In the wind...
November, 2012

The Invincible DaVinci

The other night I was watching a documentary about the life and work of Leonardo, who lived from 1452 to 1519, a time when the arts and sciences were flourishing. His contemporary, astronomer Nicolas Copernicus (1473-1543), was studying the motions of celestial bodies and developing his theory of *heliocentric cosmology,* displacing the notion that the earth was the center of the universe, and proving that a system of planets including the earth rotates around the sun. Physician Richard Bartlot (1471-1557) was working hard to understand the functions of the human body. Another contemporary was Michelangelo (1475-1564), whose genius with the visual arts in both painting and sculpture dazzles us more than five hundred years later.

Leonardo was fascinated by flight, and made hundreds of drawings of the wings of birds in various positions, theorizing about how a bird could alter the shape of its wings to affect the direction of its flight. He noticed that soaring birds used spiraling updrafts of air to ascend effortlessly, and how they braked to slow for landing. I'm in an airplane as I write, and can't help but associate the wing flaps with the drawings I saw on television.

Leonardo wondered if it would be possible for humans to fly, and imagined and sketched numerous designs of flying machines. The documentary tells of a group of aeronautical scientists in England building a glider according to one of those designs. It was a single fixed wing about thirty feet across with fabric stretched over a wooden frame weighing about ninety pounds. When it was finished, they tested it first by mounting it on the back of pickup truck and covering it with sensors. As the truck drove forward, a computer recorded everything that was going on, and the team deduced that the glider developed enough lift to fly in air that was moving around twenty miles per hour.

A pilot skilled at parasailing was engaged to try to fly the thing. Because the glider had no controls for direction or altitude, the team attached ropes to front and back and to each wingtip, and on a windy hilltop off she went. The first couple tries allowed her to get a sense of how it handled, and on the third try she went up about ten feet and flew as far as her team could run before they lost control. She flew a little farther each time, eventually getting up as high as thirty feet and flying forward for a couple hundred yards. It was fascinating to see that a design conceived five hundred years was so effective.

The film discussed Leonardo's grasp of human anatomy. His drawings of muscles and tendons in human arms, hands, and faces bore direct relationships to the forms of those body parts in Leonardo's most famous painting, *Mona Lisa.*

Perhaps most impressive was Leonardo's study of the human heart. He obviously did some very gruesome experimentation to inform his drawings, and he documented how he deduced the heart's valves functioned, even determining that the valves cause blood to form vortexes or eddies that add to the quality of blood flow. A modern heart surgeon compared Leonardo's studies with X-rays and scans that prove their accuracy. I was amazed to see how well those sixteenth-century studies stood up to modern scrutiny.

From one organ to another.
While Leonardo was quietly slicing up human hearts, the pipe organ was being developed into the most complex machine on the planet. Simple flutes had been made from grass and canes for centuries - the panpipe grew common in the sixth century BC. I wonder who was first to think of making a flute out of metal, and forming a tone-producing mouth using a horizontal languid at the connection between the conical foot and the cylindrical resonator?

In 256 BC, a Greek physicist named Tsebius created a musical instrument called the *Hydraulis* which had mounted flutes similar to organ pipes, a wind system that used the weight of water to create and regulate pressure, and a keyboard and mechanical action that operated valves to open those pipes. All this was fifteen hundred years before Leonardo was wondering about flight.

I was a young teenager when I was introduced to the unique and lovely organ in the Cathedral-Fortress in Sion, Switzerland through E. Power Biggs' recording, *The Historic Organs of Switzerland.* At the time of that recording, it was widely thought that the organ was built in 1390. There is some modern research suggesting that it was more like 1430, but I wouldn't argue about a forty-year difference – it's a mighty old organ, and it's perfectly recognizable and playable. There's a nice video on YouTube: http://www.youtube.com/watch?v=xiyy7AtMvis. It's narrated in Dutch, but even in you don't understand the language, you can see and hear this remarkable instrument.

I love recognizing the pipe organ as such an ancient art form, stopping to reflect on what life was like in Europe in the mid-fifteenth century. Think of the state of public water supplies and sanitation, personal health and hygiene, transportation and commerce. If you've ever visited a modern organbuilding workshop, you have an idea of the complexity and precision necessary to make a monumental musical instrument function. Think of the effort and ingenuity involved in building a pipe organ in 1450, when there were no cordless drills, laser-sharpened blades, or electric lights. Those early organbuilders harvested trees and milled lumber by hand, hauled it to the workshop on oxcarts, cast metal and soldered seams, fashioned parts for mechanical actions, skinned animals and tanned leather, all to make music.

