THE AUTOMATIC COMPENSATING EUPHONIUM AS THE IDEAL CHOICE FOR PERFORMING MUSIC COMPOSED ORIGINALLY FOR OPHICLEIDE

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The ophicleide was a popular instrument for a short yet important time in music history. Many orchestras perform music originally written for ophicleide on a bass tuba. By researching the music written for the ophicleide, and the history of the instruments that were related to it, we can see that the euphonium would be a more historically accurate replacement. A detailed analysis of the sound properties of these instruments help to reinforce the euphoniums dominance at matching the timbre of the ophicleide. Several famous orchestral excerpts are treated as case studies to show why the use of a euphonium is the ideal choice for performing music written for the ophicleide.

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CHAPTER 1

INTRODUCTION

The ophicleide is an antiquated instrument today, but it was popular shortly after its creation in 1817.[1] It was the last of the brass instruments that produced its chromatic pitches from vent holes. After its quick rise to popularity, it was soon challenged by the new valve brass instruments that were being developed around the same time[2]. Today it is often considered as a historical footnote, and it is widely accepted that the ophicleide was superseded by the bass tuba.[3] Even the entry in the *Oxford Dictionary of Music* says little more than: "[an] obsolete keyed brass instr. of conical bore and played with cup mouthpiece. Was a development of the serpent and existed in alto, bass, and double-bass sizes, but only the bass was much used. Was used in military bands and is also incl. in early scores of Mendelssohn , Berlioz , Verdi , and Wagner. Superseded by the bass tuba."[4]

This entry is true in a sense, as the ophicleide was formerly the lowest bass voice in the orchestra and wind band, until the adoption of the tuba.[5] However this statement is misleading and may bring people to the false assumption that the tuba is the worthiest choice to perform music originally written for ophicleide. This paper shows why the euphonium is the best modern replacement for the ophicleide.

There are four reasons that the euphonium should be considered the modern replacement for the ophicleide. There is historical precedence for euphoniums replacing

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[1] Clifford Bevan, *The Tuba Family* (New York: Charles Scriber's Sons, 1978), vol. 2, 159.

[2] Bevan, *The Tuba Family,* 141.

[3] Michael Kennedy, *The Oxford Dictionary of Music,* Edited by Joyce Bourne (Oxford : Oxford University Press, 2007).

[4] Kennedy, *The Oxford Dictionary of Music*.

[5] Bevan, *The Tuba Family,* 155.

the ophicleide. These early euphoniums, and other similar brass instruments had pitch and range encumbrances that the modern automatic compensating euphonium corrects.[6] The modern euphonium's range and tessitura matches the ophicleide, both theoretically and as exemplified in the literature. Recordings of ophicleides sound distinct from the tuba, and they sound so similar to euphoniums that it is often difficult to tell them apart. Finally, a spectral analysis of an ophicleide shows more similarities to the tone of the euphonium, and distinct from the tuba.

Conductors are particular when it comes to instrument choice, even when their ensembles do not perform on period instruments. There was a short time during the 19th century when the euphonium replaced the ophicleide's role in English orchestras, but in the 20th century, orchestras commonly use a bass tuba in F when performing these parts. Instrument choice for the lowest brass instruments is usually relegated to the specific traditions of each region,[7] instead of the instrument that would make the best aesthetic choice for the ensemble. The tradition for a tubist to perform ophicleide works has existed in most regions for more than a century. The search for a new ophicleide replacement may seem unimportant because of modern tubists' training and ability to play this music. The false assumption of the ophicleide's inferiority during its time period has kept performers from determining what the music would have sounded with the ophicleide. This impression that the ophicleide did not, and cannot sound good, creates little incentive to determine which instrument should replace it in a modern ensemble.

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[6] James G. Blane, *Reports of the United States Commissioners to the Centennial Exhibition at Melbourne*, (Washington DC: Government Printing Office, 1888) For the Secretary of State by Authority of Congress, 92.

[7]Bevan, *The Tuba Family,* 327 begins the chapters listing specific traditions by region.

There are several famous quotes of musicians mocking poor performances on the ophicleide. These quotes, especially the jocular Berlioz's quote about an ophicleide sounding like a "Bull in a china shop,[8]" are perpetuated as a critique of the instrument, whereas it was usually the performers who were being ridiculed. Furthermore, modern brass players might pick up a poorly repaired instrument, play on it for a time, and declare it inferior. These mindsets encourage musicians to consider the ophicleide an inferior relic that was replaced by the modern tuba in the orchestra, and leave little desire to find out the original instrument's tone quality.

Today there are several musicians that perform on the ophicleide at a high level, including Douglas Yeo, Nick Byrne, and Stephan Wick. Period instrument performance might be a good solution to a historically informed performance. If an ophicleide is not available, what instrument should be used to replace it? And what process should be used to make that decision?

When original ophicleide works are performed on a large modern F tuba such as the three works that are discussed at the end of this paper, the tuba gives "entirely the wrong sound."[9] If conductors have the opportunity to hear a well-prepared musician perform expertly on an ophicleide, their opinions of the instrument, and of each of these works will change. The modern euphonium has a similar timbre and range as the ophicleide[10]; however, it features a more consistent tone, attack, and larger dynamic range that would

[8] Hector Berlioz, *Grand traite d'instrumentation et .d'orchestration modernes,* trans. Theodore Frost (Paris, 1844), 296

[9] Bevan, *The Tuba Family,* 304.

[10] Bevan,*The Tuba Family,* 345.

blend better with other modern instruments[11]. I intend to demonstrate that the modern euphonium is the ideal choice to perform repertory originally written for the ophicleide.

The bore and bell size of the ophicleide, saxhorns and early tubas are examined and compared to that of modern euphoniums and tubas. Manuscripts originally written for ophicleide are compiled into categories: orchestral repertoire, wind band repertoire, chamber music, solo repertoire (and conventions), and pedagogical music. Several examples of works with different roles are compared to standard music written for tuba and euphonium. Frequency distribution of the pitches used are calculated to determine the instruments' range and tessitura as established by compositional practice. This analysis shows the appropriateness of performing this music on the euphonium.

Several recordings of varying styles that are performed on modern instruments are compared to recordings made on ophicleide. The timbre of the instruments are compared on a spectrograph to show the time frequency spectrum of various instruments and observe visible characteristics of the sound. The mathematical process of determining the centroid mean of a Fourier transform of sound samples of various instruments and mute combinations are compared. The results are factors in determining which modern instruments' overtones best match the ophicleide. Finally three major orchestral works are used as case studies to show how a euphonium would be a better choice for performance.

[11] Clifford Bevan, "Brass." *The Musical Times* 127, no. 1718 (1986): 254-255.

CHAPTER 2

HISTORICAL EVIDENCE

The serpent and its variants had been the only chromatic conical low brass instruments in history until the 19th century.[12] The serpent was commonly used to accompany Gregorian chant,[13] and was the bass voice in brass consorts. It was made by carving out two identical conical halves, and wrapping them together with leather, and drilling usually 6 or more holes. The most common serpent is the standard S Shape instrument with which most people are familiar. This shape facilitates reaching all the finger holes. However, there were various other keyed and upright serpents such as the corno inglese di basso[14], bassoon russe, serpent a pavillion, and more. These were generally regional attempts at creating a better serpent[15], until Jean Hilarie Aste created the first ophicleide in 1817.[16]

The word ophicleide is Greek and was created by combining the words “ophis” (a serpent) and “kleis” (a cover or stopper). This name was used as an advertising ploy to replace the use of serpents, but it leads to much confusion because an ophicleide is not a keyed serpent, but a bass keyed bugle. The ophicleide was derived from the keyed bugle invented by the Irish bandmaster Joseph Halliday. He created a system of large flat keys for the standard copper military signaling bugle. Halliday filed the patent for this “Kent bugle”

[12] Bevan, *The Tuba Family,* 143.

[13] Walter Hillsman, "Instrumental Accompaniment of Plain-Chant in France from the Late 18th Century" *The Galpin Society Journal* 33 (1980): 8-16.

[14] P. Bate, "Serpent d'eglise, A: notes on some structural details" *The Galpin Society Journal* 29 (1976): 47-50.

[15] Bevan, *The Tuba Family,* 86.

[16] Bevan, *The Tuba Family,* 141.

as it was called in 1811[17]. Some sources claim that he experimented with bass versions[18] but it was Jean Hilaire Asté who created an entire family of instruments in 1817 and patented them in 1821.[19] He made them of brass, wrapped them vertically, and named the lowest voice the ophicleide. The corno inglese di basso was considered a direct predecessor to the ophicleide, though still a serpent and not a keyed bugle. It too was made of metal (usually copper) which aided in projection, but it still used finger holes that were not large enough to allow the sound to carry.[20] The tone holes on the ophicleide were almost the same size as the segment of the horn's body that it is located. The tone holes themselves are raised and flat, like the kent bugle design, which allowed the keys to be flat and made a tight seal.[21]

These "vented" brass instruments had different playing characteristics than modern valve instruments. Chromatic alterations on these instruments by lifting keys would not affect resistance of the air stream, and the full conical nature of the instrument gave very little wind resistance for the performer. This effect makes the entire range of the instrument playable with little alteration of air pressure. This gives the feeling of every note on the horn being "free blowing." Enough keys are employed that they can be positioned and scaled in a way that does not create the inherent pitch problems that many valve instruments have. Pitch on the horns can be adjusted dramatically with the embouchure and, from personal experience, is much more manipulative than modern valve

[17] Ralph Dudgeon, *The Keyed Bugle.* (N.J.: Metuchen, 1993), 140.

[18] Bevan, *The Tuba Family,* 142.

[19] A Baines, *Brass Instruments, their history and development.* (London), 1976.

[20] P. Bate, "Serpent d'eglise, A: notes on some structural details." *The Galpin Society Journal* 29 (1976): 47-50.

[21] John Webb, "19th-Century Keyed Brass." *The Musical Times* 127, no. 1716 (1986): 83-85

brass. Early ophicleides did not even have tuning slides because the embouchure could adjust each note as much as a half step.[22] This was quickly apparent when I was learning the instrument. It is easy to play an incorrect interval with the correct fingerings, and this might be considered a problem for some. I found that with practice, this made the instrument much easier to manipulate and play in good pitch, but like a singer, the player must be able to clearly hear the pitch before they play. These positive benefits of the ophicleide outweighed the inherent resonance deficiency that the design has. Modern valve brass instruments have much greater pitch center but with the stability comes a lack of flexibility for adjustment.

The three and four valve brass instruments in general have an inherent pitch problem when using specific valve combinations. Valves would add length to the instrument in set segments, and multiple valves would be employed to lengthen the valves further. To accurately change the pitch of an instrument, the length needs to be changed by percentage. Therefore if two valves are in tune independently, when used in aggregate, the overall length is too short, so other valve designs need to be employed.[23] Trumpets are easily adjusted with valve slides, and even if many professional tubas and euphoniums players make these adjustments as well, there are other designs features in modern instruments to play in tune.

There were many forms of the ophicleide key work, ranging from 9 keys to 12[24]. The standard forms of the ophicleide were made in the keys of Bb and C. However there were

[22] George, Anthony, "The Ophicleide or 'Chromatic Bullocks and how to milk them" *T.U.B.A. Journal* 23, no. 4 (Summer 1996): 28-30.

[23] Bevan, *The Tuba Family,* 256.

[24] Stephen Weston, "Improvements to the Nine-Keyed Ophicleide." *The Galpin Society Journal* 36 (1983): 112.

many alto ophicleides (quanticlaves) pitched in Eb used in France and the United States. So-called "monster ophicleides" in F were made, and though they are of historical significance, it was said that they were difficult to play and were extremely uncommon. There is often confusion with nomenclature because the later "French C tubas" were also referred to as a "monster ophicleide.[25]"

The early 19th century was a time of quick development for instrument manufacturers, and there was an enormous market for new wind instruments[26]. Names of instruments were often used interchangeably, and the names changed meaning in different regions. The valve brass instruments began to be invented in Europe in the late 1830s, and valve and keyed brass were used together for a period of 50 years.[27] The period that keyed and valved instruments performed side by side was longer than the short time that the keyed brass instruments had a monopoly. In that time period, small bore German F bass tubas were used to replace the ophicleide when they were not available, but they did not have the range and good pitch that the ophicleide had[28]. The tuba inevitably took the role from the ophicleide as the lowest voice of the brass family because it has the most presence at the lowest range of all the instruments. Its sound matches that of the double bass, and it blends beautifully at the bottom of a trombone section. However, the modern bass tuba is larger than the period bass tubas, and thus it changes the tone of the instrument. The bass tuba and bass ophicleide may be mistaken as being in the same range because both instruments are designated as "bass" and the euphonium is thought of as a "tenor tuba." A

[25] Bevan, *The Tuba Family,* 266.

[26] Christian Ahrens and Irene Zedlacher, " Technological Innovations in Nineteenth-Century Instrument Making and Their Consequences" *The Musical Quarterly* 80, no. 2 (1996): 203.

[27] Bevan, *The Tuba Family,* 166.

[28] Ibid., 209.

bass tuba's fundamental length is 12-13' long, the bass ophicleide is only 8-9' long, and the euphonium's fundamental length is 9'. The bore, length, and flare of the instrument determine the instrument's tone and playing characteristics[29], and is an objective method of comparing the ophicleide with its modern counterparts.

Many thought that the vertical shape of the ophicleide was important to maintain. There were several valve ophicleides produced in Vienna, Berlin, and Paris, but they had the same issues as early tubas. The resistance was too great in valve mechanisms because the bends in the pipes were very sharp. The ophicleide was in the large vertical U shape, creating less bends and resistance. Maintaining the long vertical bell on a valved instrument would mean that the valves would have to be wrapped tighter and therefore defeat the initial purpose of the shape of the keyed ophicleide variety. All these problems made it difficult for valve ophicleides to replace the keyed ophicleides.

A further reason for the seemingly universal acceptance of the tuba's replacement of the ophicleide in Germany is the quick acceptance of the Morritz/Wieprecht tuba in both Vienna and Berlin.[30] The German people were not readily accepting of French culture after the Nepolionic War, and thus did not widely accept the ophicleide. Prussians, and most of the German areas, still used "Russian bassoons" as their bass instruments until Wieprecht designed his tuba[31]. This early tuba brought the Prussians and other German and eastern European nations to an early consensus of the bass of their orchestra. Thus the tradition of

[29] Arnold Myers, Robert W. Pyle, Joël Gilbert, Murray Campbell, "The Influence of Bore Size on Brassiness Potential " (Proceedings of the Second Vienna Talk, Austria, University of Music and Performing Arts Vienna, Sept 19–21, 2010).

[30] Bevan, *The Tuba Family,* 301.

[31] John Webb, "19th-Century Keyed Brass." *The Musical Times* 127, no. 1716 (1986): 83

performing all ophicleide works on the bass tuba began in the Germanic areas.[32] This very fact that the Wieprecht tuba replaced the ophicleide might give more merit to the modern euphonium being the best choice for performing music scored for ophicleide for two reasons.

The first reason is that the bass tuba in F was successfully able to execute the low range of the ophicleide, but could not perform in the high tessitura that was relatively easy for the ophicleide. Most regions solved this issue by creating both a bass (F) and baritone (Bb) instrument that together featured the tessitura of the ophicleide until instruments with larger ranges could be developed. Though wind bands still use this configuration today[33], orchestras have all but universally chosen the larger instrument as the sole conical low brass member. However, with the invention of the automatic compensation system in 1888, the euphonium could now play the entire range of the ophicleide in tune, because it is both a Bb and an F instrument.[34]

The second reason that the successful adoption of the Wieprecht bass tuba shows that the euphonium is the best suited replacement for the ophicleide is that a Wieprecht tuba has almost the same dimensions as a modern euphonium[35]. The tone of a brass instrument is defined by its length and flare.[36] If a modern euphonium was played on the F side of the horn, its pipes would be the same length as the Wieprecht tuba. Most

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[32] Bevan, *The Tuba Family,* 207-208.

[33] Clifford Bevan, "Euphonium," *The New Grove Dictionary of Musical Instruments*, ed.

Stanley Sadie (London: MacMillan, 1984): 722.

[34] F. C Draper, *Notes on the Boosey & Hawkes System of Automatic Compensation of valved Brass instruments.* (London, 1953).

[35] Bevan, *The Tuba Family,* 204.

[36] Arnold Myers and Raymond Parks, "How to Measure a Horn." *The Galpin Society Journal* 48 (1995): 193-199.

importantly, the Wieprecht tuba has a bore size of 14.9mm from the mouthpiece to the end of the valve section and a 7.6 inch bell. Modern euphoniums are even bigger, with most instruments beginning at 15mm, and expanding to 16mm or 17mm in the valve section, and an 11" - 12" bell.

This tradition of replacing the ophicleide with a euphonium like instrument is not specific to Germany. In France, the valve instruments that eventually supplanted the ophicleide were the basse sax horn in Bb, and even later the French C tuba[37]. The French C tuba is the smaller instrument with 5 or 6 non-compensating valves, a 10 ½-11″ bell, and a 14.5 - 15.5mm bore for the first 3 valves and 15.5mm - 16.5mm for the rest of the valves. The lead-pipe is even longer than a euphonium because the main tuning slide is between the valves and the mouthpiece. The mouthpiece itself is slightly larger than a bass trombone shank, but the lead-pipe is the same or smaller than modern euphoniums. There is room for further research on this subject. Arnold Myers discusses in length the relationships of bore size and bell flare on the "brassiness" potential of brass instruments. There is a long standing formula that can predict many aspects of the tone of a brass instrument by using specific measurements of the size and flare of the pipes.[38] I was unable to produce all of the measurements necessary on period instruments in order to tabulate the brassiness potential of this list; however, this could be undertaken in a future study. For a detailed listing of instruments and bore sizes, please refer to the appendix.

Hector Berlioz has written some of the most negative statements regarding the ophicleide, but he scored more music for the ophicleide that is performed today than any

[37] Bevan, *The Tuba Family,* 246.

[38] Myers, "How to Measure a Horn," 196.

other composer in the orchestral literature. His treatise on orchestration, written in 1843, is very specific about instrument groups, and ranges. He actually lists two instrument groups lower in score order than the ophicleide: tubas, and the saxhorn family[39]. He even discussed contrabass ophicleides or "monster ophicleides," which would be comparable to a modern bass tuba. He states in his treatise however, "up to the present nobody in Paris has been willing to play them because of the volume of breathe required."[40] This is not to be confused with the French C tuba which was referred to by the same name several decades later. In more detailed discussion on the ophicleide itself he wrote:

> The timbre of the ophicleide's lower notes is rough, but it can do wonders in some cases when placed below a mass of brass instruments. The highest notes have a raw quality which has perhaps not been sufficiently exploited. The middle range, particularly when the player is not very skilled, is all too reminiscent of the sound of the serpent and the cornetto. I think it is best for them not to be left exposed. There is nothing more vulgar, I would even say more monstrous and less designed to blend with the rest of the orchestra than those more or less fast passages written as solos for the middle range of the ophicleide in some modern operas. It is rather like a bull escaped from its stable and frolicking in a salon.[41]

Berlioz's thoughts are extremely important on this subject. Berlioz wrote the most large scale works for the ophicleide, and set precedence in French music that lasted through the entire 19th century and beyond. The previous quote about a bull in a china shop might be the most detrimental statement to the legacy of the instrument. For generations it has been the only bit of information on the ophicleide that most music students ever learned. This may have given many people the misconception that Berlioz and others did not like the sound of the ophicleide but scored for it because it was the only

[39] Hector Berlioz, *Grand traite d'instrumentation et .d'orchestration modernes,* Translated by Theodore Frost (Paris, 1844), 338.

[40] Ibid.

[41] Ibid., 339

instrument available until the tuba was created. The truth is that many people including Berlioz himself liked the sound of the ophicleide.

