Mechanical Pipe Organ Actions and their Interface with the Player

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Introduction

There is currently much discussion about whether it is possible for organists to influence the speech transients of organ pipes in organs with mechanical action by the way in which they depress the key.

This project looks at some of the characteristics of mechanical pipe organ actions and seeks to establish how they might affect the player's control of the pallet and thus the pipe speech in all phases, particularly in larger organs.

The Bar and Slider Wind Chest

The bar (groove) and slider wind chest is used almost exclusively in mechanical action organs. A cross section is shown below (reproduced from Audsley [1]).

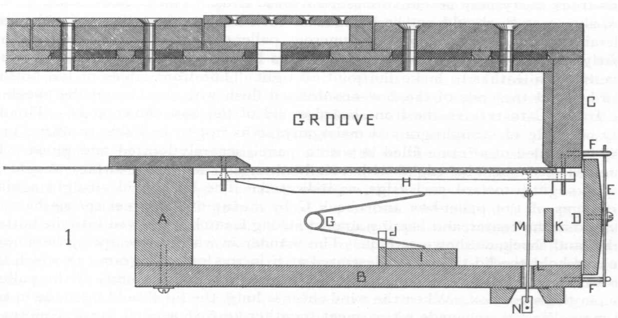

Figure 1: Cross section of bar and slider wind chest

N is connected to the tracker coming from the key and opens the pallet H when the key is depressed. The pallet is held shut by the compass spring G. The pallet box ABDH contains high-pressure air (typically 50 to 100mm wg, 5 to 10mb), which exerts a net force against the pallet when it is shut, as the pressure in the groove is atmospheric. As soon as the pallet starts to open the pressures equalise. This initial resistance is called pluck, by analogy with a harpsichord string being plucked.

It has been found empirically that a comfortable action requires a force equal to a weight of 60 to 80 grams to keep the key depressed with an additional initial pluck of 60 to 80 grams i.e. it requires 120 to 160 grams to start the key moving. Although pluck and key force can be increased in smaller organs by increasing the strength of the pallet spring and by making the pallet opening larger than necessary, they cannot be reduced in larger organs where the inertia of the action and the required repetition rate determine the strength of the pallet spring, and the maximum air requirement and wind pressure determine the pallet opening and thus pluck. Any flexibility in the action due to rollers twisting, cloth bushes compressing etc will result in the key moving until sufficient energy is stored to overcome the pluck. At this point the pallet will suddenly start opening and will catch up with the key movement.

Experimental Organ

In order to carry out this research, a small organ was built which allows for a wide range of action characteristics to be incorporated. This is shown in Figure 2. The initial tests were carried out with a wind pressure of 75mm wg (7.5mb), a key force of 80g and a pluck of 120g. Two action runs have been built – an unbushed suspended action and a bushed balanced action with rollers of aluminium tube one metre long, 8mm outside diameter and 6mm inside diameter. Measurements of the movement of the key and pallet were made using an LED and photodiode.

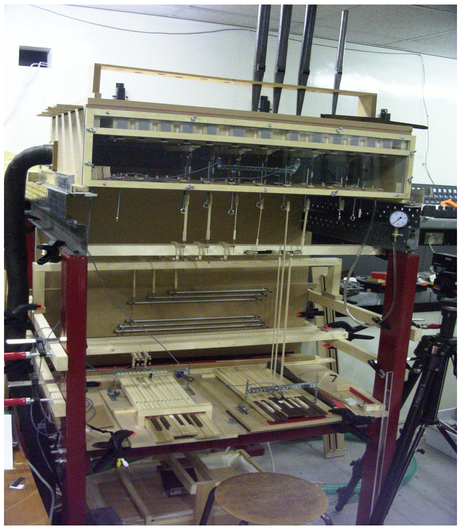

Figure 2: Experimental organ in the University of Edinburgh

Control of the Initial Transient

A number of laboratory experiments have shown that it is possible to influence the initial transient, but these were limited to individual keys depressed in isolation and/or restricted to small organs [2][3][4]. This may not relate to how players actually play a piece of music and may not take into account the characteristics of larger actions. In, say, a ten stop wind chest, a single rank will be fully winded with the pallet only partially open (around 10%) – it is this movement of the pallet that the player must be able to control. The experimental organ also allows a study of pallet closure and the timing between two successive notes.

Pluck

In a rigid action (suspended, no rollers, no bushing) pluck is overcome very quickly. The player must then immediately reduce the force on the key if the pallet is to be controlled. Figures 3 and 4 show the movement of the key (top curve, inverted), the pallet (bottom curve) and the waveform of the pipe speech with the key depressed subjectively very slowly and quickly respectively. The vertical movement is 10mm and the horizontal scale is 10ms per division.

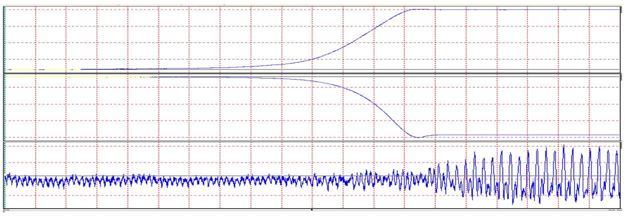

Figure 3: graph showing inverted movement of key (top), pallet (middle) and waveform (bottom) with a rigid action. Vertical movement 10mm and horizontal scale of 10ms per division. Slow key depression.

