The Very First Flute: Might It Still Be Useful Today?

by Carl B. Dodrill, Ph.D

The ten **Quick Reference** (QR) files referenced in this article can be found at https://www.pipeorganfoundation.org/links/links.html

George Ashdown Audsley, on page one of *The Art of Organ-Building*, pointed to the significance of the very first flute which was made and played several millennia ago. The pipe was a hollow tube fashioned from a reed grown near water. It was stopped, and blowing across the open end made a sound which defines what we now call *flute*.

However, pipe organ builders have focused entirely upon blowing into pipes and not across their ends for centuries. Utilizing experience garnered over the last quarter century, the present article explores the possibility that the basic mechanism of sound generation used by this first flute might still be of value to organbuilders today. The term *pan flute* denotes a flute whereby sound is generated by blowing across the end of the pipe rather than into the pipe itself.

HISTORY OF THE PAN FLUTE

ANCIENT TIMES

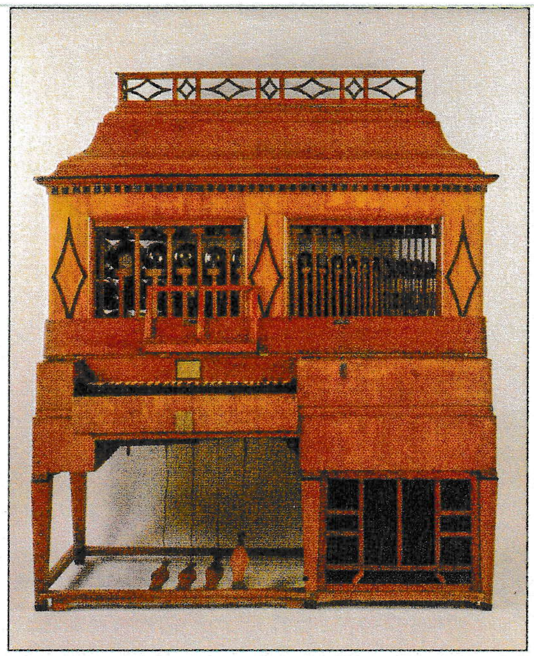
Pan flutes have been found in multiple tombs dating back more than 4000 years. Over time, these flutes were developed by joining pipes of differing lengths together— forming a *syrinx* or *Pipe of Pan*—and by boring holes in the pipe so that more than one note could be played from a single pipe. This instrument has been a part of diverse ancient cultures, including those in Egypt, Greece, and China.

THE *HYDRAULIS*

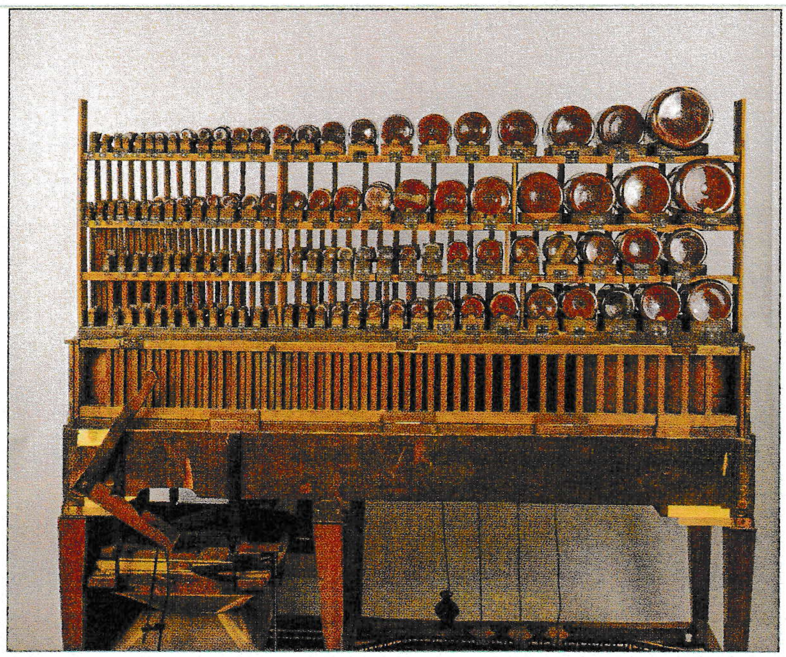
We are all familiar with the third century BCE invention of Ctesibius, namely, the *hydraulis* or hydraulic organ. It is believed to be the first pipe organ ever built, but we generally focus upon the mechanism of wind generation and distribution, and not upon the pipes. Of Ctesibius, Audsley said, "He evidently took the idea of his Organ from the syrinx or Pandean pipes, a musical instrument of the highest antiquity among the Greeks" (p. 8). Thus, Audsley alludes that the pipes in the *hydraulis* were of the pan flute variety. This seems valid, as there is nothing in the archeological record that modern-type pipes existed at that time, and, moreover, pipes with mouths as we know them are complex by nature and therefore unlikely to have appeared at this early stage.

