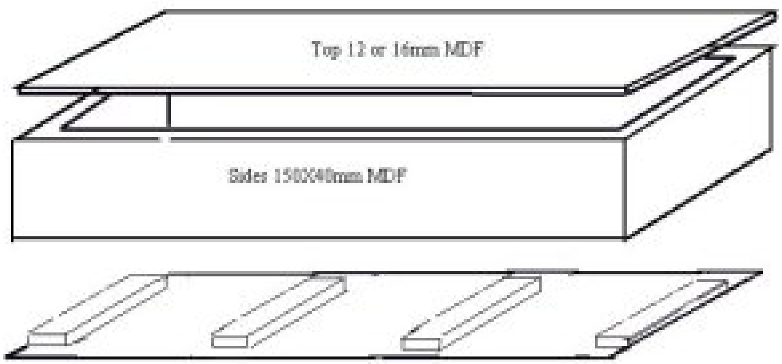
So You Want to build a Street Organ

This project started out as an exercise to make violin pipes and reed pipes. Construction of the organ chest closely follows that of the calliope.The pipes however, are a different story, being open flutes, strings and reeds.

The Pipe Chest

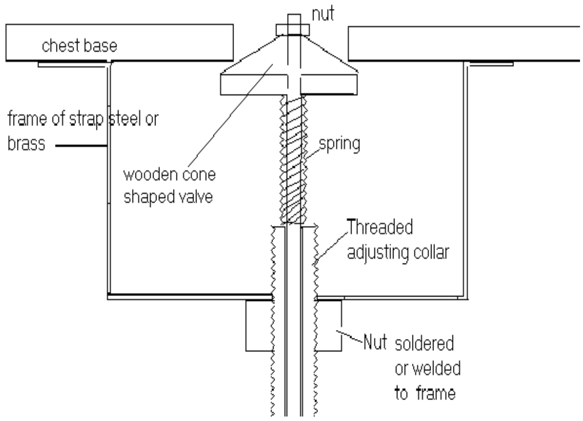
The chest dimensions are larger than the calliope and measure 700 by 1100 by 150 millimetres (27 1/2 by 45 by 6 inches approx). This gives plenty of room for expansion later on , if desired. The chest was made this size since the organ was experimental and provision was made for changing the specification by adding more pipe ranks. Matrerials for the chest are sides: 700X150X40mm, bottom: 6mm MDF cross braced by 45X19mm struts and top 12 or 16 mm MDF(Medium Density Fibreboard) (see below)



The Regulator

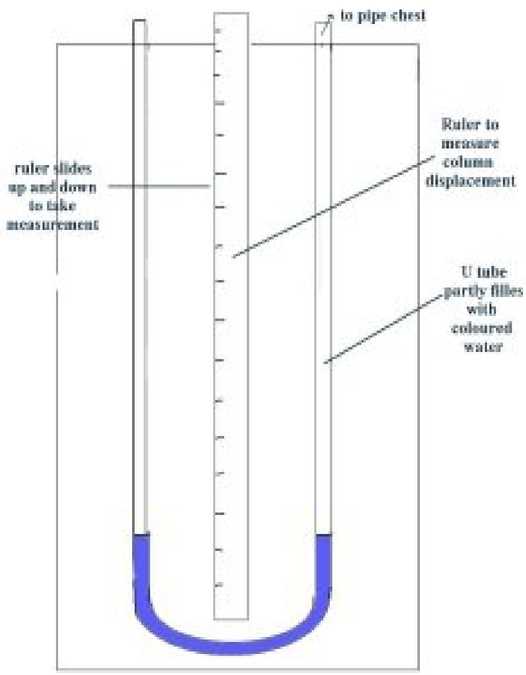
A regulator valve is fitted on the base of the chest to spill excess air and is adjustable to set the required pressure. The cone shaped design was found to be better than a trap-door type because the high air volume tended to draw it closed due to the Bernoulli effect.

Regulator valve



The Manometer

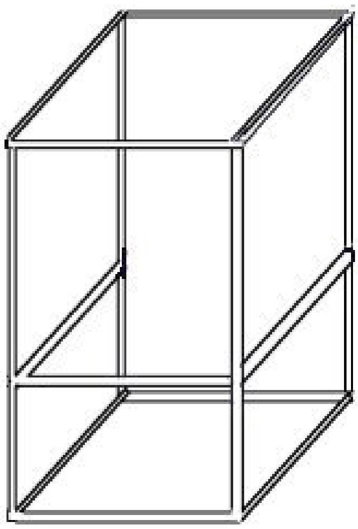
This is a fancy name for the pressure measuring device. It consists of a backboard on which is mounted a U-tube (piece of plastic tubing) with some coloured water in the bottom. In the centre is a ruler marked in inches, that slides up an down to measure the column displacement. One end of the tube is plugged into a pipe hole in the chest and the valve opened. Water will rise in one arm of the tube and lower in the pressurised arm. Slide the ruler so that the zero is aligned with the pressure end and then read off the displacement in the other arm.



