# The Early Evolution of the Saxophone Mouthpiece

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For nine decades after the saxophone's invention in the 1840s, classical saxophone players throughout the world sought to maintain a soft, rounded timbre—a relatively subdued quality praised in more recent years by the eminent classical saxophonist Sigurd Rascher (1930–1977) as a "smooth, velvety, rich tone."[1] Although that distinct but subtle tone color was a far cry from the louder, more penetrating sound later adopted by most contemporary saxophonists, Rascher's wish was to preserve the original sound of the instrument as intended by the instrument's creator, Antoine-Joseph "Adolphe" Sax. And that velvety sound, the hallmark of the original instrument, was attributed by musicians, including Rascher, in large part to the design of the saxophone mouthpiece. Although much has been written about the saxophone's history, little has been documented about the evolution of its mouthpieces. Between the 1890s and the 1930s, these underwent complex and rapid changes, from the early hand-crafted mostly wood mouthpieces of the nineteenth century to the glass, hard rubber, metal, and combined materials that became dominant after the turn of the century. These modifications in mouthpiece materials were driven mainly by practical and economic considerations, including a need to produce more stable (less prone to changing shape) and durable (less likely to break) mouthpieces and a desire by manufacturers to satisfy a boom in demand for the newly popular instruments. Yet throughout this four-decade period of experimentation and change in mouthpiece fabrication, one overriding objective was maintained by crafts people and manufacturers: the preservation of the large, rounded mouthpiece chamber design that gave the instrument the smoother timbre intended by Sax and hailed many years later by Rascher. Only after the advent of jazz and newer styles of popular music during the 1930s and 1940s did the original mouthpiece design give way to new designs that produce an edgier, brighter, and louder tone.

1. The Buescher Band Instrument Company, promotional video circa 1950.





### *The Early Saxophone Mouthpiece*

The early saxophone mouthpiece design, predominating during half of the instrument's entire history, represents an important component of the saxophone's initial period of development. To be sure, any attempt to reconstruct the early history of the mouthpiece must be constrained by gaps in evidence, particularly the scarcity of the oldest mouthpieces, from the nineteenth century. Although more than 300 original Adolphe Sax saxophones are thought to survive today,[2] fewer than twenty original mouthpieces are known.[3] Despite this gap in the historical record, this study is intended to document the early evolution of the saxophone mouthpiece through scientific analysis of existing vintage mouthpieces, together with a review of patents and promotional materials from the late nineteenth and early twentieth centuries. More than 175 mouthpieces manufactured prior to 1930 have undergone careful examination and some thirty-five have been analyzed in the laboratories of the Smithsonian Institution's Department of Mineral Sciences. Their internal shapes and dimensions have been revealed from silicone rubber casts; some were cut in half to expose their internal dimensions and construction. Their chemical compositions have been determined using specialized instruments used by geologists and materials scientists to examine a wide variety of materials including minerals, fossils, and artifacts. This research has not only uncovered historical details about the mouthpieces' fabrication and design, but also has yielded some unexpected insights. Early mouthpieces, for example, have been found to show surprisingly few tooth marks, suggesting that the instruments were frequently played with a double-lip embouchure. Some mouthpieces were also shown to contain chemical elements such as mercury and lead that today are widely thought to be potentially hazardous to human health.

The saxophone, designed by Sax to blend woodwind and brass timbres and to facilitate play though a revamped keywork and mouthpiece

2. Robert Howe, "Invention and Early History of the Saxophone, 1840–1855," *Journal of the American Musical Instrument Society* 29 (2003): 170. Howe lists more than 150 extant Adolphe Sax saxophones and states that number "constitutes less than half of those extant."

3.https://www.npr.org/sections/deceptivecadence/2015/05/02/403273608/3-d-printers-bring-historic-instruments-back-to-the-future; Tom Verde, "Deceptive Cadence," Weekend Edition, May 2, 2015, "3-D Printers Bring Historic Instruments Back to the Future." Verde quotes Robert Howe from an interview: "The problem is that there are only about ten or so surviving original mouthpieces crafted by Sax."

scheme, emerged as an increasingly popular instrument during the latter part of the nineteenth century, played in concert bands, small ensembles, and within ordinary households. As it gained popularity in the early twentieth century, an explosion occurred in the number of saxophones produced. By 1930 over one million saxophones had been made, 820,000 of them in the United States alone.[4] They were primarily fabricated in eight sizes: sopranino in E-flat, sopranos in C and B-flat, alto in E-flat, tenor in C ("c-melody") and B-flat, baritone in E-flat, and bass in B-flat. Even as mouthpiece materials evolved during the saxophone's early decades, the instrument's body and keywork underwent only modest changes. The most notable modifications introduced during this period were the single "automatic" octave key, improved key mechanisms, and some additional keys that helped the player with certain formerly awkward fingerings. The instruments were nearly always stamped by their manufacturers with a serial number, a practice that allows an estimate of their age. Because those early instruments generally outlasted their less-durable mouthpieces, the mouthpieces presumably were produced in even larger numbers. But in contrast to the saxophones, the mouthpieces were not stamped with serial numbers until much later. In addition, many mouthpieces were unbranded. As a result, mouthpiece ages are more difficult to assign.

### *Anatomy of the Saxophone Mouthpiece*

During this study, careful observations were made of both the interior and exterior dimensions of early mouthpieces. Regardless of the material used, mouthpieces generally continued to conform to Sax's original design until the 1930s. The anatomy of the saxophone mouthpiece is shown in fig. 1.

Unlike most modern mouthpieces, early mouthpieces had large barrel-shaped chambers with thin walls, a low or nonexistent baffle, and a small tip opening. In overall length, the early mouthpieces were shorter than their modern counterparts. In one respect, and because most were made from wood, the early design proved to be flawed. Pushing the mouthpiece onto the saxophone neck compressed the cork and caused ex-

4. Lawrence Gwozdz, *Das Saxophon: The Saxophone; An English Translation of Jaap Kool's Work* (Baldock, Hertfordshire: Egon Publishers, 1987), 19. Also, an examination of the serial numbers issued to saxophones by the major American manufacturers from 1920 to 1930 suggests more than 500,000 saxophones were made, supporting Kool's numbers.



