Cover feature

**C. B. Fisk, Inc.,
Gloucester, Massachusetts
First Presbyterian Church,
Santa Fe, New Mexico**

From the organbuilder

Since its incorporation in 1961, the Fisk workshop has been in Gloucester, Massachusetts, home of the oldest art colony in the United States. Just as artists have been drawn to the light and oceanscapes of Gloucester for decades, so have they been drawn to the desert light of Santa Fe. Thus, when C. B. Fisk received a letter in 1999 requesting a proposal for a pipe organ in the sanctuary of the First Presbyterian Church, we were especially excited by the opportunity to work in the Southwest, with its own quality of light and architectural styles so different from those surrounding us in our New England home.

From our first visits to John Gaw Meem's serenely beautiful 1930s sanctuary, it was evident that there were wonderful opportunities and challenges inherent in the project. When plans were made to restructure the chancel as part of a larger building project, the church wisely included us along with acousticians Kirkegaard & Associates, and architects Lloyd & Associates. The excellent result literally speaks for itself. While maintaining the simple beauty of the space, a modern approach to acoustics was applied. The walls at the chancel sides are now hard-plastered and subtly angled, allowing choir and organ to speak boldly into the sanctuary. Other changes were made invisibly above the ceiling in the sanctuary, leaving the *latillas* undisturbed, but improving the acoustical response so important to congregational singing. This commitment to the excellence of both sound and silence will pay dividends for generations to come.

Our first step was to take careful measurements and photos of the new chancel in order to construct a scale model of the front of the sanctuary. Much research was done on the vernacular church architecture of the Santa Fe area, with special attention to the surrounding historic missions. Charles Nazarian then developed the visual design within the model in consultation with the Fisk design team and the organ committee, whose members visited Gloucester several times throughout the process. Designing in the model also gave us the opportunity to communicate with the organ committee and the congregation through digital photography sent via e-mail.

The organ façade serves as a liturgical *reredos* and is divided in three—the detailed central case flanked on each side by the Douglas fir pipes of the 16′ Contrebasse. The painted casework is constructed of solid poplar, and the console of cherry. Both feature joinery designed for a dry climate. The casework and the wooden front pipes were hand-planed, providing a texture consistent with the hammered lead pipes in the central tower and the hand-carved spiral posts that support it. Great care was taken to choose materials, decorative elements, shaping and colors to create an organ design unlike any other, yet appearing to have always been there.

The mechanical design of a tracker organ must be as simple and as direct as possible in order to increase an organ's utility and reliability, and to allow an unfettered transmission of musical expression. The active musical life in Santa Fe all but guarantees that the organ will be played often, calling for the highest levels of care and attention to detail in its design and construction. Our experience with creating light, responsive actions and our increasing use of modern materials such as carbon fiber have made Opus 133 a new standard of key action touch.

Rooted firmly in historic principles, the tonal design is a unique blending of elements chosen specifically to meet the musical needs of the church. Dr. Larry Palmer of Southern Methodist University and Dr. Linda Raney, music director, consulted closely with us over a period of several years. The final stoplist is the result of careful research and thoughtful discussion in many areas of importance—the musical requirements of the Presbyterian liturgy, including leadership and accompaniment, the acoustics of the church, and the breadth and flexibility needed in a recital instrument.

The Great division is largely Germanic in nature, with most of its stops based upon our research trips to study the best 18th-century examples of organbuilding. The Great chorus, among its other duties, is designed to support congregational singing. The Swell division, by contrast, takes its character from 19th-century French examples, and is perfectly designed and balanced to accompany the choir and instrumentalists. The Solo division on the third manual can be used to enhance a hymn melody and creates the greater flexibility needed to play a wide selection of the entire organ literature.

The organ's 2,065 pipes were prevoiced at our Gloucester workshop and then each pipe was meticulously adjusted on site in Santa Fe. This tonal finishing process took place over the course of five months beginning in the spring of 2008, as the voicers refined the individual voices of the organ and balanced the overall sonority with the acoustics of the sanctuary. Because of the altitude and thinner air of Santa Fe, special voicing techniques and a larger blower were required to help the pipes speak with a full tone. The temperament is the mildly unequal Fisk II, which, while favoring the common keys, allows for music of all styles to be performed. Wind pressures are 3 inches water column for the manual divisions and 4¾ inches for the Pedal.

