CHAPTER 3

DEVELOPMENT OF THE PIANO

The making of other instruments (even the organ) can be done in the traditional way of the individual craftsman who makes each part himself and fits them together one by one, using only simple tools. But a piano involves many different technologies; the making of hammers, actions, wires, and frames requires several entirely different skills and facilities, which no one workman has. It is necessarily an industrial project with organized cooperation of many different specialities. If a modern piano was made by an individual craftsman in a small shop, it would be of greatly inferior quality, it would cost hundreds of times more than it does, and the number of pianos in the world would be a thousand times smaller than it is. For this same reason, the development of the piano was a vastly more complicated process than that of any other instrument, requiring many different people to contribute their special expertise to the solution of many different problems, and warranting a separate Chapter for it.

The Harpsichord

Although it took place in Europe, the early development of the harpsichord is slightly mysterious today. Some authors state that the principle of plucking strings with flexible crow quills started from the Spinet by Giovanni Spinetti of Venice (1503). However, others make the more plausible claim that the Italian name 'spinet' or French *épinette* comes from the Latin *spina* (thorn),† that spinets existed under that name for perhaps a hundred years before 1503, and Spinetti merely named himself for the instruments he made, a common custom then. An Italian instrument used by Queen Elizabeth I (1533–1603) may be seen in the South Kensington Museum, London; she was an accomplished performer on it.

The first spinets produced feeble sound, with a different quality for different keys. Much more experimentation with size and shape of bridge and soundboard, and string length and tension, was needed to develop a satisfactory instrument. Larger, louder, and more uniform sounding instruments called harpsichords appeared in the middle 16'th Century, and were well developed over the next 100 years, as the Belgian Ruckers instruments of 1590 – 1659 show. By the time of Alessandro Scarlatti (1659 – 1725) the harpsichord had settled down into a more or less perfected standard product, present in considerable numbers throughout Europe.

Metamorphosis Into The Piano

A harpsichord string can produce only one sound however you press the key, because the quill always breaks free at the same point – where it is placing the same force on the string. Thus there is no dynamic variation *on any one key*. However, this can be overcome in three ways. Firstly, install a second manual, which controls another set of strings and gives the player the option of plucking two or three strings on a note, making a variation

† The English words 'pin' and 'porcupine' – literally, 'pig with thorns' have the same Latin origin.

of loudness and tone. This was tried about the middle of the 17'th Century, but it was expensive and never really satisfactory.

Easier, and much better, one can recognize that in most music the dynamics is quite simple: "expression" consists mostly of emphasizing the highest notes in a phrase (in imitation of a human singer, who must work harder to produce higher notes). So the builder needs only to make the quills progressively stiffer, so they pluck the higher notes harder. In the best harpsichords, this slight automatic gradation of loudness is carried out so smoothly that it does not call attention to itself; yet in the playing one is seldom aware of any dynamical limitation compared to what can be done on the piano.‡ Nevertheless, if one wants to emphasize any note strongly in a phrase or chord, or give prominence to a bass figure over the treble, it cannot be done on a harpsichord.

But neither of these solutions deals with another major problem of the harpsichord, the harsh, twanging sound that the builders tried unsuccessfully to soften (although today many scientists could tell them how to do it). Apparently, this sound is offensive only to Western ears; the Sitar of India has it to a far greater degree than does the harpsichord, due to what we would consider inappropriate scaling (length, density, tension) of the strings; but nobody seems to complain about this. Note that "tone" is concerned with the distribution of pitch in the many vibrations produced by a single string; not the variation of overall loudness over different strings, as discussed in the last paragraph.

Actually some progress was made in this respect; the Italian harpsichords, following their early spinet tradition, were small and light (the string for C above middle C only about 10 inches long) with a shrill, penetrating tone. The Flemish instruments evolved from them achieved a darker tone, generally regarded as more sophisticated, by making the instruments bigger (the aforementioned string is now about 14 inches long; this length is still used on our modern grand pianos).

The third solution solves both of these problems; and actually it had been well known for centuries before Spinetti. The dulcimer is an ancient instrument, which is essentially a long zither played like a xylophone, with the strings struck by little soft–headed hammers held in the hand. Its pleasant tone and great possibilities of musical expression were well known, so it is very hard to understand why over 200 years passed, during which time makers of spinets and harpsichords were struggling to improve the sound, before this principle was applied to the harpsichord. Actually, we know that several people did suggest this; but they were not listened to, for reasons that we cannot comprehend today (but of course, the phenomenon of a person in deep trouble, who indignantly rejects the only thing that can help him, is observed in every field of endeavor).

Finally, in the early 18'th Century, the decisive step was made. In Florence, the Prince Ferdinand de Medici kept in his palace forty harpsichords and spinets. To maintain them all in working order required an in–house master mechanic, so he hired a young harpsichord maker from Padua named Bartolomeo Cristofori (1683–1731). Fortunately for us, it seems that maintaining the Prince's instruments was not quite a full–time job, for Cristofori found there both the time and the facilities to try out the dulcimer idea,

‡ This is not to say that the actual physical sound *energy* generated is greater in the treble; measurements show the opposite to be true. However, what matters is the loudness as perceived by human ears. Our ears are more sensitive to high pitches than to low; and this more than compensates the greater bass energy.

completing his first instrument in 1707. It was, of course, far from satisfactory on the first try, and he continued to experiment, producing a fancier looking one in 1711, and his first *real* piano in 1720. We do not know how many more he made.

The Cristofori Piano of 1721

This is believed to be the oldest piano still in existence, and it can be examined in the Metropolitan Museum of Art, New York.* The writer spent a long afternoon studying it from every possible angle and recording measurements on it (the guard became suspicious when I crawled under it, but I managed to convince him that I meant no harm, and was merely very interested in knowing how Cristofori did things; particularly the things that are usually out of sight). Here are some of the notes that I made on it:

The case has the standard harpsichord shape (like a thin grand piano, except that the back is cut off square instead of rounded). The "white" keys are of light–colored wood, the "black" keys and key blocks are apparently of ebony. It has no pedals. It was discouraging to see that there were loose strings and broken parts; no effort had been made to restore it to playable condition or even its original appearance, although the latter could have been done easily.†

This piano encompasses 4.5 octaves, ($C_2 \rightarrow F_6$).‡ Most of the notes are double strung with thin brass wires, although the lowest four are single thick brass wires. The top treble string is 5" long, and is struck 0.5" from the end; the bottom bass string is 5.5 feet long and is struck 0.5 foot from the end. The key dampers function in the same way as the modern ones, with the peculiarity that they rise on wires that go *between* the strings damped; one is working at dangerously close quarters here.

Today we would consider it an error, making a shrill, tinny tone, to strike a middle range string only one tenth of its length from the end. Probably he was only copying Italian harpsichord practice here, not realizing the importance of the striking point. For the top few notes the striking point does not matter very much as far as tone is concerned (this affects only high overtones beyond the range of human ears), but it would increase the efficiency of sound production to move the striking point further from the end of the string; this opportunity is still missed on modern pianos.

The bridge and sound board also copy harpsichord practice, but are not very different from those on a modern piano. The slanted pegs that press the strings to the bridge are identical with those on a modern piano, except that the bottom seven strings have only one peg, while a modern piano has two pegs on every string. The bridge is not undercut

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* Another Cristofori piano, dated 1726, is in the Museum of Leipzig University.

† Restoring it to playable condition would be a major undertaking, since the action had no bearings. Their function was served by leather hinges, which after 250 years would probably disintegrate on any attempt to bend them; so every one would need to be removed and replaced.

‡ By C_3 we mean the third C from the bottom on a modern piano, by A_5 the next A above C_5, etc. Thus C_4 is middle C, A_4 is the A 440 tuning base, C_2 is the "Cello low C", C_6 is the "Soprano high C", and G_3 is the lowest note of a violin. On a modern piano the lowest note is A_0, the highest C_8. Note that before 1960 some writers used an index one lower; C_3 stood for middle C. Our notation agrees with Benade (1976) and other recent writers. Also, some writers from Helmholtz (1877) to the present use small letters and primes to denote notes measured *from* middle C; thus f''' would mean the third F above middle C, what we call F_6.

on the bass end as it is for about the bottom octave on a modern piano (to give more flexibility to the sound board).

