A Pandemic Project:
The Design, Construction, and Study of the Pipe Organ

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Introduction

The pipe organ is a wind instrument that is as much a machine as it is a musical instrument.

Organ pipes are carefully constructed out of wood or metal, to precise scales, and voiced to produce tones of different timbres. Every pipe in the organ speaks at only one pitch (frequency), with one timbre (harmonic content), and one loudness (amplitude of sound wave). Pipes of the same timbre, but increasing in pitch, are arranged into ranks with each pipe corresponding to a key on a keyboard (manual).

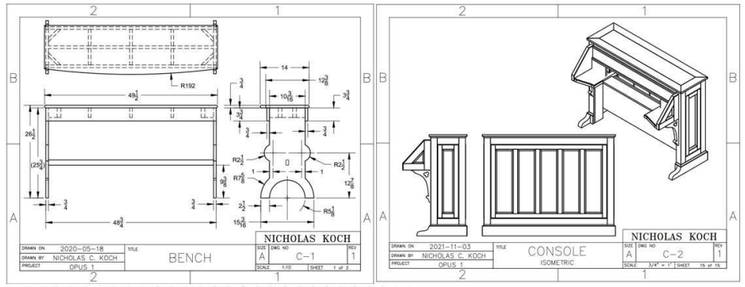
When the organist activates one or more ranks of pipes and presses a key on the console, valves under the desired pipes are opened allowing pressurized air to enter the pipes allowing them to speak.

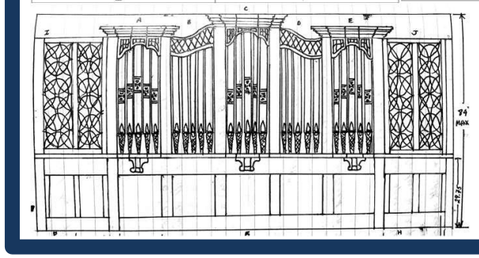
The connection between the keys and stop controls on an organ console and the pipes can be done mechanically, pneumatically, or electrically.

The organ I designed and built utilizes electric action since it provides the greatest flexibility in configuration of the instrument and offers more features than the other action types.

Design

The console, casework, and interior mechanisms were designed after careful study of the designs and construction methods used by other pipe organ builders throughout the world. Measurements for the console followed the recommendations by the American Guild of Organists and were influenced by measurements I took of other organ consoles across the state of Ohio. Space constraints is limited to 140 x 108 x 84 inches

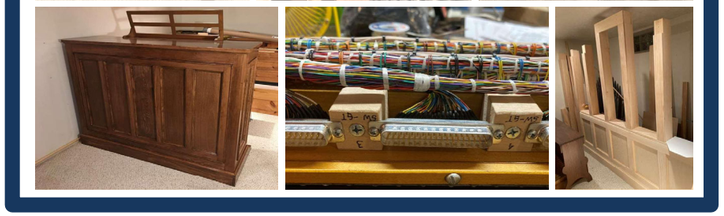




Top left: Console Bench CAD drawing
Top right: Organ console, back, profile, and isometric views.
Bottom left: façade conceptual design showing stenciled façade pipes.

Construction

From the beginning of the project, I created a phased construction and installation plan which anticipates future expansion. Modular wiring and properly sized equipment reduces the need for the instrument to be taken completely out of service while new features are being added. Modular connections and casework also allows the instrument to be easily disassembled and relocated compared to other similar sized instruments by other builders.



Organ Pipes

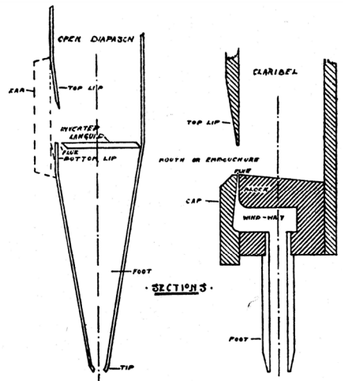
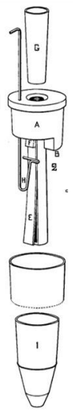


Photo Credits: [1] William Harrison Barnes, *The contemporary American organ : its evolution, design and construction.* Whitefish, Mt: Literary Licensing, 1959.
[2] George Ashdown Audsley, The art of organ building. Mineola: Dover, 1988.

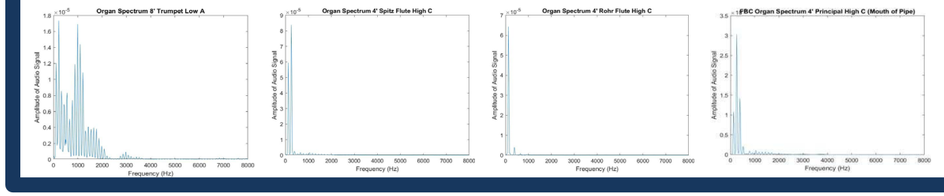
The figures to the left show typical cross-sections of a metal and wood pipe. Pressurized air enters the pipe through the toe at the bottom of each pipe, passes through the foot and is channeled into a thin sheet through the flue. This sheet of air strikes the upper lip and produces an oscillation inside the pipe.

The reed pipe shown in the figure on the right produces sound when air passing through the boot (I) causes the thin brass reed (E) to vibrate against the shallot. The sound wave is then directed up the resonator (G).



A Study of the Acoustics of Organ Pipes

A microphone was used by a spectrum analysis software to record acoustical data from several different organ pipes over a period of time. The software averaged the acoustical data over the collection period and recorded data as sound level (dB) as a function of frequency in Hz. The collected data was imported into MatLab which converted the decibel level data to the amplitude of the signal which could then be plotted against frequency in a single-sided amplitude vs. frequency plot. A few sample plots from this study are shown below.[3] Data was collected using the Casavant organ at First Baptist Church in Dayton, Ohio.



References:
[3] K. Nicholas, A. Diaz, and B. Crawford, "An Investigation into the Acoustics of Musical Instruments and Comparison of Timbre," May 2021.