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Fortepiano Hammers; A Field Report

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Little has been written or publicly spoken about the part which, functionally speaking, defines the fortepiano as an instrument, namely, the hammer. There is a body of publication on the hammers of modern pianos (for a digest of this see Fletcher and Rossing[1]). Almost all studies of the fortepiano concentrate on construction, scaling, stringing, action or furniture design. Robert Winter discusses striking-points[2] and some studies have been made of hammer-leathers (Hentzschel[3], Moog[4]); Pfeiffer, in *Vom Hammer*[5] does discuss historical hammers to some extent, though his measurements and conclusions seem to me tendentious and suspect. But as far as I am aware, there has been no specific examination of the function and historical development of fortepiano hammers, though several authors touch in passing on the subject in respect to particular cases. This is all the more surprising because there is probably no other single part of this instrument which has such a fundamental role in determining its tonal qualities and playing "feel". I have tried to include as many references as possible to these disparate writings, since lack of space here precludes more than superficial discussion; the emphasis is on pianos up to, and including, the Romantic period.

This paper is based on the two-hour workshop I gave during the *harmoniques* meeting in Lausanne, and reflects its basically practical aims of uniting some basic information and workshop practice for restorers and builders. The first part consists of a summary examination of the physics of hammers, the second part looks at the historical development of the hammer, including written source material, and the third focuses on practical techniques of hammer-making and voicing, and the materials used. The sections naturally enough overlap, and while this paper has no pretensions to being more than a sort of *mise en bouche* to the subject, I hope it will be of sufficient interest to stimulate some more serious studies of this neglected field.

1 Neville H. Fletcher & Thomas D. Rossing, *The Physics of Musical Instruments*, New York 1998.

2 Robert Winter "Striking It Rich: The Significance of Striking Points in the Evolution of the Romantic Piano", *Journal of Musicology* vol. VI, no. 3, summer 1988.

3 Roland Hentzschel, "Einige Bemerkungen zum Hammerkopfleder", *Michaelsteiner Konferenzberichte,* Michaelstein 1996.

4 Gerhard Moog, "Untersuchungen von Hammerledern aus der Zeit Mozarts bis Mitte des 19. Jahrhunderts", *Mitteilungen der Internationalen Stiftung Mozarteum*, Salzburg 2000.

5 Walter Pfeiffer, *Vom Hammer*, 1948, English translation by J. Engelhardt, Frankfurt a.M. 1978.

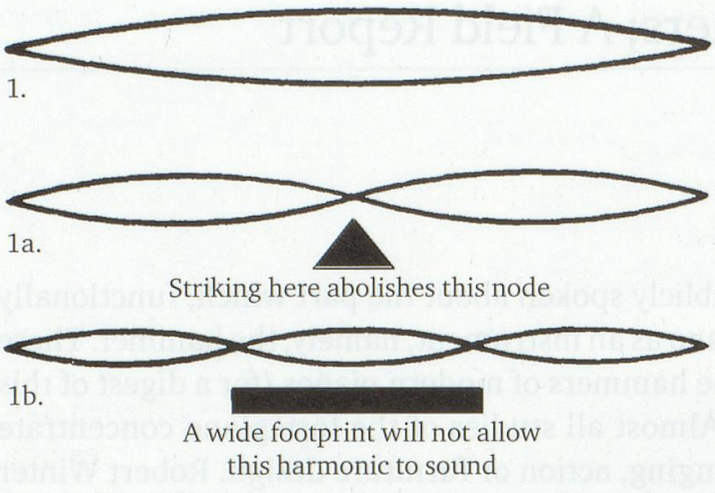


Figure 1

Physics

The way in which a piano hammer excites strings to produce a note is the result of a complex interaction between the hammer itself, the strings, the soundboard and the bridges.

Fig. 1 shows the displacement of a vibrating string at its fundamental frequency and also at the harmonics of the octave and twelfth (1a, 1b). The stationary points of any one mode of vibration of the string are known as "nodes", the points of maximum displacement as "antinodes". While a string may, of course, vibrate at a single frequency, that of the fundamental or at any one of its harmonics, in practice it will vibrate in a complicated way made up of several of the harmonics, combined with the fundamental. This complicated motion is called the "envelope" and is the result of the superposition of all the modes of vibration at once. But it is helpful for our purposes, as we shall see, to visualise the motion broken down in the manner of the diagram. The thin, flexible strings of a fortepiano are capable of producing a great number of harmonics.

When a hammer is thrown at the stretched strings (or, for simplicity's sake, let us say "string") by the action, its momentum is first halted, then reversed by the string. A pulse travels away in both directions from the point of impact, and is then reflected back by the bridge and nut, beginning a complex interaction with the hammer, tending to throw it off the string. The string is displaced and released during this process, which starts its vibration. It is easy to see that where the hammer strikes the string along its length is going to determine which harmonics are present, and in what proportion. The point at which the hammer strikes becomes one of maximum displacement, and so no node can exist there; any harmonic which has a node at that point cannot therefore sound. For example, striking the string in its centre will abolish the first harmonic

(fig. 1a). But the fundamental and the second harmonic will be very strong. Striking towards the end of a string will produce a great number of harmonics, but relatively little fundamental.

A second factor in the interaction of hammer and string is the relationship of the mass of the hammer and its striking-point to the tension and mass of the string. This determines in great measure the length of time during which the hammer and string remain in contact. Any vibration of the string which starts its return motion while the hammer is still in contact will use up its energy in throwing the hammer off the string, and it will thus be damped by the hammer. In a normal situation, this only affects the harmonics, but, for example, a too-massive hammer can easily damp the fundamental of the highest notes of a piano. On the other hand, a hammer which is too light for its strings does not have enough momentum to properly set the fundamental in vibration, resulting in an etiolated tone. The strike-point of the hammer also plays a big part; the further toward the middle of the string that it strikes, the greater the resilience of the string, and hence the longer the hammer stays in contact with it (and the more harmonics that are damped). A thick, taut string can absorb more energy than a thin one; also, it will tend to throw back a given hammer faster than a thinner, less tensioned one, and so more harmonics will be generated. However, a thick string will tend to lose harmonics to internal damping, and moreover, the phenomenon of inharmonicity (out-of-tune harmonics) can become noticeable due to the rigidity of the wire.

We have so far examined a system where the hammer is perfectly elastic and which strikes the string as a dimensionless point. While some hammers do in fact approach this configuration (the bare wooden strikers of the *Tangentenflügel*, for example), nearly all piano hammers have a considerable radius and are, moreover, covered with more or less soft material which alters the elasticity of the hammer, and indeed renders its radius variable. The width of hammer-head coming into contact with the string is called its "footprint". Clearly, the longer this footprint, the greater the number of harmonics that will be eliminated by the contact of the hammer with the string, since no node can exist along the entire length of the footprint, thus precluding any vibration which requires a node in that place. A long footprint will thus prevent the sounding of all harmonics above a certain level. Interestingly, the radius of the crown of hammers for any one note (and hence the footprint) stayed much the same over a long historical period (illus. 1, p. 234). Since a hammer striking softly will have a shorter footprint than when its blow forces the strings further into its surface, the harmonic structure of the resulting note is altered, and a light blow should cause a sound richer in harmonics than a heavy one. That the opposite is in fact the case is explained by the non-linear elastic properties of hammers; their resistance increases from a soft outer layer to a firmer core, and the dynamic hardness of felt hammers increases with greater velocity of the blow. The same is likely to be true of leather-covered hammers. This explains the phenomenon of 'colouration'

caused by a pianist's touch, and it is an essential element among the musical possibilities offered by a piano. The elastic qualities of the hammer-covering are obviously of first importance in the production of tone. An insufficiently elastic hammer-head, or one which has a high internal damping factor, will dissipate much of the energy propelling it to the string. Such a hammer will produce a quiet, dull tone because of energy loss and because its lack of elasticity causes it to remain a long time in contact with the string, hence damping harmonic and even fundamental vibration, for the reasons we have already examined.

Further "real-life" complications to the hammer-string relationship are added by the characteristics of the strings themselves (elasticity, mass, scaling, number, damping characteristics), soundboard and bridges (mass, compliance, radiating area, resonance frequencies, stiffness of bridge and nut pins ...), the fixing of the strings in the frame of the piano (mass, compliance, bearing, resonance), the presence of the other strings in the instrument (mass, pitch, sympathetic resonance, damping ...). The vibrating double or triple strings of each note interact with each other, starting in phase (reinforcing the resultant sound) at the moment of attack, and then quickly settling down to an out-of-phase continuous vibration (attenuation of the resultant sound)[6]. All these elements modify the timbre and vibrational decay patterns of the sounding strings and must be taken into account when designing or modifying hammers for any given instrument. Helmholtz[7] was the first to examine in detail the physics of struck strings in the piano, but more recent studies have benefited from modern techniques of observation and analysis[8].

The characteristics of the action used to propel a hammer towards a string have a considerable effect on tone. A Viennese action, with its key-mounted hammers, propels the hammers in an ellipse, so that they strike the strings a supple, glancing blow. Moreover, the strike-point is determined within certain limits by how far the key-lever is depressed at the moment the hammer strikes the string, and so the tone-colour produced by this type is very touch-sensitive. Other types (Cristofori, English, Erard ...) have the hammers pivoted on a rigid rail, which obliges them to describe a fixed arc and hence deliver a more direct blow. In both types, the mass and springiness of the hammer-shank modifies the attack of the hammer and introduces further directional elements to it.

Lastly, it is the player who instigates the whole process of sounding the note, and who is an inseparable part of the system. His or her musical tastes and intentions, mechanical intelligence and dexterity, are not the least of the factors which govern the working of a piano hammer.

6 Gabriel Weinreich, "The Coupled Motion of Piano Strings", *Journal Acoustic Society of America* #62, 1977.

7 Hermann Helmholtz, *Die Lehre von den Tonempfindungen*, 4th ed. 1877 = *On the Sensations of Tone* tr. Ellis 1885, reprint Dover, pp. 74–80, 380.

8 See Fletcher & Rossing, *op. cit.*, § 2.9 & § 12.4 for a more detailed explanation and bibliography.

History

The history of the piano hammer is bound up with the history of musical æsthetics. The revival of the early piano, by its emphasis on the classical Viennese instrument, has paradoxically served to obscure the rainbow variety of 'tone-worlds' which coexisted throughout the eighteenth, nineteenth and early twentieth centuries, only to be absorbed by the hegemony of the Steinway æsthetic. Recent interest in these other types of piano, manifested in restorations and copies, has begun to open our ears to alternatives to what lies beyond the very few late eighteenth-century Viennese models which form much of the basis for our musical experience of early pianos. The variety of instruments presented at the Lausanne event, both physically and through the medium of the various lectures, provided thoroughly convincing evidence for this.