The same year Berlioz was writing his treatise, he visited Mendelssohn's orchestra in Leipzig and did not like the sound of their ophicleide. "The Ophicleide, or rather the thin copper instrument shown to me under that name, was quite unlike a French one, and had scarcely any tone. It was therefore rejected, and replaced after a fashion by a fourth trombone."[42] It is speculated that the ophicleide he was referring to was a valve ophicleide.[43] We may never truly know which instrument he was referring to, but most of the keyed ophicleides in Germany were imported from Paris. The German instrument manufacturers adopted valves early, and this must have been an early example of a domestically built valve ophicleide of which Berlioz did not approve. Berlioz did not hate the ophicleide; he just hated it when it was played poorly. On his deathbed Berlioz lamented that the ophicleide was not going to survive. He was quoted as saying, "[there] were not teachers of the ophicleide of sufficient quality to maintain the standards of playing required."[44]

Berlioz even compared the German tubas to the ophicleides in his 1843 treatise. It is an interesting distinction that Berlioz refers to bombardons, which were also 8' instruments. Later in Italy and Spain, "bombardon" would become the name for the bass tuba, but these bombardons were much closer to the euphonium. "The bass tuba is nowadays very widespread in the north of Germany, especially in Berlin; it has an immense

[42] Hector Berlioz, The Memoirs of Hector Berlioz, translated and edited by David Cairns (London: Victor Gollancz Ltd, 1969), 296.

[43] Bevan, *The Tuba Family,* 209.

[44] Hector Berlioz, *Memoirs,* Translated by D. Cairns. (Paris, 1870), 296

advantage over all other low wind instruments. Its timbre is incomparably nobler than that of ophicleides, bombardons and serpents, and has something of the vibration of the timbre of a trombone. It is less agile than the ophicleide, but its tone is powerful and its range in the lower part is the most extensive available in the whole orchestra"[45] This quote, taken from a letter, can easily be misunderstood as Berlioz condemning the three instruments as being inferior to the bass tuba because their tone was less than noble. If this was his intended meaning, then wouldn't Berlioz have stopped using ophicleide and bombardon in his compositions? He continued to compose for them in his orchestral works, and as instrument manufacture improved, so did the ophicleide and bombardon.

The mechanics aside, there are opinions from important figures that shed light into what the ophicleide sounded like, and what instrument should be used to replace it. Historian Clifford Bevan describes the sound as a "a very attractive tone ... a baritone with a modicum of alto saxophone to round off the edges and add to the fullness of the tone."[46] In 1888, James G. Blaine gave an account of the exhibition of the new "compensation piston" at the Messrs. Boosey and Co. exhibit at the Centennial International Exhibition in Melbourne Australia. This is what is known today as a compensating euphonium

> A modification of the principal (compensation piston) is applied to four-valve instruments, and is specifically required on the Euphonium, which is, by its means, perfected throughout the whole of its compass. This instrument, the euphonium, is the modern substitute for the now almost obsolete "serpent" and ophicleide, and is marked by its clear and powerful tones and peculiar adaptability for solo purposes"[47] The importance of this quote cannot be overstated. It is written documentation that the Automatic compensating euphonium was created to replace the Ophicleide and was being sold as such a replacement.

[45] Bevan, *The Tuba Family,* 157.

[46] Ibid., 224.

[47] Blane, *Centennial Exhibition,* 92.

Other writers have remarked how the ophicleide sound resembles that of the euphonium. Again, Adam Carse wrote in the 1939 magazine *Musical Wind Instruments*, "the tone of the ophicleide, when properly played, is full, resonant, and not unlike that of a euphonium; the instrument is also capable of giving forth quite pleasant and gentle tones, and should not be supposed to be a roaring barbarous monster, as is suggested by many who have described it after the period of its decline."[48]

Late ophicleide solos were published to be performed on ophicleide or euphonium to expand the market of the publications. [49] England is the prime example of where the manufactories allowed the euphonium to completely supplant the ophicleide in military and brass bands. [50] Many ophicleide players were very successful, and did not wish to switch instruments. It took time to learn the keyed system, and by the time they were proficient, they did not wish to spend more money to buy a new state of the art instrument. Instrument manufacturers then began to sponsor ophicleide solo contests at brass band festivals all over England. The winner of each ophicleide contest would be awarded a brand new euphonium.[51] The best ophicleide players began to double on the euphonium,[52] and the lesser players eventually followed. For a short time in the early 1860s, most euphonium players also doubled on the ophicleide until the euphonium gained wider popularity. English brass bands did not suffer from the same range issues as other

[48] Adam Carse, *Musical Wind Instruments* (London: MacMillan, 1939).

[49] Anthony George, "The Ophicleide: (A) Historical Exchange." *T.U.B.A. Journal* 25, no. 4 (Summer 1998): 36-37.

[50] Trevor Herbert, "The Reconstruction of Nineteenth Century Band Repertory: Towards a Protocol." Edited by Stewart Carter, *Perspectives in Brass Scholarship* (Pendragon Press, 1997): 200

[51] Anthony George, "Historical Instrument Section: Ophicleide." *T.U.B.A. Journal* 24, no. 4 (Summer 1997): 36-38.

[52] George, "Historical Exchange", 37.

ensembles, because brass families were not written at the octave. They would alternate sizes between a fifth and a fourth, usually Bb and Eb, so range issues were handled by passing the line to another instrument.

There were many English soloists that spread the good name of the ophicleide and helped to establish its dominance at the bottom of the brass family.[53] Prospere was an ophicleideist that performed with the L. Jullien orchestra. Historian Adam Carse wrote a history on the Jullien orchestra and quoted a review stating that "[Prospere] set forth from his leviathan instrument with a majesty and grace that no single one ever before equaled.[54]

Further treatises have confused the modern equivalent of the ophicleide as well. Samuel Adler's "The Study of Orchestration" states that that "the tuba has completely… replaced the ophicleide" but then later compares the "quite mellow" sound of the ophicleide to the euphonium. If the euphonium is the instrument that sounds the most similar to the ophicleide, then shouldn't the replacement instrument be the euphonium and not the tuba? [55]

In 1843, there was a clear distinction in Berlioz's writings between the bass saxhorn, the German F tuba, and the ophicleide. However, in Berlioz's later manuscript, he allowed the publishers to change all of the names on the ophicleide parts to tuba.[56] Which instrument did he mean to perform these parts when he wrote the word "tuba?" The instrument named "tuba" in France at the end of the 19th century was the French C tuba discussed earlier. The instrument was based on a bass saxhorn, but had a larger bore and

[53] Stephen Weston, *Samuel Hughes, Ophicleidist* (Edinburgh, 1986).

[54] Adam Carse, "Brass Instruments in the Orchestra: An Historical Sketch." *Music & Letters 34* (1922): 380.

[55] Samuel Adler, The Study of Orchestration. 2nd ed. (New York: W.W. Norton and Co., 1982), 298-299.

[56] Bevan, *The Tuba Family*, 170.

5-6 valves and 10 inch bell. By mouthpiece, bore size, taper, and bell; this instrument is virtually the same instrument as a modern euphonium, just with a different 6 valve system. As newer models of tubas were being created, designers increased both the bore and bell size of instruments to aid in projection and tone. France kept the tradition of the small C tuba until the 1960s but the German F tuba was enlarged from the 1840s until its modern form. The euphoniums and like instruments also have grown, from this period to their modern form. Now euphoniums are the same size of the original tubas.

Table 1, instruments and bore sizes, is a compilation of measurements that I found from manufacturers, online databases, and museums. They show the gradual growth of these designs as they compare with the modern euphonium. A longer list can be found in the appendix.

There are several clear points that can be drawn from this historical evidence. The instruments that ended up replacing the ophicleide initially were roughly the same bore, length, flare, and bell size of a modern euphonium. These instruments had pitch and range problems inherent in their design that inhibited their ability to perform at the same level as a good ophicleideist of the same period. It was not until the automatic compensating valve system was invented did brass valve instruments have a 3 octave range without having to manually manipulate slides, thus ending the last superiority of the keyed instrument family. The bass tuba was refined to carry on the role of the lowest brass voice. That is why Berlioz chose to give the French C tuba the parts that were originally written for the ophicleide.

Table 1. Instrument Sizes

Name	Bell	First valve bore mm	Fourth valve bore mm	Mouthpiece receiver	Year
Modern	Euphoniums				
Yamaha Maestro 642	300mm	15	16.8mm	Large shank 12.45mm	Present
Wilson 2900	292mm	15mm	17mm	Medium/ large	Present
Miraphone M5050	310 mm	15.50 mm	16,20 mm	Large shank 12.45mm	Present
Saxhorns					
Wessex Bb compensated	280mm	15.1 mm	15.1 mm	Medium shank 11.65	Present
French C tubas[57]					
Mahillion	289mm	15.25mm	15.92mm	Extra large 13.5mm	1955
Association Generale	266.5m	14.478mm	15.5mm	Extra large 13.5mm	C. 1865
Early tubas[58]					
Schmidt f tuba	228mm	15mm	15mm	*****	c.1845
Moritz f tuba	203mm	***	****	15.3mm	C. 1849
Ophicleides[59]					
H. Sax	213mm	Crook: 35.5		12.5mm	c. 1830
Henri et Martin	236mm	Crook: 34mm		12mm	c. 1850
Modern Tubas					
Miraphone "Belcanto" (F-381C)	420 mm	19,6 - mm	21,2 mm	European Large Tuba Shank	Present
B&S Perantucci PT-15	419 mm	19 mm	21 mm	European Large Tuba Shank	Present
Yamaha 822	444.5 mm	19.5 mm	19.5 mm	European Large Tuba Shank	Present

[57] Dr. Brendan Ward, *V & E Simonetti Historic Tuba Collection.* http://simonettitubacollection.com/ (accessed may 30, 2014).

[58] Ibid.

[59] Bevan, *The Tuba Family*, 143.

CHAPTER 3

COMPARISON OF THE FUNCTION AND TESSITURA OF THE OPHICLEIDE WHEN COMPARED TO SIMILAR MUSIC WRITTEN FOR TUBA AND EUPHONIUM

The tessitura of a work can be a problem when transcribing music written for another instrument. Instruments with similar ranges may not have the same facility or ease of playing in different octaves as the original instrument. Brass instruments are no exception. Instruments of similar length tend to have the same playing characteristics, such as flugelhorn and trumpet. As the length of the instrument changes, facility in each range no longer matches. Even horns, which have a considerably different range and tessitura as other 12' brass, have difficulty when performing music of other brass instruments. Brass instruments can play a theoretically infinite number of notes above their lowest partial. Therefore, both the tuba and euphonium can play all of the notes that an ophicleide was commonly written to play. Comparing only the playable range of the tuba, euphonium, and ophicleide in itself will not be able to give us a definitive answer to what instrument is best to play ophicleide scores, so we must look at the tessitura that each instrument is commonly expected to play in different roles in music.

There is long orchestral tradition of ophicleide parts being played on F tuba[60]. Many of these pieces of music require the ophicleide to play low in its range, which is conducive to performance on F tuba. These composers knew the ophicleide's capabilities and would expect the instrument to play thematic material high in its tessitura as well. However difficult it may be for an F tuba to play the tessitura of the ophicleide, it has been done successfully over the last century. Range should not be the overriding factor on deciding

[60] Bevan, *The Tuba Family,* 98, 100, 155, 213.

which instrument choice is best; however, an instrument with a matching tessitura will function better in that range and is far more successful in performance. Orchestral composers may not have utilized the ophicleide's full potential in early compositions; so much of the bass harmony would seem simple enough to cover on the tuba. As ophicleide parts became more complicated, modern realizations have suffered because the F tuba does not fit the role as well as a smaller conical brass instrument would.

A cursory look at some of the repertoire written for the instrument gives us a better understanding of the capability of the ophicleide and gives us an idea of what modern instrument can fit the requirements given to the ophicleide. An abridged survey of orchestral, small ensemble, solo, wind band, and educational material can shed light on which modern instrument has the same tessitura. A pitch distribution analysis of these types of works are best at comparing different ranges and tesituras of these instruments in solos, etude books, and small ensemble works.

To determine the common tessitura of these instruments all of the notes used in the piece were plotted by the number of times it is used. This pitch frequency distribution compares similar of music of the three instruments. The method chosen for the etude books is to count the first 100 pitches from each method book, and compare them. In the easier etude books, several exercises were tabulated, but only the first 100 notes of some longer etudes were used. In the solo and chamber works, the pitch distribution over the entire work was calculated and the percentage that the work uses each note was plotted on a chart. Similar music is compared to see how each composer used each instrument to meet the musical requirements.

While researching the ophicleide it is interesting to discover the large number of method books written for the instrument compared to the smaller amount of solo literature. The ophicleide was a new and exciting instrument for the time, and it was often studied. Pedagogical problems included a brand new mechanism and few or no experienced teachers. In the appendix are 13 examples of etudes and method books. Many of them are simply listed as "Method for ophicleide," or "New method for ophicleide" which make it important to list the composer in addition to the title.

This first chart shows the pitch distribution of the first 100 notes in each of these method books' etude section. Early etudes are a good test example because they are generally written in the instrument's most comfortable range. The books tabulated are: *Bitsch Eudes*[61], *Kopprasch no. 35*[62], *Bordogni Vocalices*[63], For euphonium. For Ophicleide I chose the *Nouvelle Methode d'ophicléide* pg 20,[64] *Méthode d'ophicléïde,*[65] and *Methode elementere pour d'ophicléïde*.[66] For bass tuba, I chose etudes from the Vincenz Ranieri etude book,[67] *31 Etudes for Charles Kohlman*[68], and Uber *25 Early Studies for Bass Tuba*.[69]

[61] Marcel Bitsch, *Quinze Etudes De Rythme* (Paris: Alphonse Leduc).

[62] Georg Kopprasch, *Sixty Selected Studies For Trombone* (New Yourk N.Y.: Carl Fischer Music, 1939)

[63] Marco Bordogni, *Melodious Etudes for Trombone.* Edited by Joannes Rochut (New York N.Y.: Carl Fischer, 1928).

[64] Sistermann, *Nouvelle méthode d'ophicléide* (Paris: Joly, 1841).

[65] L. Franck, *Méthode d'ophicléïde* (Paris: Meissonnier, 1843).

[66] Pierre François Clodomir, *Méthode élémentaire pour ophicléïde* (Paris: Alphonse Leduc, 1866).

[67] Vincenz Ranieri, *30 Instructive and Melodic Exercises for Tuba* (Hannover: Louis Oertel, c. 1890).

[68] Charles Kohlman, *Thirty-One Etudes for F-Tuba* (Troy, MI: Encore Music Publishers, 1999).

[69] David Uber, *25 Early Studies* (San Antonio, TX: Southern Music Company, 1980)

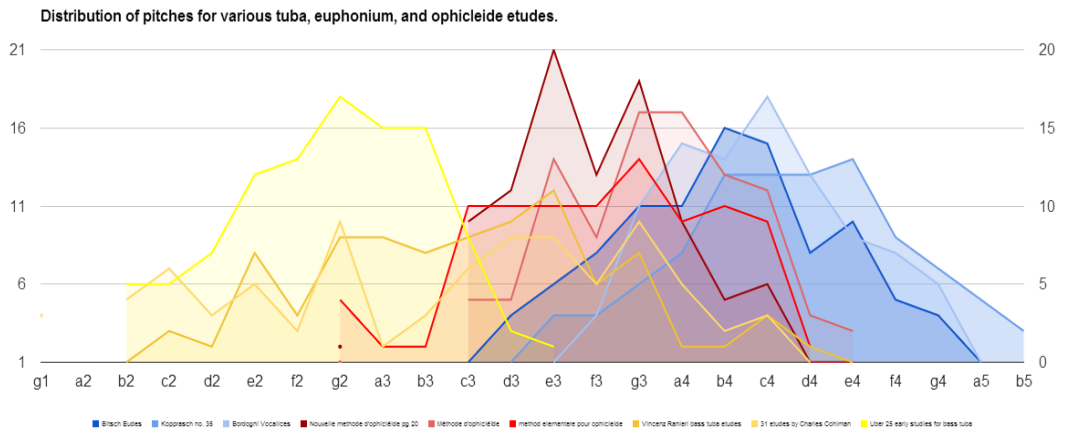


Figure 1. Method Book pitch frequency distribution. The yellow lines are tuba, red are ophicleide, and blue are euphonium.

According to Berlioz, the ophicleide was "peculiar in its ability to have a clear tone in the extreme low, and mid registers."[70] It could play high notes, but this was not excessively utilized when Berlioz first wrote his treatise. The tuba has a wonderful sound in the low register, but is not as agile in the high range. This is clearly seen when comparing the yellow shades of the tuba etudes with the red shades of the ophicleide etudes. The compensating euphonium can reach all of the low notes that the ophicleide can play, albeit with greater resistance, but also has the ability to play the more difficult high registers. These 9 etude books were chosen because the tuba and euphonium books are common educational material. These Ophicleide books were selected because they had melodic etudes that look similar to our modern etude books. One issue is that the Vincenz Ranieri bass tuba etudes, and the 31 etudes by Charles Cohlman are written for a slightly more advanced student than the rest of the method books, but even without this taken into account, it is clear that the tessitura of the F tuba is significantly lower than that of both the

[70] Berlioz, *Grand traite d'instrumentation et .d'orchestration modernes,* 338.

ophicleide and the euphonium. This next chart is the total pitch distribution of all the method books for each instrument.

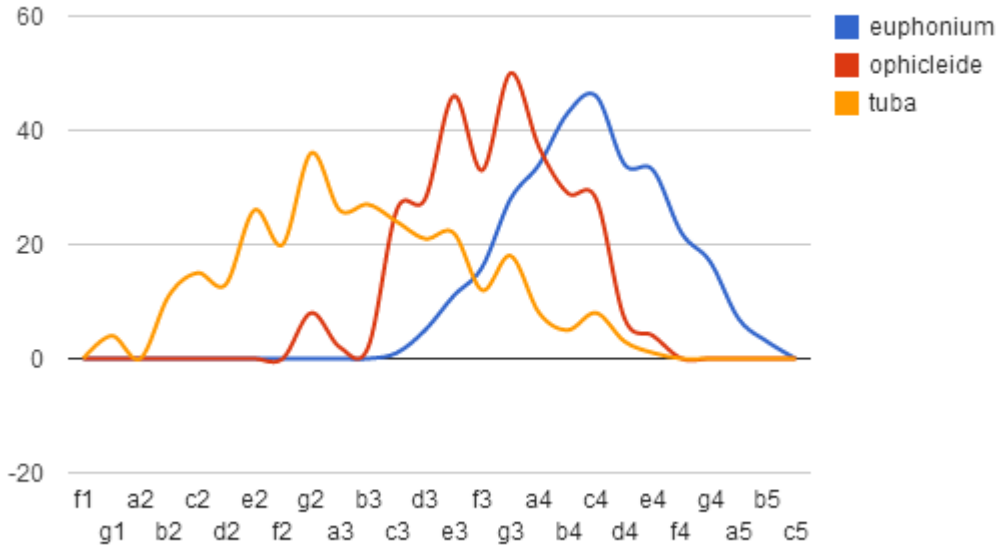


Figure 2. Combined Method Book pitch frequency distribution.

The purpose of these etudes is to teach the musician style and musicality. It is a good comparison, because the music is written with the same pedagogical purpose in mind for all of the instruments. However, these etudes are written for the novice musician.

There are not many solos available for the ophicleide. The Kummer Variations for ophicleide[71] was the most difficult and has the most musical content, so I decided to compare it to other standard tuba and euphonium solos. The two solos that I chose are the Vaughan Williams Concerto for Tuba[72], and the Horovitz Euphonium Concerto[73]. These three solos are common standards that are taught for each instrument, and would be an

[71] G Kummer, *Variations for Ophicleide* (London: Studio Music, 1995).

[72] Ralph Vaugnan Williams, *Concerto for Tuba* (Oxford: Oxford University Press, 1955).

[73] Joseph Horovitz, *Euphonium Concerto* (London: Novello and Co. Ltd., 1991).

accurate representation of the instrument's capabilities.