The top is hinged at the back with a piano hinge to allow the top to be lifted with pipes attached for maintenance and/or repair

The Cabinet

The frame for the cabinet is made from 25mm (1 inch) square aluminium tube with plastic joiners at the corners. The frame was covered in 6mm MDF which makes it quite heavy, plywood would be lighter. Doors were made for the rear from 6mm MDF with a 45X19 mm frame
The dimensions of the cabinet are 1104mm wide, 1600mm tall and 800mm deep plus the doors of 25mm. Strips of Aluminium angle were attached inside the sides to provide support for the pipe chest



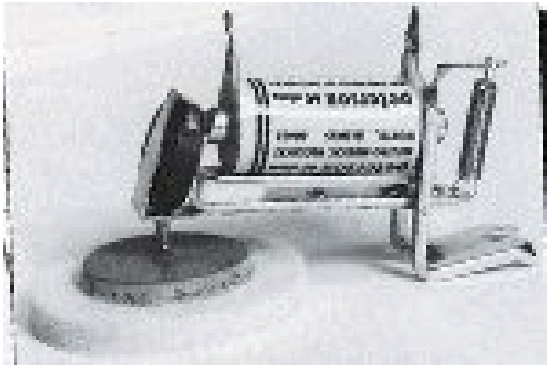
and allow the whole chest to be slid in from the back. Because the organ is experimenal, this feature allows chests of varying configurations to be fitted inside the same cabinet. It also allows easy removal for repairs or maintenance Wheels were attached under the front and castors at the back.

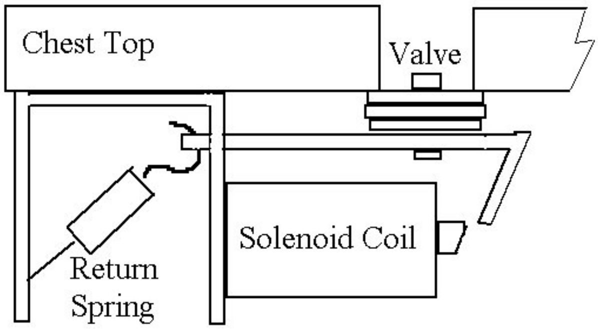
The Blower

The blower is an old vacuum cleaner motor housed in a box and surrounded by sound absorbant plastic foam. The foam is fairly expensive but worth it as the sound of the unmuffled motor is quite loud . Muffled, it will still not be silent but when the organ is playing it drowns it out

The Solenoid Valves

There are several suppliers of suitable valves, or you can make your own. The easiest is to purchase them and the valve illustrated below is from the Peterson organ Supply Co of Chicargo, USA

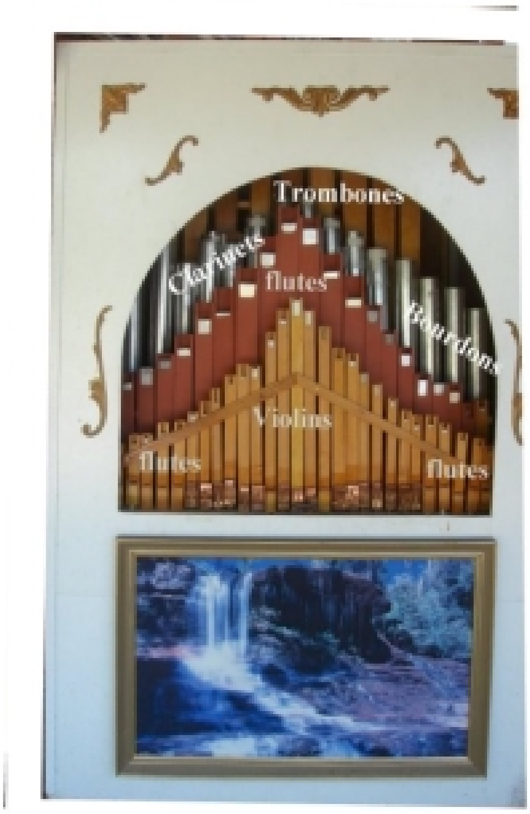




Solenoid Valve

I believe that these are available for about $5 each
The outline of the operation appears above. The valve is attached to the armature which is pulled down when the coil is energised allowing air to enter the pipe. The return spring closes the valve when the coil is disconnected

Below is the pipe arrangement of the organ, The front rank contains violins and flutes, the next rank back is flutes, behind that are bourdons and clarinets and finally bass trombones at the back. The back view shows the trombones, blower, computer and control electronics



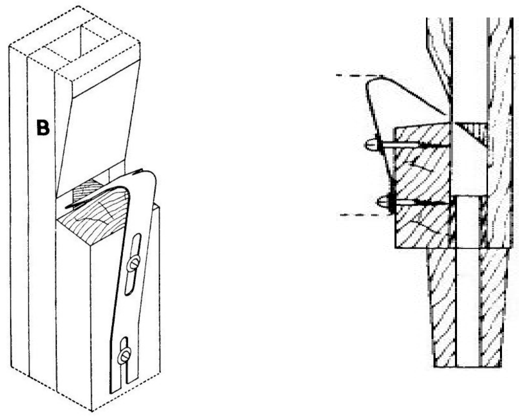
Specification

The organ is based on 48 notes from tenor C (an octave below middle C) but later I added bass reeds to take it down another octave but this octave is not chromatic, it only contains C,D,E.F.F# G A A# and B making it 57 notes in all. I also added a string section from G above middle C for 18 notes.

