Expression Devices in Pipe Organs

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Abstract

In this investigation, the three different swell systems known in organs: the wind swell, the door swell, and the crescendo wheel, were measured and compared to each other. The crescendo wheel was found to be most effective, and for frequencies around 2 kHz the increase in sound pressure level could be up to 50 dB between the softest and the loudest adjustment. The maximum dynamic range for the wind and the door swells is approximately 10 dB in the same frequency range. While the dynamic range is lower for the wind swell and the door swell, their advantage is the continuous variability.

Introduction

During the end of the 18th century, the ability to play the organ expressively was one of the organ builders greatest concerns. Especially after the introduction of the orchestra crescendo during the "Mannheim school," the organ often was said to be a "dead" instrument. To overcome this natural disadvantage, one of the most famous organ virtuosos at this time, Abbé Georg Joseph Vogler, was very keen to build an organ that could be played dynamically. Vogler found a solution to his problem on one of his travels through Russia, after he became familiar with free-reed pipes. These types of pipes were used by Kratzenstein in his new speaking machine. In contrast to the beating reeds, which are usually used in organs, free reeds swing through the frame they are attached to. Nowadays, free reeds are commonly used in reed organs and accordions. Vogler realized that when using free reeds, the so-called Gazé or wind swell can be utilized in organs. The wind swell is a valve with a variable opening that controls the air pressure the pipe is supplied with. Wind swells only work well with free reeds because their fundamental frequency is, in contrast to the fundamental frequencies of striking-reed and flue pipes, nearly independent of the playing pressure.

Interestingly, Vogler came up with a second solution to being able to play the organ dynamically, the swell-box. In this device, the stops are built into a box, which is equipped with doors that can be opened and closed by a hand lever or pedal in order to change the volume of the pipes. Vogler, however, wasn't the first person to employ the swell-box. It was invented in England towards the beginning of the 18th century by Renatus Harris or the Abraham Jordans, a father and son sharing the same first name. It is still not revealed whether Renatus or the Jordans were the first to build the swell-box. Other sources claim that the cradle of the swell-box might be found in Spain.

The third device that was invented to enable an organ to be played dynamically, was the crescendo wheel. Using this device, further stops can be added to the sound automatically by using a foot slider or a wheel above the pedal of the organ. In many organs, all of its stops are included in this process, and in modern instruments, the order of stop progression can be programmed freely. Usually, the crescendo will start with softly intonated eight foot flue pipes. At the end, loud striking reed pipes, for example a trumpet and low frequency stops like the Trombone 32', are added.

Today, the swell-box and the Crescendo wheel are commonly employed in newly built organs, while the wind swell, with few exceptions, has gone out of use. In the analysis presented here acoustic measurements of different expression devices are discussed and compared to each other. The main aim of this study is to find reasons for the disappearance of the wind swell.

Methods

Seven instruments were measured in this investigation, four organs, a Mustel harmonium, and two physharmonika prototype stops. Although strictly spoken the Mustel harmonium is not an organ, it was included in the study. This instrument is known for its large dynamic range on the basis of a wind swell, and the art of building harmoniums was still pursued long after the wind swell in organs had been abandoned. The largest instrument measured was the Klais organ of the Auditorium maximum of the Ruhr-University Bochum. This organ was built in 1998 and is, with 82 stops, one of the largest concert organs in the area. The second instrument analyzed is a romantic organ built by Eggert in 1905. The organ is located in the catholic church in Wattenscheid-Höntrop near Bochum. The organ was recently restored, and is principally in the original condition of 1905. An organ built by Franz Wilhelm Sonreck in 1874 for St. Laurentius church in Essen-Steele was the third instrument analyzed. Numerous modifications by Klais in 1906 gave the organ with its 37 stops the late romantic sound it still has today. The fourth organ measured was established by Steinmeyer in 1883 for the catholic church in Gebsattel near Rothenburg o. b. Tauber. In this organ, the physharmonika, a free reed stop equipped with a wind swell was measured. The Mustel harmonium was built in 1904 and is owned by Ulrich Averesch, who restored the instrument. Two further prototype physharmonika stops built by Ulrich Averesch were also analyzed.