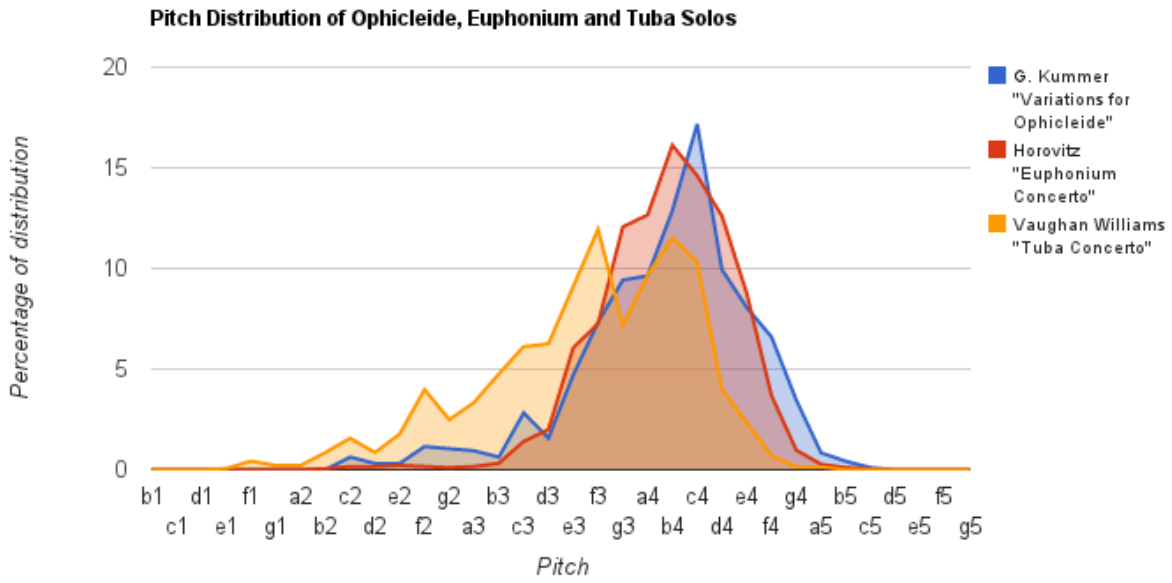


Figure 3. Solo pitch frequency distribution.

It is clear from this chart that all three instruments have reletively the same range. The Tuba only has a couple very low notes. However, the distribution of these notes is telling. The Euphonium Concerto has almost an exact note distribution as the Kummer Variations. Although the instruments have the same range, the music is written differently for the Tuba.

These three ensemble pieces were selected to compare because they all featured their instrument as the lowest voice. It was difficult to find a chamber work that featured the Euphonium as the lowest voice, but the Böhme Sextet is a rare example[74]. Most editions list the lowest voice for tuba, but it was written to be performed on a 4 valve euphonium.[75]

[74] Oskar Bohme, *Sexte.* (New York N.Y.: M. Whitmark & Sons, 1936).

[75] Denis Winter, "The use of the Tenorhorn and Baryton in the Brass Chamber Music of Oskar Bohme and Victor Ewald" (Ann Arbor, Mi: University Microfilms, 1989).

The Bellon *Quintet no. 1*[76] uses the Ophicleide as the bass voice, and the *Ewald Quartet no. 3*[77] uses tuba.

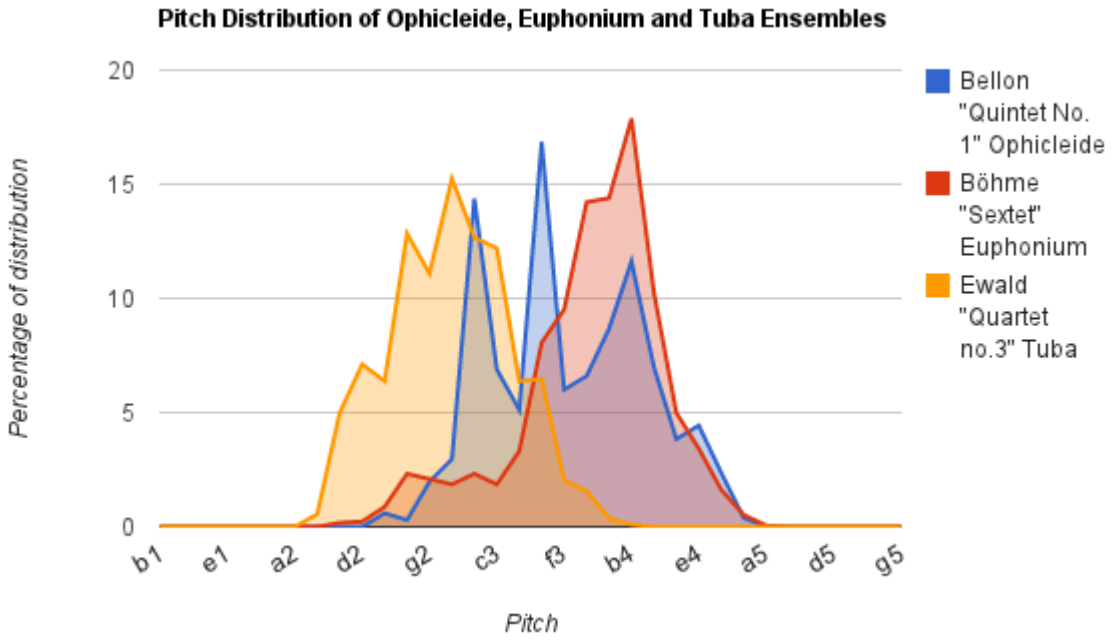


Figure 4. Chamber music pitch frequency distribution.

This chart shows the range and tessitura of each instrument when it is used as the lowest voice in a standard small ensemble. It is clear that the tuba has both a lower range and tessitura when used in this role. Each instrument can play every note in all of these three works, but it is clear that the parts originally written for tuba have a lower tessitura than the parts written for both euphonium and ophicleide. It is interesting that you can see how many more times the ophicleide part stays on dominant or tonic harmony. If this comparison was tried again, it would be possible to treat repeated notes as if they were sustained. This would help the plot show tessitura less influenced by harmonic structure.

[76] Jean Francois Victor Bellon, *Quintet no. 1* (Vuarmarens, Switzerland: Editions Bim, 1850).

[77] Victor Ewald, *Quintet No. 3* (New York N.Y.: G. Schirmer, 1978).

CHAPTER 4

A DISCOGRAPHY OF OPHICLEIDE RECORDINGS, AND SUBJECTIVE ANALYSIS OF ITS TONE

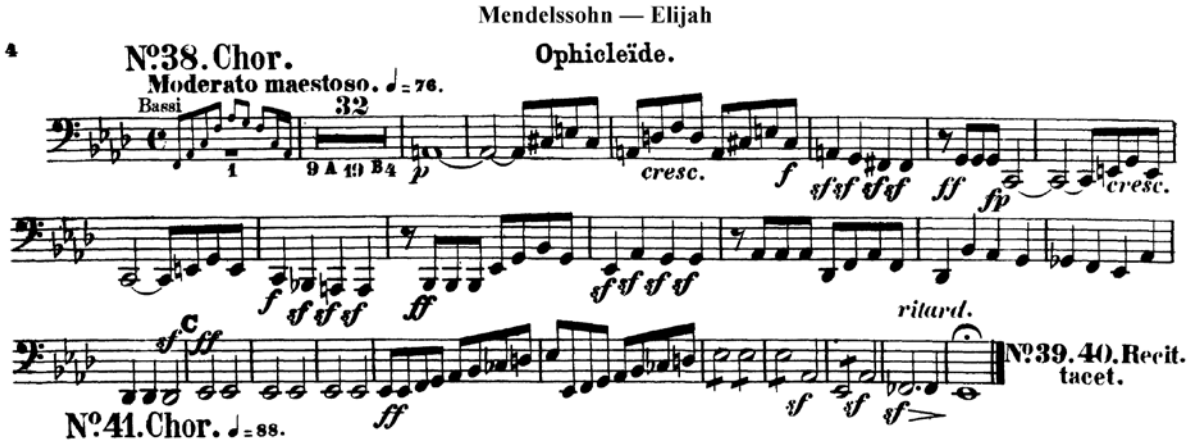
This chapter is a description of recordings that include an ophicleide. This list is not exhaustive, but is able to give the listener an idea of what the instrument sounds like. A comparison of instrumentation are provided between famous works, and the ensemble and year they were recorded. For a short compiled list of recordings that feature the ophicleide please refer to Appendix B.

Hector Berlioz was a leader in early romantic music and had great impact on the symphony. His early *Symphonie Fantastique* no doubt is a prime example of his creativity at work. Certain characteristics of the fourth and fifth movement between the John Eliot Gardiner recordings with Orchestre Révolutionnaire et Romantique, and the Louis Fremaux with the London Symphony Orchestra are compared. Both recordings are exceptionally musical, and well recorded. However, in the "Dies irae" in movement 5 of the Fremaux recording, the bassoons are almost inaudible. The Gardiner recording, on authentic ophicleides and serpents, used instrumentation from the original performance. This gives them a wonderful eerie sound. The London recording, as wonderful as it is, has a completely different, big round sound. The tuba has to play much louder in order to balance with the rest of the brass section, so much so that it either muddies the texture, or overpowers the other reed instruments. The Gardiner recording is in fact so much clearer that it is amazing that the instrument choice changes the texture as much as it does. The higher and brighter overtones of the ophicleide cut straight through the ensemble even at a soft dynamic. This is not to say that the ophicleide sounds raspy in this recording. It sounds

round and in tune, but much leaner than the tuba. Comparing these two wonderful recordings will remove all doubt that instrument choice for the Ophicleide is important.

Mendelssohn's oratorio "Elijah" might be one of the most recorded works originally written for ophicleide. The most likely reason for this might be because the part is relatively simple, and a good musician can practice the instrument enough to play all of the pitches. However, the ophicleide part is difficult to pick out in any of the recordings. Moreover, the part might blend better on the tuba. Section No. 38, "Thus did Elijah the prophet break forth" has the most prominent ophicleide part in the entire work, and truthfully it is just reinforcing the bass.

Example 1. Mendelsson's "Elijah" ophicleide excerpt



The premier of this work featured a contrabass ophicleide. This is one reason that I believe that this particular work would be an exception that works well with a tuba. Paul McCreesh recorded a reconstruction of the first performance on their album. The original premier also included a large number of bass ophicleidists as well as serpents. Personnel on this recording are Nicholas Perry, Phil Humphries and Carl Woodcroft on serpent, Stephen Wick and Andrew Kershawon ophicleide, and Tony George, playing the contrabass "monster" ophicleide that is now the only playable specimen in the world, although it was a

late 20th century reconstruction.[78] This project, recorded under the Winged Lion/Signum Classics label, is wonderful for more than the historical value. This particular section from no. 38 has a grand chorusing effect with the many bass instruments. The other two recordings I listened to were by Paul Daniel, and Philippe Herreweghe, and similarly were wonderful recordings, but the sound was equally balanced as the recording made with Robert Shaw with the Atlanta Symphony Orchestra recording that used tuba.

Nicholas Byrne of the Melbourne Symphony recorded the first solo CD for solo ophicleide in 2007 titled *Back from Oblivion.* It contains two modern works, but it also contains a version of the Giacomo Kummer *Variations for Ophicleide* This solo was performed on Euphoniumist Steven Mead's album "World of the Euphonium Vol.1" This can give a head to head comparison of a virtuoso work performed on the two instruments. The technical facility is equal on both instruments and the tone is comparable. However, the tone quality of the ophicleide is more distinct from the euphonium in the extreme ranges and when playing fast. Slurred passages have a distinct sound on the ophicleide. The key mechanism, as Clifford Bevan was quoted earlier, gives the ophicleide the "alto saxophone [sound] to round off the edges."[79]

It is apparent from listening to these two recordings that the two instruments are related in range, sound, and tessitura. The piece works the extremes of the ranges of both instruments to equal effect, and would be quite unpractical to be performed on F tuba.

[78] Bevan, *The Tuba Family,* 170.

[79] Ibid., 224.

CHAPTER 5

OBSERVATIONS AND ANALYSIS OF THE SOUND SPECTRUM AS AN OBJECTIVE COMPARISON OF TIMBRE BETWEEN THE OPHICLEIDE AND OTHER MODERN INSTRUMENTS OF A SIMILAR RANGE

It is difficult to differentiate between sounds of instruments in an objective manner. The instruments and players themselves contribute a great deal to the variances of tone quality. This chapter focuses on measuring the objective differences in the sound of various low brass instruments to prove that the ophicleide's sound is closest to the euphonium. The sound of an instrument is constructed of only four elements; timber, attack characteristic, release characteristic, and vibrato. Vibrato is an element that is added by the performer and on wind instruments is not inherent in the construction of the instrument itself. Therefore vibrato is left out of this discussion because it is entirely dependent on the performer.

The timbre of an instrument is a function of the sympathetic overtones that the instrument produces. A Fourier transform is employed to break down the complex waveform of the instrument, and show all of the frequencies that combine to create the sound. The frequencies that create the tone of the instrument can be either harmonic overtones or non-harmonic overtones.[80] Harmonic overtones are frequencies that are multiples of the initial pitch [fundamental frequency]. The amplitude of these harmonic overtones to the frequency spectrum play the largest role in determining an instrument's timbre. Non-harmonic overtones (or sometimes undertones) are other frequencies that the

[80] Giulio Agostini, Maurizio Longari, and Emanuele Pollastri, "Musical Instrument Timbres Classification with Spectral Features" *Journal on Applied Signal Processing* (2003): 5 – 14.

instrument produces that may also help to identify the instrument, but are not mathematically a multiple of the fundamental's frequency. Variables of the instrument design can cause this overtone series to drift in an effect called inharmonicity.[81] This effect is an accurate way of identifying an instrument; however, it seems to be a side effect of the instrument's sound and not the major identifying factor to the human ear. Inharmonicity can also produce resulting sympathetic frequencies that are present in the sound of an instrument. Another example of non-harmonic overtones is the sounds that brass players make while tonguing the beginning of a note, as we see later. This graph is a plot of the waveform of an early French unmarked 9 hole Ophicleide playing Bb2. All recordings were made on Adobe Audition CS5 with a Digidesign 003 A/D converter and Rode NT-5 microphone from 4 feet

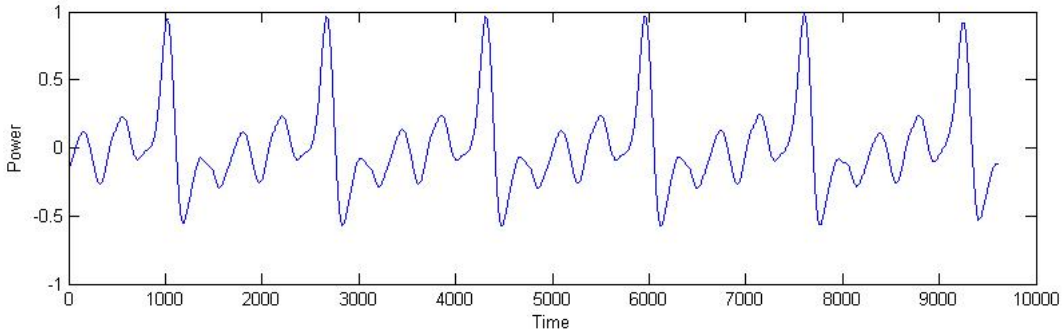


Figure 5. Ophicleide waveform

A Fourier transform of the waveform is a way to measure the amplitude of all frequencies in the waveform. Each spike shows how much energy that frequency is contributing to the composite signal. The large spikes that are evenly distributed are harmonic overtones. The smaller spikes between them are resulting tones.

[81] Ibid.

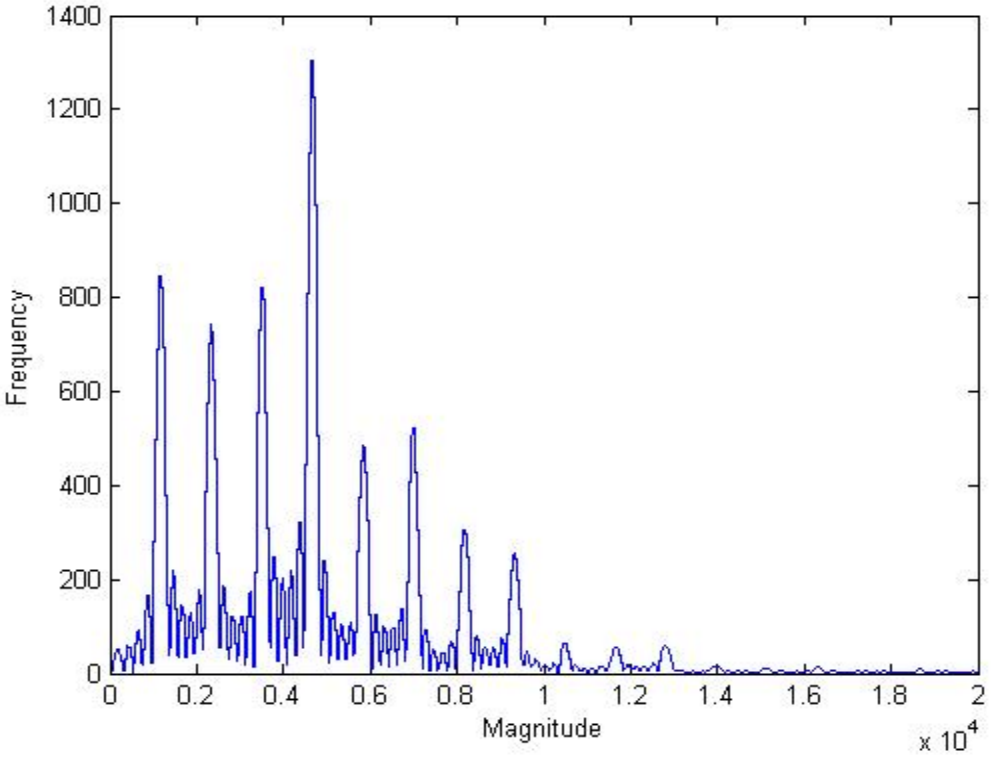


Figure 6. Fourier transform of ophicleide

This next three dimensional graph, of the same source signal, is called a spectrograph. It has the frequency domain in the X axis, the time in the y axis, and the amplitude of the value of the Fourier transform displayed in the Z axis by changing the color in that location. This will allow us to observe changes to the sound spectrum of an entire sound sample over time. This ability to see the changes to the sound spectrum will allow us the ability to compare the attack and release characteristics of the instruments, as well as observe the consistency of the sound. This is the full recording of the early unmarked French ophicleide playing Bb2- F2- Bb3 - F2 - Bb2. The above waveforms were taken from the first note on the left.

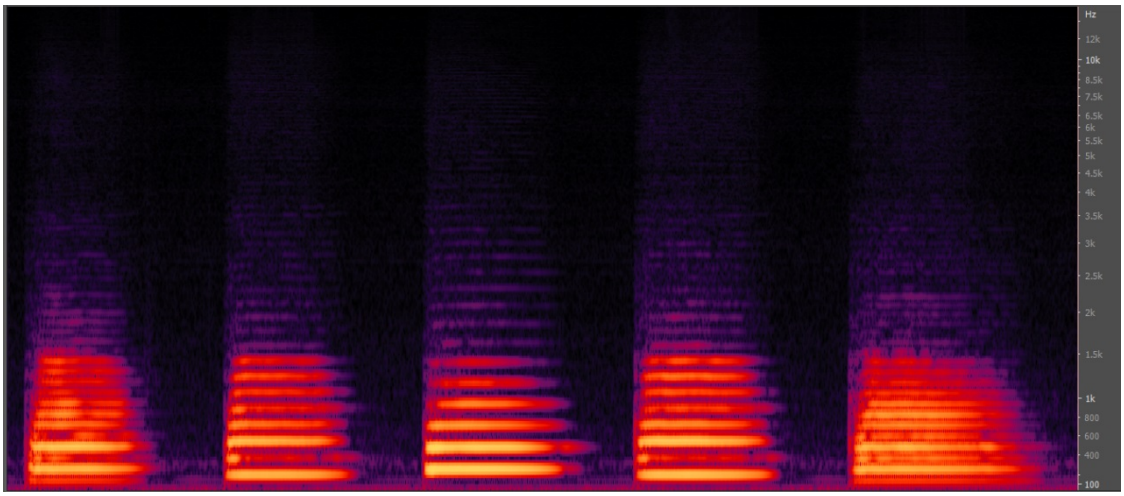


Figure 7. Ophicleide spectrograph

The next two spectrographs were recorded at the same time, in the same way, and on the same equipment. This allows us to visually compare the ophicleide with the other two instruments. There are several observations that we can make about the sound of each instrument. Although the frequency doubles across an octave, you will notice that the amplitude of the harmonic overtones maintain their intensity in relation to the absolute frequency and not in relation to the pitch being performed. The first and third notes are both Bb, but they are in octaves. You can see that the middle image of the 5 has the least amount of overtones, but the overtones that it does have are roughly the same amplitude as the first and last note. This is an essential trait in identifying the sound of an instrument. What is clearly noticeable in the banding is that the color changes from red to purple around 1,500 Hz. This particular spectrograph has background noise as black (or amplitude below 1), and each color is an increase of power by a factor of 10.