String (violin) pipes

These string or violin pipes again were experimental but seemed to work OK, although they take some delicate adjustment to get them to speak properly.

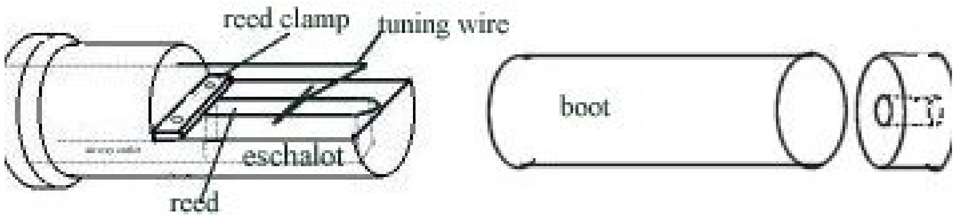
Generally speaking, violin pipes are half the width and depth of open flute pipes. The feature of these pipes is that they overblow by screeching at an octave above and have to be bought back by the addition of an harmonic bridge or Harmonic frein applied to the mouth to modify the air flow (see diagrams)



String (violin) pipe mouths showing the harmonic frein

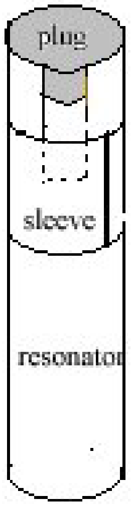
Reed Pipes

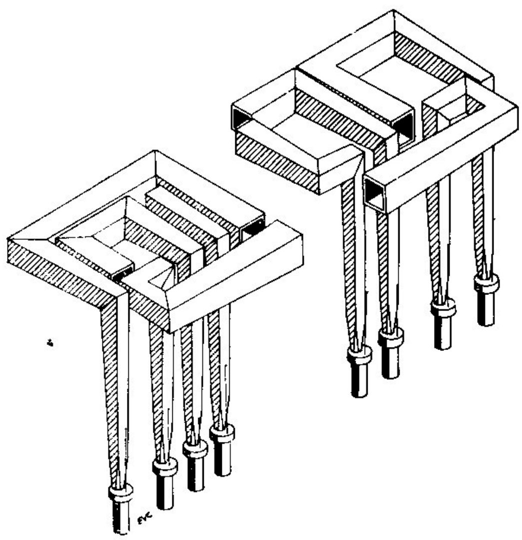
Reed pipes, as their name suggests, rely on a vibrating reed to produce the sound, as in a clarinet. The reed is usually made of hardened brass. Shim brass of 0.005 inches (about 0.2mm) thick is usually OK but you might need thicker for the bass reeds, about 0.5mm. You can usually get such thicknesses from hobby shops, shim brass from engineer's supplies, otherwise tongue brass from organ suppliers is best but expensive!



The reed block is turned from Australian hardwood. The cylinder long enough to accept the reed - about 3 or 4 inches long plus the shoulder and should fit snugly inside a plastic pipe 11/4 inches in diameter. The block carrying the reed is called the eschalot and the covering plastic pipe, the boot. The boot should be about twice the length of the eschalot. At the base of the boot is a wooden plug carrying a 1/2 inch piece of copper pipe about 1" long for the inlet.The reed needs to be slightly curved in order that it will spek properly. This is usually done by burnishing, that is, the reed is held on a flat or slightly curved surface and vigorously stroked lengthwise with a bright steel rod about 6 or 9mm in diameter.

The reed, when fixed to the block should have a gap at the tip and display a slight curve from the base. The tuning wire consists of a 2mm brass rod or lighter piano wire bent into a T- shape with the top bent under to bear across the reed to keep it pressed on to the eschalot.The wire protrudes through a hole in the top of the reed block and is bent at right angles to provide a means whereby the wire can be raised or lowered by tapping to change the vibrating length of the reed for tuning. You will probably have to experiment with burnishing to get the right amount of curvature so that the pipe will speak cleanly and promptly. Only experience can determine the "right " amount of curvature.
The resonators are made from plastic pipe and the length is the same as that for stopped pipes. You might need to modify the volume of sound by plugging the top by cutting a slot at the top of the pipe about 3/4" wide and 1" to 2" long then cover with a sleeve cut from plastic pipe, slit lengthwise and slipped over the top to modify the size of the opening.(see below)

