How to Build a Self-playing Bottle Organ

By Carl B. Dodrill and Philip Dayson

There is no doubt that the potentials of using bottles to make music have been overlooked, and especially so for automatic music. The sounds coming from bottles are so pleasing and the potentials are so remarkable that this instrument truly deserves close attention by AMICA members. However, it was only at the 2019 AMICA convention in Seattle that this instrument was introduced to people with a strong interest in self-playing instruments. In this article we will first give a brief history of the use of bottles to make music and then focus on providing enough information so that you can make your own bottle organ.

History of bottle organs

Heligoland (also spelled Helgoland) is a small and irregularly shaped island off the coast of Germany in the North Sea. In the 1700s, the island was home to a small group of people who worshipped in a church with a pipe organ. The windswept island had huge temperature changes so that keeping the hand-pumped organ in tune and in repair was a major problem. There was an obvious want to have an organ which would stay in tune much better than the typical pipe organ. The church commissioned Johann Samuel Kühlewein of Germany to build such an organ, and he created one made of bottles partially filled with sealing wax to tune the bottles. The organ functioned for many years in the church and it is now in a museum in the United Kingdom.

The next bottle organ that we know of was created by the California organ builder Justin Kramer. It was an 88 note/88 bottle instrument played from an organ console and he called it the *Jugorgel.* Kramer showed the *Jugorgel* on the Johnny Carson TV show in 1973. Mr. Kramer took out a patent on his nozzle design (U.S. Patent 3,748,945, July 31, 1973; seen at https://www.mmdigest.com/Gallery/Tech/PDayson/US3748945.pdf). The organ produced a convincing performance on the TV program, and there was a news clip in the May, 1976 issue of Popular Mechanics. Very little information is available about it after that time.

In 1998, and as part of its 50th anniversary celebration, the **Peterson Electro-Musical Products Company** of Alsip, Illinois produced the first of several bottle organs primarily using beer bottles. The organs used the bottles of different beer companies and they were usually played on a standard keyboard of three octaves. Peterson still makes such organs and are very willing to share information about these instruments.

While the above completes the recorded history of established bottle organs as known by the authors of this report, it is also known that occasionally bottles have been used in perfunctory ways in various settings. People have played them on the streets, odds and ends of bottle organs of varying qualities appear on YouTube,

Photo 1. The very first self-playing bottle organ--Manischewitz wine bottles, 43 notes, completed in 2011 by Philip

and some beer bottles have secretly been placed in church pipe organs where they functioned as flutes and were enjoyed until the church discovered that offensive items existed in their buildings and they threw the bottles out! Nevertheless, there is no evidence of a systematic study of bottles and their usefulness in musical instruments generally, and what is totally missing is a treatise on the use of bottles in automatic self-playing musical instruments. The present article is advanced as a step towards remedying these deficiencies.

Bottle Organ Basic Design

In about 2005, Philip heard a Peterson beer bottle organ. While the sound was amazing to him, the cost to have a

Photo 2. The 20-note bottle organ with the basic organ made by Carl but with decorations and enhancements by Philip

Peterson organ built was high, and he put the idea aside. In 2010, he saw on ebay another Peterson beer bottle organ, his interest was reignited, and he launched the building of such an organ. As he had to do much design work, several hundred hours were required for its completion, but it was in 2011. On August 31, 2012, he published an extended article on the Mechanical Music Digest and this article can be viewed at https://www.mmdigest.com/Gallery/Tech/PDayson/dayson1.html.

All readers of this report with a significant interest in building a bottle organ are urged to study this document carefully as it touches on almost every aspect of the construction of a bottle organ, and it even has links to audio/video files of the organ playing. It is true that some aspects of the article are now dated as improved methods of design have in a few cases been found, especially about nozzle construction and the securement of bottles. Nevertheless, the article continues to present an overview of this landmark instrument which will be found to be of great value. A photo of this organ is included in this report (**Photo 1**).

A bottle organ requires the following components: 1) <u>bottles</u>; 2) <u>nozzles</u> to convey the wind to the bottles; 3) <u>solenoids/valves</u> which open and let the wind (lightly compressed air) into the nozzles; 4) one or more <u>fans</u> which provide the wind; 5) <u>an electrical/electronic operating system including MIDI</u>; and, 6) a <u>cabinet</u> in which all of these components are located.