For each instrument, the sound of a stop or a combination of stops was measured using a microphone (AKG, C-414)

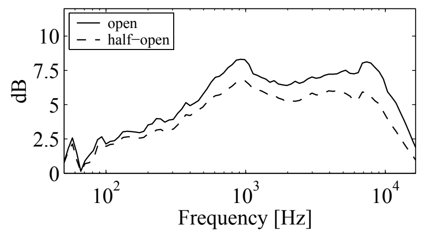

Figure 1: Spectral difference between the open and the closed door setting of the swell box (solid line), and the spectral difference between the half-open and the closed door setting (dashed line). Here, the transfer function between a loudspeaker placed in the swell-box and the left ear of a dummy head is shown.

and a DAT recorder (Tascam, DA-P1). For the measurements of the organs, the microphone was placed outside the organ case. In most conditions, a C-major chord was played for both the lowest and the highest volume of the swell device. In the case of the physharmonika prototypes, which merely consisted of c-tone reeds, the tones were measured separately and then their sound added afterwards. The frequency dependent ranges of the swell devices were obtained by subtracting the spectrum of the sound for the lowest setting from the spectrum of the same sound with the highest setting of the dynamic device. The spectra were calculated with the Fast Fourier Transform (FFT). The dynamic range for each type of swell was determined as the average over several instruments.

During the measurements of the Klais organ in the Audimax of the Ruhr-University Bochum, the transfer functions between a loudspeaker placed in the swell-box and a dummy head placed near the keyboard were measured for different door settings. The transfer functions were measured using a custom-built software based on a cross correlation algorithm.

Results

Figure 1 shows the transfer function between a loudspeaker that was set up inside the swell-box of the Klais organ of the Ruhr-University Bochum and a microphone placed in front of the organ. The graph shows the gain with respect to the transfer function measured for the closed swell-box as a function of the frequency. The solid line shows the gain for the fully opened swell-box, the dashed line for the doors of the swell-box opened at a 45° angle. The largest level increase of around 7.5 dB is found at 1 kHz, below this frequency the level increase drops with lower frequencies. Above 6 kHz, the gain also declines. The frequency dependent level enhancement leads to perceived coloration and the impression of the organ sound moving away when the doors of the swell-box are closed.

In Figure 2, the results for the tested expression devices (wind swell, swell-box, and crescendo wheel) are shown. Each curve shows the average spectral difference between the lowest and the highest setting for different

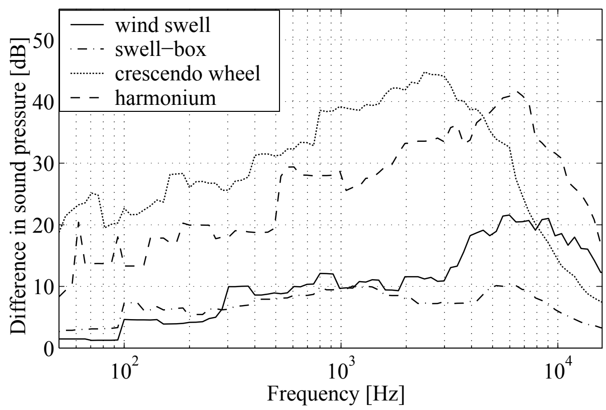

Figure 2: Spectral differences between the lowest and the loudest setting for different expression devices (wind swell, swell-box and crescendo wheel). Each curve shows the average over several instruments measured as described in the text. All values were calculated from differences in the octave band spectrum.

measurements: wind swell: Steinmeyer physharmonika, both Averesch physharmonikas; swell-box: Klais organ, Sonreck/Klais organ, Eggert organ (all three for different stop combinations); crescendo wheel: Klais organ, Sonreck/Klais organ, Eggert organ. The results for the Mustel harmonium (forte setting) are shown separately from the remaining wind-swell measurements because of its constructional differences from organ stops (The instrument has percussion and forte flaps). For frequencies below 3 kHz, the dynamic ranges of the wind swell in the physharmonikas and the swell box are in the same order. Above this frequency, the physharmonika seems to have a larger dynamic range. However, the energy of the physharmonikas is already relatively low above 3 kHz. The dynamic ranges of the crescendo wheel and the Mustel harmonium are significantly larger.

Conclusion

The Crescendo wheel turns out to be the most effective expression device. However, the effect is stepwise. The effect of the swell-box and the wind swell is quite similar. Even though the dynamic range is smaller than that of the crescendo wheel, it benefits from working gradually rather than stepwise. The advantage of the swell-box is that it can be applied to many different stops simultaneously while the wind swell is restricted to free reeds. For this reason, the swell-box was preferred over the wind swell in the latter 19^{th} century.

This work was carried out at the Ruhr-University Bochum. The authors would like to thank Christian Ahrens, Jens Blauert and the owners of the measured instruments for their endorsement during this investigation.