C. B. Fisk wishes to thank the staff and congregation of First Presbyterian Church for the opportunity and privilege of building an organ in their remarkable and inspiring church. Without the constant support and hospitality

Finished installation of Opus 133 in the sanctuary designed by John Gaw Meem in 1937

Raising the CC side pedal tower

Keyboards with grenadilla naturals and rosewood sharps capped with bone

**C. B. Fisk, Inc., Opus 133
First Presbyterian Church,
Santa Fe, New Mexico
29 voices, 31 stops, 41 ranks,
2,065 pipes**

GREAT (Manual I)
16′ Bourdon
8′ Prestant
8′ Salicional
8′ Spillpfeife
4′ Octave
4′ Rohrflöte
2′ Superoctave
Mixture IV–VI
8′ Trumpet

SWELL (Manual II, enclosed)
8′ Violin Diapason
8′ Voix céleste (from C0)
8′ Stopped Diapason
4′ Prestant
4′ Flûte octaviante
2⅔′ Nasard
2′ Octavin
1⅗′ Tierce
Plein jeu IV
16′ Basson
8′ Trompette
8′ Hautbois

SOLO (Manual III)
8′ Harmonic Flute
Cornet V (from c1)
8′ Trumpet (from Great)
8′ Cromorne

PEDAL
16′ Contrebasse
16′ Bourdon
8′ Octave
8′ Bourdon (from 16′)
4′ Octave
16′ Posaune

Couplers
Swell to Great
Solo to Great
Great to Pedal
Swell to Pedal
Swell Super to Pedal
Solo to Pedal
Solo Super to Pedal

Controls
Tremulant
Wind Stabilizer
Balanced Swell Pedal

Key action: direct mechanical (tracker), except for certain large bass pipes
Stop action: electric with a modern multi-level combination action
Keydesk: 61 keys CC–c4, grenadilla naturals, rosewood sharps capped with cowbone; pedalboard: 32 keys CC–g1
Casework: a single case with façade pipes of wood and metal, standing in the front of the sanctuary, designed to harmonize with and adorn the historic Mission church interior

Ken Wolfe preparing mixtures at the C. B. Fisk shop

Dr. Linda Raney, organist at the First Presbyterian Church, Santa Fe

Morgan Faulds Pike carving the columns that flank the Great Prestant 8′ pipes

Dean Ekmann applies corner reinforcement gussets to the wedge bellows

Jason Fouser building wooden flutes

of Dr. Raney, the members of the choir, and the organ committee, the pursuit of our art and our sojourn in Santa Fe would not have been half so rewarding and enjoyable.

—Gregory Bover
Project Manager

Photo credit: Dana Sigall

Organ Acoustics at High Altitudes

by James W. Toevs

Introduction[1]

With the installation and voicing of the wonderful new Fisk Opus 133 tracker organ in the First Presbyterian Church of Santa Fe, New Mexico, a number of interesting effects and impacts of Santa Fe's thin air became apparent. This article will note the major observations and describe the physical acoustics related to organ pipe function at high altitude.

Santa Fe is located at the foot of the southern Sangre de Cristo mountains at an altitude of about 7,000 feet above sea level. In fact, the altitude at the church is 2,127 meters or 6,978 feet. At this altitude, both the atmospheric pressure and density of air are reduced to about 77% of their values at sea level. This difference in pressure corresponds to about 92 inches of water. Considering that most organs operate with a wind pressure of 2 to 4 inches (water column), this difference is quite significant. It is not surprising that organ operation is impacted by this difference; perhaps what is surprising is that the impact is not greater. The fine people of C. B. Fisk dealt with these differences with little difficulty.

Parameters in which high altitude might impact pipe organ performance include:

- Pipe intonation—essentially no effect;
- Windchest blower requirements—observed significant effect;
- Tone production: pre-voicing and voicing—observed significant effect;
- Sensitivity to windchest pressure—observed significant effect;
- Sanctuary acoustics—small but real effect.