HELGOLAND, 1798

In the 18th century, there was on Helgoland—a small island in the North Sea—a church with a pipe organ which constantly needed tuning due to the greatly fluctuating temperature and humidity. As regular tuning visits from the mainland were totally impractical, German instrument maker Johann Samuel Kühlewein was asked to build an organ that would hold its tune. After much study, he decided to build an organ not with regular pipes, but with bottles partially filled with sealing wax. He built nozzles which directed the wind across the mouth of each bottle. There were two 56-note ranks, at 8-foot and 4-foot pitches, with the lowest six notes being stopped wooden pipes. This apparently worked quite well. It needed no regular tuning, and the church used it for about 100 years. The organ is now in the National Museums in Liverpool, England.



Helgoland bottle organ, 1798



Helgoland bottle organ, from back, case removed.

JUSTIN KRAMER—*JUGORGEL*

California organ builder Justin Kramer built a bottle organ which he called the *Jugorgel*. He spent considerable time on the mechanism by which wind was delivered to the tops of bottles, and even registered a patent for it (QR file 1). This mechanism is attached to the bottles themselves, with a hose delivering the wind over the top of each bottle, at an angle down into the opening. He had 88 bottles of about six sizes, nearly all of which had long tapered necks. As none of the bottles were small, he added 24 small flute organ pipes to the top to extend the range of the instrument upwards. He played the organ on *The Tonight Show Starring Johnny Carson* in 1973 (QR file 2). The organ seemed to make quite a hit with the audience.

PETERSON BEER BOTTLE ORGANS

Dick Peterson, founder of Peterson Electro-Musical Products, was a friend of Justin Kramer. He and Gary Rickert were inspired by the *Jugorgel*. In 1998, Gary and others at Peterson built the Beer Bottle Organ. Created to celebrate Peterson's 50^{th} anniversary, the 37-note instrument debuted at the 1998 American Institute of Organbuilders convention, and after, was displayed for several years at National Association of Music Merchants (NAMM) conventions and the Frankfurt Musikmesse in Germany. One can see the organ and hear it play (QR file 3).

The Peterson company has since made seven other similar instruments. Most of them have been beer bottle organs of 37 notes, but there have been some variations. The wind is delivered over the top of each bottle through hardwood nozzles; the tuning is accomplished with mineral oil; the pressure is usually 2-3 inches WC; they are playable from keyboards, and MIDI record/playback is typically included. Two organs were built for a musician who toured the world, playing them via a MIDI connection with a guitar.

Gratitude is expressed to Scott Peterson and Pat Bovenizer of the Peterson company who provided the above information. It is clear that Peterson has made more instruments than anyone else using the basic pan flute method of sound generation.

RECENT WORK WITH BOTTLES

A Peterson beer bottle organ caught the attention of Phil Dayson in 2005. Intrigued, he designed a 43-note Manischewitz wine bottle organ, which was completed in 2011. An article about the design and construction of that instrument is available (QR file 4).

Exposure to the Dayson organ led the author to devote considerable time researching this type of instrument. Together with Phil Dayson, he published an article which is available (QR file 5). That article gives detailed information on four sizes of bottle organs (20 to 49 notes), four different bottle types, seven different bottle sizes, pressures, blowers, nozzle construction, etc. As the author's primary work was with pipe organs, much of that effort was exploring possible application to pipe organs.

