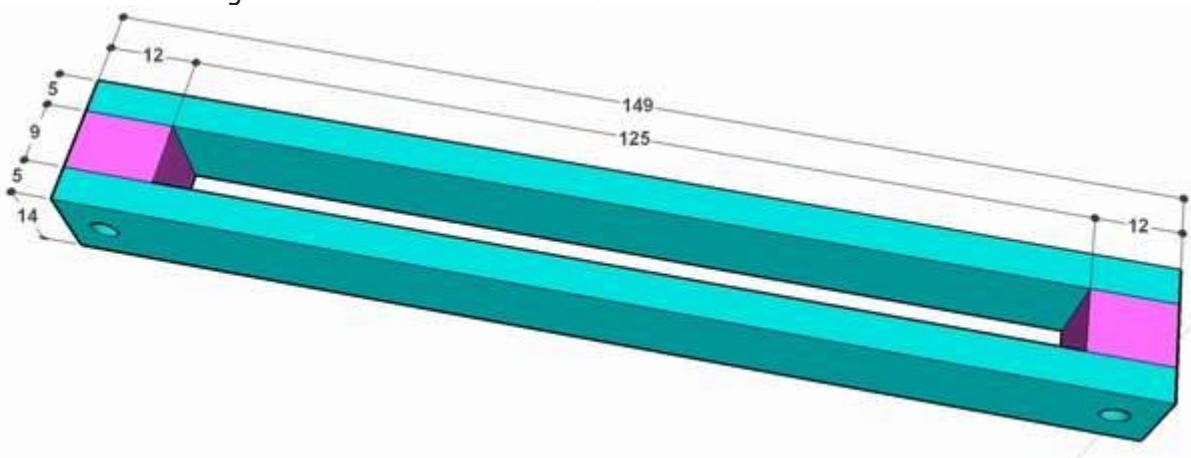


When machining the keyframe, we provided a spacing of 50 mm between the axis of the tracker bar and the axis of the drive roller.

It's not enough. There must be at least 60 mm. This is what we wrote on the sketch of keyframe. So in our case, the pipes tend to rub lightly against the pressure roller.

That is why we set up a guide on the organ n° 1 to bend plastic tubes.

We also added a second guide to the second set of plastic tubes. This allows a clean layout of plastic tubes leaving the tracker bar with no conflict with the reservoir lid.



The two guides are made of slats used in the manufacture of flutes.

Although the number of plastic tubes to pass in each guide is different, their dimensions are identical.

The first guide is attached with two brackets which are fixed on the drive roller bearings.

The second guide is attached to the first guide with two small threaded rods.





Do not forget to secure the tracker bar on the keyframe with a small screw on each side

Depending on the shape of the tracker bar, you will not necessarily need guide.

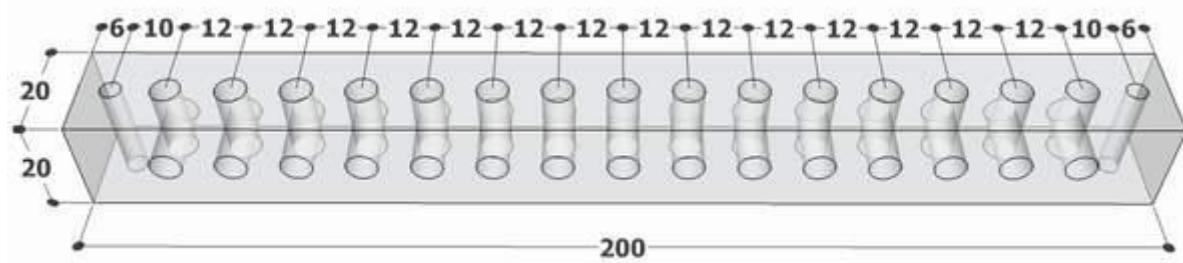
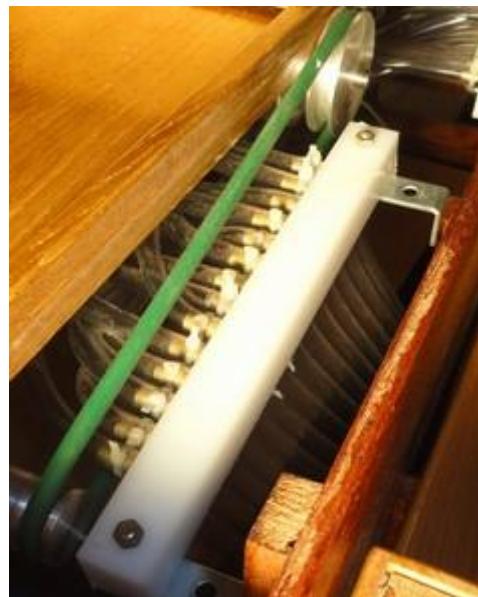
This is the case for the organ n° 2.



In this version, the plastic pipes are neatly arranged with two connecting bars which are interposed in their path.

In these two pieces cut from a block Rilsan, 58 sections of metal tubes are fitted into force.

They are plastic tubes that come from one side of the tracker bar, and the other going to the valves unit.





One of the two connecting bars will be provided for splicing 14 tubes, the other is limited to 15 tubes.

Compared to the solution on the organ n° 1, there is an advantage and a disadvantage :

- Advantage = plastics tubes are much better aligned and therefore not subject to pinching.
- Disadvantage = 14 plastic tubes pass through the belt, which somewhat complicates its replacement in case of breakage.

In all cases, it is strongly recommended to identify each end of plastic tubes.

Which number to write on each plastic tube ?

The number of the hole in the tracker bar or the number of the valve ?

It's almost like the same !



But it is more convenient to note the number of the valve. Because, it is more most likely that you will have to take off all tubes in the near future (as long as the organ is not completely finish)

Also noting the numbers of the valves, you will not have to return every time the correspondence table.

Connecting plastic tubes on the valves unit :



First, you can make quick connection like "spaghetti dish".



It is only once the operation has validated you connect properly.

Take care that the plastic tubes do not come hamper the proper functioning of the pressure relief valve on the reservoir lid.



8 - 14 - CONNECTION BETWEEN VALVES UNIT AND FLUTES

That's how we did it for the organ n° 1.

Setting up plastic tubes is a complicated operation especially for the largest one.

Indeed, radius of curvature are quite large and they take room.



We used copper elbows angled at 90 ° to both the output of the valves unit, but also at the connection at the foot of the flutes.

Even if you use cooper elbows, the larger tube will have a little trouble to clear a path between different interior parts. So here's a tip for thermoforming.

- Locate the perfect place to pass the pipe
- Estimate its length and allow for a small increase before cutting
- Introducing into the plastic tube a piece of electrical cable having an outside diameter, the closest of the inner diameter of the plastic tube
- Prepare spaghetti for dinner and keep aside boiling water
- Put the plastic pipe in the water for several seconds, until the plastic pipe softens
- Inserting the plastic pipe on the first copper elbows
- Make meander pipe
- Trim the plastic tube to the good length
- Inserting the plastic tube on the second copper elbows
- Wait for cooling
- Remember not to remove the piece of electrical cable from the plastic tube
- You can also use a heat gun to replace the hot water.
- Once the plastic tube gets cold, it should remain in the same position and without pinching

Depending on the position of the valves unit and the layout of your flutes, you can find shortcuts to meander large tubes.

You can use a big flat drill to make holes in the lower part of the vertical support flutes.