Pipe intonation

The impact of altitude on the basic intonation of the organ pipes themselves is minimal. The frequency at which a pipe sounds (fundamental) is based on the length of the pipe and the speed of sound. The length, of course, does not depend on altitude, and fortunately neither does the speed of sound because the ratio of the pressure to density remains the same so long as the temperature is fixed. Basic intonation is therefore not affected by altitude.

Windchest blower requirements

The relationship between blower output (cubic feet per minute, or CFM) and desired windchest pressure (usually measured in equivalent inches of water column supported above the ambient pressure) is given by Bernoulli's equation. This is perhaps the most fundamental law of fluid flow and basically is just a statement of the conservation of energy. Because density also decreases with altitude, ***a higher blower capacity will be required in high altitude installations than at sea level in order to obtain the same windchest pressure used at sea level***. Using a higher output blower has become standard practice for high altitude installations.

Tone production: pre-voicing and voicing

As Mitchell and Broome have pointed out,[2] windchest pressure must compensate for altitude differences when pre-voicing will be performed in a shop that is at a different altitude than the location at which the organ will be installed and receive final voicing. In both flue and reed pipes, the velocity has a direct impact on tuning and sound quality, and it is clearly desirable to produce the same pipe velocities during both pre-voicing and voicing. Once again from Bernoulli's equation, since the density of air is greater at sea level than at high altitude, a higher windchest pressure must be used at sea level to produce the same velocities in the shop as in the installation. The desired shop windchest pressure is found by multiplying the desired windchest pressure at altitude by the inverse ratio of the atmospheric pressures at the two locations. This is the formula described by Mitchell and Broome.

Pressures of 3 inches and 4 inches were required for Opus 133, and the inverse pressure ratio between Santa Fe and sea level is 1/0.77 = 1.3. Therefore, pre-voicing in the Fisk Gloucester shop used pressures of 3.9 inches and 5.2 inches (water column).

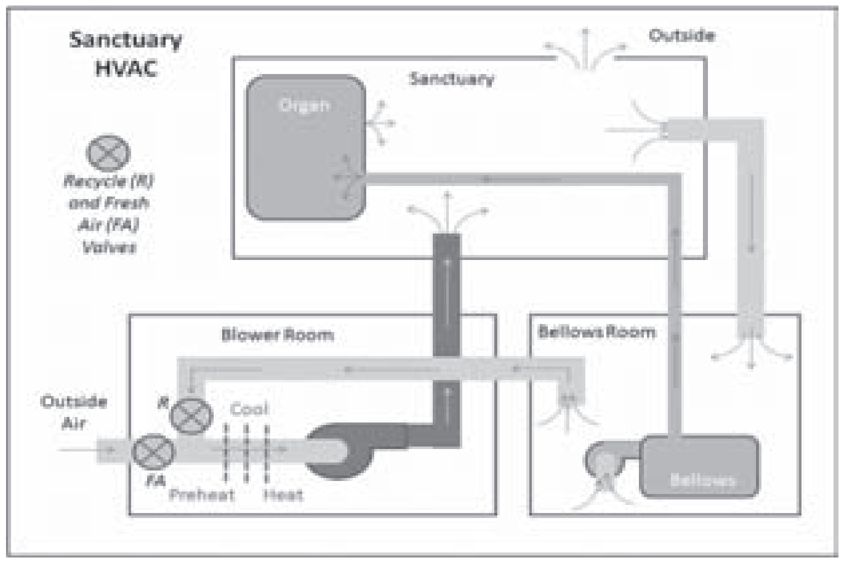

Figure 1. HVAC system of FPC Santa Fe

Sensitivity to windchest pressure

During the final stages of voicing in Santa Fe, Fisk Opus 133 was performing very well, but suddenly developed significant intonation and sound quality problems when the HVAC (heat, ventilation, and air conditioning) system for the sanctuary switched between its two modes of operation. The change resulted in an increase of windchest pressure from 3 inches to 3¼ inches (water column). At sea level a change of ¼ inch could be accommodated without greatly impacting organ tuning and voicing, but in Santa Fe such was not the case. This sensitivity was not anticipated, but can be understood through an examination of tone production in organ pipes. In both flue and reed pipes steady energy is supplied through air streams produced by the windchest pressure, and a complex mechanism converts this energy into oscillating energy (sound).