While the six items are essential to the building of all our bottle organs, note that how much of each component you will need is directly related to the size of the bottle organ you plan to build. We have built organs of 20 bottles, 37 bottles, 43/49 bottles, and 56 bottles. To provide an overall perspective, basic information about

Photo 3. The 49 note Manischewitz bottle organ made by Carl

these organs is given in Table 1. In this table, the 43 note Manischewitz wine bottle organ is the original organ completed in 2011 as described above. The other organs were built by Carl in 2014-2018, with refinements made by both of us through the years.

We provide especially detailed information about the construction of the 20-note organ in this report because it is easier to build than all the other bottle organs, and because much of this information can be extrapolated to the other organs. The 20-note organ is a good place for anyone to start who wants to build a bottle organ even though the larger organs are more versatile and give fuller and more complete sound.

<u>Bottles</u>

The best place to begin building a bottle organ is to decide what kind of bottles you want to use and how many. We will provide pictures of the organs we have created except the 56-bottle instrument which is not a self-playing instrument as it is part of a pipe organ in a church. The 37-note beer bottle organ is also not emphasized as many of the Peterson beer bottle organs can be found on YouTube. While the pictures will help in your selection of the bottle organ, we also recommend listening to the various organs on the internet (especially YouTube) through the links given. In selecting bottles, you will want to consider the following variables:

Photo 4. Boston round bottles on the 20-note organ which are glued to pieces of plywood that can be moved in and out to adjust the bottle relative to the nozzle. The plywood is screwed down to a shelf which is held in with a pin (left) but which can be pulled out like a drawer

1. <u>Amount of available space for the instrument</u>. The 20-note organ is a table model (30 inches wide, 16 deep, 24 high) whereas all the others are floor models about 40 inches wide, 20 inches deep and 70 inches tall, depending on configuration. The 20-note organ weighs about 65 pounds and the others weigh up to 300 pounds. A 20-note organ is shown in **Photo 2** with the decorations and enhancements made by Philip. You can see a less decorated form of this same organ on YouTube by searching for "20 note bottle organ".

2. <u>Availability of bottles of different sizes</u>. Boston round bottles (which are exclusively used in the 20 note organs that both of us own) are by far most available through websites such as **Ebottles.com**. They are available in many sizes ranging from 1/16 ounce to 32 ounces with close matching of similar bottles up to 128 ounces (one gallon). Extensive information on Boston rounds relative to the sizes of the bottles in the 20 note organs are given in the first part of Table 2. Beer bottles cannot be obtained less than about 7-ounce sizes, and they top out at about 26 to 32 ounces. Manischewitz wine bottles are commonly available in 750 ml and 1.5 L sizes, with the smaller antique bottles down to 4 ounces available only on ebay when you can find them, and nothing smaller than 4 ounces. Note also that you can combine bottle types in an organ, and the 49-note organ has 41 Manischewitz bottles which are topped off by 8 Boston rounds as small as ¼ ounce. Such an instrument combines the advantages of both bottle types and it extends the range of the organ up to four full chromatic octaves. The bottom three notes became possible because two 1.5 L Manischewitz bottles were glued together after the top of one and the bottom of the other had been cut off. See **Photo 3**. You can hear this organ on YouTube playing the "Anvil Polka" at https://www.youtube.com/watch?v=PifnjRDaLJI&t=80s, "Putting on the Ritz" at https://www.youtube.com/watch?v=PifnjRDaLJI&t=80s, and other tunes as well.

3. <u>Shape of bottles and sizes of openings</u>. Bottles tend to have tapered necks or not. The tapered necks of beer bottles and Manischewitz wine bottles produce more complex sounds with more overtones than the short-necked Boston rounds which have purer sounds. The difference is not noticeable to most people unless the bottles are playing side by side. Longer necks also produce lower pitches as do bottles with larger volumes, but longer and straighter necks, commonly found on wine bottles tend to kill the sound. Larger openings tend to produce higher pitches and louder sounds.

4. <u>Appearance of the organ</u>. Some people like beer or wine bottles with labels, while others do not. Thus, personal taste will impact the selection of bottles.

