

Chapter 9

The Boehm flute

We can fix no distinct moment of origin for the flutes we have considered in previous chapters – medieval flutes, various kinds for military and consort use, the one-keyed instrument, and flutes with several keys – despite recent efforts to assign credit for some of these types to selected individuals. In contrast, the modern flute's invention can be traced to one man, since few more brilliant or controversial innovations in the design of any musical instrument can ever have been made than those Theobald Boehm devised for the flute in 1832 and 1847. Yet for mechanical, musical, and economic reasons the construction of Boehm-system flutes has been changing ever since, so that the instruments of today differ in significant ways not only from those Boehm and his contemporaries built and played, but even from those made only a generation ago. Therefore we should investigate in some detail the genesis of Boehm's designs, along with those changes that came as his flutes were gradually adopted and adapted by others.¹

A man of exceptionally industrious nature, Theobald Boehm exemplified the character of his times in which ingenuity and industrial process magnified or even supplanted human skill and strength in many areas of life. The son of a Munich goldsmith, he acquired his manual dexterity in his youth, developing his knowledge of mechanics as a young man by studying the building of musical boxes in Switzerland. After beginning in his childhood to teach himself to play a one-keyed flute by Proser (London, *fl* 1777–95; now DCM 152), Boehm built himself a copy of a four-keyed instrument by August Grenser in 1810, before taking his first lessons with Johann Nepomuk Capeller, flutist of the Bavarian court orchestra. His teacher, who was already interested in devising improvements in the flute, designed a new model for which, according to Boehm's biographer, it was the young pupil who devised the mechanism.

After completing his studies with Capeller Boehm gained a place in the orchestra of the Isartor Theatre in Munich, a post from which he advanced in 1818, at the age of 24, to a royal court appointment. At this stage, the success of a concert tour (chapter 7) encouraged him to give up his goldsmith's business so as to support himself as a musician instead. His interest in instrument-making evidently continued, as he seems to have collaborated with one of the two Munich instrument-makers named Schöffl on the design and manufacture of some instruments in this period.² Though at the time Boehm himself held no legal right to conduct business as an instrument-builder, the flutist Karl August Grenser identified him as already one of the most renowned makers of his time in 1824.³

Five years later, having 'acquired flutes at great expense from almost all the famous masters and found not one without significant faults', Boehm established his own flute-making workshop. Without a background as an instrument-maker, the law required him to establish some novelty or invention to justify the award of a royal licence. Accordingly he applied on 8–10 May 1829 to make flutes in his own particular way, referring to his prior experience as goldsmith and flutist, and citing six characteristics of the flutes which, despite their unaltered acoustics, key system, and fingering, he was already calling 'improved':

1. Purity of intonation
2. Evenness of tone
3. Facility of operation
4. Secure speaking of the highest as well as the lowest notes
5. Beautiful profile
6. Thoroughly neat and robust workmanship.

41. Flutes by Theobald Boehm, Boehm & Greve, and Boehm & Mendler (DCM). (*left to right*) (1) DCM 657, by Boehm & Greve, 1828–32. (2) DCM 974, by Boehm, 1832–47. (3) DCM 652, no. 1 of two brass flutes by Boehm, 1847. (4) DCM 653, cylinder flute no. 21 by Boehm, 1848. (5) DCM 875, by Boehm, 1847–62. (6) DCM 161, by Boehm & Mendler, 1877 (Macaulay flute).



Rodolphe Greve (1806–62), who in 1829 had moved from Mannheim to Munich after training as an instrument-maker with his father Andreas Greve (1770–1840), became Boehm's chief workman and partner in 1830, forming a team with Boehm's brother Jacob (1805–71) that grew with the addition of several other workmen early in 1832.⁴ Boehm devised an apparatus for accurately setting the pillars that carried the flute's keywork, and experimented with rod-axles, which, unlike the simple lever axles in common use at the time, carried the motion of the touchpiece along a pivoted tube running along the length of the flute to a key-cover on a remote part of the body. The workshop produced eight-keyed flutes which Dayton C. Miller described as of 'perfect' workmanship, suspending most keys on pillars in the usual way but using rod-axles with right-hand levers for B₁ and C₂.

A generation after the addition of keys to the flute in England in the mid-eighteenth century (chapter 6), Germans had now carried inquiry into the construction of flutes to its most intensive stage. As early as 1781 Tromlitz had used detailed announcements of his innovative instruments in the musical and general periodicals as the most effective method of spreading the word. When others who had been experimenting with flute design began to publish their ideas in some of the same media (chapter 8), a more or less public discussion ensued, linking workmen, players, and thoughtful individuals who in the ordinary course of life might never have met to discuss their common interest. A description of Capeller's flute by Carl Maria von Weber had formed a thread in this series of publications.

However, not all those working on flute designs published accounts of their work, and Captain J. C. G. Gordon was one who left only scanty documentation. Gordon first designed a flute based on an open-key system in 1826 in collaboration with Auguste Buffet *jeune* (b 1789) (chapter 8), but nothing is known of this early effort. After the devastating loss of his position as an officer in Charles X's Swiss Guards in the Revolution of 1830, when his regiment was massacred by a Parisian mob, it occurred to Gordon that devising a better flute might provide a livelihood for himself and his wife. While visiting London in the following year he commissioned the workshops of Rudall & Rose and of Cornelius Ward to make flutes to other designs. Yet the exact nature of Gordon's flutes at this period too remains obscure, despite many attempts to investigate it. By all accounts, Gordon's flutes made use of an idea H. W. T. Pottgiesser had suggested two years before of employing crescent-shaped touchpieces on certain open-standing keys. The Rev. Frederick Nolan had patented a ring-key device in November 1808, and Pottgiesser had suggested another rudimentary ring-key in 1824,⁵ but Gordon's crescent touchpieces provided the first practical means of opening or closing a hole beneath the finger at the same time as another key some distance away. This allowed holes to be placed in their ideal acoustical positions: regarding the tonehole positions in Gordon's 1831 flute Ward wrote that 'the apertures were placed consistently with the proper length of tube required for each fundamental note in the chromatic gamut',⁶ a contention generally supported by two engravings of Gordon's flutes published during the 1830s, but contradicted by a remark Boehm made in 1847.

While Gordon was working with the London flute-makers, Boehm combined his first concert tour to venture beyond Germany, Switzerland, and Northern Italy with a

business trip to England. In partnership with his friend Karl Franz Emil von Schafhütl (1803–90), Boehm had undertaken the improvement of the Bavarian steel industry, and made the journey to Britain, the leading producer of iron and steel, to learn more about industrial methods there. No doubt he also had in mind the promotion of his flute business: the firm of Boehm and Greve was thriving, having already sold 65 instruments, 21 of them outside Bavaria.

In London, where his performances on an eight-keyed flute from his own workshop received encouraging notice, Boehm met Gordon and became familiar with his flute. He evaluated the instrument dismissively in his essay of sixteen years later, after he had been accused of pilfering Gordon's ideas:

He also had on his flute a number of keys and levers, some of which were ingeniously devised; but they were much too complicated, and of no use, as it lacked throughout a correct acoustical basis.

