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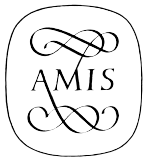

Musical Instruments and Players in J.-A.-C. Charles's *Acoustique* (Paris, c. 1787–1802) and Other French Technical Sources

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THE PRESENT STUDY is based mainly on historical data drawn from a manuscript containing a series of lessons on musical acoustics given in Paris by Jacques-Alexandre-César Charles (1746–1823). Though dated 1802, the manuscript—which critically examines all the musical instruments then in use—seems to have been compiled over a five-year period (1797–1802), and even includes references dating at least as far back as 1787.[1]

In Paris, Charles was professor of experimental physics at the Conservatoire des Arts et Métiers, president of the class of experimental physics at the Academy of Sciences, and a member of several commissions reporting on newly invented (or improved) musical instruments.[2] In the course of his public lectures, which were well attended, he successfully carried out experiments in various areas of physics, including acoustics. Of the lectures Benjamin Franklin was to say: "Nature refuses him nothing, it seems to obey him."[3] He was also a great lover of music and a fairly good flute player.[4]

In the course of these activities Charles came into contact with a series of musical personages, on whom he furnishes hitherto unpub-

1. Paris, Bibliothèque de l'Institut, MS 2104, Pièces 17–18: "Cours de physique. Par Charles, de l'Institut N.^{al} an 11. 1802. En 60 leçons" (hereafter Charles, *Acoustique;* abbreviated citations to this manuscript in the main text will be given by means of page numbers within square brackets). Lessons 57–60, dedicated to the *Acoustique,* are contained in *Pièce 17.* They appear to have been transcribed by a pupil, which may explain the misspelling of a few surnames.

2. See Jerry B. Gough, "Charles, Jacques-Alexandre-César," in *Dictionary of Scientific Biography,* ed. Charles Coulston Gillispie (New York: Scribner's Sons, 1971), 3:207–08.

3. See Charles Brainne, "Jacques-Alexandre-César Charles," in Charles Brainne et al., *Les hommes illustres de l'Orléanais* [. . .] (Orléans: Gatineau, 1851), 1:314–17.

4. See Richard Shepherd Rockstro, *A Treatise on the Construction, the History and the Practice of the Flute* [. . .] (reprint of the 1st ed. of 1890, London: Musica Rara, 1967), 343. Moreover, despite his wide-ranging involvement in science and art over the years, he also found time for the romantic sphere, for in 1804, at the age of fifty-eight, he married the twenty-two-year-old Julie-Françoise Bouchaus des Herettes, a creole girl from Santo Domingo later to be known above all for her intimate friendship with Lamartine: see Anatole France, *L'Elvire de Lamartine. Notes sur Monsieur et Madame Charles* (Paris: Champion, 1893).

lished information. Included are Gluck, Viotti, Baillot, Duport, Jarnowick, Pagin, and Madame Brillon de Jouy, as well as the luthier Socquet. On the subject of instrument-making his manuscript also includes information on the diffusion in France of Stradivari violins and on the last violin of the Amati family, apparently made by Girolamo II in 1739–40 at the age of ninety. As Charles's delivery and style is throughout both lively and forthright, in the course of the present article we shall allow him—as much as possible—to speak in his own words.

Apart from the Charles manuscript, this study will also draw on information of a technical nature from manuscripts preserved in the archives of other French scientific institutions. These include an anticipation of the double bass tuning gear mechanism as well as new proposals—with illustrations—for a more rational arrangement of the tone holes on the flute and clarinet.

The "Tartinistes" and the Last Violin of the Amatis

In his public demonstrations Charles stresses the important role that the metronome [*chronomètre*] could play in transmitting for posterity the tempos composers prescribed for their works. His words also confirm that there was a considerable increase in tempos towards the end of the eighteenth century:

> I saw Gluck noting with astonishment that after five or six years all his intentions had already been lost. We realize how much the music of Lully's day must have been changed. We learn that those operas for which the performance duration in the last century is known lasted three quarters of an hour or an hour longer. If Lully had been able to avail himself of the readings of the metronome, he would have preserved something precious: the duration of each measure.[5]

Of the pendulum metronomes he used, he also mentions one perfected by Breguet, costing as much as a thousand *écus*.[6] In the course of his practical experiments he discovered that:

5. Charles, *Acoustique,* 282: "J'ai vu Gluck s'étonner au bout de 5 à 6 ans de trouver qu'on avait déjà perdu toutes ses intentions. Nous concevons combien on a du varier la musique qui est du tems de Lully: on s'est apperçu que tel opéra dont la durée pendant la réprésentation dans le siècle dernier était connue, durait 3/4 d'heure ou une heure de plus. Si Lully avait pu se servir des déterminations du chronomètre, il nous aurait conservé une chose précieuse, le tems de la durée de chaque mesure."

6. Charles, *Acoustique,* 283. A "vieux chronometre pour la musique" appears, for example, as no. 513 of the *Inventaire des instrumens de physique, optique, géometrie, astronomie &c du Cabinet de la cy devant Académie des Sciences de Paris,* dated 1793 and signed by Charles himself (Paris, Bibliothèque de l'Institut, MS 1986-I).

> there is not a single musician who plays in time. Four years ago I had here Viotti, Duport, Jarnowich and the most skilled artists. They made the attempt and failed in the test. [. . .] Whenever I wish to put a musician to the test with this instrument, I do not ask him for an easy rhythm such as 6/8 in which all the notes are equal: [there] he would very easily keep time. I take a Siciliana, the most passionate and unequal melody. It is interspersed with a mass of secondary notes involving a greater variety of notes within the same rhythm; with such a melody it is impossible to keep time.[7]

He adds, however, that the only one to pass the test was—paradoxically—"one who is not much in the habit of playing in time, as she has often played with Pagin: Madame Brion."[8] The violinist André-Noël Pagin was in fact a pupil of Tartini's school, of whom there were quite a number in Paris and about whom Charles had this to say:

> The "Tartinistes" had a method that was utterly different from all others: they never played in time. The school came to an end with Pagin. Nordani [*sic*] is still alive, but he was obliged to part company with the school so as to make something of himself.[9] In his old age Tartini would say: "Go and hear Pagin, for you will still hear me." Between them, however, there is the same difference that always exists between the copy and the original. [. . .] [Tartini] died playing the violin at the age of 78; he kept his violin in his bed, just as Euler died calculating the elevation of the air balloon.[10]

7. Charles, *Acoustique,* 282–83: "il n'y a pas un seul musicien qui aille de mesure. J'ai tenu ici Viotti, Duport, Jarnowich et les artistes les plus habiles, il y a 4 ans. Ils l'ont essayé, et n'ont pu en venir à bout. [. . .] Quand je veux avec cet instrument pousser un musicien à bout, je ne lui demande pas une mesure facile comme le 6/8 dont tous les sons se trouvent égaux: il irait très bien de mesure. Je prends la Sicilienne, qui est le chant le plus passionné et le plus inégal. Il est intercallé d'une foule de notes accessoires qui comportent une variété plus grande de notes dans les mêmes mesures; avec un pareil air il est impossible d'aller en mesure."

8. Charles, *Acoustique,* 283: "une personne qui n'a pas beaucoup l'habitude d'aller de mesure, puis qu'elle a joué souvent avec Pagin, c'est madame Brion." Anne-Louise Brillon de Jouy was considered by Burney (in 1770) to be "one of the best harpsichordists of the age"; her *salon de musique* was famed among the Parisian aristocracy and assiduously frequented by, among others, Benjamin Franklin: see Lionel de La Laurencie, *L'école française de violon de Lully à Viotti* [. . .] (Paris: Delagrave, 1922–24), 1:181–82.

9. "Nordani" is evidently a misspelling of [Pietro] Nardini, Tartini's best pupil, who died in 1793. Until now it was not known that he abandoned his teacher's school.

10. Charles, *Acoustique,* 299: "Les Tartinistes avaient une méthode toute differente des autres; ils n'allaient jamais de mesure. L'école a fini par Pagin. Il existe encore Nordani [*sic*]: il a été obligé de s'écarter de l'école pour devenir quelque chose. Quand Tartini était dans sa vieillesse il disait: allez entendre Pagin, vous m'entendrez encore. Il y a cependant entr'eux la différence qu'il y a toujours entre la copie et l'original. [. . .] [Tartini] est mort en jouant du violon, à l'age de 78 ans; il tenait un violon dans son lit, comme Euler est mort en calculant les élévations du globe aérostatique."

