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The Professor who Unknowingly Started the Free Reed Revolution

‘so what; where the starting-point’s crazily minimal,
the outcome is often highly original.’
Henrik Ibsen, *Peer Gynt*, Act 4, Scene 9.

The eccentric Danish professor of medicine and physics, Christian Gottlieb Kratzenstein was born 30th January 1723 in Wernigerode, Germany (Figure 1). A few years before he died on July 5th, 1795, he wrote to his housekeeper that he wanted to be buried two feet deeper than usual and that he wanted to be forgotten as soon as possible.¹ His first wish was probably met; there is no grave with his name on it today. Luckily, he did not take much of his legacy to his unknown grave, one small part being his vowel organ – free reed speaking machine. Over the next 150 years this grew into an unfathomable global success – millions and millions of vibrating free reeds in harmoniums, reed organs, mouth harmonicas, blues harps, accordions, concertinas, bandoneons and all other free reed instruments.

As a student of medicine and science at the University of Halle Kratzenstein, like many of his contemporaries, was interested in the human soul and was influenced by the famous vitalist Georg Ernst Stahl (1659–1734), who held the chair of Medicine at this university from 1694 to his death in 1734. Kratzenstein’s first major publication was entitled *Beweis, daß die Seele ihren Körper baue* (Proof that the soul creates its own body).² It should be no surprise that his interests were drawn towards the

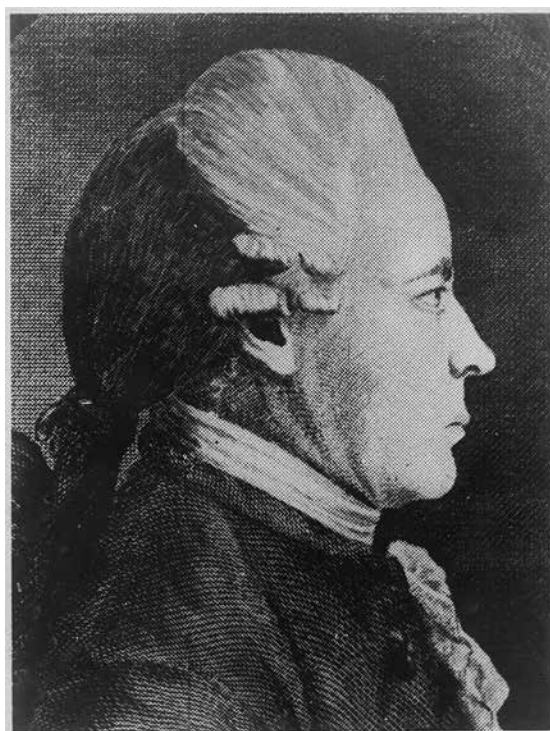


Figure 1. *Christian Gottlieb Kratzenstein (1723–1795)*. Copper etching by P. Haas after a drawing by Paul Ipsen. From the University Library, Copenhagen. [Wikimedia Commons](#).

¹ Egill Snorrason, *C. G. Kratzenstein and his Studies on Electricity during the Eighteenth Century* (Odense: Odense University Press, 1974), p.135.

² Christian Gottlieb Kratzenstein, *Beweis, Daß Die Seele Ihren Körper Baue* (Halle, 1743).

recently discovered electricity,³ which under certain circumstances could make dead or paralyzed limbs move. Kratzenstein would eventually be called the father of electrotherapy. One author even suggests that he was the model for Mary Shelley's professor Frankenstein.⁴

Kratzenstein was a true polymath and not afraid of challenging the establishment. In 1743, he submitted a manuscript about fumes and steam to the Royal French Academy of Bordeaux as a response to a prize competition, and for this won first prize.⁵ As in many such academic competitions the prize was meant for another and more senior researcher, who complained and started a campaign against Kratzenstein. The scientific community was split, but one of Kratzenstein's supporters was the famous Swiss mathematician Leonhard Euler (1707–1783), who had spotted his talent and potential. Euler, who was professor at the St Petersburg Academy of Sciences from 1727 to 1741, and then again from 1766 to his death in 1783, helped Kratzenstein obtain his first foreign academic position in 1748, as professor of mechanics at the St Petersburg Academy.

EULER AND VOX HUMANA

Euler was not only a mathematician. One of his many interests was musical harmony and the formation of sound in musical instruments⁶ and in the extension of this, how speech was generated, both physiologically and mentally.⁷ He had the idea that the well-known organ stop Vox humana could be modified in such a way that the organ could speak, or sing, the different vowels.

In 1755, when he was professor at the Berlin Academy of Sciences, but also still a member of the Petersburg Academy, Euler sent a list of fourteen *Quaestiones Mathematicae* to be considered as potential topics for the Petersburg Academy's annual

prize. Three of these were concerned with sound and the human voice:⁸

- a. A true theory of sound is sought about how it is propagated through air.
- b. An explanation is sought about how sound is perceived in the hearing organ and whether or not it exists in a similar medium as light.
- c. An explanation is sought for the formation of voice, and in what way all kinds of sound are articulated by the organ of speech.

Between 1760 and 1762, Euler wrote 234 letters to the young German princess Sophie Charlotte Frederike von Brandenburg-Schwedt (1745–1808), as part of her general education before she was to become abbess. According to Musielak,⁹ someone in Russia had read copies of the letters and thought that because of their rich scientific and philosophical content, and not least because of their easy-to-understand language, they should be published. This was also supported by Empress Catherine the Great (1729–1796), who paid close attention to what was happening at the Academy of Sciences. Consequently, *Lettres à une Princesse d'Allemagne sur divers sujets de Physique & de Philosophie*¹⁰ was published in 1768. It became an immediate success and was translated into several languages. Here, the great scientist Euler writes about complicated topics in a way that even a 15-year-old girl can understand, no wonder it became popular! Moreover, the letters were initially written in French, not in Latin, which was the language Euler normally used in his scientific publications.

In Letter XXII, *The Wonders of the Human Voice* dated 16 June 1761, his idea of a vowel organ becomes more detailed, with speculation on how the

³ Christian Gottlieb Kratzenstein, *Abhandlung Von Dem Nutzen Der Electricität in Der Arzneywissenschaft* (Halle: Carl Hermann Hemmerde, 1744).

⁴ Peter W Kaplan, 'The Real Dr Frankenstein: Christian Gottlieb Kratzenstein?', *Journal of the Royal Society of Medicine* 95 (2002), pp.577–578.

⁵ Christian Gottlieb Kratzenstein, *Théorie De L'élevation Des Vapeurs Et Des Exhalations, Démonstrée Mathématiquement* (Bordeaux: Tyrnavia, 1743).

⁶ Leonhard Euler, *Tentamen Novae Theoriae Musicae Ex Certissimis Harmoniae Principiis Dilucide Expositae* (Petersburg: Petersburg Academy of Sciences, 1739).

⁷ Olivia Hirschey and Klyve Dominic, 'The Missing Meditatio - Leonhard Euler's (1707-1783) Contribution to Articulatory Phonetics', *Historiographia Linguistica* 42/1 (2015), pp.63–83.

⁸ Hirschey (2015), p.67.

⁹ Dora E. Musielak, 'Euler and the German Princess', (Austin, Texas, 2014), available online at <<https://arxiv.org/abs/1406.7417>> (accessed 18 September 2024).

¹⁰ Leonhard Euler, *Lettres à Une Princesse D'Allemagne Sur Divers Sujets De Physique & De Philosophie* (Petersburg: Petersburg Academy, 1768).

traditional organ stop *Vox humana* could be further developed, so that '[...] preachers and other orators, whose voice is either too weak or disagreeable, might play their sermons or orations on such a machine, as organists do pieces of music'.¹¹

Euler is predicting something that would eventually materialize first in the twentieth century, but he does not seem well informed about the limited potential of the organ stop *Vox humana*. However, his logical next step was to find a person who could build such a talking machine. This man was probably already identified as Christian Gottlieb Kratzenstein, whom he had helped into his first academic post. In a letter to a friend, written in 1748 shortly after Kratzenstein had visited him in Berlin on his way to his new assignment in St Petersburg, Euler wrote:

The day before yesterday, Mr. Kratzenstein left here for Hamburg and Lübek [sic] [...] I have had every opportunity to get to know him better, and can now truly assure you, Your Venerable, that his dexterity far exceeded my conjecture, although I already had a very good impression of him. In fact, no more capable person could have been found for the mechanics, since he not only possesses a perfect knowledge of all machines, but is also able, in every case, to find the most convenient way of repairing and make it work again. [...] I have every reason to rejoice, from the bottom of my heart, that through my proposal, the Imperial Academy of Sciences has acquired the talents of such a skilful, thoroughly competent man.¹²

In May 1765 Euler again sent a list of possible themes for prize competitions to the Petersburg Academy, where item number 3 was:

Although the theory of sound has now developed to the point that the ratio of low and high sounds that serves as the foundation of harmony is understood clearly enough, and other distinctions between

sounds can be explained, the variation in sounds which produces the vowels a, e, i, o, u is still utterly unknown, and thus it is proposed to explain the inherent quality of the sounds by which the individual vowels are produced. At the same time, the question is posed whether or not instruments can be made to perfectly imitate vowel sounds.¹³

Later in 1765 Euler moved back to St Petersburg with his extended family: his wife, two daughters and three sons with their families. His son Johann Albrecht (1734–1800), also a mathematician, became his secretary since Euler's eyesight, that had long been deteriorating, by now was almost gone. From 1769 Johann Albrecht also acted as the official secretary of the Academy. Finally, in 1777, the prize was announced.