On the organ n° 1, the support table for vertical flutes was mounted on the base via 2 hinges, and 2 brackets 90°.

This is handy when connecting flutes avoiding all moves in any direction by exerting unwanted traction forces on the plastic tubes.

During the connection operations, slightly tilt the row of flute and hold the assembly in position by a small chain.

The connection exercise of flutes is still a bit of a chore. We have tried and tested several solutions:



1st test - Connecting with turns :

Due to the space taken by the plastics tubes, it is virtually impossible to fold the row of flutes while maintaining a reasonable distance dimension between the valves unit and the row of flutes.



2nd test - Connecting with elbows :

Difficult to get a compact connection.



3rd test - thermoforming :

It seems to be the good solution.

As explained a little earlier, boiling water or using a heat gun.

(using electric cable inside during cooling)





Warning : in a near future, the thermoforming solution seems to be not 100% reliable.

The plastic tubes will sometimes have the wrong idea of pinching sharply.

This will have some impact on the volume of the flute connected to this pipe !

In this case, extend the length and make the pipes to meander



Let us now see the solution for organ n° 2.

Given the completely different provision, we went to another system.

All output tubes coming out of the valves unit are ended with 90° copper elbows.

Ditto on all tubes which are within the flutes of the pipe base block.

Between these two 90° copper elbows, it only remains a small length of plastic tube.

This solution has the advantage of having no pinching in the tubes as they are all straight.



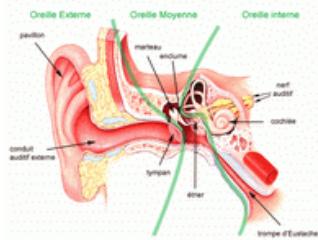
Whatever the solution for connecting the valves unit on flutes, you must make a final check before the tuning phase

- Hide all holes of the tracker bar with scotch tape.
- Turn the crank
- No flute should sing. Otherwise, it is imperative to find the cause



After the implementation of the various components, we have to move on to the tuning of the flutes and the setting of the valves unit.

To treat these two steps, we must be sure of the perfect operation of all components :



- The flutes are 100% finished and they all sing - no matter whether there are out of tune or not
- The blower pulses well with 12 to 14 cm pressure, and the pressure is constant
- The valves unit is complete, and its operation has been validated at 300%
- Plastic tubes are in place without any inversion between tracker bar and valves unit
- Plastic tubes are in place without any inversion between valves unit and flutes
- The set which is composed of keyframe, drive roller, upper pressure roller, pressure system on the tracker bar, is also in perfect working order, with smooth scrolling and smoothly.

9 - 1 - TUNING FLUTES

To perform the tuning operation, you must get help from an electronic tuner chromatic type.

The investment is not huge, and can be reused for other purposes (except making apple pies).



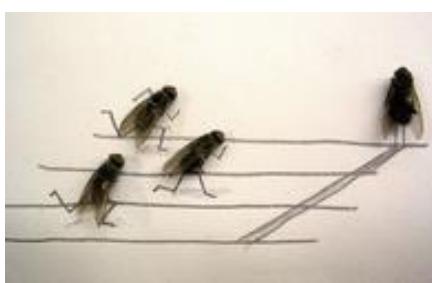
As we had explained in a previous chapter, tuning operation should be done in a real situation, which means "flutes connected to the blower via the valves unit."

This is where you will use the test book which has already been discussed before.

This test book is perforated so that each note is tested sequentially.

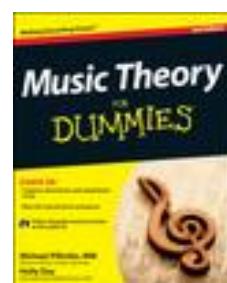
The test book must be pressed on the tracking bar without any move.

This implies that, during tuning operation, the transmission belt is not in place.



It is possible for you (it is our case) that there is no difference between a group of flies and a group of notes on a musical stave.

It doesn't matter. We are going to make it as simple as possible.....



Here are the range of notes we want to tune.

From BASS to SHARP												
C	C #	D	D #	E	F	F #	G	G #	A	A #	B	

Take one flute, and position the stopper arbitrarily.

Then look for the note on the tuner by moving the stopper slowly inward to have a highest note, or outward to have a more bassed note.

Setting example flute n° 21 which must sing F:

- If the tuner displays F #, G, G #, A, A #, or B, you must move outward the stopper
- If the tuner displays E, D #, D, C #, or C, you must move inward the stopper

This is where you will need your magic tool for catching the stopper.



Note that tuners operate on the basis of the A, which itself can vary from 410 to 480 hertz.

So, before tuning your flutes, set your tuner on A 440 Hz allowing you to be in the most widespread standard.

Most tuners have 3 LEDs and 3 labels :

- A flat sign (b)
- A central sign (arrow)
- A sharp sign (#)



During tuning, the fact that the "flat" LED light bright does not mean that you are tuned to the note in flat.

This simply means that your flute is too low for a given note. Conversely, the illumination of the LED "sharp" indicates that your flute is too sharp.

Correspondence notes for each flute :

Flute number	notes
1	C 2
2	D 2
3	F 2
4	G 2
5	A 2
6	C 3
7	D 3
8	E 3
9	F 3
10	F # 3

Flute number	Notes
11	G 3
12	G # 3
13	A 3
14	A # 3
15	B 3
16	C 4
17	C # 4
18	D 4
19	D # 4
20	E 4

Flute number	notes
21	F 4
22	F # 4
23	G 4
24	G # 4
25	A 4
26	A # 4
27	B 4
28	C 5
29	D 5

In these correspondence tables, we see that some notes are assigned with a number from 2 to 5.

This corresponds to different octaves. This does not affect the tuning of the desired note.

During this tuning operation flutes, we got into troubles on a particular point.

For 3 flutes out of 29, the desired note was not displayed as expected on the tuner.

Looking more closely, the three notes were found to be notes # key. In fact, our tuner showed the note in flat.

Yes, you must know that a sharp note is identical to the upper flat note !
Example: A sharp = B flat.

If we had not considered the time of music theory classes in school as a time of recreation, we would not have fallen into this trap today.



Will you have to come back from time to time on these tuning operations ?

Not normally, unless you regularly wander your crank organ on roads with big holes, which would be the effect of changing the position of the stopper in the flutes.

It must still know that despite the fact that the caps do not move at all, flutes will still be subject to be slightly out of tune for the following reason :

The frequency of the sound coming from a flute, as described above, depends on the air pressure produced by the blower of course, but also the air temperature, its water content, and atmospheric pressure !

You're surely not even check the weather forecast every day and tune your instrument accordingly.



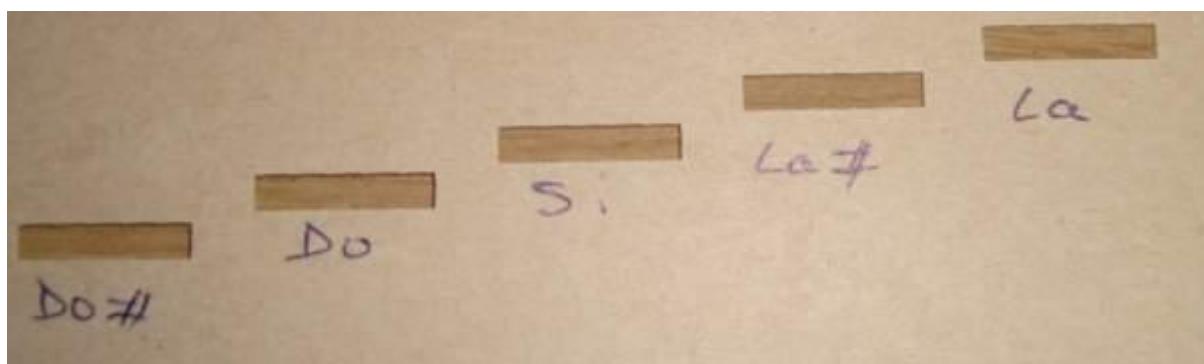
And as all things change all the time, notes may vary all the time !