ADDITION OF THE PAN FLUTE TO PIPE ORGANS TODAY

We've looked into pan flute use over the centuries; how is it applicable today? Its fundamentally different mechanism produces a tone different than that produced by regular organ pipes, wood or metal. Therefore, let us explore the possibility of incorporating this stop, in one form or another, into modern pipe organs. There are two ways in which this can be done, and they pertain to the materials used.

METAL PAN FLUTE PIPES

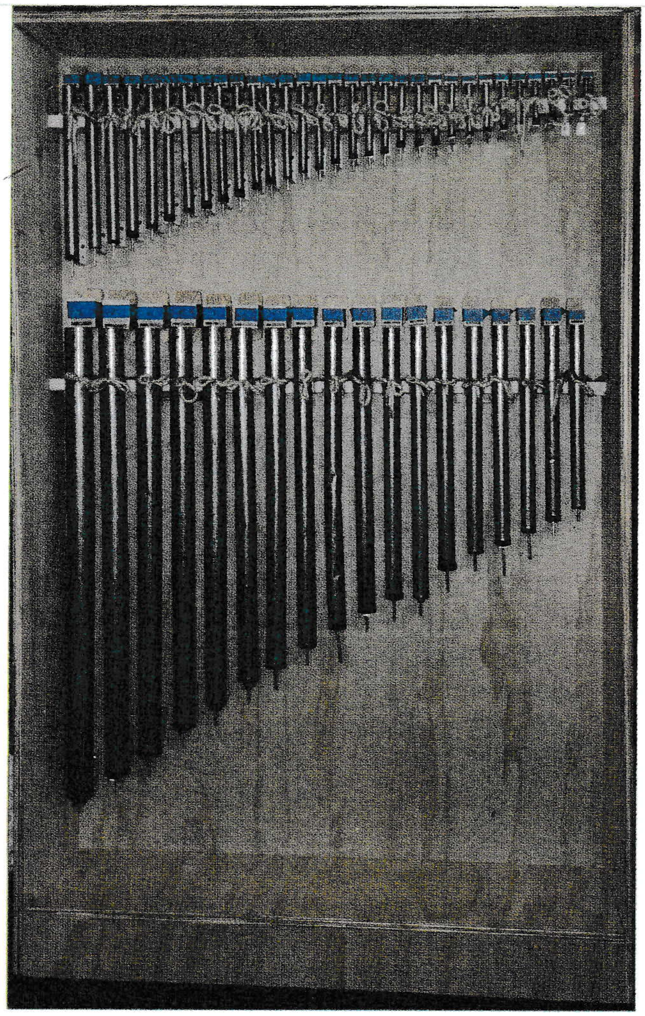
Using metal pipes is the most obvious way of creating a pan flute rank, and can be easily done with surplus metal pipes. As the pipes will be stopped, full length 8′ pipes in good condition are not needed and almost any metal can be used. Furthermore, as larger pipes produce greater sound volume, the pipes can be rescaled according to the size of the anticipated listening space. The mouth and foot of each pipe are cut off so that each end is smooth and even, the length tuned to the proper pitch with a stopper. The other end accepts the wind blowing across it.

While there are many ways to make tuning stoppers, we have used tapered rubber plugs, trimming them to the diameter of each pipe. A pin inserted into the stopper slides into a right-angle bracket mounted to the windchest, securing the bottom of the pipe. The top of the pipe is held in a scallop rack with ties. The pipes can be adjusted in and out with felt added to the scallop rack. There are many different ways to achieve the above ends so that the pipes are secured in place and tunable.

Four-sided hollow wooden nozzles were constructed to convey the wind from the chest to the tops of the pipes. Each nozzle had a slot in the lower front, forming the wind sheet over the end of the pipe. The wind must be delivered precisely for a pure and clear tone. For vertical adjustment, the base of the nozzle is slotted, with screws fixing it to the windchest. These are the same nozzles used with glass bottles. You can read more about them in the Dodrill and Dayson article already cited, and in the sections below.

A 49-note pan flute rank (8′ G to ½′ G) was constructed as described above. Crafted from a 72-scale string rank, it plays the same notes as the Manischewitz organ previously mentioned. You can see the spotted metal pipes, the pinned stoppers, and the nozzles that deliver the wind to each pipe. Behind each nozzle is a vertically mounted electromechanical valve, delivering the wind horizontally.

