

Preface

While the other branches of physics have been moving forward, acoustics has always lagged behind. The sounding vibrations of most elastic bodies were entirely unknown, and, ordinarily, only the transverse vibrations of a string have been considered. These have therefore been regarded as the basis of all harmony and we have tried to extend its laws to all other sounding bodies. The results of the research that many scholars such as Daniel Bernoulli, Euler, Lagrange, Giordano Riccati, and others conducted on various acoustical subjects were not introduced into the mass of knowledge that is expounded in treatises on physics. This is what caused me to undertake the development of this vast uncultivated field, and to uncover the laws of vibrations and their different modifications in all sorts of sounding bodies, according to the research of the principal geometricians and physicists, and according to numerous experiments. My aim was to give the results of both theory and experiment in a sufficiently clear and precise manner, so that at least the greatest part would be within the range of those who had only a slight acquaintance with physics and mathematics. Those who are more advanced will lose nothing because they will find sufficient data for further research and because I have always cited the principal works and dissertations which will serve for their further instruction.

Among the experiments whose results I have related here, there are none that I have not performed myself, and that I cannot repeat. I respect nature too much to want to attribute anything to it that would perhaps be only a play of my imagination.

Everything that is printed at the end of several paragraphs by way of the strictest justification contains notes or additions to the text of the paragraph, marked in such a way that the connection of the materials should suffer the least interruption.⁵

In publishing this *Treatise on Acoustics*, I am responding to the desires of several persons whose commendations and kindnesses provide a powerful motive for me to attempt to merit them by such useful work in science. I am especially honored by

⁵ In this edition, these notes appear in a greyed-in box.—MAB

the fact that I have been brought to this purpose by the illustrious author of *Celestial Mechanics*, who is also respected for his benevolence and his zeal in encouraging those who work in the sciences, as well as by what he has done for the increase in human knowledge. My German work could not be translated into another language without some appropriate changes; another translator would perhaps have problems of his own, and he might have had me saying something that I did not say.⁶

Therefore, I have undertaken this work myself. It must therefore be excused if a stranger who has not spent a long time in France does not always express himself with sufficient clarity. Friends who have had the kindness to preview my work have corrected some of the mistakes; I do not know if outside critics will be as indulgent as my friends; however, if they wish to be fair, they will spend more time on the subject than on the language. It has often been asked, by what chance did I happen to make certain discoveries. But chance has never favored me; to be successful I had, nearly always, to employ opinionated perseverance. Following the advice of several estimable persons, I must add here some remarks concerning the story of my discoveries, these being the result of individual circumstances. I believe that these circumstances should interest a number of readers.

My father (First Professor of Law at Wittenberg in Saxony, one of the most esteemed judicial consultants in this county because of his activity, his talent, and his probity) had provided a good instruction for me, but it was at home, and then in the provincial school of Grimme; my education therefore allowed me little liberty, so that, whereas others may recall their youth as the happiest period of their lives, I cannot say the same about mine. This continual constraint, which was not at all necessary, because I was not disposed to abuse my freedom, produced a completely contrary effect on me, imprinting an almost irresistible desire to choose my occupations myself, to travel, to struggle against adverse circumstances, and so on. Returning to Wittenberg, it was necessary, following the will of my father, for me to apply myself to jurisprudence.

After having studies at Wittenberg and at Leipzig, and having satisfied the requirements, I obtained the degree of Doctor in Philosophy and in Law at Leipzig. Fate seemed to have destined me to remain always at Wittenberg and for me to obtain employment as a Professor of Law. But, after the death of my father, I quit jurisprudence, because it conformed too little to my tastes, and applied myself principally to the study of nature, which had always been my secondary occupation, and that dearest to me. As an amateur musician, of which I had begun to learn the basic elements (a little late), in my nineteenth year, I noted that the theory of sound was the most neglected part of physics, which gave birth in me the desire of remedying this defect and of being of use to this part of physics by making a number of discoveries. In performing numerous very imperfect experiments in 1785, I had observed that a plate of glass or of metal gave off different tones when it was clamped and struck in different places, but I did not find any instruction

⁶These rules have been violated in the present translation, but then Chladni never undertook the translation into English. Sorry Ernst!—RTB

as to the nature of these types of vibrations. At that time, journals had given some publicity to a musical instrument, made in Italy by the Abbé Mazzochi.