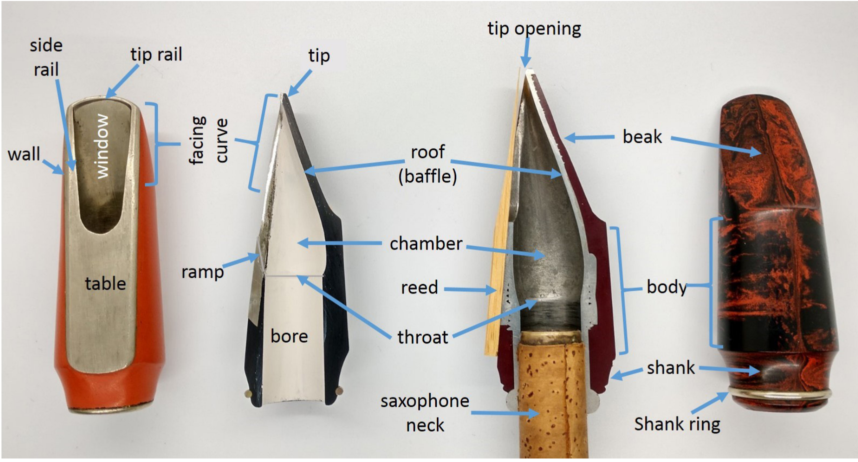


FIGURE 1. The parts of a saxophone mouthpiece. From left, a hard-rubber Holton alto saxophone with a nickel-silver core and table; cross-section of a hard-rubber Naujoks-McLaughlin Sil-Va-Lae alto (nickel-silver table painted white on the interior for photography); cross section of a Bakelite-and-metal Holton Perfected model c-melody attached to a saxophone neck; an unbranded marbled hard-rubber alto. Author's photo.

pansion stress on the shank, leading to common cracking of wood mouthpieces. This defect was later remedied by the introduction of a metal rings added to the shank.

In his 1846 patent, Sax described the mouthpiece's interior as "very flared.[5]" Rascher referred to it as "barrel-shaped." Examples of the large chambers inside early saxophone mouthpieces can be seen in the two cross-sections in fig. 1. Silicone rubber casts taken from the insides of three mouthpieces show the expanded large chamber (fig. 2).

Images from later years, including four patent drawings filed from 1919 to 1925[6] as well as those published in advertisements during the 1920s,[7] demonstrate that this internal design persisted until the 1930s.

5. Steven Cottrell, *The Saxophone* (New Haven and London, Yale University Press, 2012), 62. William McBride. "The Early Saxophone in Patents 1838-1850 Compared," *Galpin Society Journal* 35 (1982): 112–121.

6. M.H. and J. Babbitt. Mouthpiece for Wind Musical Instruments. United States patent 1385239 filed December 11, 1919, and issued July 19, 1921. Paul Arthur. Saxophone Mouthpiece and Process of Making the Same. United States patent 1,771,109 filed December 10, 1923, issued July 22, 1930. William H. Grant. Mouthpiece and Method for Making the Same for Wind Instruments. United States patent 1,771,217 filed April 15, 1925, and issued July 22, 1930. Harry E, O'Brien. Mouthpiece for Musical Instruments. United States patent 1,401,634 filed November 29, 1920, and issued December 27, 1921.

7. https://www.saxophone.org/museum/publications/id/74. King Saxophones and Clarinets 1928. Advertisement for the Holton Perfected mouthpiece in *Music Trade Review*, May 3, 1924, page 28.

FIGURE 2. Wood, metal, and hard-rubber mouthpieces paired with silicone-rubber casts of each interior cavity. From left, an unbranded wood alto; Goldbeck Superb nickel-silver alto; Conn eagle trademark hard-rubber alto. The casts show the exact shape of the respective large chambers. Gridlines in the background of this and subsequent images are one centimeter apart. Author's photo.

The large chamber proved to be a key to the early saxophones' tone color. So important was the large-chambered mouthpiece to achieving the tone of the original instruments that Rascher, who had long championed the use of vintage saxophones and mouthpieces, turned to producing his own mouthpiece brand in the 1970s. Modeled on the original Sax design, and a close copy of early Buescher mouthpieces, it was intended to supply classical players with a suitable mouthpiece, the likes of which were no longer being made, with which they too could achieve that "smooth, velvety, rich tone" as originally intended by Sax. In a letter to Rascher after hearing him play in a concert in 1934, Sax's daughter apparently stated that he did indeed play with the sound sound matching her father's intentions.[8]

Just as the larger-chambered mouthpiece design was maintained throughout the saxophone's early decades, careful measurements of sixty-six alto saxophone mouthpieces from the late nineteenth and early twentieth centuries also confirm that the associated small tip openings and relatively short overall lengths also persisted during that period. The tip openings of these alto mouthpieces range from 0.8 to 1.5 mm, compared with the 1.8 to 2.0 mm range typical to today's alto mouthpieces.

8. Michael Segell. *The Devil's Horn: The Story of the Saxophone, from Noisy Novelty to King of Cool.* (Farrar, Straus and Giroux, 2005): 246, quoting John-Edward Kelly, "Rascher's anointed successor."



These smaller openings would likely have required the use of relatively hard reeds. The average length of these sixty-six mouthpieces is 81.4 mm–about 10 to 12 mm less than those of commonly used modern alto mouthpieces made by Vandoren and Selmer.[9] Early soprano and tenor mouthpieces also were found to be shorter than their modern counterparts. In contrast, however, measurements of eight early baritone saxophone mouthpieces—a comparatively small sampling—averaged 132 mm in length, similar to modern baritone mouthpieces.

The design of the early saxophone mouthpiece differs in several respects from that of its single-reed precursor, the clarinet. A tenon at the bottom of the mouthpiece fits into a socket in the clarinet's wooden barrel or, in the larger sizes, a metal neck. Clarinets of all sizes have largely cylindrical body bores, and that bore diameter continues right into the bore of the mouthpiece. The bore size, a set characteristic for each clarinet size, is typically about 15 mm for B-flat soprano clarinets, 17.5 mm for E-flat alto clarinets, and 23.5 mm for B-flat bass clarinets. Saxophones are continuously tapered to the end of the neck, where the mouthpiece fits *over* the neck. Hence, much of the mouthpiece bore is filled with the neck and cork covering. The bores of the shanks of 121 early saxophone mouthpieces were measured. Those dimensions, in millimeters, are: for soprano, average 13.0, range 12.4 to 13.3; alto, average 15.6, range 15.2 to 16.3; c-melody, average 16.0, range 15.3 to 16.6; tenor, average 16.5, range 15.8 to 17.2; and baritone, average 17.6, range 17.3 to 17.8. The difference in the average mouthpiece bore diameter across these saxophone sizes (spanning a twelfth) is 4.6 mm, with much overlap in the ranges of alto, c-melody, and tenor saxophones. This is only about half the difference, in diameters, between mouthpieces of B-flat soprano and B-flat bass clarinets (pitched one octave lower). In addition, the straight-walled, small chamber of the B-flat soprano clarinet mouthpiece contrasts with the large-chambered early mouthpieces for alto saxophone (which were of comparable length). This was changed in the 1930s, when many designs of saxophone mouthpiece chambers were changed to a smaller shape more closely resembling the clarinet mouthpiece.[10]