You can hear a demonstration of this metal pan flute (QR file 6). The winding of this rank required special attention. While a single pressure is sufficient for ranks of three octaves (like the beer bottle organs), a full 73-note rank playing at 8′ and 4′ requires two pressures in order to maintain uniform timbre. An increase from low to high pressure is best made at around 1′ C. In the unit pictured, the blower in the bottom of the case delivers wind to the bottom row of pipes at 1¾ inches. A small booster fan increases the pressure to 2½ inches in the upper chest for the top row of pipes. A small regulator could also achieve two pressures from a single blower.



Metal pan flute rank of 49 pipes.

For the metal-pipe pan flute, we have found the sound is quite satisfactory and distinguishable from other flutes. The materials required are commonly available, and there is flexibility in many aspects of its construction.

GLASS BOTTLES USED AS PAN FLUTE PIPES

The second approach to adding a pan flute stop to a pipe organ utilizes glass bottles. In the historical review, glass bottles have been used far more often than metal pipes. There is a vast array of bottles available in different sizes and shapes which produce satisfactory flute sounds. While beer bottles dominate this "market," there is no reason to limit yourself to the two or three sizes of beer bottles that are commercially available. A dozen or more sizes of bottles from diverse sources will fill out a rank nicely for inclusion in a pipe organ.

Bottles are readily tunable with fluids that do not evaporate, in particular, mineral oil. As mentioned above, the Helgoland bottles were tuned with sealing wax. Further, tuning is very stable.

The tone produced by bottles is very pleasing. The sound is in the flute family, but it is different than that of the other flutes used in pipe organs today, so it makes a unique contribution. Further, the volume of sound produced by selected bottles is quite generous, the sound blends well with other ranks, it makes a pleasing solo voice, and the bottles respond very quickly. You can see a demonstration of their speed on the Manischewitz organ (QR file 7).

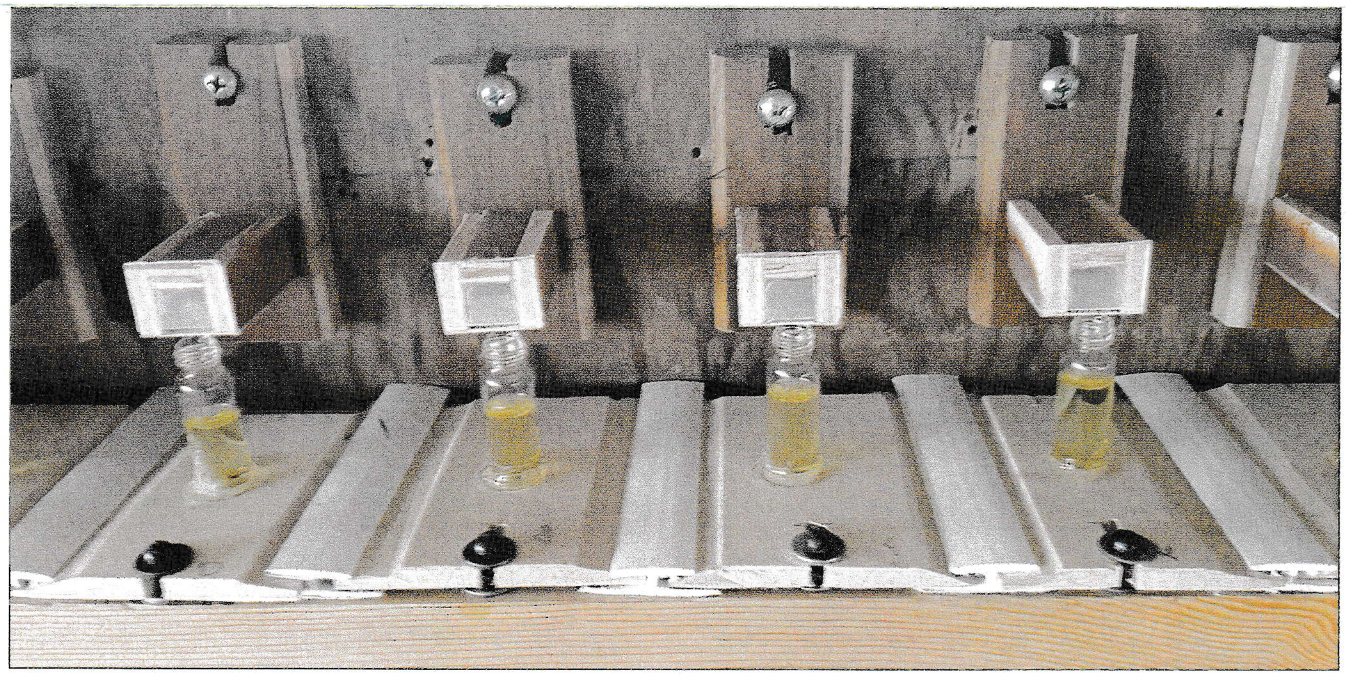
The minimal cost for bottles and their tuning medium is far less than for either wood or metal pipes. Basic windchests will support them, and special attention is needed only for bottle selection and mounting, wind pressure, wind delivery, and tuning. Guidance on each of these requirements is found below.