But all flutes are subject to the same changes at the same time, any shifts in the same direction, and that is fine, as long as we do not play with another instrument.

And yet, in this case, one must have a very sharp ear to detect the difference.

9 - 2 - SETTING THE FLUTE VOLUME

The test book includes a succession of all notes in long version.



You should not hear any difference of volume between a short and a long note. If this is the case, it means that the flute lacks of air for short notes.

In this case, you can set the adjustment screw on the valve which is concerned.



It is a little difficult to hear the short notes on the bass flutes; this is normal on a test book.

With a "real" book, notes are always longer and more spaced.

Ideally, all flutes should generate the same volume.

Use the flute which sings the lowest as a reference point. Then set the other flutes to the same level by adjusting the stop screw.

By cons, we cannot increase the volume of a flute. If this level is really too small, you have completely to remake the flute.

In general, there may be some difficulty in obtaining sufficient and equal level especially on bass flutes (the largest).

Keep also in mind that in a song, the bass flutes never sing alone. Furthermore, with the harmonic phenomenon, during a real music, basses seem more powerful than individually.

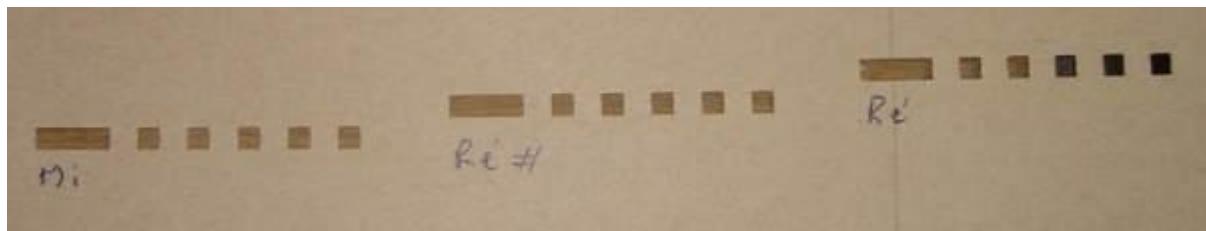
For the anecdote, note what happened to us on one of our flutes. Its volume was particularly low. Looking more closely, we found the body of a wasp that had taken up residence in the pipe base block.



It's true that many months had passed between the flute making and the tuning phase.

9 - 3 - STETTING THE REPETITION SPEED

On our test book, each note is "programmed" 6 times with 5 short notes and 1 longest note.

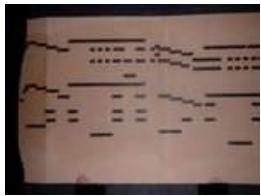


During listening, notes should be well detached from each other. We must achieve a good result by acting on the repeat speed adjustment screw.

Tip : do not get a headache to look for a perfect setting which is almost impossible.



In fact, "real" book always better passes the test which has a very high standard.



So, you have also to validate the operation of your organ with a real book (not a test one) you have purchased or borrowed.

The book will be discussed in Chapter 11 of this document.

Anyway, you will have to repeat the whole process at least a second time, after having painted or varnished flutes, and give the same height to all stoppers.

Oh, we almost forgot : when the baby comes out his first sound, it is a very important step. It is true that after many months or even many years for some amateur builders, it is a happy event.

Do not forget to record the first sounds that come out, even if they do not seem perfect to you.



The first performance of the organ n° 1 was held with a small audience, in fact just one spectator !

This is Jean-Marc, the builder of the organ n° 2 who had the honor to enjoy the beautiful melody of "Girl of the Bedouin. ».

10 - FINISHING THE ORGAN

If you are reading this chapter, it means that your crank organ works. Although it could remain in its current version, it is desirable to give it a nice look.

You think you have almost finished, and in fact you will see it is not !

10 - 1 - ADJUSTING THE STOPPERS HEIGHT

When all the flutes will have been tuned, there is no chance to have all stoppers with the same visible height.

Some stoppers may even be downright invisible.

We will therefore seek for a proper alignment.



You can choose between two solutions :

If you want...	You must...
Make all visible stoppers at the same height	Re-cut flutes
Do not see any stopper	Re-cut stoppers

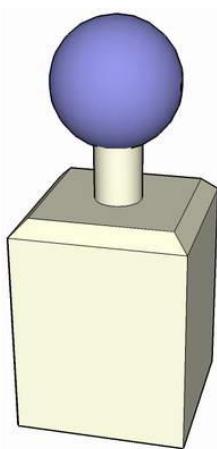
Solution n° 2 is simpler to implement.

So, this is the one we chose.

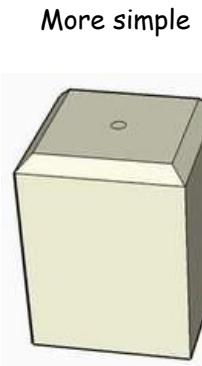
In all cases, you will have to make another tuning once flutes are painted or varnished.



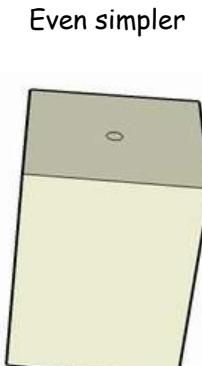
Examples of finish for the top of the stopper :



Chamfered top with small round button that gives a nice look and facilitate gripping.



Chamfered top without round button (provide a ring piton for tuning operations)



Flat top on without round button (provide a ring piton for tuning operations)

The first two solutions are of course of real interest if the top of the stopper is visible and not embedded in the body of the flute.

10 - 2 - FINISHING FLUTES AND FINISHING OF INTERNAL PARTS

One last sanding on each flute is recommended to have a good surface finish. Then you must apply 2 coats of varnish or paint.



The secret to a good result is to invest in a quality brush suitable for this use, and not be tempted by the promo "5 brushes for 2 euros"

For even better results, you can do the job with a paint/varnish spray gun.



Whatever the method used (brush or spray gun) think to clog temporarily with scotch tape the windsheet over its entire width to prevent the varnish to mute the flute.



To facilitate the operation of varnish (or paint) it is easier to plant flutes on a screw mounted on an old wooden panel.

In chapter 4-7 on the stopper, you were told that the ring piton for catching the stopper would be useful latter. Here we are.

In fact, it is a good way to keep the flutes upright during drying.

As a smoker chitterlings, you'll be able to suspend all flutes.



As the brushes are out, take the opportunity to paint all other internal parts (support pillars, flutes mounting table).