9. The Selmer C* mouthpiece is about 93 mm long and the Vandoren A25 is about 91 mm long.

10. William C. Willett, "Evolution of the Saxophone Mouthpiece," *The Instrumentalist* 16 (1956): 31–32.

### *Materials of Saxophone Mouthpieces*

While the configuration of the early saxophone mouthpieces largely adhered to Sax's original design throughout the instrument's first nine decades, the materials from which they were made evolved over the years. Some mouthpieces were composed of a single material: wood, ivory, bone, hard rubber (commonly called ebonite), Bakelite (the first synthetic plastic), metal, glass (commonly called crystal), or ceramic. Others were made of combinations of materials (such as metal combined variously with wood, hard rubber, or Bakelite) and are termed here composite. While these shifts in materials improved the stability and durability of the mouthpieces and also enhanced manufacturing efficiency, they probably had little effect on the sound of the instrument. Although the issue has remained controversial, many saxophone players, fabricators and scholars believe that the internal shape of the mouthpiece has a far greater influence on the instrument's timbre than do the materials of which it is composed.[11]

An examination of over 150 catalogs and brochures[12] from major saxophone manufacturers between 1900 and 1930 indicates that the vast majority of mouthpieces sold at that time were made of hard rubber. Hard rubber is made by blending natural rubber, sulfur, mineral, and other additives and subjecting that mixture to extended heating in molds of various shapes. That process, patented by Nelson Goodyear in 1851,[13] became widely used in mass production of consumer items (e.g., buttons, combs, fountain pens, and dentures). Rudall Carte & Co. exhibited an "indestructible ebonite clarinet" in London, 1885,[14] an indication that hard-rubber mouthpieces may have been made before then. Other evidence also suggests that the early wood mouthpieces were probably being phased out around that time. Only one of the catalogs (Buescher, 1913) offered a wood mouthpiece, a less expensive option than hard rubber. Further, a 1905 mouthpiece patent stated that mouthpieces are "generally made from wood or hard rubber, more generally the latter."[15] Wood was largely abandoned as a saxophone mouthpiece material by around 1920.

Although most saxophone manufacturers initially made their own mouthpieces, the demand became so great by 1920 that smaller independent manufacturers began supplying finished mouthpieces to saxophone manufacturers and the general market with their own innovative, often patented designs.[16] Major manufacturers in the United States were Naujoks-McLaughlin, Harry E. O'Brien, and the Arthur Goldbeck Company. Naujoks-McLaughlin and Harry O'Brien specialized in composite mouthpieces, composed of hard-rubber bodies with metal tables (primarily made of nickel-silver, an alloy of approximately 60 percent copper, 20 percent nickel, and 20 percent zinc).[17] The Arthur Goldbeck Company made limited numbers of composite mouthpieces as well, combining silver (or rarely gold) cores and tables with hard-rubber bodies. Goldbeck was also probably the first large manufacturer of all-metal (nickel-silver) mouthpieces, produced in all saxophone sizes as well as an unusual clarinet design.[18] Another company, Sinclair, patented an all-metal mouthpiece design with a tunable shank in 1920.[19]

### *Evidence of Early Embouchures*

A close examination of early mouthpieces has provided an unexpected glimpse into the way the instruments were played. As mentioned above, the vast majority showed little evidence of teeth coming into contact with the beak. As a protective "patch" had not yet been devised, the scarcity of tooth marks suggests that many players avoided placing their upper teeth on the top of the mouthpiece. Instead, they apparently curled both lips

11. Frederick Stearns Wyman, *An Acoustical Study of the Alto Saxophone Mouthpiece Chamber Design* (PhD diss., University of Rochester, 1972).
Roger McWilliams "Does Saxophone Mouthpiece Material Matter?" https://www.philbarone.com/blog/saxophone-news/post/does-saxophone-mouthpiece-material-matter.
Ralph Morgan "Does the Material Used Make Any Difference In How Mouthpieces Play?" *Saxophone Journal* (February/March 1995): 60–62.

12. Catalogs and promotional literature for Holton, Buescher, C. G. Conn, H. N. White, Martin, and Selmer. Found online at https://www.saxophone.org/museum/publications.

13. Nelson Goodyear. Improvement in the Manufacture of India-Rubber. United States patent 8,075 issued May 6, 1851.

14. William Waterhouse, *The New Langwill Index* (London: Tony Bingham, 1993), 339.

15. Friederich Starke. Mouthpiece for clarinets. US Patent 787,127 filed January 18, 1905, and issued April 11, 1905.

16. See appendix A for specific information on patents mentioned in this article.

17. Analytical methods and results are given in appendix B.

18. *The International Musician*, 21 November 1921. Another all-metal mouthpiece manufacturer, Carl A. Bauman, is advertised, but no examples have been examined.

19. Alfred J. Sinclair. Tuning Device for Musical Instruments. United States patent 1,362,629, filed for April 3, 1920, issued December 7, 1920.

over their teeth in a double-lip embouchure. Prior to publishing the first saxophone method,[20] George Kastner asked Sax himself about the proper embouchure. Sax endorsed the double-lip embouchure but equivocated a bit, saying that in some cases placing the teeth on top of the mouthpiece could be useful.[21] Studies of early published saxophone methods[22] indicate that placing the teeth on top of the mouthpiece was most commonly taught. In addition, the well-known early saxophonists Rudy Wiedoeft and Marcel Mule, as well as Rascher, one of the most outspoken proponents of the original Sax tone, all played with their teeth on the beak of the mouthpiece.

Yet many surviving mouthpieces made as late as the 1920s show no tooth marks. It is possible that badly damaged early mouthpieces may have been discarded, and that players may have devised other ways to protect the beaks of their mouthpieces. Nonetheless, the combination of published descriptions of the double-embouchure technique[23] together with the scarcity of tooth marks on most of the early mouthpieces still available for study suggests that the double-lip embouchure was still commonly used in the 1920s.

### *A Sampling of Early Mouthpieces*

Originally, the wood, ivory, and hard-rubber mouthpieces were hand-crafted from solid material, a technique that entailed turning on a lathe, boring out the inside, and significant hand-finishing to open the chamber, sand and polish the exterior, and create the facing curve. Henri Selmer catalogs from 1921 to 1924 provide confirmation that some mouthpieces were "bored" from rubber rod. The introduction of hard-rubber mouthpieces allowed manufacturers to shift from hand-crafting and expensive natural materials to casting and molding techniques, employed for both small- and large-scale production. In the mid-1920s, the American Hard Rubber Company supplied roughly cast mouthpieces

20. George Kastner, *Méthode complete et raisonée de Saxophone* (Paris: Troupenas, 1846).

21. Gail Beth Levinsky, "An Analysis and Comparison of Early Saxophone Methods Published Between 1846-1946" (PhD diss., Northwestern University, 1997), 19.