To determine the key variables, considerable research was undertaken over several years with an array of bottles, nozzles, and wind pressures. Further, advice was sought from successful builders, including the Peterson company and Phil Dayson. An organ was built with three different sets of bottles: beer, Manischewitz wine, and Boston round. Renowned Pacific Northwest organist Mel Butler played these three types of bottles at length: alone and together in various combinations. His feedback was immensely valuable in guiding the selection of bottles and wind delivery.

You can see and hear Mr. Butler play this instrument (QR file 8). Note that the far left stop tablet controls the 37 beer bottles on the far side of the console. The second stop tablet plays at 8′ from tenor C the 56 Boston round bottles to the left of the organist and their upper extension on top of the console. The third stop tablet plays the same Boston round bottles but at 4′. The final stop tablet plays the 37 Manischewitz bottles on the left and behind the organist. Note that the beer and Manischewitz bottles are similar in sound, whereas the Boston round bottles produce a somewhat less complex sound. In person, this difference is more apparent than the 2016 cell phone recording provided.

Our research revealed several key conclusions:

- The bottle neck shape has the most influence on tone. **Short-necked** bottles such as Boston rounds give the purest sounds with the fewest overtones. We believe these are the best candidates for additions to pipe organs. **Long-necked bottles** come in two basic varieties: cylindrical and tapered. The cylindrical necks of some wine bottles dampen the sounds they produce, forming a less interesting tone. Tapered necks, on the other hand, seem to generate more overtones, and have a more complex and pleasing tone. This is more suitable for a solo instrument. The tone of the Peterson instruments is full and musical. The vibrations at all elevations within the neck likely contribute to the complexity of the sound, which, while interesting, likely would not blend well with most pipe organ choruses.
- Uniformity of timbre between bottles is slightly improved when each bottle is ⅕ to ⅘ full of oil. When at least ⅕ full, the surface of the oil is little disturbed while playing, helping stabilize its tone. Having the bottle no more than ⅘ full allows engagement with a significant portion of the inside walls, creating a more even sound across the compass.
- There is a curvilinear relationship between bottle size and pitch. Table 1 shows that it is impractical to go more than a few notes lower than 4′ C with bottles because they become too large. An 8′ tenor C rank playing at 8′ and 4′ is the easy answer. An extension down to 8′ C is possible with a stopped wooden bass, just like the 1798 Helgoland organ. On the upper end, the top five notes call for 1⁄32 ounce bottles; one can meet this requirement with ¼ dram vials. Thus, one can get to the top of a 4′ rank, but no higher.
- With some experience, you will find that bottles require much less work and time than regular organ pipes. There is no cutting to length, no stoppers to make, and no mouths, languids, or rackboards. The bottles can be permanently bonded to thin wood bases with glue (we like E6000, as it holds well, yet remains flexible). These bases slide into strips of plastic wall panel divider moulding. The moulding strips are tacked down and hold the bottle bases snugly.
- Initial tuning is best done with oil and by adjusting the bottle in or out horizontally to achieve maximum loudness. With all the bottles tuned, check for even sound level. Move any louder bottles slightly in or out to match their neighbors and retune. Check this again in a few days, after everything is stabilized. When installed in the organ, you will find that you can make minute tuning adjustments simply by moving the bottles slightly in to make them sharper and out to make them flatter.