Anchors aweigh.[1]
We can compare that effort to shipbuilding. We all have pictures of Christopher Columbus' little armada, the *Nina,* the *Pinta,* and the *Santa Maria* in our minds' eyes. The names roll off our tongues like "I before E, except after C, or when sounding like "A" as in neighbor or weigh." The largest of those ships, *Santa Maria,* was about sixty feet long on deck with a forty-one-foot keel, about eighteen feet wide, and weighed about a hundred tons, smaller than many modern personal pleasure yachts. While we might sail in a sixty-foot sailboat on a sunny afternoon with six or eight people on board, the *Santa Maria* had a documented crew of forty. The reason that a lavatory on a boat is called "The Head," is because in those early sailing ships, the crew's sanitation facility was to hang over the side at the head of the ship.

Mechanically, *Santa Maria* had three masts and a bowsprit, and five spars bearing five sails. Each sail would have had about eight control lines (halyard, sheets, downhauls, etc.) and many of the lines ran through blocks (multi-wheeled pulleys) for increased leverage. Complete the catalogue with a rudder for steering, a wheel with related lines and pulleys, and a capstan (winch) for mechanical advantage for hoisting sails and anchors, and we can estimate that *Santa Maria* had a couple hundred moving parts. The simplest two-manual organ of the same era, with forty-five or forty-nine note keyboards, would have some four or five hundred moving parts, including keys, trackers, squares, rollers, and valves. It's amazing to me that such a complex machine would be devised and built for the purpose of making music in a time when most machinery was so very primitive.

Johannes Gutenberg developed movable-type printing, producing the Mazarin Bible about forty years before Columbus' great adventure. His printing press had only three or four moving parts – but that was one of the greatest advances in the history of communication. Without Gutenberg, we wouldn't have email.

That ingenious business.[2]

Let's jump ahead three hundred years. By the 1860's, science and technology had leapt forward exponentially. During that decade, the Transcontinental Railroad, the Suez Canal, and the Transatlantic Cable were completed, and Alfred Nobel invented dynamite. And Aristide Cavaillé-Coll built the grand organ at Église Saint-Sulpice in Paris with a hundred two stops, five manuals, and a fantastic array of pneumatic registration devices.

Cavaillé-Coll's masterpiece at Saint-Sulpice must be one of, if not *the* most influential organs in existence. The bewildering array of levers and knobs gave those organists unprecedented control over the instrument, and the music written by Widor and Dupré, inspired by the sounds and mechanical assets of the Cavaillé-Coll organ, form a centerpiece of the long history of organ music. And like the ancient organ in Sion, the instrument at Saint-Sulpice is still in regular use, not as an antique curiosity, but as the church's main instrument that is played every Sunday for Mass, and for countless concerts and recordings.

Forty years later in Dorchester, Massachusetts (a neighborhood of Boston), Ernest Skinner was at work on a new revolution. Starting around 1890, a number of American organ companies were experimenting with pneumatic and then electric organ actions, but none was more creative or prolific than Mr. Skinner. As an employee and later factory superintendent of the Hutchings Organ Company, and later in the company that bore his name, Mr. Skinner invented and produced the Pitman Windchest, the first electro-pneumatic organ action in which the stop action functioned as quickly as the keyboard action. That simple fact, which when combined with Skinner's fabulous electro-pneumatic combination action, was as influential to organists as Cavaillé-Coll's fantastic pneumatic and mechanical console appliances, because for the first time, dozens of stops could be turned on or off simultaneously as quickly as an organist could move from one key to the next. And those actions operated instantly there was no mechanical noise.

A combination innovation

As I mention Mr. Skinner's combination actions, I repeat a theory that I have proposed a number of times. Those machines, built in Boston around 1905, allowed the organist to select any combination of stops and set it in a binary memory, ready to be recalled at the touch of a button. Decades earlier there were water-powered looms that could be programmed to weave intricate patterns using blocks of wood with patterns of holes, the forerunners of the computer punch cards that people my age used to register for college classes. *But it's my theory that Mr. Skinner's combination actions were the first industrially produced, commercially available, user-programmable binary computers.* The first, ever.

I've had a number of opportunities to propose my theory to scientists outside the organ world, and have not heard any contradicting theories. If any of you out there in *Diapason* land know anyone who is expert in the history of computers, I'd be grateful if you'd pose this theory to them and let me know what you learn.

As electro-pneumatic actions allowed organists unprecedented control over their instruments, so they allowed instruments to be larger than ever before. In 1865, forty or fifty stops made a very large organ. By 1920, such an organ had become commonplace. It was usual for a large church to commission an organ with four manuals, many dozens of ranks of pipes, and components of the organ in multiple locations around the church. Imagine yourself as the first to play an instrument with an Antiphonal Division – how your mind would race with ideas of how to exploit it.

If we compare pipe organs that Leonardo, Michelangelo, and Copernicus might have known, those that Henry Ford, Thomas Edison, and Claude Monet heard, and those of the time of Steve Jobs, Mark Zuckerberg, and Bill Gates, what milestones of development should we recognize. What innovations brought our instrument from the panpipe to Walt Disney Hall?