The comment that the "Tartinistes" did not play in time is, to date, otherwise undocumented and indeed contradicts what Rousseau claimed in 1768: that Italian music—unlike French music—was rigidly subject to the metronome.[11] What the above quote only vaguely hints at is the hostility with which the "Tartinistes" were received by the general Parisian public, a situation that soon forced Pagin to limit his concert appearances to the salons of the aristocracy.[12]

Referring to Pagin, Charles also relates the following:

> Amati, at the age of ninety, made a violin at Tartini's request. This violin is the one owned by the celebrated Pagin. He left France at the age of twenty and was one of France's best violinists. A pupil of Gaviniez, he made a trip to Italy to hear Tartini: he was so startled by Tartini's playing that he joined his school. Tartini kept him playing scales for six months. Pagin had the modesty and good sense to join the school. He came out of it as the only true copy of Tartini in existence. He died three years ago and with him ended Tartini's school. It is a school that cannot be revived because the kind of music we have adopted is unsuited to it.
>
> Anyway, Tartini begged Amati to make him a violin for a young man he had adopted. Amati said: I must get my spectacles. Inside the instrument he wrote that he made it at the age of ninety. This violin is one the best instruments in existence.[13]

From the above passage we may deduce that the luthier in question is clearly Girolamo II Amati (26 February 1649–21 February 1740), the very last representative of the family. Pagin's violin (1739–40) can thus be considered as the last to be made by an Amati. (Philip J. Kass kindly informs me that this instrument must be considered lost, unless perhaps it survives with another luthier's label, most likely either Nicolo Amati or Giovanni Battista Rogeri.) Girolamo II was the son of the

11. Jean-Jacques Rousseau, *Dictionnaire de Musique* (Paris: Duchesne, 1768), 99–100.

12. See La Laurencie, *L'école française de violon,* 1:179–83.

13. Charles, *Acoustique,* 297–98: "Le sieur Amati à 90 ans a fait un violon à la prière de Tartini. Ce violon est celui que possédait le celèbre Pagin; sorti de France à l'age de 20 ans, ce fut un des premiers violons de France. Eleve de Gaviniez, il fut faire un tour en Italie pour entendre Tartini: il fut si effrayé du jeu de Tartini, qu'il se mit à son école. Tartini le tint pendant 6 mois à faire des gammes. Pagin eut la modestie et le bon sens de se mettre à l'école. Il en est parti la seule et vraie copie de Tartini qui ait existé. Il est mort il y a 3 ans, et avec lui l'école de Tartini a fini. C'est une école qui ne pourra pas renaître, parce que le genre de musique que nous avons adopté ne se prête pas à cela.

"Tartini pria donc Amati de lui faire un violon pour un jeune homme qu'il avait adopté. Amati dit: il faut que je prenne mes lunettes. Il a écrit dans l'interieur qu'il a fait cet instrument à l'age de 90 ans. Ce violon est un des meilleurs instrumens qui existent."

famous Nicolo Amati (1596–1684),[14] whose best pupil was Antonio Stradivari (1644–1737). Stradivari made his last three violins in 1736 and 1737, adding on their (printed) labels in his own hand that in those years he had reached the ages of 92 and 93 respectively.[15] It is understandable, therefore, why the less prolific, and much less famous, Girolamo wished to demonstrate, with a rather late outburst of pride, that he was equal to the same feat. Little appreciated in the past, today the work of Girolamo II is being reassessed,[16] and Charles's high opinion of him is being confirmed. From the context we may further deduce that Pagin was born c. 1720, and that his date of death, still unknown, must be no later than 1799. (Pierre Gaviniès, his teacher and also a celebrated "Tartiniste," died in 1800.)

As regards the diffusion of Stradivari violins in France, Charles points out that "the Stradivari have more power, the Amati a more pleasant sound; those who play in quartets or duets prefer the Stradivari."[17] This contradicts Gallay's statement (made in 1869) that—as far as chamber music was concerned—the preference was for Amati instruments until 1810.[18]

Charles turns out to be the first French writer interested in the techniques employed by the Cremonese luthiers. Much of this information appears to have been provided by the luthier [Louis] Socquet, with whom Charles says he spent much time discussing technical matters.[19] Socquet had also dismantled and accurately copied a Stradivari

14. It is worth mentioning here that one of Tartini's violins was made by Nicolo Amati, at least according to the label inside the instrument: see *Mostra di cimeli di Giuseppe Tartini voluta dal comune di Trieste* [. . .] (Trieste: Tipografia Moderna, 1971), 17. Tartini also had a violin by the Paduan [Pietro?] Bagatella: see *Esposizione internazionale di musica in Bologna. Catalogo ufficiale* (Parma: Battei, 1888), 34.

15. See W. Henry Hill et al., *Antonio Stradivari: His Life and Work (1644–1737)* (London: William E. Hill and Sons, 1902; reprint New York: Dover Publications 1963), plate facing p. 217, reproducing the original labels.

16. A start was made by Hill, *Antonio Stradivari,* 31–32. Umberto Azzolina, *Liuteria italiana inedita. Unpublished instruments of known Italian makers* (Cremona: Turris, 1991), 29, publishes a photograph of a 1697 violin by Girolamo II Amati characterised by "fine workmanship" and "a beautifully clear and powerful sound, rarely found in other violins made by the same family."

17. Charles, *Acoustique,* 296: "Les Stradivarius ont plus de force, les Amati ont un son plus agréable; les personnes qui jouent des quatuors, des duos, préferent des Stradivarius."

18. Jules Gallay, *Les luthiers italiens aux XVII^e^ et XVIII^e^ siècles* (Paris: Académie des Bibliophiles, 1869), 175.

19. Charles, *Acoustique,* 297–98. Louis Socquet worked in Paris between 1750 and 1775: see René Vannes, *Dictionnaire universel des luthiers,* 2nd ed. (Brussels: Les amis de

cello, managing however to obtain only a mediocre [*assez ordinaire*] instrument [p. 298]. The reasons for the decadence of late eighteenth-century violin making are summarized by Charles as follows: poor choice of wood (he says the Cremonese used prized woods, and only the part of the trunk exposed to the south), oven drying (instead of natural seasoning), and the use of spirit varnishes (instead of oil-based ones). He also refers to a constructional modification of great interest today: after saying that the shape of the violin had long remained unchanged, he goes on to specify that "only certain alterations to the fingerboard have been made, in order to facilitate the movement of the fingers: [previously] we did not have the fast and brilliant motions that we have today."[20] Recent research, however, has shown that in Italy such an adjustment is already documented at least as early as c. 1760.[21]

Viotti and Baillot, Violins and Double Basses

Charles puts the violin "at the head of all instruments," thanks to the exactness and flexibility of its intonation [p. 299]. His research on this point led him to collaborate with the greatest violinists in the city at the time. One of the first to play an active part in his public lectures was Giambattista Viotti, during his first Parisian stay (from late 1781 to 1792). Viotti's close relations with the scientific world are incidentally confirmed by the fact that he arrived in the French capital bearing a letter of introduction—addressed to d'Alembert—from Giuseppe Luigi Lagrange, the celebrated mathematician and a fellow-citizen of Turin.[22] It is interesting to note what Charles reports on Viotti and his "vibrato":

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la musique, 1951), 337. His date of death is unknown, though he must have died by 1802, for in our manuscript Charles says (p. 297) "for a long time we had a certain Socquet, a highly skilled man who was also very learned."

20. Charles, *Acoustique,* 297: "on a seulement modifié quelques dispositions de la touche, pour rendre plus facile la marche des doigts: on n'avait pas la marche rapide et brillante qu'on a actuellement."

21. See Pierluigi Ferrari, *Interventi per l'ammodernamento degli strumenti ad arco della collezione mediceo-lorenese, 1733–1765,* paper presented to the Conference on "Strumenti-Musica-Ricerca" organized by the Ente Triennale internazionale degli strumenti ad arco, Cremona, 28–29 October 1994.

22. See *Oeuvres de Lagrange publiés par les soins de Joseph-Alfred Serret* (Paris: Gaulthier-Villars, 1882), 13:371–73: letter from Lagrange to d'Alembert, dated Berlin, 7 December 1781. D'Alembert was to reply on 1 March 1782, informing him that Viotti had come to see him as many as three times (though not finding him at home on the first two occasions).

> You know the way artists provide expression on the violin: the finger falls slightly below [the pitch] resulting in a very slight detuning. It is one of the things that tormented Viotti most. One day I showed him that in order to be expressive he played out of tune; I surprised him at a moment in which he made a sideways movement; I showed him that that meant changing the length of the string and consequently playing out of tune. One must disturb the ear without it being able to detect the error—therein lies expression. It produces an emotional sound resulting from this slight vacillating uncertainty.[23]

After Viotti had left Paris, Charles made use of Pierre Baillot to show that—even at the Paris Conservatoire—the violinists of the time employed a particular kind of just intonation called "*gamme Européenne.*"[24] When necessary they could also resort to tempered intonation, because "at a concert the violin is like a man of wit at a party: being unable to elevate the others to his own level, he descends to theirs."[25] These public demonstrations by Charles on violin intonation were to be remembered later, in 1823, during a course of acoustics given—again in Paris—by the physicist Jean-Baptiste Biot.[26]

Charles also took an interest—though only marginally—in the lower-pitched instruments of the violin family, concerning which he observed:

23. Charles, *Acoustique,* 291: "Vous savez la manière dont les artistes déterminent l'expression dans un violon: le doigt se rejette un peu au dessous: il en résulte une détonation très legere. C'est une des choses qui a le plus tourmenté Viotti. Un jour je lui démontrai que pour avoir de l'expression il jouait faux; je le surpris dans le moment ou il faisait un mouvement de côté: je lui démontrai que c'était changer la longueur de la corde, et conséquemment jouer faux. Il faut inquiéter l'oreille sans qu'elle puisse découvrir l'erreur, telle est l'expression. Elle produit un son sentimental resultant de cette petite incertitude vacillante." Charles does not tell us how frequently Viotti used vibrato, an ornament on which the major contemporary treatises express strongly conflicting opinions. Francesco Geminiani, *The art of playing on the violin* [. . .] (London: Johnson, 1751), Ex. XVIII-14, recommends its use also "on short notes" and "as often as possible," given that it "contributes to make their sound more agreable." On the other hand, Leopold Mozart, *Gründliche Violinschule* [. . .] (3rd ed., Augsburg: Lotter und Sohn, 1787), 243–44, counsels sparing use, and only on very long notes (advice that appears already in the first edition of the treatise, dating back to 1756).