The action of the piano is shown in Fig. 3.1:

cristex6.pcl2.54

Figure 3.1. The Cristofori Piano Action

One can recognize several features of the modern piano action; the key K which turns on a pivot so that its back end rises when a key is depressed, the hammer H with a familiar shape but unsatisfactory material (wood covered with leather), the vertical jack J which conveys the key motion to the hammer, the escapement E, which disconnects the hammer from the jack just before it strikes the string, the back check B which catches the hammer on the first rebound from the string and prevents it from striking the string a second time, the damper D which stops the string from sounding when the key is released. He surely worked long and hard to get that far. This action was successful enough to survive for some time in the works of other piano makers; it was easy to play (requiring less force than does a modern piano), but lacked the rapid repeated action that we are accustomed to today; after playing a note one must release the key all the way up and allow the hammer to settle back down to its original position before the note can be repeated.

All in all, it is astonishing how many features of the modern piano were worked out already by Cristofori, in only about fifteen years of part–time experimentation. But it required 150 more years to complete the development, up to the stable design that was reached about 1870.† There were several obvious things still needed; a sustaining pedal (although this is a triviality that Cristofori could have added at any time); better materials for strings, which were not available then, better materials for hammers (this required a major research effort with results that are not yet 100% satisfactory), a stronger and more stable frame, so that it could stand a higher tension on the strings and stay in tune when the weather changes; but most of all, a faster, more reliable repeating action.

Silbermann, Stein, and Broadwood

Gottfried Silbermann (1683–1753) of Freiberg, Saxony, was an organ builder who became interested in the dulcimer principle and started experimenting with a simple action invented by Cristoph Schröter, a German organist. In 1728 Silbermann made a pianoforte with the Schröter action; but then learned about the Cristofori action and switched to it. The action of Fig. 3.1 is found unchanged in the pianofortes [said by Forkel (1802) to number originally 15] made by Silbermann for the various palaces of Frederick the Great. His *Sanssouci* palace at Potsdam was completed in 1747, and in that same year Johann Sebastian Bach visited it and, as narrated by Forkel, played on several of them.‡ He had tried previously

† We do not mean to imply that the modern piano is now perfect; only stable. As noted later, it still has many serious imperfections that could be corrected easily without any increase in cost.

‡ In December 1991 the writer visited *Sanssouci* and saw one of these pianos, still there in Frederick's magnificent music room [depicted very accurately – even to fine details of the rococo wall decorations – in the painting by von Menzel, reproduced on the inside covers of the Larousse Encyclopedia of Music (1974), which shows a concert in progress with Frederick himself at the flute]. The piano is fancier than Cristofori's, with four trumpet–turned front legs and a cover that

one of Silbermann's first efforts and complained that it was weak in the treble – which Silbermann tried to correct, without success.* This would be particularly bothersome to one who was used to good harpsichords which, as noted, become progressively louder in the treble. But Bach was too polite to repeat that complaint to Frederick, and instead he improvised grandly on a theme that Frederick gave him, which later expanded into his *Musical Offering.*

In spite of their defects, the Silbermann pianos remained in use for many years and played an important role in piano pedagogy. Carl Philipp Emanuel Bach spent several years at Frederick's court starting in 1740; and while there, with Silbermann pianos available for his use, he wrote his famous "The True Art of Playing the Clavier" which, 50 years later, Beethoven required his piano pupils to read. In 1772 C. P. E. Bach was living in Hamburg and the English writer Charles Burney visited him. He reported (Burney, 1773) that Bach had a Silbermann piano in his music room, and played it beautifully for hours.

Silbermann had four apprentices who learned the craft and, about the time of his death, went out into the world to seek their own fortunes. Johann Andreas Stein went to Augsburg with the Schröter idea, and developed it into the light "German action" which he manufactured with great success, as we shall see. The characteristic feature of the Schröter action is that the hammer butt is not fixed, but moves up and down on the key. Christian Friederici went to Gera in West Saxony and started the development and production of vertical and square pianos, in particular some square art pianos which found their way into the finest palaces, although more as beautiful furniture than as viable musical instruments; for over 100 years square pianos continued to use the Cristofori mechanism. Johannes Zumpe and Americus Backers took the Cristofori idea to England, where Zumpe made several square pianos, also not very successful as musical instruments. Far more important, they interacted with the just forming Broadwood company.

John Broadwood (1732–1812) was a Scotsman who as a young man, according to plausible legend, walked penniless all the way to London and found employment as a workman in the Schudi harpsichord factory. Zumpe, Backers, and Broadwood developed the Cristofori mechanism into the stiffer but more powerful one that came to be called the "English action" and added the sustaining pedal. The energetic Broadwood rose in the company to become a partner of Schudi, married Schudi's daughter; and thus came eventually into possession of the company. It went through some complicated name changes, but became *de facto* the Broadwood company in 1783 and turned to piano manufacture. Their last harpsichord was made in 1784; by 1984 Broadwood had produced some 270,000 pianos. For many further details, see Wainwright (1984).

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closes over the keyboard. Unfortunately, the public was not allowed within touching distance of it and the cover was closed (with Frederick's plain black flute lying on it as if to hold it closed), so the keyboard could not be seen.

* This remains one of the major defects of our modern grand pianos and the cause of bad, muffled sound by inexperienced pianists; to achieve any kind of balance between bass and treble, we are still obliged to work the right hand much harder than the left. This is particularly exasperating, because it would be so easy to correct today; yet no piano maker appears to be doing it, and modern piano actions seem designed specifically to make the problem worse. See further comments below and in Chapter 5.

The Roles of Mozart and Beethoven

In October 1777, Mozart passed through Augsburg on his way from Salzburg to Paris, encountered his first Stein piano, and wrote back enthusiastically to his father in words that have been quoted so many times that we must apologize for quoting them still another time:

> "Before I had seen any of Stein's make, Späth's claviers had always been my favorites. But now I much prefer Stein's ···. His instruments have this splendid advantage over others, that they are made with an escape action.† Without an escapement it is impossible for a piano to continue vibrating after the note is struck. When you touch the keys, the hammers fall back again the moment after they have struck the strings, whether you hold down the keys or release them."

This gives very important – but rather shocking – testimony about the kind of instruments Mozart was obliged to use before then. A sharp staccato touch on the key would be necessary in order to play anything at all on the primitive non–piano made by Franz Jakob Späth of Regensburg; but this is presumably the instrument on which Mozart practiced, and developed his habits of playing. It is startling to realize that the Mozart piano works composed before October 1777 (the six sonatas K. 279–284, which contain some of his most familiar themes) were written for such an instrument.

Since the Stein piano made such an impression on Mozart, we might expect that it would have an influence on his later piano music; some of his biographers take this for granted, although none seems ready to tell us exactly what that influence was.‡ Evidently, however, the appearance of a *legato* marking would tell us that the work was for a Stein instrument rather than a Späth; such works could not have been composed before October 1777. But for the next four years in his travels he would have difficulty in locating a piano with *legato* capability and the inspiration must have faded. Only after he made Vienna his home in 1781 would he have a piano of his own with a Stein action, so we might expect to find *legato* markings used freely in his piano works composed after about 1783 or 1784.

So we checked through the Second Schirmer Edition, revised by Richard Epstein (1918) of the nineteen Mozart piano sonatas believed to be authentic. In view of the criticisms by Saint–Saens⋆ of those early Editors who took liberties with *legato* markings in Mozart's scores, it is very hard to believe that Epstein would have inserted any spurious *legato* markings, much less removed any put there by the hand of Mozart. But we find a surprise; none of these sonatas – early or late – have any *legato* markings, with two exceptions; *sempre legato* occurs in the opening *allegro* of the Sonata in C, K. 309 known to have been composed in Mannheim – the next leg of his journey after Augsberg – in

† If the hammer does not "escape"; that is, if it is not disconnected from the key just before it strikes the string, it cannot bounce away freely from the string. As Mozart notes, although not very clearly, continuing to press the key would then keep the hammer pressed against the string and prevent it from sounding.