Early pianos can be divided into two types, which although far from watertight, embody two quite different approaches to piano sound. Throughout the eighteenth century and into the nineteenth, pianos containing an action provided with an escapement mechanism tended to have large, soft hammers, long striking-points and long bass strings, while those containing actions lacking escapement had light, hard hammers striking the strings close to the nut, and often, foreshortened bass strings. In both types, the hammer is freed from the key a short distance before it strikes the strings. An escapement mechanism allows the hammer to then fall far away from the strings, possibly onto a check, permitting a more vigorous blow, at the expense of the need to 're-arm' the mechanism by releasing the key.[9] The first type of piano was well suited to expressive, dynamically and tonally shaded playing, while the second type, with its drier sound, more incisive attack and lightning-fast action, was an ideal vehicle for virtuoso performance. I have argued this division elsewhere.[10]

The 'non-escapement' piano co-existed on an equal footing with the 'escapement' type until around 1810, when improvements to piano actions with escapement in the late eighteenth and early nineteenth centuries made it possible to combine the rapidity of the non-escapement types with the nuance and power that escapement and hammer-check alone could provide. Paul Poletti has convincingly demonstrated, for example, that Stein's *Prellzungenmechanik* of around 1780 (an escapement action) in fact works as a non-escapement action under certain conditions;[11] his reasoning also holds good for the English Grand action of Backers (1772) which was used for the next 120 years.

9 Walter Pfeiffer, *op. cit.*

10 Christopher Clarke, "Escapement Double-Take – A New Look at Some Old Facts", *Gedenkschrift für Kurt Wittmayer*, ed. Silke Berdux, Munich 2004.
Christopher Clarke, "Avantage ou Atavisme? les mécaniques de piano-forte sans échappement" colloquium *Aux Origines de l'Ecole française du piano-forte*, Clermont-Ferrand 1999.

11 Paul Poletti, "Understanding the Prellmechanik", manuscript Utrecht 1992.

From about 1790, the accelerating quest for intensity of sound led makers to increase the tension of piano strings by increasing their diameter. At the same time, they reduced their speaking lengths, partly because thicker strings are relatively weaker, and partly in order to increase the safety margin needed for louder playing. These thicker strings required softer hammers to damp out the higher harmonics which become disagreeable at great intensity. Moreover, notes could now sound noticeably "dirty" due to the phenomenon of inharmonicity which lowers the frequency of the harmonics of thick, low-stressed strings. The introduction of steel strings in the late 1820's and their subsequent improvement permitted higher stress levels; the longer scalings and higher tensions of the Romantic piano were the result, aided by the increasing use of metal in the frames of these instruments. Hammer design was intimately linked to these developments; hammers became ever more massive, calling for new materials and techniques in their construction. The norm for the first part of the century was a hammer with a more or less massive wooden core covered with from two to ten layers of leather, usually deer- or sheep-skin. These hammers were typically several times larger in the bass than in the treble; the extension of compass during this period emphasised this graduation. Wool or hair felt, first patented in 1826 by Henri Pape, had supplanted leather as an outer covering by around 1840 except for the trebles of certain instruments, mostly for economic and practical reasons. Early felts were made of mixtures of wool and rabbit or hare fur, and were astonishingly soft in consistency (illus. 2b, p. 242). They tended to wear rather quickly, and so it is rare to find a piano of this period with original felt hammers, whereas surviving leather covers are relatively more common. Some English makers (Broadwood, Ball) occasionally used a rough woolen cloth called 'molton' for the lower two-thirds of the compass of their square pianos in the 1820's, something first noted by Kützing in 1833[12] and repeated by many writers thereafter.

We shall examine hammer-covering methods presently; suffice it to say here that I believe that the progressive abandonment of leather was more because of the real difficulty of finding sufficient quantities of consistently good material than because of the apparent difficulty of covering hammers with a great number of layers, or because leather was inappropriate to an evolving taste in tone-colour.

12 Carl Kützing, *Theoretisch-praktisches Handbuch der Fortepiano-Baukunst*, Bern and Chur 1833 (my thanks to Georg Senn who provided me with a photocopy of this capital work).

Early hammers 1690–1790

The earliest piano hammer design known is that of Cristofori's escapement action as represented by Scipione Maffei in 1712[13]. To what extent it represents a real object is difficult to say, but the wide, flat pad of leather shown glued to a squarish wooden block must have damped many of its strings' harmonics even as it sounded them[14]. Cristofori's later designs have rounded hammers, also topped with leather. The 1726 Cristofori in Leipzig has hollow rolled paper hammerheads of a constant diameter of around 11mm, which are covered by a pad of soft deerskin, about 7,5 mm thick in the bass and 1 mm in the treble. The large diameter and weight of such hammers, and the relatively thick, soft covering gives an agreeable, round tone, though the diameter and mass are disproportionately large for the treble notes, making for an over-long 'footprint' and long contact time, which, as we have seen, causes severe damping of harmonics. Thus the emission of the treble notes is compromised by this design, though with careful setting-up they can work quite well. This design was used by many builders throughout the eighteenth century, notably by Gottfried and Jean-Henri Silbermann, and also by Johann Andreas Stein, Johann David Schiedmayer and many others, sometimes with variations as to materials and bass-to-treble diameter.[15] Sometimes the leather is glued across its whole surface (Schiedmayer), sometimes it is secured only at the ends (Silbermann).

The other great family of pianos, those without an escapement mechanism, are first mentioned and described in Christoph Gottlob Schröter's articles of 1747 and 1764, claiming that he invented the hammer action in 1717 (see Pollens p. 159ff.). As I mentioned above, the hammers of any piano action without escapement must have little mass. This is so that the residual momentum after they have struck their strings is quickly dissipated in mechanical friction, reducing the probability of multiple blows to the strings, which results in a confused sound. In order to obtain a satisfactory intensity of sound, the hammer must transmit as much as possible of its energy to its strings; the damping effect of soft coverings is a handicap, and many such actions have hammers with little or no covering; others, where volume of sound is not a prime consideration (e.g. English square pianos) have rather firm leather or another softish material, such as Baumann's use of cork, and only late versions of actions such as 'Zumpe's second action' (*mécanique à double pilotes*) succeeded in increasing hammer-mass and softening their coverings, since these actions reduce the endemic 'non-escapement' problem of multiple blows of the hammer when played hard.

13 See Stewart Pollens' excellent book *The early pianoforte*, Cambridge 1995, for this and for other early developments.

14 For an illustration, see Kerstin Schwarz, "Historische Hammerflügel mit Cristofori-Mechanik – Anmerkungen zu Konstruktion und Klang", this volume p. 35.

15 See Michael Latcham, "Mozart and the Pianos of Johann Andreas Stein", GSJ vol. LI, 1998.

But this was after 1810 or so, when the tonal æsthetic of piano sound was firmly in the camp of the escapement type.

The æsthetic of non-escapement pianos could be said to be more heavily influenced than their counterparts by the dulcimer, notably that of Pantaleon Hebenstreit. The effects of undamped or variously muffled strings, different striking materials, and an iridescent panoply of mechanical tonal modifiers are all typical of this approach, and serve to palliate the inherent paucity of nuance in the tone-colours of these instruments.

The tonal starting-point of such instruments is generally the bright sound of a firm, small hammer (short 'footprint', low mass, low damping). This is typically modified by such devices as the damper-lifter (often split treble-bass; some early instruments have no individual dampers at all), the harp or buff stop, which damps the ends of the strings, muffling the sound, and which is present on practically all square pianos, the moderator or sourdine, which brings tongues of soft material between the hammers and strings, softening the blow (this stop is sometimes normally in the "on" position and must be voluntarily de-activated) and the lid swell, which opens part or all of the closed lid to augment the sound. These devices, and other more exotic ones are operated by hand-stops, pedals or knee-levers, or a combination of them; hand-stops tend to be the rule for earlier instruments. The effects of these modifiers need to be taken into account in hammer-design, since they alter the response of the piano to a hammer-blow, and the various tonal possibilities they offer should all be in harmonious balance with each other. While the moderator acts as a sort of temporary additional loose hammer-covering, and can thus be seen as an extension of the hammer, the harp and lid-swell act in a more passive manner, often severely modifying the frequency response of the whole instrument. The "normal" position (lid open? lid closed?) determines whether a brighter or duller sound is required from the hammers.

As I mentioned above, 'non-escapement' piano hammers (or 'escapement' pianos influenced by this school, which I have here suffixed thus: *e*) can be of bare wood (*Tangentenflügel*, many early squares and harp-shaped pianos, Stein *vis-à-vis* 1777*e*) or they may be tipped with a pad of cork (Baumann 1775) or leather (Backers 1772*e*).

German squares from the 1780's and later typically have narrow wooden hammers mounted on a threaded metal rod, tipped with a small pad of cork or deerskin which is then covered with one or two layers of thin white sheepskin (Bätz 1789).

English and French squares of this period usually have D-shaped wooden heads glued to a flat, tapering wooden shank, and covered with three to five thin layers of brown or white sheepskin, skin side out. The hammers are about 12mm diameter in the bass, 8mm in the treble of a five-octave piano. They are generally made considerably wider than necessary, being trimmed to size using the strings as a template at the moment of fitting. Some grands use this type

of hammer (Taskin 1788, Erard(?) 1791[16], both in the Musée de la Musique, Paris).

Just as some 'escapement' pianos embody 'non-escapement' hammer-types, the converse is also true and Cristofori-type hollow paper hammers with or without soft covering can be found in some grands and squares (Hellen c. 1780 (Berlin), L'Epine 1772 in Dom Bédos[17]) (illus. 2a, p. 242).