Whatever bottles are selected, it is a major advantage to secure them so they will not move on their own when playing and that the organ can be made more portable. The easiest way is to glue them to carefully cut pieces of finished plywood using a glue such as **E6000**. Each piece of plywood can then be slid in and out when screws are loosened, and the screws can be tightened when the bottle is in exactly the right position. Each row of bottles can be mounted on a board which is held in place with pins, but which can be pulled out like a drawer to remove all bottles at once (see **Photo 4**).

<u>Nozzles</u>

The wind must be conveyed from the vertical windchest or plenum behind the bottles to the tops of the bottles. In 1973, Kramer took out a patent on a nozzle involving a hose attached to an apparatus which delivered the wind to the top of the bottle and was clamped to it. This must have worked well for him, but the Peterson company did not use this design nor have we. The nozzle design we utilized is shown in **Photo** 5. It enables us to make fine adjustments to how the wind is delivered, to stabilize the delivery method firmly for transport, and to make the appearance of the organ more appealing, making it possible to add LEDs.

Technical information about the nozzles for the 20-note organ is provided in the Nozzles section of Table 2. The nozzles are constructed of quality plywood about 3/16" thick. The nozzles are square on the inside dimensions and the sizes of the insides are directly related to the openings of the bottles which they serve. We have found it useful to have the widths of the openings in the nozzles to be a little greater than the openings in the bottles because if the bottles and the nozzles are not absolutely squarely aligned, it is likely the full bottle opening will still receive ample wind from the nozzle.

Table 2 shows the width of the strips of 3/16" thick plywood to be cut for the width and the height of each nozzle. Because the measure for the vertical boards on each side of the nozzle are greater than the horizontal board that runs on the top, the horizontal boards on the top and the bottom fit between the vertical boards producing an opening which is essentially square. The

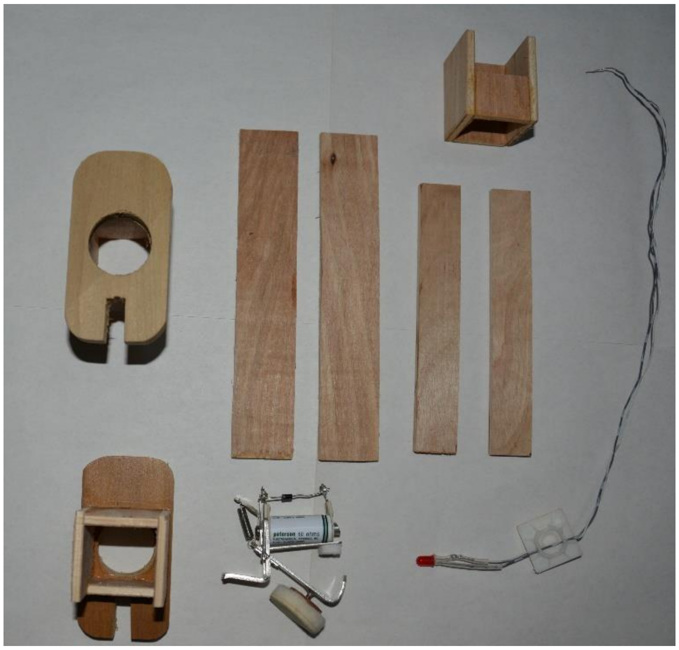

Photo 5. In the middle are cut sides and tops of different sizes of nozzles. On the top right is a nozzle body ready to have the end base glued on. On the left, two large nozzles are shown with their bases already glued on (view from the back side shown above; view from the front side shown below). A Peterson solenoid is pictured as is a diode and its attached wire

plywood can be cut on a table saw and the boards can be glued together with wood glue and clamps.

Not clear from Table 2 is that the horizontal board on the bottom goes out only one half the length towards the bottle. This provides stability to the entire rectangular structure of the nozzle when gluing it together while allowing for thinner material to be applied to the bottom of the nozzle near the end of the nozzle's construction. The thinner material is LED or fluorescent light diffusion plastic 0.025-inch-thick and assists in cleanly delivering a sheet of wind out the end of the nozzle as near as needed to the top of the bottle. This is because small bottles require the bottom of the wind sheet be very close to the top of the bottle. Glue the plastic to the bottom of the nozzle (smooth side against the wood) so it comes out exactly to the end of the wood.