Through the good offices of George Rudall (1781–1871) Boehm met Charles Nicholson, the power of whose tone – due in part to the large-holed flutes he played and marketed – was a legend in his own time (chapter 7). Boehm evaluated his own performance in comparison to Nicholson's in an oft-quoted passage from a letter of 1871 to his English friend W. S. Broadwood:

I did as well as any continental flautist could have done in London in 1831, but I could not match Nicholson in power of tone, wherefore I set to work to remodel my flute. Had I not heard him, probably the Boehm flute would never have been made.⁷

Before he left London Boehm had already built an instrument to a new design in the workshop of Gerock & Wolf, where he also developed overstrung pianos that the American piano manufacturers Steinway and Chickering brought to fruition a quarter century later. The London firm rushed to market with the new design, which it promoted in a pamphlet on 'Boehm's Newly-invented Patent Flute' (ill. 42a).⁸

Boehm's model of 1831 made dramatic advances in mechanics and changes in fingering. The new design introduced the concept of the ring-key to flute construction: in his essay *On the Construction of Flutes* he wrote of 'adopting' the device rather than 'inventing' it. Probably Buffet *jeune* already knew of it from the clarinet: some years before, in 1826, at about the time he was working with Gordon, he had seen a clarinet with a ring-key which another Parisian maker, Lefèvre, had made for the clarinetist Blève of Le Havre.⁹ The ring-key, surrounding the tonehole like *Brille* or spectacles, transmitted the motion of a finger onto keys beyond its reach in a more effective manner than Gordon's crescent touchpieces.

Boehm employed these ring-keys to bring about the change in fingering for F and F[♯] that Pottgiesser had suggested in 1803: he assigned the right-hand index finger to play F and the third finger of the right hand to play F[♯], achieving the change by giving F₄ a new hole of its own. He placed the toneholes for the left-hand third finger (A) and the right index finger (G) out of the fingers' reach and covered them with

*Table of Notes affected by Quock's & Wolff's Newly Invented Flutes,
with Studies and passages that cannot be perfectly executed on any other.*

(a)

Tablature de la Flûte Diatonique.

Les Lettres A, B, C, D, E, designent diverses Branches correspondant à des Clefs et servent aux Trilles, Trilles majeure et mineur de chaque Note un indiquée par le signe de dans la Clef de Do, de cette Note, savoir le trille mineur après, et le trille majeur après la dite notation: des Trilles.

Autres Notes

* Chaque fois que le *do* se grave au lieu du *do* mineur prendront: immédiatement une *do* pour laquelle le cinquième trou doit être fermé, en fermant ce trou en pressant la clef de *do* à droite.
 * La clef de *do* peut également indifféremment être ouverte ou fermée (pour toutes les *do* pour lesquelles elle n'est pas indiquée fermée) en a la flûte dans la position que l'on croit la plus commode pour la main dans l'exécution de l'air.

(b)



42. (a) Boehm's flute of 1831 from Gerock & Wolf's prospectus (c1831); (b) Gordon's flute c1833 from Gordon's *Tablature* (1834); (c) Gordon's flute c1838 from Coche's *Examen critique* (1838).

Precise details of Gordon's work before Boehm devised his London flute of 1831 (ill. 42a) are unknown. Gordon published the first illustration of his flute (ill. 42b) only in his prospectus of 1834, after he had further developed it in Boehm's workshop. That prospectus, of which no copy survives, was reproduced by Welch (facing p. 102). Its picture of the c1833 flute was reprinted in John Clinton's tutor of 1846 and in the German version of Boehm's *Essay* of 1847. Ill. 42c appears to derive from a drawing Mme Gordon sent Coche with a letter of 20 May 1838 (Welch, *History*, 127–9). Horizontal lines at each tonehole and key touch probably indicate that the drawing once formed part of a fingering chart, as in the other two cases in this figure.

Philip Bate (*The Flute*, p. 239) and Nancy Toff (*Development*, 50–1) incorrectly stated that ill. 42c had appeared in 1833 rather than five years later. Toff (*ibid.*) mistakenly wrote that ill. 42b had first been published in 1846, twelve years after its actual appearance, and that it represented a Gordon flute of c1831, that is, before he had visited Boehm's workshop.

open-standing keys, while the keys for G \sharp and D \sharp both stood open rather than closed. Despite these similarities to the instrument Gordon depicted in his prospectus of 1834, the lack of a clear chronology does not permit us to trace whether or not Gordon's 1831 model had any practical influence on Boehm's new flute of that date, or vice versa.¹⁰

Boehm returned to Bavaria to follow up the 1831 flute's advances in a new model he built in his Munich shop in the following year. On 25 January 1832 he petitioned the King, without success, for a subsidy of 1000 florins from the Fund for Bavarian Industry, citing the expenses of his travels and experiments in London, and the purchase of materials from England, as having used up his means. He held out the prospect that his new flute 'opened up a happy prospect of a lucrative livelihood for me as the tirelessly active head of a household of a wife and seven children'.

The new mechanism of Boehm's 1832 flute used ring-keys operated by interlinked parallel rod-axles, made to a design of his own which the Boehm and Greve keyed flutes had employed in a simpler form for some years. It carried over the fingering for F and F \sharp and the open key for G from the design of the previous year. But instead of leaving the left hand so that it could cover the open toneholes towards the top of the tube, Boehm shifted its position downward by a semitone so that the fourth finger could once again reach its lowest tonehole, for A, and the A key of the 1831 system could be dispensed with. Now the tonehole for B \flat , formerly located under the tube, was given a new position in line with the other toneholes, and assigned the left-hand

middle finger instead of the closed-standing thumb key that had traditionally played that note. This freed the thumb to fulfil the principal function it had had in Tromlitz's 1785 flute of governing a nearby tonehole for C, rather than having the right index finger do duty from a remote position. A separate key for C \sharp governed its own hole, now placed too high up the tube for the left index finger to reach. To help steady the instrument now that the left thumb was occupied with the C key, Boehm added a T-shaped crutch to rest in the player's hand between the thumb and index finger.

For the first time, all the flute's keys with the exception of the D \sharp key and special trill keys stood open in their default positions, while in practice the D \sharp key was always held open except to play D and the notes below it in the first octave. Thus in the 1832 flute every note was now produced by its own tonehole which, when opened, had no closed holes below it on the tube, so that all the artificial fingerings in the flute's chromatic scale had been eliminated. To increase the contribution the open keys made to a powerful tone, Boehm made the toneholes as large as feasible, following Nicholson's example as well as Weber's observation that only the largest holes with the lowest end-correction factor could be placed in their acoustically ideal positions.

Boehm and Greve's workshop began to manufacture the new instrument, using cocus or grenadilla wood, in the course of 1832. Boehm himself inaugurated it at performances in Munich on 1 November 1832 and 25 April 1833, a review of which contained the first published reports of the new flute.¹¹ Also in 1833, Boehm's pupil Eduard Heindl (1837–96) performed a Kuhlau *Fantasie* on the ring-key flute. A prospectus describing the new instrument, with charts for fingerings and trills, was published in the autumn of 1834. Boehm, though now much occupied with his work in the Bavarian steel industry, found time to demonstrate the new flute in Paris and London in 1833–4. Though he remained in London for a year he found acceptance slow and had sold only one instrument there by 1835.