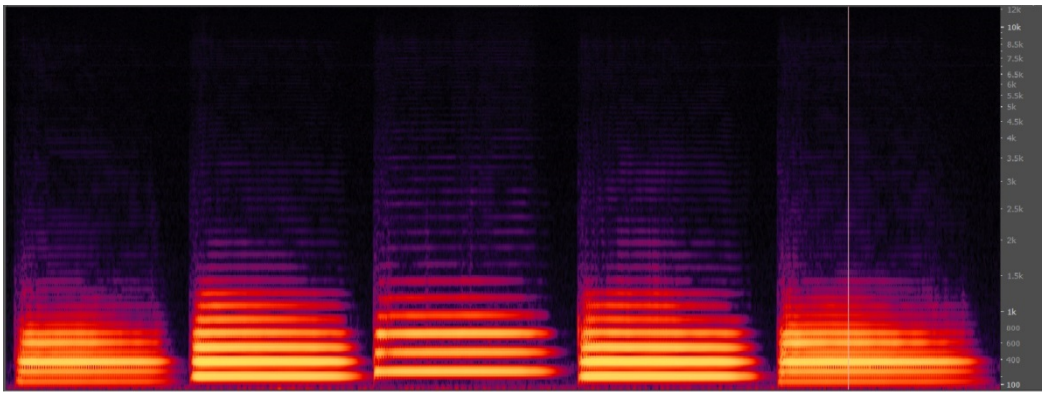


Figure 8. Euphonium spectrograph

The spectrograph of the euphonium shows the banding changes from red to purple in roughly the same place: 1,500 Hz. On the third spectrograph this frequency cutoff can be compared to that of the F tuba. The tuba has strong banding in the low range, but has a frequency roll of at 800 Hz.

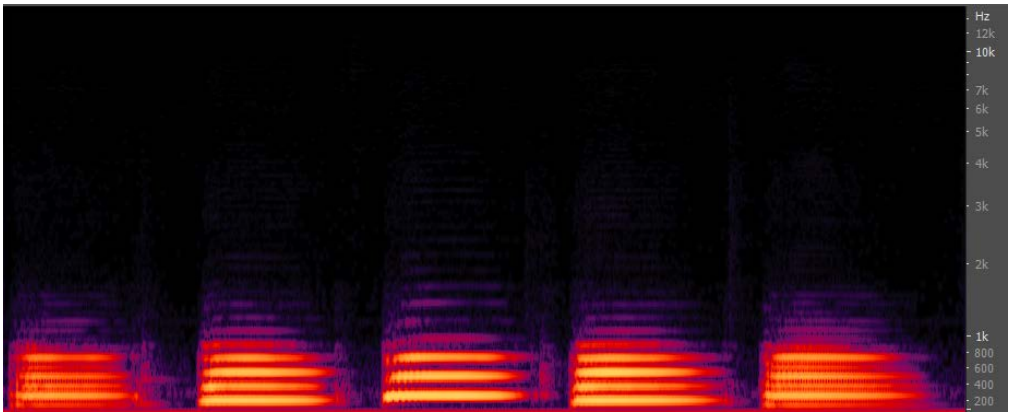


Figure 9. Bass tuba spectrograph

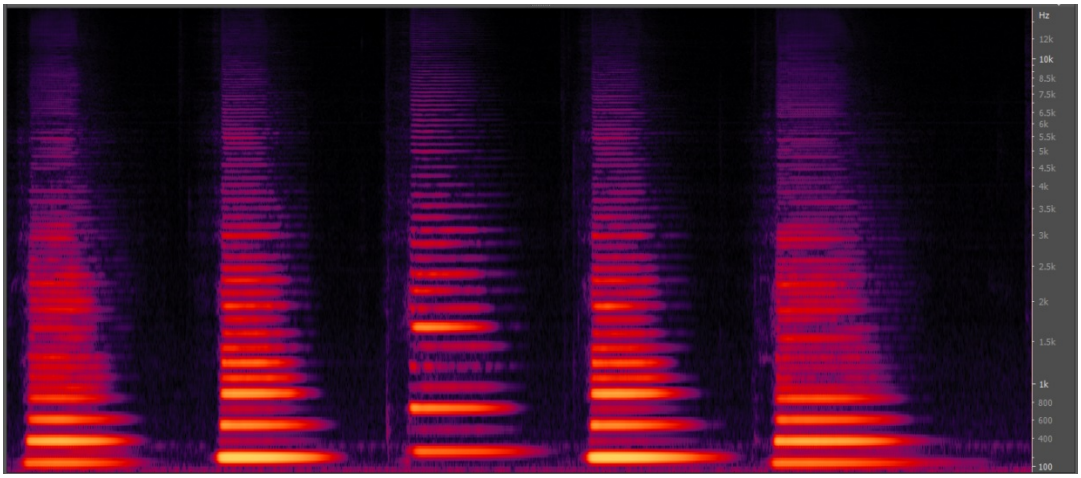


Figure 10. Bass clarinet spectrograph

A bass clarinet spectrograph of the same three pitches is included in order to compare these three brass examples to a woodwind example. The bass clarinet tessitura and range overlaps these three instruments as well the tuba and euphonium. In the spectrograph the amplitudes of specific bands are different and the overtones of the bass clarinet reach above 10,000 Hz. The tuba euphonium and ophicleide do sound and look similar in a spectrograph. However the euphonium is much closer to the ophicleide's characteristics.

There is one more trait the bass clarinet has in common with the ophicleide. The bass clarinet has a slight slope on the attack side of the note, and a large slope on the release. This is not just showing a diminuendo at the end of the notes, it shows that the lower overtones speak earlier and last longer than the upper overtones. This characteristic can be seen in the ophicleide spectrograph, but it is not as prominent in the tuba and euphonium spectrograph.

These observations are helpful in determining which instrument's tone more closely resembles the ophicleide, but there are more objective ways of finding the amount of correlation.

The details of this experiment can be found in Appendix C. In summary, the spectral centroid mean deviation ranked all 12 recordings of instrument and mute combinations in the order that most closely resembles the sound of the Ophicleide. The details of this experiment can be found in appendix C. The Spectral Centroid Mean does a Fast Fourier Transform over the recording, and finds the barycenter, or center of mass of the energy in the spectrum, and averages the results over time. This number gives the perception of how bright or dark a sound is to the human ear.[82] The presiding issue of outside noise and how it interfered with the equations was also a factor. This experiment compared all of the sounds including harmonic and non-harmonic overtones. The results of this test are as follows:

Table 2. Spectral Centroid Data

Instrument/ or Euphonium mute	Centroid Variance to Ophicleide	Standard Deviation of Centroid	Spectral Centroid
Ophicleide	0	0.1527	6.5927
Euphonium – Wilson 2900	0.065176	0.411507	6.527555
Balu Euphonium mute	0.34082	0.286717	6.933551
Bucket Mute Stone Lined	0.343112	0.50974	6.249619
Stone Lined Cup Mute	0.368557	0.250828	6.961288
Bucket Mute Stone Lined, closer to bell	0.42984	0.618564	6.16289
Yamaha Contrabass Tuba BBb	0.467473	0.572925	7.060204
Besson F Compensating Tuba	1.297877	0.307216	5.294854
Trombone- Getzen 3047	2.388081	0.436035	8.980811
Schlipf SIR Combo Mute	2.589774	0.20999	9.182505
Baritone - Pan American	2.882465	0.759144	9.475195

[82] J. M Grey, J. W Gordon, "Perceptual effects of spectral modifications on musical timbres." *Journal of the Acoustical Society of America* 63, no. 5 (1978): 1495.

Denis Wick Strait Mute	4.955496	0.610565	11.54823
Bass Clarinet- Buffet Prestige	8.66383	1.755967	15.25656

The above chart shows the order of the smallest centroid variance to the ophicleide to the largest, and the standard deviation of all the results. The spectral centroid takes all of the energy in play and determines the position of the center of that energy to include non-harmonic tones and resulting tones. As a result of these measurements, the euphonium again is closest in results to the ophicleide. In using various mutes with the euphonium the bucket and Balu mutes are the closest to the ophicleide measurements.

CHAPTER 6

A CASE STUDY OF 3 MAJOR ORCHESTRAL OPHICLEIDE EXCERPTS FROM WORKS OF 3 MAJOR COMPOSERS

Mendelssohn's “A Midsummernight's Dream” was composed in two parts. He first composed the overture op. 21, in 1826 while he was still 17 years old. He then had originally scored it for “corno inglese di basso” or english bass horn[83]. It was an upright all metal serpent. Mendelssohn had first seen the instrument in the windband of the court at “Bad Doberan” Germany in 1824.[84] He had stated that he was looking for a low instrument that was rustic sounding that would contrast to his fairy music. Later, when the music was published in 1832, Mendelssohn had the “corno inglese di basso” part changed to Ophicleide. This leads to much speculation as to which instrument should be considered the period performance.[85] There was 8 years where Mendelssohn took his overture on tour across Europe, and he found it exceedingly difficult to find players of the corno inglese di basso who were able to perform the music without disrupting the performance. The ophicleide was not available to Mendelsohn in 1826, and the keys variety was never very popular in Germany. However, Mendelsohn was traveled a lot, and had many musical acquaintances.[86] His geography did not limit him to what his instrumentation could have been and he did include it in the printed score.

The second version of Mendelssohn's “A Midsummernight's Dream” was commissioned by the Prussian King Friedrich Wilhelm IV as the incidental music to the

[83] Clifford Bevan, "What do you play in A Midsummer Night’s Dream Overture" *T.U.B.A. Journal* (26) 2, (Winter 1999): 61.

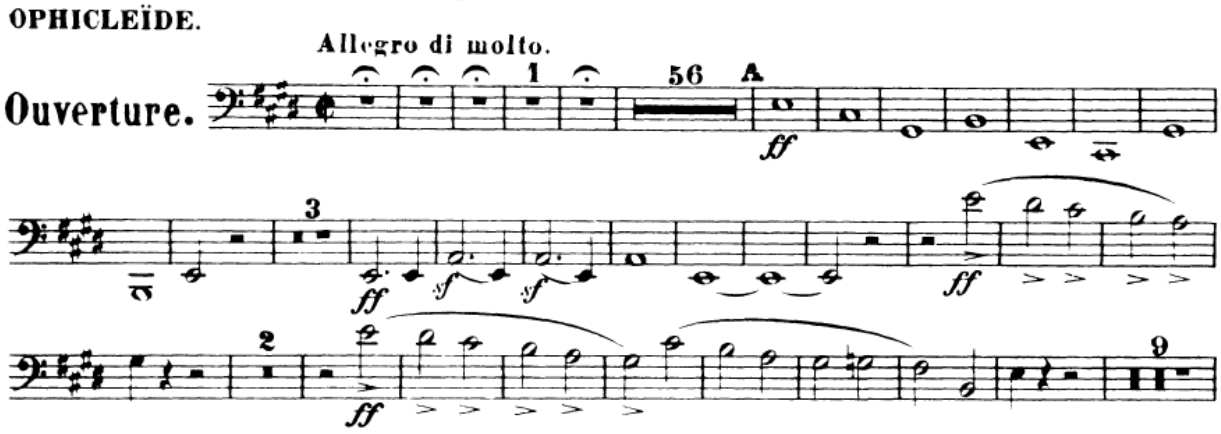
[84] Ibid.

[85] Ibid., 62

[86] Ibid.

Shakespearean play. His op. 61 was first performed in 1843 in Potsdam, where bands of the area firmly accepted the bass tuba as the lowest wind voice. However, Mendelssohn still kept the overture the same as his op. 21, including the designation of ophicleide. This part of Germany was the birthplace of the Berliner-pumpen valve. There were many examples of valve ophicleides from this area in the 1830s, and little evidence of the keyed ophicleide's presence. It is safe to assume that Mendelssohn scored for and used a valve ophicleide for his German performances.

Example 2. Mendelssohn's "A Midsummer Night's Dream" Ophicleide Excerpt



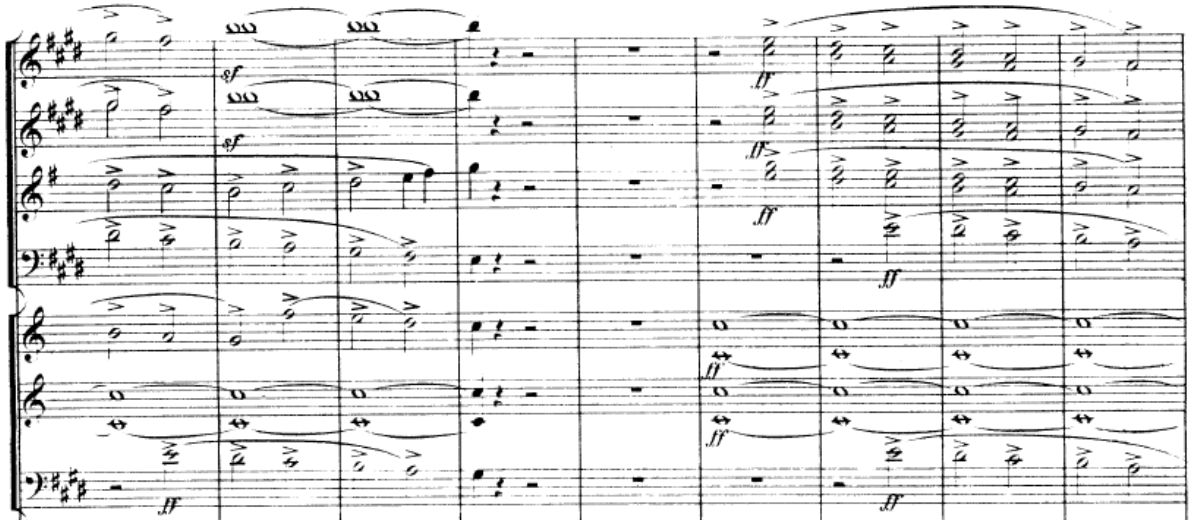
The incidental music was also performed in England that same year by the London Philharmonic Society, but used a keyed ophicleide. This same year, Berlioz visited Mendelsohn in Leipzig and, as mentioned in Chapter 2, wrote "the ophicleide or rather the thin copper instrument shown to me with that name" is further evidence that the instrument used was a valve ophicleide."[87]

Modern performances use an F tuba to play the Ophicleide part. However, you can see in the score that the ophicleide is scored as a 3rd bassoon even though it grouped under the trombones. Tubas would not blend well in a trio with two other bassoons. The

[87] Berlioz*, The Memoirs of Hector Berlioz*, 296.

euphonium, perhaps a Bucket mute, will have the best timber to blend with the other instruments. This will help the musician keep the balance and prevent this voice from overpowering the rest of the ensemble.

Example 3. Mendelssohn's "A Midsummer Night's Dream" Score



The original 1826 draft has the corno inglese di basso written between the bassoons and the horns. However, the print editions have the ophicleide beneath the trombones. This shows the two functions of the ophicleide in this movement. It is both the foundational harmony in the chorale in measure 62, and it has the descending diatonic motif in measure 81 and later. The ophicleide has great character in both of these ranges. It projects with clear overtones in the chorale to tie the trombones together with the woodwinds, and it is a clear solo line in the descending diatonic motif. It is interesting that the horns play along with the bassoons in the first iteration of these descending lines. Mendelssohn uses this as an orchestration technique to introduce the combined brass and woodwind sound of the two sections before introducing the ophicleide. In Germany, this instrument was not widely used in orchestral music, so Mendelssohn does a good job in carefully introducing its sound

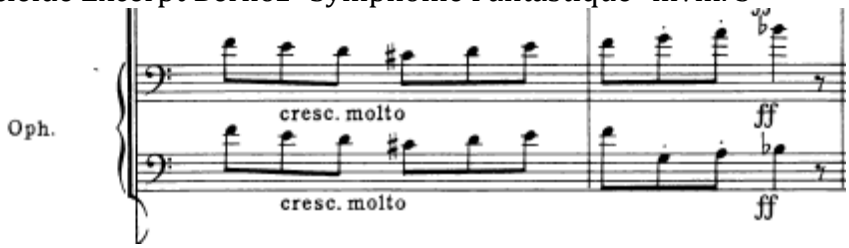
before giving it an exposed part. It is clearly evident that Mendelssohn's scoring had the ophicleide part be considered a 3rd Bassoon instead of a 3rd trombone

Berlioz has more popular works that were scored for the ophicleide than any other composer during that period. He also knew the ophicleide's strengths and limitations. The reason Berlioz decided to score the *Symphonie Fantastique* for two ophicleides was not harmonic in nature. It also was not solely to strengthen the bass of this large ensemble. It was because of an inherent design flaw of the early ophicleides. Notes that did not need any keys depressed projected well and had an easily adjustable pitch center. On many early instruments there were several notes that needed many key depressed. These notes had a bad sound. The note that was usually the hardest to play in tune with a good sound was the note an octave and a fourth above the fundamental. This is an enormous problem because when playing in the key of Bb, a Bb ophicleide's worst note is Eb; the subdominant. Berlioz must have encountered this problem many times because his solution was quite ingenious. He decided to write for both a Bb and a C ophicleide with overlapping parts. This would make sure that any troublesome notes on the one instrument is played well on the other. This solution was quite common until later ophicleide models were quickly designed to compensate for this design flaw.

This leads to an interesting question: should the *Symphonie Fantastique* be performed with two ophicleide parts or one modern instrument? Many editors have already changed much of Berlioz's original scoring, as well as re writing some original bass trombone for tunas. A modern bass tuba or euphonium would be able to cut through the entire orchestra, so two would not be needed. Also, there are only two times that the two ophicleide split into separate parts in the final movement. One location the second

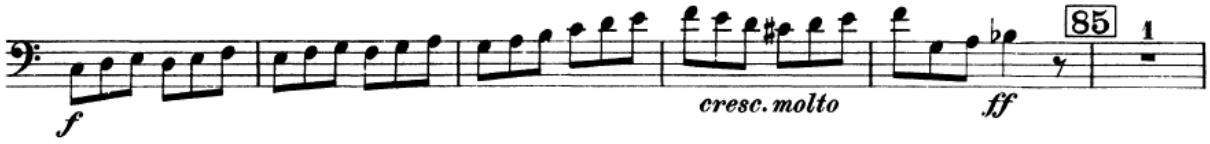
ophicleide has a pedal point benieth a technical first ophicleide passage, but the only other locations, the two ophicleides are displaced at the octave.