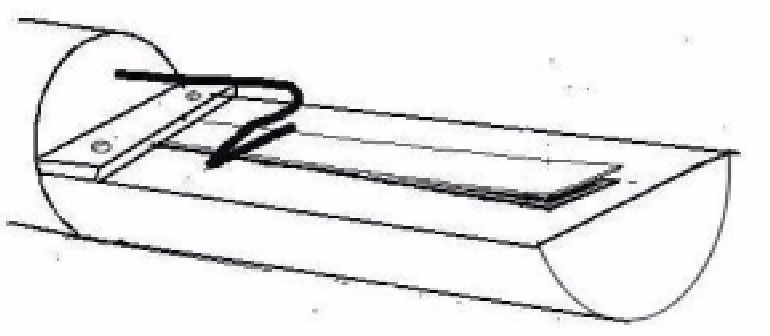




adjustable clarinet resonator

Variousmethods of Mitring bass reed pipes

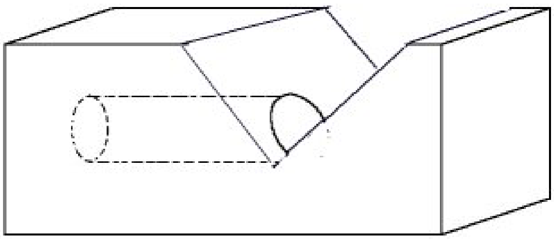
The bass reeds are tapered to give a trombone sound. The taper is about 1" to every 2 ft (25mm every 600mm). Theywill need to be mitred in order to fit them inside the organ case (see above). The volume of sound may need to be reduced and this can be accomplished by plugging the ends and cutting a slot in the end at the top that can be covered by an adjustable metal plate

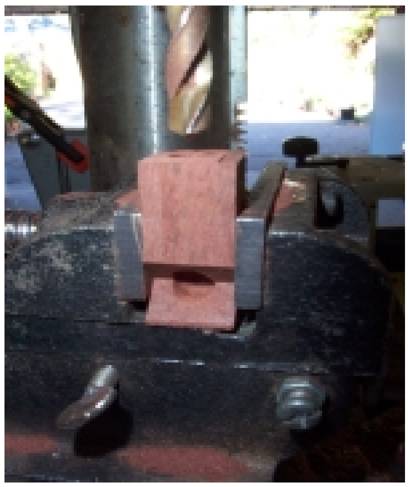


Reed Eschalot showing reed tongue deflection

Open Flutes and Violins

These were made from 6mm MDF and give a satisfactory tone. The dimensions for the pipes are given in Tables 1 & 2. Stopped flutes follow the same basic plan but differ in that there is no tuning slide at the top but a moveable plug The base is made from Australian hardwood - jarrah or red gum. I have found these to be a very stable timbers and give good results. The block is 45mm long, of square section and dimensioned for the particular inside measurements for the pipe being made. A v-notch is cut near the end, leaving a lip of about 1mm wide. The inlet hole is bored from the opposite end to intersect the notch (see photo)



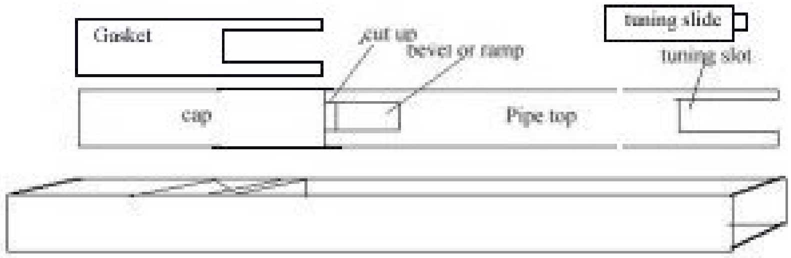


pipe base block

the sides are cut to the length given in the table and exactly the same width as the base block. The back and sides are cut 12mm wider than the sides.

Assembly:

Glue the back of the base block to the pipe back then apply glue to the sides of the block and run a bead of glue along either side of the back for the sides. Place a block of the same dimensions as the base block at the top and place the sides in position, rubbing back and forth to spread the glue. Then tie all together with rubber bands ensuring that everthing is square. The top is left for the moment and the cap is cut from it the same length as the base block and an end squared off and sanded smooth at the end for the lip. Set the assembly aside for the glue to set. It is often a good idea to lightly clamp the centre of the sides to the back, a block of the same dimensions as the base block in the centre would suffice, fastened with rubber bands.Alternatively, sliding wedges can be used.Simpl;y insert the wedges with the ramps together and slide against one another th achieve the desired thickness.



The pipe top needs to have the tuning slot cut (see table), make it slightly narrower than the inside width of the pipe, and the bevel or ramp is cut with a sharp chisel, the same width as the inside of the pipe. The sides of the ramp can be incised with a hacksaw blade as are the tuning slide grooves.

The cut-up or mouth is made as in the table. A rule of thumb is 40% of the pipe width but this can vary according to the pressure used(see below). The edge need not be absolutely sharp but needs to be very thin. Once the glue is dry, paint the inside of the pipe with shellac or varnish to seal it. Also paint the underside of the top to the inside width. The gaskets for the cap are now cut. For these, I used 3 layers of plasterer's paper tape to give a gasket of 1/32nd inch thick or 0.6mm. Any paper type gasket of the right thickness will do (blotting paper is good). The gaskets are U-shaped and cover the sides and base of the block .