Gordon, meanwhile, was still determined to develop a viable flute of his own. Boehm lent him his Munich workshop and his foreman Greve to conduct further experiments in early 1833 while he himself again travelled to Paris and London. In July Gordon sent out descriptions of his latest model in a pamphlet entitled *Tablature of the Diatonic Flute Manufactured in the Workshops of Boehm*, of which, though Welch reproduced it in 1896, no original is known to survive (ill. 42b).¹² Still, his flute did not meet with the success he hoped for, and he retired to Lausanne where he continued his work until mental breakdown struck in 1836. Gordon is thought to have died in 1838.

Boehm's revolutionary flute of 1832 won its first champions beyond his immediate circle in Paris. Three men, Paul Hippolyte Camus (*b* 1796), Vincent Joseph Steenkiste *alias* Louis Dorus (1812–96), and Victor Jean Baptiste Coche (1806–81), played important roles in the Boehm flute's acceptance in France during the crucial year of 1837. Nonetheless, Boehm himself won its first official notice in France by presenting it in person. While visiting Paris in the spring, he showed one of his ring-key flutes to the acoustician Félix Savart (1791–1841), who had been elected to the Institute of France's Academy of Sciences in 1827 after a decade's work on electrostatics and

acoustics. Savart arranged for the flute to be examined by the Academy at a meeting of 8 May 1837. On that occasion Boehm read a short description of the flute, and a commission consisting of Savart, another scientist, and two musicians from the Academy of Fine Arts, was appointed to give a formal judgement. On leaving Paris Boehm appointed Camus to represent him before the commission when it met. Tula Giannini (1993) surmises that Boehm chose Camus to represent him in preference to Dorus because the latter had already altered aspects of the original design,¹³ but the suggestion that Dorus even possessed a ring-key flute in the spring of 1837, despite Schafhäutl's assertion (see below), is far from certain, and it seems more probable that Camus was its only advocate until the Academy took notice of Boehm.

THE RING-KEY FLUTE IN PARIS

Which prominent Parisian flutist first took up Boehm's ring-key flute? Claims have been made by, or on behalf of, three men: Paul Hippolyte Camus (*b* 1796), Vincent Joseph van Steenkiste *alias* Louis Dorus (1812–96), and Victor Coche (1806–81).

According to Boehm's own testimony, he first showed his flute to Aristide Farrenc (1794–1865), Camus, and Laurent, 'manufacturers of flutes', on a visit to Paris in 1833.¹ Farrenc confirmed this in an article of 1838 in which he contested Coche's claim to have been the ring-key flute's first advocate. At the same time he noted that Camus had devoted himself to the new flute only on a subsequent visit by Boehm four years later, when for the first time the inventor was able to lend an instrument to interested players:

In March 1837 M. Boehm came to Paris for the 3rd time with his new flute.² Until then he had brought only one flute, the one he played on, but this time he had several with him. M. Camus asked to borrow one, and the same day he declared that he would not play any other flute than Boehm's; he kept his word. ... When M. Camus adopted the Boehm flute there was as yet only one instrument of this type in Paris, even in France, thus it was indeed M. Camus who first played this flute, and it was he who *first propagated it*.³

Camus put the date of his conversion two months later in his own account, which otherwise confirms Farrenc's.⁴

Schafhäutl claimed that the twenty-two-year-old Dorus had switched to the ring-key flute immediately on hearing Boehm play one in Paris as early as 1834, while the inconsistently reliable musical biographer François-Joseph Fétis (1784–1871) put the date even earlier, at 1833.⁵ However, Dorus could not have taken up the ring-key flute unless he had bought a flute from Boehm, at that early date the only possible supplier of such an instrument, and no evidence of such a purchase exists. Dorus must have come by a ring-key flute by 1838, when he appeared as one of three advocates for it before a Conservatoire commission, but by that time two firms in Paris had developed versions of the Boehm & Greve instrument Camus had shown them during 1837 (see p. 172). Dorus adapted his method of 1840 to Godfroy and Lot's flute, which appeared late in that year.

The third claimant, Victor Coche (1806–81), as the narrative illustrates, tied his fortunes to Buffet's version of the ring-keyed flute, which he claimed to have first played in public in about 1838.⁶

Since it appears that neither of the French makers who developed the ring-key flutes Dorus and Coche played had any opportunity to study Boehm's model before Camus presented them with it during 1837, Farrenc's claim that Camus took up the Boehm flute when 'there was as yet only one instrument of this type in Paris' remains standing as the most plausible.

That situation changed when Boehm left one or more of the 'several' instruments he had brought to Paris in the hands of Camus for the Academy to study. During the course of 1837 Camus, acting as Boehm's agent, delivered a ring-key flute to Buffet.¹⁴ Welch, whose information came directly from Buffet, described the nature of Camus's mission as follows:

He had, it seems, been commissioned by Boehm not only to act as an intermediary in procuring flutes from Boehm's factory for purchasers in France, but also to enter into arrangements for the manufacture of the new instrument in Paris. Buffet became acquainted with the flute thus brought to Paris [or more probably, retained there on Boehm's departure] by Camus; indeed, according to Buffet's statement, it was placed in his hands by Camus himself.

Welch concluded that Camus and Buffet failed to devise a satisfactory business arrangement, and so Camus transmitted the model to another Parisian flute-maker, Vincent Hypolite Godfroy, then working in a partnership with Louis Lot established four years earlier under the trade name of Godfroy's father, Clair Godfroy *ainé*.¹⁵ Godfroy and Lot lost no time in producing the first French commercial model of a ring-key flute. A notice of 21 October 1837 in the *Courrier français* indicates that they had produced a Boehm flute by that date, making them the ring-key flute's first manufacturers outside Boehm's own workshop. The Godfroy firm's public announcement signalled that the new instrument had a commercial potential that they were prepared to realize.

On the authority of his acquaintance with Buffet, Welch credited that maker with various modifications to the mechanism of Camus's ring-key flute, which, if he was correct, were made during the course of 1837 around the time Lot and Godfroy were developing their version. Buffet reportedly used needle springs in place of the traditional flat springs, repositioned all the rod-axles on the side of the tube facing the player rather than distributing them on both sides, and developed clutches and sleeves that allowed a single rod to transmit the motion of several independent cups and rings. Despite Welch's testimony, two contemporary illustrations of Buffet's flute show mechanism on both sides of the tube.¹⁶ But whoever was responsible for the mechanical innovations, the French makers modified Boehm's instruments to make them not only more mechanically robust and easier to manufacture, but also more marketable. Boehm's open G[♯] forced players who might have been ready to take up the ring-key flute to make a troublesome change in fingering. All the keys on the 'ordinary' flute operated as closed-standing levers: the fingers did not touch them except to open the holes beneath them. The open G[♯], on the contrary, functioned as an open-standing key in the manner of Tromlitz's C₂ key. It required the player to keep the key closed with the left-hand fifth finger, except to play a G[♯], when it was allowed to return to its default open position. Though this action made the fifth finger behave in a way more consistent with the other fingers, flutists of the time were already accustomed to give it a contrary motion, and so the change was an awkward one.