24. See Patrizio Barbieri, "Violin Intonation: A Historical Survey," *Early Music* 19 (1991): 71–72.

25. Charles, *Acoustique,* 317: "Le violon est dans un concert ce qu'est un homme d'esprit dans une compagnie: ne pouvant mettre les autres à sa hauteur, il descend à leur portée."

26. Paris, Bibliothèque du Conservatoire des Arts et Métiers, MS 8°.C.4: *Leçons de physique sur l'acoustique, par J. B. Biot, recueillies par Baudot,* p. 82 (on the Pythagorean comma).

> there are some very low sounds that we cannot distinguish well except by long habit, or when we compare such a sound with another, higher pitched than itself. For example, even the most skilled artists, used to playing a high-pitched instrument, such as the violin, have great trouble tuning a double bass. I have heard that said by Jarnowich, Viotti, and several others. One has to live, as it were, with low sounds in order to have a very pure perception of them.[27]

On the subject of the double bass, let us digress briefly from Charles's manuscript in order to draw attention to an anticipation of the modern tuning mechanism based on worm-screws, presented in France as early as 1758. The source is a hitherto unknown handwritten memorandum from the archive of the Academy of Sciences in Metz, in which the invention is attributed to a certain Coré, a watch-maker of that city (fig. 1).[28] His proposal substantially modified a similar previous attempt made by Jean-Baptiste Domenjoud in 1757, who used not worm-screws—as Coré proposed—but plain screws, like those used today for the fine-tuning of a violin top string.[29] The invention of the worm-screw

27. Charles, *Acoustique,* 269–70: "il y a des sons très graves que nous ne pouvons bien discerner que par une grande habitude, ou lorsque nous comparons ce son avec un autre, à l'aigu de celui là. Par exemple, les artistes mêmes très habiles qui ont l'habitude de jouer d'un instrument de dessus, comme du violon, ont assez de peine à accorder une contrebasse. Je l'ai entendu dire à Jarnowich, à Viotti, et à quelques autres. Il faut vivre, pour ainsi dire, avec les sons graves, pour en avoir une sensation très pure."

28. Bibliothèque-Médiathèque Municipale de Metz, MS 1337, pp. 229–41: *Memoire* [*lu*] *à l'Assemblée du Mardy 17 Janvier 1758, en luy présentant une cheville pour accorder avec precision les instrumens de musique à cordes, inventée* [*par*] *le S.r Coré, horloger de cette ville* [. . .]. The manuscript specifies that one complete turn of the worm-screw *D–E* made the peg *B–b* rotate by one fortieth of a turn; on p. 237 we also read that for a preliminary, approximate tuning (to speed up operations when mounting a new string), one could turn peg directly, "without doing the slightest damage to the worm-screw"—which seems frankly impossible, at least on the evidence of the drawing. The French text of the legend, visible in fig. 1, is as follows: "*A.* Manche du Violon, ou Basse, tel qu'il est ordinairement. / *B.b.* Cheville ordinaire, excepté qu'elle est de cuivre, et qu'elle est brisée. / *C.* Roue dentelée pour l'engrenage d'une vis sans fin. / *D.* Vis sans fin, mûe par le bouton *E,* fixé par les supports *F.[F.]* engrainant dans la roue *C.* / *G.* Vis d'arrêt de la cheville *B.b.* separée du bois du manche par [la] rosette *H,* qui fait point d'arret au cilindre *b* de la cheville, et qui empeche en même tems que la tête de la vis ne mange le bois du m[anche]."

29. Domenjoud's invention was put into practice first by François Gaviniès, a luthier working in Paris and father of Pierre, the famous violinist (mentioned above); the handles of Gaviniès' screws were made of ivory and projected from the neck very conspicuously. The same manuscript tells us that later another luthier managed to preserve the neck's traditional appearance and weight by inserting Domenjoud's screws inside the neck, making them out of iron and reducing their thread: see *Memoire,* 234–35. The first version of this mechanism is described by Jean-Baptiste Domenjoud himself in *De la préférence des vis aux chevilles pour les instruments de musique* [. . .] (Paris: Thiboust, 1757).

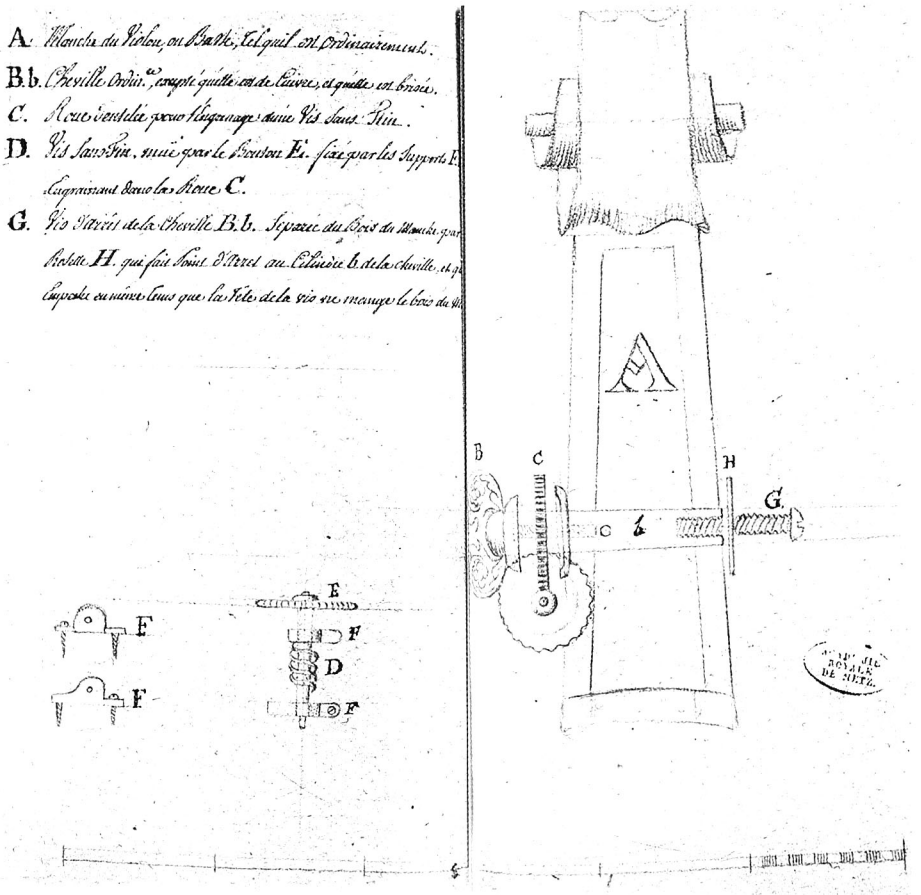

FIGURE 1. Tuning gear mechanism invented by Coré, 1758 (Bibliothèque-Médiathèque Municipale de Metz, MS 1337, pp. 240–41). *A.* Pegbox of the violin or [double] bass, as it usually is. / *B–b.* Ordinary peg, except that it is of brass, and open-carved. / *C.* Gear wheel which engages with a worm-screw. *D.* Worm-screw, activated by the knob *E,* fastened [to the peg box] by brackets *F–F* and engaging with the gear wheel *C.* / *G.* Set-screw for the peg *B–b,* separated from the wood of the peg box by the washer *H,* which stops the cylinder *b* of the peg, and which at the same time prevents the head of the set-screw from eating [away] the wood of the pegbox.

tuning mechanism, today normally used only on the double bass and guitar, has hitherto been attributed to the German luthier Anton Bachmann (1778),[30] even though similar mechanisms may have been developed before then.[31]

Glass Harmonica, Harp, Organ, and Piano

Apart from stringed instruments, Charles also concerned himself with many other instruments, above all the glass harmonica, at the time much in vogue in Paris.