The tuning slide is made from thin metal sheet, galvanised iron is OK. Stainless steel or aluminium about 1/32nd or 0.6 mm or slightly thicker is good. The tab at the top is bent forward to provide for moving the slide up or down for tuning. The cap is glued in position over the gasket and the edge set slightly back from the edge of the block, less than 1mm. The top can now be positioned and fixed with rubber bands. Now test blow, making sure that there are no gaps in the join. If a good tone is achieved, the top can now be glued on. After the glue is set, bevel the edges of the mouth towards the cap.Finish off by sanding smooth and cover with clear laquer or shellac.I made the inlet (foot) from copper tube of 1/2 inch dia for the larger pipes and 3/8 inch for the smaller ones (the top octave).

A word about Pipe Scales

For fairground and small organs, the scale refers to the range of pipes used and is usually not chromatic but for larger pipe organs, the scale of an organ pipe refers to the ratio of the width to length. A short fat pipe will produce the same note as a more slender and longer pipe but the harmonic structure will be quite different. Thus we have various names for pipes of different scale e.g. Diapason, Clarabella, Waldflute etc etc. A wide pipe will produce a more hollow sound and will be poorer in harmonics, producing more odd harmonics. A narrower pipe will be richer in harmonics and will sound "stringier" the ultimate being violin pipes that need roller bridges or harmonic freins to make them sound properly. A stopped flute will produce only the odd harmonics, the hollow sounding theatre organ Tibia is a good example. Pipe organ builders soon found that pipes producing higher notes became impossibly narrow and didn't sound "right", the further up the diatonic scale they went so they devised pipe scales that halved the width about every 16th, 20th or 22nd pipe so that pipes could more easily be made to produce the required note (see below)

The pipe mouth also has a relationship to the width of the pipe. The lower the wind pressure, the narrower the mouth and several rules of thumb have been produced for the mouth at 30, 40 or 50% of the pipe inside width. There is a mathematical relationship and formulas for this and a wealth of other information can be found on the World Wide Web, particularly at the Mechanical Music Digest web site at http//mmd.foxtail.com/tech/index.html. So there is no reason why you cannot devise your own scale to produce pipes with a distinctive sound - The following is part of a table of pipes halving at the 16th going from middle C to E an octave above.The tables 1 and 2 give dimensions for two different scales but either will work quite well

Note	Equal Square (ins)	Quad (ins)	Equal Square (mm)	Quad (mm)
C	3.06	2.71	77.7	68.8
C#	2.93	2.39	74.4	60.7
D	2.8	2.48	71.1	63.0
D#	2.68	2.38	68.1	60.5
E	2.57	2.28	65.3	57.9
F	2.46	2.18	62.5	55.4
F#	2.36	2.09	59.9	53.1
G	2.26	2.00	57.4	50.8

Note	Equal Square (ins)	Quad (ins)	Equal Square (mm)	Quad (mm)
G#	2.16	1.91	54.9	48.5
A	2.06	1.83	52.3	46.5
A#	1.95	1.73	49.5	43.9
B	1.9	1.68	48.3	42.7
C1	1.82	1.61	46.2	40.9
C#1	1.74	1.54	44.2	39.1
D1	1.66	1.47	42.2	37.3
D#1	1.59	1.41	40.4	35.8
E1	1.53	1.35	38.9	34.3