Consequently Louis Dorus, working with Godfroy and Lot, devised a mechanism that retained the traditional function of the G[♯] key as a closed-standing lever, at the

same time as allowing it to remain open when idle. The Dorus G[#] key added a ring-key to the tonehole for A, governed by the left-hand fourth finger. This ring-key engaged the open-standing G[#] key by means of a clutch, causing it to close when the ring-key was depressed, that is, when a G was sounded. To play G[#], the key was applied in the accustomed way, re-opening the tonehole placed between A and G. Victor Coche collaborated with Buffet, whose design adopted the Dorus G[#] mechanism, to add a D[#] trill-key and a ring-key for the left-hand third finger to play a B₁, with the same fingering used on the 'long' B₁ key of the ordinary flute.

Tula Giannini has made the insightful observation that the alterations Godfroy effected on Boehm's design made it from a musical standpoint more like the instruments French flutists knew:

Godfroy's flute differed from Boehm's in that its dimensions were modified to produce a sound that was a compromise between that of Boehm's instrument and that of Godfroy's ordinary flute of the 1830s. He accomplished this by giving the bore a steeper angle of decline [i.e. a more pronounced taper] and reducing the size of the embouchure, the tone holes, and the thickness of the body on average by a millimetre. In addition, he eliminated Boehm's crutch and rectangular creviced embouchure, replaced the open G[#] key with the Dorus G[#], and further refined the keywork. The overall effect was a Boehm flute which retained some characteristic features of the ordinary French flute.¹⁷

By the autumn of 1837 the two French versions of the Boehm flute were ready with their respective advocates to compete for acceptance. Following Godfroy's announcement of 21 October, Coche wrote Boehm a secret letter on 6 November in which he tried to gain the advantage for Buffet by persuading Boehm to take legal action against Godfroy to prevent his making Boehm flutes in Paris, and to appoint Coche his agent in Paris. Two days later Coche, inflating his title as Tulou's teaching assistant to 'Professor at the Conservatoire', wrote directly to the French Minister of the Interior and the Fine Arts to request a hearing for the Boehm flute before the Musical Division of the Commission of Fine Arts:

Having examined a new flute invented by M. Theobald Boehm, a German maker, I have recognized that this instrument, built on an entirely new system, affords extremely valuable advantages and that its propagation should be considered a most important step forward for art. This thought prompts me to petition of your benevolence the favour of having this flute heard before the Fine Arts Commission, Musical Division, so as to put it in a position to appreciate the advantages which I have just mentioned. ...¹⁸

Boehm responded with a letter, dated Christmas Day 1837, to the Secretary of the Academy, M. Quatremère de Quincy, in which he notified him that his application of May, with Camus as his deputy, should take precedence over Coche's separate approach to the Minister. Camus likewise wrote to the Academy to remind it of his pending candidacy. But Coche's intrigues apparently ensured that Boehm's flute as he

conceived it never received the commission's attention. Instead, on 24 March 1838, Coche presented the Music Committee of the Academy of Fine Arts of the Institute of France with the flute he and Buffet had devised. A new panel, consisting of the original two musicians with the addition of four more including the Conservatoire's Director, Luigi Cherubini, considered 'flutes on the Boehm system by M. Coche', as well as a method book Coche had written for the new instrument. Coche had carefully primed the commission with a paper entitled *Examen critique de la Flute Ordinaire comparée à la Flute de Böhm* (Critical examination of the ordinary flute compared with the Boehm flute), in which he claimed that Gordon had invented the new instrument but that Boehm had stolen the credit, emphasizing in the end his own modifications. Clearly Coche designed these manoeuvres to bring Boehm into disrepute and gain the commercial advantage over Godfroy and Dorus for Buffet and himself.

Coche pursued this claim in promotional literature for a partnership he formed with Buffet, to build flutes 'invented by Gordon, modified by Boehm, and perfected by Coche'. In the *Examen critique* Coche had described the new flute as the 'Boehm flute', while in his *Méthode* of the same year it was called 'the new system flute', or the 'flute of Gordon modified by Boehm'. On 19 April 1838 Camus wrote to Boehm (in an unsigned letter) to inform him that, despite his efforts to secure recognition for him as the inventor of the ring-key flute, 'as regards the Institute, the mischief is done' by Coche's campaign of disinformation.

In pursuit of the advantage thus gained, Louis Auguste Buffet submitted a patent application on 10 October 1838 for the 'new flute' he had developed in collaboration with Coche. In the following year, Buffet and Godfroy each presented their 'new flute' to the jury of the Paris Exhibition, but the instruments were not judged on that occasion owing to their novelty.

Coche's efforts to deprive Boehm of the credit for inventing the new flute set off a dispute that took until the end of the nineteenth century to die down. Hector Berlioz took Coche's part in the *Constitutionnel* of 18 August 1839 when he depicted him as an insurgent against the orthodoxy of the old flute maintained by the tenured professor Tulou. The controversy spread to England when a voluminous correspondence from amateur and professional flutists filled the columns of *The Musical World* in 1843. Cornelius Ward's pamphlet *The Flute Explained* (1844) espoused Gordon's side, while Boehm's case was taken up by John Clinton, Professor at the Royal Academy of Music, in his *Theoretical and Practical Essay* (1843) and *Practical Instruction Book* (1846), as well as by Richard Carte in *A Complete Course of Instructions for the Boehm Flute* (1845, with extracts printed separately in the following year). In 1890 Richard Shepherd Rockstro revived the Boehm-Gordon dispute in his heavily prejudiced account of the events of the 1830s, to which Christopher Welch responded with magisterial thoroughness six years later.

Victor Coche achieved his objective with the Academy of Fine Arts commission when it produced a report that parroted his *Examen critique* and accorded him high praise for his and Buffet's work on the flute. He followed up this success by requesting a meeting of the Conservatoire's Committee on Teaching to consider setting up a special class in the Boehm flute. The Committee, consisting of professors of

composition, voice, and instruments other than the flute, most of whom had also served on the Academy's panel, met on 30 December with the institute's President, Luigi Cherubini, in the chair. But owing to the Conservatoire's more formal structure, this Committee could not as easily be swayed. The meeting of 30 December 1839 adjourned for a week so that the panel could summon Tulou, whose standing as Professor of Flute rendered his opinion indispensable. Tulou's commercial interests, as official supplier of flutes to the Conservatoire and author of its official teaching method, made his hostility to any new idea that had not first won his patronage a foregone conclusion. According to Giannini's transcription of the minutes of the meeting, he presented detailed opposition to the Boehm flute:

He cites quite a number of passages that are much more difficult to execute on the new flute than the old, and he adds that the sounds in general of the Boehm instrument are far from having a quality as agreeable as that of the flute taught at the Conservatoire.¹⁹

Count A. D. de Pontécoulant reported Tulou's specific objections to the 1832 flute's tone in an account of the Committee's proceedings published in *La France Musicale*:

[Tulou] said that one must first acknowledge that the flute is a pastoral instrument, with which one must seek more to please than to astonish; that one must express only sentiments that are sweet, tender, expressive, passionate, and not those by which one would want to paint anger or tempest. It requires, therefore, above all, a beautiful quality of sound, or, to say it in a better way, a beautiful voice, a voice that approaches as much as possible the human voice.²⁰

Tulou further objected that the flute's mechanism remained a work in progress, since Coche, Camus, and Dorus played on instruments modified differently. Consequently the Committee decided to meet again and hear what these performers, as well as others who had tried and given up the Boehm flute, had to say.