Example 4. Ophicleide Excerpt Berlioz "Symphonie Fantastique" mvm. 5



In this section the original ophicleide part reaches a high Bb above the staff. Most editions have removed the top line from the score and have both tubas play the Bb ophicleide part. This octave displacement tells us more about the tessitura that the ophicleide is expected to perform, and the quality of the tone in different ranges. This following line is taken from the Ophicleide I where The upper octave cannot be found.[88]

Example 5. Revision Tuba 1 excerpt, Berlioz "Symphonie Fantastique" mvm. 5 1910

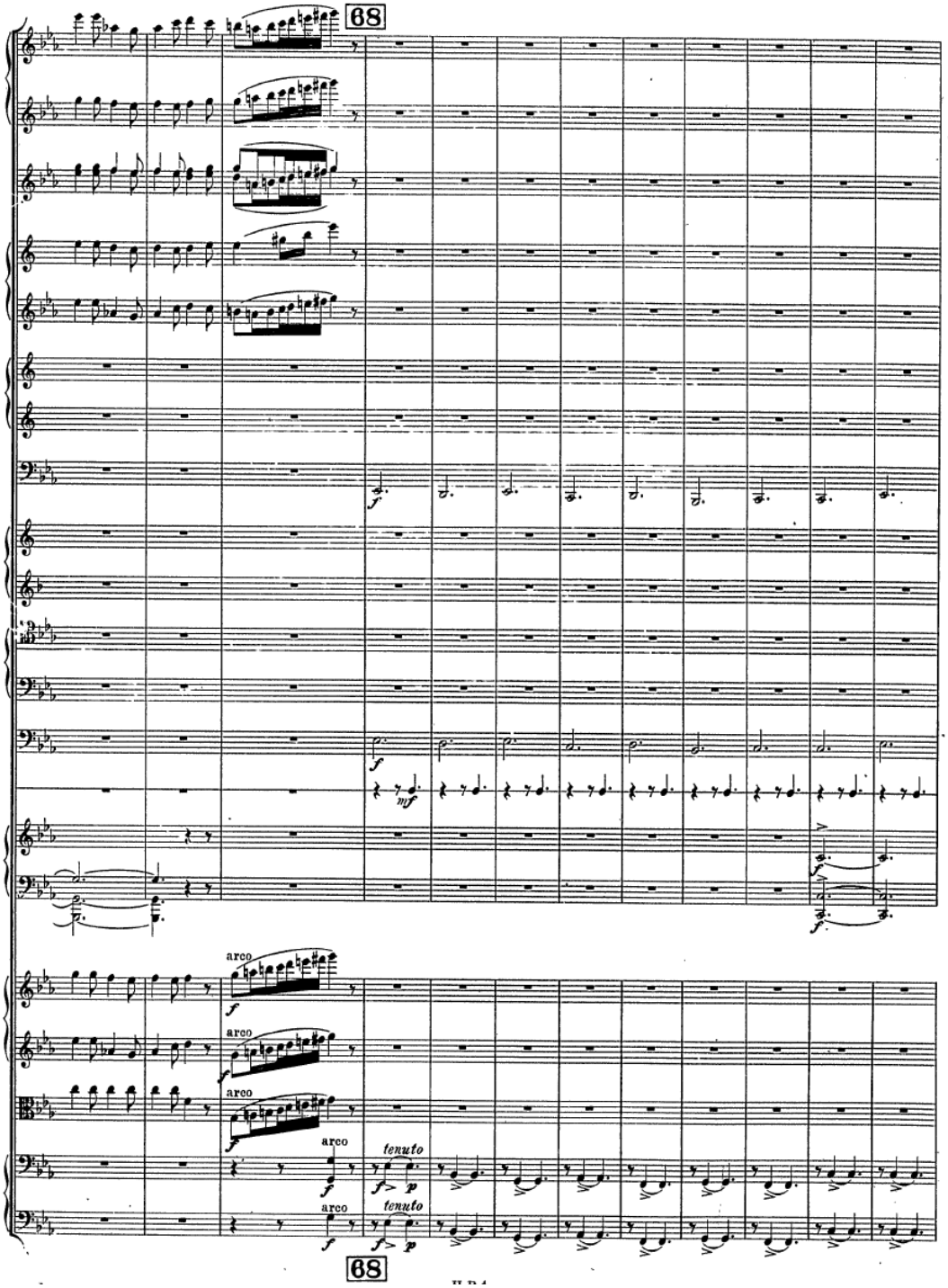


All of the low notes on the ophicleide are easily reachable on the euphonium and the high range is very comfortable. Two euphoniums would help to project the sound and balance out the large orchestra.

There is a different reason that Berlioz used the ophicleide in this work. The instrument choice was not made just to be in the style of grotesque romanticism, or to create an eerie sound. The ophicleide was very common in France at that time in church choirs. It was so common that Berlioz used the instrument to create a type of aural illusion. Without having a choir, he gave the audience the impression of male voices singing.

[88] Hector Berlioz, *Syphonie Fantastique* (Leipzig: Breitkopf & Härtel, 1910)

Example 6. Full Score Excerpt from Berlioz "Symphonie Fantastique" Dies irae



The aural correlation to the ophicleide and liturgical singing was so close that it was more than a programmatic special effect; audience members thought that there was a hidden

choir. The witchcraft topic of the fifth movement set the expectation for the audience to hear an evil choir of singers arise from the instruments even though none was there. This is the true reason the ophicleide was scored this way. Unfortunately no modern audience would hear this effect because it is based on auditory memory of liturgical music that no longer uses these traditions. So what instrument should be used? The tuba by itself is so dark, warm, and big, that the piece changes its character. The euphonium would not cover up the bassoons, and can have a thin eerie effect. Furthermore a specialized mute, such as a bucket mute can change the quality of the tone enough that it will sound unfamiliar and perhaps even grotesque to the audience.

Rienzi is often a difficult work to truly understand. It calls for both a serpent and ophicleide to play in the orchestra. This may seem strange for a German ensemble, but this was standard practice in Paris. In 1839, while still trying to complete his opera, Wagner took a vacation in Bologna had a chance meeting with Meyerbeer. Some say this is when he began to write in the French style, however, his previous overture to "Rule Britannia," written in 1837 had the same configuration[89]. Wagner was encouraged by this meeting with Meyerbeer, and continued to write his opera for the chance to have it performed in Paris. He probably should not have gone on that trip, because he was thrown into debtor's prison shortly thereafter. Wagner moved to France for 2 years to try to establish himself in that music community, but failed. He was not famous enough to be established upon his arrival, and opportunities did not present themselves to allow himself to show Paris the caliber of composer that he was to become. Meyerbeer convinced him to move back to Germany, and helped Wagner get his opera performed in Dresden later in 1842. This opera

[89] Bevan, *The Tuba Family,* 303

was a tremendous success, and made him famous.[90] If he had that fame before moving to Paris, he would have been accepted. Although this opera was his first major success, he would later distance himself from it, as well as all music with a French tradition.

This background is important because it will help to answer some question of instrument choice. Wagner was very specific about the instruments for which he scored. He was one of the first orchestral composers to write for the contrabass tuba. He also even helped to develop the "Wagner tuba" to better allow the tone of the tuba to blend with the horns. Wagner chose to write for the ophicleide and serpent because this was a French opera and he wanted it to be performed in Paris. In Paris, they would have used a keyed ophicleide but at its premiere in Dresden, they had neither a keyed ophicleide nor a bass tuba. The older Wagner would not be a reliable source for performance practice of this French inspired work, but there is little information left from this part of Wagner's life. When Wagner modeled himself and his music around the ideal German, he lost much of the material and opinions he had of his earlier compositions. It is difficult to determine which modern instruments the younger Wagner would have preferred, because the manuscript score and original parts were lost in events 100 years later.

Adolf Hitler watched a performance of *Rienzi* in 1907, and some say this story of a charismatic populist common man Rienzi set him on his future political road. During WWII, the original orchestral parts were lost in the firebombing of Dresden, and the original manuscript was taken to Hitler's bunker during the final days of the war, never to be seen again. This destruction of the early materials leaves us only with the printed parts to research.

[90] Ibid.

When we look at the score, it is clear that the serpent has the lowest part whenever there is octave doubling. The serpent itself is not that much lower in range than the ophicleide, so it is interesting that the ophicleide has the higher role. This leads me to believe that the ophicleide part is a member of the trombone consort, and not the foundation to it. In ”Rule Britannia,”[91] Wagner specifically states that the serpent should be the lowest woodwind, and the ophicleide is the lowest brass voice.

In this figure the ophicleide is in unison with the lowest trombone, not below it. The ophicleide fits into the sound. The bass tuba has such a broader and bigger sound that it overwhelms the timbre of the trombones instead of coloring it. If the euphonium is used, it blends with the trombones instead of powering underneath the trombones.

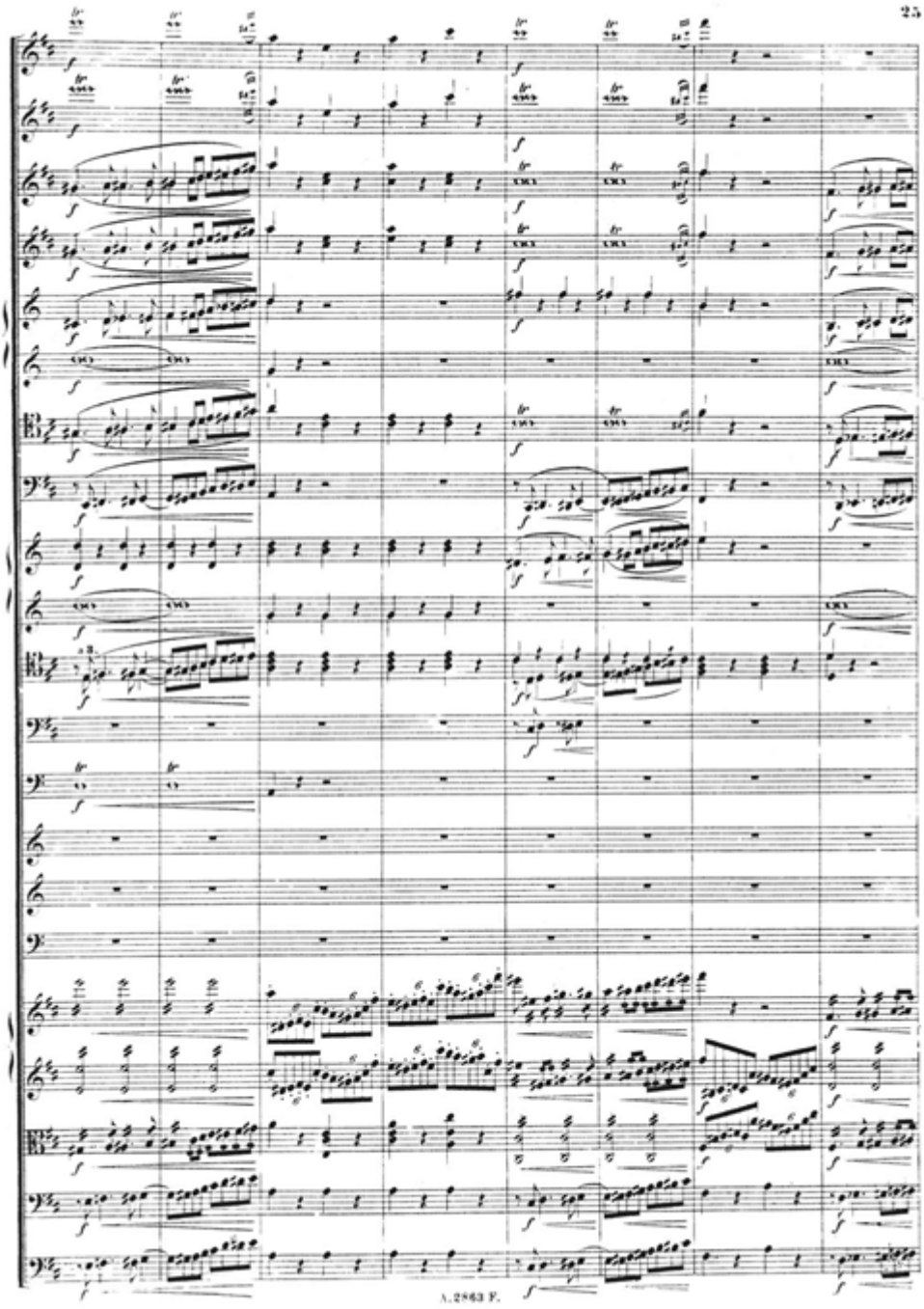
The same can be said in the broad chorale. The bass tuba has a wonderful broad character, but it smoothes out the chorale. The ophicleide has a completely different character. It is a low rattle with a raspy sound, much like 8’ reed pipes in a pipe organ. It allows the bright, higher instruments to shine through without having to compete for the audience's attention. A euphonium in this low range has much the same effect. It can put out the same amount of sound, but it is more centered, brighter, and more edgy than that of the bass tuba.

The serpent sound in itself is peculiar, and is hard to replicate. Although it is outside the realm of this paper, either a tuba or euphonium should most likely be muted to have the same effect as the serpent. Another option for this work might be a contrabassoon. Although the Mendelsohn above uses the ophicleide as a 3rd bassoon, the difference is the scoring for the Mendelsohn uses the ophicleide in both roles, and Rienzi uses the ophicleide

[91] Bevan, *The Tuba Family,* 303

as a soft bass of the brass. The modern contrabassoon might have a blend that would be successful for the bass reinforcement of the woodwinds.

Example 7. Full Score Excerpt from Wagner's Overture to "Rienzi"



CHAPTER 7

CONCLUSIONS

The ophicleide is a beautiful instrument that enjoyed a long history in many areas of music in the 19th century. Many compositions from this time period have a different character and balance when performed with modern instrumentation. Since the 19th century, an increase in size of instruments has increased projection and improved pitch, but the bass tuba that is normally chosen to supplant the ophicleide no longer has many positive qualities of the older instrument. The euphonium is a better choice to replace the ophicleide because it sounds closer to the ophicleide than does a tuba. The euphonium's range and tessitura match the strengths of the ophicleide and will aid in performing technical passages in the range that both instruments' excel. The historical record shows that the euphonium was originally a common choice as a substitute for ophicleide in the bands. The automatic compensating euphonium was designed to have the same range as the ophicleide, and also have superior pitch, range, and a more accurate valve mechanism than the earlier euphoniums, and euphonium like instruments.

Cliff Bevin, the most celebrated historian of low brass instruments writes "Generally speaking the euphonium is probably as close as it is possible to approach to the narrow-tuba/ophicleide Berlioz knew without using the ophicleide itself, a procedure which may not always be appropriate to modern performances.[92]" A bass tuba can be used to play ophicleide parts, but it does not have the same effect. Conductors will have to weigh many variables when selecting instrumentation for early 19th century performances: personnel, availability of instruments, as well as composer's intent and personal aesthetic taste. Many

[92] Bevan, *The Tuba Family,* 341

conductors do not even know that there are different historically informed options to replace this bass instrument. There are a large group of period performers of keyed brass instruments both in the United States and abroad. Now performances of a high caliber involving real ophicleides are possible. Conversely, there is a historical and musical precedent for allowing the euphonium to cover music originally written for ophicleide and early tubas. There are several options for replacing the ophicleide but the best modern equivalent is the euphonium.

APPENDIX A

INSTRUMENT MEASUREMENTS

If not listed, data was taken from instrument manufacturer's website

Name	Bell	First Valve Bore mm	Fourth Valve Bore mm	Mouthpiece Receiver	Year
Modern	Euphoniums				
Boosey Imperial	279mm	14.73mm	14.73mm	Medium shank 11.65	Present
Besson Sovereign 968	282mm	15mm	16mm	Medium shank 0.459	Present
Besson Prestige 2052	304mm	15mm	16mm	Large shank 12.45mm	Present
York Eminence 4052	305	14.75mm	14.75mm	Large shank 12.45mm	Present
Sterling Virtuoso	300mm	15mm	17mm	Large shank 12.45mm	Present
Courtois 167 II	310mm	15mm	16mm	Large shank 12.45mm	Present
Yamaha Maestro 642	300mm	15	16.8mm	Large shank 12.45mm	Present
Yamaha Custom 842	300mm	15	16.8mm	Large shank 12.45mm	Present
Mienl Weston 451	300mm	14.99mm	16.98mm	Large shank 12.45mm	Present
Mienl Weston 551	300mm	14.99mm	16.98mm	Large shank 12.45mm	Present
Wilson 2900	292mm	15mm	17mm	Medium/ large	Present
Wilson 2950	310mm	15mm	17mm	Large shank 12.45mm	Present
Hirsbruner HBS 378	305mm	15	16 mm	Medium/Large	Present
Hirsbruner HBS 479	305 mm	15	17 mm	Medium/Large	Present
Miraphone M5000	310mm	15.50mm	16.20mm	Medium/Large	Present
Miraphone M5050	310 mm	15.50 mm	16,20 mm	Large shank 12.45mm	Present
Saxhorns					
Wessex Bb compensated	280mm	15.1 mm	15.1 mm	Medium shank 11.65	Present

French C tubas[93]					
Couesnon Conservatoire	280mm	15.5mm	16.75mm	Extra large 13.5mm	1985
Mahillion	289mm	15.25mm	15.92mm	Extra large 13.5mm	1955
Association Generale	266.5m	14.478mm	15.5mm	Extra large 13.5mm	C. 1865
Early tubas[94]					
Schmidt f tuba	228mm	15mm	15mm	*****	c.1845
Moritz f tuba	203mm	***	****	15.3mm	C. 1849
Ophicleides[95]					
H. Sax	213mm	Crook: 35.5		12.5mm	c. 1830
Henri et Martin	236mm	Crook: 34mm		12mm	c. 1850
Modern Tubas					
Miraphone "Petruschka"	420 mm	19.6 - mm	20,4 mm	European Large Tuba Shank	Present
Miraphone 'Firebird' (F-281C)	400 mm	19.,6 - mm	21.2 mm	European Large Tuba Shank	Present
Miraphone "Belcanto" (F-381C)	420 mm	19.6 - mm	21.2 mm	European Large Tuba Shank	Present
B&S Perantucci PT-15	419 mm	19 mm	21 mm	European Large Tuba Shank	Present
Yamaha 822	444.5 mm	19.5 mm	19.5 mm	European Large Tuba Shank	Present

[93] Dr. Brendan Ward, *V & E Simonetti Historic Tuba Collection.* n.d. http://simonettitubacollection.com/ (accessed may 30, 2014).

[94] Ibid.

[95] Bevan, *The Tuba Family,* 143.

APPENDIX B

LIST OF COMPILED OPHICLEIDE LITERATURE

A. – Orchestral

1. Adam, Adolphe

    a. Messe Solenelle

2. Auber, Daniel

    a. La Muette de Portici

    b. Gustave ou Le Bal masqué

3. Berlioz, Hector

    a. Messe Solenelle

    b. Huit Scenes de Faust

    c. Resurrexit

    d. Les Francs-juges

    e. Scene Héroïque

    f. Waverley

    g. Hymne des Marseillais

    h. Symphonie Fantastique

    i. Le Roi Lear

    j. Harold en Italie

    k. Grande Messe des Morts

    l. Benvenuto Cellini

    m. Romeo et Juliette

    n. Grand Symphonie Funèbre et Triomphale

    o. Tristia

    p. Le Corsaire

q. La Damnation de Faust

r. L' Imperiale (Cantate)

s. Les Troyens

4. Bennet, William Sterndale

a. The May Queen

5. Bizet, Georges

a. Ouverture Patrie

6. Catalani, Alfredo

a. Dejanice

7. Cherubini, Luigi

a. Messe Solennelle,

b. Ali Baba

8. Costa, Michael

a. The Dream: a Serenata

9. Dargomyzhsky, Alexander

a. Rusalka

10. Delibes, Leo

a. Coppélia

11. Donizetti, Gaetano

a. Lucia de Lammermoor

b. Belisar

c. La Favorite

d. Maria Padilla

e. Dom Sébastien

f. Poliuto (Les Martyrs)

12. Glinka, Michail Iwanow

a. Iwan Sussanin

b. Jota Aragonesa

13. Gounod, Charles

a. Gallia

14. Halévy, Jacques François-Fromental-Elie

a. La Juive

15. Heinrich, Anton Philip

a. The Wildwood Spirit's Chant

b. Manitou Mysteries, or The Voice of the Great Spirit

16. Herold, Ferdinand

a. Zampa

17. Henze, Hans Werner

a. Das Floß der Medusa

b. La Cubana oder Ein Leben für die Kunst

18. Lalo, Edouard

a. Rapsodie

19. Lortzing, Albert

a. Die Schatzkammer des Ynka (LoWV 36)

20. Mendelssohn-Bartholdy, Felix

a. Festgesang zur Gutenbergfest WoO9

b. Schauspielmusik zu "Ein Sommernachtstraum" op.61

c. Athalia op.74

d. Festgesang an die Künstler op.68

e. Elias op.70

21. Mercadante, Saverio

a. Orazi e Curiazi

22. Meyerbeer, Giacomo

a. Robert le Diable

b. Les Huguenots

c. Le Prophète

d. L'Africaine

23. Offenbach, Jacques

a. Die Rhein-Nixen

24. Poncielli, Amilcare

a. La Gioconda

25. Puccini, Giacomo

a. Missa da Gloria

b. Preludio a orchestra in Mi minore-maggiore SC1

c. Motetto per San Paolino SC2

d. Preludio sinfonico in La maggiore per orchestra SC32

e. Capriccio sinfonico in Fa maggiore per orchestra SC55

26. Reißiger, Carl Gottlieb

a. David

27. Ries, Ferdinand

    a. Die Könige in Israel

28. Rossini, Gioacchino

    a. La siège de Corinth

    b. Moïse et Pharaon

    c. Hymne à Napoléon III

    d. Petite Messe Solennelle

29. Saint-Saens, Camille

    a. Timbre d'Argent

    b. Samson et Dalila

30. Schumann, Robert

    a. Das Paradies und die Peri op.50

31. Stuntz, Joseph Hartmann

    a. Maria Rosa; Oper in 4 Akten

32. Sullivan, Arthur

    a. Kenilworth

    b. In Memoriam

    c. The Prodigal Son

    d Overture di Ballo

    e. On Shore and Sea

    f. Festival Te Deum

    g. The Light of the World

    h. The Martyr of Antioch

33. Verdi, Guiseppe

a. Jérusalem

b. Les Vespres Siciliennes

c. Don Carlo

d. Aida

e. Missa da Requiem

34. Waldteufel, Émile

a. Vele werken voor salonorkest, wo.:

b. Chantilly:Valse

c. A Toi

d. Toujours ou Jamais

e. Les Sirènes

f. Dolores

g. Tout en Rose

h. Pomone

i. Mon Rève

j. Brune ou Blonde, Valse

35. Wagner, Richard

a. Nikolay

b. Rule Brittania Overture

c. Rienzi

d. Der fliegende Holländer

B. Wind band

1. Mohr, Jean Baptiste (1823-1891) Galop / J. Mohr. 186..
2. Fessy, Alexandre (1804-1856) Marche du Sultan Abdul Medjid : de G. Rossini : arrangé en pas redoublé pour musique militaire / par A. Fessy. 1854.
3. Fessy, Alexandre (1804-1856) L'élan : pas redoublé / par Aldre. Fessy ; dédié à son Fd. Dubois, de l'Opéra. 1865.
4. Edmond Dédé. (1889) Méphisto masque : polka fantastique à grand orchestre d'instruments mirlitonés / par

C. Chamber

Many copies that I have found are missing the title pages, or have other missing information

1. Corbin, Albert (18..-1893). *Compositeur. Tentatès. Fantaisie mystique pour cornes à pistons Si ♭ et ophicleide ou basse en Ut, avec accompagnement* 1886.
2. Bellon, Jean Francois Victor (1795-1869) *Quintette de Cuivres No.1*-12 c.1848- 1850

D. Solo

1. Vasseillière fils.. *Air varié pour ophicléide avec accomp.t de piano* 1860.
2. Ramain, J *Air varié pour ophicléide* 1868.
3. Verroust, Stanislas (1814-1863) *Variations , sur un thème de Bellini, pour l'ophicléide avec accompagnement... de piano* 1869.
4. Simon, A *La Saint-Loïse. Polka pour trombone ou ophicléide (et orchestre)* 1898.