This will give a more authentic look to the realization



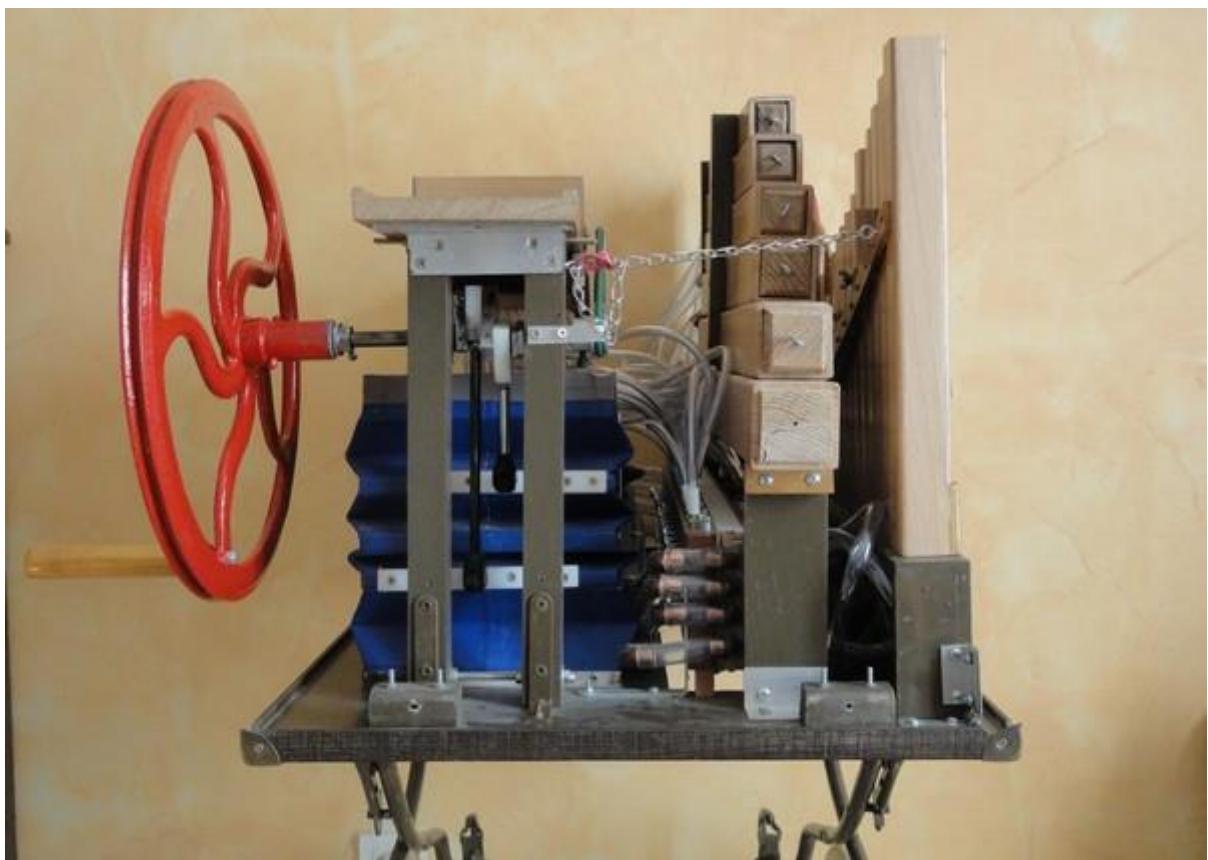
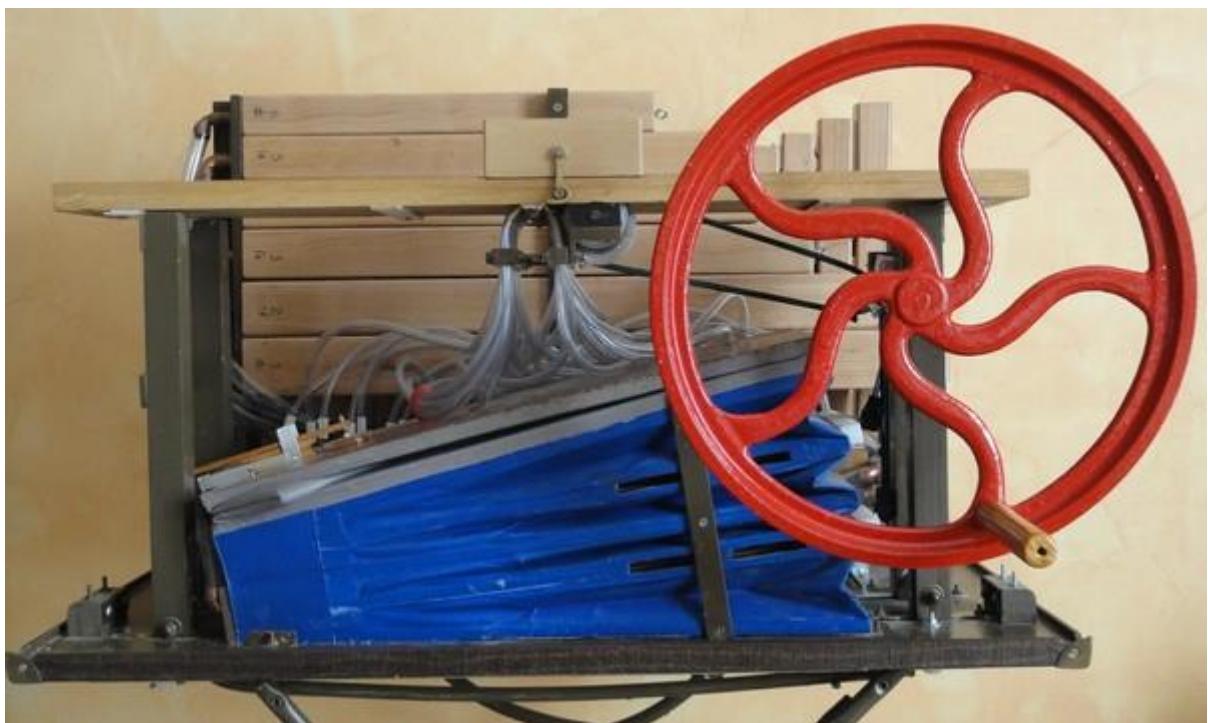
Ditto under the base, even if it is not the most visible part.