22. Levinsky, 121; Frederick Hemke "The Early History of the Saxophone" (PhD diss., University of Wisconsin, 1975).

23. An illustrated description by Kool in 1931, for example, showed both lips curled over the teeth as the preferred embouchure. Gwozdz, *Das Saxophon*, 179.



Figure 3. Hard-rubber mouthpiece castings made by the American Hard Rubber company in the 1920s. Note the longitudinal line on most of the mouthpieces, indicating that they were cast in a multi-piece mold. Image by Jesse Bross; courtesy of the Butler Museum, Butler, New Jersey.

to the Babbitt Brothers, a mouthpiece manufacturing company, and to two saxophone manufacturers, the Buescher Band Instrument Company and C.G. Conn.[24] Fig. 3 shows a variety of these mouthpiece castings.

Finishing mouthpieces from castings saved substantial time and material. In addition, other components of the mouthpiece, primarily metal tables and cores, could be cast into the rubber. Most of the composite metal and hard-rubber mouthpieces examined in this study were clearly cast in molds. Today, it is difficult to distinguish the hand-crafted vintage mouthpieces, made from solid hard rubber, from those fabricated from castings. But the majority of hard-rubber mouthpieces produced after about 1930 were probably cast in molds.[25] The evolution in mouthpiece materials is illustrated in figs. 4 through 10.

The first saxophone mouthpieces were made from natural materials, primarily wood or ivory (fig. 4).

24. Documents and images of mouthpiece castings from the 1920s made by the American Hard Rubber Company were provided by Cindy Sokoloff from the Butler Museum, Butler, New Jersey.

25. In spite of the evidence, the idea that hard-rubber mouthpieces were made from solid stock (rod rubber) was perpetuated into the 1960s, as evidenced by a statement in *The Art of the Saxophone* by Larry Teal stating that hard-rubber mouthpieces are made of "hard rod rubber." Larry Teal, The Art of Playing the Saxophone (Miami: Summy-Birchard, 1963), 17.


Figure 4. Saxophone mouthpieces made from natural materials. On the left are two ivory mouthpieces. The smaller one has the telltale grain of modern or fossil elephant ivory. The larger mouthpiece for baritone, labeled "THE BUESCHER," lacks the indicative elephant ivory grain. A tiny chip removed from the inside of the mouthpiece, examined in an analytical scanning electron microscope, confirmed it is ivory. Judging from the characteristics of the non-elephant ivory and from its size, the mouthpiece was likely made from a hippopotamus incisor. The four mouthpieces to the right are all wooden, likely grenadilla, also known as African blackwood. From left, they are a baritone by Buffet-Crampon; a c-melody also by Buffet-Crampon; an unbranded alto or c-melody with an ornate shank ring; and an Henri Selmer alto. Author's photo.

Bone was also used (not shown). Ivory mouthpieces were machined from the tusks and teeth of elephants and likely hippopotamuses.[26] The wood used in mouthpieces was ebony and granadilla, also known as African Blackwood. Probably the first change in mouthpiece materials was the addition of shank rings to wood mouthpieces (fig. 4). These rings, found on all the wood mouthpieces examined in this study except for the soprano mouthpieces, were designed to prevent their shanks from splitting upon being pushed onto a saxophone neck faced with compressed cork. The rings would likely have been slid over the end of the shank and crimped into a groove turned on the shank. Because of the tendency of

26. Close examination of the grain of ivory can in most cases discriminate elephant tusk from the teeth of other animals.



Figure 5. Both sides of wooden clarinet mouthpieces with silver facings. The middle one is from a Triebert clarinet in the key of C; markings on the instrument indicate it was made prior to 1912. The other two are unbranded. Author's photo.

Figure 6. Hard-rubber tenor and alto saxophone mouthpieces. The two on the left, both labeled with the Conn eagle trademark, have very different shank designs. To the right of those are an Henri Selmer alto, a Buescher tenor, and a Meyer tenor. At far right is a marbled red-and-black alto, unmarked. The red color is from cinnabar pigment; a color change in the marbling down the length of the mouthpiece indicates it was cast. Author's photo.

Figure 7. Bakelite saxophone mouthpieces. At left are two of Bakelite with filler material. The King alto is shown with a gold-plated three-band ligature of the exact design advertised as early as 1919. Second from left is another alto branded by the Martin Company. Third from left is a tenor of translucent red Bakelite by or for C. G. Conn. At right is a similar alto mouthpiece with the Conn eagle trademark. Author's photo.

wood to change shape when wet, from mouth saliva and perhaps ambient humidity, a metal facing was applied to some wood mouthpieces. Fig. 5 shows three clarinet examples of these composite wood mouthpieces with silver facings.

Although no examples of wood saxophone mouthpieces with metal facings have been found, the concept of improving the stability of the wood body of the mouthpiece with a metal facing surely influenced later composite saxophone mouthpiece designs.

Examples of mouthpieces composed of hard rubber, the first major substitute for many natural materials, are shown in fig. 6, including some with shank rings. Careful examination of images shown in early twentieth-century catalogs and promotional literature reveals that shank rings were more common prior to about 1925, possibly a holdover from wood mouthpieces that were prone to splitting. Shank rings eventually were found to be unnecessary on hard-rubber mouthpieces, and those seen today on some modern mouthpieces are primarily decorative.

Mouthpieces made entirely from Bakelite are relatively rare. Examples produced by Martin, King, and Conn are shown in fig. 7. The Martin and King mouthpieces are opaque Bakelite with filler material added for strength. The Conn mouthpieces are made from the same translucent



Figure 8. At top, six hard-rubber mouthpieces with metal cores and tables; below are opposite sides of the same. From left are three with silver cores and tables: an unmarked clarinet mouthpiece closely matching the 1905 Starke patent drawing, an Arthur Goldbeck clarinet mouthpiece, and an unlabeled alto closely resembling the Goldbeck clarinet mouthpiece design.

Continuing rightward are three saxophone mouthpieces by the Holton Company. The larger one is a c-melody Perfected model, made of a Bakelite body cast over an integrated core and table of tin-antimony (pewter) alloy. The two at right, for alto and soprano saxophones, are made from cinnabar-pigmented hard rubber, cast over a nickel silver core with a separate nickel-silver facing. Author's photo.

red Bakelite used in their Visible Embouchure brass horn mouthpieces, made during the mid-to-late 1920s.[27]

### *Mouthpieces of Composite Materials*

In 1905, Friederich Starke patented the design for a composite mouthpiece with a metal core and table for clarinet "or the like."[28] After the expiration of the Starke patent, metal core and table mouthpieces were later made by the Holton and Goldbeck companies (fig. 8).