‡ Some have supposed that his early works were written for the harpsichord rather than the piano. But the appearance of *forte* or *piano* or *crescendo* is a sure indication that it was not for the harpsichord; and virtually all his scores are full of these marks. The only exceptions are a few very early works (K. 37–41 and 107); all of Mozart's other clavier works must have been written for an instrument with at least touch–sensitive dynamics, with or without an escapement.

⋆ Quoted in Chapter 7 below.

November 1777 (where he would have had a Stein piano available), and in the *andante* of the familiar "easy" Sonata in C, K. 545, published in Vienna in June 1788. Mozart enjoyed considerable success with his concerts in Mannheim, which at the time had the finest orchestra in Europe under the conductor Christian Cannabich,† and he stayed there over four months, composing several works before resuming the journey to Paris. So the Stein influence must have been rather transitory; we can point convincingly to such an influence on only those two sonatas. But why are they so far (11 years) apart?

There is a very plausible explanation: we suggest that the K. 545 was actually composed in Mannheim in November 1777, but not touched up for publication until 11 years later. The Mozart biography by W. J. Turner (1938, p. 231) sheds light on this. In Mannheim, Mozart gave lessons to Cannabich's young daughter Rosa on a Stein piano. In a letter of November 4, he reports that "I am working now on a sonata for his daughter, which is already complete up to the Rondo." Elsewhere he states that the *andante* is intended to be a tone picture of Rosa. Turner supposes that he is referring to the K. 309; but its *andante* seems to us too clumsy and uninspired for that purpose, and its *rondo* is long, difficult, and not very interesting; not what one would expect a young piano pupil to want to – or be able to – play. In contrast, the K. 545 has always been recognized as pedagogical music to serve just such a purpose; not only technically easy, but attractive to the pupil. Its *andante* is smooth and easy–flowing, with Schubertian simplicity and piquant but unobtrusive little harmonic embellishments, making an effect much like Beethoven's *Für Elise* and eminently suited to be a tone portrait of a young girl; its *rondo* is bright and easy to play, also eminently suited for this pedagogical purpose, yet with (we think) superior musical content to the K. 309 *rondo*.

This theory makes the 11 year delay in publication easy to understand also; in Mannheim, Mozart was preoccupied with turning out major works in hope of securing a good position; that was the whole purpose of his Paris trip. His efforts with Rosa were made only to ingratiate himself with her father, in hope of securing such a position in Mannheim. That having failed, the K. 545 was not, in his mind, a big enough work to advance this purpose with others, and any further time spent on it would have been counter–productive. Later in Vienna, when he again had a Stein action piano available and pupils to write for, he would finally have good reason to dust it off and put it back to use.

But whether our theory is right or wrong, the surprising thing is that, even after he had a Stein action piano of his own, it appears that (with this one possible excepton) Mozart never again indicated the *legato* in a piano work. After his initial excitement at discovering the Stein possibilities, he must have reverted back to his previous mind–set (a common phenomenon) and did not think of piano music in terms of finger legato. He would still prefer the Stein action because of its other virtues noted in his letter; this agrees with the later testimony of Czerny and other contemporaries about the status of staccato

† As an amusing circle of coincidences, the reason why Mannheim had the finest orchestra in Europe was that the local Elector, Karl Theodor, had inherited immense wealth from his grandmother, who was the sister of none other than that Prince Ferdinand de Medici who had supported Cristofori in the development of the first pianos! And Karl Theodor was bound by her will, which stipulated that it could be used for support of musical activities but not for raising of armies; the musical tastes of the Medici continued to have a good influence long after their time.

and legato piano playing before Beethoven.

The Stein action that Mozart praised but failed to exploit very much is shown in Fig. 3.2.‡ In all the following piano action drawings, the letters K, H, J, E, B, D denote the homologous parts of key, hammer, jack, escapement, back–check, and damper. They perform basically the same functions in all actions, with varying degrees of efficiency and reliability.

Fig. 3.2. The Stein Piano Action, Sometimes called 'the Mozart piano'

Stein's pianos became so popular that he was unable to produce them fast enough, and several competitors went into business making copies of them; in the 1780's both Mozart and Haydn bought copies made in Vienna. But throughout Mozart's lifetime, Stein action pianos were still far from ubiquitous, and Mozart had his own piano carried all over Germany for his concerts. The Stein pianos had a five octave range [that is, five full octaves, 61 keys, $(F_1 \rightarrow F_6)$], and all of Mozart's piano works are of course confined to that range (since no more advanced piano existed until some years after his death).

Nannette and Beethoven: While Mozart had high praise for Stein's pianos, it was otherwise for Stein's little daughter Nannette, then 8 years old and playing the piano as

‡ These illustrations are the best we are able to offer and they are sufficient to make the important points; but we do not claim absolute accuracy for them. They started from drawings made perhaps 100–150 years ago, with some draughtsman's conception of the action but without any indication of whether he actually had it before him as a model. Predictably, different draughtsmen produced different renditions of what was presumably the same action; so these were computer processed to combine additional information, graphical and verbal, from several different sources including White (1906), Fischer (1907), Dolge (1911), Schauffler (1937), and White (1946). No single source can be regarded as entirely trustworthy on these details, and our Stein and Streicher drawings still appear to us lacking in something; the escapements seem too crude to serve their function reliably. Of course, it is also possible that Stein or Streicher changed their actions more than once without making any public announcement of this. As in all historical research, more information would be needed to resolve puzzling questions. Today, absolute accuracy about every detail of an old action could be obtained only by examining an actual specimen of the piano, known to be still in its original condition. This would be a major undertaking, requiring years of study and travel throughout Europe; yet we wish that somebody would do it.

best she could. In a letter he makes sarcastic criticisms of everything she does, in effect condemning her for not being a fully mature musician. This tells us more about Mozart than about Nannette; it is hard to imagine any other musician becoming incensed over how an eight–year–old child plays. [Of course, Mozart himself was, at age 8, famous all over Europe for his keyboard feats.] But if not a prodigy, Nannette grew up to be an accomplished pianist who performed in public concerts and had, in most areas, a good deal more sense than Mozart had.

Stein died in 1792, and Nannette, then 23 years old, and her brothers moved the Stein piano factory to Vienna. But soon Nannette married a musician named Johann Andreas Streicher and set up the Streicher piano factory. She had thorough knowledge of every detail of piano construction and action, and managed the company herself. It was long the largest piano factory in Germany, and so Streicher pianos became familiar everywhere. In addition, she took a motherly interest in Beethoven (who was only one year younger than herself, and had also moved to Vienna in 1792) and saw to it that he had what he needed to do his work.

Beethoven was presented with a Stein piano. We have found no record of the exact date at which he received it, but several sources state that his early piano sonatas, starting with Op. 2 (1796) were composed on it. But five octaves were not enough for his needs; this is seen in many places.‡ Beethoven complained to Nannette about the 5 octave range, and she had a special Streicher piano made for him, with 5.5 octaves ($F_1 \rightarrow C_7$); several sources state that Beethoven composed many works on it.

The Streicher action of 1794 is shown in Fig. 3.3; it has evolved somewhat from its Stein forerunner.

Fig. 3.3 The Streicher Action of 1794 used by Beethoven

‡ For example, the first movement of the Sonata Op. 10 #3 has a rising figure that Beethoven obviously wanted to carry up to A_6; but he was out of piano keys at F_6, and had to truncate it with a clearly contrived alternative (bars 104–105). A player on a modern piano may complete the passage as Beethoven wanted; particularly since he repeats the same passage a fifth lower and then terminates it as expected without the contrived ending (bars 285–286). On a modern piano he could have gone on up to C_8.

We have found no record of the exact date on which he received the Streicher either (the Beethoven biographers seem curiously uninterested in such matters), but the internal evidence of his sonatas is suggestive. The sonata Op 54, published in 1806 uses the exact range ($F_1 \rightarrow F_6$) of the Stein, and all those before it are also within this range. His third piano concerto, Op. 37, believed to have been completed 1803 and the next sonata in opus numbers, Op. 57, published in 1807 but thought to have been composed in 1804, suddenly use the full range ($F_1 \rightarrow C_7$), and so could not have been played on the Stein piano.