1. Tsebius' *Hydraulis* was the first huge leap, introducing mechanically produced wind pressure, mechanical action, and a keyboard for the first time, as far as we know.
2. Adding a second set of pipes foreshadowed the complexity of the modern organ. There would have been no stop action – two pipes played simultaneously with one key. I suppose they were pipes of similar character at different pitches, like today's Principals eight-and-four.
3. In the early Renaissance, organ divisions called *Blockwerk* were developed. These consisted of numerous voices, including the fractional pitches we know as mutations.
4. The stop action was the next obvious innovation, allowing the musician to select individual voices, or multiple voices in any combination.
5. The stop action would have led to the idea of contrasting voices. Instead of two or more similar voices, there would have been different timbres for each pitch, like our modern Principals and Flutes.
6. I'm not sure when the first reed stop was introduced or who made it, but I sure know that a wide variety of reeds were present in organs in the very early sixteenth century. The tones of all organ flue voices are produced by the splitting of a "sheet" of air that's formed by the slot between the front edge of a pipe's languid (horizontal piece at the joint between the conical foot and the cylindrical resonator) and the lower lip, which is a portion of the circumference of the conical foot that's made flat. The tone of a reed pipe is produced by a vibrating brass tongue, which creates a sharp contrast of timbre.
7. The addition of a second keyboard made it possible for a melody to be accompanied by a contrasting sound, or echo effects to be achieved without changing stops. I am not researching this as I write, but I guess this innovation dates from around 1475 or 1500.
8. The logical and magical extension of multiple keyboards was the invention of the pedal keyboard and development of the technique for mastering that most "organistic" of skills.

Playing melodies or the individual lines of polyphonic music with ones feet allowed organ music to develop deeper complexity. This level of sophistication was achieved late in the fifteenth century.

9. A wonderful example of a very early organ with two manuals and pedals was the first Große Orgel of the Marienkirche in Lübeck in Germany, the church later made famous in our history by organists Franz Tunder and his successor Dietrich Buxtehude (who married Bruhns' daughter). That organ had thirty-two stops and was built between 1516 and 1518, just at the time of the death of Leonardo da Vinci, and when Michelangelo was about forty-five years old.
10. By the time Heinrich Scheidemann (1595-1663), Tunder (1614-1667) and Buxtehude (1637-1707) were composing their catalogues of organ music, the use of the pedal board for independent voices was in full swing. More complex forms of composition, in those days especially the fugue, exploited the versatility of the organ. And of course, it was Johann Sebastian Bach (1685-1750) who brought pedal technique to a level of virtuosity that was the true forerunner of the near-maniacal feats of the feet of early twentieth-century virtuosi like Edwin Lamare and Lynwood Farnum, that school of players who took organ playing to new heights in response to the innovations of Ernest Skinner in the same way that Widor and Dupré responded to the genius of Aristide Cavaillé-Coll.
11. The Expression Enclosure (Swell Box) was an invention that transformed organ playing. Its earliest forms were like the *Brustwerk* of Baroque and Neo-Baroque organs, with doors that the organist could open and close by reaching up from the bench, or (God forbid) standing on the pedal keys.
12. Pneumatic motors such as Barker Levers allowed huge organs with otherwise mechanical actions to be played with little effort.
13. The introduction of electric actions gave us the modern symphonic organ, the detached and remote console, and the possibility of dispersing various organ divisions throughout a large room.
14. I discussed combination actions earlier.
15. And more recently, solid-state control systems for pipe organs have given us multiple levels of memory, piston sequencers, transposers that are considered a crutch by some and a God-send by others, and playback sequencers that allow an organist to capture a performance as a digital file, then ask the organ to play it back allowing critical listening to registration, balance, technique, and accuracy.

Today we anticipate wireless consoles, tap-screen music racks, and heaven knows what else. Just as Leonardo da Vinci could not possibly have imagined the automobile or the cellular telephone, Jan Sweelinck (1562-1621) would be astonished by our massive consoles and high-pressure reeds.

I wonder what the organ would be like today had Leonardo included it in his sketchbooks.

Notes:

1. Nautical. While "anchors away" may seem the intuitive spelling, implying casting off dock lines or hoisting an anchor and setting a vessel "underway," the correct spelling, *aweigh*, defines the moment when the anchor is lifted off the seabed and is "weighed" by the anchor line. *Anchors Aweigh* is the fight song of the United States Naval Academy. The text of the chorus:

“Anchors Aweigh, my boys
Anchors Aweigh.
Farewell to college joys
We sail at break of day, 'ay 'ay 'ay
Thou our last night ashore
Drink to the foam
Until we meet once more
Here's wishing you a happy voyage home!”

2. *That Ingenious Business,* Ray Brunner, The Pennsylvania German Society, 1991.
    a. In 1762, Benjamin Franklin referred to organbuilding in Eastern Pennsylvania as “that ingenious business.”