Hammer-design in the Classical period (1790–1820)

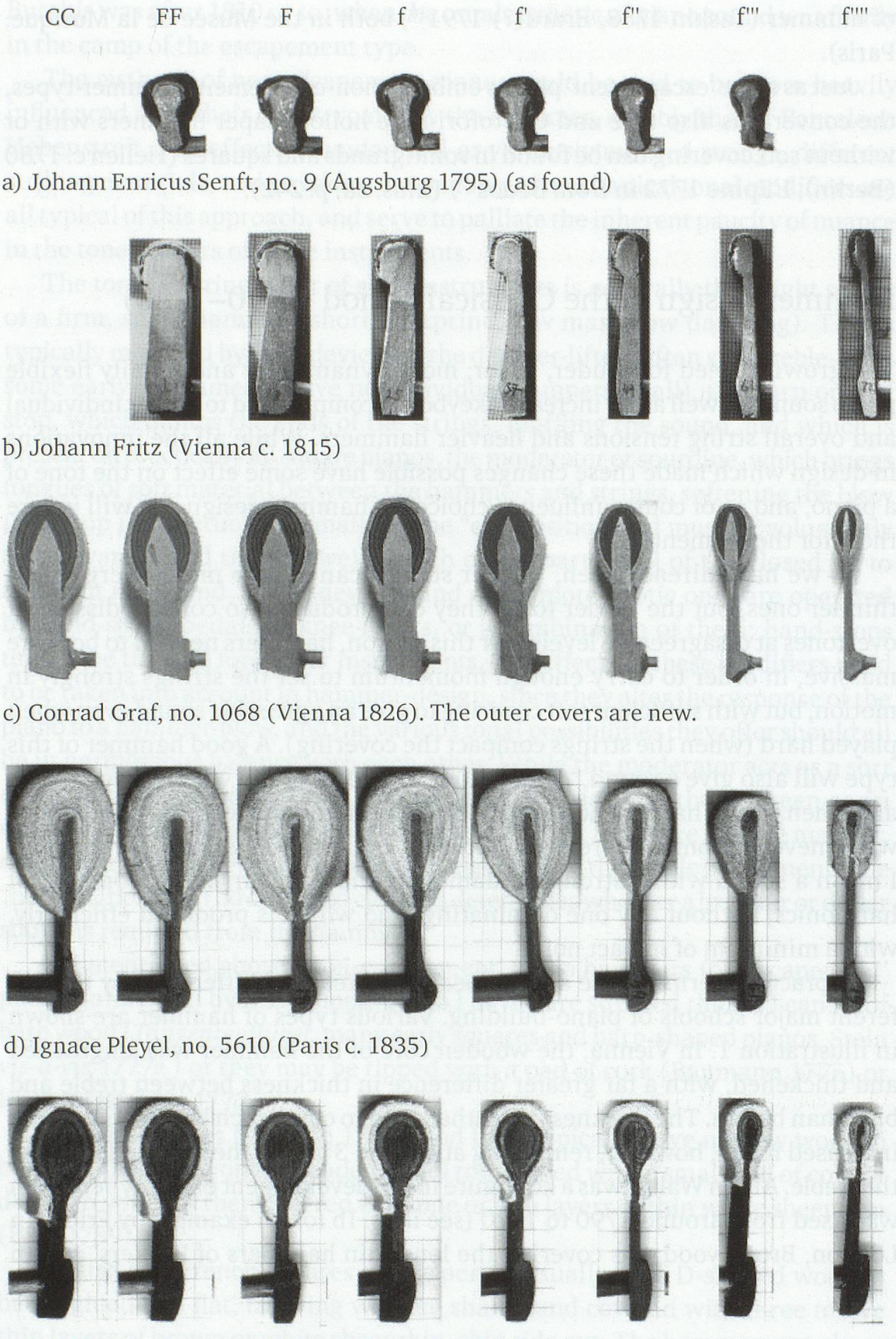
The growing need for louder, fuller, more dynamically and tonally flexible piano sound, as well as for increased keyboard compass, led to higher individual and overall string tensions and heavier hammers. While all the innovations in design which made these changes possible have some effect on the tone of a piano, and so of course influence choices in hammer-design, we will ignore them for the moment.

As we have already seen, thicker strings can absorb more energy than thinner ones, but the louder tones they can produce also contain dissonant overtones at disagreeable levels. For this reason, hammers needed to be more massive, in order to carry enough momentum to set the strings strongly in motion, but with sufficient soft covering to give an agreeable sound even when played hard (when the strings compact the covering). A good hammer of this type will also give a round, 'centred' (or 'focused') sound when played softly, and when played harder, the 'centre' will come more and more into prominence while never becoming agressive (except at extreme *fortissimi*). By 'centred', I mean a sound with a strong fundamental and a colourful development of harmonics, without any one dominating, and which is produced efficiently, with a minimum of impact noise.

In practical terms, these aims appear to be realised differently by the different major schools of piano-building. Various types of hammer are shown in illustration 1. In Vienna, the wooden core of the hammer was lengthened and thickened, with a far greater difference in thickness between treble and bass than before. The thickness of leather used to cover such hammers was not increased much, however, remaining at around 3 mm in the bass and 2 mm in the treble. Anton Walter was a key figure in the development of this type, which was used from around 1790 to 1820 (see illus. 1b for an example by Fritz). In London, Broadwood was covering the long thin hammers of Backers' design

16 Since writing this article, I have learned that the action in this piano is probably not original.

17 Dom Bédos de Celles, *L'Art du Facteur d'Orgues* vol. IV, Paris 1778. Facsimile edition Bärenreiter Tours-Kassel-Basel-London 1977.



a) Johann Enricus Senft, no. 9 (Augsburg 1795) (as found)

b) Johann Fritz (Vienna c. 1815)

c) Conrad Graf, no. 1068 (Vienna 1826). The outer covers are new.

d) Ignace Pleyel, no. 5610 (Paris c. 1835)

e) William Stodart, no. 9587 (London c. 1835). The outer covers are new.

Illustration 1: comparison of hammer-types (approximately to scale)

with multiple layers of sheepskin and a final layer of doeskin, forming a roughly cylindrical head of around 15 mm diameter for a bass note in about 1800 (see illus. 1d for a late example by Stodart). This specifically English pattern, developed to exploit the thicker treble strings and powerful action of the English grand, sounded better in *fortissimo* playing than the Viennese, since its generous thickness of leather was not crushed onto the wooden core, resulting in a 'hard' sound. For the same reason, the voicing tended to remain more stable over time. Von Schönfeld[18] wrote in 1796 that Walter's pianos have a somewhat dull tone in the treble which became very clear after some time with playing, before degenerating into a sharp and metallic sound, necessitating re-leathering.[19] It was the English pattern which was developed into the typical hammer of the Romantic period, from the 1820's on.

In Classical hammer-designs, the crucial importance of tension in hammer-coverings began to be appreciated. Since hammers were now covered with multiple layers of material, the potential for energy loss between layers in poor contact with each other was correspondingly increased. Much energy is lost in compressing the hammer-material to make it firm enough to act as a reflective surface; hammers behave exactly like early bullet-proof waistcoats, with their multiple layers of silk which absorb the projectile's energy. While some absorption of energy is inevitable and even neccessary to the production of 'good tone' (damping of undesirable harmonics), loose hammer-coverings give a 'dead' 'centreless' sound with very little dynamic range and a noticeable thud at impact. We shall look at this problem more closely in the following section, but suffice it to say that the different layers of covering must be applied with carefully-controlled tensions. This puts further constraints on the quality of the material used, especially for the layer which comes directly into contact with the strings. This layer was now called upon to take much more of a drubbing than in previous designs, and needed to be of a material soft, firm and elastic, with long-term resistance to crushing.

18 J.F. von Schönfeld, *Jahrbuch der Tonkunst von Wien und Prag*, Wien 1796 (K. Komlos, *Fortepianos and their Music*, Oxford 1995).

19 Stephen Birkett pointed out in a private communication: "The reason for the increase in harmonic content with playing force and volume is related to the non-linear nature of the elasticity of the hammer ... A modern piano hammer felt cover is designed to provide an increasingly stiffer spring force the more it is compressed, like the stiffening springs in car suspensions. In other words the spring constant increases as a function of the compression, causing it to appear harder the greater the force with which it is played into the string. Historical hammers with soft outer covering and hard core that comes into play with *forte* touch provide just the same sort of gradient in spring constant, although more extreme than the modern felt gradient (until the modern core comes into effect). The relationship between spring constant and compression is a function of the hammer design, and this factor contributes to the difference in tonal response for one type of hammer construction vs a different design (e.g. Streicher vs Graf, Walter vs Stein, Walter vs English, or your other examples). Also one of the factors which is specifically adjusted during the voicing operation is this spring constant gradient, especially if the lower layers are fiddled with."

Many materials were tried, but the most popular and successful were oil-, vegetable-, or combination- tanned skins of deer or certain breeds of sheep. Carl Kützing, who was a piano-builder in Chur (Switzerland) wrote the earliest serious manual of piano-building, published in 1833[20]. For him, deer-leather was the best material, and sheep came a very poor second: "alles Schafleder ist untauglich, weil ihm die erforderliche Elasticität ganz fehlt, und eine starke Belederung davon gewöhnlich den Hammeranschlag mit einem unangenehmen Klatschen begleitet" (all sheep-leather is useless, it is so lacking in the requisite elasticity, and the blow of a hammer heavily leathered in it is usually accompanied by an unpleasant slapping sound). He goes on to mention the use of hat-felt in Paris (see illus. 2b) and molton (a coarse woollen cloth) in England. Dr Gustav Schilling, writing in 1835[21], disagrees and quotes the names of several famous builders (Graf, Streicher, Schiedmayer ...) who he says use sheepskin tanned in a special way (*Wiener Patentleder*[22]). It is certain that there is no modern equivalent to the incredibly soft and supple, yet resistant, leather which may still be found on some old pianos. Oil-tanned deer or antelope was a good substitute until recently, but cost-cutting and loss of skills at the tanneries have degraded quality to the point where even the most expensive of such skins are now only fit for washing windows.

Hammer-design in the Romantic period 1820–1870

During the Romantic period, from the mid 1820's up to the end of the century, multiple-layered hammers became the norm, first all leather, and then increasingly with only the under-layers of leather and the outer layers of felt. The wooden cores for English-inspired actions grew somewhat, and the Viennese became smaller, with respect to earlier models. Builders all had their own ideas about hammer-weight, but the general tendency was for ever-increasing hammer-weight (to match the ever-increasing string tensions made possible by new wire technologies). Conrad Graf was a pioneer in this respect in Vienna, using hammers half as large again as some of his contemporaries such as Joseph Schrimpf[23] – Schilling singles him out as using five layers of skin in the treble as against the more usual three or four. He also pioneered hammers of diamond shape, allowing greater mass and support while keeping the 'footprint' relatively

20 Cf. note 12.

21 *Encyclopädie der gesammten musikalischen Wissenschaft, oder Universal-Lexicon der Tonkunst*, Stuttgart 1835 (see Appendix 1) (thanks to Gerard Tuinman for sending me a copy of this entry, along with a translation).

22 For this term, see the contribution of Susanne Wittmayer, this volume p. 206 ff.

23 See Deborah Wythe, *Conrad Graf, Imperial Royal Court fortepiano maker in Vienna*, Ann Arbor 1990, p. 220 for Graf hammer-types.

small (illus. 1c). It will be noted that hammer-diameter remains almost constant for the bass 3 1/2 octaves, and then tapers more rapidly into the treble. Pleyel in Paris followed this plan, while considerably increasing the diameter of the hammers (illus. 1d). During the 1830's, Pleyel offered either leather or felt as a covering material for his grand pianos.

As I previously noted, early felt was very soft-textured and wore quickly. Viennese makers (and others working in this style) who adopted its use protected the outer surface against the scything action of the strings with a thin layer of leather, a practice which continued until the Viennese action was finally abandoned in the 1920's. Felt-making techniques evolved to meet the increasingly rigorous demands of piano-builders; the exclusive use of merino wool and improved mechanical methods of carding, felting and pressing meant that graduated thicknesses and firmer textures became possible. Alfred Dolge[24], a hammer-manufacturer and trade chronicler, tells us "About 1835 Wilke, piano maker at Breslau, invented a machine in which a full set of hammers could be covered with felt at one time" (p. 97). By the 1880's sets of hammers were occasionally being made with a single tapered layer of felt[25].