Table 1

Pipe Dimensions for open flutes Halving on the 20th note

dimensions in millimetres

Note	frequency	C-C len	actual len	width	Tuner slot	cut up
C	130.8	1248.9	1283.0	68.2	34.1	11.3
C#	138.6	1177.3	1210.3	65.9	32.9	10.9
D	146.8	1109.7	1141.7	63.7	31.8	10.5
D#	155.6	1046.2	1077.0	61.5	30.7	10.1
E	164.8	986.0	1015.7	59.4	29.7	9.8
F	174.6	929.4	958.1	57.4	28.7	9.5
F#	185	876.0	903.7	55.4	27.7	9.1
G	196	825.5	852.4	53.5	26.8	8.8
G#	207.7	778.0	803.9	51.7	25.9	8.5
A	220	733.3	758.2	49.9	25.0	8.2
A#	233.1	690.9	715.0	48.2	24.1	8.0
B	246.9	651.3	674.4	46.6	23.3	7.7
C	261.6	613.7	636.0	45.0	22.5	7.4Mid C
C#	277.2	578.1	599.9	43.5	21.7	7.2
D	293.7	544.8	565.7	42.0	21.0	6.9
D#	311.1	513.3	533.4	40.6	20.3	6.7
E	329.6	483.6	503.2	39.2	19.6	6.5
F	349.2	455.4	474.5	37.8	18.9	6.2
F#	370	429.0	447.3	36.6	18.3	6.0
G	392	404.1	421.9	35.3	17.7	5.8
G#	415.3	380.7	397.8	34.1	17.0	5.6
A	440	358.6	375.2	32.9	16.5	5.4
A#	466.2	337.8	353.8	31.8	15.9	5.3
B	493.9	318.0	333.5	30.7	15.4	5.1
C	523.3	299.7	314.5	29.7	14.9	4.9
C#	554.4	282.2	296.4	28.7	14.4	4.7
D	587.3	265.7	279.4	27.7	13.8	4.6
D#	622.3	250.2	263.4	26.8	13.4	4.4
E	659.3	235.5	248.4	25.9	12.9	4.3
F	698.5	221.7	234.2	25.0	12.5	4.1
F#	740	208.8	220.7	24.1	12.1	4.0
G	784	196.6	208.0	23.3	11.7	3.8
G#	830.6	184.9	196.1	22.5	11.3	3.7
A	880	174.0	184.9	21.7	10.9	3.6
A#	932.3	163.8	174.2	21.0	10.5	3.5
B	987.8	154.2	164.3	20.3	10.1	3.4
C	1046.5	145.0	154.9	19.6	9.8	3.2
C#	1108.7	136.4	146.1	18.9	9.5	3.1
D	1174.7	128.5	137.7	18.3	9.1	3.0
D#	1244.5	120.9	129.5	17.7	8.8	2.9
E	1318.5	113.5	122.2	17.0	8.5	2.8
F	1396.9	106.9	115.1	16.5	8.2	2.7
F#	1480	100.6	108.5	15.9	8.0	2.6
G	1568	94.5	102.1	15.4	7.7	2.5
G#	1661.2	88.9	96.3	14.9	7.4	2.4
A	1760	83.6	90.7	14.4	7.2	2.4
A#	1864.7	78.5	85.6	13.8	6.9	2.3
B	1975.5	73.9	80.5	13.4	6.7	2.2
C	2093	69.3	75.9	12.9	6.5	2.1

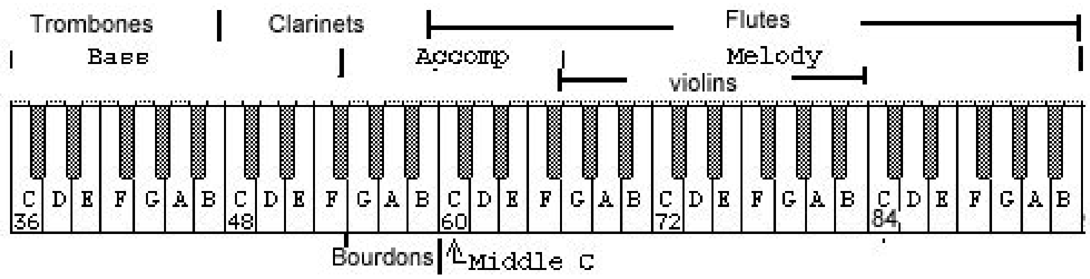
Pipe Dimensions in Millimetres
Halving on the 24th note

Note	MIDI	Freq	Width	Length Open	Length Closed	Mouth (cut up)
C	36	65	84.3	2640.9	1471.1	94.3
#C	37	69	81.9	2491.6	1392.1	91.9
D	38	73	79.6	2350.7	1317.4	89.6
#D	39	78	77.3	2217.8	1246.9	87.3
E	40	82	75.1	2092.4	1180.3	85.1
F	41	87	73.0	1974.2	1117.4	83.0
#F	42	92	70.9	1862.6	1057.9	80.9
G	43	98	68.9	1757.3	1001.7	78.9
#G	44	104	66.9	1658.0	948.7	76.9
A	45	110	65.0	1564.3	898.5	75.0
#A	46	117	63.2	1476.0	851.1	73.2
B	47	123	61.4	1392.6	806.3	71.4
c	48	131	59.6	1314.0	764.0	69.6
#c	49	139	57.9	1239.8	724.0	67.9
d	50	147	56.3	1169.9	686.2	66.3
#d	51	156	54.7	1103.9	650.5	64.7
e	52	165	53.1	1041.7	616.7	63.1
f	53	175	51.6	983.0	584.8	61.6
#f	54	185	50.1	927.6	554.7	60.1
g	55	196	48.7	875.4	526.1	58.7
#g	56	208	47.3	826.1	499.2	57.3
a	57	220	46.0	779.7	473.7	56.0
#a	58	233	44.7	735.9	449.6	54.7
b	59	247	43.4	694.6	426.9	53.4
c’	60	262	42.2	655.7	405.3	52.2
#c’	61	277	41.0	618.9	385.0	51.0
d’	62	294	39.8	584.3	365.8	49.8
#d’	63	311	38.7	551.6	347.6	48.7
e’	64	330	37.6	520.8	330.4	47.6
f’	65	349	36.5	491.8	314.1	46.5
#f’	66	370	35.5	464.4	298.7	45.5
g’	67	392	34.4	438.6	284.2	44.4
#g’	68	415	33.5	414.3	270.4	43.5
a’	69	440	32.5	391.3	257.4	42.5
#a’	70	466	31.6	369.7	245.1	41.6
b’	71	494	30.7	349.3	233.4	40.7
c’’	72	523	29.8	330.1	222.4	39.8
#c’’	73	554	29.0	312.0	212.0	39.0
d’’	74	587	28.1	294.9	202.1	38.1
#d’’	75	622	27.3	278.8	192.8	37.3
e’’	76	659	26.6	263.6	184.0	36.6
f’’	77	698	25.8	249.3	175.6	35.8
#f’’	78	740	25.1	235.9	167.7	35.1
g’’	79	784	24.4	223.2	160.2	34.4
#g’’	80	831	23.7	211.2	153.1	33.7
a’’	81	880	23.0	199.9	146.4	33.0
#a’’	82	932	22.3	189.3	140.1	32.3
b’’	83	988	21.7	179.3	134.1	31.7
c’’’	84	1047	21.1	169.9	128.4	31.1
#c’’’	85	1109	20.5	161.0	123.0	30.5
d’’’	86	1175	19.9	152.6	117.9	29.9
#d’’’	87	1245	19.3	144.7	113.1	29.3
e’’’	88	1319	18.8	137.3	108.5	28.8
f’’’	89	1397	18.2	130.3	104.1	28.2
#f’’’	90	1480	17.7	123.7	100.0	27.7
g’’’	91	1568	17.2	117.5	96.2	27.2
#g’’’	92	1661	16.7	111.7	92.5	26.7
a’’’	93	1760	16.3	106.2	89.0	26.3
#a’’’	94	1865	15.8	101.0	85.7	25.8
b’’’	95	1976	15.3	96.2	82.5	25.3
c’’’	96	2093	14.9	91.6	79.6	24.9