5. Pilati, Auguste (1810-1877). Compositeur. Le Serpent de village ! Air bouffe avec accompagnement de serpent ou ophicléide (en ut) ad libitum..., paroles de MM Julian et J.-B. Vasseur 1862.
6. Kummer, Giacomo *Variations in C* "Variations for ophicleide" (1816?)

E. Pedagogical/ method books

1. Blancheteau, A. Petite méthode d'ophicléïde. 1864.
2. Boscher, A.. Méthode de Ophicléïde en si ♭, à 9, 10 et 4 clefs (extrait de la méthode générale d'ensemble). 1875.
3. Clodomir, Pierre François (1815-1884). Méthode élémentaire pour ophicléïde. 1866.
4. Cornette, V.. Méthode d'ophycléïde alto et basse. 1835.
5. Franck, L.. Méthode d'ophicléïde (Nouvelle édition). 1843.
6. Garnier, Th.. Méthode élémentaire et facile d'ophicléïde à pistons ou cylindres. 1844.
7. Guilbaut, E.. Méthode très facile pour ophicléïde en si ♭ et ut. 1874.
8. Moreau, D.. Méthode pour l'ophicléïde à 9, 10 et 11 clés. 1869.
9. Ploosen, Henri C. de Nouvelle méthode d'ophicléide. 1855.
10. Projean, C. P.. Méthode complète d'ophicléïde pour l'accompagnement du plainchant. 1846.
11. Schultz, Ni.de Nicomède. Nouvelle méthode progressive pour ophidéïde. 1842.
12. Sistermann. Compositeur. Nouvelle méthode d'ophicléide. 1841.

13. Vobaron, Félix Nouvelle méthode d'ophicléïde basse avec le doigté du Bass-horn (dit sap-horn) B.sse et contrebasse à 3 et 4 pistons à boîte cylindrique, en 2 parties. 1846.

APPENDIX C

PITCH FREQUENCY DISTRIBUTION OF REPERTOIRE

A spreadsheet was used to count each note in each of the musical samples collected. Accidentals were not tabulated, and repeated notes were. The inclusion of series of repeated notes did affect the results by having spikes on the dominant and tonic of the Ophicleide Quintet. If this experiment was repeated, it might be best to consider 4 or more repeated notes as a pedal. This may eliminate some harmonic clustering. This being said, the other works exhibited much less clustering. This could be attributed to the time period of the compositions, as the early Romanic ophicleide music may have had less harmonic progression than some of the 20th century works, that exhibit smooth probability curves.

After totaling the number of pitches in each work, each value was divided by one hundredth the sum of each value. This then gives the percentage that each note was used in the piece. This normalization of the graphs allows any comparison between the pitches to be of the same value.

APPENDIX D

OPHICLEIDE DISCOGRAPHY

List Compiled in part from research done by John Davies[96] and Cliff Bevan[97]

1. Berlioz Historical Brass BHB 101 Le Monde du Serpent (The World of the Serpent); Berlioz Historical Brass, Gloria Dei Cantores choir, members of the Boston Symphony Orchestra, Douglas Yeo, serpent & the contrabass serpent, with Craig Kridel (serpent) and Phil Humphries (serpent & ophicleide)
2. Capriccio 67 068 Mendelssohn: Athalia; Das Neue Orchester, directed by Christoph Sperling; Erhard Schwartz, ophicleide
3. Carol Album 2; Taverner Consort, Choir & Players, Andrew Parrott directing; Stephen Saunders, ophicleide "Hark! The Herald Angels Sing" Chestnut Brass, no catalog number
4. CPO 777 221-2 Ferdinand Ries: Die Könige In Israel; Rheinische Kantorei and Das Kleine Konzert, Hermann Max, director; Erhard Schwartz, ophicleide
5. De Organographia "The One Horse Open Sleigh" (1996, Pandourion Records, PRCD1004). ("The First Nowell" for two ophicleides.
6. Decca/London # 455 688-2 Mendelssohn : Elijahh; Orchestra of the Age of Enlightenment & Edinburgh Festival Chorus with Bryn Terfel & Renée Fleming, directed by Paul Daniel; Tony George, ophicleide
7. Deutsche Harmonia Mundi 82876 64071 2 Richard Wagner: Der fliegende Holländer (The Flying Dutchman) - Original Paris Version; WDR Rundfunkchor Köln, Prager Kammerchor (the choirs), Cappella Coloniensis (the orchestra), Bruno Weil directing; Marc Girardot, ophicleide

[96] Davies, 2009.

[97] Bevan, *The Tuba Family*.

8. Doyen DOY CD162 The History of Brass Band Music: The Early Years 1850-1920; Grimethorpe Colliery (UK Coal) Band, Elgar Howarth cond.; Clifford Bevan, ophicleide
9. Frémeaux & Associés FA 166 Choro (1906-1947); Pixinguinha (flute), João Pernambuco (guitars), Jacob do Bandolim; Irineu de Almeida, ophicleide
10. Glossa # GCD 921101 Mendelssohn: A Midsummer Night's Dream
11. 1994, Philips 442 137-2 H. Berlioz "Messe Solennelle" (Orchestre Révolutionnaire et Romantique and Monteverdi Choir, John Eliot Gardiner cond.). ophicleide, buccin and serpent
12. 1993, Philips 434 402-2 H. Berlioz "Symphonie Fantastique" (Orchestre Révolutionnaire et Romantique, John Eliot Gardiner cond.). ophicleide and serpent.
13. Harmonia Mundi (France) # 901463.64 Mendelssohn: Elijahh (Elias); Orchestre des Champs Elysées, La Chapelle Royale, Collegium Vocale with Petteri Salomaa & Soile Isokoski, directed by Philippe Herreweghe; Marc Girardot, ophicleide
14. Melba MR 301111 Back from Oblivion; Nick Byrne, ophicleide & David Miller, piano
15. Mooncrest # CRESTCD 011 No Roses; Shirley Collins and The Albion Country Band; Alan Lumsden cond., ophicleide & Gregg Butler, serpent
16. Nimbus #NI 5470 The Origin of the Species: Virtuoso Victorian Brass Music; The Wallace Collection; Stephen Wick & Tony George, ophicleides
17. Nonesuch H-71313 (LP) 19th Century American Ballroom Music; Smithsonian Social Orchestra & Quadrille Band, directed by James Weaver; Robert Eliason and Robert Kraft, ophicleides, Robert Sheldon, quinticlave

18. Orchestra of the Eighteenth Century, directed by Frans Brüggen; Stephen Wick, ophicleide
19. Orfeo C 689 061 A Victorian Christmas (a.k.a. Victorian Christmas for Brass); Passion des Cuivres (19th Century brass quintet, Constanze Backes, soprano; Erhard Schwartz, ophicleide
20. RCA Red Seal 2 CD 88697 (27155 2) Robert Schumann: Das Paradies und die Peri; Bavarian Radio Orchestra and Choir (Symphonieorchester des Bayerischen Rundfunks), directed by Nikolaus Harnoncourt; Erhard Schwartz, ophicleide
21. Saydisc SDL 361 Fill Your Glasses: Convivial English Glees; London Serpent Trio; Serpentist: Christopher Monk, Ophicleide: Clifford Bevan, Anaconda: Andrew van der Beek
22. Signum Records SIGCD280 Berlioz: Grande Messe des Morts (Requiem); Gabrieli Consert & Players, Wroclaw Philharmonic Orchestra, Chetham's School of Music Symphonic Brass Ensemble, Wroclaw Philharmonic Choir, directed by Paul McCreesheli; John Elliott, Phil Humphries, Stephen Wick, Andy Kershaw, ophicleides
23. Crystal Records CD562 1988, The Chestnut Brass Company "Pastime with Good Company". C ophicleide the Eb quintclave. Tacks: Conrad Fay:"Wrecker's Daughter Quickstep", Francis Johnson:"Dirge", and Louis Jullien:"Prima Donna Waltz."
24. Virgin Classics 7243 5 45706 2 9 Hector Berlioz: Benvenuto Cellini; French National Orchestra, Radio France Chorus, directed by John Nelson; unnamed ophicleide
25. Winged Lion/Signum Classics SIGCD 300 Felix Mendelssohn: Elijahh 1846; Gabrieli Consert and Players & Gabrieli Young Singers Scheme & Wroclaw Philharmonic Choir, with Simon Keenlyside, baritone (Elijahh), directed by Paul McCreesh; Nicholas Perry &

Phil Humphries & Carl Woodcroft, serpents; Stephen Wick & Andrew Kershaw, ophicleides; Tony George, contrabass 'monster' ophicleide

APPENDIX E

INSTRUMENT WAVEFORM ANALYSIS

Method

It was difficult to find a good objective measurement of the overtones. Thirteen instruments in total were recorded, from a distance of four feet with the same equipment. The volume controls were the same, so the frequency response was the same across all of the recordings. Each sound was recorded over 5 seconds with a tuner, and segments that were in tune on each instrument were found. The files were normalized, and had DC offset removed. Each segment was .050 seconds long for processing with no change in pitch and volume.

The data processing was done on Matlab 2013 on a PC. Preliminary experimentation was done only with ophicleide, euphonium, tuba, and bass clarinet. Observing the spectrographs of these recordings show that the brass instruments looked similar, but the bass clarinet was not. If the results from the equations reflected the observation then testing would be done using that equation. This became problematic quickly because correlation coefficients of the waveform did not equal perception of similarity. Returning to more acoustical research in order to find better objective comparisons of the recordings led to the spectral centroid centroid standard deviation becoming increasingly relevant. An instrument's overtone frequency does not proportionally change and maintain its amplitude. The overtones change proportionately, but the amplitude of each overtone is affected by the specific frequency that it is creating. Some instruments, like the bass clarinet have almost zero amplitude in the first 3 even harmonics. Some instruments, like the ophicleide have seemingly equal amplitude of overtones, until a specific roll off frequency. These characteristics are indicative of the instrument's sound, and the algorithms used were not including this relationship in the data. Research into instrument

classification showed several algorithms that worked as classifiers. Inharmonicity was speculated to be the most accurate classification method but was not used because the offset is more pronounced and thus measured more easily in higher order overtones such as strings. The instruments being investigated only produce 15-20 overtones, and I was unable to reliably measure the inharmonicity of these with any degree of accuracy. However, the Spectral Centroid gave accurate results, by grouping conical brass with similar values, and the other instruments further away. This equation compares the Fourier transforms of each recording and calculates its "center of mass" or averages every frequency. Similarly, the standard deviation of the centroid was able to measure how dense the spectral distribution is, and was listed as the third most accurate classification method, so that data was included on the tables as well.

The deficiencies of a test like this is it compares specific mathematical properties of the sound but does not measure human perception. A large blind survey of an audience listening to these different instruments could be done in the future to measure human perception, and compare those results to this and other forms of signal analysis. However, the Spectral centroid is a well-documented property of timbre, and it reinforces the previous observations.