Holton made five different versions of these mouthpieces, four for saxophone and one for clarinet. The first was composed of a core and table made from two pieces of tin-antimony (pewter) alloy threaded together with a Bakelite shell cast over it. It was sold as the Holton Perfected mouthpiece.[29] These were apparently made in colors coded to the size of the saxophone.[30] The maroon and brown colors of existing c-melody and tenor Perfected mouthpieces do match the colors stated in early advertisements, but if alto and soprano mouthpieces were originally fabricated in green and blue, those colors have essentially faded to black. The soft and corrosion-prone pewter metal proved to make poor tables and was replaced by a nickel-silver facing.  Holton later began production of a mouthpiece with a nickel-silver core and facing, a hard-rubber body cast over it.[31] Some of these were made in bright orange and red-brown, colors produced from a pigment of powdered cinnabar (a mercury sulfide mineral, also known as vermillion).[32] No examples of Holton-made composite baritone saxophone mouthpieces have been seen.  Goldbeck "metal-lined" hard-rubber mouthpieces for clarinet were made with silver or, more rarely, gold cores and facings. These are stamped with a serial number on the end of the table.  Some were made after the transfer

27. E. J .Gulick. Mouthpiece for Musical Instruments. United States patent 1,740,013 filed in 1927, and issued December 17, 1929.

28. Starke, US Patent 787,127, 1905.

29. Paul Arthur. Saxophone Mouthpiece. United States patent 1,770,965 filed May 17, and issued July 22, 1930.

30. Advertisement for the Holton Perfected mouthpiece in *Music Trade Review*, May 3, 1924, 28. There is no mention of baritone or bass mouthpieces made in this model

31. Paul Arthur. Saxophone Mouthpiece and Process of Making the Same. United States patent 1,771,109 filed December 10, 1923, issued July 22, 1930.

32. See appendix B for a discussion of the potential toxicity of mercury sulfide.



Figure 9. At top, hard-rubber saxophone mouthpieces with metal tables; below, the same, shown from opposite sides. From left, orange O'Brien c-melody cinnabar-pigmented mouthpiece, branded for Henton; O'Brien alto also branded for Hento; Naujoks-McLaughlin Sil-Va-Lae; Lelandais alto; Sinclair mouthpiece with a patented adjustable shank mechanism; and a brown cinnabar-pigmented TaylorMade alto. The O'Brien and Naujoks McLaughlin mouthpieces have nickel-silver tables cast into them. The other three have silver tables applied onto their hard-rubber bodies. Author's photo.

of the company to Frank L. Kaspar and only a few hundred were ever produced.[33] An unmarked alto saxophone mouthpiece of identical design is attributed to the Goldbeck Company, and is also shown in fig. 8.

In 1921 and 1922, three manufacturers in the United States were granted patents for versions of a hard-rubber mouthpiece with a metal table.[34] A similar patent was granted to A. Lelandais in France in 1926. Examples of these are shown in fig. 9.[35]

This innovative composite design may have been derived from the earlier wood mouthpieces with metal facings. It is unlikely that this design would have improved stability or durability compared to that of a good-quality hard-rubber mouthpiece, although the perceived improvement might have helped these mouthpieces stand out in the growing mouthpiece market. In the United States, the tables cast into nearly all Naujoks-McLaughlin and Harry O'Brien (most branded as Henton) mouthpieces are nickel-silver. O'Brien made thousands of hard-rubber mouthpieces,[36] many in orange and brick-red colors produced with cinnabar (mercury sulfide) pigment (a potentially hazardous substance, noted above). More rarely, O'Brien made some mouthpieces of this type with silver tables. The few Lelandais mouthpieces analyzed in this study also have silver tables cast into the hard rubber. A variation of this composite mouthpiece design has a silver table applied onto a hard-rubber body, two examples of which are shown in fig. 9.

### *Mouthpieces of Metal or Glass*

Although some early metal mouthpieces may have been made from

33. Mr. Chester Rowell provided the original letter written by Frank L. Kaspar, in which Kaspar makes this statement. A transcript of the letter is found at: The Clarinet Bboard. http://test.woodwind.org/clarinet/BBoard/read.html?f=1&i=444584&t=239128

34. William Lewerenz. Mouthpiece for Reed Instruments. United States patent 1,401,159 filed May 31, 1921, and issued December 27, 1921.
Harry E, O'Brien. Mouthpiece for Musical Instruments. United States patent 1,401,634 filed November 29, 1920, and issued December 27, 1921.
William Naujoks and Everett McLaughlin. Mouthpiece for Wood Wind Musical Instruments. United States patent 1,413,929 filed May 11, 1921, and issued April 25, 1922.

35. Albert Lelandais. Perfectionnement à la construction des becs de clarinettes, saxophones et instruments analogues. France patent FR614540 filed April 4, 1924, issued December 16, 1926.

36. http://jonesandrelated.blogspot.com/2013/09/letters-from-1929.html Harry O'Brien in a letter dated to 1929 states that he "invented the Henton mouthpiece and manufactured over 40,000."



FIGURE 10. Early saxophone mouthpieces of metal or glass. From left, three made by Arthur Goldbeck of nickel silver, cast in two halves and silver-soldered together; mouthpieces of aluminum, and of silver plate over nickel silver, both by the Sinclair Company, with the adjustable shank mechanism patented in 1920. At right, a glass (crystal) mouthpiece for c-melody, made by O'Brien, possibly after 1930. Author's photo.

solid metal, those produced by the Goldbeck Company prior to and after 1920[37] were cast in two halves of nickel-silver, joined by silver solder (indicated by a thin line down the length of the mouthpiece). No such line is seen in two examples of Sinclair metal mouthpieces, one of which has a body of silver-plated nickel silver and the other of aluminum. Early metal mouthpieces are shown in fig. 10.

Glass mouthpieces, commonly referred to as crystal, were advertised in 1910 and 1914 Selmer catalogs, but not again until 1927.[38] This hiatus was mentioned in a 1929 letter by Harry O'Brien referring to Selmer that states: "They were without a crystal mouthpiece from 1914 until 1926, at the time when I perfected a crystal clarinet mouthpiece and turned over to them to market."[39] Crystal clarinet mouthpieces made by O'Brien, branded as O'Brien or Selmer, are fairly common and somewhat sought

37. Some Goldbeck Superb metal mouthpieces are stamped "PAT APLD FOR" and others have "PAT. FEB, 10, 1920" presumably meaning the patent date of February 10, 1920. We can assume the "patent applied for" mouthpieces were made prior to the patent of 1920. Multiple searches of the United States Patent and Trademark Office online database have not found this patent.

