UNIVERSITY OF CALIFORNIA, SAN DIEGO

Timbre: Metaphors, Negatives, and Catch-alls

A Thesis submitted in partial satisfaction of the requirements
for the degree Master of Arts

in

Music

by

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2011

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University of California, San Diego

2011

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ABSTRACT OF THE THESIS

Timbre: Metaphors, Negatives, and Catch-alls

by

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Master of Arts in Music

University of California, San Diego, 2011

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Here I present a portfolio of three projects completed during my degree at UCSD. In "Timbre: Metaphors, Negatives, and Catch-alls" I provide an overview of the development of an aesthetic discussion of timbre in the 18th and 19th centuries. Next, in "Multiphonic Production on the Clarinet," I present a project detailing the acoustic underpinnings of playing multiple pitches simultaneously on the clarinet and practical pedagogical uses for exercises designed to assist in playing them. Finally I present the content and impetus of a long term performance project in which I interpreted several pages of Cornelius Cardew's epic graphic score *Treatise*.

1. Timbre: Metaphors, Negatives, Catch-Alls

Timbre eludes definition: on one extreme it is a scapegoat for all things surface and exterior in music, a metaphor for the moral degradation of modern culture, on the other it is the core, music's purest resonance, its essence. As it (whatever it is) has no "domain specific" physical attribute we have little specific language to define it and at best most authors define it negatively or metaphorically to other attributes of sound or another sense entirely. Rather than suggest that we should develop formal laws and vocabulary to deal more specifically with the notion of timbre I simply propose that the buildup of layers of linguistic meaning mirrors the cognitive perception of multiple physical domains of sound in constructing a mental gestalt of timbre.

Rousseau penned the first distinct definition of timbre in Diderot's *Encyclopedie* of 1765:

> Tymbre. N. m. A sound's tymbre describes its harshness or softness, its dullness or brightness. Soft sounds, like those of a flute, ordinarily have little harshness; bright sounds are often harsh, like those of the *vielle* or the oboe. There are even instruments, such as the harpsichord, which are both dull and harsh at the same time; this is the worst tymbre. The beautiful tymbre is that which combines softness with brightness of sound; the violin is an example.[1]

His adjectives are all borrowed from either touch or vision and he ends up simply using the term as a vehicle to express his personal taste in instruments. Only three years later, Herder completed his *Fourth Grove* which uses the term in passing to critique Sulzer's theory of agreeable sensations:

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[1] Jean-Jacques Rousseau "Tymbre," Denis Diderot, Jean rond D'Alembert, ed., *Encyclopedie,* trans. Emily Dolan in *The Idea of Timbre in the Age of Haydn* (PhD diss., Cornell University, 1991), 60.

> It does not explain why, for example, abstracted from loudness or softness—which is something else entirely—the essence of a tone (insofar as the French call this timbre) is agreeable or disagreeable. Why two equally vivid tones convulse us in the most contrasting fashion. Why with respect to its nature a tone can make the most contrasting impression on two people possessed of an equally *strong* sensibility. Why, even with an agreed definition of *pleasure*, the same tone can arouse two different yet agreeable sensations in two different people…. Does it explain anything of the *nature* of sensation?[2]

Herder's reference to tone defines timbre first in the negative—the leftovers of sound after one disregards its volume—then as the vague "essence" of sound which causes an emotional response. These authors did not have any knowledge of a physical cause of timbre as they did for pitch and volume but even as Helmholtz described its newfound scientific understanding in his 1877 *Die Lehre von den Tonempfindungen als physiologische Grundlage für die Theorie der Musik* he used similarly vague and negative terms as Herder to describe "quality of tone" as "that peculiarity which distinguishes the musical tone of a violin from that of a flute or that of a clarinet, or that of the human voice, when all these instruments produce the same note at the same pitch."[3] Helmholtz's translator, Alexander Ellis, rejected the term on purely etymological terms, charting its strange path through French to its current abuse:

> I can find no valid reason for supplanting quality of tone… timbre, properly a kettledrum, then a helmet, then the coat of arms surmounted with a helmet, then the official stamp bearing that coat of arms (now used in France for a postage label), and then the mark which declares a thing to

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[2] Johann Gottfried Herder. "Critical Forests: Fourth Grove, On Riedel's *Theory of the Beaux Arts"* in *Herder: Selected Writings on Aesthetics*, edited and translated by Gregory Moore. (Princeton: Princeton University Press, 2006), 238.
[3] Hermann von Helmholtz, *On the sensations of tone as a physiological basis for the theory of music*, trans. Alexander J. Ellis (New York: Dover, 1954), 24.