Very small (1⁄16 ounce) bottles with nozzles and visible tuning oil. Note the bottles mounted to wooden bases, held snugly in wall panel moulding strips.

Bottle volume	No. of bottles	Opening dia. (mm)	Pitches
96 or 128 ounce	2	35	4′ C, C♯
64 ounce	5	29	4′ D, D♯, E, F, F♯
32 ounce	6	25	4′ G, G♯, A, A♯, B, 2′ C
16 ounce	5	20	2′ C♯, D, D♯, E, F
8 ounce	4	15	2′ F♯, G, G♯, A
4 ounce	4	15	2′ A♯, B 1′ C, C♯
2 ounce	4	12	1′ D, D♯, E, F
1 ounce	5	11.5	1′ F♯, G, G♯, A, A♯
½ ounce	6	10.5	1′ B ½′ C, C♯, D, D♯, E
¼ ounce	5	9	½′ F, F♯, G, G♯, A
⅛ ounce	5	8	½′ A♯, B ¼′ C, C♯, D
1⁄16 ounce	5	5	¼′ D♯, E, F, F♯, G
¼ dram vial (1⁄32 ounce)	5	6	¼′ G♯, A, A♯, B ⅛′ C

Table 1. Boston round bottles for 61 note Glass Flute rank.

Notes: The bottles can be obtained from various vendors. For the sake of convenience, it is noted that all of them can be obtained in the exact quantities desired from Specialty Bottle Supply (specialtybottle.com). The smallest bottle is a glass vial with straight sides and a full opening.

- In consideration of the factors above, Table 1 specifies the bottles necessary to construct a 61-note 4′ rank. See the note on the availability of the bottles at the foot of the table. The two largest sizes are often called "jugs" but all the rest are "Boston rounds" except for the smallest which is a "vial." Note that by following the rule of having each bottle ⅕ to ⅘ full, each size of bottle accommodates 4-6 notes.

WINDING

Our experience has uncovered these wind pressure facts:

- Working pressures are low, usually between 2 and 3½ inches WC.
- The larger bottles speak best with a generous supply of lower pressure wind, while smaller bottles are happier on higher pressures and less wind.
- A single wind pressure is perfectly adequate for up to three octaves. Much beyond that, uniform tonal characteristics are most easily obtained across the gamut by using two pressures. A four or five octave 8′ tenor C or 4′ rank will require two pressures. Our work indicates that about 2 inches WC is sufficient for the bottom three octaves and about 3½ inches for the top two octaves.

Similar to the Peterson and Dayson organs, and in contrast to the Kramer organ, it is most useful to have nozzles mounted to the windchest rather than connected to the bottles themselves. This allows precise control and adjustment of the nozzle relative to the bottle. There is more information on nozzles in the Dodrill and Dayson article.

The key points for nozzle construction are as follows:

- The bottle opening diameter determines the size of its nozzle. Square nozzles with a slot slightly wider than the openings seem to work best. There is some leeway if the nozzle is not precisely aligned with the bottle: the wind sheet will still cover the top of the bottle.
- Using 3⁄16" thick material for all four sides of the nozzle works for the bottom two octaves. For the top three octaves, thinner material for the underside near the end of the nozzle is used, to get the wind sheet closer to the top of the smaller bottles. The same thin material can cap off the outer end of each nozzle after you have confirmed that the wind sheet is the right thickness (typically 1⁄16 to 3⁄16 inches). The photo below shows nozzles under construction, some of which have yet to be cut in half, as it is convenient to make two at once. Note that the undersides are half filled with wood, which provides support for the structure, while thin sheet material will cover the entire underside.

Stop controls for the Glass Flute at Mercer Island Presbyterian Church, Mercer Island, Washington.

- The wind sheet must be at a slight downward angle for the bottle to speak, hitting the far inside edge of the mouth and energizing the air in the bottle. The construction of these nozzles automatically deflects the wind sheet downward at an angle which activates the bottle.
- Each nozzle has a mounting base, as shown near the center of the photo below. This slotted base allows the height of the wind sheet to be adjusted relative to the bottle. The round hole in the base is sized to the nozzle area, and should be larger than the hole in the windchest to allow vertical adjustment. Mounted over the hole inside the windchest we have always placed an electromechanical valve.