Two questions were to be answered and documented:

1. What is the nature and character of the sounds of the vowel letters a, e, i, o, u, which are so remarkably different from each other¹⁴
2. Construct an instrument with a series of organ pipes, similar to the type of stop marked as *Vox humana*, that produce the sounds of the vowels a, e, i, o, u¹⁵

In the Academy meeting of 18 October 1777, it was decided to announce the prize internationally, with a deadline of 1 January 1780.¹⁶ The actual prize was a gold medal weighing 350 grams. The language could be Latin, Russian, French, or German.

ENTER KRATZENSTEIN

Finally, Euler would have his vowel organ! The prize competition was clearly designed for Kratzenstein, who had already for many years experimented with this kind of sound generation. In §6 of his handwritten manuscript in Latin, he wrote:

¹¹ David Brewster, *Letters of Euler on Different Subjects in Natural Philosophy Addressed to a German Princess. With Notes, and a Life of Euler 2* (New York: Harper & Brothers, 1840), p.158.

¹² 'Der Briewechsel Leonhard Eulers Mit Christian Gottlieb Kratzenstein', in Andreas Kleinert et al. (eds.), *Leonhard Euler Briefwechsel* (Basel: Birkhäuser Basel, 2018), pp.124–25, translated from German by the author.

¹³ Hirschey (2015), p.68.

¹⁴ *Qualis sit natura et character sonorum litterarum vocalium a, e, i, o, u tam insigniter inter se diversorum.*

¹⁵ *Annon construui queant instrumenta ordini tuborum organicorum, sub termino vocis humanae noto, similia, quae litterarum vocalium a, e, i, o, u sonos expriment.*

¹⁶ Christian Korpiun, *Tentamen Resolvendi Problema Christian Gottlieb Kratzenstein. Studentexte Zur Sprachkommunikation, Band 82* (Dresden: TUDpress, 2016), p.117.

Indeed, I have never been occupied in making the mute talkative, like Cl: Ammann,¹⁷ nor in calling an ivory statue to life, like Pygmalion,¹⁸ but for many years now, in my few consecutive hours, I have sometimes occupied myself in constructing a machine which would be able to imitate human speech, and like the keys of a musical instrument might be induced to speak; but this intention requires a more exact study of the mechanism of speech, than the intention of teaching speech to the dumb, whose individual organs are already present in a perfect state, does not need demonstration. Nor is my study completely fruitless, for my machine will pronounce most of the syllables distinctly, but not all. The modifications which I have observed in this examination of the organ of human speech, so that each vowel is produced, I am now going to describe as distinctly as my powers permit.¹⁹

One other paragraph also suggests that he already had been working on a vowel organ for many years, and perhaps that this work was not one of his priorities. In §28, which is about how to generate the vowel ‘i’, he wrote ‘For more than ten years ago I made a larynx [...] from one simple tube that with some modification could pronounce “Ja! Ja!” or something like “i”’. But he had not kept this tube, and forgotten how he made it, so he had to start anew.²⁰

A handwritten and illustrated manuscript in Latin, along with a completed vowel organ, was sent from Copenhagen to St Petersburg in good time before 1 January 1780. The manuscript was anonymous, but for identification it had the words ‘plus ultra’ with reference to a sealed envelope with Kratzenstein’s name inside. The last paragraph reads:

In order that the Venerable Imperial Academy may judge the reality of this work of art on the basis of examination and observation, I have taken a small pneumatic organ suitable for the expression of the vowels to the nearest port, so that it may be brought across the sea to St Petersburg and delivered there.

Now I am truly plagued by strong doubts as to whether the ship will succeed in taking this course at this time of year. Nevertheless, I hope that the Venerable Academy will excuse its delay all the more easily, the less the task at hand involves such a transmission and presentation of the organum. At the end of winter, if not sooner, it will surely be handed over to the Venerable Academy, unless it sinks in a shipwreck.²¹

In the printed version of the manuscript from 1781 was added: ‘This author’s Organum pneumaticum arrived at the Academy on time and in good condition’.

The title of the manuscript was:

TENTAMEN RESOLVENDI PROBLEMA AB
ACADEMIA SCIENTIARUM IMPERIALI
PETROPOLITANA AD ANNUM 1780 PUBLICE
PROPOSITUM.

Attempt to solve the problem publicly presented by
the Venerable Imperial Academy of Sciences at St
Petersburg in 1780

It had two parts: PARS PRIMA – de Genesi vocalium – about the generation of vowels, twenty numbered paragraphs, §1 to §20, pp.3–32, which refers to the first question, and PARS SECUNDA – Construendis fistulis, vocales a, e, i, o, u, enunciantibus – about the construction of the pipes to pronounce a, e, i, o, u, 12 numbered paragraphs, §21 to §32, pp.33–46, referring to the second question. The last three pages contained a list of 14 figure captions (p.47) and figures 1 to 14 (pp.48 and 49).

PARS PRIMA – THE GENERATION OF VOWELS
Kratzenstein insisted that the sound generator for the human voice was a vibrating epiglottis, and not the vocal cords. This is rather strange, since the function of the vocal cords was already established knowledge, thanks to the publications of two French scientists: Denis Dodart (1634–1707)²² and Antoine

¹⁷ Johann Konrad Amman (1669–1724) was a Swiss doctor who developed a method for teaching mute people to talk.

¹⁸ From Greek mythology (Ovid): Pygmalion was a sculptor who created a statue of a perfect female body that he fell in love with and later married.

¹⁹ Korpiun (2016), p.31, translated from German by the author.

²⁰ Korpiun (2016), p.87.

²¹ Korpiun (2016), p.96, translated from German by the author.

²² Denise Dodart, ‘Memoire Sur Les Causes De La Voix De L’homme, Et Des Différens Tons’, *Histoire De L’academie Royale Der Sciences, Anné MDCC, Avec Les Memoires De Mathematique & De Physique, Pour La Mème Année* (Amsterdam, 1701), pp.308–373.