This instrument consisted of glass bells to which he had applied one or two bowings of a violin; from this I conceived the idea of using the bow of a violin to examine the vibrations of different vibrating bodies. When I applied the bow to a round brass plate, stationary at its center, the plate made different sounds which, when compared with one another, were proportional to the squares of 2, 3, 4, 5, etc.; but the nature of the movements to which these tones correspond, and the means of producing each of these movements at will were still unknown to me. Experiments on the electric figures that are formed on a plate of dusted resin, discovered and published by Lichtenberg (in the *Memoirs of the Royal Society of Göttingen*), led me to presume that the different motions of a vibrating point ought also to show different appearances if one were to put a little sand or other similar material on its surface.⁷ In making use of such means, the first figure that I observed, on the round plate of which I spoke, resembled a star with 10 or 12 rays, a little like Fig. 102a, and the most acute sound was, in the series cited, the one which corresponded to the square of the number of diametral lines. One can judge my astonishment in viewing this phenomenon, which no one had previously seen. After having reflected on the nature of these motions, I did not find it difficult to vary and to multiply these experiments, from which results followed rather rapidly. My first dissertation, which contained some research on the vibrations of a round plate, of a square plate, of a ring, of a bell, etc., came out in Leipzig in 1787. The results of the research that I have carried out since that time on longitudinal vibrations and on other subjects of acoustics have appeared in several German journals and in the papers of various Societies.

Finally, after having made still more experiments and after having consulted further the research that others have performed, I joined the results together, so far as it was possible, in my *Treatise on Acoustics*, which came out in Leipzig in German [*Die Akustik*]. The present work is a translation of that book, a work that I have abridged, changed, and expanded a great deal, according to what seemed to me to be most appropriate.

It was Lichtenberg, whose ingenious ideas in physics I found most interesting, who gave a second impulse to the advance of my ideas. Being in Göttingen in 1792, I asked his opinion on the nature of fiery meteors (which are called *bolides* or fireballs), whose phenomena, such as a flame, smoke, and explosions, were little in conformity with the electrical phenomena with which they are identified. He responded that the best way of explaining these phenomena would be to attribute to these meteors an origin that is *cosmic* rather than *terrestrial*, that is to say, to suppose that it was something foreign that had arrived from the outside into our atmosphere, a little as Seneca had well explained the nature of comets, which,

⁷ In 1777 Lichtenberg obtained what are now called Lichtenberg figures by discharging a high voltage point to the surface of an insulator and recording the resulting radial patterns by sprinkling various powdered materials onto the surface.—JPC

nevertheless, had a long time after been regarded as atmospheric meteors until the Saxon pastor, Dörfel, had shown that Seneca was correct. Struck by this observation of Lichtenberg, I consulted works and dissertations that contained reports of similar meteors, and of stones or masses of iron that one had seen fall at one time or another as the result of a similar meteor, and I finally published my research in a dissertation that came out in Leipzig in 1794, the French translation of which, made by Eugène Coquebert-Mombret, is to be found in Vol. V of the *Journal des Mines*. I demonstrated the following observations in this paper (before the fall of rocks [meteorites] that took place at Siena on June 15, 1794).⁸ First, that the reports that had been given concerning rocks and masses of iron that had fallen with great impact as the result of a meteor fireball were not fictions or illusions, but observations of a real phenomenon; second, that these masses and these meteors were something foreign to our globe, and had arrived from the outside. In the beginning, no one agreed with me; several German critics even supposed that I had not advanced this idea seriously, but with a somewhat evil intent of seeing what fraction of physicists accepted them and how far the credulity of these individuals might extend.