A week later two flutists named Connix and Robert Frisch (*b* 1804) testified that the Boehm flute was out of tune, defective in tone, and mechanically unsound, considerations that had led Connix to give it up after only a fortnight's trial. Dorus and Coche, though they played flutes with slightly different embouchures and mechanisms, spoke in favour of the Boehm flute and demonstrated its potential. Dorus also played an 'old' flute for the sake of comparison, upon which the Committee observed that the old flute was 'more in tune and more agreeable'. Nevertheless, Camus had not yet been heard from, so the Committee adjourned once again.

Four days later, with Camus still absent, Tulou, Connix, and Frisch played passages Coche claimed were 'impossible to execute well' on the old flute. Their brilliant demonstration, combined with Tulou's well-timed announcement that he was working on a 'perfected' flute based on the old system, persuaded the committee that the old flute was perfectly adequate and indeed superior to the Boehm flute in some respects, and it voted unanimously against authorizing the new Boehm flute class. Coche, having lost the battle, also forfeited his position as Tulou's assistant at the

Conservatoire in the following year when the senior professor effectively prevented any of his subordinate's students proceeding to their diplomas.

Giannini interprets Camus's failure to participate in the Conservatoire test as a sign that, as a representative of the original Boehm flute with the open G \sharp , he had dropped out of the contest. Coche's loss of his position at the Conservatoire doubtless lessened his ability to promote the Buffet version, leaving Godfroy and Lot for the time being as the Boehm flute's foremost manufacturer. Still, Coche remained along with Camus and Dorus a champion of the ring-key flute: his method had appeared in August 1839, two months after Camus's, and he claimed in his *Mémoire* of 1859 that he had been the first to use the new flute successfully in a dramatic orchestra in his position as solo flute at the Théâtre de la Renaissance. Dorus continued to display his superb artistry on a ring-key flute by Godfroy and Lot. Certainly the approval of this prominent soloist, a member of the Opéra orchestra and of the Société des Concerts du Conservatoire, had an important influence in 1838, and his support was to be even more crucial a quarter century later when he succeeded Tulou as Professor at the Conservatoire and made the cylinder flute the official instrument of that powerful institution in 1860 (chapter 11). Dorus's reputation and his method for the Boehm flute of 1840 so raised the ring-key flute's standing that Boehm named him as the man responsible for its success in France and dedicated the French translation of his 1847 essay to him rather than to Camus.

The events of 1837–8 suddenly ended a five-year period during which acceptance of the ring-key flute had been stalled. With the steel industry making heavy demands on his time from 1833 onwards, Boehm had been unable to continue any personal involvement in his Munich workshop, and in 1839, once the French ring-key flutes appeared to have gained the ascendant over his own, he sold the business to Greve for 600 florins, about the value of four and a half flutes. But first it was necessary to renew the establishment's operating licence, which was about to expire, and without which Greve would have no right to make instruments in Munich. In a petition of 7 May 1839 to extend the licence, Boehm noted the enterprise's limited scope:

I founded my flute business less for profit than to promote a good business and for the sake of honour, to make instruments in the Fatherland that have twice been awarded silver medals at our industrial exhibitions, designated the most perfect by the Institute of France, and hitherto copied by the foremost London, Paris, and Vienna instrument-makers only with difficulty and shortcomings.

However this perfection of my instruments was achieved initially by means of researches that cost me dearly in time and money, and still the prices were not raised in proportion, so as to ensure their publicly beneficial domestic distribution as well as a market abroad, distant transport and high import taxes notwithstanding.

Furthermore, a larger expansion of this business is not really possible due to the great difficulty of finding suitable workers and checking their work carefully, and therefore the pure profit of it is only very small. ...²¹

- 1831 In London Boehm's Gerock & Wolf flute appears; Gordon has flutes built by Rudall & Rose and by Cornelius Ward.
- 1832 Boehm develops his ring-key flute in Munich; demonstrates it in Munich, London, and Paris.
- 1833 Boehm to Paris and London; shows flute to Camus and others.
Gordon to Munich; in July publishes a prospectus showing his flute.
- 1836 Gordon's mental breakdown.
- 1837 May: Boehm presents his flute to the acoustician Savart and the Institute of France's Academy of Sciences. He commissions Camus as his deputy.
October: Godfroy and Lot produce a Boehm flute in Paris.
November: Coche reports this to Boehm, asking him to suppress the Godfroy and Lot flute and make Coche his agent. Coche writes to Minister of the Interior.
- 1838 Coche publishes *Examen critique*. Music Committee of the Royal Academy of Fine Arts considers Coche-Bufferet-Boehm flute, parroting Coche's pamphlet in its report, but ignores Boehm's application pending from the previous year.
- 1839 Buffet and Coche patent their new flute, which appears alongside Godfroy's at the Paris Exhibition. A Conservatoire Committee meets at Coche's request to consider Boehm flutes by Godfroy and Buffet, but rejects both. Coche is frozen out of the Conservatoire by Tulou.
- 1842 The ring-key flute is adopted at the Brussels Conservatoire.
- 1843 John Clinton, Professor at the Royal Academy of Music, London, publishes *Theoretical and Practical Essay* on the Boehm flute. Series of letters in *The Musical World* on the Boehm-Gordon controversy.
Rudall & Rose begin production of the 1832 flute in London under the supervision of Greve.
- 1844 Cornelius Ward takes Gordon's side in *The Flute Explained*.
- 1847 Boehm's cylinder flute; production licensed to Godfroy and Lot in Paris, and, after Clinton declines, to Rudall & Rose in London.
- 1859 Tulou retires; Coche's *Mémoire* asserts his right to be reinstated at the Conservatoire.
- 1860 Dorus appointed Professor at the Conservatoire, the Boehm flute is adopted, and Louis Lot becomes official supplier.
- 1890 Rockstro's *Treatise* prejudiced against Boehm.
- 1896 Welch's *History of the Boehm Flute*, 3rd edition, rebuts Rockstro.

The silver medals Boehm referred to were awarded at industrial exhibitions of 1834 and 1835 in Munich, for instruments Greve made after Boehm had ceased working on the flutes himself. Greve continued to win prizes for his instruments, under the trademark Boehm & Greve, in the Industrial Exhibition of 1840 at Nuremberg and the General German Industrial Exhibition of the Hessian Trade Association in 1842.