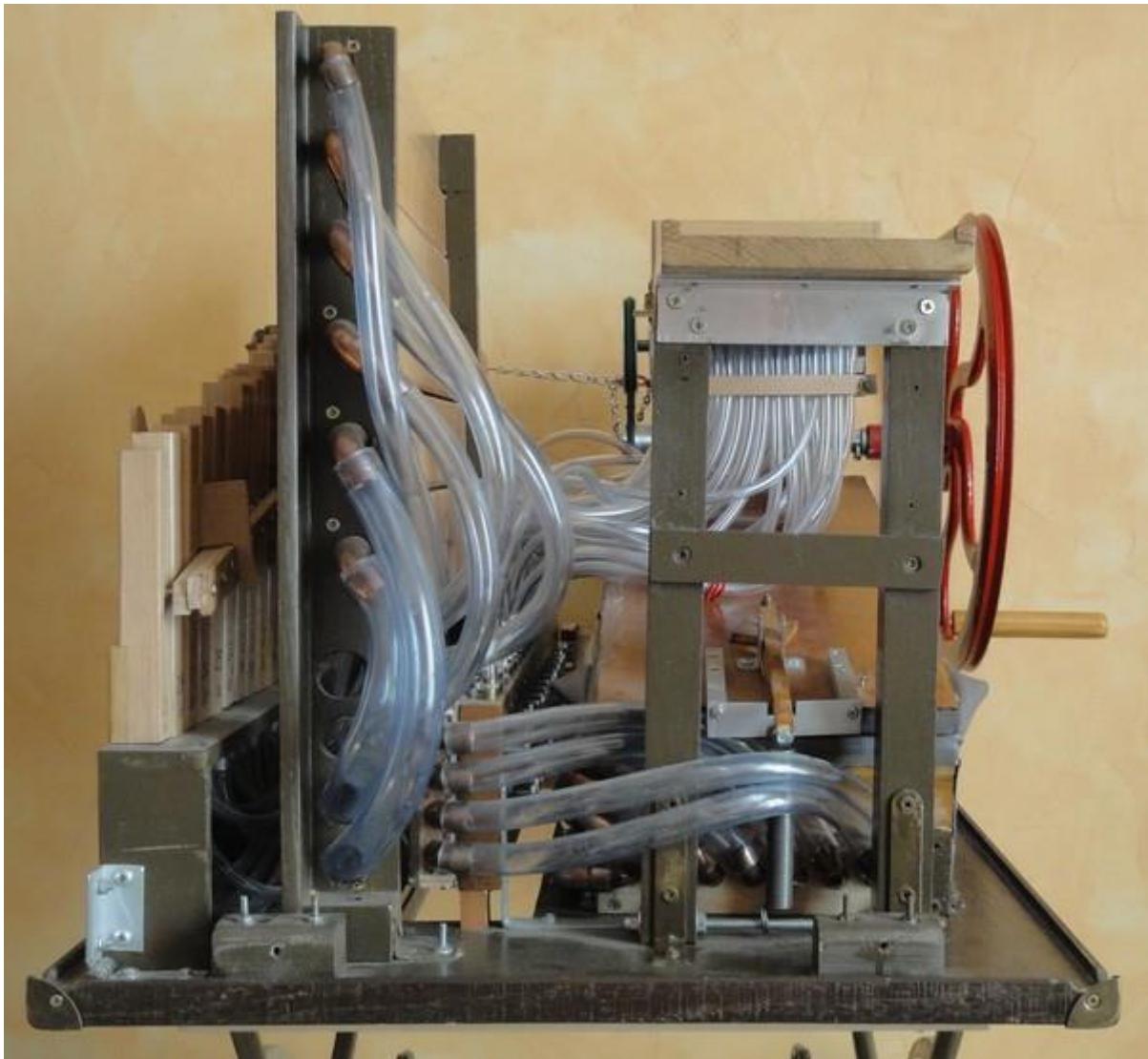


10 - 3 - SOME INSIDE VIEWS

For the organ n° 1 :







The organ n° 2 is internally built on the same principle as the organ n° 1. That's why we do not add photos to avoid overloading the document, which is already quite big.

10 - 4 - THE CABINET



Now that the baby is born, you have to dress him up.

Technically, this is not the most complicated, because the production of cabinet is independent of the pieces in it.



If you do not want your cabinet go into pieces at the first lift, you've to take care of its mechanical fabrication.

Actually with a weight of about 16 kilos for its interior parts, it will be subjected to strong efforts. So be generous on glue and screws !

The crux is strength. We must find a compromise between strength and weight of the cabinet.

Certainly if you use wood 22 mm thick, it will be tough, but the weight will be a serious inconvenient.

Views of the organ n° 1



Overall dimensions = 850 x 500 x 510 (L / H / D) - Volume = 0.22 m³

Total weight 26 kg (16 kg inside + 10 kg for cabinet)

Cabinet is made of floorboards thickness 8 mm. A wide choice of colors and patterns is available. Tinted pine strips cut at 45 ° cover the ends of the slats, hide the mounting screws off interior aluminum profiles, and provide edge protection.

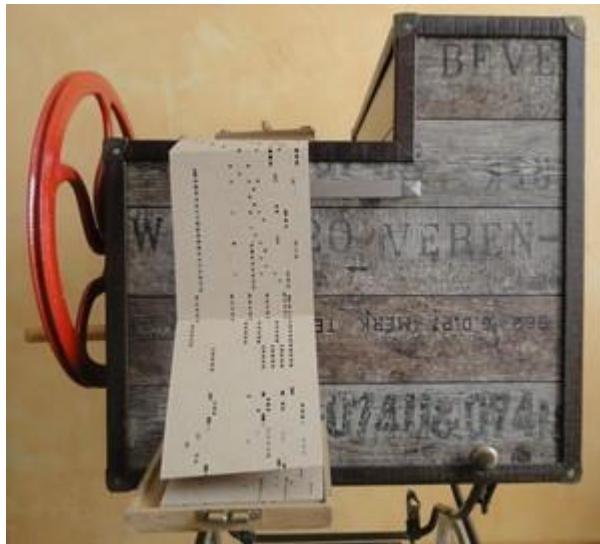
Metal pieces protect the corners.

The first few people who had the privilege of seeing the organ in operation without its cabinet were intrigued and especially surprised by the movement of the bellows.

Also, it was decided to leave the bellows visible without disassembly by placing a plexiglass plate of 5 mm thick as a rear panel.

This takes off a little authentic side of realization, but avoids removal of the cabinet.

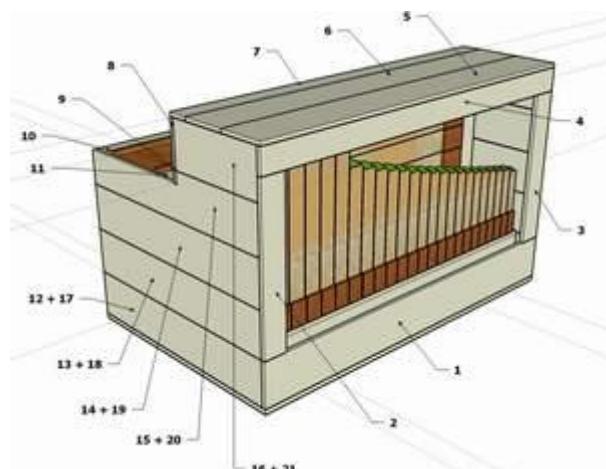




It is convenient to provide the cabinet so that the rollers box can rise completely at 90 ° without being limited its rotation by the cabinet.

This facilitates the introduction of the book.

With Sketch'up software, we were able to accurately determine the mode of assembly of the cabinet, and its dimensions.



Without pendulum saw,
the strips are cut from a box.



For attachment, they are carefully glued to the neoprene

The low thickness of the slats (8 mm) is taken into account by setting 10x10 aluminum profile at all angles inside the cabinet.

In this way, there is no deformation.

Aluminum profiles are bonded to the neoprene, and also screwed.



Outside, the screws are rather ugly.

Therefore calculate screws position to ensure they are all hidden by tinted pine strips.

Given the number of screws to put in place, a drilling template is handy.



To ensure good contact during drying, no need to invest in clamps of great width.

A belt, a cleat, a wire, and voila !

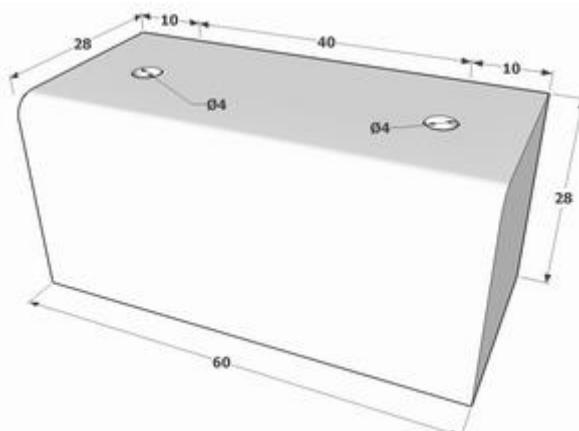
In order to keep the cabinet in place, we founded a very simple and ingenious system which has many advantages :

- It is discreet
- It allows disassembly and reassembly of the cabinet quickly and without any tools
- It is easy to implement
- It is economical

In the leftover of cleats used in the manufacture of supporting support pillars, simply cut four lengths of 60 mm.