The great advantage of felt over leather is that, being an entirely manufactured product, albeit from natural fibres, it can be made with great consistency as to its physical properties. Anyone who has worked with leather as a hammer-covering material knows that only a small proportion of any batch of appropriately prepared skins are in fact good for this purpose, and perhaps only half of each skin is useable, at least as an outer coat. The enormous expansion in the numbers of pianos produced each year during most of the 19th. century, coupled with the increasing quantities of material used to make a set of hammers, made the growing use of felt inevitable. However, as noted above, leather continued to be used for under-layers throughout the century, and also, due to its better resistance to cutting by the strings, for the trebles of many instruments (Erard was still using leather for the high trebles of concert grands in the mid 1890's). Montal[26] (p. 115) mentions exactly the problems outlined above.

Apart from various patent specifications concerning hammer-materials and rather arcane variations of standard design[27], there is little written material concerning the design and construction of hammers before Schilling's thoughtful article. Kützing skirts round the subject: Montal's manual merely explains how to replace leathers which have started to produce a 'brittle, sour, yapping' sound.

24 Alfred Dolge, *Pianos and their Makers*, Corvina 1911 (Dover reprint).
25 For a detailed history of this later period, see Dolge, *op. cit.*, pp. 97–103.
26 Claude Montal, *L'art d'accorder Soi-meme son Piano*, Paris 1836, reprint Minkoff 1976.
27 For some of these, see Rosamund Harding, *The Pianoforte*, Cambridge 1933, 2nd. ed. Woking 1978.

It is not until 1868 and the publication of the excellent treatise by the Neapolitan maker Giacomo Sievers[28] that we get a glimpse of how hammers might have been made. I reproduce extracts in full here (appendix 2), since there is no modern reprint of this key work; a recently-published condensed version in English is so full of errors that it is only good for the illustrations it reproduces. The method he describes is basically that for producing a felt or leather covered hammer of Graf-inspired form, though he goes into some detail concerning the choice and cutting of leather (from a well- but not too well- fed male deer of middle age). He describes the use of hammer-moulds (*stringitoi*) exactly adjusted to the size of the hammer-heads and which clamp the layers tightly. He illustrates part of a block of them, making up an octave. The underlayers, of felt, or of leather for the treble two octaves, are easy to glue layer to layer; use of the mould is essential here. The last layer, of felt or leather, can be clamped in the hand.

The apparent precision of Sievers' description camouflages some holes in what is presented as a production rather than a repair method. He seems to be calling for one *stringitoio* for each hammer, a reasonable proposition with a single felt underlayer, but he makes no mention of any different gluing technique for the four or five layers of ram's leather which constitute the underlayers in the treble, though he is careful to warn against gluing the last underlayer at the part that lies at the nose of the hammer.

I believe that this coyness on the part of piano-builders to describe how they made what all of them agree is perhaps the single most important part of their instrument is entirely intentional. As we shall see presently, another builder-author, Julius Blüthner[29] gives hardly any help over the reality of hammer-making, while he is very detailed about every other aspect of the instrument, and indeed the theory and requirements for a good hammer, and the materials used to make it. And as we have already seen, Kützing stops short even of this.

We can be sure that Sievers made his hammers individually – rather than in blocks of several at once; Dolge (p. 97) writes that most European makers preferred individual hand-covering to collective machine-covering. But were Sievers' treble underlayers (and those of the entire compass in earlier instruments) really put on one by one? I have come to believe, by observation and experiment, that the underlayers were in fact generally applied all at once, being previously glued to each other in long, tapered strips, appropriately shaped and then cut into individual hammer-coverings (see illus. 2c). This way, the layer-to-layer gluing is sequential simply in a spatial, not in a temporal sense; a confusion writers in the profession were happy to foster in order to make the

28 Giacomo Ferdinando Sievers, *Il pianoforte, guida pratica per costruttori, accordatori, dilettanti e possessori di pianoforti* ..., Napoli 1868 (many thanks to Marieke Teutscher, who kindly gave me a photocopy of the whole book).

29 Julius Blüthner, *Lehrbuch des Pianofortebaues*, Weimar 1872, reprint Bochinsky 1992.

task seem even more difficult than it already is. Using such a method, only as many *stringitoi* as there are notes are required, and the end result is far more consistent, since each prepared piece follows on from its neighbour and the tension in the covering is determined by its geometry. By experience, I can say that the process is four or five times quicker than covering layer-by-layer. We will look at this procedure in the last section.

The last author I would like to examine is Julius Blüthner, already mentioned. His section on tone production (p. 48) is taken largely from Helmholtz. He devotes pp. 101–103 to a discussion and history of suitable hammer-materials, and pp. 169–170 to a discussion and history of hammer-types, with illustrations. He explains in a few lines that one, two or three layers of material (generally felt) are used to build up the covering , either hammer by hammer, pulling the covers tight with special pliers and a band of material round the circumference and then clamping them in a special press, or all at once, by laying the previously prepared tapered layers of felt in a mould whose shape is a negative of the final shape of the hammer-heads, and pressing the whole set of cores, clamped together, into the glue-covered felt (see Dolge pp. 100–103 for the appropriate equipment). His illustration fig. 47 shows tapering strips of felt numbered 1 to 6, with 5 1/2 between 5 and 6, explained on p. 101 as the felt-manufacturer Weickert's gauges; he gives appropriate thicknesses for different instruments and discusses national preferences for hammer-weight (American hammers are the thickest, with a bottom note covered in 27mm of felt; German hammers are in the middle, though tending to the American model, and French hammers are the smallest, from 6 to 12mm thick in the bass, hand-covered). A murky photo of the Blüthner hammer-covering shop, taken in 1903, (p. 249 of the Bochinsky edition) shows a workman in the foreground preparing sets of covers; the strips, half the piano compass wide, are laid over each other on a board which is lying on a short bench with a screw vise at the end and some pliers lying on it. To his right a man operates a light machine; he could be cutting up the strip of felted hammers into individual pieces; in the background a seated man is doing something fiddly at a bench and another, standing, works another machine. No industrial espionage is possible, alas! and Blüthner, like his fellows, has taken his secrets to his grave.

What is fascinating and unexpected about Sievers' and Blüthner's accounts is the emphasis placed on the use of leather, after more than 40 years of enormous design changes since Pape's patent for the use of felt. As both report, they were still using it in the treble of some of their instruments, but Sievers gives instructions for using an outer cover of leather for the whole compass, and devotes considerable space to the selection of this material. He seems to be working in a leather tradition, but to have adapted it to the use of felt. For this reason, the information he gives (or does not give) is particularly pertinent to the practises of the Classical and early Romantic period which form the focus for much of the activity of the early-piano revival.

Workshop Techniques

This last section is neccesarily impoverished by the impossibility of conveying the contact through eye, ear, touch, and even smell which are essential to the physical process of making and voicing piano hammers. It is the same gap as that between recipe and cooking. It reflects my own practice, learned over thirty-four years of observation, trial and (lots of) error, reading, discussion and so forth. I learned the basics of voicing from Derek Adlam in the legendary days of Adlam Burnett, and the learning process goes on ... the germ of my method for multi-layer hammer-covering came from a trainee in my shop, Maurice Rousteau.

What I am about to describe concerns principally the leather-covered hammers of pianos in the Classical and Romantic period. There is apparently a broad consensus as to tonal æsthetic amongst writers and (as far as it is possible to tell) amongst instruments surviving in a more or less original state – the desirable formula of "volle, runde, molligte Tone" ("full, round, plump tone") as opposed to "scharfe, schneidende, grelle" ("sharp, cutting, shrill") which Andreas Streicher[30] described in 1801 is repeated by almost every writer thereafter, though his ideal for piano sound approaching that of the best wind instruments is one which seems essentially Viennese. Blüthner, writing seventy years later, emphasises the differences in national and individual taste in sound which were still very much in evidence – e.g. English hammer-felt will not answer to German taste, giving a sound that is not singing enough, too dry (p. 232). Both Blüthner and Sievers give quite detailed accounts of voicing procedures (Blüthner pp. 230–232, Sievers p. 137) both for felt and for leather.

I am going to assume that the basic design parameters of hammers and strings are already established in the examples discussed below.

Dolge says (p. 97),

> The art in hammer making has ever been to obtain a solid, firm foundation, graduating in softness and elasticity toward the top surface, which latter has to be silky and elastic in order to produce a mild, soft tone for pianissimo playing, but with sufficient resistance back of it to permit the hard blow of fortissimo playing.

To realise this ideal, materials and techniques must be optimised.

30 Andreas Streicher, *Kurze Bemerkungen über das Spielen, Stimmen und Erhalten der Fortepiano* ..., Wien 1801.

Materials and equipment

As far as materials are concerned, a modern builder is severely hampered. The carefully-prepared deer- and sheep- skins available to the original makers no longer exist; indeed, the breed of sheep (hair-sheep) does not exist either. There is no equivalent for early hammer-felt. The silky, elastic quality required for the outer layer of hammers is best provided today by the oil-tanned skins of deer (or other *cervidæ*). But, catastrophically for us, the quality of even the best such skins commercially available has declined precipitously in the last ten years, to the point of being virtually useless for our purpose. Old stocks are the best hope for the moment. Merino sheep-skin is worthless in any form, and is quickly beaten hard and flat either as a hammer or a damper-covering.

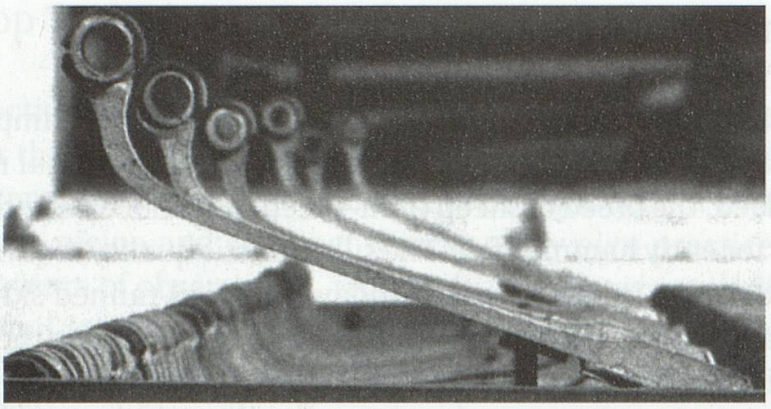
A good skin should feel wonderfully soft, warm, dry, flexible yet elastic, should not stretch or thin out significantly when pulled, should not keep the mark of a fingernail driven into it, the surface should remain silky-soft even when pulled taut. It should have 'body' and not flop like a wet rag when suspended. It should not smell strongly of fish or other oil, nor feel oily. With such a skin, practically any basic tone-colour within reason may be obtained by varying the tension with which it is applied to the hammer, and whichever is chosen, gives a wide range of colours from *pianissimo* to *fortissimo*. Skins which do not meet these criteria sound monochromatic – aggressive or wooly, and usually do not last well. A skin whose fibres are not soft enough cannot be voiced to give an agreeable sound.