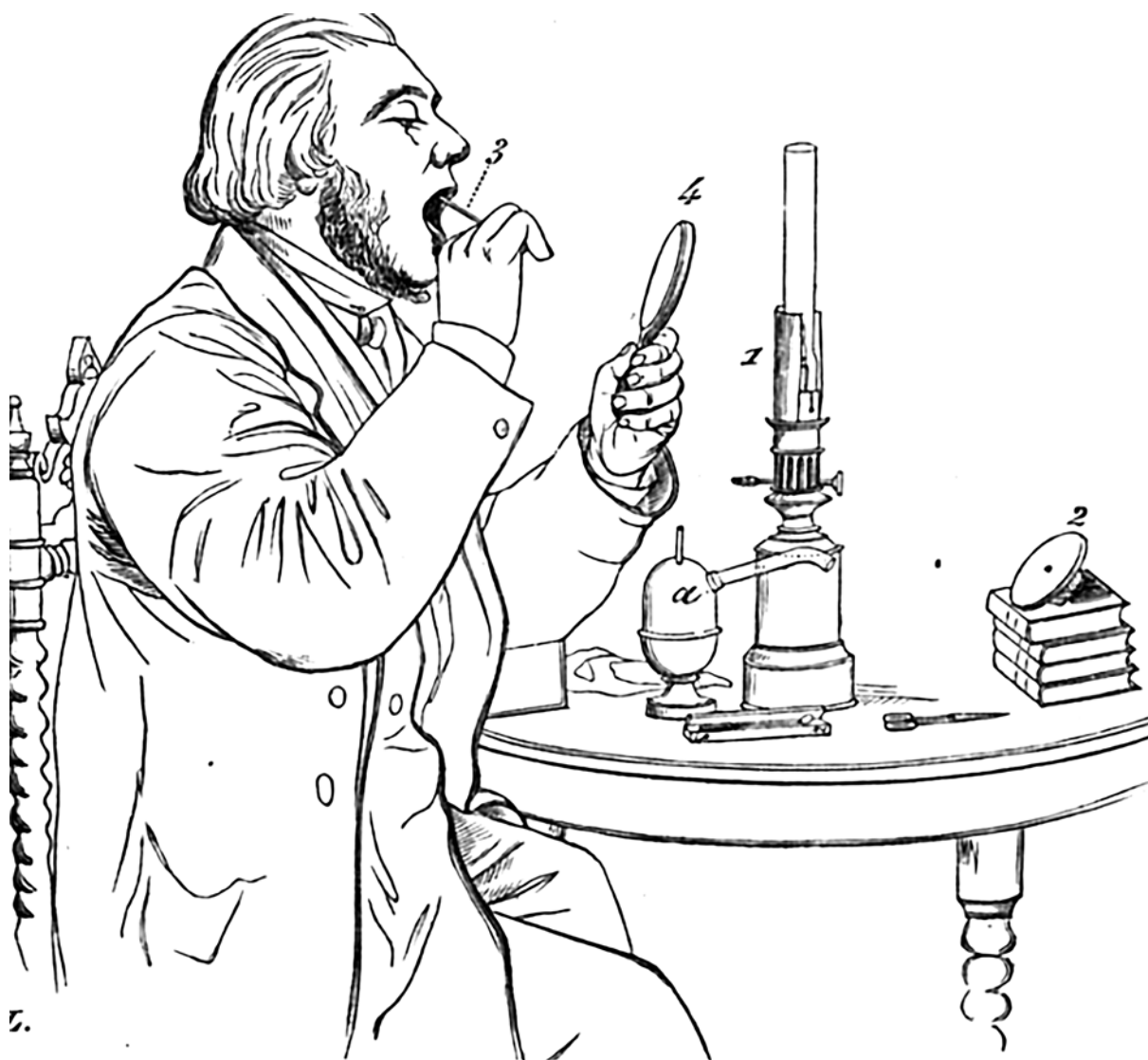


Figure 2. From Fournié (1853), p.21. Original caption: 1. Réflecteur en papier blanc. 2. Miroir réflecteur. 3. Miroir guttural. 4. Miroir de toilette. a. Inspirateur à poudre.

Ferrein (1693–1769).²³ In the theoretical first part Kratzenstein disputes this knowledge. This was possible since nobody at that time had observed the human vocal cords in action, the evidence was based on anatomical dissections on dead bodies only.

If Kratzenstein had not made this error, to insist that the epiglottis was the sound generator, and then

*later tried to copy it, the European type of free reeds²⁴ might not have been discovered, at least not at this point in history.*²⁵

Direct *in vivo* observations of the human vocal cords happened first in the 1850s. In 1853, the French surgeon Édouard Fournié (1833–1886), published an instruction on how to observe vocal cords in action

²³ Antoine Ferrein, 'De La Formation De La Voix De L'homme', *Histoire De L'Academie Royale Der Sciences, Anné MDCCXLI, Avec Les Memoires De Mathematique & De Physique, Pour La Même Année* (Paris, 1741), pp.409–432.

²⁴ I use *European free reeds* for the voices that Kratzenstein discovered, as opposed to *Asian free reeds* which have been known for millennia: *Sheng* in China, *Khaen* in Laos. The difference lies in whether the reed is separate and fixed at one end over the slot – European – or an integrated part of the plate – Asian. Only the European free reed can sound without a resonator.

²⁵ The correct word may be re-discovered, since there are some indications of earlier non-consequential examples of free-swinging reeds, as in Michael Praetorius, *Syntagma Musicum II, De Organographia* (Wolfenbüttel, 1619) p.143.

Table 1. Kratzenstein's table of vowel generation. From Korpiun (2016), p.37. Translated from German by the author.

1'' = 1 inch = 25.4mm 1''' = 1 ligne = 2.26mm

	Throat (Larynx)	Tongue (Lingua)	Opening to the palate (Apertura viae palatin)	Opening between teeth (Apertura dentium)	Opening between the lips (Apertura labiorum)
A	The sides pressed slightly against each other. The epiglottis slightly raised.	The tip of the tongue against the teeth of the lower jaw. The back of the tongue has led the crook.	$\frac{2}{3}''$	$\frac{1}{3}''$	Height 5''' Width 18'''
E	Epiglottis slightly raised and retracted.	The tip of the tongue against the molars of the lower jaw. Tongue back strongly raised.	$\frac{1}{3}''$	$\frac{1}{6}''$	4''' 18'''
I	The same movement but with larger articulation. Epiglottis with edges highly elevated.	The tip of the tongue in the middle of the upper jaw and midway between the rows of teeth. Tongue back maximally raised. The tongue forms a drain through which the sound passes.	$\frac{1}{6}''$	$\frac{1}{12}''$	2''' 18'''
O	Same as A.	About the same position as with A with tongue $\frac{1}{10}''$ more retracted and raised.	$\frac{1}{2}''$	$\frac{5}{12}''$	$3\frac{1}{2}'''$ 8'''
U	The opening of epiglottis and the articulation surface somewhat smaller than for I. Without raising the epiglottis.	The tip of the tongue slightly more retracted from the lower teeth than with O.	$\frac{1}{3}''$ to $\frac{5}{12}''$	$\frac{1}{2}''$	$2\frac{1}{2}'''$ 5'''

using mirrors and a light source (see Figure 2):²⁶

In Part 1, Kratzenstein also discusses how the oral cavity and throat function as resonators for the vibrating epiglottis. In paragraph §9 he tabulates how the positions of the throat, tongue, palate, teeth and lips vary with the pronunciation of the five vowels, using his own measurement scale based on trials with a wooden wedge.²⁷

If Kratzenstein had known that it works perfectly well to blow directly on a framed and channelled free reed by simply placing it against your lips like a mouth harmonica, he would certainly have appreciated the next figure, made for those blues harp players who 'speak' into their ten-hole harmonica and manipulate the sound by 'bending' (inhaling) or 'overblowing' (Figure 3).²⁸

PARS SECUNDA – MAKING THE VOICES

In Part 2 Kratzenstein describes how the different voices were made. According to Professor Jonas

Braasch this process had three phases with two unsuccessful trials.²⁹ He firstly made an artificial larynx, a tube with a flap valve (epiglottis) at one end, but the result was clearly not satisfactory. In the second phase, Kratzenstein decided to look closer at the organ stop *Vox humana*, and this is where he consulted a professional organ maker in Copenhagen, believed to be Nicolai Kirsnik, but in all probability was Daniel Wroblewsky whom he knew well (see below). He learned how to make a beating reed voice, maybe he even took some home for further experimentation. He tried out reeds made from different materials, like ivory and bone, and tried to cover the shallot edges on which the reeds were beating with thin leather. But the sound was still too harsh. In the third phase the breakthrough came when he let the reed swing freely in a tightly fit aperture in the shallot. This produced a soft and pleasant tone – eureka! See Figure 4.

²⁶ Édouard Fournié, *Étude pratique sur le laryngoscope et sur l'application des remèdes topiques dans les voies respiratoires*. (Paris: Delhaye (Adrien), Libraire, 1853). Available online at: <https://books.google.no/books/about/Etude_pratique_sur_le_laryngoscope_et_su.html?id=OhhbAAAQAAJ&redir_esc=y> (accessed 17 September 2024).

²⁷ Korpiun (2016), p.37.

²⁸ James Major, *C Harmonica Book*, ed. Mel Bay (The Complete 10-Hole Diatonic Harmonica Series; Pacific, MO, USA: Mel Bay Publications Inc., 2005), p.11. Used by permission of Mel Bay Publications, Inc.

²⁹ Jonas Braasch, *Orgelregister Mit Durchschlagzungen Geschichte, Konstruktion Und Akustische Eigenschaften* (Berlin: Logos Verlag, 2004), p.14ff.