38. https://www.saxophone.org/museum/publications

39. http://jonesandrelated.blogspot.com/2013/09/letters-from-1929.html

after by players today. Although long considered an option, crystal saxophone mouthpieces from earlier years are rare. One example by O'Brien (fig. 10), having a smaller chamber design than the other mouthpieces discussed here, was likely made in the 1930s.

### *Epilogue*

By 1930, experimentation with new materials and composite designs had largely ended. Hard rubber and metal proved to be stable and durable materials, to be joined later by modern plastics. The composite designs, while novel, were essentially over-engineered and unnecessary. Saxophone mouthpiece production became a specialty industry of companies like J. J. Babbitt, The Woodwind Company, and Otto Link in the United States, and Charles Chedeville and Riffault et Fils in France. Hard-rubber mouthpieces were largely molded rather than machined from solid material. In the 1920s, the J. J. Babbitt Company, C. G. Conn, and The Buescher Band Instrument Company, probably along with others, are known to have finished mouthpieces from castings that had been manufactured in many styles and high volume by the American Hard Rubber Company. In the 1930s, the course of saxophone mouthpiece evolution shifted from experimentation with materials to experimentation with its interior design. In place of the original Sax design, with its large chamber and small tip openings, mouthpieces began to be made with smaller chambers, all manner of baffle designs and more open tips—modifications that substantially altered the instrument's sound, particularly through increased volume and a brighter tone. These changes were driven in part by saxophonists' need to play louder in small ensembles, often including amplified instruments, and they enabled those, particularly in jazz and other non-classical performance groups, to produce their own unique "sound." But for some classical saxophonists, notably Rascher, the sound of players using modern mouthpieces was particularly disturbing. His own Sigurd Rascher mouthpiece brand, designed to replicate the original Sax sound, is still on the market today and used by many classical players, and is the embodiment of the design that had prevailed through the instrument's first nine decades.



## Appendix A

### Mouthpiece and Related Patents (US and France)

| Patent no. | Assignee | Applied for | Granted | For what innovation |
|---|---|---|---|---|
| 8,075 | N. GOODYEAR | | May 6, 1851 | Hard rubber |
| 787,127 | F. STARKE | Jan. 18, 1905 | April 11, 1905 | Metal core, beak and reed plate, HR body |
| 1,361,629 | A. J. SINCLAIR | April 3, 1920 | Dec. 7, 1920 | Sliding shank mechanism all metal mouthpiece |
| 1,401,159 | W. LEWERENZ | May 31, 1921 | Dec. 27, 1921 | Metal reed-plate on rubber body |
| 1,401,634 | H. E. O'BRIEN | Nov. 29, 1920 | Dec. 27, 1921 | Metal reed-plate on rubber body |
| 1,413,929 | W. NAUJOKS AND E. McLAUGHLIN | May 11, 1921 | Apr. 25, 1922 | Tapered reed-plate on rubber body |
| FR61450(A) | A. LELANDAIS | | Dec. 16, 1926 | Metal table on hard rubber |
| 1,740,013 | E. J. GULICK | Mar. 24, 1927 | Dec. 17, 1929 | Visible embouchure (Bakelite) mouthpiece |
| 1,770,965 | P. ARTHUR | May 17, 1922 | July 22, 1930 | Two-piece metal core, bakelite shell |
| 1,771,109 | P. ARTHUR | Dec. 10, 1923 | July 22, 1930 | One-piece metal core reed-plate added |
| 1,771,157 | P. ARTHUR | Mar 28, 1924 | July 22, 1930 | Clarinet metal core |
| 1,771,217 | W. H. GRANT | April 16, 1925 | July 22, 1930 | Screw tightener on shank of metal core |

## Appendix B

### Analysis of Mouthpiece Materials

Analyses and images of the mouthpiece materials were carried out on an FEI NovaNanoSEM variable-pressure scanning electron microscope (SEM) outfitted with a Thermo Electron energy dispersive x-ray spectrometer (EDS) located in the Department of Mineral Sciences, Smithsonian Institution, Washington, DC. With this system in low-vacuum mode, whole objects, in this case mouthpieces (fig. 11), can be imaged and analyzed nondestructively at the sub-micron scale. Operating conditions were typically 15 kilovolts and two to three nanoamps.

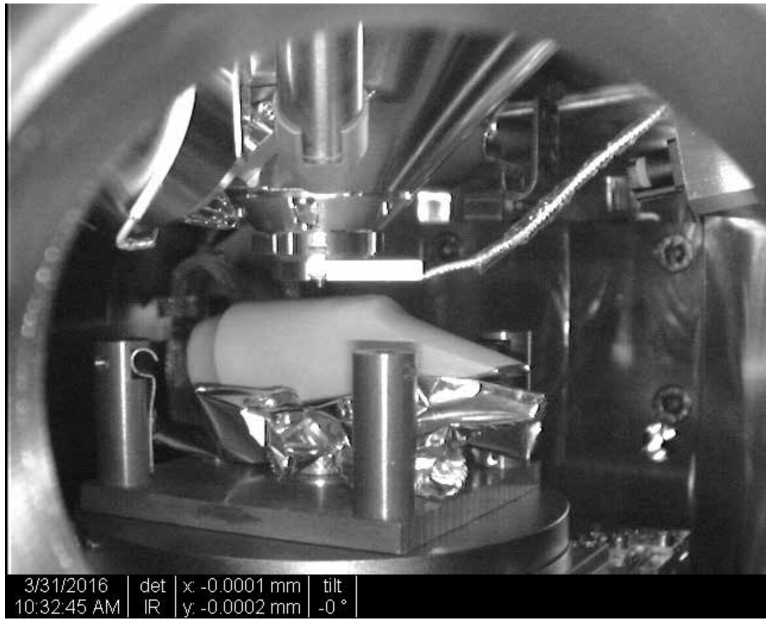


Figure 11. Infrared camera view of a Holton alto saxophone mouthpiece in the chamber of the scanning electron microscope used in this study. Author's photo.

### *Metal and Metal Alloys*

Silver tables are found on the following branded mouthpieces: Starke, Benisch, Lelandais, TaylorMade, Sinclair, Ben Davis "Silverlay," O'Brien "Silvervoiced," Goldbeck for clarinet, a suspected Goldbeck for alto saxophone, and four wood-body unmarked mouthpieces. Two have silver cores or linings: the Goldbeck clarinet and the suspected Goldbeck alto saxophone mouthpiece. Silver iodide alteration was found in abundance on the Starke mouthpiece.