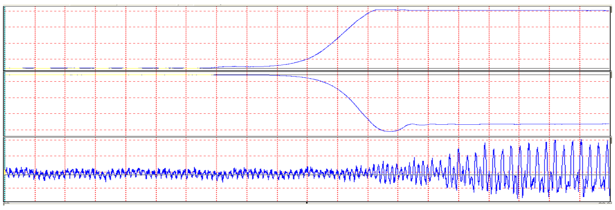

Figure 4: graph showing inverted movement of key (top), pallet (middle) and waveform (bottom) with a rigid action. Vertical movement 10mm and horizontal scale of 10ms per division. fast key depression.

It can be seen that although the keys were depressed subjectively in a very different way, the actual movement does not differ greatly.

Flexible Action

With the flexible action, the key moves about one third of its travel before the pallet suddenly starts to open. Figure 5 shows this movement with its characteristic shape.

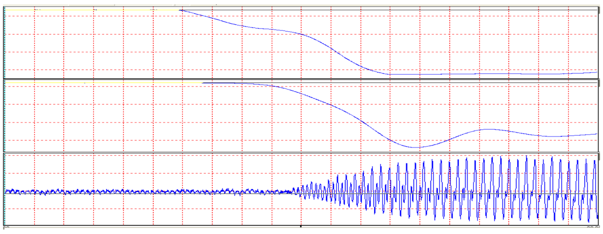

Figure 5: graph showing movement of key (top), pallet (middle) and waveform (bottom) with a flexible action. Vertical movement 10mm and horizontal scale of 10ms per division. Slow key depression.

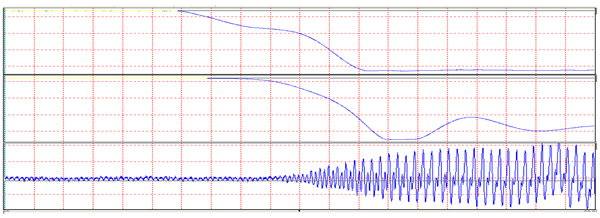

Figure 6: graph showing movement of key (top), pallet (middle) and waveform (bottom) with a flexible action. Vertical movement 10mm and horizontal scale of 10ms per division. Fast key depression

Real Music

Some key movements were then recorded with a concert organist playing the Hauptwerk of the 1978 Ahrend in the Reid Concert Hall in Edinburgh. This organ has a reputation for being difficult to play because of its very light action (100g on Hauptwerk, including pluck), but which should allow for a significant variation in touch. Figure 7 shows the movement of G above middle C during the performance of a "fast" piece of music.

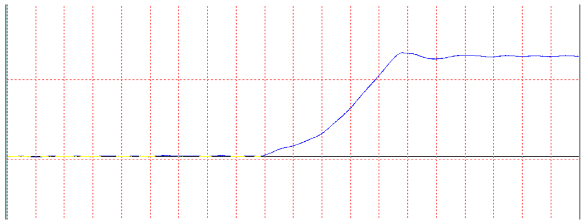

Figure 7: graph showing movement of key, Ahrend organ Reid Concert hall, 10ms per division. Fast music.

Figure 8 shows the same key in a "slow" chorale prelude.

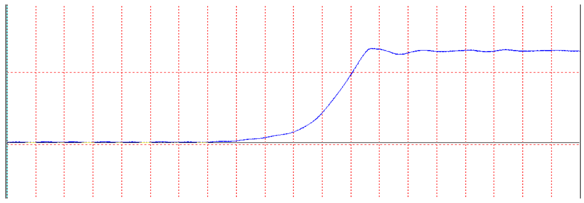

Figure 8: graph showing movement of key, Ahrend organ Reid Concert hall, 10ms per division. Slow music.

The average speed of key movement does not vary greatly

Conclusion

In these preliminary results, the speed of movement of the key and pallet do not reflect the player's perception of speed or relate to the speed of the music. Further work needs to be done in order to establish how a variety of organists play real music on real organs with varying characteristics and whether this allows for the control of the initial transient. It is also necessary to establish whether the player is influencing the sound by controlling the ending transient, or by some other means such as varying the rhythm as suggested by Robert Noehren [5]. It should also be considered whether it is simply the degree of tactile feedback that a mechanical action gives to the player that is significant.

References

[1] The Art of Organ-Building. Dodd, Mead & Co., New York, 1905, Fig CLIX

[2] Caddy, Roy S, Pollard, Howard F. An Objective Study of Organ Actions. Organ Institute Quarterly **Vol 7, No 2**, (Summer 1957) p44

[3] Pollard, H F. Time Delay Effects in the Operation of a Pipe Organ. Acustica **Vol 20 No 4** (1968) p189

[4] Castellengo, M. Acoustical Analysis of Initial Transients in Flute Like Instruments. Acustica – Acta Acustica **85** (1999) 387 - 400

[5] An Organist's Reader. Harmonie Park Press, Michigan, 1999, p161