We have not provided lengths for the nozzles in Table 2 because it depends upon which nozzles you use and how you to decide to arrange the bottles. **Photo 6** gives you a view of the front of a 20-note organ with the sizes of the bottles indicated with temporary markers. You can use this arrangement of bottles or any other.

The square nozzle body you create will need to be glued to a base which is shown in **Photo 5**. The base provides a way of affixing the nozzle to the vertical windchest behind the bottles. Using the slot at the bottom through which a single screw is inserted into the windchest, the nozzle can be raised or lowered. Your nozzle is now complete with a piece of diffusion plastic on the end of it, smooth side against the wood. We suggest you initially

Photo 6. The bottles in the 20-note organ with the sizes of each bottle temporarily indicated in ounces

apply a piece of masking tape with the approximate height of the opening shown in Table 2. By initially taping it on, you can later adjust it up or down for the optimal sound. Once you are happy, you can glue it on.

At this point you can add a 12-volt red LED in each nozzle that is hooked in parallel to the valve so that when the valve opens the LED goes on. These LEDs can be obtained from **All Electric Corporation** in Van Nuys, California and from other vendors. The LEDs add interest to the instrument as it is playing. To install the LEDs, solder an LED to two 18-20-gauge wires of different colors with attention to polarity being careful not to heat the LED to avoid ruining it. Twist those two wires together and run their ends into the windchest through two small holes you will make on either side of the valve. The wires will ultimately be hooked (with attention to polarity) in parallel to the two wires hooked to the valve. See **Photo 7**. The two wires should be stiff enough to stick out the front of the windchest and at right angles to it. To have even illumination across nozzles as the organ plays, the end of every LED should be about 1.5 inches from the bottle end of the nozzle. The completed nozzle can be slipped over the LED and the twisted wires to it secured to the windchest. This entire procedure makes it possible to remove and install nozzles without disturbing the LEDs.

Solenoids/ valves

Electromechanical valves are mounted in the windchest area and upon receiving a 12-volt DC signal, they open and let the wind from the windchest into the nozzles. We favor the electromechanical solenoid valves shown in **Photo 7**, sold by **Peterson Electro-Musical Products** of Alsip, Illinois. A variety of pallet sizes are available, but the ones we recommend are ¼ inch in diameter larger than the holes in the windchest. Those holes vary depending upon the size of the bottle. The ohms that the magnets in the valves draw need to be enough to open against the anticipated wind pressure of up to two inches. For the 20-note organ, the holes in the

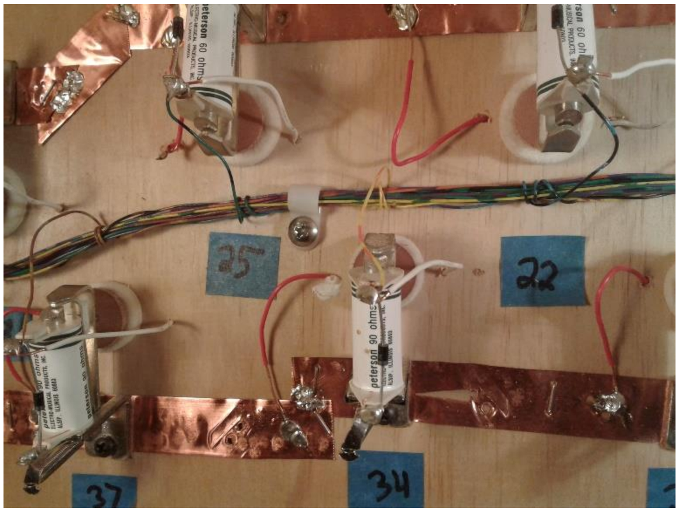

Photo 7. Views of the valves inside the 20 note windchest and of the red and white wires which go through the front of the windchest, into the nozzle, and are connected to the LEDs

windchest, the sizes of the pallets, and the ohms need for each magnet are given in Table 2.

Note the electrical wiring in **Photo 7**. There is a common copper strip upon which the magnets sit and connect electrically to the positive terminal of the power supply. The negative switching signals for each magnet come through a wire soldered to the pallet end of the magnet valve and connected to the appropriate terminal of the MIDI decoder. If desired, these wires can be part of a 25 pair telephone cable, the connector of which is near the MIDI decoder board which is wired with a mating telephone connector. This gives an alternative means of activating the solenoid valves and extra flexibility in doing maintenance and tuning as the connector going to the solenoid valves can be connected to a keyboard or pin board. A diode needs to be soldered to the two terminals of each solenoid magnet to manage unwanted reverse electrical currents which can produce a bounce upon pallet closure. The band end of the diode is on the end opposite the pallet.