Two holes are made for the fastening screws to the basis.

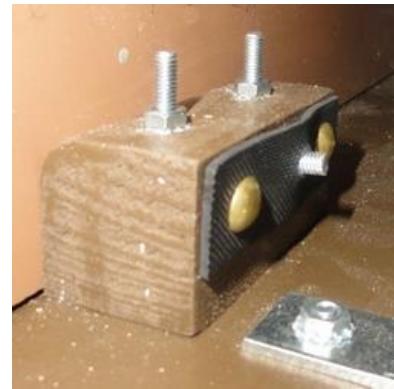
One upper edge is rounded to facilitate proper positioning of the cabinet.



On the interior side of the block is fixed by two upholstery nails a piece of rubber 2 to 3 mm thick.

Have a look at your shoe repairs shop.

Then the blocks are glued and screwed on the basis of the organ, leaving a 8 mm gap from the border to make room for the cabinet itself (8 mm in our case)



Positioning the cabinet, and use counter drilling technique.

This is the only way to have a perfect alignment of the two holes.



Cut 4 threaded rod.

At the end of each, glue a metal knob (see kitchen accessory range from DIY stores)

Then insert the 4 threaded the cabinet to lock it.



The organ fits quite well in the boot of the car.

We can even keep the tablet in place which has the effect of hiding the instrument.

Anyway, the dog stands guard !



For decoration, you can free your imagination.

From simple painted or varnished cabinet, to clever animation systems.



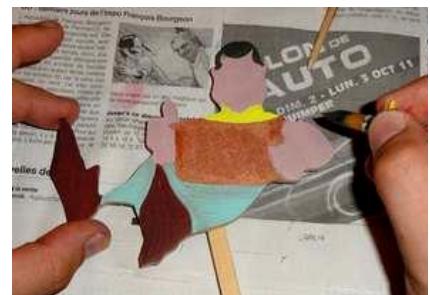
The organ n° 1 hosts a series of little musician elves.



Design and duplication on thin medium plate



Tiny cut with specific saw



Painting

Here is the result :



Flutist drowsy
with the owl who hanged itself



The crazy couple of dancers



The diatonic player who looks like to....



The mischievous imp



The rabbit which doesn't like music



Frank, goblins 's dad



Once the decoration in place, we did a test with a lighting LED strip.

Unfortunately in our case, it was too upright goblins, which did not allow to fully illuminate.

He would have had a cabinet a little deeper.

Views of the organ n° 2



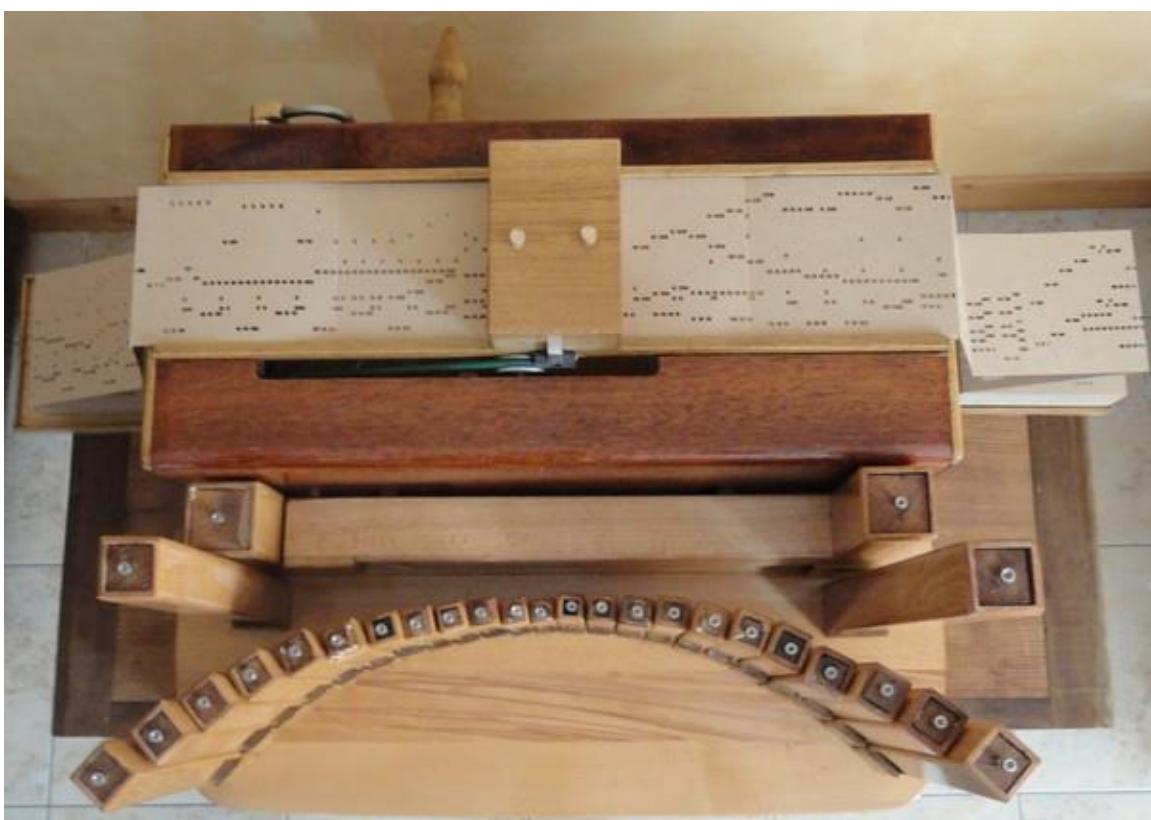
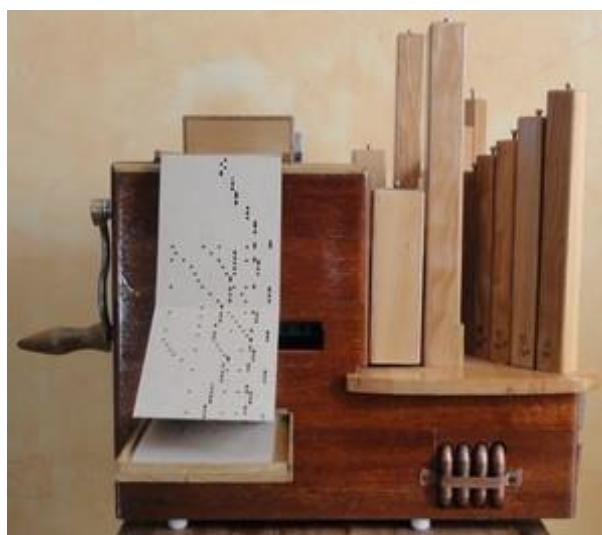
Overall dimensions = 700 x 640 x 560 (L / H / D)

Volume = 0.25 m³ - Total weight 27 kg

We had the desire to have two crank organs at different look. For organ n° 2, we opted for solution to fully observe all flutes, hence the lack of cabinet. In fact, only a few little unsightly mechanical parts have been masked by exotic wood slats. A color contrast is visible with light wood color of flutes, the keyframe of the rollers box and shelves.