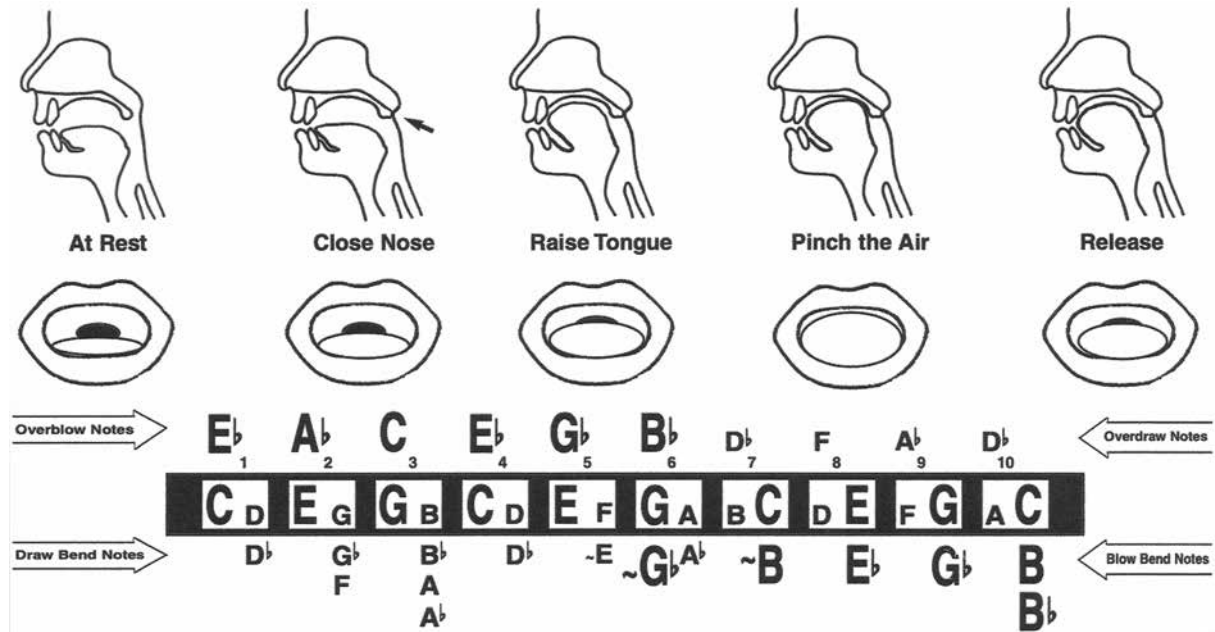


Figure 3. How to bend (lower the pitch) and overblow (heighten the pitch) on a mouth harmonica (blues harp) by use of changes in the oral cavity. From Major (2015). Reproduced with permission from Mel Bay Publications, Inc.



Figure 4. Organ voices with tuning springs, beating reed (left) and free reed (right). Made in 2022 by J.M. Fiskvik in Levanger, Norway for a new organ. Photo J.M. Fiskvik.

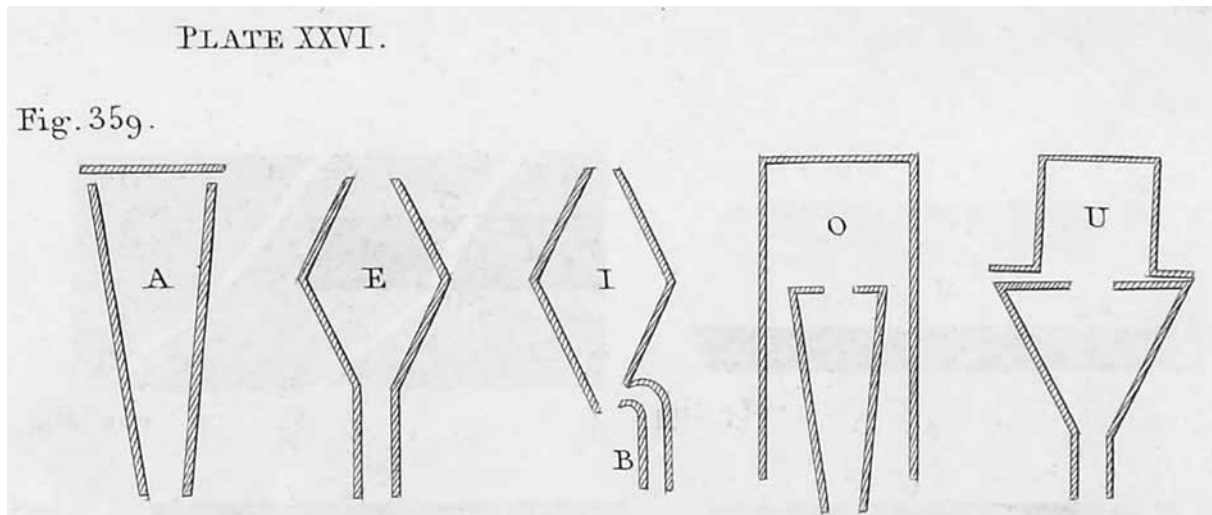


Figure 5. *Kratzenstein's five resonators, redrawn in Thomas Young, A Course of Lectures on Natural Philosophy and the Mechanical Arts. 2. (London: Taylor and Walton, 1845), p.156.*

Now was the time to experiment with differently shaped resonators to reproduce the vowels. His method was also trial and error here, and he landed on the following shapes, shown in Figure 5:³⁰

As seen in Figure 6, these resonators are not that different from those used in organs today.

We now know that resonators on the European type of free reeds usually do not influence the pitch but can modulate the sound. Most contemporary free reed instruments have no resonator. In other words, Kratzenstein's potential for vowel variation was rather limited.

MUSICAL INSTRUMENT?

Kratzenstein was very interested in music, he played the harpsichord and was the director of the first musical society founded in Copenhagen in 1769.³¹ It is therefore puzzling that in his manuscript, he hardly mentions the musical potential of his talking reeds. The closest he comes to this subject is probably in

the penultimate paragraph, where he suggests that the vowel *e* could be the tone *c*, *o* the tone *e*, and *a* the tone *f* sharp.³² What is not discussed is the unique expressive ability of the European free reeds, the almost unchanged pitch whether the air flow is weak or strong. This is different from the two other organ sound generators, the beating reed and the flue pipe, where crescendo and diminuendo must be created by increasing or decreasing the number of sound generators or opening and closing sound chambers, and not simply by a variation in air pressure.

DARK HORSE KIRSNIK

A dark horse had appeared in St Petersburg, probably unexpectedly. On 9 December 1779, a well-known local organ maker and organist in the St Annen church, Franz Nicolai Kirsnik (1741–1802), originally from Bohemia, submitted a locked and sealed chest to the Academy, with reference to the announced prize competition. It contained organ

³⁰ From Thomas Young, *A Course of Lectures on Natural Philosophy and the Mechanical Arts* (London: Taylor and Walton, 1845), Vol.2, p.156. Thomas Young (1773–1829), a British medical doctor and physicist, redrew the rather primitive drawings in Katzenstein's thesis for his impressive catalogue of all kinds of technical innovations.

³¹ Snorrason (1974), p.116.

³² §31 It should be clear from the foregoing that, by means of measures derived from organ building, it is not difficult to make a pneumatic vox humana pronounce the vowels *a*, *e*, *o* distinctly. Moreover, it can be seen that this organ stop will produce an excellent and extraordinary effect. If, for example, the note *c* is the vowel *e*, the note *e* is the vowel *o*, the note *f* sharp is expressed in turn the vowel *a*, etc., and the melody is expressed in simple tones that can be accompanied based on another register, be it dulcian, flute or viola da gamba, then a song very similar to the human voice will clearly be heard in the course of this variation. Experiments show that consonants can hardly be understood when spoken at a distance, but vowels are very easy to understand, and from the order in which they follow one another, we guess the consonants to be inserted, no doubt because the shape of the air disappears more easily in consonants than in vowels. Thus, the repeated speech produced by echo is usually more of a repetition of vowels than of consonants. In music, on the other hand, neither fifths nor thirds, etc., can be combined in singing in the manner proposed, which produce another vowel, and not even indefinite diphthongs such as *ae*, *oe*, *ao* (Translated from German by the author).