Glass harmonica. Charles first examined the type he refers to as *harmonica à vases,* in other words one consisting of a series of glass bowls filled with water in quantities varying according to the note to which each was tuned. The performer set the glasses into vibration by directly rubbing the rims with his fingers, previously moistened with water and vinegar so as to roughen the skin of the fingertips and thereby increase their grip on the smooth surface [p. 288]. On this subject, Charles added that:

> quite commonly the glasses are covered with a damp cloth. The finger is pressed down on the cloth, the cloth presses down on the glasses and makes them resonate, in such a way that all the fingers produce sounds of the same character. Those who have practiced, and not very oily, fingers prefer to use their fingers.[32]

The instrument is characterised by a "singular and melancholy sound, that seems to arrive from space."[33] Charles is perhaps the only writer to describe the strange effect of this timbre on audiences:

30. See, for example, Vannes, *Dictionnaire universel des luthiers,* 15.

31. See Isaia Billé, *Gli strumenti ad arco e i loro cultori* [. . .] (Rome: Ausonia, 1928), 45. Duane Rosengard, *Contrabassi cremonesi. Cremonese double basses* (Cremona: Turris, 1992), 77 and 113, describes a double bass by Nicola Bergonzi, 1777, whose head "bears three unaltered peg holes, two of which retain somewhat roughly hand wrought tuning gears" (perhaps also by Bergonzi?).

32. Charles, *Acoustique,* 294: "assez ordinairement on couvre les vases d'un drap mouillé. Le doigt est appuyé sur le drap, le drap mouillé appuye sur les coupes et les fait résonner, de sorte que tous les doigts produisent des sons du même charactère. Aussi les personnes qui ont leur doigt exercé, et qui ne l'ont pas très onctueux, aiment mieux se servir de leur doigt."

33. Charles, *Acoustique,* 288: "[un] son singulier et mélancolique, qui semble sortir de l'espace."

> It attacks the organs of the delicate and even those of the more robust. I have seen many people faint when this instrument was being played; another, vigorous person ardently protested at those being taken into the antechamber, [but] within a minute, she herself was among them. They are peculiar feelings that affect us. We are moved without the melody contributing to the effect.[34]

Charles also mentions a type of harmonica based on that invented by Benjamin Franklin and worked by a keyboard and pedal mechanism [p. 292]. In this model, glass bowls were not tuned by being filled with more or less water, but by having different diameters and thicknesses. Tuning was much more problematic than on the other model, due to the difficulty of obtaining bowls of well-defined and constant thicknesses using the technology of the time. To the many instrument builders who turned to him for advice on the matter, Charles would reply philosophically that the best solution would be "to own a glass-works or to have free access to one" so as to be able to choose the right sizes. But he also adds that, leaving aside such practical problems, "we have a very ingenious and skilled craftsman, Grenier, who has given the matter thought and done some interesting research. He has calculated the best curvature and opted for an almost hemispherical one."[35] Of Grenier's calculations, however, not a trace has survived and Charles's report is the sole surviving evidence.

Of the two types of harmonica described, Charles shows a marked preference for that using glasses: during performance the undulation of the water in the glasses gave the sound an "*accent vocal*" he associates with the vibrato obtainable on the violin [p. 291].

Harp. At that time the harp was "too commonly known" to merit a detailed description from Charles. Nonetheless he judged it disparagingly, owing to its many "serious defects": appreciable detuning, no-

34. Charles, *Acoustique,* 292: "Il attaque les organes des personnes délicates, et même des personnes robustes. J'ai vu plusieurs personnes s'evanouir pendant qu'on jouait de cet instrument; une autre très vigoureuse se plaignait assez intensivement de celles qu'on transportait dans l'anti-chambre: au bout d'une minute, elle était elle même à côté. Ce sont des sentimens particuliers qui nous affectent. On est ému sans que la mélodie y ait contribué."

35. Charles, *Acoustique,* 293: "nous avons un artiste très ingénieux et très habile qui s'en est occupé, et a fait là-dessus des recherches intéressantes. C'est Grenier; il a calculé la courbure la plus convenable, il a pris presque l'hemisphère." The instrument maker, otherwise unspecified in the manuscript, may be identified as Gabriel-Joseph Grenié (1756–1837), who in 1810–16 patented two models of *orgue expressif* (see note 43 below).

ticeable at the moment the player plucks the string; short retention of tuning (generally no longer than half an hour); lack of dampers and, consequently, an excessive blurring of sounds [p. 301]. Worst of all was the lack of sonority in the top notes compared to that of the low notes, a defect explaining the instrument's exclusion from the *Concert spirituel:*

> I have always seen that this instrument was absent at the *Concert spirituel.* It was judged unfavourably. I would ask people "where were you seated?" Those too far away were dissatisfied: they could only hear the low notes, [while] the top notes made hardly any effect at all.[36]

In light of this statement it is surprising to learn how many of the harp models patented in Paris in the early years of the nineteenth century aimed to reinforce not the high notes, but the low ones.[37] Jean-Baptiste Krumpholtz himself, in the acclaimed concerts given in Paris even before 1790, used a harp that rested on a soundboard fitted with extra strings—played by special pedals—to make up a contrabass register.[38]

Despite the above faults, Charles does admit that on the harp one can "make music that is not only tolerable, but sublime."[39]

Organ. About this instrument Charles's opinion is even more unfavorable. He considers the organ as little more than an "assemblage" of disparate musical instruments, adding scornfully that "its moral power is of little account."[40] Moreover, he objected that, unlike the piano, the manner of playing the keys does not lead to any difference in musical

36. Charles, *Acoustique,* 302: "J'ai toujours vu cet instrument manquer au concert spirituel. On le jugeait défavorablement. Je demandais aux personnes: où étiez vous placé? Les personnes qui étaient trop loin étaient mécontentes: elles n'entendaient que des graves, les aigus ne produisaient presque aucun effet."

37. See, for example, Archives Nationales, MS F.12.1014/17: Patent no. 514, 9 June 1809, for a "*Harpe harmonico-forté*" invented by Keyser de Lisle, resident in Paris, Rue du Temple 123. Apart from the usual gut strings, this instrument also had strings of brass or copper [*cuivre*] for the contrabass register. See also MS F.12.1024.B/10: *Demande d'un brévet d'invention,* an application made by André-Jean-Baptiste Thory, "*facteur de pianos et de harpes,*" Paris, Rue de Cléry 64, concerning a "*Harpe d'harmonie*" with—among other things—the bass notes sounding "louder and much more harmonious" (9 August 1815).

38. See Gaspard-Claire Riche de Prony, *Instruction élementaire sur les moyens de calculer les intervalles musicaux* [. . .] (Paris: Firmin Didot, 1832), 104.

39. Charles, *Acoustique,* 302: "faire de la musique, non pas seulement tolerable, mais sublime."

40. Paris, Bibliothèque de l'Institut, MS 2104, Pièce 18 (60^{e} séance, no. 22): "son pouvoir morale est très peu de chose."

effect. Undoubtedly Charles's views already bear the clear imprint of the Romantic aesthetic:

> the least skilled hand extracts precisely the same sound as the most practiced artist. The organ thus offers no advantage in the quality of sound. It only speaks through the nature of the things it has to say, as if a man of wit were to have an interpreter repeat what he has to say.[41]

This impression is confirmed by a further observation that throws light on the fortunes of the instrument during the French Revolution and on the attempts to turn it into a "theater organ":

> The organ owes much to its location, and it stands, as you know, exclusively in places where solitude inclines one naturally to meditation. [. . .] Removed from its place, it is worth nothing. About a dozen years ago, all the organs were destroyed and someone had the barbarous idea of putting them in the theaters. They were in our orchestras. That made no effect whatsoever, which is what I remarked, with as much philosophy as was possible in those days. I asked myself: to what do we owe the organs' lack of effect? It is because they are no longer in their [proper] place.[42]

The time was clearly ripe for the *orgue expressif,* and already for some time Paris had been witnessing a period of intense research culminating in the models patented by Gabriel-Joseph Grenié in 1810 and 1816.[43]

But to return to the traditional organ, in 1802 Charles reminds us that the bellows of the old "wedge" type had been replaced by lantern reservoirs fed by bellows. This modification reduced the bulk of the bellows and ensured a more even wind supply. But instead of viewing the greater stability of the wind pressure as an advantage, Charles saw

41. Charles, *Acoustique,* 321: "la main la moins habile tire absolument le même son que l'artiste le plus exercé. L'orgue n'offre donc aucun avantage pour la qualité du son. Ce n'est que par la nature des choses qu'il a à dire, comme si une personne d'esprit faisait répéter par un interprète ce qu'elle a à dire."

42. Charles, *Acoustique,* 321–22: " L'orgue doit beaucoup à sa place, et il est comme vous savez exclusivement dans des lieux dont la solitude mène naturellement à la méditation. [. . .] Sorti de sa place, il ne vaut plus rien. Il y a une douzaine d'années, on avait détruit tous les orgues, et on avait eu l'idée barbare de les mettre sur le théatre. Ils étaient dans nos orchestres. Cela ne faisait aucune espèce d'effet: j'ai remarqué cela avec autant de philosophie qu'on en pouvait mettre dans ce tems là. Je me disais: d'où vient le peu d'effet des orgues? C'est qu'ils ne sont plus à leur place."