3 good coats of "marine" varnish give a great visual aspect.

As the organ n° 1, the rear panel is Plexiglas 5mm



10 - 5 - HANDLES AND BOOK SHELVES

There must be a handle on each side of the organ

Unless you have a weightlifting passion, it needs two people to carry the instrument.

The instrument weighs +/- 30 kilos, in addition the handles are well spaced from one another, so it is not easy to carry.



For organ n° 1, a pair of handles purchased in DIY stores largely will do.

Although you are not supposed to carry the organ over a long distance, we advise you purchasing handles with rounded profile, it is more comfortable (this is not the case on our photo)



For organ n° 2, two slots have been made on the sides of the cabinet.

No way to make more economical !



Before placing your two handles just anywhere, take into account the size and location of the two book shelves.

The keyframe will be at a height of about one meter from the ground. However, we will not put book on the floor. We must install on each side of the cabinet two folding shelves.

The subject of the size of the shelves and their positioning is not as simple as it seems.

Before starting to cut the shelves and making holes anywhere in your beautiful cabinet, you have to find the best position just empirically.

Once you are sure of good running and good receiving, you can go further.



After multiple tests, here are the interior dimensions of the two shelves :

	Shelf "book departure"	Shelf "book arrival"
Interior length	180 mm	180 mm
Interior width	132 mm	150 mm

The positioning height is very important, but even more on the departure side that the arrival side, if we want the book folds well and alone. We must therefore take into account the following:

Shelf "book departure"	<ul style="list-style-type: none"> The shelf width should be slightly greater than the book width (132 mm in this case) At no time a fold should coincide with the edge of the keyframe (or edge of the cabinet strip for the organ n° 1) The book must be shifted back from the cabinet side (about 2/3 cm). Therefore the effective length of the shelf is greater than that of the book (180 mm in this case)
Shelf "book arrival"	<ul style="list-style-type: none"> The width of the shelf should be larger than that of the book to allow a somewhat tortured book find its place. 150 mm seem to be sufficient. On leaving the keyframe, the book tends to stay a few seconds horizontally. Only after it slumps. So, it is better to place shelf in rather low position.
For both of them	<ul style="list-style-type: none"> The book must stay perfectly in the axis of travel (obviously) The book should not interfere with the establishment carrying handles

The shelves thickness is not critical.

Small cleat oak border the perimeter of the two shelves.

Varnish will be welcome.



For organ n° 1, mini brass hinges allow shelves to fold back to vertical position.

You need to insert a small slat between the hinges and the cabinet (if not, the folding is impossible).



For organ n° 2, we used brackets.



A latch blocks shelves in upright position during transportation.

10 - 6 - SOME CABINET EXAMPLES

Here are some beautiful creations presented in Pontrieux Mechanical Music Festival in July 2007.



10 - 7 - THE CART

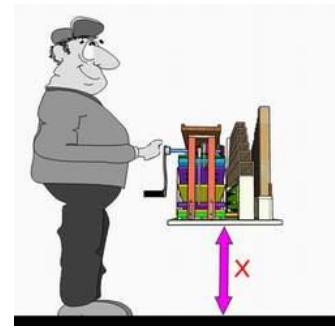
No matter where you turn the crank, you will need to put the instrument on a stand. The ideal is that it is mobile.

One detail that is important : What is the ideal height for the organ?

If your organ is placed too low or too high, you will get a painful arm after a few moments.

The ideal height is that which allows for the crankshaft axis to be in line with the arm when it is bent at right angle from the body.

It should be taken into account during the manufacture of the organ cart.



This of course is difficult to apply in the case where several people of different sizes would play on the same instrument. Be selfish, and consider YOUR height.



You can also find a pram at a flea market or on the net an old pram.

Make your choice on a model of the 70's..

Essential condition : it must roll perfectly.

Tip : you have to remove the baby before disassembly.



- In this case, the cabinet will not be used and the handle is removed.
- Only the lower part will be reused.
- The brake system is kept
- The folding system is handy to put the pram inside your car
- The lower rack can accommodate books



The horizontal tubes are drilled for receiving screws.



A board is permanently fixed on the tubes - heads must be drowned

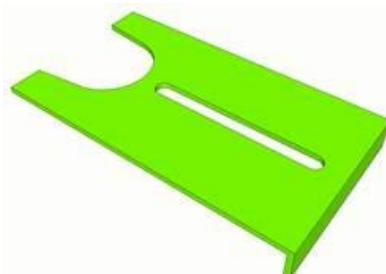


You must drill blind holes to drown heads screws which are located under the organ base



One aperture is made in the base to allow access to repeat speed adjustment screws

The organ is placed on the base. Initially, we set up a system with feet to center the organ on the base and also a locking system.



This system soon proved impractical in that it is difficult to accommodate the feet in the holes, because we must target the holes, and from top view we see nothing.

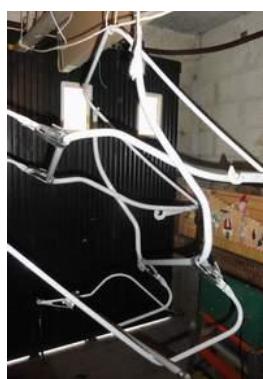
The system has subsequently been replaced by 4 cleats placed just outside the base.



A shiny chrome tubing does not match with the retro look of the crank organ itself.

So, it is best to paint it. Who says paint on chromium was a very long and delicate operation ?

Well no ! Just pass a strip of emery cloth grain 120 to clean the tube. It does not remove the chromium film, but it does not matter.



A first layer of any color to prepare the surface



Two layers with the right color.
With an air gun, it would be perfect...

Here is the result of the crank organ and its cart ready to go.



Essential accessory: a plastic cover in case of rain (normal usage = protecting gardens salons)

10 - 8 - SURVIVAL KIT

Despite all the care you have brought to the realization of the set, we recommend that you provide one survival kit for dealing with small faults in a hostile environment. (that is why we recognize the pros).

This kit, which will be left inside the organ (provided that it can be dismantled without tools) is composed of :

- Screwdriver set
- Wrench to adjust the valves stop screws
- Hexagonal key to set the repeat speed adjustment screws
- Hexagonal key to tighten the pulleys on their axis
- Key to tighten the crank on its axis
- Relief belt
- Special tool to catch the stoppers if there are embedded



If the construction of an organ is one thing, making books is another, and it is not the easiest.