We are pleased with this system of valves. Some may require adjustment initially, but once they are functioning in place, they will likely function well for many years.

Fans

Selecting fans to play your bottle organ is not an easy task because it is difficult to calculate how much wind is needed (how many bottles might play at once times how much wind is needed for each). Further, variations in pressure during playing can be troublesome as they can impact pitch, and fan noise can also be a problem. Unfortunately, there is little information about these variables for most of the inexpensive fans on the market. There are two solutions to this problem of fan selection.

First, one can take the route that pipe organ builders take who face similar problems every day. For such a problem with one group of smaller pipes (bottles in this

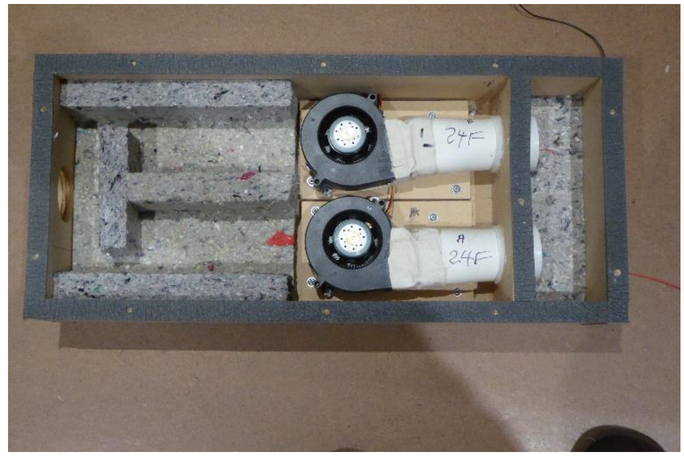

Photo 8. Fan sound control system devised by Phil and placed inside his Manischewitz organ. Two of the Sanyo Denki San Ace B97 fans are shown

case), they would use a very small (1/10 to 1/6 hp) pipe organ blower which has known output in cubic feet per minute, known pressure in inches of water, known sound levels, and a fixed voltage for input to the motor (120 volts for a small blower). The output for the blower goes into a small regulator which keeps the wind pressure constant even when the demands change. As Carl is a pipe organ builder, this solution is exactly the one he used on the 49 and 56 note organs he built with the advantage of greater wind stability but at increased cost. All the other organs described in Table 1 use the second solution to winding which is now described.

The second solution to winding is to use commonly available low-cost fans. More than one may need to be installed in parallel. A tremendous amount of experimentation was done with single fans, dual fans, triple fans and even quadruple fans. After a great deal of work, we recommend the **Sanyo Denki San Ace B97** (two are shown in **Photo 8**) or a similar fan for most organs that readers of the article are likely to want to build. One fan is quite adequate for a 20-note organ and possibly also for a 37-note beer bottle organ, but it is not likely to be sufficient for a larger instrument. For the 43 note Manischewitz organ, two of these blowers are being used (originally there were three), and for larger organs, three or possibly four would be required.

The Sanyo and similar fans all operate on 12 volts DC current as do the MIDI board, solenoid valves, and LEDs. A single power supply under 10 amps therefore typically provides all the current needed for these components. It is to advantage to obtain a power supply which allows some adjustment in output voltage since one can vary the speed of the fan(s) and thus the wind pressure and noise by adjusting the voltage. However, our experience is that if the voltage from the power supply is reduced to below about 10.75 volts that the solenoid valves start to operate erratically. If it is desired that the fan(s) turn more slowly yet, this can be achieved with the installation of a second power supply which only operates the fan(s).

Noise is a major issue about inexpensive fans. We have spent a considerable amount of time with this issue with results that are quite satisfactory. To manage the noise, it is recommended that the fan(s) be installed in a box made of ¾ inch medium density fiberboard with a gasket cover that allows easy access to the inside. Ensure that there is no hard connection of the fan(s) with the wooden enclosure by using something like soft silicone grommets. Insert as much acoustic cotton sound insulation as there is room both inside the box and inside the organ case where the box is placed. The air inlet to the fan from outside the organ should be rather narrow and as long and convoluted as possible. The air outlet from the fan should be fed via a very flexible and soft duct into the windchest of the organ where the valves are located. See **Photo 8** to see the basic setup which is inside Philip's 43 bottle organ. While sound management does take effort, the result can be truly satisfactory with an almost whisper quiet result possible if all is done correctly.