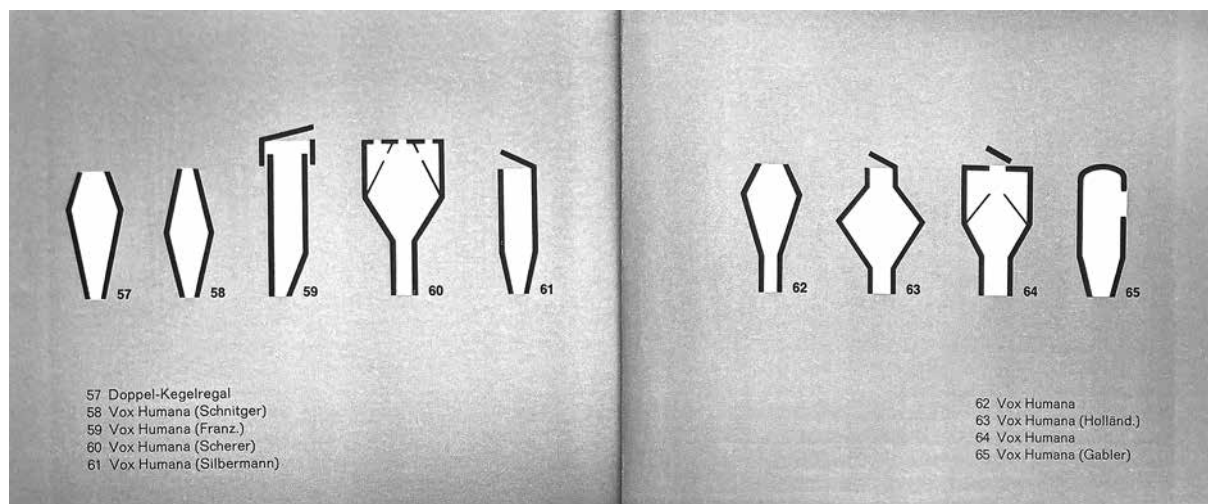


Figure 6. *Different contemporary resonators for Vox humana. From Carl Giesecke & Sohn, 'Zungenstimmen' (Göttingen: Carl Giesecke & Sohn, 1963), pp.70–71.*

pipes that, with the help of a bellows and keys, could play sounds like the vowels of the human voice. Although the Academy found that the sounds were not that perfect, especially regarding the vowels a and e, it was nevertheless decided to keep the machine in the archive until the meeting when the Academy would announce a winner.³³ Whether the chest also contained a manuscript with answers to the first question, is unknown.

The winner was declared at the Academy meeting on 24 August 1780. The minutes state:

The secretary showed and demonstrated the organum that the author of the treatise on the nature of the human voice had sent to the Academy with the devise *Plus ultra*, with instruments and manuscript, as a contribution to this year's prize. The assembly compared this instrument to that submitted by an accomplished instrument maker in the city on December 9 of the previous year. After both had been demonstrated, the Academy decided without hesitation that that with the devise *Plus ultra* reproduced all the vowels much more clearly than the other from December 9.³⁴

Kratzenstein won the gold medal and Kirsnik was granted a silver medal.

A second vowel organ may have been demonstrated in Paris, in connection with the publication of a French version of the manuscript in 1782,³⁵ but for the creator, this effort was soon in the past. He continued his research along a very different and futuristic vein with a project on the art of navigating through the air.³⁶

A TRUE NOVELTY?

Susan Splinter gave her Kratzenstein biography the title 'Zwischen Nützlichkeit und Nachahmung' [Between usefulness and imitation]³⁷ and wrote on the book cover (translated from German by the author): *Since Kratzenstein did not put forward a groundbreaking theory or invent anything 'new', he is largely unknown today; he is an ordinary scientist of the 18th century.*³⁸

Splinter's biography is both good and recommendable, but in my opinion, it lacks a better understanding of the uniqueness of professor Kratzenstein's free reed organ voices. They were very different from the Asian type of free reeds, which

³³ Korpiun (2016), p.119.

³⁴ Korpiun (2016), p.117, translated from German by the author.

³⁵ Christian Gottlieb Kratzenstein, 'Essai. Sur La Naissance & La Formation Des Voyelles; Par M. Kratzensteinius, De L'Academie Des Sciences De Saint-Petersbourg', *Sur L'Hist. Naturelle et les Arts*, Supplement 1782, Tome XXI (1782), pp.358–78.

³⁶ Christian Gottlieb Kratzenstein, *L'art De Naviguer Dans L'air* (Copenhagen, Leipzig: Martin Hallager, 1784).

³⁷ Susan Splinter, *Zwischen Nützlichkeit Und Nachahmung. Eine Biographie Des Gelehrten Christian Gottlieb Kratzenstein (1723–1795)*. Europäische Hochschulschriften 1047 (Frankfurt am Main: Peter Lang, 2007).

³⁸ Da Kratzenstein weder eine bahnbrechende Theorie aufstellte noch etwas "Neuartiges" erfand, ist er heute weitgehend unbekannt; er ist ein ganz gewöhnlicher Wissenschaftler des 18. Jahrhunderts.

require resonator pipes to sound. Hence hundreds of European free reed voices can be assembled in a very small space, like in a modern full-size accordion with almost 500 individual reeds. The tuning springs are only used in traditional organ stops, all other free reed instruments are tuned by removing (filing) metal from the reed, from the tip for higher and from the base for lower pitch. A lower pitch can also be achieved by soldering a weight to the tip of the reed instead of making it longer. The discovery of these sound generators opened the door to a completely new and vast musical instrument universe.

FROM SPEECH TO MUSIC

The silver medal winner Nicolai Kirsnik could have been present at the Academy meeting on 24 August 1780, when the two instruments were demonstrated, since he lived nearby. In that case he would have heard the difference, we must assume that his vowel organ was using beating reeds for sound generators, similar to a regal. In any case, as an accomplished organ maker he must have been among the first to realize the musical potential of Kratzenstein's invention.

In his acceptance letter dated 31 October 1780, Kratzenstein donated the vowel organ to the Academy, and asked for some scientific publications for his personal library in return. He also promised to send the Academy a revised and corrected copy of the prize manuscript for printing. The printed version is dated 1781 (Figure 7).³⁹

In the minutes from the St Petersburg Academy the vowel organ is also mentioned on 14 June 1781: '[...] that the vowel machine submitted by Dr. Kratzenstein has been so damaged by the curious to whom it has been shown since the last Annual General Meeting that it no longer produces a single sound. It was decided that one Herr Koulibin should repair the machine so that it may again bring forth the tones of all the registers that are in it.'⁴⁰

Among the curious must surely have been the

runner up Nicolai Kirsnik, wanting to find out why Kratzenstein's machine was better than his. Perhaps the Academy let him examine it, or even borrow it? Could this be the reason why it had become damaged and unrepairable? Anyway, Kirsnik became the person who introduced the new type of reeds to the musical community.

In his book *The history of the organ in the Russian music culture*,⁴¹ Leonid Rojsman writes that, in the 1780s, Nicolai Kirsnik became the first organ maker to use free reeds in his organs, and that by means of a special mechanism he could vary the loudness of the tones. Kirsnik had acquired a new skill, and we can only guess how. However, some clues are found in an article in the *Allgemeine Musikalische Zeitung* from 1823 by Johann Friedrich Kaufmann (1785–1866), the creator of the famous automatic trumpet player,⁴² on 'die Erfindung der Rohrwerke mit durchschlagende Zungen' (the invention of organ pipes with free reeds).⁴³ He sent letters to several 'honourable men', but only received one relevant response, from Georg Christoffer Rackwitz (1760–1844) in Stockholm. Rackwitz, who came to Kirsnik's workshop in St Petersburg in 1782 as a 22-year-old apprentice, was by then 62 and writes about something that happened 40 years previously. Unfortunately, Kaufman is not quoting him, but narrates Rackwitz' response in his own words:

About the year 1780 Mr. Kirsnick in St Petersburg made the first very laborious attempts to transform the pipes of the Kratzenstein speaking machine into organ pipes and to attach tuning springs. After he had completed this, he mounted such a register in his orchestrion, which Abbé Vogler tried in 1788, when he came to St Petersburg. He liked it so much that he in 1790 wrote from Warsaw to Mr. Rackwitz, who had worked on it as an assistant to Mr. Kirsnick and asked him to come to him in Warsaw. Mr. Rackwitz complied with this request, but it did not come to the construction of such an organ

³⁹ Christian Gottlieb Kratzenstein, *Tentamen Resolvendi Problema Ab Illustri Academia Sientarium Imperiali Petropolitana Imperiali Petroplitana Ad Annum 1780 Publice Propositum* (Petersburg: Academia Scientiarum, 1781). A digitalized version is available online at <<https://gdz.sub.uni-goettingen.de/id/PPN59586435X>> (accessed 18 September 2024)

⁴⁰ Korpiun (2016), p.121. Translated from German by the author.

⁴¹ Leonid Rojsman, *Die Orgel in Der Geschichte Der Russischen Musik-Kultur*, trans. Nina Balz (Würzburg: Gesellschaft der Orgelfreunde, Martin Balz, 2001), p.153.

⁴² The automaton Trumpet Player (Deutsches Museum, München) was made c1810 by Johann Friedrich Kaufmann and first presented in 1812 in Dresden. Approximately 180cm tall, the man, dressed in Spanish costume, could originally blow two different notes simultaneously using reeds.

⁴³ Friedrich Kaufmann, 'Ueber Die Erfindung Der Rohrwerke Mit Durchschlagenden Zungen', *Allgemeine musikalische Zeitung*, 1823/10 (5 March 1823), columns 149–155.