The skin for underlayers is less critical, and I have successfully used vegetable- or even chrome- tanned deer for this. Sometimes alum-tawed (white) leather or vegetable-tanned sole leather is used. Any leather used should be as non-stretch and as elastic and soft as possible.

Sievers gives careful instructions as to the choice of skins and the manner of cutting them in the direction of least stretch.

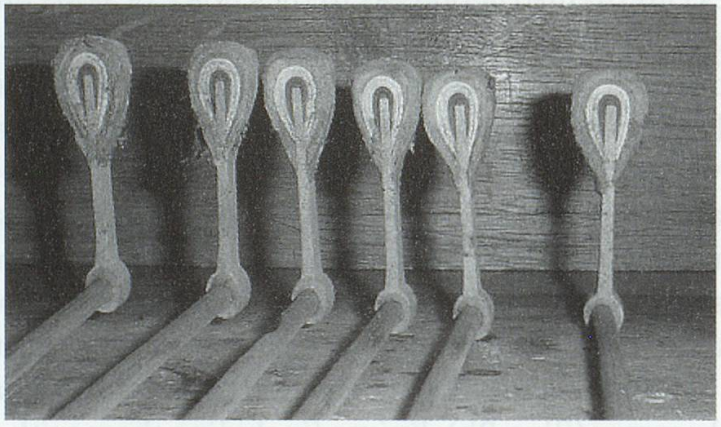
For gluing the covers to the core, a good-quality hide glue is best, though for repairs and for outer layers I often use liquid fish glue, more hygroscopic but very handy to use.

Clamping can be effected by a variety of strong spring clamps; it can help to encircle the hammer with a taut strap of some kind at the moment of clamping, as Blüthner describes; pliers can be used to tighten the cover. For fat multiple-layer hammers, some kind of mould is necessary in order to ensure consistent size and shape. Moulds for trimming the covered hammer-blanks are also useful for this type of hammer (illus. 2h). Knives (including those with a bevel on one side only), straightedge, square and chisel are needed for cutting; small saws and the type of secateur sold for cutting plastic tubing are useful. Knives must be exceedingly sharp; when trimming hammers, I strop the tool between working on each hammer and sharpen after five or six hammers.



a) Paper hammers (late Cristofori type). Anonymous French grand piano, c. 1795.

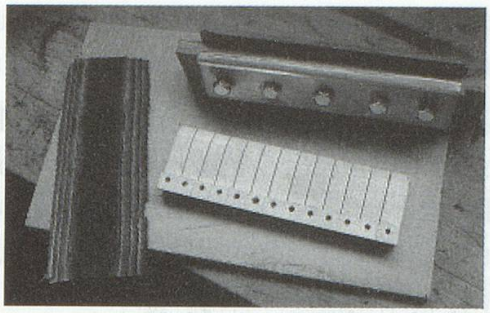
b) Felt-covered hammer by Pape, c. 1825. The outer layer is impregnated with a green solution against moth attack.



c) Leather-covered hammers by Pape. Note how the asymmetry of the underlayers continues from hammer to hammer; it is probable that the underlayers were applied simultaneously to a block of several hammers.

Illustration 2: materials and construction

d)



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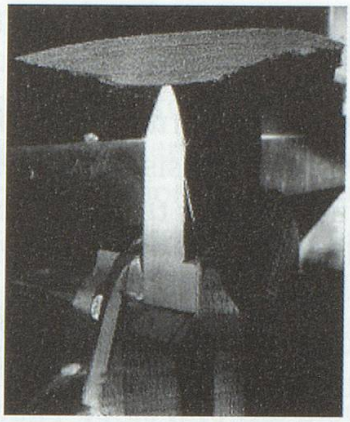
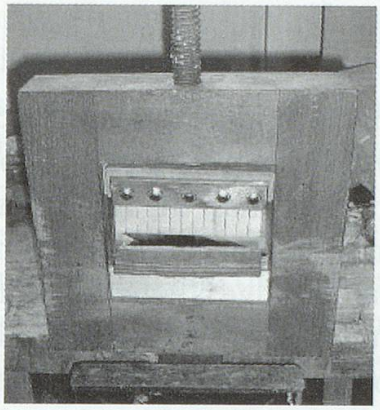
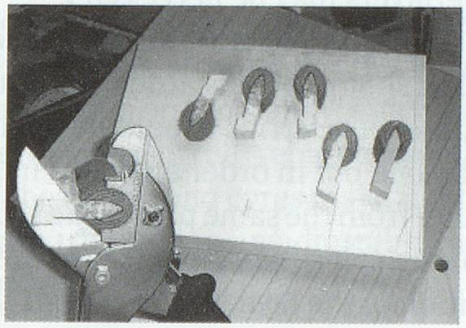


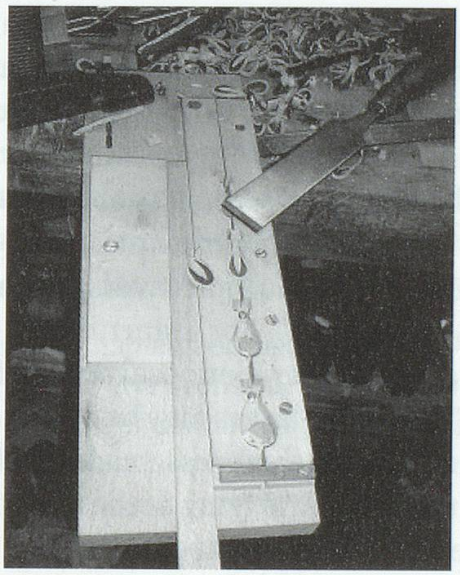
f)



g)



h)



d)–h) Stages in simultaneous covering of a block of Graf hammers – strips of leather are glued together and chamfered, then glued to the cores in a mould before being separated, receiving their outer cover, and finally trimmed.

Techniques

Classical South German and Viennese hammer designs from around 1785 to 1825 typically consist of a fairly massive wooden core, rounded on top, graduated in size from treble to bass, with two to three layers of very soft leather, generally flesh side out (illus. 1b, Fritz, c. 1815). The "silky, elastic surface" is there, but solid wood is not far away, and aggressive *fortissimi* can result; the voicing is not particularly stable, especially if the strings and covers are drawn tight enough to enable a lively dynamic response. I think that the layers were put on to the core blanks one by one; I use medium tension for all layers, increasing it slightly in the bass and progressively so in the treble above about f"; notes above f"' need to be pulled very tight using pliers, and even ironing the underlayers may be neccessary.

The skin is cut into strips in the direction of minimum stretch; stretchy bits of the skin should be discarded, since they will slacken with playing once on the hammer. The strips should be somewhat wider than the hammers. They should be laid out in order and used in sequence, so that contiguous hammers use leather from the same part of the skin. A feather-edge is generally cut on the inside of each piece where it glues to the core; the angle of this is determined by the position of the layer in the overall shape of the hammer. This feather-edge only should be glued to one side of the core, at the appropriate height. When it is dry, feather the other end at the appropriate point, apply glue further up on this side (avoiding the crown of the hammer) and on the free side of the hammer. With the pliers, stretch the leather vertically and then bring it round, evenly aligned, into place and clamp using the strap and spring-clamp. Avoid getting glue on the outside of the cover. The tension should be consistent from hammer to hammer. Glue on succeeding layers in the same way. When all is complete, trim off the protruding leather; new hammers are made slightly overwidth, so leather and wood are trimmed at the same time.

The method for hammers with multiple layers (i.e. more than two or three) is rather different (illus. 1c–e, 2d–h). For a start, it will be noted that the cores are of a very different shape to earlier Viennese models, being relatively thinner and somewhat pointed. The under-layers may be prepared all together as a long strip, suitably tapered in width and thickness, made up of individual layers glued together (in such a way that the parts lying at the crown remain unglued). The individual layers can be tapered in thickness in such a way that the breaks in the number of layers which occur at various points in the compass from, say, five layers to four, can be managed without discontinuity. The actual number of layers depends on the thickness of the skin and the overall dimensions desired; the edges of the made-up strip are feathered all together after assembly. The trapezoidal cross-section thus produced needs to be adjusted by experiment in order to produce the desired shape of hammer once applied to the core; the

angle of feathering may be different for inner layers than for outer. The finished strip is placed apex up above a female mould of the shape of the hammer less its outer layer, glue is applied, and the wooden core is forced into the leather, pushing it into the mould. The tricky bit is gluing the feathered 'ears' to the core; I must admit that I have not yet found a satisfactory solution to this. The gluing process can either be done hammer by hammer or in strips; the illustration shows an octave of hammers being covered at once. This is a bit riskier, since the trapezoidal strip can slide as it is being forced into the mould, resulting in a run of lopsided hammers (illus. 2c: hammers from a Pape square of around 1825). The pressure applied to force the hammer-cores into the mould, the shape and size of the mould, core and trapezoid all determine the tension in the finished hammer-head, but unlike a layer-by-layer application, this tension is predictable by geometry and adjustable by overall pressure, and above all results in great consistency of form and elasticity. The inner layers are in considerable compression, the outer in considerable tension. For this reason, the moderately-tensioned soft outer layer should go on separately, much as Sievers implies. I do, however, cover all the layers at once in the treble octave; the great tensions required and the small size of the covers and cores make it difficult to work by hand. The finished hammers are trimmed in an adjustable mould, as shown, which ensures their correct dimensions.

Voicing

Some people have raised doubts as to whether early piano hammers were voiced at all, citing the absence of any literature on the subject before the Romantic period. I have already pointed out that earlier writers give no details of hammer construction, either, so maintaining a certain logic. But practice in the sister-trade of organ-building is apposite, the more so since many piano-builders were also organ-builders. Dom Bedos, writing in 1770[31] says

> This is the most important Chapter, because it treats of the Sound of the Organ. The whole Instrument may be very well constructed, its Pipes perfectly well-made and in good order, and yet be an extremely bad Organ. This Instrument, being made only that it may be heard, it is essential to give to it a good and agreeable harmony.

Further: (p. 437)

> ... (the Pipes should be) equal in force and harmony. One goes back over them several times at different moments, always to render perfect the most imperfect Pipes. *Equalising force* is to operate in such a way that all the Pipes make themselves equally heard, and that one is not stronger than another. *Equalising harmony* is to give to all

31 Dom Bedos, op. cit 1770 iiè partie chap. 10 (p. 425); my translation.

> the Pipes the same quality of sound and of harmony; for if one had a dry and meagre, another a rounded sound, &c, they would not be equalised in harmony.

What follows is my inevitably personal view of this process as applied to historical instruments. The approach to any individual instrument must be made in context; it is obvious that an early Stein with bare wooden hammers does not call for the same æsthetic approach as a lush and pearly Pleyel from the 1830's, but it is perhaps not so obvious to decide how to treat a slightly later Stein or an early Walter in the same light. While many old instruments come to us with thicker, more recent hammer-coverings which reflect a later æsthetic, many others in their original state clearly prefigure tastes later to become dominant. None should be 'normalised'. The techniques and judgments I propose here are in no way statements of dogma, rather a practical response to my observations of mainstream classical pianos.