On one occasion Nannette Streicher discovered that Beethoven did not have any good coat, a single whole shirt, or a decent pair of shoes. When he was asleep, friends would tiptoe into his rooms, and replace the old clothes with new ones. In the morning he would put them on and never notice the difference; he simply did not think about such things when engaged in the 'throes of creation', which was most of the time. But he did express his appreciation to Nannette Streicher in many sincere letters. And Beethoven did return value for what he received; the Streicher firm got the benefit of his practical suggestions about improvements in piano action, took them seriously, and markedly improved their product. By 1824 the Streicher action had evolved on to that shown in Fig. 3.4.

Fig. 3.4 The Streicher Action of 1824

This came to be called the 'Viennese action' or 'German action' with a light touch and mellow tone. Perhaps unfortunately, this seems to be the limit of development of the piano action embodying the Schröter idea; our modern pianos have evolved from a different line involving the ideas of Cristofori, Broadwood, and Érard.

In 1817 Beethoven complained to Nannette that he needed a louder piano, due to advancing deafness. This time he did not get another Streicher piano, but his plea was heard by another. Thomas Broadwood, who with his brother James had inherited their father's piano manufacturing business in England, visited Vienna and met Beethoven about this time. On his return to London he had a Broadwood grand made with special stringing, four strings to the note, which Beethoven received in March 1818.

A Broadwood action is shown in Fig. 3.5. We see that it has the same basic simplicity as the Streicher action, although with a stationary hammer butt and moving jack where Streicher used a moving hammer butt and stationary jack. This has the consequence that

when a Streicher hammer contacts the string, it "brushes" along it slightly, contributing to a mellow tone; while the Broadwood hammer bounces off the string in a purely percussive way. But there is no really fundamental difference in mechanical efficiency; the Broadwood had no great advantage in key repetition, and it need not have been any stiffer than the Streicher. It appears that it was stiffer only because it was made of heavier parts, which made the Broadwood more rugged; one had a wider dynamic range before something broke.

Fig. 3.5 A Broadwood Action

But there is an ominous sign in those three holes in the back end of the key. These are a pure invention of the devil; they were filled with varying weights of lead slugs for the specific purpose of making the action as stiff for the treble notes as the bass ones.* As we go toward the treble, the weight of the lead slugs is increased progressively to 'compensate' for the smaller weight of the hammers. One is deliberately wasting the strength of the player in just the region where the piano was already weak, without contributing anything to its musical function; something which would receive the unqualified condemnation of all pianists, if they knew it was being done to them.

Beethoven's Broadwood had a range of 6.5 octaves, ($C_1 \rightarrow A_7$) and we see its effects immediately in Beethoven's output. The 'Hammerklavier' sonata Op. 106, published in 1819, not only has a much heavier 'feel' than the earlier ones; it breaks out of the Streicher confines and uses ($D_1 \rightarrow A_7$). The remaining three sonatas, Op. 109, 110, 111, use respectively ($D_1 \rightarrow C_7$), ($G_1 \rightarrow C_7$), ($C_1 \rightarrow E_7$). Thus the evidence of Beethoven's scores tells us that his last four sonatas were composed on the Broadwood; and this checks with the known dates.

* Unfortunately, this practice still persists today; we shall return to it in Chapter 5 and see that it makes the action cheaper to build because it enables the maker to use identical mechanisms on all keys. But the musical purpose would be far better served by progressively changing the lever ratios so that in the treble notes the exertion of the player's fingers goes into useful motion of the hammers instead of useless motion of lead slugs. This, plus changing the striking point on the treble strings, would surely correct the defect that Johann Sebastian Bach complained about to Silbermann.

Of course, we do not suggest that these "baseball–type" statistics about his sonatas are of any musical significance; he would have written equally good works whatever range he was confined to. They are noted because they provide evidence on the kind of piano (and therefore the kind of piano mechanism) Beethoven had available at different times. Indeed, in the end he was totally deaf and it did not matter to him that by then he had reduced the insides of the Broadwood to a tangle of broken wires; the keys still had the same feel to him.

But how do we know that the range of Beethoven's published scores corresponded to the range of the instrument on which he composed them? Might he not have anticipated what type of piano they would be played on by others, and written the score with their needs in mind? The cogent argument against this theory is that the discrepancies go in the wrong direction; it would have defeated his purpose. His own piano had, almost always, a *greater* range than would be available to most who tried to play his works. Then, had he tried to accommodate the needs of others he would have had to ignore the extra range of his own instrument; but then that range would have been useless. The evidence of his scores is that, whenever he acquired a wider range piano, he took full advantage of it immediately, leaving others to figure out as best they could what to do about it. But what else *could* he do, if that extra range was to serve any purpose? Instead of coming down to existing instruments, he quite properly stimulated the development of better instruments that came up to him.

Our tentative conclusion from all this is that the sonatas through Op. 54 were composed on the very light Stein piano, not essentially different from what Mozart had in the last seven or eight years of his life, Op 57 – 101 were probably composed on the Streicher, and Op 106 – 111 were composed on the stiffer and more powerful 'English action' Broadwood, with dynamic capabilities more like those of a modern piano; and Beethoven was keenly aware of the difference.† But Beethoven never knew a piano with felt hammers or the modern fast repeating action.

We think that an artist performing his works today might like to have this information. By all means, use legato on all Beethoven's works just as his pupil Czerny recommended; when Beethoven did not wish the *legato*, he so indicated. But the booming dynamics sometimes heard – straining the resources of both finger and instrument – is appropriate only in the last four works (and not very often there). We think that it is utterly wrong to pound those *ff* chords in the first movement of the Op. 57 sonata to the point where the piano makes a harsh, offensive sound, as so many pianists do today; Beethoven may have been vigorous, but he never exaggerated things to the point of bad taste.

On Beethoven's death in 1827 the Broadwood was bought at auction by a dealer who later presented it to Franz Liszt, and it is now in the National Museum in Budapest. Nannette Streicher and her husband both died in 1833 but the Streicher business continued under their son and grandson until 1871 and Streicher pianos became familiar throughout Germany. But during this period the tradition passed gradually into other hands.

† Another difference, of which Beethoven may or may not have been aware in view of his hearing problem, is that the Broadwood had a much more shrill, penetrating tone than the Viennese pianos. In 1788 Broadwood instituted the design in which all strings are struck at 1/9 of their length from the agraffe, which has acoustical consequences that we shall study later.

In 1828 a new Viennese piano maker, Ignaz Bösendorfer, appears on the scene. He was also a pianist, born in 1795, who grew up in the Vienna of Beethoven and the Stein and Streicher pianos. He and his son Ludwig continued to make notable improvements in the Viennese piano, readily taking advantage of later technical advances such as faster repeating actions and cast iron frames; but always insisting on retaining the mellow "Viennese tone". However, it was found that the mellow tone could be produced just as well with a stationary hammer butt, by using a softer hammer and by moving the striking point further from the agraffe, perhaps as much as 1/6 of the length of the string. Today the Bösendorfer company is still active and continues that policy. Many – including this writer – consider the Bösendorfer piano better suited than any other for playing Beethoven.‡

Liszt and Erard: Chopin and Pleyel

Sebastian Erhardt (1752–1831) was a cabinet maker from Strasbourg who moved to Paris and changed his name to the French–like Sébastien Érard. There he learned harpsichord construction, made an experimental piano much like Cristofori's in 1777, and founded a piano factory in 1785. But he soon saw the imminence of the French Revolution (1789) and, because some of the aristocracy (including King Louis XVI himself) were his patrons, decided that it would be safer in England. There he waited out the Revolution and learned about the Broadwood piano mechanism. Then he returned to Paris with this knowledge and in 1796 resumed manufacture of pianos, becoming the dominant French piano maker (but now with Napoleon as a patron).⋆

Most important for our purposes, Érard also resumed experimentation on improvements in the piano mechanism, seeking to retain the good features of the English and German actions but to add the capability of rapid repetition of a note. This proved to be possible to an astonishing degree, although it required many years to perfect it. His "double escapement" mechanism finally reached a state of high performance and reliability in 1821, the date of his basic patent. While it was intermediate between the German and English actions in ease of playing, it was superior to both in reliability and range of controlled sounds, therefore in possibilities for musical expression. Its double escapement principle permits extremely rapid repetition of a note, beyond anything Mozart or Beethoven ever knew, and limited more by human fingers than by the mechanism.† Since 1821 the appearance of the action has changed (nearly every manufacturer has made some small

‡ My own instrument is a 6' 4" Bösendorfer made in 1953. During a year (1983–1984) at Cambridge University, England, I used a new English piano which had a much stiffer action and was much harder to play with good control; it felt as if a strong spring was opposing any effort to depress a key. With the Bösendorfer you feel that the work you are doing is going directly into the useful accelerating of a hammer – exactly what it should be doing (in the treble, however, this is an illusion, as we have just seen). The Steinway has a feel intermediate between these.