Flue Pipes

In both a tin whistle and in flue pipes, production of oscillation, that is, tone, is through "edge tone generation." The edge tone frequency depends strongly on air velocity through the windway, and must resonate with one of the natural modes (frequencies) of the pipe; the fundamental mode is always chosen. However, a small change in frequency of the edge tone can pull the edge-tone-pipe system away from the desired intonation. A small change in windchest pressure at altitude will result in a larger change in velocity (and therefore in pitch) than at sea level, due to the reduced density of air at altitude.

Reed pipes

In a reed pipe, air is supplied to the boot from the windchest at a pressure greater than the pressure in the resonator. This causes air to flow under the reed (tongue) into the resonator. Oscillation and therefore tone generation occur when very specific relationships are met among the variables and the stiffness of the reed. Both the stiffness and the oscillating length of the reed are set by the tuning wire.

The effect of a small change in windchest pressure on the frequency of a reed pipe is also greater than it is at sea level. Furthermore, the operating point of the reed, that is, the zero point of its oscillation, moves closer to the shallot as windchest pressure is increased. This may sharpen the onset of each cycle of the oscillation, increasing high frequency content, and, if close enough to the shallot, cause the flow under the reed to become turbulent. Both effects can alter the sound quality of the reed pipe.

To summarize this discussion, ***for both reed and flue pipes the sensitivity to small changes in windchest pressure is greater at altitude than at sea level***, as the Fisk personnel discovered. The solution to this problem for Opus 133 was to gain a better understanding of the Santa Fe FPC sanctuary HVAC system and take appropriate steps to minimize the windchest pressure difference between the two operating modes. Figure 1 is a schematic of the system. The two modes of operation are as follows:

- **Recycle mode**: Air flows from the blower room to the sanctuary and is returned through the bellows room to the blower room. Valve R is open and Valve FA is closed down to 15%.
- **Outside air mode**: Outside air is brought in to the blower room and distributed to the sanctuary, and exits through the roof when the sanctuary pressure rises above that of the outside. The recycle valve is closed and the fresh air valve is 70% open.

Cost and environment are the two reasons for two modes of HVAC operation. During winter when outside air is well below the desired ambient temperature in the sanctuary, the air exchange is limited to the 15% required by code for healthy fresh air in the sanctuary (corresponding to the 15% setting of the fresh air valve). A larger percentage of fresh air would require more preheating, increasing gas costs. During summer when outside air is warmer than that desired for the sanctuary, a larger fresh air fraction would increase electric costs for cooling. On the other hand, during spring and fall, when some cooling is needed and outside air is marginally cooler than the desired sanctuary temperature, an increased recycle fraction saves cooling costs. Of course, environmental concerns track with increased gas and electric costs.

Organ pressure is supplied by the small blower in the bellows room and regulated by the bellows. It was found with a simple manometer (U-shaped tube with water) that the organ pressure during the recycle mode was 3 inches of water (that is, water in the manometer rose 3 inches), and in the outside air mode, the organ pressure was 3¼ inches (water column). The ¼-inch change significantly impacted tuning and sound quality. The reason for the ¼-inch change was that the recycle mode involved a great amount of air flow in the return ducts through the bellows room to the blower room, creating a pressure drop of ¼ inch in the return ducts. In this mode, then, the bellows regulating system had to supply 3¼ inches of pressure in order to yield the desired 3 inches of windchest pressure.

When the recycle valve closed to change to the fresh air mode of operation, the only flow in the return duct from the sanctuary to the bellows room was the much smaller flow used by the organ itself. Therefore, there was no loss in that section of duct, and the bellows room was essentially at the same pressure as the sanctuary. With the bellows regulation system still set at 3¼ inches, the windchest pressure became 3¼ inches.