43. Paris, Archives Nationales, MS F.12.1016/32: Patent no. 583, 23 June 1810, relating to an "*Orgue expressif*" invented by "*S.r Grenié demeurant à Paris rue de la Convention n° 1.*" See also MS F.12.1025/7: Patent no. 1014, 22 January 1816 (another "*Orgue expressif*" by "*Gabriel-Joseph Grenié, rue du Dauphin n° 1*").

it as a defect, for it conferred "a bit too much monotony" on the instrument's sound [p. 324]. On this matter, it is incidentally interesting to note that some organ builders today aim to restore the "breathing quality" to the "lungs" of their instruments, thereby showing themselves to be in perfect agreement—at least on this point—with the opinion of our author.

Piano. In his lectures Charles largely ignores this instrument, limiting his observations to the stop called *jeu celeste,* a particular type of damper [*sourdine*] that he associates with the mute used on the violin bridge [p. 304]. Later, however, in a technical report published in 1810, the *piano-forté* was to be the subject of more extended treatment. Here he relates that "forty years after the pianos banished the harpsichords from our concerts they have assumed a position of such prominence that today, for many amateurs, the orchestra consists solely of singing voices and the piano, which—all alone—replaces all the other instruments."[44]

He attributes its success to the "sweetness of its timbre" and to the "appeal of this slightly veiled, melancholy voice" (melancholy being a characteristic that has all but disappeared on modern instruments). From the technological point of view, however, he observes that, unlike the great longevity of violins by Stradivari, Amati, Guarneri, and Stainer, and of harpsichords by Ruckers, "the fate of the pianoforte has been very different. Many have utterly deteriorated after 25–30 years, and we do not know of a single one that has not lost something through time and prolonged use."[45]

Wind Instruments

Charles displays very little interest in instruments such as the mandolin and guitar (the latter is indeed almost ridiculed as being a mere

44. *Rapport fait à Institut de France par MM. le Compte de La Cépede, Haüy, Charles, Gossec, Grétry, Méhul* [. . .] *dans les séances des 24 et 29 Décembre 1810, sur les nouveaux piano de M. Schmidt, rue du Pont-de-Lodi n° 2 (M. Charles, Rapporteur)* (Paris: Pillet, n.d.), 1: "Depuis quarante ans que les piano-forté ont banni les clavecins de nos concerts, ils y ont pris un tel empire, qu'aujourd'hui, chez beaucoup d'amateurs, l'orchestre se compose uniquement de voix récitantes et du piano-forté, qui remplace à lui seul tous les autres instrumens."

45. *Rapport,* 2: "Le sort du piano-forté a été bien different. Plusieurs ont totalement dépéri depuis 25 à 30 ans, et nous n'en connoissons point à qui le tems et un long travail n'ait fait perdre quelque chose."

"diminutive of the harp"). In contrast, he stresses the leading role played by wind instruments within the orchestral ensembles of his day:

> In the last century, concerts included a number of parasitical instruments, such as theorbos, guitars, etc; [otherwise] nothing but violins were used. Later came the wind instruments, which took possession of the scene and now occupy a prominent position.[46]

He then goes on to devote a few pages to the wind instruments. Concerning the brass, it is worth noting his reference to a performing expedient adopted by the famous Bohemian horn-player Jan Václav Štich (1746–1803), here referred to by the Italianized version of his name, Giovanni Punto:

> Fifteen or sixteen years ago, Viotti was present at a lesson I was giving on acoustics, at which I was explaining the theory of the hunting horn. He recollected something extremely difficult, which was that he heard Punto at a concert reach a very high note after having sounded a low note.[47] I said to him: if that is true, then there is no longer any theory. This bothered him greatly; that evening he came back like Archimedes, saying: I have found out how, it is a trick.
>
> This is what Punto did: even while blowing into the hunting horn one can sing at the same time. I have seen people play the transverse flute and sing as well; the same can be done on a hunting horn: one emits a sound a just third above the original sound, but it is only a trick. In no way does it discredit the theory of acoustics, because the thing is simply impossible.[48]

46. Charles, *Acoustique,* 301: "Dans le siècle dernier il y avait dans les concerts beaucoup d'instrumens parasites, tels que des théorbes, des guitarres, &c.; on n'a plus employé que des violons. Après cela sont venus les instrumens à vent, qui se sont emparés de la scène et qui occupent une place eminente."

47. It seems likely that Charles's pupil who transcribed this lesson was mistaken in writing *après avoir entonné,* "after having sounded"; the context suggests that the correct meaning must instead be "while simultaneously sounding."

48. Charles, *Acoustique,* 319–20: "Il y a 15 à 16 ans, Viotti était à un cours d'Acoustique que je faisais, et où j'exposois la théorie du cor de chasse. Il lui vint en pensée une difficulté extrême, ce fut d'avoir entendu Punto dans un concert arriver à un son très aigu après avoir entonné [*sic*] un son grave. Je dis: si cela est, il n'y a plus de théorie. Cela le tourmenta beaucoup; il vint le soir comme Archimede, en disant: je l'ai trouvé, c'est une charlatanerie.

"Voici ce qu'avait fait Punto: on peut tout en soufflant dans un cor de chasse, chanter en même tems. J'ai vu des personnes qui jouent de la flûte traversière en chantant; on peut faire la même chose dans le cor de chasse: on produit un son à la tierce juste du son primitif, mais ce n'est qu'une charlatanerie. Cela ne detruit rien à la théorie de l'acoustique, car la chose est impossible."

Charles also mentions the trumpet, saying that "it is normally in D." In presenting a glass trumpet to his pupils, he adds that it should come as no surprise that its quality of

In a subsequent comparison between the oboe and the transverse flute he is somewhat critical of the flute's intonation. As for contemporary oboists, he singles out for special praise an otherwise unspecified member of the famous Besozzi dynasty (probably Gaetano), while pointing out that the intonation of François Sallentin—professor at the Conservatoire from 1795 to 1816—was not always impeccable:

> I do not know of a single flute that plays in tune. If we think of accurate intonation as a straight line, the flute moves in an undulating manner, it is sinuous. I have never in my life heard a false note from Besozzi, the greatest of all living oboists; there are certain oboists around of whom one cannot say the same, such as Sallentin. On the flute nobody plays in tune. There are plenty of things to be said about that: I have studied the instrument sufficiently to say all the bad things I say about it.[49]

Regarding the last comment, a document of 1838 confirms—as mentioned above—that Charles was "a great lover of music and a fairly good flute-player," and that he "very much regretted having studied the flute rather than the violin," precisely because of the flute's poor intonation.[50] After stating that the oboe—insofar as it is fitted with a reed—offers "a great advantage" over the flute, Charles continues as follows:

> The natural scale of the flute is D [major]; that of the oboe is C. The oboe plays very well in the keys of C, F and E flat; it is extremely difficult in the sharp keys; and practically impossible in the key of E major. On the flute the key of F is weak because the tonic of F is extremely weak and that causes the falseness of the key.[51]

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sound should be equal to that of the brass trumpet: in fact, "the material of which wind instruments are composed does not affect their timbre except in the greater or lesser ease with which the air flows along their walls" ("La matière dont les instruments à vent sont composés n'influe sur leur timbre que pour la facilité plus ou moins grande avec laquelle l'air glisse sur leurs parois" [*Acoustique,* pp. 320–21]).

49. Charles, *Acoustique,* 315: "Je ne connais pas de flûte qui joue juste. En regardant la justesse comme une ligne horizontale, la flûte marche d'une manière ondoyante, elle est sinueuse. Ja n'ai jamais entendu de ma vie faire un faux ton à Besozzi, le premier hautbois qui existe; il y a quelques hautbois dont on ne peut pas dire la même chose, comme Sallentin. Personne ne joue juste de la flûte traversière. Il y a bien des choses à en dire: j'ai assez étudié cet instrument pour en dire tout le mal que j'en dis."

50. Institute of France, Royal Academy of the Fine-Arts, Minutes of the Meeting of Saturday, March 24th, 1838, quoted in Rockstro, *A Treatise,* 343.

51. Charles, *Acoustique,* 316: " La gamme naturelle de la flûte est *ré;* celle du hautbois est *ut.* Le hautbois joue très bien les tons de *ut,* de *fa,* de *mi* bémol; il est extrêmement difficile dans les tons de dièze; il est presque impossible dans le ton de *mi* dièze. Dans la flûte le ton de *fa* est foible parce que la tonique de *fa* est extrêmement foible, et cela emporte l'infidelité du ton." By 1838—following the addition of extra keys—these

Although Charles does not specify the model of flute he is discussing, fig. 2 shows a four-key instrument of the type still widely used in Paris during the early years of the nineteenth century.[52] The validity of his last criticism is confirmed by a new model of flute patented in 1807, whose inventor goes out of his way to emphasize the improvements to both the F and F-sharp of the first two octaves.[53] Still on the subject of the flute, Charles gives the following advice to composers:

> The only way to control this instrument is to give it little to do, to make it play things that are very fast and easy. Most of the composers who have made it do things beyond its capacity have made it sound detestable. You never have heard the performer of a flute concerto land on a D [and play it] in tune. The note is nearly always out of tune.[54]

We deduce, therefore, that the flute was not always satisfactory even in the key in which it was built, namely D major.