Ophicleide

Centroid Standard Deviation= 0.1527 Centroid Mean= 6.5927

Baritone - Pan American

Centroid Standard Deviation= 0.759144312 Centroid Mean=9.47519529

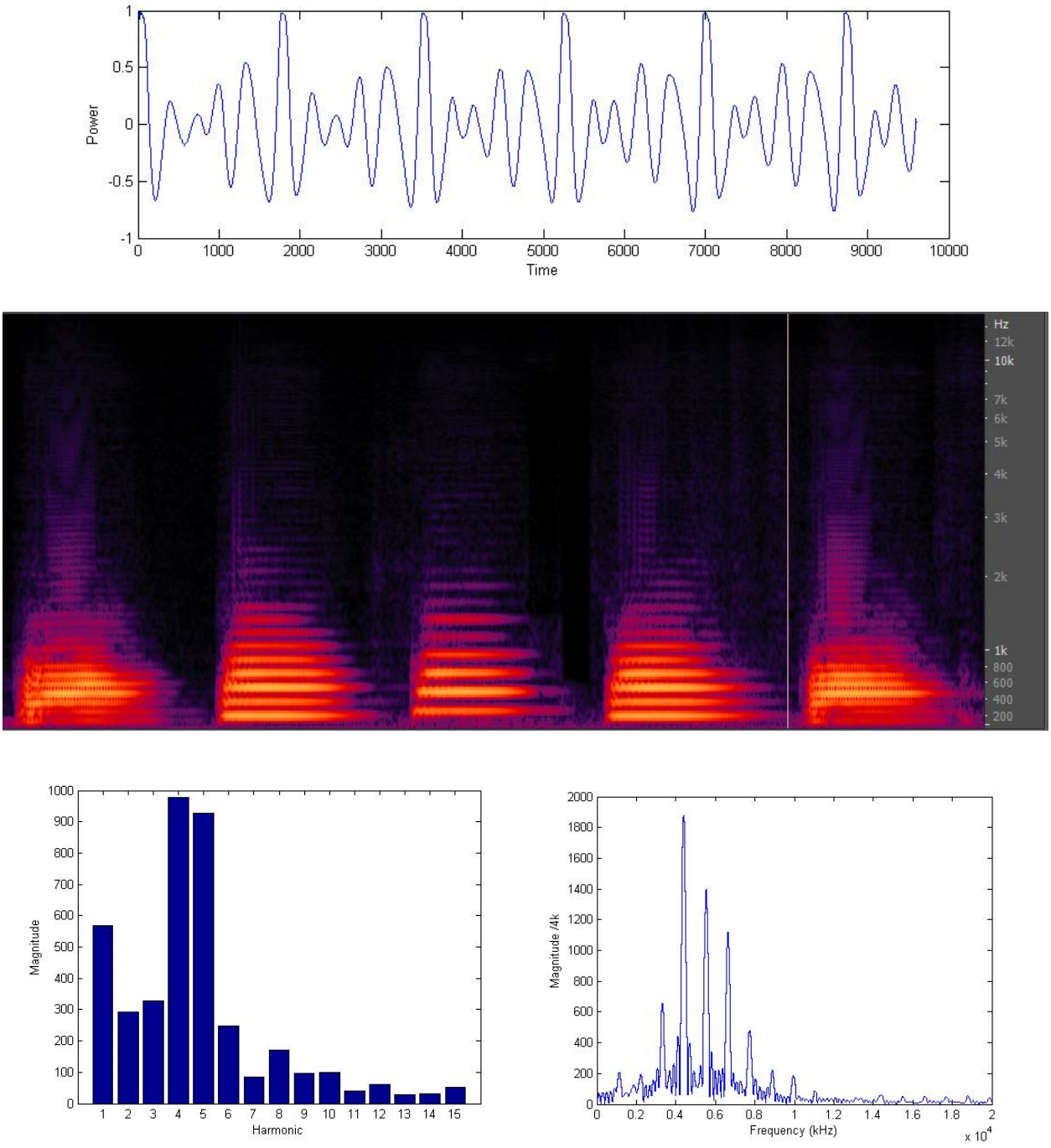


Figure E.1. Combined data for Baritone

Bass Clarinet- Buffet Prestige

Centroid Standard Deviation= 1.755967316 Centroid Mean=15.25656052

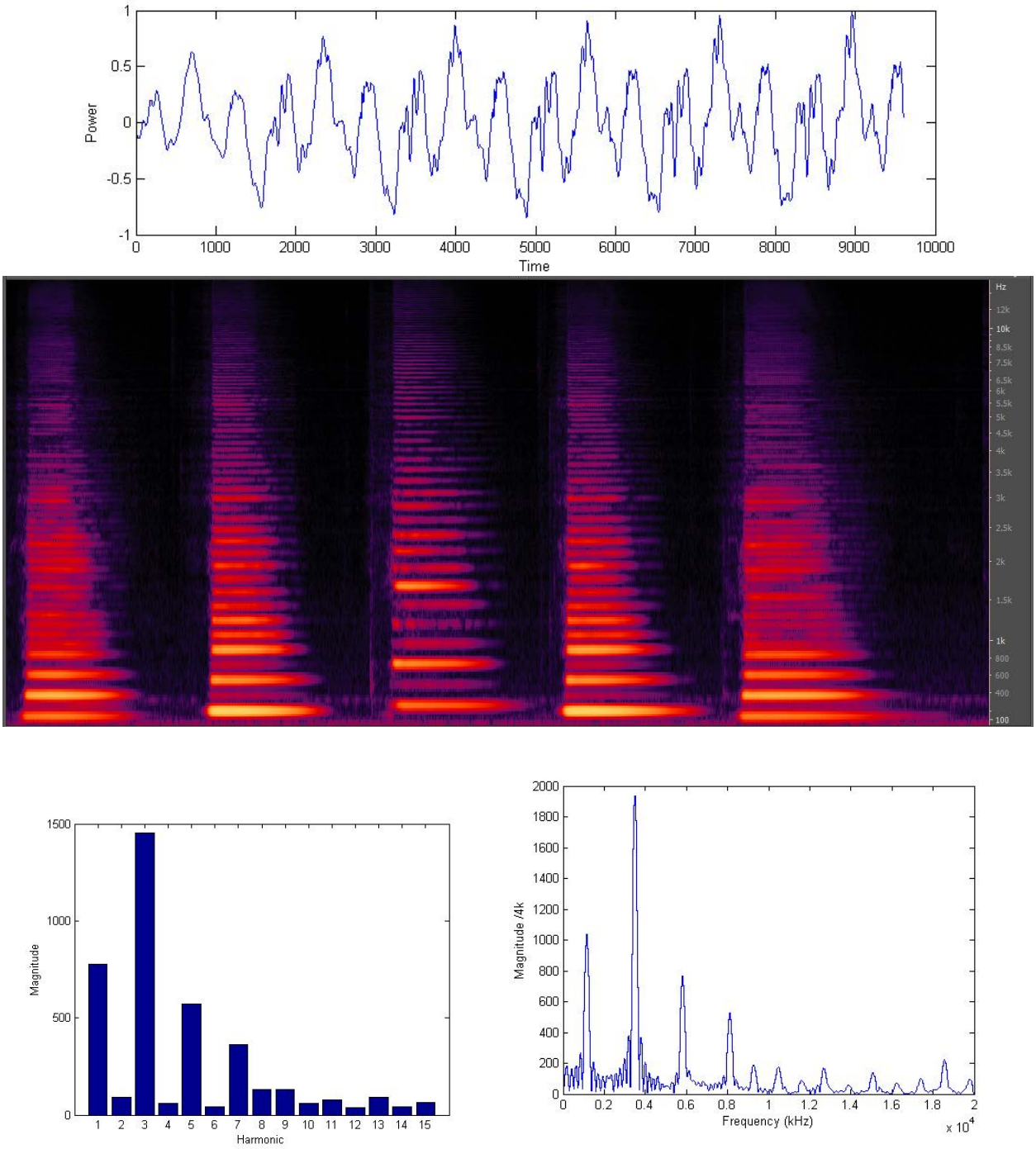


Figure E.2. Combined data for Bass Clarinet

Besson F Compensating Tuba

Centroid Standard Deviation= 0.307216483 Centroid Mean=5.294853701

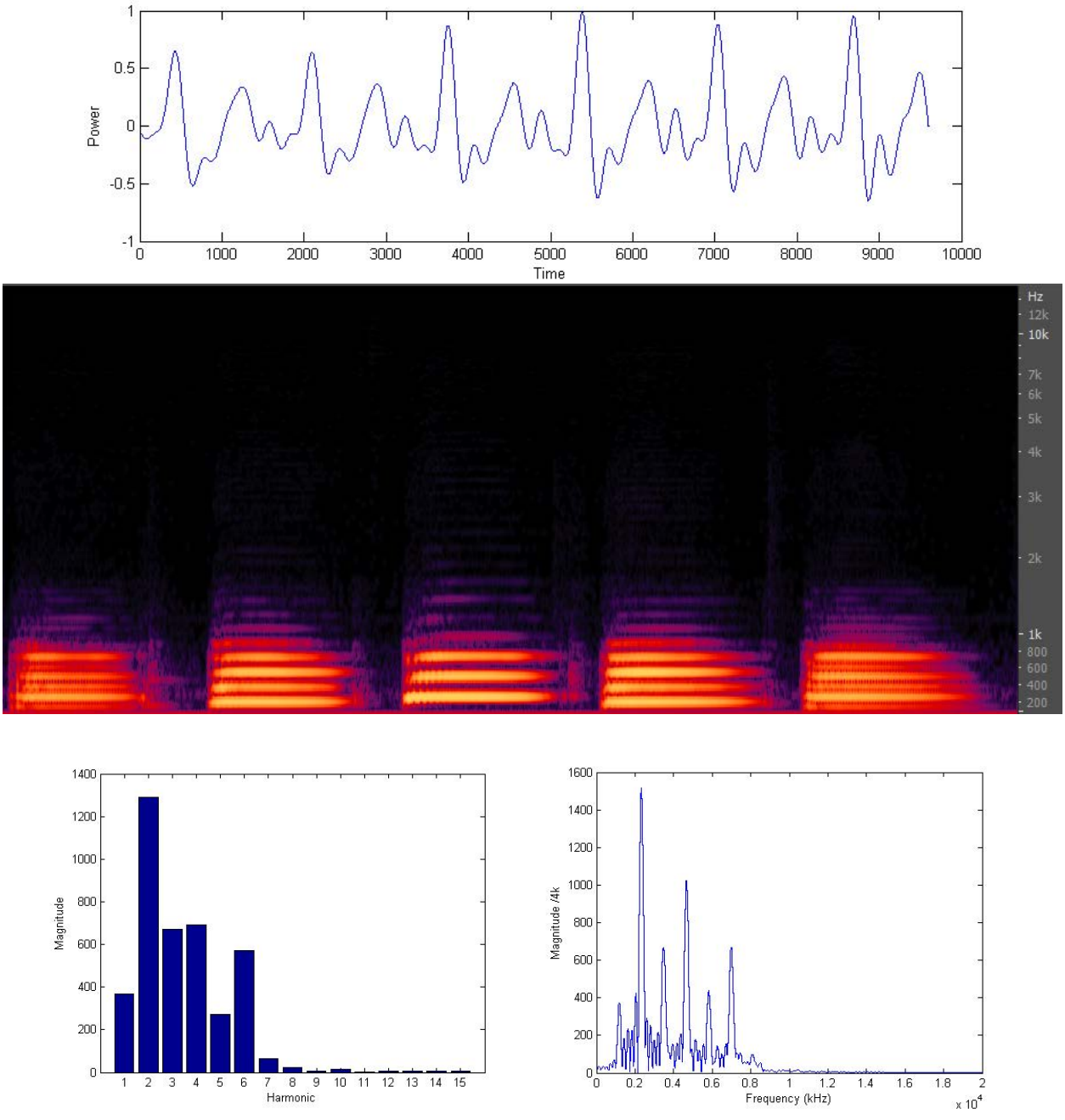


Figure E.3. Combined data for Bass Tuba

Yamaha Contrabass Tuba BBb

Centroid Standard Deviation= 0.572924837 Centroid Mean=7.060204095

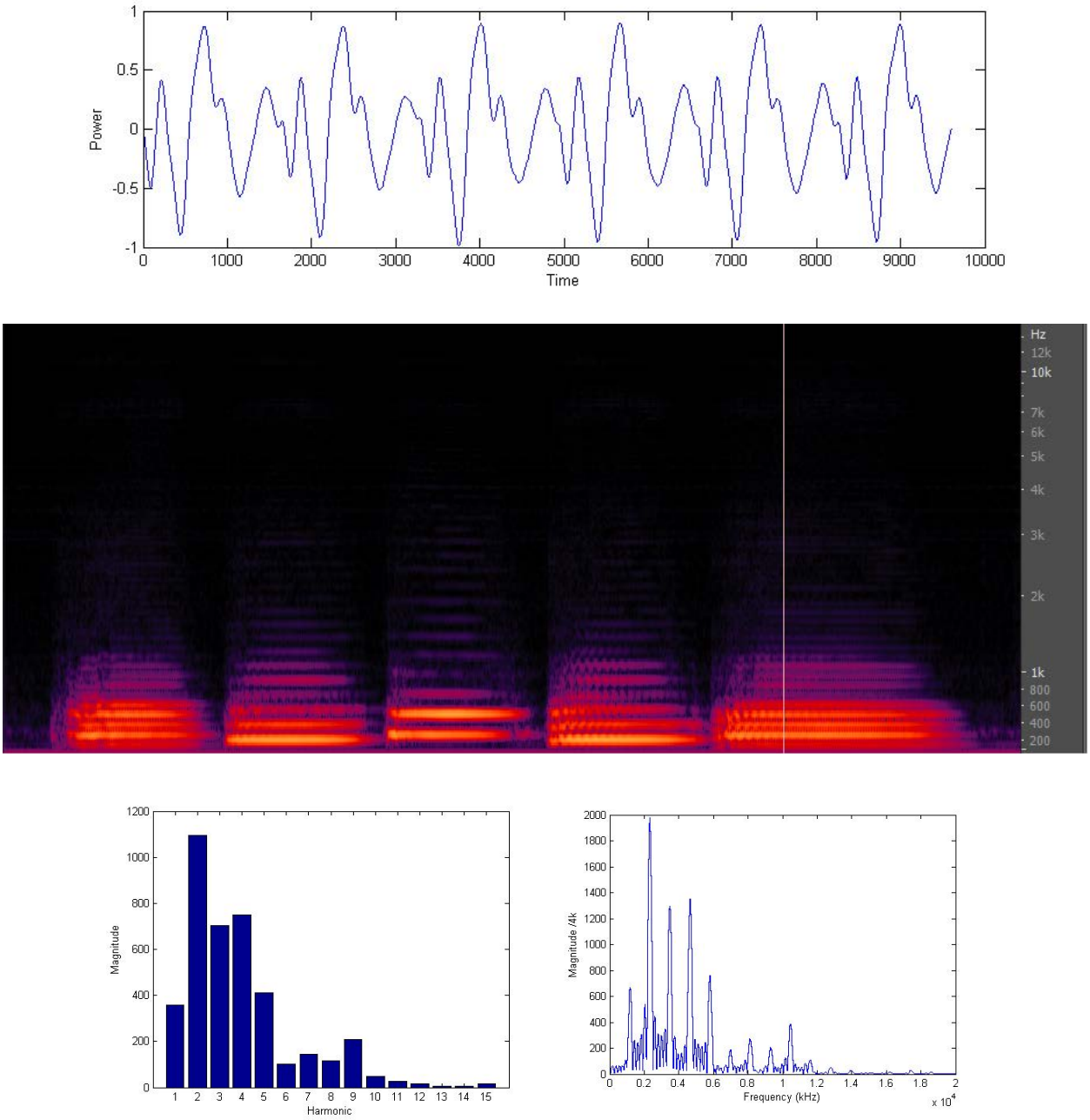


Figure E.4. Combined data for Contrabass Tuba

Stone Lined Bucket Mute closer in

Centroid Standard Deviation= 0.618563952 Centroid Mean=6.162890304

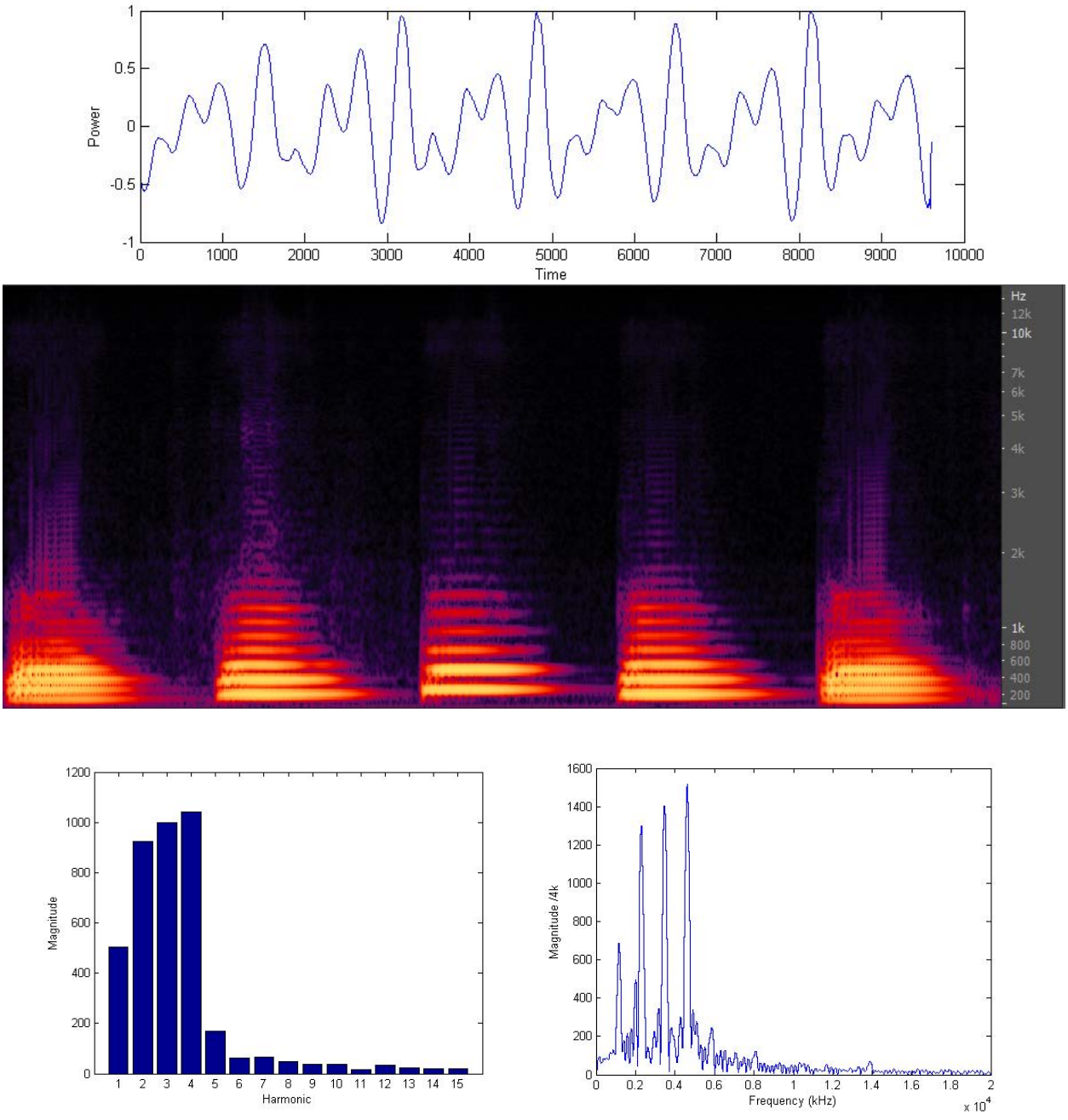


Figure E.5. Combined data for Bucket mute, pulled away

Stone Lined Cup Mute

Centroid Standard Deviation= 0.250828438 Centroid Mean=6.961287962

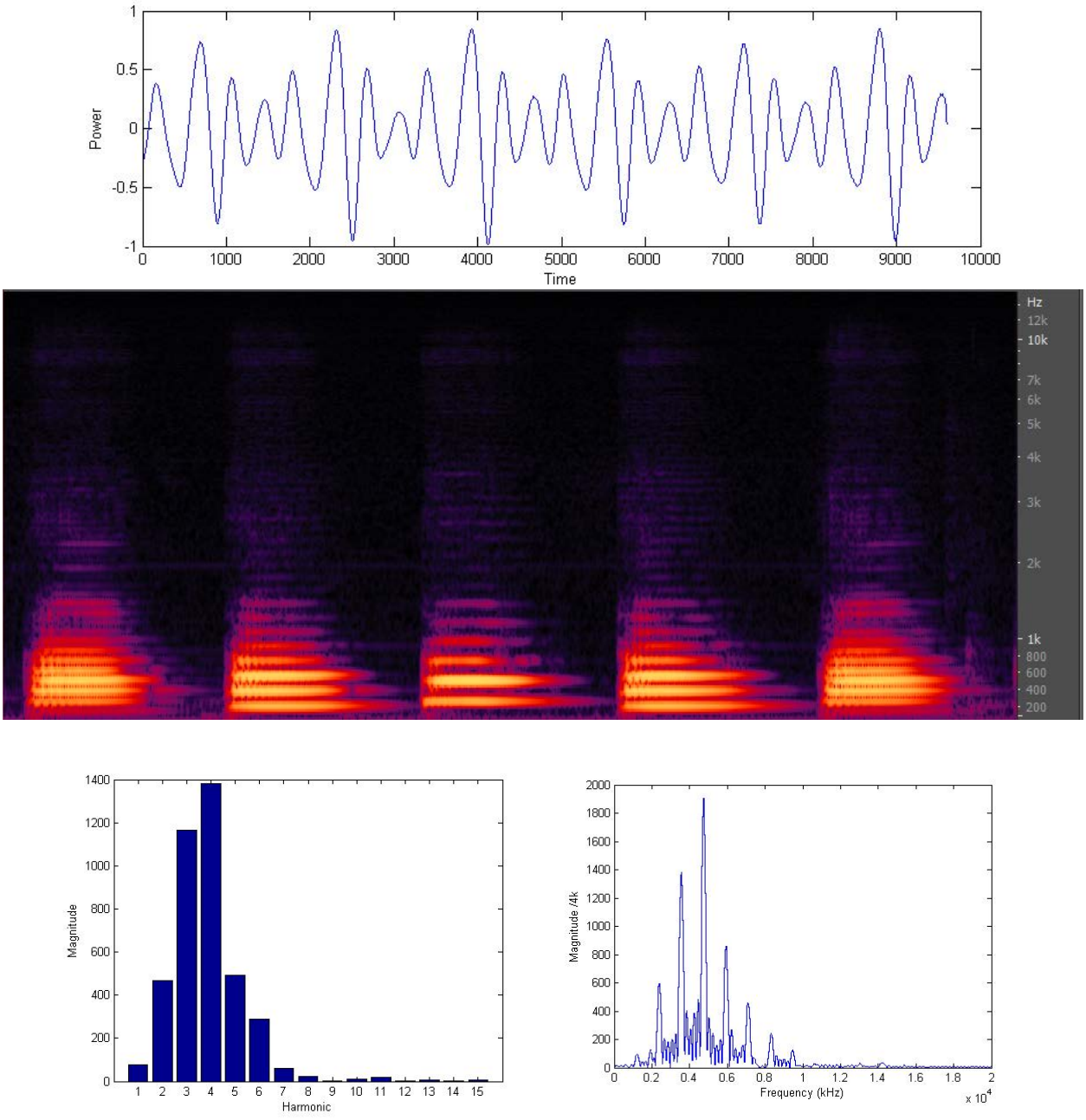


Figure E.6. Combined data for Cup Mute