Copper zinc nickel alloy, commonly called nickel-silver, was widely used by Holton, O'Brien, and Naujoks-McLaughlin in their mouthpieces. Most tables of Holton, O'Brien and Naujoks-McLaughlin mouthpieces are this alloy. In addition, the cores of some Holtons, and the "H" inlay on O'Brien mouthpieces branded for Henton are nickel-silver. Some analyses show minor amounts of silver. Fig. 12 shows analytical results from tables and some cores of seventeen mouthpieces. The metal used in Goldbeck Superb metal mouthpieces is also nickel-silver. The two Sinclair metal mouthpiece bodies analyzed are nickel silver with silver plating and aluminum.

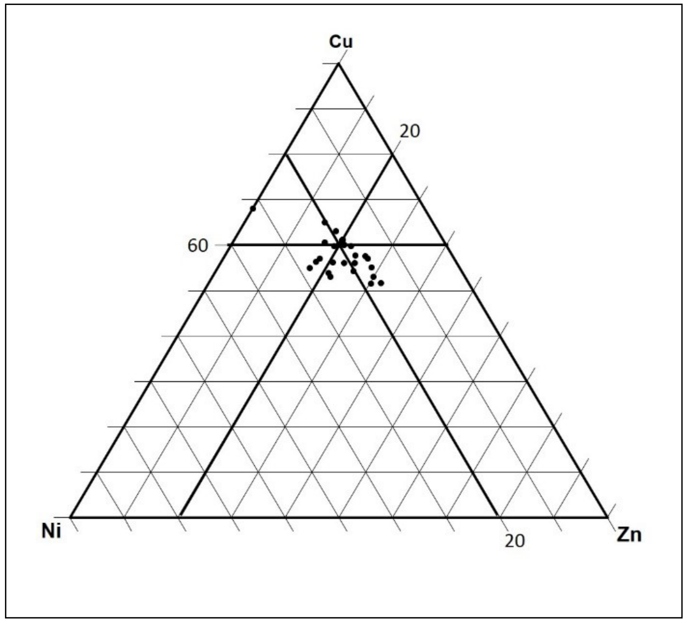


Figure 12. Ternary diagram showing the copper (Cu), zinc (Zn) and nickel (Ni) compositions in 33 analyses of the tables and cores of seventeen mouthpieces.

The metal core and some tables in Holton Perfected model mouthpieces are an alloy of tin with antimony and copper, similar to modern pewter compositions. The alloy is 60 to 75 weight percent tin, 21 to 34 weight percent antimony, and 1 to 4 weight percent copper. Grains four microns and smaller of what appear to be pure lead are common in this alloy and can be seen in fig. 13. Mouthpieces made of this alloy commonly have corrosion on the table.

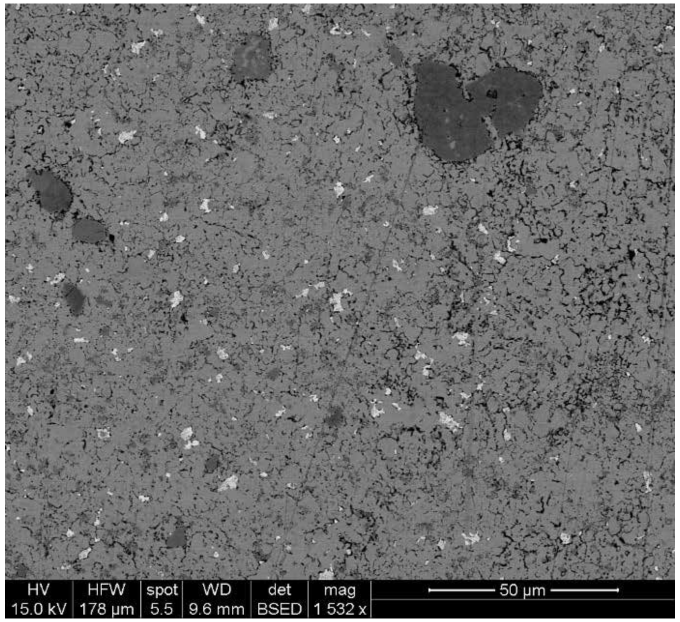


FIGURE 13. Backscattered electron image of the polished metal surface in the cut Holton Perfected mouthpiece seen in fig. 1. The majority of the material is a tin antimony alloy. The dark gray grains are a copper zinc tin alloy. The tiny bright grains, measuring 4 microns or smaller and difficult to analyze cleanly, are mostly or entirely lead. Author's photo.

Holton and Goldbeck mouthpieces have tables soldered to the cores. The solder can be imaged and analyzed in the SEM where the table meets the core near the tip, on the inside of the mouthpiece. The solders analyzed from four mouthpieces, shown in table 1, are silver-based. The solder in sample 12 was heavily corroded to silver chloride. The composition given for this solder is calculated chlorine free.



TABLE 1. Silver-solder compositions in weight percent.

| sample # | Ag | Zn | Cu | Ni | Cd |
|---|---|---|---|---|---|
| 10 | 82 | 10 | 7 | 1 | |
| 12 | 81 | 14 | 5 | | |
| 64 | 77 | 16 | 6 | 1 | |
| 64 | 76 | 18 | 6 | | |
| H-X | 54 | 7 | 11 | | 26 |

## *Bakelite and Hard Rubber*

Cellulose and mineral additives have been identified in the Bakelite bodies of Holton Perfected mouthpieces. Identification of the coloring agents however has been elusive, except in a brown mouthpiece that has

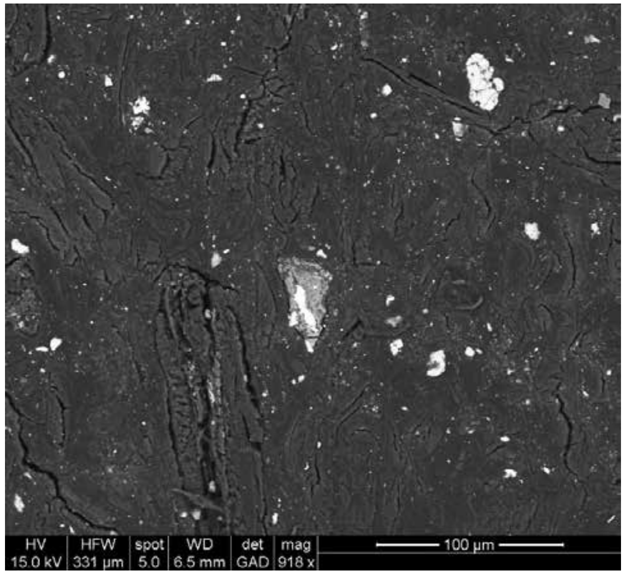


FIGURE 14. Backscattered electron image of the Bakelite body of a brown Holton Perfected tenor saxophone mouthpiece. A silica grain in the center of the image, likely the mineral quartz, has a smear of bright silver metal on it, likely from a silver-plated ligature. The brightest grains in the field of view are barium sulfate, the mineral barite. The much finer, darker gray grains are iron oxide, likely added as pigment. Large elongate grains, somewhat difficult to see in the phenolic resin matrix, are cellulose, probably finely ground wood dust. Author's photo.

abundant iron oxide grains. Cellulose and grains of silica, likely quartz; and barium sulfate, likely the dense mineral barite, are common. These materials add durability to the Bakelite but not color other than white. Fig. 14 shows examples of inclusions in Bakelite.