MIDI

The MIDI board or decoder is simply a circuit board that takes the MIDI signal from any source (phone, tablet, SD card reader, computer, etc.) and sends out a separate electrical voltage to each solenoid valve in the organ to make the bottle play. Because the bottle organ solenoids use relatively small currents, no extra electronics are required. We have used the **J-Omega MTP-7** MIDI to parallel converter board with 32 outputs for our 20 note organs and the **J-Omega MTP-8** board with 64 outputs for the 43 and 49 note Manischewitz instruments. However, these may not be easily available as they come from the UK, and you can use other MIDI decoder boards bearing in mind cost, size, ease of wiring to the solenoid valves, and programming.

Although this article is focused upon construction of the bottle organ rather than on the music played on it, many MIDI files can be obtained from the internet and often at low cost or free. Many free files have multiple tracks from which the desired tracks must be changed to MIDI track #1 (or whichever single track you have your MIDI decoder board reading) to play those tracks. In some cases, you will want to transpose those files so that they are playing within the range of your bottle organ. The app we like that can do these tasks, and more is **MIDI Voyager** which is now available free. Both of us have profited greatly from a series of tremendous arrangements by David Leach in England which was arranged for by Philip. These arrangements are both classical and popular music, and they play extremely well on our Manischewitz organs.

All the files referred to in the last paragraph assume that the organ being used is playing on a chromatic scale with 12 bottles per octave and with both naturals and sharps/flats represented. With the 20-note organ, however, a Carl Frei scale is used, and so special MIDI files are needed. Fortunately Mel Wright in the UK makes available many of these files at reasonable cost (www.melright.com/music) and they are available elsewhere as well.

Organ cabinet

A few comments are offered concerning the cabinet you will need to build to house your organ. As already indicated, the 20-note organ is essentially a table model and the others are likely to wind up as floor models. In all cases except for the 56-note church organ, we found it useful to have the winding and electrical driving mechanisms in the cabinet at the back of the organ and/or at the bottom of it. The lower part of the back of Carl's 20 note organ is shown in **Photo 9** with the box containing the fan on the left, the telephone connectors next, the power supply attached to the back wall, and the MIDI board in the foreground.

As you sketch out the plan for the cabinet, the vertical plenum/windchest will be at the back and that it requires at least 5 inches in depth to accommodate all that must go into it. A removable full width back panel is essential in order to allow access to the solenoid valves and to much of the wiring of the organ. While the rectifier and the MIDI decoder board can theoretically go into this space, we typically have put both items outside and under the windchest along with the fan(s) for easier access. For the cabinet overall, we have typically used either solid one-inch wood or high quality ¾ inch plywood. If you put grooves in the vertical end pieces of the case in the right places, each shelf holding the bottles and the front board of the windchest with the valves and nozzles on it can slip into place on each end and be glued in with not a single screw or nail needed.

For all floor model organs, portability should be given major consideration in design and construction. Castors are essential, and nothing smaller than 3-inch wheels should be used. It is to real advantage if the bottles are sitting on removable shelves held in by pins (headed nails work well as pins). By sliding the bottles out, the organ case can be made much lighter and on site the shelves can be slid back in and when pinned the bottles are in exactly the correct position and are ready to play.

The advantages of these suggestions can be illustrated by the 49 note Manischewitz organ. The full unit with the doors is seen in **Photo 10**. It is 67 inches high, 40 wide, 18 deep and weighs 300 pounds. When you remove the doors with their lift off hinges, the weight is reduced by 20 pounds. There is a top and bottom part with the top secured to the bottom with boards on the sides. The two wind chests on the back of the two parts are connected to each other by an airtight compression gasket. With the bottles removed, the top part weighs only 65 pounds and can be lifted off using the handles on each end with two people, each of whom lifts less than 40 pounds. The bottom part can be run up into the transport vehicle using a ramp without the bottles being removed. Less than 15 minutes is required to dissemble or reassemble this instrument, and it is immediately playable.