Table 2

Configuration

So much for pipe design. We now need to look at pipe layout and configuration. I have arranged the pipes so that the longest is in the centre. The smallest pipes go in front and the larger ones behind. I placed the 18 violin pipes in the front centre, the longest is G above middle C. the pipes ascending are placed alternating either side. Thus we have G in the centre, to the rightof G is G#, th the left of G is A to the right of G# is A# and so on. The violin pipe solenoids are wired in tandem with the flute pipes of the same note. The next row back is of flutes going down to middle C, behind them are bourdons (stopped flutes) and clarinets going down to tenor C and behind them are the bass reeds. The graphic below illustrates the relationship of the piano keyboard to the organ compass



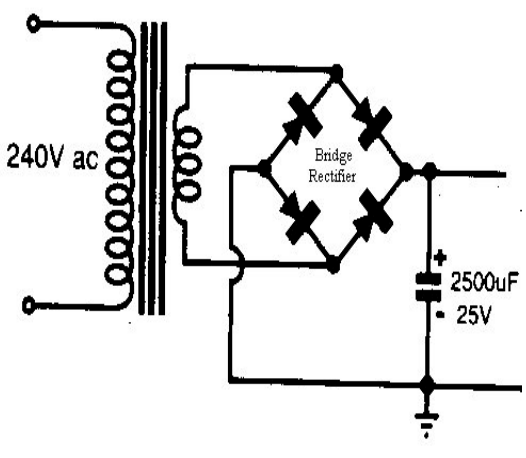
Relationship of piano keyboard to MIDI notes and the organ compass

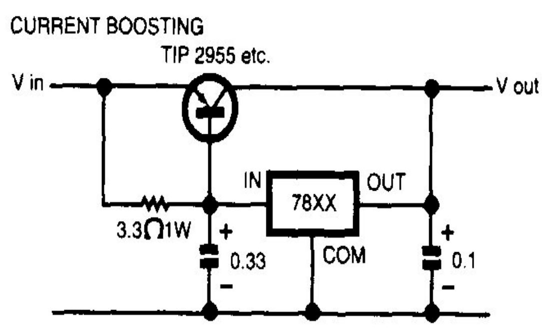
Wiring

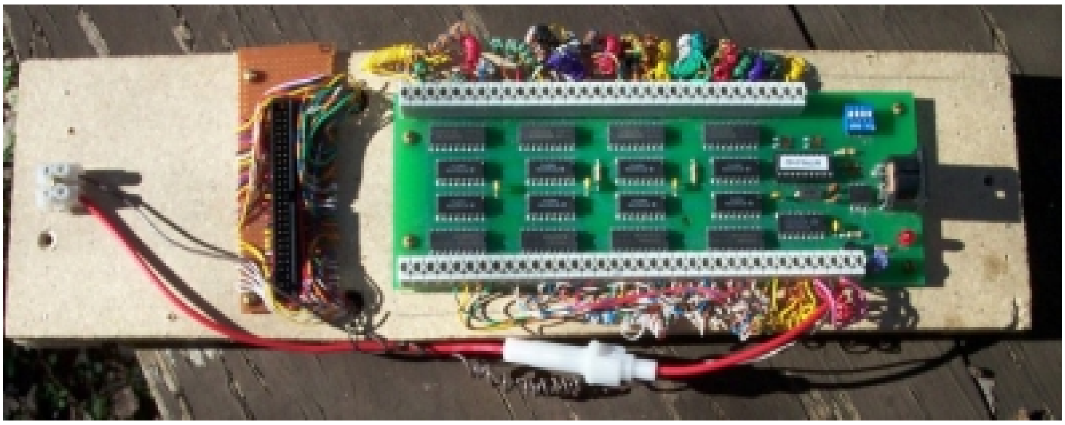
Be sure to leave enough room between the rows so that the solenoids and associated wiring can be fitted in underneath. The solenouds need enough room so that any wiring does not foul the action. The solenoids (usually referred to as “magnets’ in organ parlance) are wired with one connection as the positive common. I used thick plain copper wire for this and insulated telephone wire for the other connection. The wiring is laced and the ends soldered to brass escutcheon pins driven through the chest top. The other ends of the pins on the top of the chest have wires soldered to them and connected to 50-way computer (SCUZZI) cable connectors.