By the time Boehm made his fifth visit to England in 1839, his ring-key flute had won some attention there. According to a letter of 7 November 1843 to *The Musical World* from Cornelius Ward, Ignazio Folz²² was performing in London at that time on a Boehm-system flute Ward had been building since 1839, and the performer and teacher William Card (1788–1861), Nicholson's successor at the Antient Concerts,²³ had promoted the ring-key flute unsuccessfully. Ward's letter intimated that French advocates were also making an effort to advance various ring-key flutes in England, in that 'we had Camus and Dorus endeavouring to introduce it to "English players",

by both public and private performances'. Camus reportedly 'caused some sensation' by performing Boehm's music on a Godfroy flute with a Dorus G[#] key.²⁴

The first significant conversion in England came when John Clinton, Professor of Flute at the Royal Academy of Music, took up the Boehm flute in 1841. Clinton explained his advocacy of the ring-key flute in his tutors of 1843 and 1846. He singled out for praise, besides its more obvious attributes, the instrument's potential for the English technique of 'Harmonics', providing a table of fingerings as well as musical examples by Cherubini, Rossini, Kuhlau, Nicholson, and Drouët. Clinton explained:

I do not mean it to be inferred that a thorough knowledge of [the harmonic fingerings] is indispensable, but I offer them, as additional resources, hitherto unknown on the old flute, as an amusing study, and as a means to heighten the effect of Flute music generally, consequently to elevate the character of the Instrument, and as an inducement to the Studious and Talented Flautist, to explore still further, the vast resources offered in Boehm's system.²⁵

Clinton's enthusiasm was not enough, however, to bring the new flute widespread acceptance in England. It had to make its way against the priorities and expectations of both amateur and professional flutists, as the series of letters in *The Musical World* for 1843 illustrates. Despite such opposition, Richard Carte (1808–91), a pupil of George Rudall's, invited Boehm's successor Rodolphe Greve to London in 1842 or 1843 to instruct the Rudall & Rose company's workmen in the manufacture of Boehm flutes. Though this has been called the first licensing of the ring-key flute outside Bavaria, the question of whether the inventor authorized or even approved the idea is in fact uncertain, as his business association with Greve had ended several years before. In any event Carte and Rudall had joined Clinton in taking up the ring-key flute by 1843 and its viability in England seemed assured for the time being. Greve returned to Munich in the middle of that year and was granted his own licence as an instrument-maker as well as citizen's rights.²⁶ Another Boehm flute came on the London market about two years later, when Thomas Prowse, who had vigorously defended his Nicholson-model flute in *The Musical World*, began to manufacture it under the direction of Camus.²⁷

Despite his own preoccupation with the steel industry, Boehm's ideas about the flute continued to find applications in the other woodwinds. In 1839, Hyacinthe Eléonore Klosé, Professor of Clarinet at the Paris Conservatoire, exhibited a Boehm-system clarinet he had developed with Buffet *jeune*. The holes of Klosé's instrument were generally larger and more rationally spaced than previously, and the mechanism employed Boehm's ring-keys. Klosé's method for this instrument appeared in 1843, the same year Buffet and Klosé patented the system. According to Macgillivray (1961) the new clarinet was soon adopted in France, but not in England, where in the provinces and the army bands the Boehm clarinet was a rarity as late as 1925.²⁸ In 1844 Buffet also produced a Boehm oboe, with the assistance of Pedro Joachim Raymond Soler (1810–50) and some acoustical advice from Boehm himself. Macgillivray wrote that it 'had little success save where loudness was the prime consideration'.

The ring-key flute took a few years longer to reach the United States. In about 1844 a Mr Brix visited New York City from South America, bringing with him a ring-key flute he had acquired in Europe.²⁹ After first seeing the flute at a musical party the flutist John A. Kyle, by his own account, called on the visitor, borrowed the instrument, and took it to the workshop of James D. Larrabee (*d* c1847), who made a copy. Larrabee exhibited his ring-key flute at the Seventeenth Annual American Institute Fair in New York in 1844, winning a silver medal for the 'best Boehm system flute'.³⁰ In a slightly different account given by the flute-maker Alfred G. Badger in 1853 neither Kyle's name nor Larrabee's appears:

About the time of my commencement, the first Boehm Flute made its appearance in this country. It was in the possession of a gentleman tourist. Mr W. J. Davis, an eminent Flute professor of New York, examined the peculiarities of its construction, at once perceived its merits, and predicted that its ultimate destiny would be its general adoption. He immediately engaged in its manufacture, but the undertaking proved far from profitable. He found an abundance of opposing interests. The manufacturers of the old Flute did not see the way clear from the profitable investment of their labor and capital in the new. It wanted a mechanical ability they did not possess. Professors of the Flute found they must unlearn their bad habits, and consequently discouraged its adoption.... Philip Ernst, of this city [i.e. New York], a Professor of the Flute, of high standing, and thirty years' experience, was the next to adopt the Boehm Flute. His position was more commanding, and his influence among amateurs great. Many followed in his wake, and it was through the assurances of his patronage, and of its ultimate success, that I commenced the manufacture of the *Boehm Flute*.³¹

Precisely how Davis engaged in the ring-key flute's manufacture remains unclear; Susan Berdahl (1985) has suggested a possible relationship with Theobald P. Monzani (*fl* 1835–66), on the strength of David Ehrlich's assertion that Monzani made a Boehm flute as early as 1843.³² Berdahl also identifies William Rönningberg (1803–c1889) as a maker of conical Boehm flutes in New York at a possibly early date, though the first evidence of this appears to be an entry in an exhibition of 1857.³³ In any case, when Badger (1815–92) set up his flute-manufacturing business in New York in 1845, he became the first American maker to produce ring-key flutes in the regular course of business. He based his instruments rather closely on Boehm's design, employing cocus wood, a double thumbhole, and vaulted arms with adjusting screws, but a Dorus G[#] rather than Boehm's open G[#] key. Seven of these instruments survive. When Boehm later developed the cylinder flute Badger made his own version as no U.S. patent protected the invention.

Badger made strenuous efforts to promote the Boehm flute. He entered instruments at numerous exhibitions in New York, Massachusetts, London, and Paris, beginning with the American Institute of the City of New York Exhibition of 1846, where he won a silver medal. He used paid advertising, letters to editors, broadsides, testimonials, and personal approaches to professionals to heighten public awareness of the new flute. His *Illustrated History of the Flute* (1853, 1854, 1861, and 1875), the first

such work to appear in the United States, borrowed heavily from Carte's history (1851) to argue for the advantages of the Boehm system.

Philip Ernst (1792–1868) became, according to Badger's account, the second leading New York player to take up the ring-key flute. Ernst, a German immigrant, held high standing in New York, having served as flutist to Charles X in Paris and as Nicholson's successor at the Italian Opera in London before taking up a position with the New York Philharmonic.

Meanwhile Boehm's activities in the iron works brought him health problems and financial losses, so that from 1845 he returned to his former profession as court musician and flute teacher. John Clinton visited him in Munich during 4–19 August 1845, at a time when Boehm had begun a study of acoustics under the guidance of his friend Schafhäutl and was ready to enter into a frank discussion with his guest of how the ring-key flute might be improved.³⁴ Another visitor in August was Moritz Fürstenau, whom Boehm's pupil Eduard Heindl had won over to the ring-key flute, and who remained in Munich to study it from 13 August to 11 November.

In his own account of his work in 1847, Boehm wrote:

I was never able to understand why, of all wind instruments with tone-holes and conical bore, the flute alone should be blown at the wider end: it seems much more natural, that with a rising pitch and shorter length of air-column, the diameter should become smaller ... I finally called science to my aid and gave two years to the study of the principles of acoustics under the excellent guidance of Herr Professor Dr von Schafhäutl. After making many experiments, as precise as possible, I finished a flute in the latter part of 1847, founded on scientific principles. ...