Refinements to the Completed Bottle Organ

The following points may be of assistance in making final adjustments to the organ:

Pressure. Early on, check your wind pressure using a manometer. Inexpensive and easy to use, digital manometers are available on eBay. For most of these organs, a good general initial target is about 1 ½ inches of pressure. Of relevance is how loud you wish the organ to be (higher pressure tends to result in a louder instrument) and relevant is the size of the smallest bottle in your organ. If the smallest bottle is ½ ounce or larger, you may not need more than 1 ½ inches, but if the smallest is ¼ ounce, 2 inches is likely needed to give the smallest bottles a clear sound (if the smaller bottles sound wimpy, the pressure is not high enough). If you use bottles as small as 1/16 ounce, 3.5 inches of pressure is required but that pressure is too high for bottles 1 ounce or larger and so two pressures are required as is true for the 56-bottle addition to a pipe organ. Overall, we suggest you initially set the pressure at a level that sounds good to you with all bottles and proceed with the other refinements indicated here.

Tuning. Set up an electrical system that allows you to play individual bottles from a keyboard, computer, or a pin board. Mineral oil or even baby oil can be used in all bottles to tune them although if you have the top ¼ of an inch as oil, the rest of the fluid can be water which will sink below the oil and not evaporate. If you color the fluid in the bottles, you can use any of several different dyes, but you may wish to use all oil so that a line is not evident between the water and the oil. You can use an electronic tuner or tuner app on a smart phone to set the pitch of each bottle, and plastic pipettes or needle syringes help to get small amounts of oil in and out.

Bottle vs. nozzle adjustments. You need to account for all three dimensions as you adjust the bottles relative to the nozzles. Hopefully, on the right-left (x) dimension as you face the organ, no adjustments are needed because you have aligned the bottles with the nozzles so that the full opening of each bottle is served by the nozzle. If this is not true, stop and adjust the position of the bottles so that it is true. Next, adjust the in-out (y) dimension by moving the bottle towards or away from the nozzle. In general, big bottles have nozzles further away from the bottles, intermediate bottles have the nozzles coming up to the opening, and small bottles have the nozzle coming out over the tops of the bottles. Finally, you can adjust the height of the bottle relative to the nozzle (z) by moving the nozzle up or down using the screw under the nozzle. The vertical space between the bottle and the nozzle is greatest for big bottles and progressively less as the bottles get smaller. Finally, the height of the slot at the end of the nozzle (see Table 2) can be adjusted slightly. In these adjustments, the key is to make each bottle play as loudly and clearly as possible which is an indication that you are dead on in your adjustments.

Final refinements.

Once you have all bottles playing clearly and with full-bodied sounds, go through all the bottles one after another and check for equal loudness. In the typical circumstance, a few bottles will be louder than the others. The louder bottles need to be made quieter since if you have made the adjustments correctly, you have made the bottles speak as loudly as possible already. For bottles which need to speak quieter in order to match the other bottes, make adjustments in the y and z dimensions above so that these bottles do not play as loudly as they could, but rather so they will play at the same loudness as the other bottles.

Very occasionally, you will find that one bottle speaks quieter than all others and that the adjustments detailed above do not result in increased loudness. In that event, check first whether the valve is opening as widely as the other valves as it must open as fully as the others and at times even more so to make the bottle as loud as its neighbors. Second, check the nozzle especially for leaks in the gluing and it may pay you to exchange that nozzle for another as they are not likely to all be the same even if constructed carefully. If these solutions do not work, exchange the bottle for another one as it may not be precisely the same even though you may certainly think that it should be.

CONCLUSIONS

Our hope is that following the above instructions will result in your producing one of the most amazing automatic instruments that you have ever heard. However, if you have questions or concerns at any point, feel free to be in touch with one of us, and we will be happy to advise you in any way that we can.