⋆ Incidentally, Érard also manufactured harps and invented the double action key–change mechanism of the modern harp. It is illustrated in the *Larousse Encyclopedia of Music* (1974); p. 262.

† This is possible because, when the hammer is only about half way down to its bed and the key about half way back up, a spring slips the jack back under the hammer, so that pressing the key back down repeats the note. At this point one can feel the tension on the key increase. Those who are used to this are dismayed upon trying to play a modern electronic piano; even though the note always sounds at the same point in key descent however high the key started above that point; and thus it might seem to realize the purpose of the escapement perfectly, one loses the

alteration), but this involved only unimportant, nonfunctional details; our present grand piano action, shown in Fig. 3.6, still operates on the same principles and so is still properly called the Érard action.

Figure 3.6. The Modern Érard Double Escapement Action

Érard became wealthy and a princely entertainer; his home, the *Salon Érard*, was one of the centers of the cultural and intellectual life of Paris. He built a concert hall, the *Salle Érard*, an enormous four–story high room encircled by a balcony at the second floor level, much like our present, even larger, Boston Symphony Hall. Here Liszt and nearly all the great virtuosi except Chopin held concerts. But Sébastien died a little too soon to see the full fruit of this, and his nephew Pierre Érard carried on the enterprise in its greatest days.

One can get some idea of the repetition capabilities of the early pianos by examining tempo markings on the music that was written for them. Franz Schubert (1797–1828) had a predilection for rapid repeated notes. Living in or near Vienna all his life, he probably never laid hands on any kind of piano except a Streicher or an old, worn–out Stein (he never had the money to buy, or even rent, a piano of his own). Then the pace of the last movement of his piano trio in E♭ Op. 100 written in late 1827, in which fourfold sixteenth notes occur many times, probably indicates the limit of the Streicher's repetition capability; Schubert marked it *Allégro Moderáto*. In a recent videotape recording (a concert at Indiana University) of this work with a modern piano, the Beaux Arts Trio takes it at a pace that we would call *Prestíssimo*. The pianist, Menahem Pressler, playing at what must be close to the limit of possibility of human fingers, uses the finger sequence 4-3-2-1 for each quartet of repeated notes. This must be considerably faster than was possible on a Streicher piano; further evidence for this is given by the Viennese pianist Adolph Baller, performing the same work 40 years earlier with the Alma trio[‡] at a considerably slower tempo and

tactile sense of when this happens, and so cannot judge how high to let the key rise before trying to repeat it. The result is that, although in general things can be done electronically thousands of times faster than mechanically, one cannot execute trills on the electronic piano as rapidly as on the acoustic one; an unexpected bonus from the Érard action.

[‡] Allegro Records, AL 1, ca. 1950.

managing the repeated notes with one finger 2-2-2-2, as the writer observed at a recital in 1953. This must be closer to what Schubert's contemporaries heard, although we can well imagine that Schubert would have preferred the Beaux Arts tempo if it had been possible then.

A half–Century later the rapid repetition that Schubert would have liked was available, and in the Liszt *Hungarian Fantasy for Piano and Orchestra* can hear repeated notes at the limit of possibility of the Érard action. But on listening to the effect we understand why, after another Century, no faster action than the Érard has been developed. Anything still faster would not be perceived as repeated notes at all; they would blend into a continuous buzzing sound. In the matter of speed, the Érard action reaches the limit of possibility of both human fingers and human ears.†

Another example is Louis Moreau Gottschalk's *Grand Tarantella*, with its chords repeated so rapidly that the human ear is barely able to detect this. It could not be played at all at the pace we are used to hearing it, on a piano without the Érard action. On the other hand, if successive notes are different, the piano mechanism places no limitation on velocity; only the capability of human fingers matters then. The Mendelssohn G minor Piano Concerto – a youthful show–off which says, in effect, "Look how fast I can play!" has no repeated notes, so perhaps Mendelssohn could play it just as fast on a Streicher as Liszt could on an Érard.

Érard pianos became ubiquitous in Paris and Hector Berlioz, in his role as music critic, gave them the strangest testimonial a piano make ever received (Barzun, 1956). At the *Conservatoire*, he had been obliged to hear a piano competition at which all the contestants played that Mendelssohn concerto on an Érard piano. After thirty performances, he reports, the Érard starts playing the concerto by itself. Nobody can stop it, so they send for the manufacturer; but Érard himself cannot stop it. He sprinkles it with holy water, with no effect. They remove the keyboard but it continues to play; Érard has it chopped up with an axe, but each piece still dances about playing Mendelssohn's Concerto. Finally they are obliged to throw them all into a fire. Berlioz concludes: "*There was no other way to loosen its grip. But, after all, how can a piano play a concerto thirty times in one day without contracting the habit of it? M. Mendelssohn won't be able to complain that his music isn't being played. But think of the damage!*"

Enter Pleyel: Érard had one important competitor in France. Ignaz Pleyel (1757–1831) was born near Vienna, a child prodigy who studied harpsichord and piano with Haydn for five years. He became a successful composer and, in 1783, Kappellmeister of Strasbourg Cathedral. But he too needed to escape the French Revolution; after some

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† It is also coming up against an even more fundamental limit, arising from the nature of sound itself. Each note has a definite number of vibrations per second, and it must last long enough for several cycles before it is perceived as having a definite pitch. For example, the note A440 vibrates at 440 cycles per second. If it sounds only for 1/40 second, only 11 cycles are present; this would be perceived by the ear only as a sharp click with hardly any definite pitch. Every time we go up an octave, the vibrations are twice as fast, and the note need be held only half as long in order to have a definite perceived pitch. Thus the superfast treble tinklings of Liszt's *Gnomenreigen* cannot be perceived as musiucal sounds at all by the ear if played on bass notes, even though the Érard action itself is just as fast there.

time concertizing in London he moved to Paris and started a music publishing business in 1797. Several years later his son Camille Pleyel (1792–1855), also a talented pianist, was sent to England to study piano making with Broadwood, and by 1813 the Pleyels were manufacturing English model pianos in France.

As far as we know, the Pleyels, musically well–educated but not craftsmen, made no contribution to the mechanical development of the piano.‡ But they prospered financially nearly as well as Érard, and perhaps appealed to a more refined taste. The *Salle Pleyel*, opened in 1830, was smaller (only about 1.5 stories tall with no balcony) and much more intimate than the *Salle Érard*. It also became a musical and cultural center of Paris; Chopin, Rubinstein, Gottschalk, and Saint–Saëns made their Paris debuts there and Chopin used it in public concerts.

The Mystery of Chopin: It seems a curious twist that would lead the weak and sickly Chopin to prefer the stiff English action which must have hampered his performance; while the powerful Liszt – breaker of hammers and strings – used the easier Érard action, which he did not need. How can we understand this?

One might be tempted to see in these relationships a crass commercial arrangement; indeed, in the cases of Clementi and Kalkbrenner the commercial possibilities were never out of sight, as the historical record shows abundantly. Loesser (1954) suggests this also in the cases of Liszt, Chopin, and several other prominent artists.† Of course, Érard and Pleyel would perceive that associations with great artists would raise their prestige and help to sell their pianos; that is why they built their halls, and nobody would suppose otherwise. But in passing judgment on anybody's behavior, it is essential to consider what alternatives were available to him and the consequences had he behaved differently. Also, we need to ask: what was the alternative from the standpoint of the artist?