Indeed, Boehm's studies with Schafhäutl led him to revise the most fundamental aspects of the flute's design. His new instrument featured a cylindrical bore with a so-called 'parabolic' headjoint, a tube of metal instead of wood, toneholes of the maximum possible size closed by padded keys, and a mechanism that built on the innovations of his 1832 pattern.

As early as 1810 the London instrument-maker George Miller had patented a two-jointed fife in brass with a cylindrical bore for use in hot climates, but for thirty-five years no other maker had taken up the idea of a metal tube. Noting that cylindrical wood tubes he made to conduct experiments were unstable, Boehm replaced them with hard drawn brass. This experience convinced him that, as he put it, 'the molecules of the flute tube shall be set into vibration at the same time as the air column', and he determined that a lighter tube, such as one of drawn silver having a mass less than half that of the thinnest possible wood one, required less expenditure of energy to sound. In 1846 he began to experiment with flutes of brass, silver, and German silver (an imprecise term for various alloys of nickel, copper, zinc, and even brass and bronze), noting that the hardest, German silver, gave a 'clear but shrill tone'.

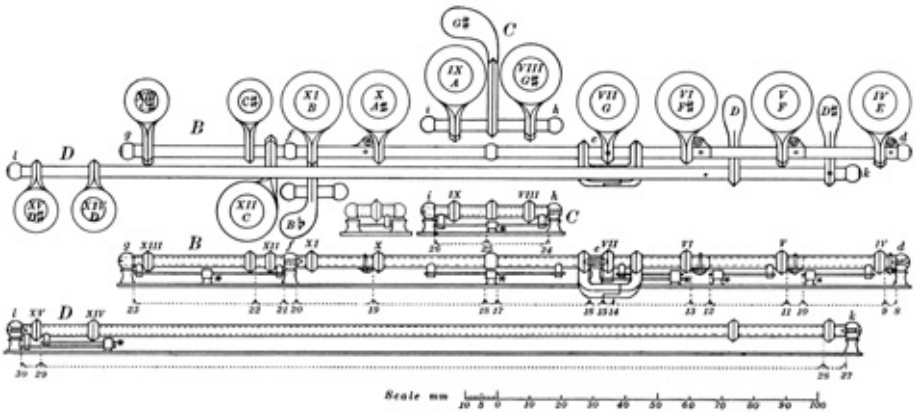
Though his acoustical studies enabled Boehm to calculate the positions of the toneholes, they did not remove the need to determine the length of the tube, its



43. Antoine Sacchetti (*left*) and Theobald Boehm (DCM).

diameter, and the size of the toneholes by experiment. In the end Boehm settled on an internal diameter of 19mm for the tube; he preferred 20mm for the richness and volume of tone in the first two octaves, but found that a slightly narrower bore helped the high register to be played softly. Likewise the bore of the headjoint appears to have been arrived at empirically rather than by calculation. Though his acoustical studies did provide a method for calculating the relative positions of the toneholes on the tube, the method he actually used, according to the account he gave in *On the Construction of Flutes*, was still based on experiment as much as on theory. 'For an exact examination of [the first three notes of the second octave], as well as the tuning proportions in general,' he explained, 'I made a model flute with movable tone holes, by which I was able to tune all the notes higher or lower at pleasure.' This perforated brass tube with rotating and sliding collars is preserved in the Dayton C. Miller collection (DCM 471).

Now that Boehm had returned to work on the flute and was contemplating the production of a new model, he had occasion to contest the continued use of his name by the workshop he had sold to his erstwhile foreman Greve.³⁵ On 21 January 1846 he obtained an injunction from the Munich magistrate against Greve's use of the name 'Boehm' under a penalty of 10 florins. Greve responded in a written protest of 9 March that Boehm was neither an instrument-maker himself nor proprietor of a



44. Mechanism of the 1847 flute's body section. Dayton C. Miller, trans. and ed., *The Flute and Flute-playing in Acoustical, Technical, and Artistic Aspects* by Theobald Boehm (Cleveland: Author, 1922 R/1963), Fig. 20, between pp. 77 and 78.

business that made instruments, but a Court Musician, that from the beginning Greve and not Boehm had actually made the instruments, and that Boehm had contributed only his name, the right to use which in the instrument business he had duly sold to Greve. Nevertheless, as a result of this dispute, Greve's workshop changed its mark in March 1846 from *Boehm & Greve à Munich* to *Rodol. Greve à Munich*. Munich directories of 1850 and 1852 noted that Greve's shop, still making ring-key flutes, was 'known as the Th. Boehm and Greve establishment'. The fact that Boehm did not mention Greve in any of his publications or letters suggests he bore his former partner a grudge over the matter, though the two continued to live on adjacent floors of the same building.

A Royal Bavarian trade licence for 'a new kind of flute in acoustical proportions and materials' of 13 April 1847 provided Boehm with the legal basis to open a new flute business to produce cylinder flutes, while his injunction against Greve made it possible to use his own name in the firm's trademark, *Th. Boehm in München*, which he used from 1847 to 1861. In the following year he retired on pension as a musician, citing his failing eyesight, to devote himself to making flutes.

Although Boehm judged at first that the toneholes should decrease in size from the bottom to the top of the flute, he found the manufacturing difficulties of this outweighed the advantages and established a standard size for the holes. This size was too large for any hole to be covered by a finger: all were now sealed with padded cups like those he had devised for the G and A holes of the 1832 flute. The pads were of a quite new type, thinner and more rigid than those used on other wind instruments, and held in place by a washer and a screw which engaged in a nut soldered to the inside of the cup. To couple the padded cups to the mechanism Boehm adopted Buffet's solutions of rod-axles, needle springs, and clutches.

On 20 June 1847 Boehm entered the first two silver closed-keyed cylinder flutes in his ledger, and at the end of the month he took them on a journey to London and Paris. Two years earlier he had agreed with Clinton to try to resolve the perceived

defects of ring-key flute's fingering and tone, and that if he succeeded in satisfying him, Clinton 'was to have the sole right of his improvements in the Instrument for England'. Boehm accordingly proceeded to London to offer his English champion a licence to manufacture the 1847 flute. Yet the new design disappointed Clinton:

A most careful and impartial trial fully convinced me, that, as a whole, he was as far as ever from removing the defects, or of perfecting the Instrument; and feeling that I could not adopt it with pleasure or satisfaction, nor conscientiously recommend it to my Pupils, I was (most reluctantly, I confess) compelled to decline it.³⁶

In the meantime Boehm travelled to Paris, where on 27 July 1847 he obtained a French patent covering the principle of a cylindrical bore and a parabolic head.³⁷ Two weeks later, on 14 August, he sold the exclusive French rights under that patent to Godfroy and Lot for 6000 francs, the value of about fourteen silver flutes. He had already sold the partners his second cylinder flute a month previously, evidently so that they could begin preparing a production model of their own.³⁸ Boehm's passport records that he left Paris two days after the sale. The French makers re-interpreted Boehm's design for the cylinder flute as they had the ring-key instrument. To streamline manufacture, they arranged the toneholes in a straight line, and they perforated some of the cups of the closed keys in the manner of the ring-keys to allow increased venting.