The art of voicing represents the bringing to artistic fruition of a piano, as of an organ; the whole of its design and manufacture may be seen as simply the preparation for this moment (Blüthner pp. 230–232, Sievers pp. 137–139). The piano must be perfectly regulated and perfectly in tune, and the voicer must work in a calm, quiet environment. Each instrument, however similar it may seem to others, has its own character, and moreover is destined for a particular use and often for a particular musician, who will approach and exploit it in his particular way. The voicer's task is to intuit the inherent possibilities and weaknesses of the instrument, and to optimise these within an appropriate style so as best to serve the character of both instrument and musician. A good voicer must possess these empathetic qualities, a refined sense of musical sound and balance, patience and perfectionism.

The actual process of voicing consists of adjusting the tensions in the various layers of the hammers, possibly adjusting the mass of the hammer (which is critical in the treble) and even the mass and springiness of the hammer-shank. To some extent, one can work on the nature of the surface of the hammer. The principal tool of the voicer is the needle, held in an appropriate handle, often four or five needles at a time. As Blüthner advises in the pages just cited, the needles for voicing leather need to be very fine; thick needles quickly destroy the structure and 'kill' the hammer. No. 11 (or 12) embroidery needles work well; Paul Poletti uses acupuncture needles, which are even finer. A smoothing iron is sometimes helpful, if drastic. A fine wire brush is useful for raising the nap of the leather. A stout needle can be used for separating glued layers in order to re-glue them at greater tension.

A piano with new hammers needs to be 'run-in' for a while so that the hammers begin to be worked on by the strings. They will certainly sound brighter after some hours' playing. The voicer should choose notes that are pleasing here and there throughout the compass (if there are any at this stage!) and work on the other hammers by pricking them in order to soften them.

As can be imagined, the method of pricking is rather important. Since leathered hammers, unlike felt ones, are composed of thinnish discrete layers, it is possible to work layer by layer, starting with the outermost. I prick along the layer, in the direction of the strings. Light voicing is accomplished at the crown of the hammer; this will 'take the edge' off a note that is slightly too bright. A note that is a bit too bright at *piano* and *mezzo-forte*, but aggressive at *forte* and *fortissimo* needs to be pricked further down the shoulders of the hammer, and, if this is not enough, lower layers need to be pricked. Don't try to do too much at one time. Play the newly-voiced notes (and their neighbours) for several minutes at least in order to stabilise the work. They will become brighter, and perhaps will need further attention. Notes which are too strong (but otherwise are well-proportioned harmonically) need to have their lower layers pricked. The practice of wiggling a needle between layers, to ease the excess tension, is in my view to be proscribed absolutely, as it invariably leads to loose covers which must be replaced or at least re-tensioned. The practice of pulling threads between layers is little better and should also be avoided.

Notes which still sound dull when the main outlines of the voicing are established should be examined carefully. A loose hammer-cover gives a slapping sound on striking the string, and may well blend with its neighbours when played *piano*, but refuse to become louder when struck vigorously (beware, in a Viennese action, of over-flexible beak tongues, which can have something of the same effect – though here the sound can actually diminish with increasing vigour of the key-stroke). Pinching the hammer between the fingers will often reveal air between the layers. The only remedy is to unglue and re-tension the cover, or replace it. Hardening solutions ("Supertone") have absolutely no place in our work. A note may sound dull because the leather is softer than the rest, or too thick. Replace it. Dull notes in the extreme treble, if they are not caused by the above faults or by loose nutpins, for example, can sometimes be improved by carefully dry-ironing the leather, using a certain amount of pressure and the iron set between 'silk' and 'wool'. Avoid 'frying' the leather, and fluff up the nap on the hammer. If this is not successful, try removing the top layer, checking the tension of the underlayers, perhaps ironing them (don't do this with old leather as it will probably shrivel!), ironing the *inside* of the new top leather, and putting it on with greater tension. Or try another type of leather – I once had to change the outer layer of all the treble hammers in a Broadwood grand four times before I was happy.

One important thing to realise about voicing is that everything is relative. A note which seems too dull can be percieved as too bright when the hammers all around are voiced down. A seemingly weak treble can be brought into perfect balance by voicing down an over-vigorous bass. An instrument is well-voiced when all the registers are in a plausible balance with each other, the timbre during normal playing never tires the ear, there is a wide dynamic range and a variety of tone-colours according to (and in a satisfying relation with) the touch

of the player, and every note is a continuation of its neighbour. In a Viennese instrument, the contrast when the moderator is applied or removed should not be shocking. A poorly-voiced instrument might only be playable *pianissimo* with great difficulty, or maybe it lacks an intense *forte*, or perhaps there is a dynamic or tonal preponderance of certain registers, a general timbre that sounds too insistent or too muffled, and a lack of egality of power and timbre between notes. Because of the effects of inharmonicity in thick strings, later pianos usually will not take bright voicing as well as earlier ones; however, many early pianos were softly-voiced and each instrument must be taken in its context.

It is important not to spend too much time on any one session of voicing. After a period when the ears become sensitive to small differences in timbre can come another when they become hypersensitised; it is easy to lose a conception of the whole instrument and to concentrate obsessively on individual notes, over-voicing the whole to a state of blandness. Best to leave and come back the next day!

Appendix 1

Entry „Beledern" from *Encyclopädie der gesammten musikalischen Wissenschaften, oder Universal-Lexicon der Tonkunst.* Ed. Dr. Gustav Schilling. Stuttgart, 1835:

Beledern heißt bei den Clavierinstrumentenmachern das Ueberziehen der Hämmer mit Leder. Wegen des großen, wesentlichen Einflusses einer zweckmäßigen Belederung auf die Schönheit der Klangfarbe ist dies einer der wichtigsten Puncte im Instrumentenbau. Durch sie erst erhält das Clavierinstrument (Flügel oder Fortepiano) seine höchste Vollkommenheit. Und dennoch lassen sich keine in allen Fällen gülthige Regeln dafür aufstellen; so mancherlei Umstände und Verhältnisse, die dabei zu berücksichtigen sind, machen es allein zur Sache der tiefen Einsicht des practischen Meisters, dessen richtiges Verfahren sich stützt auf eine Menge durch allerlei Versuche gemachter Erfahrungen, auf deren Mittheilung denn auch wir hier beschränkt sind.

Die Ursache erst, warum die Hämmer mit Leder überzogen werden, ist die Kraft, Fülle, Rundung und wohlthuende gesangreiche Klangfarbe, die der Ton selbst dadurch erhält. Die alten Pantalons lehren deutlich, daß ein un- oder wenig belederter Hammer, wegen der Härte des Holzes, immer nur einen schneidenden, schreienden Ton hervorbringt. Dies hat Einige zu der Ansicht verleitet, daß, so bald man durch wenig aufgelegtes Leder dem Tone das unangenehm Schreiende und Schneidende genommen habe, man nur schwach beledern dürfe, um dem Tone eine in jenem Schneidenden immerhin enthaltene markige, volle Klangfarbe zu belassen; allein auch der Unerfahrenste wird sich von der Nichtigkeit dieser Ansicht sogleich überzeugen, wenn er nur neben ein so schwach- ein besser beledertes Instrument stellt, und beide mit einander vergleicht; jenes wird allemal, auch was die Kraft und Fülle des Tones betrifft, von diesem weit übertroffen, wenn anders nur Resonanzboden, Mechanismus und überhaupt die Construction in sonst gehörigem Verhältnisse zu einander stehen. Ja es ist sogar allgemeine Regel, daß, je mehr und stärker ein Instrument beledert ist, desto stärker, voller auch sein Ton ist; freilich mit Maaß, so wie überall ist auch hier jeder Ueberfluß von Nachtheil.

Neuester Zeit belegen die anerkannt geschicktesten Meister die Hämmer der Flügel im Basse bis zum eingestrichenen e oder f mit einem fünffachen, weiter hinauf dann mit einem vierfachen, und die tafelförmigen Claviere durchgehends mit einem vierfachen Leder; doch hat Graff in Wien auch mit eines Theils glücklichem Erfolge den Discant seiner Flügel fünfmal beledert, und

dagegen das Holz des Hammers verdünnter genommen, damit dieser in seiner ganzen Masse in richtigem, verjüngterem Verhältnisse zu denen des Basses stehe. Was er dadurch gewonnen, ist eine größere Klangfülle, ein allerdings glockentöniger Gesang des Discants, der aber zu überwiegend gegen den Baß ist, und diesen daher in völliger Dumpfheit, Heiserkeit, Breite und zu schwach erscheinen läst. Durch eine mehrzählige (also sechsfache) Belederung des Basses dem abzuhelfen, wird schwerlich gehen, da der Ton alsdann wegen der, im Verhältniß zu der Härte des angeschlagenen (Saite), zu großen Weichheit des anschlagenden Gegenstandes (Hammer) kraftlos, patschig werden muß. Um eben dieses Umstandes willen muß denn auch das Leder möglichst straff angezogen seyn; zu locker aufgelegt macht es den Ton ebenfalls kraftlos, heiser, patschig, platt; das unterste, auch wohl die untersten beiden Lagen Lederstreifen werden durchgehends über das Hammerholz fest geleimt, die übrigen aber nur an beiden Enden; in der Mitte liegen sie frei, die innere Seite nach außen oder oben gewandt, weil der mehrmals aufgetragene Leim den Hammer sonst wiederum zu hart und dadurch den Ton zu schneidend machen würde.

Natürlich müssen die beiden Enden der Leder abgeschärft, und die oberen Leder immer um etwas länger als die unteren seyn, um mit dem Holze eben zuzulaufen. Eine besondere Rücksicht ist noch zu nehmen auf das Verhältniß der Lederstreifen zu einander; zur obersten Lage muß immer das beste, ebenmäßig dickste und weichste Leder genommen werden, bei einer durchgehends vierfachen Belederung (Fortepiano) aber so, daß die Baßhämmer immer noch stärkeres Leder bekommen als die des Discants, deren Holz natürlich auch schwächer ist, und bei einer fünf- und vierfachen (Flügel), daß der Uebergang zu beiden Verhältnissen unmerklich wird. Hieraus folgt nun aber noch nicht, daß *alle* Claviere vier- oder fünf- und vierfach beledert werden müssen; es hangt dies noch sehr ab von der Stärke der Saiten und des Resonanzbodens; bei einem schwachen Bezuge kann jenes Verhältniß schon mehr als zu viel and daher nachteilig, eine drei- und vierfache Belederung schon vollkommen hinreichend sein, und erhalten wir vielleicht noch stärkere Saiten, die die nöthige Spannung aushalten, oder einen noch stärkeren Bezug, so wird auch eine noch mehrzählige Belederung nöthig werden. Wir urtheilen hier nach den bekannten Berliner Saiten, und nach dem Verfahren der jetzt berühmtesten Meister, Graff in Wien, Rittmüller in Göttingen, Schiedmaier in Stuttgart und Streicher in Wien.