CHRISTIANI THEOPHILI
KRATZENSTEINI

MEICINAE DOCTORIS, PROFESSORIS PHYSICES PU-
BLICI ORDINARI IN UNIVERSITATE HAFNIENSI,
ACADEMIAE SCIENTIARUM IMPERIALIS PE-
TROPOLITANAE MEMBRI,

TENTAMEN

RESOLVENDI PROBLEMA AB ACADEMIA SCIEN-
TIARUM IMPERIALI PETROPOLITANA AD AN-
NUM 1780 PUBLICE PROPOSITUM.

- 1) *Qualis sit natura et character sonorum litterarum vocalium a, e, i, o, u tam insigniter inter se diversorum.*
- 2) *Annon constitui queant instrumenta ordini tuborum organico- rum, sub termino vocis humanae noto, similia, quae litterarum vocalium a, e, i, o, u, sonos exprimant.*

In
Publico Academiae Conventu
die XIX. Septembris MDCCLXXX.

Praemio coronatum

Plus ultra.

PETROPOLI
TYPIS ACADEMIAE SCIENTIARVM
MDCCLXXXI.

Figure 7. *Kratzenstein's thesis. Title page of the printed version from 1781. Copied from the free online version at <http://resolver.sub.uni-goettingen.de/purl?PPN59586435X> (accessed 17 September 2024).*

in Warsaw. Abbé Vogler persuaded him to go to Rotterdam in order to make various such voices for an organ which Abbé Vogler had built there.⁴⁴

Supposedly it was not so much a process of transformation as one of creation that Kirsnik faced, since Kratzenstein's machine only had four reeds — the 'i' pipe was without a reed — whereas

his orchestrion must have contained at least 12, one for each semitone, more likely two or three times this number. The challenge would be the extremely narrow fit between the reeds and their individual slots necessary for a good result, more a watchmaker's skill than an organ maker's (Figure 8).

What Kirsnik's orchestrion looked like we do not know. The Russian accordionist and collector

⁴⁴ Kaufmann (1823), translated from German by the author.

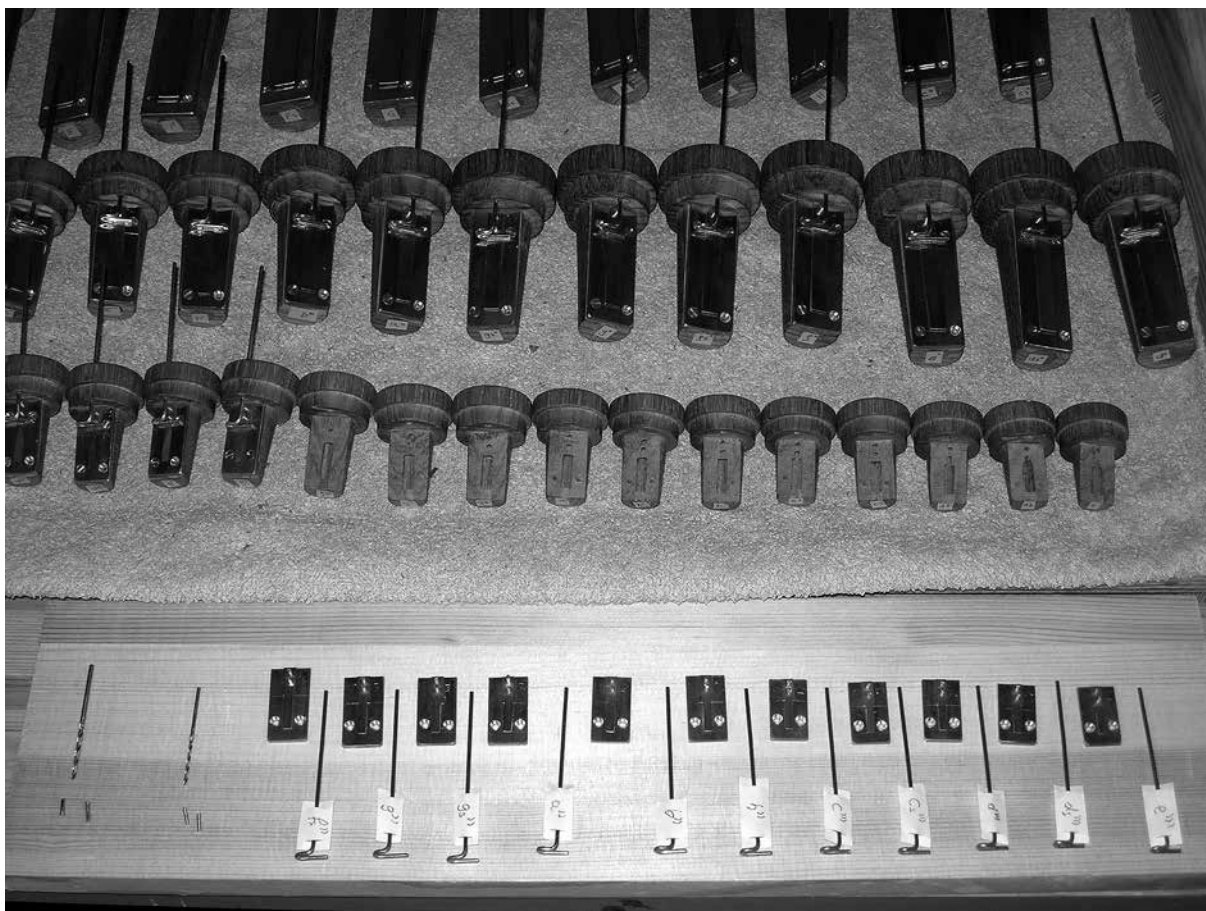


Figure 8. Free reed voices for a new organ under production in the workshop of Jann Magnar Fiskvik in 2022 in Levanger, Norway. Photo by the author.

Alfred Mirek (1922–2009) has published an illustrated catalogue with chronologic descriptions of all kinds of free reed instruments, in Russian and English, including two instruments by Kirsnik.⁴⁵ Unfortunately, Mirek does not reveal his sources, and several errors can be found in his publication. However, two small portable keyboard instruments bear Kirsnik's name, one regal-like and one accordion-like (see Figure 9).

What is well documented, however, is that one of Kirsnik's colleagues in St Petersburg, Johann (Ivan) Gabrahn (1775–1812), had in 1783 already made a *fortepiano organisé*, a stringed keyboard instrument with hammers and free reeds with bellows, because this instrument still exists in the Pavlovsk Palace in St Petersburg.⁴⁶ Another restored and playable similar *organochord*, made by Rackwitz in 1802, restored by

Felix Wolff in 1974 and meticulously documented by Niclas Fredriksson in 2002⁴⁷ is in The Performing Arts Museum in Stockholm. The piano range of this instrument is FF to f³ and the organ range C to f³. A video where Mikko Korhonen demonstrates the instrument can be found at <www.oabandoneon.com/organochord> (accessed 17 September 2024).

KIRSNIK OR WROBLEWSKY?

With reference to Rackwitz's letter, Kaufman (1823) wrote that

Hr. Rackwitz ging im Jahre 1782 zum Orgelbauer und musikalischen Instrumentenmacher, Hrn. Kirsnick zu St Petersburg in Arbeit. Dieser war zuerst in Kopenhagen etablirt, von wo er nach St Petersburg zog.

⁴⁵ Alfred Mirek, *Reference Book. Scientific and Historical Explanation to the Scheme of the History and Classification of the Harmonicas (Accordeons)* (Moskva: Mirek, 1992), p.4. Available at <<https://oabandoneon.com/mirek-poster>> (accessed 18 September 2024).

⁴⁶ Rojsman (2001), p.148.

⁴⁷ Niclas Fredriksson, 'The History of Free Reeds in Organbuilding - Free Reeds in Organochordia Towards the End of the 18th Century, Part 2', *ISO Journal* 15 (November 2002), pp.20–40.