With Clinton out of the picture, the firm of Rudall & Rose, which had made at least 240 ring-key flutes between 1843 and 1847, now presented itself as candidate for the rights to the cylinder flute in Britain. On 2 September 1847 George Rudall wrote to Boehm to ask him to send one of his new flutes with toneholes of the size he thought best. Rudall's letter reveals both that the firm already possessed a silver flute by Boehm – evidently the one Clinton had rejected – and that by September at least one of Godfroy and Lot's silver flutes had already reached England. Rudall, however, apparently thought the French modifications no improvement:

The French seem to be going from your original Intention, and their Instruments are not usual [i.e. similar] to your silver flute in our possession. There is not the slightest doubt as to the vast superiority of your metal flute over every other ... I have been playing upon one of Godfroy's which is not a first rate Instrument; and I shall not rest satisfied until I possess one from the Inventor.³⁹

Four days later John Mitchell Rose filed a British patent on behalf of the company, 'being partly a communication from a foreigner residing abroad', for Boehm's metal tube, cylindrical bore, and parabolic headjoint. The company continued to experiment with hole sizes, bore, and fingering: between 1849 and 1851 it built flutes to at least ten different designs based on the Boehm cylinder flute.

On his return to Munich in September 1847 Boehm set to the production of cylinder flutes of his own, assisted at various times by his sons Wilhelm and Theobald. The workshop began with two ring-keyed cylinder flutes of gilded brass with silver mechanisms, one of them for Giulio Briccialdi of Rome (who visited Munich from 11

June until 18 November 1848), and a silver ring-keyed cylinder flute for Sir Charles Douglas of London. Nonetheless, all was not plain sailing. Instruments from Boehm's Munich workshop cost twice as much as other flutes, and German flutists found their mechanism fragile and frequently in need of repair. In 1853 the workshop sold only two instruments, and by the following year Boehm had produced a more robust French-style silver flute 'after Godfroy', which however failed to satisfy him. On 18 March 1854 he patented an 'improved key-mechanism for wind instruments' with the aim of eliminating its most fragile components and simplifying its regulation, but eventually settled on the French manner of mounting the keys on the player's side of the instrument. In 1848 Boehm's workshop made the first flute (no. 20) with a gold lip-plate, and from 1854 on he began to make cylinder flutes in wood as well as metal, sometimes combining wood headjoints with metal bodies. As to the special qualities of the silver instruments, he later wrote that the 'unsurpassed brilliancy and sonorousness' of his silver flutes very often led players to overblow, 'causing the tone to become hard and shrill; hence its advantages are fully realized only through a very good embouchure and diligent tone practice'. He estimated that not one player in twenty had the feeling for a good tone on a silver flute or the patience to develop it, and for the rest he recommended instruments of wood, of which the first two, nos 83 and 84, were delivered to Philip Ernst in New York in November 1854. In 1848 Godfroy and Lot also began to make cylinder flutes in wood, perhaps at the suggestion of Dorus.⁴⁰ In 1855 the firm made only five silver flutes to sixty-seven wood ones, but silver flutes became more popular among leading players in Paris after 1860 (chapter 11).⁴¹

Boehm's cylinder flute won distinction at several international exhibitions of the 1850s. After entering it at Leipzig in 1850 and winning a silver medal, the inventor visited England again in 1851 and presented the new flute at the Great Exhibition, winning first prize and a gold medal. In 1854 at Munich and in 1855 at Paris the cylinder flute again won silver and gold medals respectively, the latter in recognition of 'important scientific improvements to the flute and the successful application of these principles to other wind instruments', namely the Boehm oboe and bassoon. Only the Boehm flutes and clarinets, however, made any headway with professional musicians.

Boehm's workshop ledger precisely details the instruments he made, an average of ten a year between 1847 and 1861. From 1847 to 1858, a total of 130 cylinder flutes were sold, 15 with ring-keys. The vast majority, 76 flutes, remained in German-speaking countries, Poland, and Russia, while 23 were made for English players. America accounted for eight flutes, the low countries seven, and Italy five. Of the eleven sold in the rest of the world, not a single one went to France.

Philip Bate made a study of the early 1847 pattern flutes from Boehm's workshop which Dayton C. Miller had collected. He found that though in the earliest examples the 1832 mechanism was simply applied to a cylindrical tube with larger toneholes, Boehm continued for some time to experiment with covered keys, open rings, and various mechanical variations.

Different methods of playing B_♭ in particular continued to occupy Boehm's inventiveness. He originally provided a single open-standing key for C, as in Tromlitz's flute of 1785, assigning B_♭ to the right forefinger as in the Tromlitz 1796 system, but dispensing with the thumb B_♭ key Tromlitz provided as a duplicate. But

since certain note patterns require some other way of playing B₁ than the 'long' or right-hand B₁ provides, Boehm returned to the concept of a B/B₁ for the left thumb. After several experiments (1832, 1849, and 1854) he settled on a version he first supplied on cylinder flute no. 24, built in February 1849 for a Mr Damiani of Liverpool. In this slightly counter-intuitive arrangement, the B₁ touchpiece lies higher on the tube than the C key, which is kept closed by the left thumb. Rolling or shifting the thumb sideways onto the touchpiece keeps the C key closed at the same time as closing the B₁ hole, thus producing B₁. Rockstro ascribed the invention of this key to his friend Dr Burghley, and its first application to Giulio Briccialdi (1818–81) in May or June 1849, and consequently Boehm's 1849 B₁ key is now universally known by Briccialdi's name.

Boehm also devised a closed G[#] arrangement of his own that Philip Bate thought superior to the Dorus G[#] because it did not depend on the relative force of two opposing springs. In Boehm's version, which he built in 1877 on a flute for General Daniel Macauley (DCM 161; ill. 41(6)), the G[#] cover was held closed by a spring while its lever was split into two sections to reverse its effect. To counteract the flattening effect of the closed G[#] key, Boehm placed the A hole 1.2mm above its normal position.

To find the theoretical tonehole positions for a flute built to play at any of the pitch standards then current (he used A=435), Boehm devised a geometrical diagram he called the *Schema*, which he submitted *hors de concours* to the 1862 London exhibition at which he served on the jury for musical instruments, though he did not attend in person. The *Schema* was later submitted to the Paris exposition of 1867, but because its matter was scientific rather than artistic, the jury declined to consider it. It was criticized by the organ-builder Aristide Cavallé-Coll, who later retracted his objections.⁴² The Bavarian Polytechnic Society first published the diagram in its *Kunst und Gewerbeblatt* (October 1866).

In about 1854, when he was around sixty years of age, Boehm produced an alto flute in G. He exhibited it at the Munich Regional Industry Exhibition of the same year and sold the first such instrument in January 1858. Also in 1854, Carl Mendler (1833–1914), a watchmaker, joined Boehm's Munich operation, becoming foreman in 1862 and a partner five years later. Two of Boehm's pupils trained under him as makers: Emil Rittershausen (1852–1927), who established his own firm in 1876, and Thomas Mollenhauer (1840–1914), a member of an instrument-making family, who made a conical-bore piccolo to Boehm's specifications in 1864.

The revolutionary nature of the Boehm flute caused or intensified sharp divisions among flutists, composers, and conductors not merely over the fingering and mechanism of the instrument but over its tone and very character. These controversies raged for more than a hundred years, in terms and with outcomes that form the topics of later chapters.