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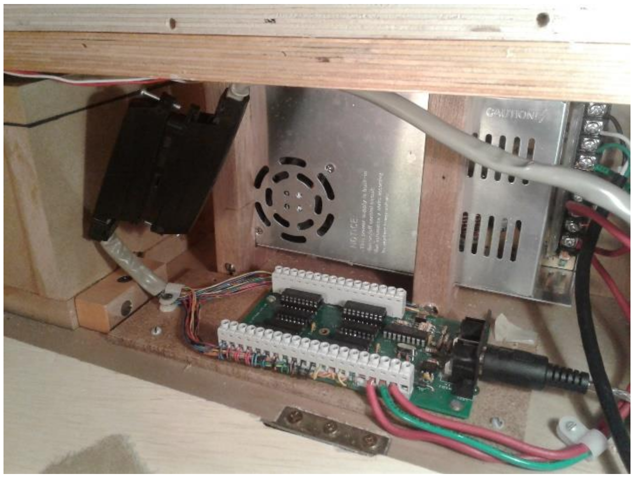

Photo 9. Inside the lower back portion of Carl's 20 note organ. Left to right are the fan box, the telephone connectors, the power supply, and the MIDI driving board

Table 1. Overview of bottle organs built by the authors.

Item	20 bottles	37 bottles	43/49 bottles	56 bottles
		Size of organ		
Type of bottle	Boston rounds	Beer (common)	Manischewitz wine	Boston rounds
Sizes of bottles	32 oz to ½ oz	26 oz to 7 oz	43: 1.5 L to 4 oz 49: c2.5 L to ¼ oz (top 8 are Boston rounds)	96 oz to 1/16 oz
Range of notes played	MIDI 53-86 (1st F below middle C to 3rd D above middle C)	MIDI 48-84 (1st C below middle C to 2nd C above middle C)	43: MIDI 46-88 49: MIDI 43-91 (2nd G below middle C to third G above middle C)	MIDI 48-103 (1st C below middle C to 4th G above middle C)
Musical scale	Carl Frei	Chromatic	Chromatic	Chromatic
Primary use	Compact, easily transported	Fairly compact home organ	Complete home organ	Addition to pipe organ in a church setting and playable at 8' and 4'
Air pressure used	1.0-2.0 inches	2 inches	0.9-1.9 inches	2.0-3.5 inches

Photo 10. The 49-note Manischewitz organ with the doors on it. Note the handles on the middle of each end the upper ones of which are used to lift the top off the bottom once the doors are lifted off

Table 2. 20 Note Bottle Organ—Detailed Information by Bottle Size

Variable	½ oz	1 oz	2 oz	4 oz	8 oz	16 oz	32 oz
				Bottle sizes—Boston rounds			
BOTTLES							
Bottle opening	3/8	7/16	7/16	9/16	11/16	3 / 4	15/16
Height	2 3/4	3 1/8	3 11/16	4 1/2	5 7/16	6 11/16	8 1/4
Diameter	1.01	1.28	1.51	1.9	2.4	2.94	3.68
Base pitch*	A6	D#6	A#5	G5	C#5	A#4	F4
MIDI note	81	75	70	67	61	58	53
Hz (cyc/sec)	831	587	440	360	270	220	175
Notes using this bottle (MIDI No.)	C7 (84) D7 (86)	F6 (77) G6 (79) A6 (81) A#6 (82)	C6 (72) D6 (74) D#6 (75) E6 (76)	A5 (69) A#5 (70)	E5 (64) F5 (65) G5 (67)	A#4 (58) C5 (60) D5 (62) D#5 (63)	F4 (53)
NOZZLES							
Inside width	5/8	5/8	5/8	3/4	7/8	1	1 1/8
Inside height	5/8	5/8	5/8	3/4	7/8	1	1 1/8
Wood to be cut for nozzles (width of strips to be cut for each dimension):							
Width	5/8	5/8	5/8	3/4	7/8	1	1 1/8
Height	1	1	1	1 1/8	1 1/4	1 3/8	1 1/2
Height of Opening	1/16	3/32	3/32	3/32	3/32	3/32	1/8
WINDCHEST/PLENUM AND SOLENOID VALVES							
Hole in windchest	1/2	5/8	5/8	3/4	3/4	7/8	1
Valve pallet	3/4	7/8	7/8	1	1	1 1/8	1 1/4
Valve ohms	90	90	90	60 or 90	60 or 90	60	60

NOTE: All measurements reported in this table are in inches.
*Base pitch is the next half step above the place at which the empty bottle sounds. C5 is middle C (MIDI note 60), C4 is one octave below middle C, C6 is one octave above middle C.