Among the other woodwind instruments, the French physicist strangely does not seem to have noticed the increasing importance of the clarinet, despite a comment on its "duck-like sound" [p. 318]. He also appears to be skeptical about the possibility of adding contrabass instruments to the woodwind family, such as the contrabassoon. Consulted on this matter by the Conservatoire, he says that he replied as

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limitations could be said to have been completely overcome in the flute, but only partially in the oboe: see Alexandre-Étienne Choron and Juste-Adrien-L. de La Fage, *Nouveau manuel complet de musique vocale et instrumentale* (Paris: Roret, 1838), Part III, pp. 25–26, 31.

52. Paris, Archives Nationales, MS F.12.1008/19, Patent no. 382, 21 November 1806: glass flute invented by [Claude] Laurent, "clockmaker" with his business at Quai de Gevres 34, Paris. The document points out that Laurent had already made "many" instruments of this kind, adding that "the shape of these flutes differs in no way from that established by the best instrument makers."

53. Paris, Archives Nationales, MS F.12.1010/2: Patent no. 393, 3 January 1807, for a "*Flute traversière perfectionnée*" by [Jean-Jacques] Holtzapffel, an instrument maker from Strasbourg, but resident in Paris, Rue St. Honoré 215. In a letter dated 27 November 1806, Holtzapffel states that "this new flute is approved" [*cette nouvelle flute est approuvée*] by, among others, "*[Henri] Besozzi, artiste de la musique de l'Empereur et Roi et première flute du Theatre de l'Opera Comique*" and "*Felix Rault, ci devant premier flute de la musique du Roi et de l'Opera, Pensionnaire du Gouvernement*" (from which we can infer that Rault was still alive in 1806).

54. Charles, *Acoustique,* 316–17: "Le seul moyen de contenir cet instrument, c'est de lui donner peu de chose à faire, de lui faire exécuter des choses très rapides et très faciles. La plupart des compositeurs qui lui ont donné à faire des choses au dessus de ses forces l'ont rendue détestable. Vous n'avez jamais entendu, dans un concerto de flûte, l'artiste retomber juste sur le *ré.* Presque toujours le son est faux."

FIGURE 2. Drawing of glass flute invented by [Claude] Laurent. Paris, Archives Nationales, MS F.12.1008/19, Patent no. 382, 21 November 1806.

follows: "look for some Goliaths or Gargantuas to play them, because it is impossible for [ordinary] men to expend such a large quantity of air."[55] Soon after, however, he was to change his mind, for in 1811—together with Gossec, Grétry and Méhul—he approved Dumas's "*Contre-basse Guerrière,*" a double bass clarinet designed for military bands. In the pertinent technical report presented to the Institut de France this instrument appears to have been chosen on account of its timbre (the bassoon is in fact considered as "plaintive and melancholy," while the trombone "is very penetrating but has little brilliance").[56] From the same report we also learn that "with Montéclair's introduction of the double bass [of the string family] at the Opéra in 1732 and Gossec's of the trombone in 1773, the power of these deep sounds was recognized in France."[57]

55. Charles, *Acoustique,* 323: "cherchez des Goliaths, ou des Gargantuas pour en jouer, il est impossible que des hommes fassent une telle dépense d'air." The same negative judgement is given of the contrabass trombone: "Many years ago I was consulted by the Conservatoire, which wished to dream up some special instruments: I said that they would also have to dream up the men to play them. We already have trombones that expend a large amount of air, and they wanted to make contrabass trombones!"

56. See *Rapport fait par MM. Gossec, Grétry, Méhul, membres de la Classe des beaux-arts, et MM. Haüy et Charles, membres de la Classe des sciences physiques et mathématiques, dans les séances des 6 et 8 Avril 1811* [*sur la basse et contrebasse guerrières de M. Dumas*] (Paris: Institut de France, 1811), 4–6. The *contrebasse* was pitched an octave below the *basse.*

57. As far as the double bass is concerned, we now know that its first appearance at the Paris Opéra dates from at least as early as 1703. It was introduced by Montéclair and Giuseppe Fedeli, apparently in an attempt to get closer to the composition of the Italian opera orchestra, which had strong basses: see James R. Anthony, "Montéclair, Michel Pignolet de," in *The New Grove Dictionary of Music and Musicians* (London: Macmillan, 1980), 12:508.

Some Unpublished Proposals by Guerre for Rationalizing the Tone Hole Positions of Wind Instruments

The intonation problems discussed above are also the subject of a brief manuscript study by Georges Guerre, a woodwind instrument maker about whom we know only that he worked in Paris between 1825 and 1853. His study is dated 1826 and thus immediately precedes the years in which Theobald Boehm was to embark on the same type of investigation.[58] The manuscript opens with a clear statement of intent:

> The construction of wind instruments was still a long way behind string instruments—in the justness and equality of the sounds—even though the theory of physics tells us that an aerial string must be the same as an animal string. All the experiments made until then were unable to prove it and there remained such a great difference in justness that it utterly removed the hope of obtaining the same result on an aerial string as on an animal one, [when] divided into aliquot parts.[59]

This statement is not, however, followed by any mention of how Guerre proposed to solve the problem of how to subdivide an "aerial string" (i.e., a cylindrical column of air) using the same ratios as those for an "animal string" (i.e., a gut string). He merely adds a few drawings of contemporary wind instruments, in which he draws attention to the way the positioning of the tone holes noticeably differs—even when the bore is cylindrical—from the geometric progression of a monochord subdivided according to equal temperament (which in Paris in those very years was in the process of definitively superseding the unequal temperaments used until that time).[60] Given their historical interest, the drawings are reproduced in figs. 3–7 along with their original captions.[61]

58. Paris, Bibliothèque de l'école des ponts et chaussées, MS 713: "Guerre, *Recherches sur les instruments à vent,* 1826" (the date is given in the library catalogue). On the activity of Guerre, see William Waterhouse, *The New Langwill Index: A Dictionary of Musical Wind-Instrument Makers and Inventors* (London: Tony Bingham, 1993), 150.

59. Guerre, *Recherches,* 1: "La construction des instruments à vent était encore très éloignée—de justesse et d'égalité de sons—de ceux à corde, quoique la théorie physique donne connaissance qu'une corde aérienne doit être la même qu'une corde animal. Toutes les expériences que l'on a fait jusqu'alors ne l'ont pu prouver et il se présentait une si grande différence de justesse, que cela détruisait totalement l'espoir d'obtenir d'une corde aérienne le même résultat que de celle animal, divisée en parties alicotes."

60. See Patrizio Barbieri, *Acustica accordatura e temperamento nell' Illuminismo veneto* (Roma: Torre d'Orfeo, 1987), 232.

61. The original French texts of these captions read as follows: for the present fig. 3, "*Planche 1, fig. 1.* Presente le chalumeau ou l'origine de la clarinette. / *fig. 2.* Représente

As for the problem raised by Guerre, today we may observe that in the calculation of the vibrating lengths of an "aerial string" we must also account for something called "end correction," a factor whose importance was at the time insufficiently appreciated. Let us now see how this applies to the two following practical cases.

1. Cylindrical bore and tone holes of constant diameter. When comparing the distances between the individual tone holes and the mouth hole with the corresponding lengths on the monochord, we find them to be shorter by a quantity equal to the end correction. And as the shortening is not directly proportional to the previously mentioned monochord lengths, the actual succession of holes will not follow a strictly geometric proportion. This explains, for example, why the Pythagorean 2:1 ratio no longer applies to two bore lengths corresponding to an octave.[62]

2. Cylindrical bore and tone holes of variable diameter. In Guerre's proposed plans for the clarinet (fig. 5, right), the higher the pitch of the hole, the smaller its diameter: by closely regulating the amount of reduction, the interhole spacing could effectively be restored to strict geometrical progession (in this case, the end correction would turn out to be independent of the frequency, and thus equal for all notes).[63] But not even by this expedient was a perfect correspondence with the monochord

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une clarinette dont nous devons l'invention de la sixième clef F au celèbre Lefèvre Xavier. Cet instrument n'entre pas du tout en rapport avec le monochorde." For the present fig. 4, "*Planche 2, fig. 3.* Représente une clarinette perfectionnée par le célèbre Muller, à qui on doit l'application des 13 clefs. J'ai ensuite fait l'application de la corde animal divisée par les mathématiques pour prouver évidemment qu'il n'y a pas de rapport entre les ouvertures lathérales et les parties alicotes de la corde; cela nous aurait laissé très long-temps dans la croyance qu'une corde aérienne ne pouvait être la même qu'une corde animal sous tous les rapports, quoique y manquait un intervalle. / *fig. 4.* Représente la corde aérienne, en rapport immédiat, pour la justesse et l'égalité des sons, de la corde animal, ou monocorde, en y ajoutant une clef de fa dièze pour remplir les intervalles musicaux." For the present fig. 5, "*Planche 3, fig. 5.* Je représente cet instrument comme ayant été considéré juste; mais on s'est convaincu qu'il était faux quoiqu'il ait 13 clefs et que l'on ne pourra jamais jouer juste avec un instrument mal construit et avec lequel on ne peut atteindre la justesse qu'au détriment de la sonorité. Ces sons se rangent au nombre de ceux envisagés comme bruit par la physique. / *fig. 6.* Présente une corde aérienne ou monocorde aérien." For the present fig. 6, "*Planche 4, fig. 7.* Représente une flute perfectionnée quoiqu'il manque un intervalle musical. / *fig. 8.* Représente une corde conique à laquelle j'ai ajouté une clef de fa dièze." For the present fig. 7, [left]: "Partition de M. Guerre"; [center]: "Partition ancienne"; [right]: "Division du monocorde applicable à la corde aérienne."