How to make his books :

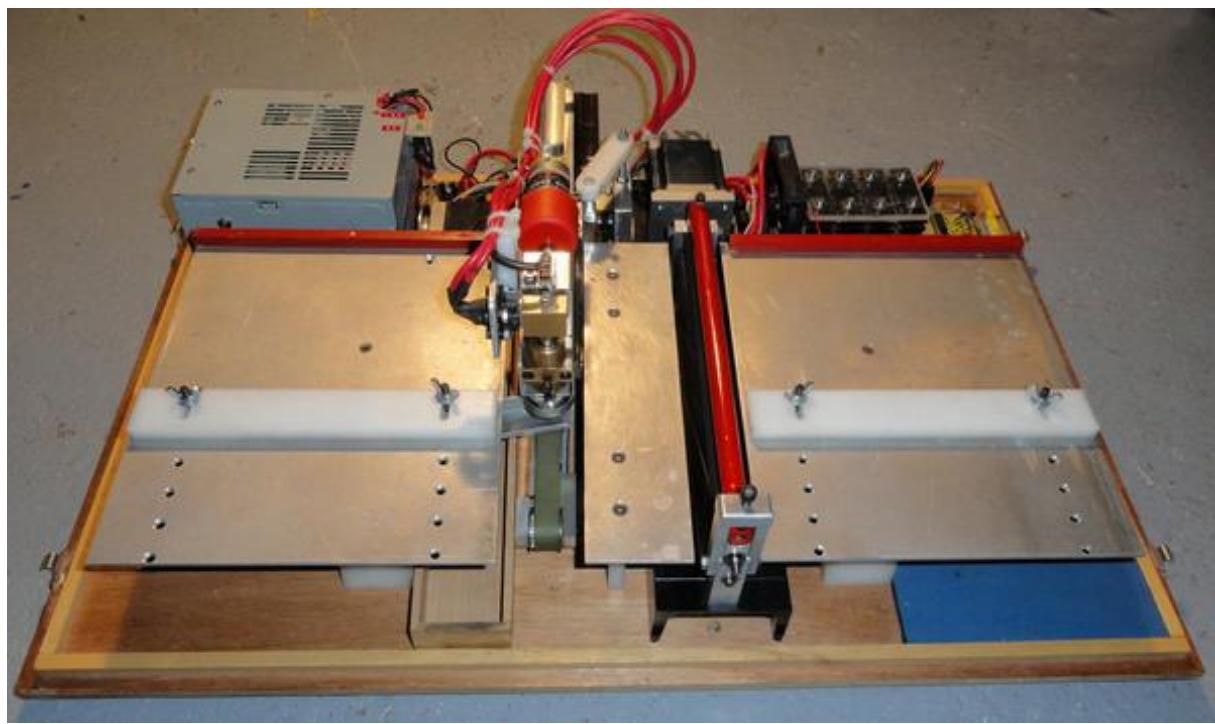
- You have to buy the cardboard - this is not the most complicated.
- Then you have to punch the cardboard, either by hand with a punch, with a manual machine, or with a punch machine controlled by a computer.
- You must fold the cardboard in accordion for a perfect alignment - contrary to appearances, this is not easy!



The manual solution is very laborious, given that on average a book is about ten meters long, and has thousands of holes.

If errors are made towards the end of the carton, you have to start over.

The solution with a punch machine controlled by a computer is of course very powerful and very economical.



The construction of an automatic punch machine requires both very good mechanical and electrical knowledge, and of course a lot of time



On the other hand, be aware that the manufacture of books is not limited to make simple holes, whatever the system which is used.

In fact, you must have musical knowledge to determine the right position of the holes to get a perfect reproduction of the song.

The alternative, much simpler, is to buy books "ready to use". There is no shame in buying his books, while we do not do it for the crank organ itself.

Where to buy books ? Little chance to find a store at the corner of your street. So, you guessed it, it's still INTERNET which will save you.

You can also find second hand book sold on auction sites (eg EBAY).



In one case as in the other, we must ensure the compatibility of books.

You must know that there are two standards for so-called 27/29 Notes organs. It's better to choose the good one...

12 - CONCLUSION

We hope that this construction manual will inspire you to get started in making your crank organ, and thus allow you to add on your business card "Crank Organ Builder".

It's long process to go, but it's worth it, certainly with as much as pleasure during construction and afterwards when you play the instrument.

Despite its consistency, this construction manual does not pretend to answer to all questions. We also talked about unsuccessful solutions to save you time by not following the same way.

You do not have to comply 100% with what is described.

Indeed, we have made choices that are not necessarily the best. You can also innovate and find other ideas to get the desired result.

Do not have sentiment complex by comparing your crank organ with a brand new one built by a pro. Keeping in mind that the Titanic was built by professionals and the Raft of the Medusa by amateurs ...

To go even further, both in theory than practice, INTERNET certainly bring you the additional information which are missing.

Jean-Claude and Jean-Marc would like to thank particularly people who helped us to complete this great project.	
	Pierre PENARD One of the two popes of the crank organ in France. He was always available for a lot of details.
	Jean-Pierre COSSARD The second Pope of the barrel organ in France. His web site is also quite helpful.
	Didier DYOLE For information about belt speed and turn ratio

		Bernard WANTELET For additional advices
		General engineering company François Meunier The Quimper agency for the provision of machine tools The Lorient agency for the supply of bronze rings for the crankshaft
		Chantal MEISSONNIER - Kitchen manufactures in Lozère For providing the oak for the pipe base blocks, blocks and stoppers.
		Laurent COMPIGNE, manufacturer of tables and chairs in Haute-Loire. For providing the beech slats for flutes
		The company FILEUSE d'ARVOR in Quimper For the provision of the belts
		Company CHANCERELLE in Douarnenez. For advice on some technical points
		Olivier THEBAULT - company ARTHUR BONNET in Vendée. For providing oak flutes tables
		The BODYWORK OF HIPPODROME in Quimper. For the provision of the blower control rods
		Company NANTES INDUSTRIE SERVICE in Quimper For the provision of two plexiglass plates
		The company CUISINE PLUS in Quimper For providing a leftover of paint from the seminary in Biarritz
		The company FRANPAC in Douarnenez For advices on some technical points
		Company PERE DODU For advices on some technical points
		Pascal PARMENTIER - printer in Quimper For providing the cardboard for blowers stiffeners
		Le Géant Casino (super market) For providing the plastic film for the valves (packaging bags)

	<p>La société HARTEREAU à Quimper</p> <p>For advices on some technical points</p>
	<p>Mister Google SketchUP</p> <p>For putting its 3D design software free access on the net And Google Traduction software even with some weird translations</p>
	<p>Gérard MEHAULT</p> <p>For providing and debited throats of the blower.</p>
	<p>Marcel LARVOL</p> <p>For a few router operations</p>
	<p>Jean-Yves BERTHOLOM</p> <p>To have debited the sides and lid of the rollers box.</p>
	<p>Nicole MEHAULT</p> <p>For recovering in a flea market the wheel of sewing machine</p>
	<p>Pascal SEZNEC</p> <p>For providing the chamois skin butchered in his garage</p>
	<p>Bruno MORANDA</p> <p>For providing the leather hinges</p>
	<p>George GLEMAREC</p> <p>For the loan of his belt sander (although he had to repaired it)</p>
	<p>Thierry BEUZE the ACCORDION WORKSHOP in Quimper.</p> <p>For precision cutting on the keyframe</p>
	<p>Marin L'HOPITEAU - manufacturer of Celtic harps in Quimper</p> <p>For advice on varnishes</p>
	<p>Dominique SPINOSI</p> <p>Reduction in thickness of the vertical table and the manufacture of book shelves</p>

		Véronique ZONZON For the loan of her router.
		Daniel LEO - former King of the Paté in Concarneau For providing the pork intestine valves, although this solution was later abandoned.
		Jacques QUELENNEC and Philippe HERBERT For doing nothing, except morally support us
		Jacqueline LARHANT For providing the plastic film for blower valves
		François HASCOUET For advice on tuning and explanations of octaves
		Loïg LEGRAND-LAFOY To teach us that a sharp note is the equivalent of the upper flat note.
		Frank ECALARD To have drawn and painted the little elves on the organ n° 1
		Thérèse ECALARD For kindly lent her tubes of paint to color the elves.
		Emmanuelle FARAH et Sébastien CORDIER For teaching Jean-Claude how to use Sketchup software
		Vincent GERMAIN For proofreading this document as "candid"
		Dany GERMAIN For spellchecking of the document in French.

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