Bucket Mute Stone Lined

Centroid Standard Deviation= 0.509740074 Centroid Mean=6.249619224

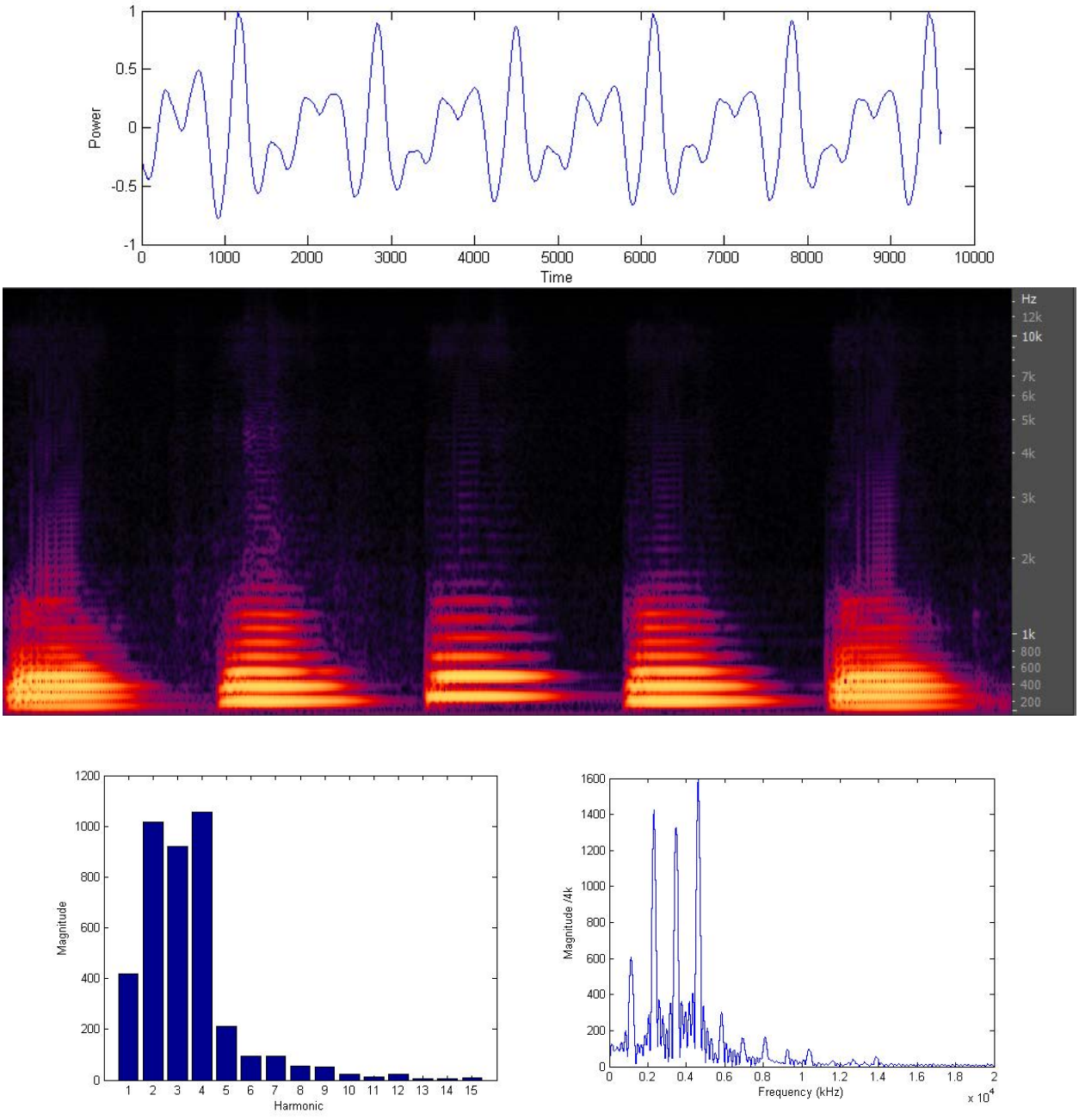


Figure E.7. Combined data for Bucket Mute, Pushed in

Euphonium – Wilson 2900

Centroid Standard Deviation= 0.411507329 Centroid Mean=6.527554806

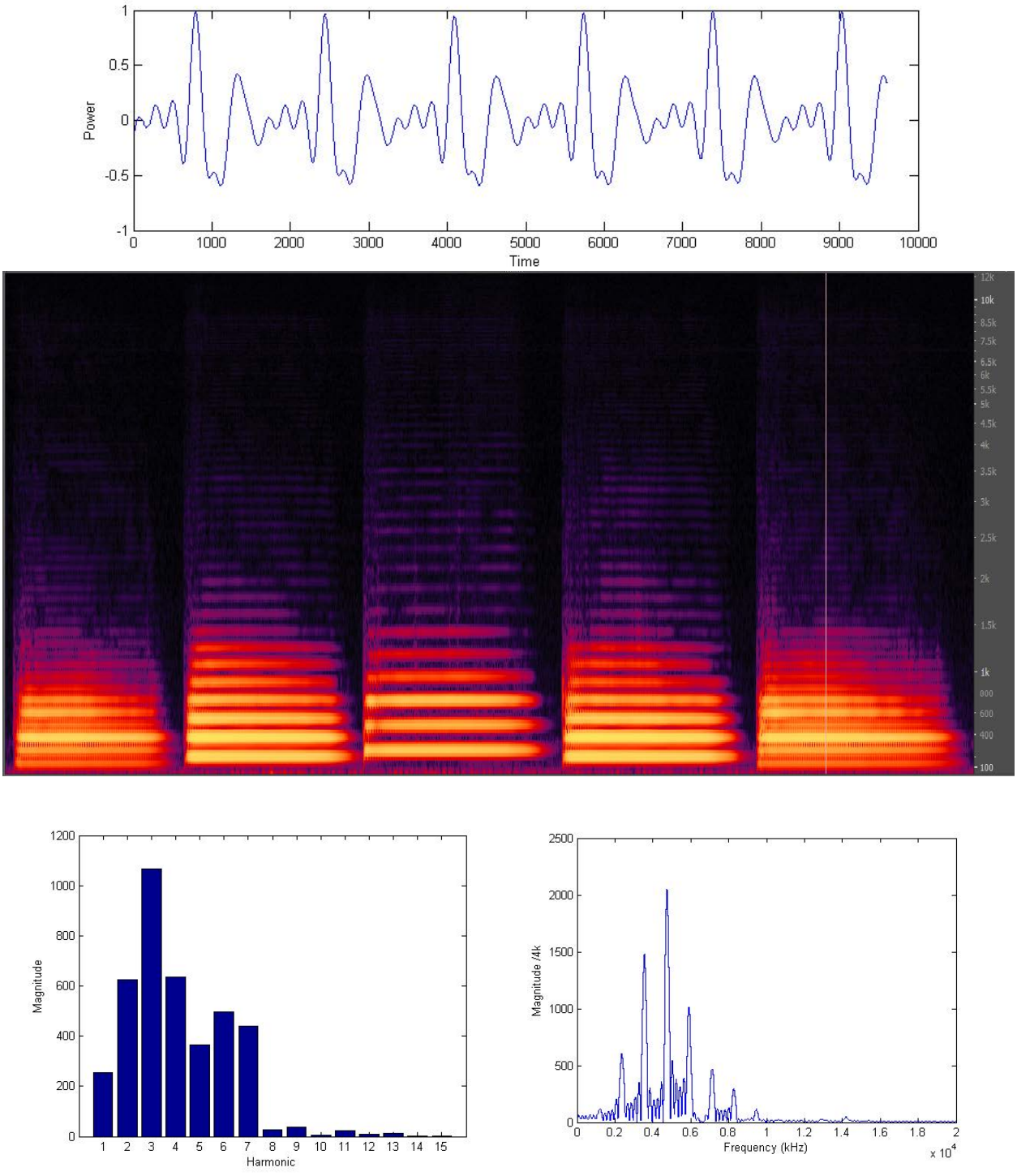


Figure E.8. Combined data for Euphonium

Balu Euphonium mute

Centroid Standard Deviation= 0.286716565 Centroid Mean=6.933551058

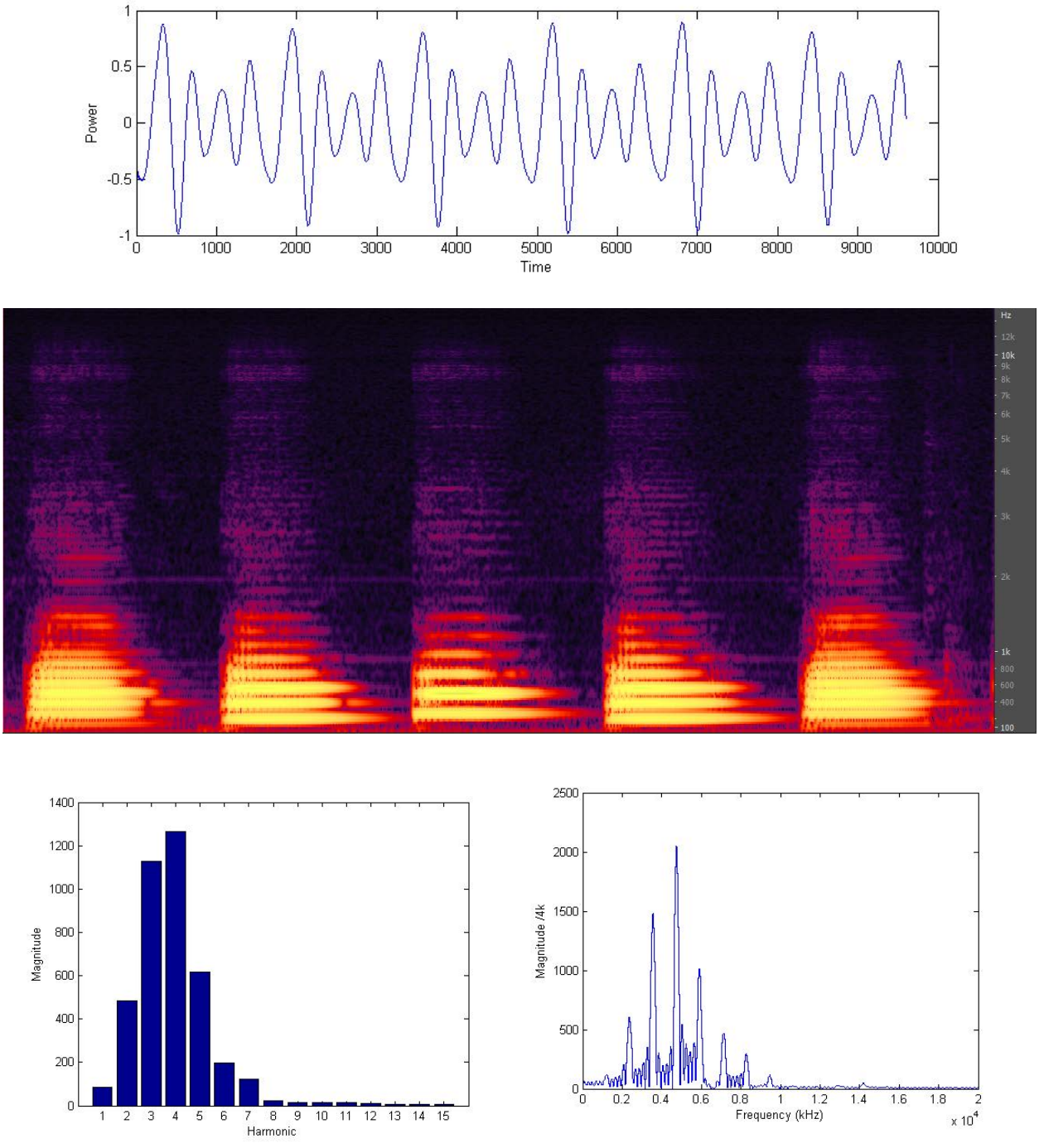


Figure E.9. Combined data for Balu Wood Mute

Schlipf SIR Combo Mute

Centroid Standard Deviation= 0.209990418 Centroid Mean=9.182504881

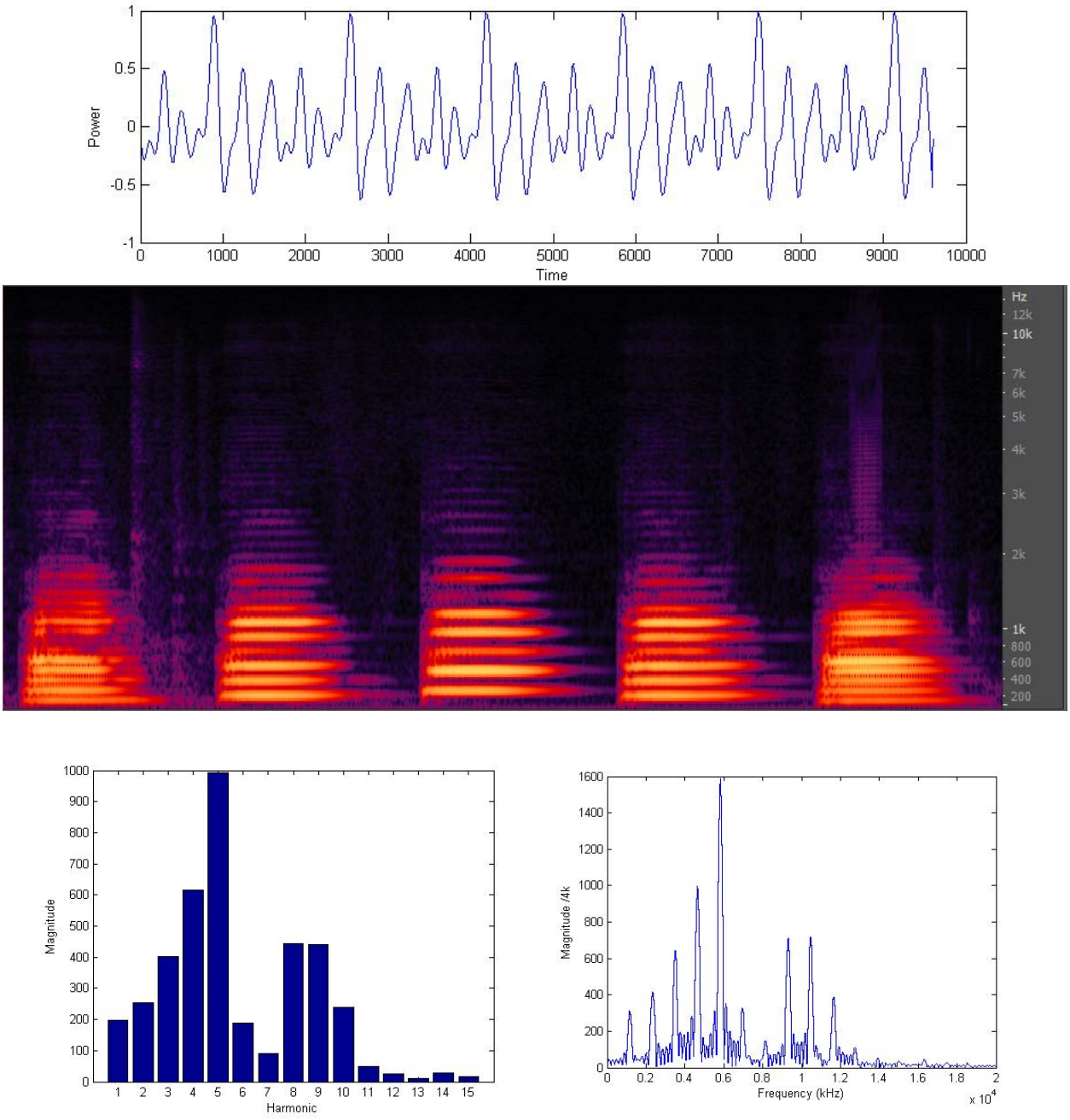


Figure E.10. Combined data for Plastic Composite Mute

Denis Wick Strait Mute

Centroid Standard Deviation= 0.610565053 Centroid Mean=11.54822683

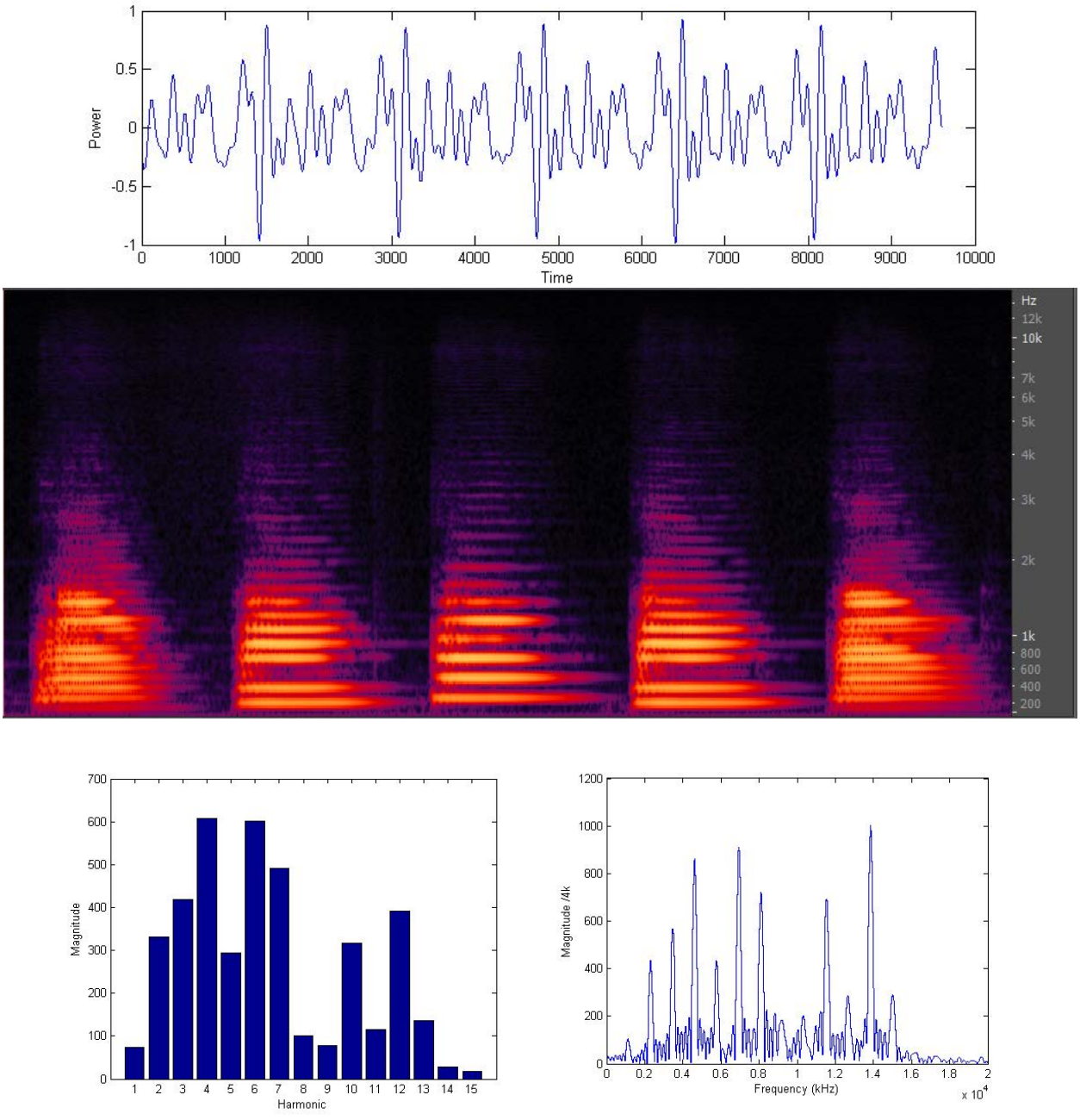


Figure E.11. Combined data for Metal Strait Mute

Trombone- Getzen 3047

Centroid Standard Deviation= 0.436035374 Centroid Mean=8.980811265

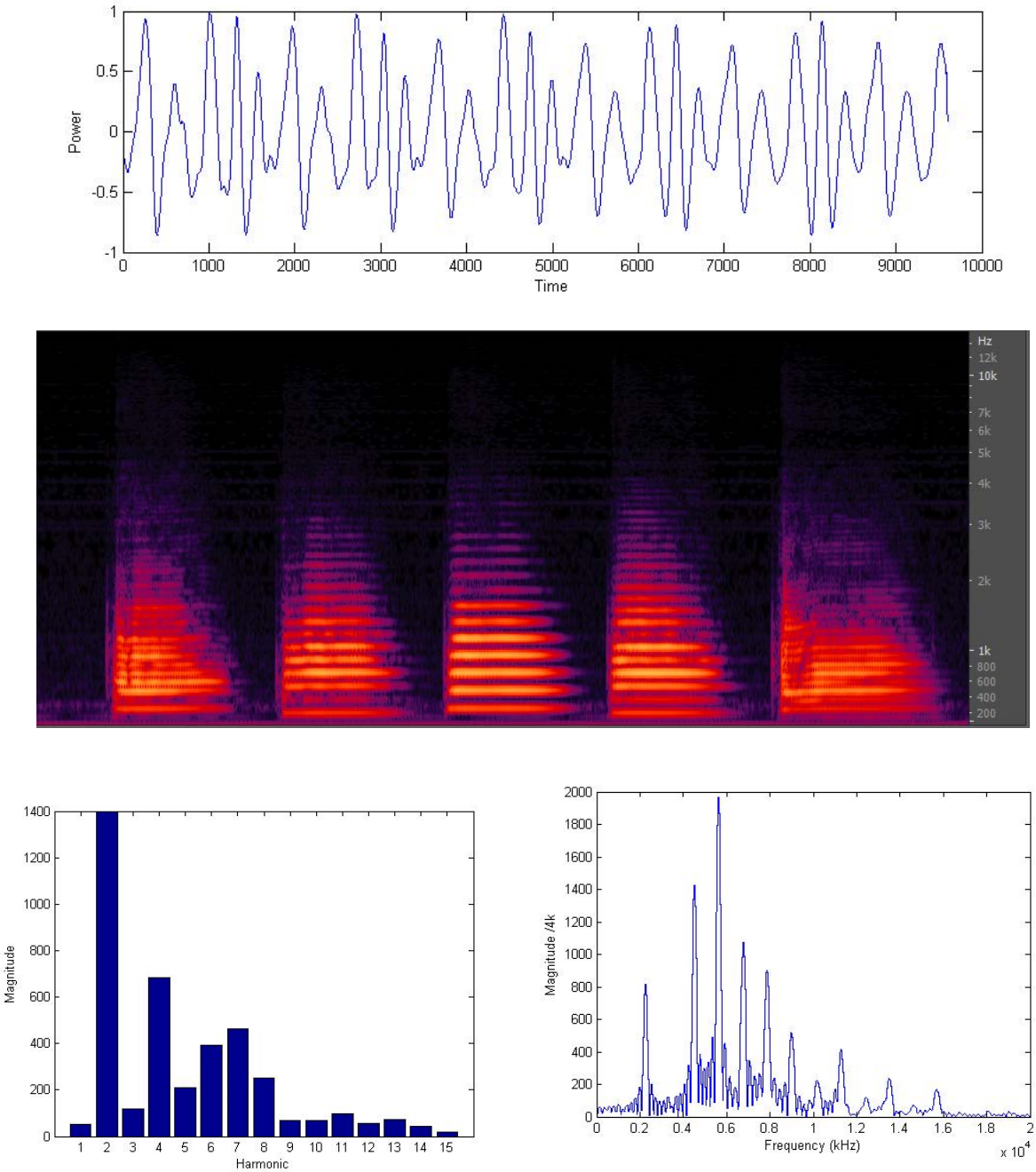


Figure E.12. Combined data for Trombone

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