Chopin and Liszt necessarily used concert halls and pianos built by *somebody* and whatever choice they made, it would appear inevitably to be an endorsement. Of course, it really was a weak endorsement in the sense that a great artist cannot afford to appear in public with an instrument that he knows is inferior for his purpose. The fact that he chooses a particular kind of piano does not by any means indicate that he considers it the finest in existence; but it does indicate that he has found no defects in it serious enough to hinder his performance. But Chopin and Liszt had no need, musically or financially, to enter into exclusive commercial arrangements with anybody and were free to choose whatever facilities they wished. Indeed, Liszt also spoke just as highly of several other piano makes, and we have the well–known painting of a Liszt recital in which the name *Bösendorfer* is clearly legible on the piano.

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‡ However, the introduction of felt hammers instead of the original leather was done in 1826 by a former worker in the Pleyel factory, Jean–Henri Pape.

† But Loesser had, like many social ideologues, a morbid preoccupation with the subject of money, and took a stance of high moral indignation over *every* commercial activity. What he finds intolerable is that the successful business man is making money; but never does he recognize that, in return for this he is contributing something that society wants, at a price that people are willing to pay voluntarily. And what was the alternative? If those despised 'money barons' had not been successful at supplying society's needs, and everyone had to supply them for himself, Loesser himself would have lived out his life at the material level of a medieval peasant, without ever seeing a piano.

Any difference in the piano actions would be more important to Chopin than to Liszt; but Chopin disliked the Érard action, which he called "too insistent". This seems incredible to us today; indeed, once one is used to the Érard action, it seems remarkable that Chopin's music could be played at all with an early Pleyel or Broadwood action. This suggests a different line of inquiry.

Long Distance Piano Moving: What kind of pianos did Chopin learn on in Warsaw in the 1820's? At first we say, "Surely, Steins, Streichers, or their imitators; the difficulty of transportation before the days of railroads would have made it impractical to transport Broadwoods or Pleyels there." But a glance at a map shows that the situation is just the opposite. In 1818 Beethoven's Broadwood had to go by sea through the strait of Gibraltar to the port of Trieste, then by horsecart 350 miles over the alps to Vienna, over roads worse than any we can imagine today. It is a wonder that it arrived in a repairable condition at all.

To transport a Broadwood to Warsaw would be trivial by comparison: first by sea to the port of Danzig, then by barge up the Vistula, right into the center of Warsaw. A horsecart would be required only for a few blocks, over city streets. We conclude that, in the 1820's, Broadwood pianos were far more likely to be found in Warsaw than in Vienna. In fact, it would be far easier to transport a Broadwood from London to Warsaw or a Pleyel from Paris to Warsaw, than to transport a Streicher from Vienna to Warsaw (the latter requiring some 400 miles of horsecart over bad roads). Loesser (1954, p. 332) confirms this, noting that the German musician Johann Friedrich Reichardt visited the Érard factory in 1802 – eight years before Chopin was born – and reported that already then, they were exporting their pianos "to all countries of Europe, wherever water transport favors it." Therefore it seems highly likely that Chopin had been used to stiff action English or French pianos all his life; and just never outgrew his early training.‡

But perhaps the piano actions were not the only consideration. A glance at the two halls makes it clear that for public concerts Liszt would prefer the ostentatious *Salle Érard*; and Chopin would prefer the more tasteful *Salle Pleyel*, whatever brand of pianos came with them. Dolge (1911) gives pictures of both of these Paris halls (as well as the much plainer *Saal Bösendorfer* of Vienna, which opened in 1872 with a recital by Hans von Bülow, and really looks like a University classroom). In any event, the piano and hall considerations reinforced each other for Chopin.

On the other hand, both the Érard and Pleyel pianos were much stiffer than the easy German Streicher pianos; we have evidence about this from the first concert tour of Paris by Clara Wieck (later Clara Schumann) in 1832. She was an outstanding performer on the Streicher pianos of her native Leipzig; but her efforts in Paris were a rather dismal failure due in part to the unaccustomed hard action French pianos which her father cursed as "tough bones." ⋆

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‡ This sounds very much like the case of Mozart, who as we have noted, probably learned to play on primitive instruments on which a legato touch was mechanically impossible and, even after he had a Stein action instrument of his own on which it was possible, he did not outgrow his early mindset and made no appreciable use of this capability.

⋆ But Clara had started adjusting to this; on her return to Leipzig her future husband, Robert Schumann, was shocked at the change in her playing, and recorded in his diary that she now attacked the Streicher pianos "like a hussar." The German and French pianos were indeed different!

We have seen that the four most famous pianists – Mozart, Beethoven, Chopin, Liszt – all had interesting connections with the development of the piano. Nevertheless Hector Berlioz (1803–1869), himself no pianist at all, gets the last word in the Pleyel story also. A beautiful and accomplished woman pianist, Marie Moke (1811–1875), had a romantic involvement with Berlioz, who expected to marry her. But while Berlioz was safely away on a visit to Rome in 1831, the practical Marie, perceiving that Berlioz was penniless and would remain so, suddenly married the much older Camille Pleyel instead, opting for a life of luxury and high society; whereupon Berlioz came close to assassinating both of them. He did not realize how fortunate he had been until some years later.†

The Iron Frame: Babcock, Chickering, Steinway

Up to this point the pianos were all of wooden construction, and with the development of the Érard action, this became the main remaining bottleneck. Wooden frames were barely able to sustain the total tension of all the strings (amounting to a few tons) and prevented any further increase. Furthermore, wood absorbs moisture and expands, so changes in temperature and humidity could throw the instrument out of tune; every serious pianist was obliged to be also his own tuner, touching it up again every few days (as harpsichordists still do). Broadwood started by replacing the main structural members by iron bars, but this solved only a small part of the problem. Several other European piano makers tried similar things, but nothing permanent came of them.

Then an American inventor, Alpheus Babcock, made a one–piece cast iron frame for a square piano in 1825. But the idea was not quick to catch on; there was a prejudice against the use of a metal frame, due to a quite mistaken but persistent belief that this would make a "metallic" or "tinny" tone. However the Chickering piano Company of Boston then studied the possibility and in 1843 developed a similar frame for a grand piano. It was successful enough to be produced, but not really great; it tended to have a weak tone not because of the iron, but because the scaling (combination of length, density, and tension) of the strings was not right.

This introduces us to the Steinways (no relation to Stein), a family of like–minded men as numerous and energetic as the Bachs and the Strausses combined. Henry Engelhardt Steinweg was born at Wolfshagen, Germany in 1797 and, thanks to Napoleon, found himself a homeless orphan at the age of 15. He apprenticed himself to an organ builder at Seesen, and started experimenting on the side with building pianos, completing his first good instrument in 1825. In 1839 he exhibited three of his instruments at the fair of Brunswick, for which he received the top prize gold medal and sold one of them to the Duke of Brunswick for a high price. His reputation thus established, he received so many orders that he was obliged to set up a factory, hire and train workmen, and bring his sons Theodore, Charles and Henry Jr. into the business as soon as they were old enough.

Then disaster struck again with the attempted revolution of 1848, which paralyzed all nonessential business. Charles, having been an active revolutionist, was obliged to flee to Switzerland and made his way to New York. He sent back such glowing reports of the possibilities in the New World that the entire Steinweg family (except Theodore, who stayed behind to pursue scientific study related to acoustics and continue the piano business) arrived in New York in 1851 and changed their name to Steinway.

† For the details, see Berlioz' memoirs (Cairns, 1975), Chapters 28, 34; pp. 553–554.

Instead of starting a business at once, they decided to acquire first a knowledge of the current American business methods and customs. Henry, Charles, and Henry Jr. found employment in three different piano factories, and observed closely the good practices and the errors being made. After two years they had absorbed enough information to see what was needed to start their own factory in 1853.* With their better knowledge of scaling, they proceeded to develop a better cast iron frame design with cross–stringing, heavier strings under greater tension (about 20 tons, which increased eventually to over 30 tons in the Steinway concert grand), producing a stronger sound. One of their early pianos created a sensation at the American Institute Fair of 1855, and their business prospered so rapidly that they constructed an enormous six–story, block–long factory in 1859, at what is now Park Avenue and 53'rd Street. Soon it was producing 2,000 pianos per year, about a quarter of the total United States output. All other piano makers were obliged to adopt the iron frame quickly; or perish.