In France, Mr. Pictet was the first to call to the attention of physicists as to what my paper contained (Vol. 16 of the British Library); but no one believed in the possibility of a fall of rocks until Howard's dissertation in 1802. And in 1803, the fall of rocks took place at L'Aigle, and it was established by Mr. Biot that I was not given to fits of imagination; this finding has been further demonstrated by numerous meteors which have been observed, and by the research that has been conducted. In the *Bulletin of the Philomatic Society* of April, 1809, I published a catalogue of sizeable meteors that have been observed to date, to which one could add still others that have been found; including those which Soldani has cited in Vol. 9 of the *Memoirs of the Academy at Siena*.

The invention of the *euphone* and the *clavicylinder*, and their execution under less than favorable circumstances, cost me a great deal of time, more work, and more expense than my research on the nature of sound, of which these two instruments are practical applications. Those who have worked in a similar area, as, for example, those who have tried to perfect the glass harmonica,⁹ know how many unforeseen difficulties are encountered in such work. Too often, when one wishes to put into practice those ideas which appear to conform to theory, nature, being consulted by means of experiments and tests, denies our conjectures and places insurmountable obstacles in front of us, obstacles that had not been foreseen. Then, after having worked without success for a long period of time, it becomes

⁸ There was an eruption of Mt. Vesuvius on June 15, 1794 near Siena, Italy, followed by the fall of a meteorite the following day, 200 km to the north.—RTB

⁹ There are two types of glass harmonica: glass harps, which consist of wineglasses rubbed by the fingers, and the armonica, invented by Benjamin Franklin, in which glass bowls are mounted on a shaft so that they rotate (partially in water) as the shaft rotates. The first type was probably most familiar to Chladni. *When the word "harmonica" is used throughout this text, it is understood to mean "glass harmonica," not the modern wind instrument.*—TDR

necessary to set aside everything that has been done and begin anew. But the least success makes us forget all these tests of our patience.

The *euphone*, invented in 1789 and perfected in 1790, consists exteriorly of small cylinders of glass that one rubs longitudinally with fingers moistened by water. These cylinders, of the thickness of a writing pen, are all of equal length, and the difference in the tone is produced by an interior mechanism. The tone resembles more that of the harmonica than that of any other instrument. In several trips that I have made to Germany, to St. Petersburg, and to Copenhagen, this instrument has received widespread approval. The one that I had with me most recently has been destroyed during the voyage by some accident, but the construction of another, on which I am now working, is almost complete.

The *clavicylinder*, invented at the beginning of 1800 and perfected since that time, consists of a keyboard, and behind this keyboard a glass cylinder, which is turned by means of a pedal and a leaden wheel. This cylinder is not itself the sounding body, as in the bells of the harmonica, but produces the tone by its rubbing of the interior mechanism. The principal quality of this instrument is its ability to prolong the sound at will with all the nuances of crescendo and diminuendo, as one augments or diminishes the pressure on the touch. The instrument is never out of tune. The reports of the Institut de France and of the Imperial Conservatory of Music, which have given very favorable judgment on this instrument, relieve me of the necessity of talking of it at length.

For some time, I have again been occupied with conducting research and experiments on different methods of constructing a *euphone* or *clavicylinder*. As the possible methods are very numerous, and as it is difficult to judge in advance the preference for one or the other, this subject will continue to keep me busy. Each invention being the property of its author, I do not merit reproach for the fact that I have still not published the internal mechanism and the construction. I have still not lost the hope that there will come a time when a compensation proportional to the sacrifices I have made will allow me to publish everything concerning the theory and construction of these instruments.

The great value that I attach to the approval of the Institut de France, and the respect that I have toward that leader of scholarly societies, whose members I have the honor of knowing personally, has encouraged me to have printed at the end of this work the prize program that it has proposed on the mathematical theory of vibrating plates and the reports that it has kindly wished to make on my research and their applications to the arts.

E.F.F. Chladni

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