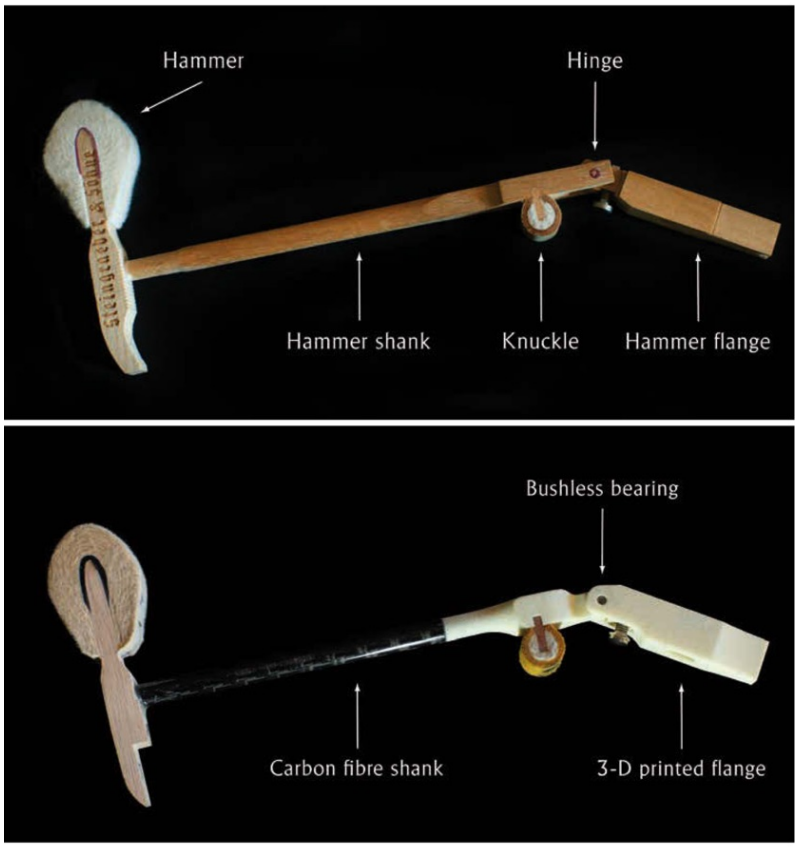

***Top**: Traditional wooden hammer assembly; **Above**: Phoenix D3D hammer assembly*

interface. Felt is prone to swelling through absorption of atmospheric moisture. A traditional assembly may seize up almost completely in wet weather or tropical conditions, wreaking havoc for any pianist. The opposite applies to traditional wooden parts, which may become loose in dry weather, to the point where they produce distracting 'clicks' each time a note is played.

No matter how much money you spend on a piano, all traditional wooden hammer assemblies have the same problems. Dain has therefore sought to reimagine the design of the hammer assembly from the ground up.

Assessing modern, high-performance materials which could be used for hammer shanks, he opted for helically-woven carbon fibre tubes, which have the benefits of enormous strength and stiffness, climate resistance and a weight equivalent to hornbeam. But it is the hinge part of the assembly – the 'hammer flange' – where the real innovation takes place. Partnering with Igus UK – specialists in high-performance bearing materials – Dain redesigned the two hinge components so they could be produced with extreme accuracy and consistency by 3D printing. Crucially, the hammer flange no longer requires a felt interface for the pin. Using larger, buttery-smooth bush pins, the materials used for the flange are lower stressed but far stronger, self-lubricating and climate resistant

When the 'D3D' (Dain + 3D printing) hammer assembly prototypes were tested, pianists noted that they offer an exceptional sense of control, immediacy and reserve power – much as tennis players felt when carbon fibre rackets appeared to replace their wooden predecessors.

A series of refinements have since been made to D3D, and in summer 2019, the first commercial hammer assembly was fitted for a discerning London pianist with a Phoenix Model 212. Another was built for a specialist recording studio's Bösendorfer Imperial 290, followed by other actions for Phoenix grands. One professional pianist of wide international experience recently described D3D as the best action he has ever played.

From 2021, D3D actions will be fitted as standard to all new Phoenix grand piano models. They are also available for retrofit to most makes and models of grand piano. Dain and his engineering team have ensured the parts used in D3D are extensively serviceable and adjustable. Each part of the assembly can be replaced without discarding the other parts. Both the strike line and the bearing clearance are adjustable.

CNC CARBON FIBRE BRIDGE CAPS

In late 2018, Dain began to address another area of weakness in traditional piano design: the bridge caps. Traditional bridge caps are strips of beech or maple wood glued to the bridge root. They act as the initial interface between the strings of a piano and its soundboard.

Having already patented his acclaimed bridge agraffes over a decade ago (and having since found their application most effective in the bass and tenor registers), Dain started to consider a new bridge cap design for the upper registers.

Traditional bridge caps are susceptible to material inconsistency, leading to patchy energy transfer from the strings to the soundboard – a source of unevenness in terms of power, sustain and timbre. Cracks and splits can also develop in the wood due to the forces exerted by string tension over long periods of time. Furthermore, the intrinsic weakness of wooden bridges limits the angles at which the bridge pins can be fitted and thus the efficiency with which sound energy from the vibrating string reaches the soundboard.

With a number of successful carbon fibre designs already gracing Phoenix instruments, this material was a natural choice. Partnering with specialists in 3D computer modelling, Dain has engineered perhaps the most precise and perfectly uniform bridge caps ever made for acoustic pianos. They are manufactured using computer numerically controlled (CNC) machining to exceptional levels of accuracy. The result is an even, powerful, singing sound, right up to the highest parts of the treble register, where piano sound, with conventional bridge caps, is notoriously short and weak.

With the pins set now at greater angles, sound energy transfer is optimised with no fear of the bridge cap splitting. Having indefinite lifespan, these bridges are now fitted as standard to all new Phoenix grand pianos as well as being available to retrofit on other pianos.