A third disaster was the sudden death of Charles and Henry Jr. in 1865, just at the peak of their powers. But the prolific Henry Sr. had two more sons, William and Albert, who were now old enough to help, and Theodore sold his German factory to his workers and joined them in New York. For almost the first time some real scientific knowledge entered into piano building as the well–educated Theodore took over technical aspects of their piano design. Having done this he returned to Germany to continue studying acoustics with Helmholtz, then the most authoritative scientist in the world on such matters. He returned to New York periodically to superintend Steinway's technical operations.

Steinway Hall, seating 2,500 persons,† was built in 1866 and was the main New York concert facility for a quarter–Century, until the opening of Carnegie Hall in 1891. It was the home base of the conductor Theodore Thomas and his orchestra, and most of the famous pianists of the time performed there.

With the death of Henry Sr. in 1871, William took over management of the Company, which now prospered more than ever. He started a branch house in London in 1875 followed with a London Steinway Hall in 1876, and another factory in Hamburg in 1880. He bought 400 acres of land on Long Island (now a part of Astoria, Queens), and made it the village of Steinway. The youngest son, Albert, took over its development, and by 1910 all of the American manufacturing operations had been moved there. In 1972 the Steinway company became a subsidiary of CBS, but it continued to be managed by descendants of the founders.

There were many other American piano manufacturers [Knabe, Chickering, Mason & Hamlin, Baldwin, Weber, Aeolian, American Piano, Cable, Kimball, *etc*]; but the sheer magnitude of the Steinway operations – only a small part of which we have noted here – has guaranteed that in the twentieth Century it would be the most familiar piano name in the United States, used more than any others for concerts and recordings. They were just as active in their relations with artists as in business [for details see Loesser (1954)].

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* It would be quite wrong to condemn this behavior as 'industrial espionage'. The Steinways already had the superior knowledge of how to design and build pianos. What they needed to learn were the social customs of conducting business in a strange new land – very different from those in Germany, but common knowledge among American businessmen.

† By contrast, *Salle Pleyel* accommodated only 300.

Steinway pianos are characterized generally by a louder and more brilliant tone and longer sustained sound (but at a price of a somewhat stiffer action), than most others. In the early days of recording this did indeed make them preferred, resulting in a cleaner final sound (but today, with sensitive directional microphones, it no longer matters, because very little of the reverberation of the recording studio is picked up by the microphone anyway). In recent years there has been a movement back in favor of the more mellow Viennese tone of the increasingly popular Bösendorfer.

The Yamaha piano is a relatively new name outside of Japan; but it is hardly a new company. Torakuso Konan Yamaha started his business in 1880, concerned with musical instruments in general. By 1910 his factory at Hamamatsu was producing annually about 13,000 violins and 8,000 organs; but only 600 pianos; by 1932 this rose to 4,000 pianos per year. They were patterned after the Viennese models, and today Yamaha grand pianos are often thought to be copies of the Bösendorfer; indeed, their design is similar in may ways due to a common ancestry. Therefore, as Bösendorfer pianos became popular in the United States in the 1950's and 1960's,‡ the fact that Yamahas were almost identical in appearance and sound and could be bought considerably cheaper, guaranteed Yamaha a good ready–made market here.⋆

Many other piano manufacturers are or were in existence, even in the mid–18'th Century. Wier (1940) gives a list of over 200 of them, mostly German and American (but in the 19'th Century there were a dozen piano factories in Barcelona). Most contributed nothing to the actual development of the piano and had no interesting dealings with famous musicians, so we have not considered them here. A number of other technical problems called for creative solutions; in particular the making of uniform piano wire and durable hammers, and the seasoning and planing of soundboards. For the many somewhat tedious details of these developments, we refer the reader to Dolge (1911).

Suggestions for Further Study

Many readers will want to know more than we have given here. In trying to understand the development of other musical instruments, the problem is the scarcity of material. In understanding the development of the piano we faced the opposite problem; so much material is available, scattered in so many different places, that nobody could possibly locate and read it all. And, as in all historical research, different sources give contradictory accounts of details.

We have consulted about a dozen sources, but found that almost all of the material unearthed is contained in two of them: (1) the book of Alfred Dolge (1911), a German craftsman who emigrated to the United States in the 1860's and became the main developer of our present felt hammers and soundboards; and (2) The less technical account by Arthur Loesser (1954), a professional pianist and teacher at the Cleveland Institute of Music. Also, the *Larousse Encyclopedia of Music* (1974) has lavish illustrations of many things discussed

‡ Thanks largely to Adolph Baller, a former prodigy who had performed as soloist with the Vienna Philharmonic Orchestra at the age of eight, and who migrated to California after WWII.

⋆ In 1981, American prices for the Bösendorfer ranged from $29,000 for the 5' 8" grand to $60,000 for the 9' 6" concert grand; the corresponding Yamaha prices were $6,300 to $18,000. A 9' Steinway concert grand cost about $26,000. By 1992 these had roughly doubled; a 7' 4" Bösendorfer had a $78,000, and the 9' 6" Bösendorfer a $125,000 list price (doubtless subject to negotiation).

here. The interested reader should consult these works for far more details than we can give here; but should be forewarned about their shortcomings.

Dolge gives a vast amount of technical information about piano making, with detailed drawings of almost every piano action ever made. He also gives biographical sketches and likenesses of dozens of the great piano makers and players. His section "Literature on the Pianoforte" describes an astonishing number of other works on the history of the piano. Unfortunately, he also reveals inadvertently some appalling things about the level of scientific understanding in 1911; the most elementary facts about vibrating strings and acoustics of soundboards, clearly demonstrated and explained by Helmholtz fifty years earlier – just the things that Theodore Steinway had returned to Germany to learn from Helmholtz forty years earlier – were not yet comprehended by Dolge.

Dolge developed some incredibly ingenious machinery for mass production of felt hammers, which could turn out an entire 88–key set, of 88 different sizes, as a single mass of felt with 88 wooden hammer heads imbedded in it. This was then sliced like a loaf of bread into the separate hammers. He also developed the planing machinery for mass production of sound boards (with which two workmen could turn out 30 sound boards per hour), but he had no comprehension of what sound boards actually do acoustically in a piano; or indeed, what a sound wave is.

It has to be said that the thinking of uneducated craftsmen is all right on things like hammers and boards that they can see and feel directly for themselves. But in trying to reason about unseen things like vibrations and sound waves, Dolge's thinking was dominated by the ignorant folklore of his peers, quite unrelated to the real facts and the laws of physics. The low point of Dolge's work is on p. 426 where he actually *endorses* some completely false, incompetent attacks on Helmholtz.

But this makes it easy to understand why the development of the piano required so long. The most eager, energetic craftsman would require many years to discover by laborious, uneducated trial–and–error what a scientist of the caliber of Helmholtz could have told him in five minutes. Of course, a sufficiently persistent craftsman will arrive eventually at a usable solution – after all, he cannot violate the laws of physics, even if he does not comprehend them – but he is unlikely to live long enough to finish the job properly.

Since 1911 there have been many small technical improvements which do not seem to have been written up in any common place. In particular, the replacement of some parts by modern high–quality plastics is not in any sense a "cheapening" of the instrument. Plastic is a far better material than ivory for piano keys; it is not only tougher, longer wearing, and free from that dirty yellow stain and brittle cracking of old ivory keys; but also easier to work (and, of course, it requires no killing of elephants). Likewise, the replacement of felt bearings by teflon has made piano actions far more reliable and trouble–free, virtually frictionless and impervious to moisture and moth. Where a felt bearing will wear out in fifty years, a teflon bearing should remain dimensionally stable and fully functional for Centuries. If Cristofori had had such materials, we could still play his pianos today.