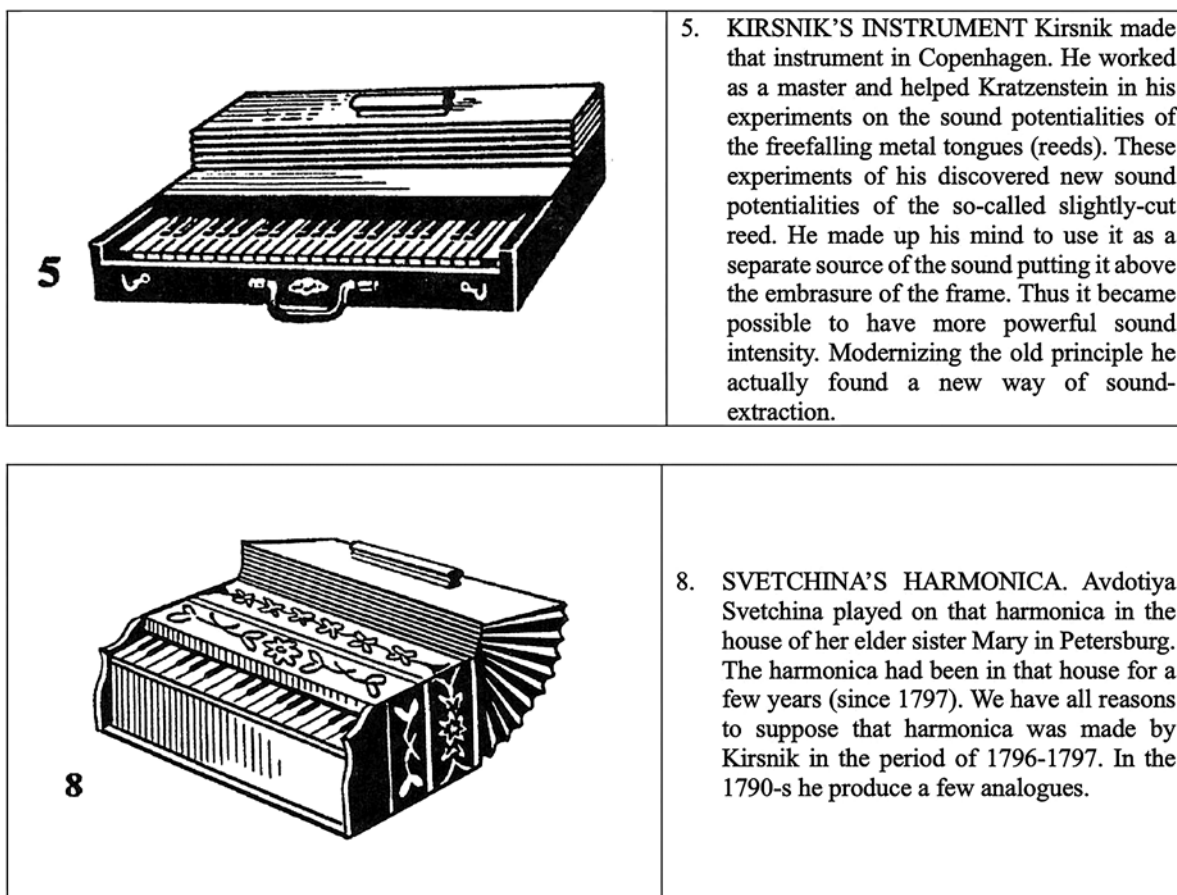


Figure 9. The two instruments described by Mirek with relation to Kirsnik. From Mirek (1992) p.4. Reproduced with permission from the Mirek museum, Moscow.

In 1782 Mr Rackwitz took a job in the workshop of the organ builder and musical instrument maker Mr Kirsnick in St Petersburg. He was first active in Copenhagen before he moved to St Petersburg.

Other authors also suggest that Kirsnik lived and worked in Copenhagen before moving to St Petersburg and some even speculate that Kratzenstein and Kirsnik knew each other from Copenhagen and perhaps collaborated on the vowel organ project.⁴⁸

The Danish organist and organ researcher Ole Beuchert Olesen (b. 1943) wrote a book in 2004 about the organ builder Daniel Wroblewsky (1744–1818), in which Kratzenstein also is mentioned.⁴⁹ Wroblewsky was originally Polish and received his

journeyman's license as an organ builder in 1769. On his way to England in 1770, Wroblewsky was robbed of everything but his journeyman's licence and left abandoned in Copenhagen harbour. It was here that he met professor Kratzenstein, out for a stroll. Kratzenstein took pity on him, and eventually found him work with the carpenter and instrument maker Christian Ferdinand Speer (1726–1797). It would take another ten years and three rounds of applications before Wroblewsky finally became a privileged master 'with the right to have apprentices and journeymen' on 19 January 1780 in Denmark and Norway, not least thanks to recommendations from Kratzenstein, who at the time was a well-known university professor and 'legal advisor'⁵⁰ in Copenhagen.⁵¹

⁴⁸ Kaufmann (1823), Mirek (1992), Braasch (2004), and Christian Ahrens, 'Free Reeds', in Douglas E ; Kassel Bush, Richard (ed.), *The Organ. An Encyclopedia* (Second edn.; New York, London: Routledge, 2015), pp.210–211.

⁴⁹ Ole Olesen, *Orgelbyggeren Daniel Wroblewsky* (København: Ivan Wroblewski, 2004).

⁵⁰ In Danish 'Justisraad', an honorary title that did not imply any administrative power.

⁵¹ Olesen (2004), p.106. Dorthe Falcon Møller, *Danske Instrumentbyggere 1770-1850. En Erhvervshistorisk Og Biografisk Fremstilling* (København: G.E.C. Gad, 1983).

Olesen has searched in vain for an organ builder in Copenhagen with a name like Kirsnik. He argues convincingly that it must have been Wroblewsky who helped Kratzenstein with the vowel organ and provided him with some Vox humana voices for experimentation. There is no information, however, on whether Wroblewsky himself made and used free reed voices.

TEAM VOGLER-RACKWITZ INTRODUCE FREE REEDS TO THE WORLD

Abbé Georg Joseph Vogler (1749–1814) was a famous, busy, and controversial character, with both clerical and musical competence. One of his many life projects was to build a true orchestrion, an instrument that contained voices representing all major orchestral instrument groups. In comparison with an ordinary organ, Vogler's orchestrion was compact and relatively portable, measuring nine feet high, nine feet wide and nine feet deep, with detachable manuals and pedals.⁵² He travelled Europe giving concerts on famous organs, on smaller keyboard instruments, and sometimes on his own orchestrion. In 1788, he also visited St Petersburg, where he played several concerts and visited organ makers' workshops. In Kirsnik's workshop, where he met Rackwitz, he heard the new free reed voices for the first time and supposedly uttered 'er hat hier das gefunden, was ich lange und vergeblich gesucht habe' (here he has found what I have been searching for, in vain, for a long time).⁵³ Within a couple of years Vogler had recruited Rackwitz to follow him on his Europe-wide tours to install new free reed stops in existing organs before his spectacular concerts. He also included a free reed manual in his orchestrion, which now had the following specification:⁵⁴

Manual I	
1. Rossignol-Cimbalino	1½, 1½, ¾
2. Campanella	2
3. Jeu d'acier	2½
4. Tromba marina	6, 4
5. Trias harmonica	2, 1¾, 1½ (c ¹ to g ³)

Manual II	
1. Flauto piccolo	1½ (FFF to c ¹)
Ombra	4 (c ¹ to g ³)
2. Flûte à bec	3
3. Flûte à cheminée	6
4. Flautone	12
Manual III	
1. Vox angelica	3 (FFF to d ¹)
Fluttante	3½ (d ¹ to g ³)
2. Clarinett	6 (FFF to c ¹)
Vox humana	4 (c ¹ to g ³)
3. Fagotto e Oboe	12
Manual IV	
1. Violini	3 (FFF to d ¹)
Flauto traverso	1½ (d ¹ to g ³)
2. Viole d'amour	6 (FFF to g ¹)
Pedal (from Manual I)	
1. Tromba marina	6, 4
Pedal (from Manual II)	
1. Flauto rustico	1½
2. Flauto dolce	3
3. Sylvana	6
4. Basse de Flûte	12
Pedal (from Manual III)	
1. Cornetta	3
2. Clarion	6
3. Serpent	12
Pedal (from Manual IV)	
1. Viola da Gamba	6
2. Tremolo	

According to Grave and Grave,⁵⁵ this specification departs from traditional approaches to the selection

⁵² Bynum Petty, 'Charlatan or Visionary? Abbé Vogler and His Theory of Organ Design', *The Tracker - Journal of the Organ Historical Society* 57/2 (2013), pp.20–22.

⁵³ Rojsman (2001), p.136.

⁵⁴ Petty (2013).

⁵⁵ Floyd C Grave and Margaret G Grave, *In Praise of Harmony - the Teachings of Abbé Georg Joseph Vogler* (Lincoln and London: University of Nebraska Press, 1987). p.252.

and grouping of registers because Vogler wanted to create a quasi-orchestral rather than organ-like sound.

After some years ‘on the road’ with Vogler, Rackwitz ended up in Stockholm, where he established himself in 1791 as a skilful maker of organs, organochords and other keyboard instruments. Vogler had already lived there since 1786, in the service of the art-loving Swedish King Gustav III, with a favourable contract that included 6 months free every year for travelling, and a generous pension. Vogler left Sweden in 1799, while Rackwitz remained until his death in 1844.