62. See, for example, Rockstro, *A Treatise,* 171–75.

63. See Arthur H. Benade, "On the Mathematical Theory of Woodwind Finger Holes," *Journal of the Acoustical Society of America* 32 (1960): 1602.

lengths possible, for Guerre's plan would need correcting by shifting all the tone holes upwards by the same amount; and though the interhole spacing would remain unchanged, this operation would also lead—again in relation to the lengths measured on the body of the instrument—to a stretching of all the harmonic intervals, including that of the octave.

Summary

Because of their miscellaneous character it is difficult to draw comprehensive conclusions from this review of Charles's remarks and related materials by other writers. But it is worth summarizing some of the new and often surprising information they provide on a broad range of topics, including famous musicians and luthiers, technological innovations in instrument building, and aesthetic judgements of various instruments.

1. Skilled performers like Viotti, Duport, and Jarnowick were unable to play in time with a metronome, while Pagin and the other "Tartinistes" active in Paris played with such freedom that, according to Charles, "they never played in time."

2. Girolamo II Amati was on friendly terms with Tartini, and as late as 1740 produced, for Tartini's pupil Pagin, the last violin made by any member of that celebrated dynasty. Charles's praise of it as "one of the best instruments in existence" will certainly assist in the reassessment of Girolamo II's work, which in the past has been little appreciated.

3. The first proposal for a tuning mechanism based on the worm-screw, such as that used today on the double bass and guitar, turns out to be the one by a watch-maker of Metz by the name of Coré, dating from as early as 1758, fully twenty years earlier than the proposal by Anton Bachmann, to whom the invention of such a device has hitherto been attributed.

4. Passing comments about certain instruments reveal attitudes radically different from the ideas we have of them today. The "singular and melancholy sound" of the glass harmonica evidently caused "many people [to] faint when this instrument was being played," but the weakness of the harp's upper range was considered a drawback so severe as to cause its exclusion from the Concert spirituel. The organ, according to Charles, lost what little value it possessed when removed from "places where solitude inclines one naturally to meditation," and attempts to make use of it in theater orchestras were a complete failure. On the other

hand, he attributes the tremendous success of the fortepiano in the decades prior to 1810 to its sweet and "slightly veiled, melancholy voice," whereas in comparison to the modern piano, or indeed to early nineteenth-century models, pianos from the period to which Charles refers are usually thought of today as having a much brighter, even if less powerful, sound. Finally, as a flutist himself Charles asserts that "on the flute nobody plays in tune," even though by the time he gave his lectures, at the turn of the century, keys to correct the intonation of that instrument's cross-fingered notes had been in use for several decades. Guerre's manuscript confirms this need to improve the intonation of woodwind instruments and to rationalize the placement of their tone holes.

Translated by Hugh Ward-Perkins

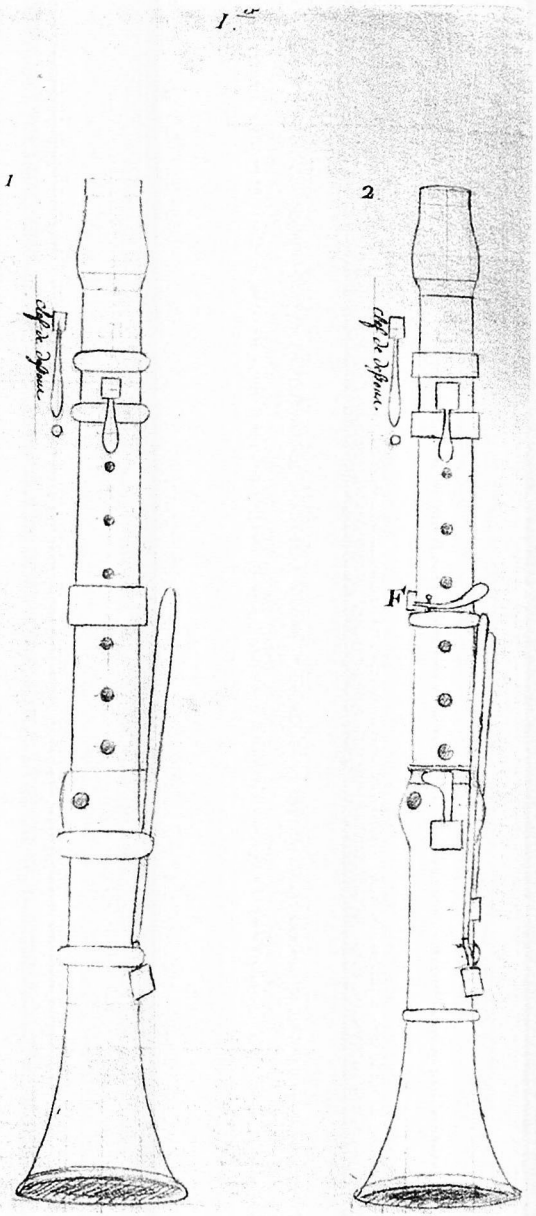

FIGURE 3. Paris, Bibliothèque de l'école des ponts et chaussées, MS 713: Original tables and captions by Guerre, 1826. *Plate 1, fig. 1.* Shows the chalumeau or the origin of the clarinet. / *fig. 2.* Shows a clarinet for which we owe the invention of the sixth key [marked with the letter] F to the celebrated Lefèvre Xavier. This instrument does not at all correspond [in ratio] with the monochord."

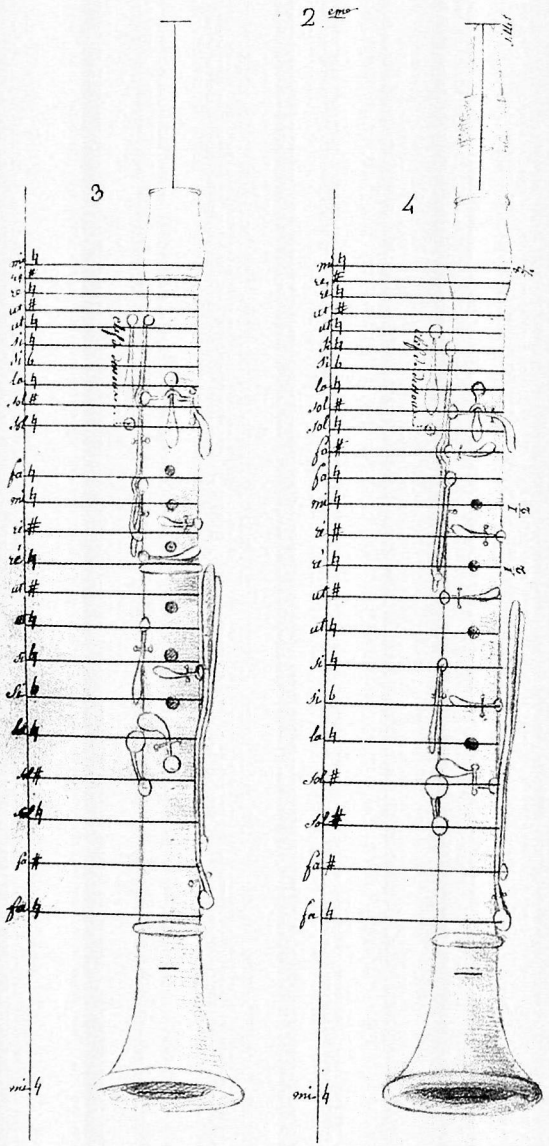

FIGURE 4. Ibid. *Plate 2, fig. 3.* Shows a clarinet perfected by the celebrated Muller, to whom we owe the application of the 13 keys. I have also added the animal string divided by mathematics to demonstrate clearly that there is no correspondence between the side openings and the aliquot parts of the string; that would have allowed us to go on believing that an aerial string could not be the same as an animal string in all its ratios, even if [in this division] an interval [F♯] was missing. / *fig. 4.* Shows the aerial string in immediate correspondence—as regards justness and equality of the pitches—with the animal string or monochord, by adding an F-sharp key to fill in the musical intervals.