Was nun endlich noch das anzuwendende Leder an sich betrifft, so herrschen verschiedene Meinungen. Einige ziehen das Gems-, Reh- und Hirschleder vor (namentlich alle Engländer und Franzosen) und verwerfen das Schaafleder ganz; auch Carl Kützing, der 1833 ein "theoretisch-practisches Handbuch der Fortepiano-Baukunst mit Berücksichtigung der neuesten Verbesserungen" zu Bern und Chur herausgab, spricht dem Schaafleder alle zu diesem Behuf erforderliche Elasticität ab; allein wir können alle dem nicht beistimmen. Schiedmaier, dessen Instrumente, Flügel sowohl als tafelförmigen Fortepiano's, unstreitig in jeder Hinsicht, besonders aber was Schönheit des Tones anbelangt, den ersten

Rang behaupten und wahrlich keinen klatschenden oder patschigen Anschlag haben, so wie alle die übrigen Meister wenden kein anderes als Schaafleder an, freilich nicht jedes, sondern das braun gegerbte, sogenannte Wiener Patentleder, das selbst das Gemsleder noch an weicher, elastischer Masse übertrifft; Reh- und Hirschleder ist selten eben und wollig genug. In einigen Pariser Fabriken, namentlich in der von Kalkbrenner, wird auch ein besonders zubereiteter Hutfilz dazu genommen; allein so gut auch der dadurch hervorgebrachte Ton anfänglich ist, so ist die Masse dennoch zu locker und faserig, als daß sie nicht gar zu leicht durchgespielt werden könnte und dann binnen kurzer Zeit einen gedämpftzischenden und unebenen Ton hervorbrächte, also durchaus nicht dauerhaft genug. Ganz unzweckmäsig ist Molton oder dicker Flanell, und es muß auffallen, wie auch jetzt noch manche englische Instrumentenmacher, selbst der vielgerühmte Broadwood, ihn – wenigstens im Basse – anwenden. Ein 1826 von diesem verfertigtes Instrument, das wir vor Kurzem zu Gesicht bekamen, überzeugte uns von der Klanglosigkeit, Mattigkeit und Plumpheit des dadurch erwirkten Tones. Wie hier wird auch in allem Uebrigen ein gutes geübtes Gehör und verständiges Nachdenken bei Versuchen sicher zum Ziele führen.

Appendix 2

Extracts from Giacomo Ferdinando Sievers, *Il Pianoforte. Guida pratica per Costruttori, Accordatori, Dilettanti e Possessori di Pianoforti con 300 disegni parte intercalati nel testo e parte in apposito atlante di Giacomo Ferd. Sievers Fabbricante di Pianoforti in Napoli,* Naples 1868:

On hammers (pp. 127–130)

Martelli.

Le diverse figure N° 218, Atl. Tav. 4, dimostrano le grossezze dei martelli che convengono a tutti i generi di pianoforti; benchè molti fabbricanti non usano martelli con teste di legno, e la fanno invece con grossezze di cuoio di suola, od altra specie di pelle più dura possibile, pure ognuno dovrà convenire che le teste fatte di legno presentano maggiore eguaglianza di durezza e di forme rispetto alle altre fatte di pelle. Un pezzetto di pelle può essere più teso dell'altro, più spugnoso o sfoglioso, può anche scollarsi, mentre il legno sarà sempre eguale.

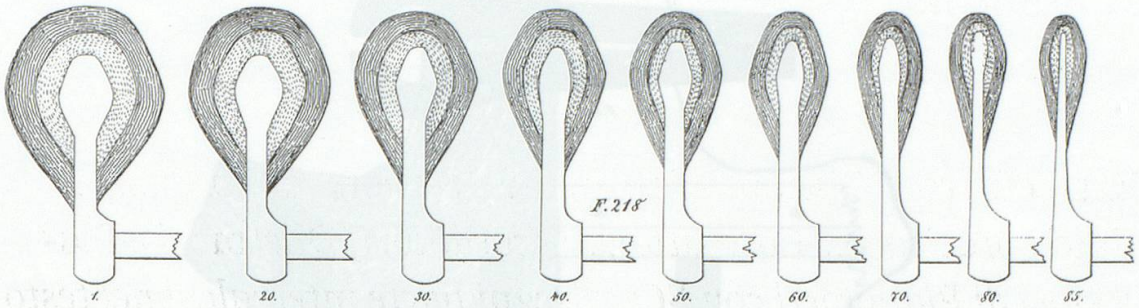
Nelle figure 218 le teste dei martelli sono di forma conica invece della rotonda anticamente usata; noi stessi abbiamo sperimentato e trovato excellente questo genere, purchè il disopra del martello sia di proporzionata ampiezza.

Il feltro in questo modo piegato intorno al capo, presenta maggiore tensione ed aderenza, mentre coll' antico sistema dei capi rotondi era meno teso e rendeva un colpo fiacco.[1]

Perciò la grossezza dei martelli influisce molto sulla qualità del suono; un martello piccolo nei bassi produce un suono secco, piccolo ed esile, mentre un altro proporzionato alla grossezza e lunghezza delle corde dei bassi, produce un suono grave, grosso e rotondo, purchè non si esca dai limiti; così un martello troppo grosso negli acuti rende voce ottusa piuttosto che suono.

Come un grosso maglio a guisa di una palla col manico, di cui i musicisti si servono a percuotere il timpano della gran cassa, farebbe un cattivo effetto sopra un piccolo tamburo, e la bacchetta del tamburo un meschino effetto sulla

1 All'esposizione 1867 a Parigi fra i pianoforti d'Austria abbiamo veduto che qualche fabbricante ha voluto imitare questo genere, ma i loro martelli erano divenuti talmente aguzzi, che i primi dei bassi, benchè grossi o pesanti, avevano il piano di sopra come qui nella fig. 218 il N. 40; ne doveva risultare un effetto meschino.



gran cassa, così le grossezze dei martelli per i pianoforti debbono anche stare in proporzione delle grossezze e lunghezze delle corde.

Preferiamo i martelli di legno duro, più sottili (purchè resistano al tiraggio delle pelli) e non troppo alti. I martelli alti tremolano alla percussione, e diventano più pesanti; perciò è cosa ottima di farli tanto bassi, per quanto il pancone lo permette nei pianoforti a coda, e che abbiano l'altezza giusta per potervi bene incollare i feltri o le pelli, acciocchè le teste acquistino anche la necessaria ampiezza.

Ora dacchè per la prima grossezza dei bassi e dei medii abbiamo feltri a scelta, che s'incollano con colla forte e coi stringitoi a tenaglie intorno a tutto il capo del martello, diventa facile a fare le giuste grossezze delle teste; ma per più di due ottave negli acuti il feltro non regge, perciò bisogna incollare 4 a 5 grossezze di pelle di montone, delle quali soltanto l'ultima sottopelle non dev'essere incollata sopra il piano delta testa che tocca le corde. Per le prime grossezze è buono di aver pelli alquanto crude e dure di concia; solamente le due ultime grossezze di sotto pelle debbono essere di qualità più morbida.

Quelle del genere chiamato *pelle Basin* sono da noi preferite; esse si tagliano in strisce a traverso e si assottigliano diminuendole verso gli acuti con una pietra pomice.

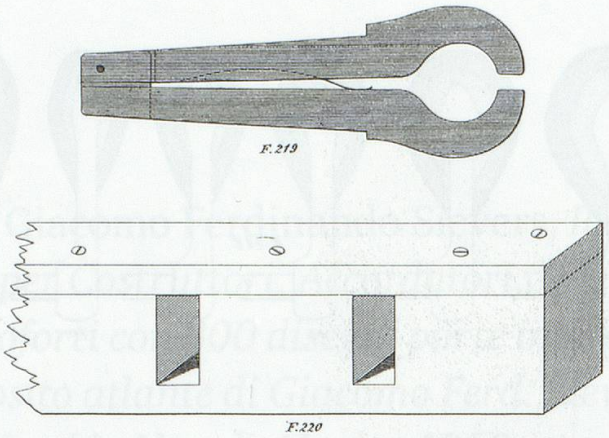
Si badi però che la pelle non sia sfogliosa, poichè con le parti sfogliose sarebbe lavoro perduto.

Per ben incollare i feltri e le sotto pelli, gli stringitoi sono di assoluta necessità; i pezzetti di feltro debbon essere un poco più lunghi per afferrarli meglio ed il soverchio poi si toglie col coltello.

Ridotta alla metà di grandezza la fig. 219, Atl. Tav. 4, rappresenta uno di questi stringitoi, e la fig. 220 è un lungo pezzo di legno con 13 fori quadrati che formano giusto il numero occorrente per un' ottava.

Dopo incollato il feltro al martello, si spinge lo stringitoio, che ha figura conica, in uno dei fori e si seguita a fare lo stesso con tutti gli altri martelli.

Tanto i feltri quanto le sotto pelli debbon essere incollati cogli stringitoi prima di una parte del martello; quando questa è asciutta, si può tirare il feltro con tutta la forza per incollarlo dall'altra parte e rimetterlo bene stretto nel foro.



Quando i martelli sono ben preparati di grossezza, forma e compattezza, le sopra pelli sono facili ad incollare da lato a lato, evitando sempre la colla sopra il capo dove il martello tocca le corde.

Queste ultime pelli non han bisogno degli stringitoi; la sola mano basta, e le dita avvezze sapranno stirarle tanto quanto è necessario.

Vi è però da osservare che si deve sempre prescegliere la sopra pelle di cervo, che sia dalla parte carniccia pelosa morbida, e nell'istesso tempo che non cedesse troppo allo stirare, quando s' incolla sulla testa dei martelli.

Sono da preferirsi le pelli di cervi maschi, perchè quelle delle femmine in generale sono troppo cedevoli, dovendosi allargare quando sono nello stato di gravidanza.

Prima della conciatura si riconoscono benissimo alle mammelle, ma dopo, questa distinzione sparisce, e si possono conoscere solamente alla cedevolezza in tutti i versi.

La ragione di questa preferenza sta in ciò che, se il pezzetto di pelle sul martello è troppo tirato per farlo ben appoggiare, si sente al tocco sotto le corde, locchè in arte si chiama arenoso, come se vi fosse della sabbia nella pelle; se al contrario si tira meno, allora non appoggia bene e si sente un guazzare molle molto dispiacevole alla percussione della corda.

Del resto anche le pelli dei maschi, quando sono stati ammazzati dopo la stagione di buon pascolo, si ritrovano più grassi; se l'animale è di media età o piuttosto giovane, anche la pelle è più grassa, doppia e più cedevole, e le pelli grasse non sono mai ben secche.

Il miglior punto è quanto l'animale non è nè troppo grasso nè troppo magro e di giusta età.

La pelle di cervi in generale si deve tagliare a traverso per aver i pezzetti per lungo, perchè quelle pelli non cedono col verso dei peli (ved. fig. 221).

