



<Spiro>

Particularly in performances related to ancient music, our regular collaborators - Xavier Verhelst and Sebastian Bradt - felt the need for a plucked string instrument such as a harpsichord. Since harpsichord making is not really what our workshop is equipped for, we started looking for specialized instrument builders in order to have them make an instrument without a keyboard so that we could undertake the automation efficiently. Of course we could have started from a complete instrument, more or less copying the design of the Vorsetzer we made for the grand piano. However, early experiments demonstrated clearly that the intermediate action of the keys added unnecessary noises and that directly pushing the jacks in a vertical plane was a better way to go. Looking around into the many possibilities, we decided to go for a rather small instrument: the spinet. This decision was taken because of the lack of space we were experiencing within the complete robot orchestra, now already composed of 48 robots. Therefore a large harpsichord was to be avoided. A virginal would also have been a possibility, but we did not like it very much because of its uninspiring rectangular shape. Thus our search led us to Walter Maene, a retired instrument builder - Chris Maene's older brother, by the way - who had a spinet almost ready to meet our demand. This instrument formed the basis of the <Spiro> robot.

After taking the instrument apart and removing the jacks and keyboard, it came out that our initial idea of pushing the jacks directly with 56 solenoids was not really workable as the undersides of the jacks had been cut and shaped individually to fit the keys, in order to avoid keys striking more than one jack at the time. The triangular pattern of the jack arrangement was clearly the reason that individual shaping was required. This arrangement, though historically correct, has some implications with regard to the key force required: even numbered notes need a slightly greater force than the odd numbered ones. Of course we could have designed an intermediate mechanism to make inline striking of the jacks possible but after a little drawing it was clear that such a mechanism would end up with a striking resemblance to a keyboard... So we went on experimenting with the original keyboard itself. Although actually an afterthought, we also realized that the tuning of the instrument without a keyboard could become quite cumbersome, as it would dictate the use of a controlling computer with a suitable user interface. Tuning being one of the very periodic nuisances intrinsic to such stringed instruments. Measurement with the keyboard in place taught us that the required striking force for the keys was in the order of 0.8 Newton. The trajectory for the plunger movement required was less than 10 mm. The use of Ledex tubular solenoids in the 0.5" x 1" form factor came into sight. For a harpsichord it is mandatory that the jacks are lifted up very fast and with some force, much higher than the force required to keep the jacks up after plucking the string. Even though velocity sensitivity in harpsichords is no more than minimal, this dictates the application of a pulse-hold system for controlling the solenoids.

60 degree plungers were selected first of all because maximum holding force was not an issue here and also because these plungers have a much smoother movement characteristic than flat types. As an equally important bonus, we also get much quieter operation. Of particular concern in this design was the avoidance of mechanical noises from the action. Therefore we decided to provide all plungers in the solenoids with a 6 mm nylon ball that pushes the keys upwards. The wood of the keys was covered with a layer of very thin felt at the place of activation, damping any bounce-back noises. Of course we did not neglect the fallback profile, with a thick layer of felt on the underside of the solenoids. The spacing between this profile and the solenoid carrier determines the movement trajectory of the plungers and has to be carefully adjusted in conjunction with the velocity scales implemented in the microcontroller firmware.