The restless Vogler moved on to Copenhagen, Berlin, Prague, Vienna, München and finally to Darmstadt, where he died in abject poverty in 1814, at the age of 65. But his many travels certainly must have enhanced the dissemination of free reed knowledge and competence throughout Europe and thus prepared the ground for the upcoming revolution.

RECONSTRUCTION ATTEMPTS

Kratzenstein is said to have made two copies of his vowel organ, one that was sent to St Petersburg and one that he kept in Copenhagen, but none of these can now be traced. One would think that with the exact description of the vowel organ found in his manuscript it should have been easy to build such an instrument, but it turns out that it is not that simple, especially because Kratzenstein’s drawings do not contain absolute measurements.⁵⁶

There are two examples in our time where scientists have attempted to recreate Kratzenstein’s vowel organ. John Jerome Ohala (1941–2020), professor of phonetics at the University of California, Berkely, wrote in 2011:

I have experimented with cardboard resonators approximating these shapes and although I accept

that those for [a] and [o] sound more or less like the intended vowel, that for [e] does not. It is possible that what he was aiming for is that the sounds emitted through these resonators at least sounded different.⁵⁷

Christian Korpiun (1948–2017), professor at the University of Duisburg, published a page-by-page translated and annotated text from Kratzenstein’s original manuscript in 2016.⁵⁸ The book was a spinoff of his extensive work with the resonators, and he gave a presentation in 2015 at the First International Workshop on the History of Speech Communication in Dresden based on experiments with resonators made from sheet zinc, published in ISCA Archive. He wrote:

On the basis of these rather scant notes I began in 2005 to design resonators from sheet zinc from the above sketches and a comparison with the corresponding sections through the vowel tract. In treatments of the subject ‘vowel production’ in the course of several lectures on the physiology of language, the accompanying demonstration of the resonators served to considerably raise the students’ interest in phonology. Subsequent measurements with the vowels stimulated by a saw tooth frequency resulted, over and above the subjective hearing impression, in a distribution of the formants that correlated surprisingly well with the spoken vowels.⁵⁹

Korpiun also found that the ‘e’ resonator was depicted upside down in Kratzenstein’s original manuscript, and that the ‘i’ resonator was really a kind of flue pipe that did not require a reed to sing, which may explain why Ohala was not so successful with these sounds. Unfortunately, Korpiun died in 2017, before realising a planned English language annotated translation of Kratzenstein’s manuscript. Korpiun’s zinc reproductions of Kratzenstein’s five resonators are shown in Figure 10 in the colour section.

⁵⁶ Fabian Brackhane, “Kann was natürlicher als Vox humana, klingen?” Ein Beitrag Zur Geschichte Der Mechanischen Sprachsynthese’, Thesis, Universität des Saarlandes, 2015, p.164.

⁵⁷ John J. Ohala, ‘Christian Gottlieb Kratzenstein: Pioneer in Speech Synthesis’, *Journal of the International Phonetic Society*. Proceedings from the 17th International Congress of Phonetic Sciences in Hong Kong, 17– 21 August 2011 (2011), pp.17–21.

⁵⁸ Korpiun (2016).

⁵⁹ Christian Korpiun, ‘Kratzenstein’s Vowel Resonators - Reflections on a Revival’, in Rüdiger Hoffmann and Jürgen Trouvain (eds.), *First International Workshop on the History of Speech Communication Research* (Studententexte zur Sprachkommunikation, Vol.79 (Dresden: TUDpress, 2015). A detailed description of the five resonator replicas, plus two tone generators and five 3D prints, can be found in Rüdiger Hoffmann, *Historische Objekte der Sprachakustik. Katalog der historischen akustisch-phonetischen Sammlung (HAPS) der Technischen Universität Dresden – Zweiter Teil* (Dresden: TUDpress, 2021), pp.48–53.

THREE PIONEERS

Kratzenstein himself evidently did not take this work any further. It is unclear whether he even knew that his free reed voices were increasingly being used, both in ordinary organs and in smaller domestic instruments. When Rackwitz wanted to visit him in Copenhagen in 1791 to have a look at the vowel organ, he was turned down and told that the machine was not working and that Kratzenstein was too old and sick to see him.⁶⁰ This is a bit strange, since another source describes Kratzenstein in 1784 as having a 'dauerhaften Gesundheit aufgrund seiner enthaltsamen und vorsichtigen Lebensart und einer robusten körperlichen Konstitution' (long lasting good health due to his sober and careful lifestyle and a robust physical constitution).⁶¹ In any case, in 1791, three of the free reed pioneers, Kratzenstein, Rackwitz and Vogler, were in the same place at the same time. If Vogler had given one of his spectacular organ concerts, which is not unlikely, Kratzenstein could have been in the audience and Rackwitz inside the organ.⁶²

THE REVOLUTION STARTS

During the first three decades of the nineteenth century a growing number of professional and semi-professional musical instrument makers, artisans and handymen experimented with free reeds. The aim was to make an instrument, or a toy, that was cheap to produce and at the same time so popular that the maker could make a living. A few variants, like Charles Wheatstone's concertina in London and August Victor Mustel's *Kunstharmonium* in

Paris were meant for experienced musicians, but the great majority of the new free reed instruments were marketed towards the 'man in the street', who could now make his own music with only a few hours of practice. The downside was that these new mouth-blown or bellows-blown instruments gained little acceptance within the established classical music world, whereas according to Christoph Wagner, the upside was, 'a historic turning point that was to fundamentally change the world of music'.⁶³

The on-going industrial revolution enhanced the mass production of free reed instruments, especially after Julius Berthold (1835–1944) in c1870 invented machines for punching and routing reeds and reed plates. In Germany, bandonion and concertina clubs became very popular, from c1900 and onwards, especially among the fast-growing ranks of industrial workers. Before the NS-regime started to 'rectify' these popular cultural movements in 1933, there were 1200 clubs with more than 30,000 members in Germany.⁶⁴ By 1900 the Hohner factory in Trossingen alone produced three million mouth harmonicas per year, increasing to 25 million in 1939.⁶⁵ In Italy, the annual accordion export was 690 in 1907 and increased to almost 200,000 in 1951.⁶⁶

Now there is probably no inhabited place in the world where you cannot find a mouth harmonica or an accordion.

ACKNOWLEDGEMENTS

Thanks to Steve Morrall and Simon Haines for language help.

⁶⁰ Kaufmann (1823).

⁶¹ Splinter (2007), p.53.

⁶² The most likely venue would have been the Church of Our Saviour, famous for its external spiral staircase and 1698 organ, where Vogler is reported to have given a concert on 13 June 1786. The organ, originally by the Botzen brothers, was revised and expanded several times, including the addition of some free reed pipes in 1798 and according to Vogler's instructions. Personal communication from Marie Martens, curator of The Danish Music Museum, 19 August 2024. It has not been possible to document a concert in 1791.

⁶³ Christoph Wagner, *Das Akkordion Oder Die Erfindung Der Populären Musik. Eine Kulturgeschichte* (Mainz Musik International: Schott, 2001), p.7. 'The invention of the accordion in Vienna in 1829 led not only to the arrival of a new member of the great musical instrument family, but also to a historic turning point that was to fundamentally change the world of music. The accordion represented a transition from an exclusionary to an inclusive participation in music for most people. Together with the harmonica, the concertina and new brass wind instruments with valves that appeared around the same time, it ushered in a new democratic era in the history of music, which allowed everyone to actively participate in musical life.' (Translated from German by the author).

⁶⁴ Karl-Georg Schroll, *Bandonionvereine - Vereint - Beliebt - Vergessen. Arbeitermusik Zwischen «Lust & Leben» Und «Profitum»* (Wilringen, Germany: blattFuchs Verlag, 2020).

⁶⁵ Hans-Peter Graf, *Entwicklung Einer Instrumentenfamilie: Der Standardisierungsprozess des Akkordeons*. Europäische Hochschulschriften / European University Studies 36, Vol.175 (Frankfurt am Main: Peter Lang, 1998), p.466.

⁶⁶ Alexander Georg Braunschmied, 'Internationalisierungspotentiale Der Fisarmonica-Industrie in Italien', PhD Dissertation, Universität Passau, 2013, p.229.

OLAF GJERLØW AASLAND

The Professor who Unknowingly Started the Free Reed Revolution



Figure 10. Korpiun's sheet zinc reproductions of Kratzenstein's five resonators, based on Thomas Young's illustrations from 1845. From Hoffmann (2021), pp.50–52. Courtesy of professor Rüdiger Hoffmann.

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