Mineral additives identified in hard-rubber mouthpieces include the minerals quartz (silicon dioxide), barite (barium sulfate), calcite (calcium carbonate), and cinnabar (mercury sulfide). Likely the powdered quartz, barite and calcite were added to improve the durability and machining characteristics of the rubber. Cinnabar, also known as vermillion, was added in powdered form as a pigment. Orange, brick-red, brown, and some black hard-rubber mouthpieces contain cinnabar. Barite is almost always seen in mouthpieces with cinnabar.

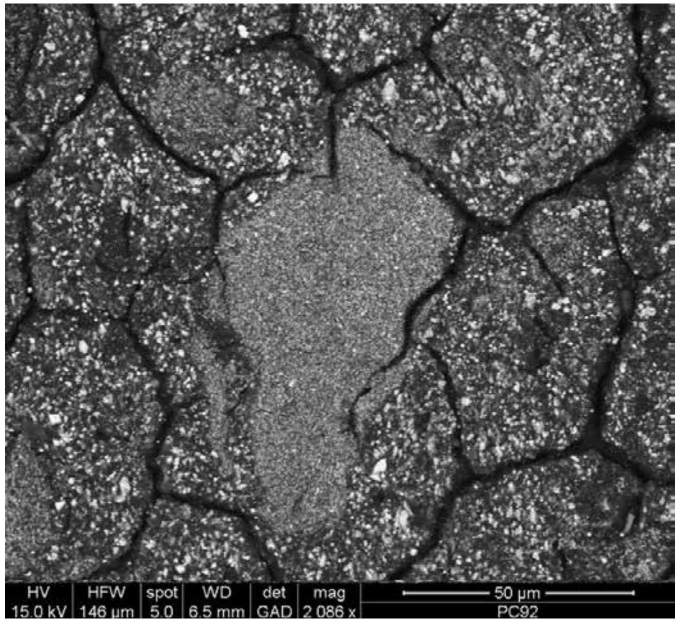


FIGURE 15. Backscattered electron image of a bright orange Holton hard-rubber body alto saxophone mouthpiece. A 50 micron-wide grain of finer material is seen in the center of the image. Brightest grains in the surrounding material are mercury sulfide (cinnabar). Darker gray and generally smaller grains are predominantly barium sulfate (barite). Cracks seen in black are partially filled with organic material; these result from aging of the hard rubber, not from being subjected to the low vacuum in the chamber of the microscope. Author's photo.



The toxicity of mercury has long been known. The main ore of mercury is the mineral cinnabar. In powdered form, cinnabar was and is a valuable commodity, as it can be added to paint, plaster, and other materials to produce brilliant red and orange hues. The use of cinnabar as a pigment in hard rubber began not long after its invention by Charles Goodyear in the mid-nineteenth century. Dentists discovered that upper dental plates (dentures) could easily be cast in hard rubber from a mold made from a patient's palate. Cinnabar was added to the rubber compounded for dental plates to achieve a gum-like color. Concern over the use of cinnabar in dentures is mentioned in an 1870 patent for a vermillion substitute.[1] Even so, a study commissioned in 1875 by a large dental supply company declared that "the pink and red vulcanite artificial gums and palates now so generally in use are absolutely harmless."[2] The safety of cinnabar pigment in hard rubber was again questioned in the early twentieth century.[3] Nevertheless, cinnabar-colored hard rubber for saxophone mouthpieces was sourced from dental supply companies, and period advertisements proclaim the use of "the finest" dental rubber. Harry O'Brien, the Holton Company, and others made composite mouthpieces in the same brick-red color as dentures, as well as bright orange shades.

Because it contains mercury, cinnabar is widely believed today to be toxic, as evidenced by its inclusion on many lists of the most toxic minerals. The actual toxicity of different mercury compounds, however, is highly variable and in fact, cinnabar is "insoluble and is poorly absorbed in the gastrointestinal tract."[4] The real safety issue with mercury sulfide is that over time it can oxidize or degrade, producing other known toxic mercury compounds, specifically in combination with chlorine.[5] Twenty-three

1. A.D. Schlesinger. Improvement in coloring Vulcanite or hard rubber. United States patent 99,956 dated February 15, 1870.

2. John Attfield, "Report of the Committee on the Supposed Mercurial Poisoning by Coloured Vulcanite," *Transactions of the Odontological Society of Great Britain* 9, new series, (1877): 203–16.

3. L. Eilerstein, "La Nocivité du vermillion employé comme colorant des bases de la prothèse dentaire. "*Le Progrès Dentaire* 33, no. 1 (1906), 364–67. Available online: https://www.google.com/books/edition/_/5r01AQAAMAAJ?sa=X&ved=2ahUKEwjs37OktcbqAhV5JzQIHbOnBvgQre8FMBF6BAgHEBM.

4. Jie Liu, Jing-Zheng Shi, Li-Mei Yu, Robert A. Goyer, and Michael P. Waalkes, "Mercury in Traditional Medicines: Is Cinnabar Toxicologically Similar to Common Mercurials?" *Experimental Biology and Medicine (Maywood)* 233(7) (2008): 810–17.

5. Marine Cotte, Jean Susini, Nicole Metrich, Alessandra Moscato, Corrado Gratziu, Antonella Bertagnini, and Mario Pagano, "Blackening of Pompeian Cinnabar Paintings: X-ray Microspectroscopy Analysis," *Analytical Chemistry* 78 (2006): 7484–92; M. Rade-

analyses of mercury sulfide grains in seven mouthpieces were carefully inspected for the presence of chlorine, and two, both from a bright orange mouthpiece, have about one weight per cent chlorine. This suggests that potentially toxic chlorine-containing compounds may form over time from degradation of mercury sulfide pigment used in hard-rubber mouthpieces. In an abundance of caution, one who wants to play these mouthpieces should consider this potential health hazard.

pont, Y. Coquinot, K. Janssens, J.-J. Ezrati, W. de Nolf, and M. Cotte, "Thermodynamic and Experimental Study of the Degradation of the Red Pigment Mercury Sulfide," *Journal of Analytical Atomic Spectrometry* 30 (2015): 599–612.