Constructing nozzles. Note the clamped nozzles and the ones in the middle are double ended; these will be cut into two

The above system grants complete control of the nozzles relative to the bottles. The bottle openings are lined up with the nozzles (X axis), the movable nozzle base allows height adjustment of the wind sheet (Y axis), and the bottle can also move in and out (Z axis).

WINDCHEST

Windchest construction is very straightforward. Routinely, the chests are vertical, the wind chamber is often 4-6 inches deep, and there are two chambers if two pressures are required. It is most convenient to place the chamber serving the bigger pipes/bottles on the bottom and the one serving the smaller ones on the top. The two pressures can be obtained in any standard way.

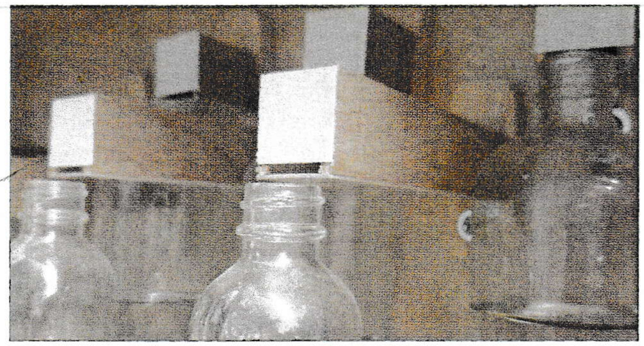
Electromechanical valves are mounted in the chest. It is good to attach a diode across each magnet coil to slightly retard the release of the magnet. We have found that it is best to have all pipes/bottles at hand before planning the windchest. If you lay them out, the best plan for the windchest will likely be evident.

The complete 56-note Glass Flute in place behind the Aeolian Harp.

THE GLASS FLUTE

The final product, based upon all the information above, can now be seen and heard. We call it the Glass Flute, a name which we hope will be generally adopted to maintain consistency. In 2017 we installed a 56-note Glass Flute in the organ at Mercer Island Presbyterian Church, Mercer Island, Washington. It speaks at 8′ and at 4′ pitches in the Antiphonal division of a III/27 instrument rebuilt and installed by the Pipe Organ Foundation and listed on the OHS website. The Glass Flute rank was installed on one side of the sanctuary (at 9 o'clock) behind the 49-note Aeolian harp so it could be heard but not easily seen. The room seats nearly 300 people and has good acoustics.

The photo above left shows the Glass Flute in place. Beginning at the top, one can see the smallest (1⁄16 ounce) bottles in place. Note the relationship between the nozzles and the bottles. The bottom thin plastic of each nozzle sits very close to the top of the bottle, in some cases they touch, and in some cases the bottle is slightly under the end of the nozzle. Had the bottom been the same thickness as the sides of the nozzle, the bottle would not have spoken at all. Above right, you can see this relationship with much larger (8 ounce) bottles. Here, they clearly do not touch, and the wind sheet is much thicker.



Nozzle structure and relationship with 8-ounce bottles.

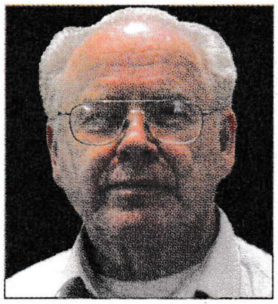
You can hear and see the Glass Flute playing first at 8′ alone and then 8′ and 4′ together (QR file 9). It is easily and clearly heard throughout the sanctuary. You can also hear the Swell 8′ Salicional and the 8′ Voix Celeste play alone and then with the addition of the 8′ Glass Flute (QR file 10). The Glass Flute blends well with the strings and its usefulness as a solo voice is evident.

The Glass Flute has not taken the place of the other flutes in the organ, and it does not appear best to think of it in this way. However, it gives a new and different flute sound to the music being played, and as a solo stop, it is especially striking. It has proven to be a positive addition to this instrument, and has generated a surprising amount of positive interest. Exploring new ideas in our shops is certainly worthwhile, and the first flute may still be of benefit to our industry.

REFERENCES

Audsley, George Ashdown, *The Art of Organ-Building*, New York: Dodd, Mead and Co., 1905.

Helgoland organ: https://minim.ac.uk/index.php/explore/?instrument=31565 used under Creative Commons CC0 1.0 Universal.



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