Looking to the future, if the wood parts of the action were replaced by the tough plastic now available, or by die–cast metal, all glued joints would be eliminated and it would become practically indestructible.[†] We still need a better material than felt for

[†] To appreciate the strength and toughness of plastics now available, we note that protective

hammers; presumably, some future soft plastic will make hammers impervious to wear, moisture, and moth; and actually improve the range of tone quality available. Cracking of dried–out sound boards would become a thing of the past if we replaced the wood by modern laminated plastic, which can be made to duplicate every acoustical property of wood, including its grain structure if that should prove to be important (we think that it will not). Going out of tune by slipping of tuning pins could be eliminated, while at the same time making it much easier to tune a piano accurately using only a small screwdriver, by mechanisms along the lines of the fine–tuner for the violin E–string, or the geared mechanism for tuning guitar strings.

But far more important, we could now redesign the lever–ratios in the action for the treble notes and revise the striking points for the treble strings, to correct the defects that were noted already by Johann Sebastian Bach, and are made even worse today by those lead slugs. We examine the possibilities here and "redesign" a treble key piano action to exploit them, in Chapter 5. There is still plenty to do in improved mechanical design of the piano; and the manufacturer who has the initiative to do it, will reap the same kind of rewards as did Érard and the Steinways, while becoming a benefactor to music and musicians. Of course, many minds are still filled with ignorant folklore and superstition about these things, and they would oppose all the changes we have suggested; but when faced with the accomplished fact all such opposition would melt away as fast as did superstitious opposition to the cast iron frame.

But is it likely that electronic pianos will soon make all these suggestions irrelevant by making the acoustical piano obsolete anyway? We discuss electronic musical instruments briefly in Chapter 8, and conclude that, while this is certainly a technical possibility – and even a very promising and attractive one – there is no present sign of its actually happening. Electronic pianos produced to date have been such abysmal failures musically that manufacturers appear to be moving away from trying to imitate a piano. There seem to be no electronic engineers who have any comprehension of what is needed musically, so while the low–end 'spinet' piano is headed for swift obsolescence from this competition, we think that the high quality acoustical grand piano is still safe for many years to come, and it is very much worth while to continue improving it.

Loesser (1954) also gives many interesting names, dates, places, and details about the successes and failures of those who tried to build better pianos; but is more concerned with the experiences of the composers and performers who were obliged to use those pianos at various stages of their development. But he too is, just as much as Dolge, a victim of the folklore and mythology of his peer culture; the reader of today quickly perceives that his unceasing social commentaries really tell us more about the conventional social ideology of American academics in the 1950's than about the actual social conditions of the earlier times being discussed.† Someone writing 40 years earlier or 40 years later than Loesser would often draw quite different sociological conclusions from the same historical facts.

Also, Loesser tends to get his musical judgment and his social moralizing scrambled

goggles and bullet–proof windows are made of Lexan polycarbonate plastic; bullets fired directly at them merely bounce off, leaving behind only a slight scratch on the otherwise intact plastic.

† The characteristic identifying feature of this ideology is the constant jumping to instant, absolute value judgments of what other people do on ostensibly moral grounds – but without ever considering the alternatives available to them, or the consequences had they behaved differently.

up, to the confusion and bewilderment of the reader. For example, on p. 340 he compares the tone of the harpsichord and the piano thus:

> "A gulf lies between these two ideals of sound. The former belongs to a philosophy that values logic, that wants to control the world by dividing it into neat, tight, inviolable categories, order, and ranks. The latter is characteristic of a fluid, pietist, libertarian cast of thought, which has little respect for what it regards as contrived boundaries or limits – a frame of mind harboring the mystical suspicion that anything might merge into everything."

The prospective reader is warned that, in order to extract from Loesser a few wanted hard facts about the history of pianos and their users, it may be necessary to plow through pages of this kind of drivel. In spite of this, we recommend reading Loesser; it still has a more compact collection of interesting and useful historical facts – on a higher intellectual level than Dolge's – than one can find elsewhere. By this we mean that, however bizarre his social views and motivations may be, Loesser's academic training still enables him to recognize – unlike Dolge – what is and what is not a real historical fact, and to report the facts with scholarly standards of documentation.

Loesser (a professional pianist and piano teacher) reveals, just as much as Dolge, an appalling lack of understanding of what is actually happening mechanically in a piano. For example, (p. 339) he explains the function of felt hammers thus:

> "··· it was found that impact by a larger, softer–striking surface at the hammer's end allowed the string to develop its vibration more slowly along its entire length, thus encouraging the formation of stronger lower harmonics–on which a richer quality of sound depends."

This is a comedy of errors. The softness of the felt does not make the lower harmonics stronger; it makes the upper harmonics weaker because the hammer remains in contact with the string for several cycles of a high harmonic, cancelling out its effect. The string does not develop its vibration 'more slowly' along its entire length; the wave of string displacement moves away from the hammer always at the same velocity determined by the tension and density of the string, as Newton's laws of mechanics require, and as we describe in detail in Chapter 5. If this were not true, the string would not generate any definite pitch at all.

In the 1920's these mechanical actions of piano hammers and strings were analyzed and explained in detail by the great Indian scientist Sir C. V. Raman, and published in several articles; yet by 1954 this knowledge had not yet reached Loesser, who had the need for it.*

The greatest pianists have just as serious misconceptions as Dolge and Loesser about the unseen happenings in their instruments. For example, we noted that Adolph Baller was largely responsible for the introduction of Bösendorfer pianos into the United States in the 1950's. The present writer admired him more than any other contemporary artist and never missed an opportunity to see and hear him in action and watch his hands closely. Yet in conversation with him, it developed that he believed that the mellow tone of the Bösendorfer was due to sympathetic vibrations in the small segments of the strings

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* Similarly, the basic facts about vibrations of piano strings were established in the last Century by the German scientist Hermann von Helmholtz, and the English scientist Lord Rayleigh, and were understood correctly by Theodore Steinway in the 1870's; yet forty years later, as we noted, this knowledge had not yet reached Dolge.

between the agraffe and the tuning pins! He thought that some deep secret of the design was amplifying those vibrations in the Bösendorfer but not in other pianos. In fact, those segments are hardly vibrating at all in any piano because they are not being struck or plucked, and whatever vibrations they have are communicated through the agraffe by the bending of the string and are at the same pitch as the main segment of the string. But these neglibly small vibrations produce no sound because they are not connected to any bridge or sound board.

The real reason for the Bösendorfer tone lies in the different position of the striking point on the strings – as one can verify at once by converting it back into a dulcimer by striking the strings at a different point, with felt or soft rubber hammers held in the hand (with, of course, the dampers up). One can make the Bösendorfer sound like a Broadwood, a Steinway, or even (by striking at the exact center of the string) a clarinet. Just as easily, one can make a Steinway sound like a Bósendorfer in this way.

Dolge and Loesser give conflicting accounts of many historical facts. In particular their descriptions of the details of Nannette Streicher's efforts with regard to Beethoven are totally at variance with each other. Dolge has Nannette giving him a specially built 6.5 octave Streicher in 1816, which would make nonsense of the story of the Broadwood. Yet the Broadwood is a tangible fact, supported by many contemporary eyewitnesses and records, and still in existence, so we concluded that Dolge is completely wrong here. Dolge also gives impossible sequences of dates, having Albert Steinway dying three years before acquisition of the land for Steinway village which he developed – but we have found equally bad factual errors in every source we have consulted. For example the *Larousse Encyclopedia* states (p. 260) that the Pleyel company was established in 1809; then (p. 264) gives a photograph of a square piano with 5.5 octaves, ($F_1 \rightarrow C_7$), described as a Pleyel dated 1800, owned by Beethoven. This not only contradicts itself; it contradicts all other sources both about Pleyel and about Beethoven. Other sources give 1797 for the date of Pleyel's establishment, and 1807 or 1813 for the date of Pleyel's first French pianos. It is conceivable that in 1800 Pleyel smuggled[‡] some English pianos into France and put Pleyel labels on them; and that over the next twenty years one of these found its way to Beethoven. But there is no hint of this in any other source we have seen.

Only further independent historical study – presumably requiring access to archives in Bonn, Vienna and Paris and to authentic specimens of old pianos – can resolve our puzzlement over many of the issues raised here.

[‡] Anti–British feeling was so strong after the Revolution that a French law of 1796 made it illegal to import – or even own – any British goods.