Alle giunture delle gambe, dove i peli s'incrociano in tutt'i sensi, non vi è modo di trovare un verso in cui la pelle non cedesse.

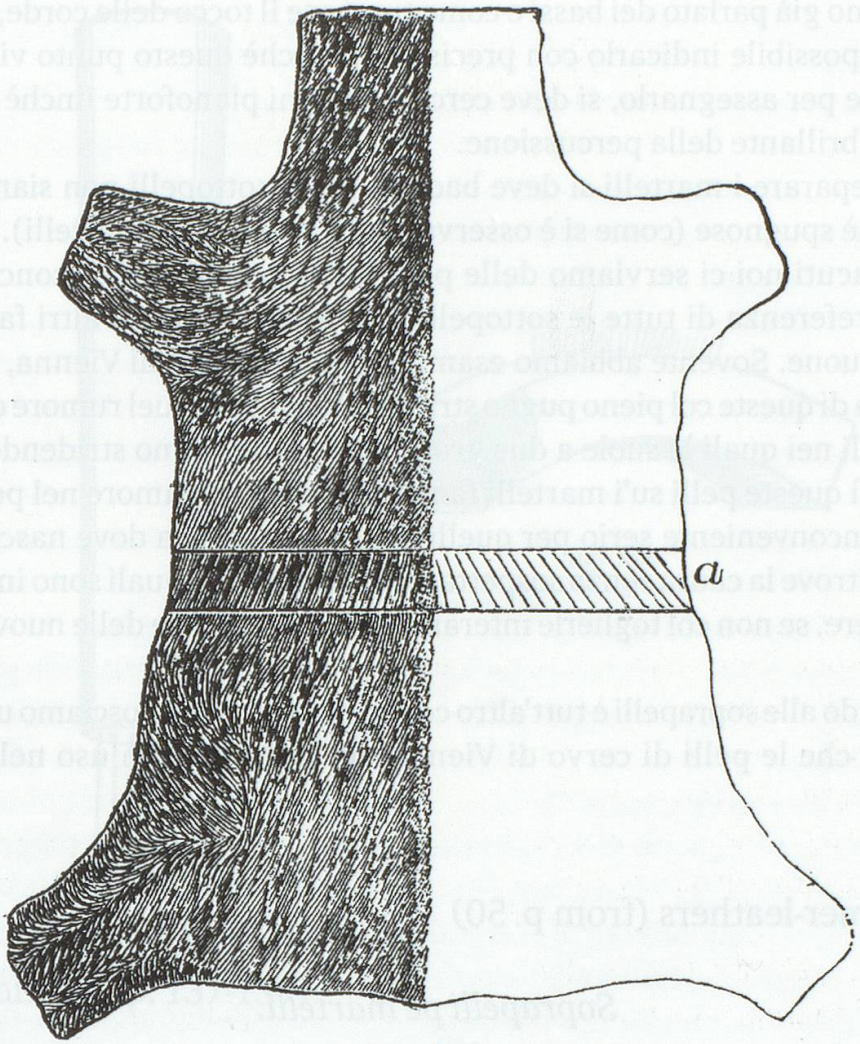


fig. 221.

È buono anche di tagliare i pezzetti per lungo come si vede nella fig. 221a, acciocchè corrano nel verso dei peli; debbon essere anche di eguale larghezza, perchè i pezzetti più larghi hanno più resistenza degli stretti, e le dita dell'artefice non possono sempre cambiar forza e tatto; perciò è buono che ogni pezzetto abbia l'istessa resistenza. Se l'artefice non è distratto, la forza ed il tatto delle dita non cambia, e cosi i martelli riescono tutti di eguale carattere e colorito per la voce.

Further remarks on hammers (pp. 136/7)

In primo luogo si deve vedere se i martelli sono in grandezza proporzionale alle corde; i martelli troppo grossi al piano di sopra negli acuti producono piuttosto rumore che voce; se sono troppo piccoli, la voce diventa secca e meschina.

Indi si veda se arrivano ben in squadro sotto le corde e se le percuotano al loro giusto punto.

Abbiamo già parlato dei bassi e come trovarne il tocco delle corde, ma negli acuti è impossibile indicarlo con precisione, perchè questo punto vi è troppo sensibile, e per assegnarlo, si deve cercare in ogni pianoforte finchè si trovi il punto più brillante della percussione.

Nel preparare i martelli si deve badare che le sottopelli non siano troppo morbide nè spugnose (come si è osservato nell'articolo dei martelli).

Negli acuti noi ci serviamo delle pelli Basin napolitane di concia mezzo crude a preferenza di tutte le sottopelli di Germania che gli altri fabbricanti credono buone. Sovente abbiamo esaminato le sottopelli di Vienna, ma prendendo una di queste col pieno pugno stringendo, si sente quel rumore che fanno certi stivali nei quali le suole a due grossezze si stroffinano stridendo ad ogni passo; così queste pelli su'i martelli fanno un continuo rumore nel percuotere le corde, inconveniente serio per quelli che non sanno da dove nasce, perchè cercano altrove la causa senza sospettare le sottopelli, le quali sono impossibili a correggere, se non col toglierle interamente ed incollarne delle nuove di altro genere.

Riguardo alle soprapelli è tutt'altro conto; in fatti non conosciamo un miglior materiale che le pelli di cervo di Vienna, da molti anni in uso nella nostra fabbrica.

On hammer-leathers (from p. 50)

Soprapelli pe'martelli.

I fratelli Geyer in Eisenberg usano una loro speciale concia con le pelli di cervo del Canada per le soprapelli dei martelli, che dà un ottimo materiale di bell' effetto per la voce, e di lunga durata; eglino hanno una delle più grandi fabbriche di questo genere in Germania.

Cosi anche le fabbriche di Tomas Gallasch, Hundsthurm Hauptstrasse 104, e l'altro Joseph Gallasch anche Hundsthurm Hauptstrasse 98 casa propria, ambi in Vienna, hanno le loro specialità di concia per le soprapelli dei martelli giustamente rinomate; eglino lavorano per lo più le pelli di cervo della Germania, benchè abbiano anche quelle del Canada; ambe le specie di un colore legno giallognolo; ben scelte sono ciò che si può desiderare di meglio.[2]

2 Il costo di queste pelli varia secondo la qualità e la grandezza da 6 a 20 fiorini d'argento per una pelle.

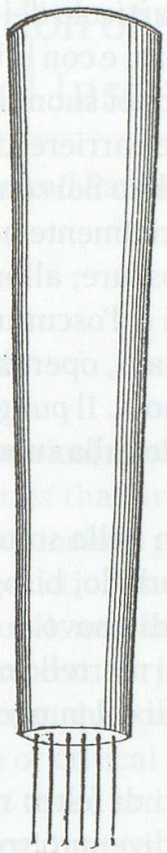


fig. 228.

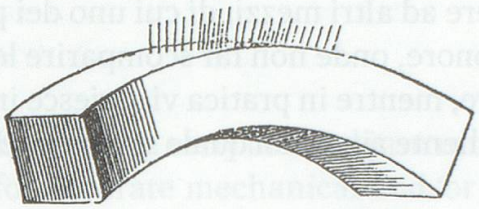


fig. 229.

On intonation (pp. 137-139)

Sull' Intonazione.

L'artefice deve aver guarnito molti martelli per arrivare a conoscere il modo di stabilire l'uguaglanzia dell'intonazione.

Non si deve avvilire quando gli capita un pianoforte ribelle, perchè non di rado si debbono strappare cinque o sei volte le pelli di una porzione di martelli, senza poter indovinare il colorito.

L'udito si stanca, ed allora è meglio abbandonare il lavoro, per poi reprenderlo un altro giorno con la mente fresca e riposata.

A pianoforti di false proporzioni, falsi punti di percussione, o difettosa tavola armonica, sarà impossibile di colorire il suono in gradata eguaglianza dai bassi fino agli acuti. Le pelli possono dare un suono più o meno flautato o brillante, ma la vera scintilla mancherà sempre negli acuti, e la diversità di timbro da un tasto all' altro sarà sensibile nei medii e nei bassi.

Ogni corpo ha il suo suono naturale. Le note che corrispondono in diretta armonia col suono naturale della cassa con tutti i suoi aderenti saranno più favorite delle altre, cioè: se la cassa corrisponde alla nota di *Do*, questa con la sua terza e quinta saranno più sonori naturalmente del *Do diesis* e di tutte le note che non stanno in armonia col *Do*, suono fondamentale del corpo.

Coll' accordare la tavola armonica, come noi nell'articolo dei tompagni l'abbiamo descritta, si ovvia molto a questa inconvenienza, e con le ben scelte pelli e feltri messi ad arte si ricava da questi tompagni quei suoni fluidi della più bella qualità. Alle volte però s'incontra l'intoppo fra le barriere, dove la voce del basso entra nel baritono, il baritono nel tenore, e questo nel contralto ecc.; nei bassi e medii non si sente tanto, ma negli acuti, specialmente nella penultima ottava, vi si sentono tre a quattro note più o meno oscure; allora si è costretti di ricorrere ad altri mezzi, di cui uno dei più efficaci è d'oscurare diverse note troppo sonore, onde non far scomparire le meno chiare, operazione difficile a descrivere, mentre in pratica vi si riesce in diversi modi. Il *pungitore* (fig. 228) è un eccellente ajuto, col quale si rende pelosa la pelle sulla superficie del martello.

Se questo è troppo duro, il pungitore penetra fin nella sottopelle d'avanti oppure di dietro; se è troppo aguzzo e alquanto morbido, bisogna scollare la sopra pelle da un lato, tirarla più forte ed incollarla di nuovo.

Qualche volta una moderata battuta sul piano del martello con un pezzo di legno a ciò preparato corregge; dopo si rialzano i peli col pungitore per aver il tocco vellutato.

Nell'istesso modo si pratica coi martelli guerniti di feltro nei medii e nei bassi, senza però alzare troppo la lana; una volta divenuto troppo vellutato il feltro, non si può più indurirlo che col togliere la lana con le forbici, locchè guasta la grossezza del feltro e la forma del martello. Altri premono la lana con un ferro caldo; pessimo sistema! Il martello che ha subito un ferro caldo è guastato interamente, mentre chi sa bene adoperare il pungitore, farà sempre buona figura per l'eguaglianza della voce; si può adoperarlo in tutte le parti del meccanismo dove vi sono dei feltri e delle pelli ad ammorbidire.

Utilissimo è il piccolo ordigno chiamato il *cardo* (fig. 229 di naturale grandezza); esso consiste in un pezzetto concavo di legno pioppo o tiglio pulitamente fatto, avendo in mezzo circa 30 punte d'aghi finissime appena sporgenti. Questo ordigno si passa attentamente sopra il capo dei martelli nuovi per alzare i peli del feltro e renderlo vellutato. Così non si maltratta la superficie del martello; egli diventa morbido, pulito ed eguale, e quello che è più: produce un buon effetto.