Power Supply

You will need a power supply that supplies at least 3 amps at 12 volts DC. It consists of a transformer, bridge rectifier and filter capacitor and can be built for about $30 . The following is a typical circuit to provide the voltage and current required. You should not need a voltage regulator since the jw-electronics board can handle up to 37volts DC. However, if you feel the need for one, the second circuit below will provide the current required.







Midifying the Organ

In order to MIDIfythe organ , or make it play music automatically, you will need a MIDI interface and a computer with a Soundblaster card with a Joystick/MIDI output socket. The computer I used is a laptop with a docking station that provides the MIDI output - laptops don't usually have such an out put on their own Alternatively, you can use an old 486 or later computer with a soundblaster card. You can pick these up second hand for about $50 or less. The software you'll need is a MIDI player which will play the midi files through the MIDI output, I used AudioRack, which came with the soundblaster card. It allows you to create a play list for the output, but there are others, e.g. the media player that comes with Microsoft Windows. The second piece of equipment is a MIDI interface board. There are several of these available but the most satisfactory one is a 64-note controller board manufactured in England by jw electronics who can be found on the Internet at:- http://www.j-omega.co.uk/mtp6.htm or by e-mail at:- john@j-omega.co.uk. The boards cost $US142 or 86 English Pounds. (about $Aust246 depending on the exchange rate)The picture above shows the controller board ona chipboard base, wired to a 50-way connector together with the power connections.

Selecting MIDI Files

There is a large number of MIDI files available on the internet. Most of them are multi-channel since MIDI can respond to 16 channels. However, the MIDI controller board can only respond to one of 16 channels which is selected by on board dip switches. This means that unmodified MIDI files will only play one channel on the organ so we need to combine the channels to the one channel the organ can respond to. This means we have to select music which has few channels since combining several channels can lead to unpredictable and confusing results.

The simplest MIDI files to select is piano since it usually only consists of two channels, channel one for the melody and channel 2 for the accompaniment. The problem now becomes combining the two channels to one. This is done by mapping both channels to the one channel and saving it as a type 0 MIDI file. There are several pieces of software that will do this including Cakewalk and Noteworthy composer but there are many others. These allow you to modify the MIDI files to map several channels to one and also allows you to edit the music itself.

The following table lists the MIDI note numbers needed for configuring the board. You will need to supply these to the manufacturer in order that the e-prom on the board can be programmed for the organ notes. The connecor pins refer to the 50-way connector. The Output No refers to the controller board outputs. The bass reeds are connected direct to the controller board.

MIDI Controller Board Connection

ouput No	Midi No	Note	Connector Pin	ouput No.	Midi Note	Note	Connector Pin
1	32	g#		33	64	e	17
2	33	a		34	65	f	18
3	34	a#		35	66	f#	19
4	35	b		36	67	g	20
5	36	c	direct	37	68	g#	21
6	37	c#	not connected	38	69	a	22
7	38	d	direct	39	70	a#	23
8	39	d#	not connected	40	71	b	24
9	40	e	direct	41	72	c	25
10	41	f	direct	42	73	c#	26
11	42	f#	direct	43	74	d	27
12	43	g	direct	44	75	d#	28
13	44	g#	not connected	45	76	e	29
14	45	a	direct	46	77	f	30
15	46	a#	direct	47	78	f#	31
16	47	b	direct	48	79	g	32
17	48	c	1	49	80	g#	33
18	49	c#	2	50	81	a	34
19	50	d	3	51	82	a#	35
20	51	d#	4	52	83	b	36
21	52	e	5	53	84	c	37
22	53	f	6	54	85	c#	38
23	54	f#	7	55	86	d	39
24	55	g	8	56	87	d#	40
25	56	g#	9	57	88	e	41
26	57	a	10	58	89	f	42
27	58	a#	11	59	90	f#	43
28	59	b	12	60	91	g	44
29	60	c	13	61	92	g#	45
30	61	c#	14	62	93	a	46
31	62	d	15	63	94	a#	47
32	63	d#	16	64	95	b	48

A Final Word

I hope you have as much fun building the organ as I have. It has been a challenging and rewarding experience and I have learned so much in the process. If you have any problems please let me know via e-mail. Iwould welcome comments and criticism (constructive of course!)