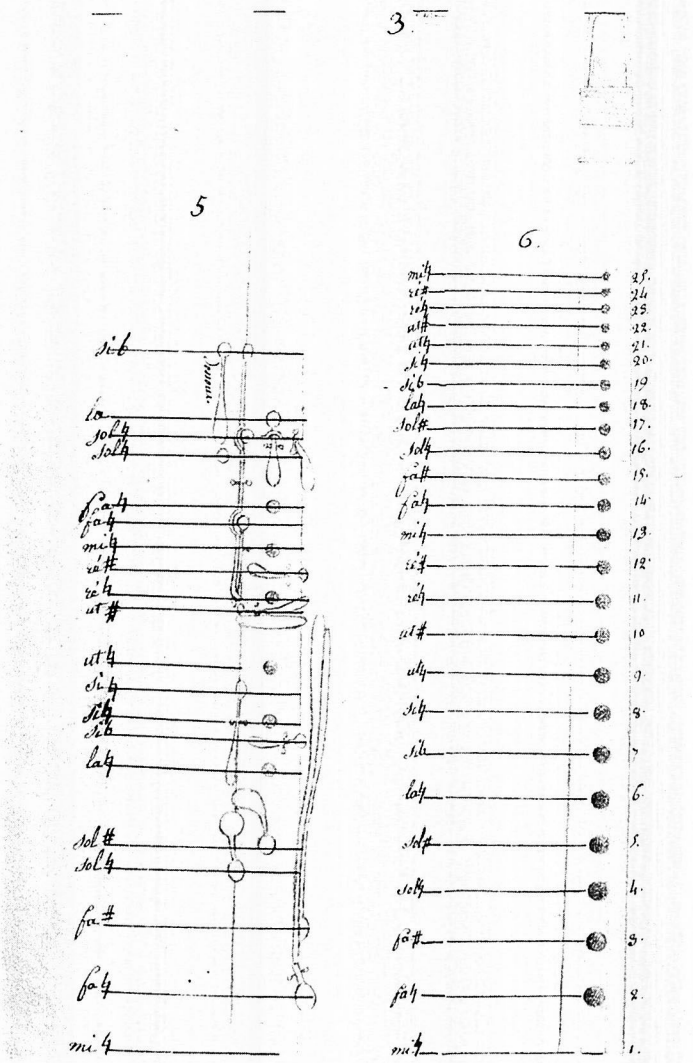

FIGURE 5. Ibid. *Plate 3, fig. 5.* I show this instrument as having been considered in tune; but it is clear that it is out of tune even though it has 13 keys and that one could never play in tune on an instrument that is badly made and on which one could not achieve correct intonation except by harming the sonority. These sounds are counted among those regarded as noise by physics. / *fig. 6.* Shows an aerial string or aerial monochord.

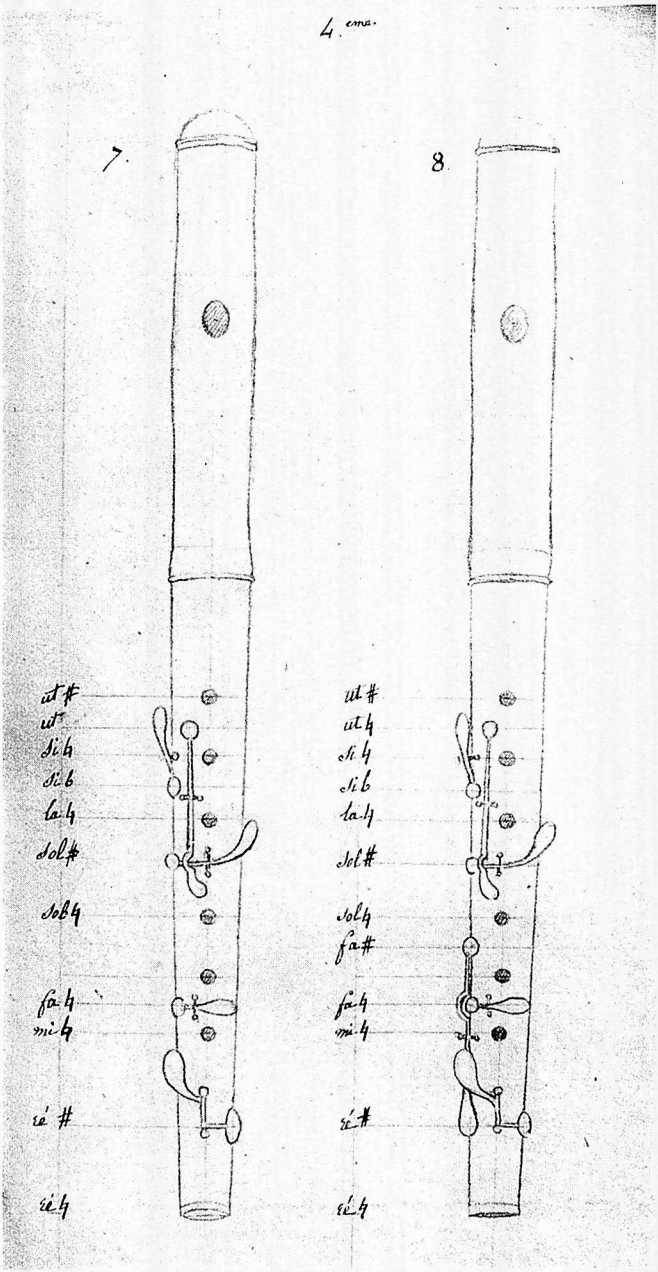

FIGURE 6. Ibid. *Plate 4, fig. 7.* Shows an improved flute although a musical interval is missing. / *fig. 8.* Shows a conical string to which I have added an F-sharp key.

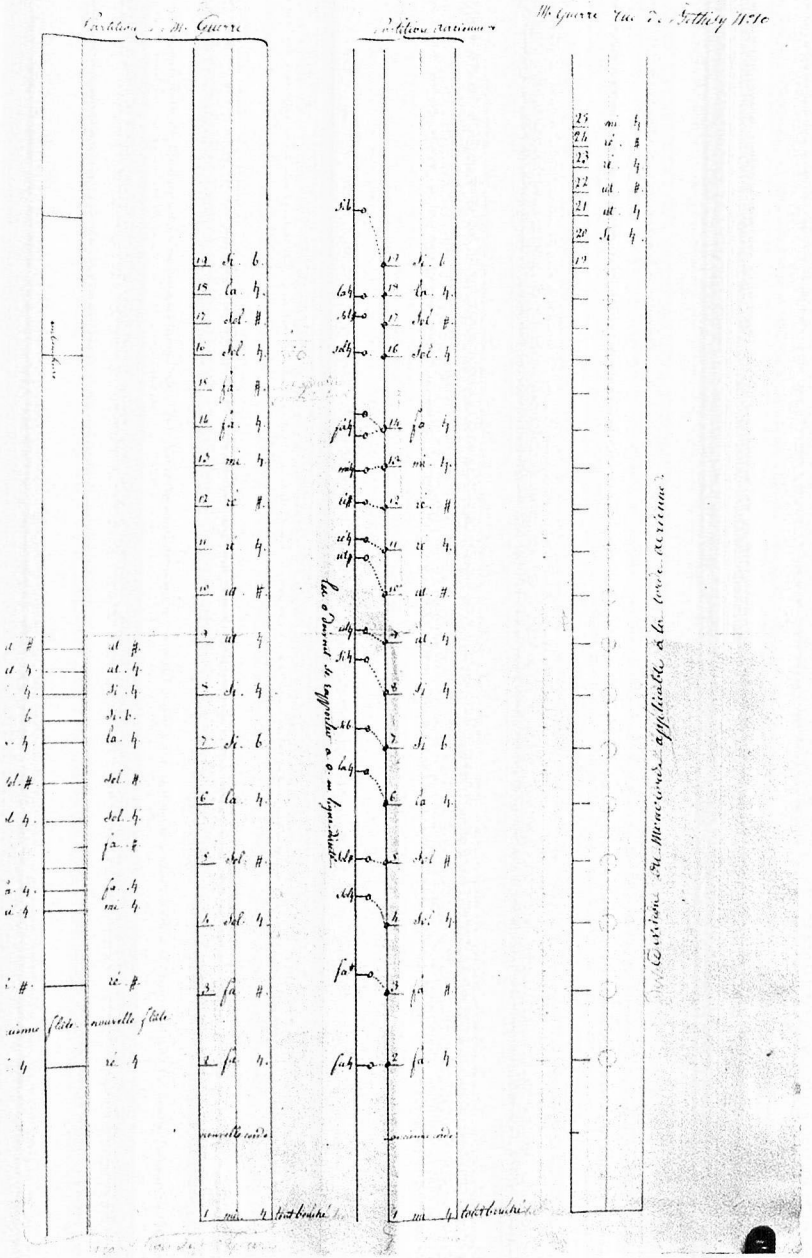

FIGURE 7. Ibid., unnumbered plate (top right: *M. Guerre, rue de Béthisy n° 10*). [*Left:*] Division by *M. Guerre;* [*center:*] Former division; [*right:*] Division of the monochord applicable to the aerial string.