> be what it pretends to be, Burns's 'guinea's stamp,' is a foreign word, often odiously mispronounced, and not worth preserving.[4]

Today it is still used in France to denote a diverse set of objects including postage stamps, both a small bell and the sound it makes, even a nicotine patch (*timbre anti-tabac*). But, then again, isn't that fitting for a concept with such an identity crisis? Cornelia Fales suggests in "The Paradox of Timbre" from 2002 "that while timbre is a dimension of central importance to identifying sources, it is also the dimension that is most divergent from the sound in the physical world."[5] She claims this divergence by analyzing spectrograms of a divergent set of world music traditions including Tuvan throat singing, didgeridoo playing and the Burundi music tradition using a plucked string instrument, the inanga, accompanied by whispering in which the pitch of the inanga is less important than the illusion of tonal whispering created by it. Even here the idea is founded on a concept of timbre which attempts to straddle a digital visual representation of the harmonic content of sound with a loose definition of timbre which seems to point again to a vague idea of the general surface of sound:

> Timbre is a slippery concept and a slippery precept, perceptually malleable and difficult to define in precisely arranged units. Though human auditory acuity, on one level at least, is greater for the discrimination of timbre than pitch, contrasts in pitch register on a conscious level more immediately and starkly than timbre contrasts of equal magnitude. To the general listener, pitch and loudness are variable characteristics of sound, timbre is a condition; pitch and loudness are things a sound does, timbre is what a sound is.[6]

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[4] Alexander J. Ellis, translator's note to *On the sensations of tone as a physiological basis for the theory of music,* by Hermann von Helmholtz (New York: Dover, 1954), 24.
[5] Cornelia Fales, "The Paradox of Timbre" *Ethnomusicology* Vol. 46, No. 1 (2002): 58.
[6] Ibid.

This recalls Herder's description of timbre as the "essence" of sound but here it differentiates the trained tech-savvy ear from that of the lowly "average listener," whose only definition of timbre is based on the perceptive trickery of the mind. A recent textbook in the field of acoustics clarifies that timbre is a subjective perceptual concept with no single physical attribute that can be directly physically quantified: "Four attributes are frequently used to describe sound, especially musical sound. They are loudness, pitch, timbre, and duration. Each of these subjective qualities depends on one or more physical parameters that can be measured."[7] The physical parameters listed are pressure, frequency, spectrum, duration, envelope. They point out that the perception of each of these common attributes is reliant on the sense of more than one acoustic signal but those other than timbre depend heavily, in contrast, on a single sense: "Timbre is a sort of catchall, including all those attributes that serve to distinguish sounds with the same pitch and loudness."[8] This again harkens back to Herder and Helmholtz definition of timbre as a silhouette against the backdrop of pitch and volume uniformity, albeit armed with the knowledge that it is an entirely perceptual rather than physical concept. Similarly Fales points out timbre is the least "domain specific" attribute and Rossing, Moore and Wheeler later describe timbre as a "multidimensional attribute of sound" citing the impossibility of creating a scale for timbre in the same manner that sones and mels assign values to loudness and pitch, respectively.[9]

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[7] Thomas D. Rossing, Richard F. Moore, Paul A. Wheeler, *The Science of Sound* (Reading: Adisson—Wesley, 2001), 94.
[8] Ibid.
[9] Ibid. 135.

The visual mapping of color onto sound existed long before *Klangfarbe* became a widely used German language version of timbre and cemented the notion of its relation to sound color. Newton describes a color scale corresponding to d minor in his *Opticks* of 1704 by way of a comparison of the spectrum of pitch to the refracted spectrum of light. Louis-Bertand Castel picked up on this idea and in 1725 suggested that a new art form could be created by way of the ocular harpsichord in the *Mercure de France*. He built off of the work of Athanasius Kircher who suggested that this seeming vibrational relationship between sound and light could form a connection between music and painting: "If, when a musical instrument sounds, someone would perceive the finest movements of the air, he certainly would see nothing but a painting with an extraordinary variety of colors."[10] Castel simply took this idea one practical step further to suggest that a keyboard instrument could be invented to translate Newton's concept of a seven color spectrum (conveniently corresponding to a seven note diatonic scale) and Kircher's musical painting metaphor into performance. He was never able to complete a model of the instrument by his death in 1757 but he constructed models of a number of possible solutions to the problem generally consisting of either colored silk ribbons or other objects displayed by a system of levers when a corresponding key was depressed. Castel used the invention from the outset as a method for discussing the value of the perceptual effect of isolated sounds versus isolated colors:

> The same sequence and the same combinations being given to colors would bestow upon them the same beauty and charms, which is so much the more true given that colors on their own are infinitely more pleasing and agreeable for the eyes than [isolated] sounds are for the ears. Such is

[10] Athanasius Kircher, *Musurgia universalis sive ars magna consoni et dissoni.* Trans. Maarten Franssen in "The Ocular Harpsichord," *Tractrix* 3 (1991): 19.

> the power of harmony and melody that even though single colors please more than simple sounds; it is nevertheless true that beautiful music produces more pleasure, and has something more gripping than the most beautiful painting, which consequently must be regarded as so far very imperfect; given that with a richer foundation, its effect is much smaller than music's.[11]

His relative disinterest in sound without compositional form in contrast to isolated colors is indicative of both early 18th century musical aesthetics and the earlier debate between painters from the 16th century in painting, namely the debate between Florentine and Venetian painters—Florentine painters argued for the use of preparatory sketches as a means to emphasize compositional form while the Venetians painted color directly onto the canvass in an attempt to gain the freedom necessary for spontaneous expression thereby validating color as a valued material even in a non-subservient role to form.[12] Validation of the isolated tone had yet to find its audience in music, but it would be essential for the development of a timbral concept of color. Though Castel succeeded to an extent in generating interest in the idea of color-harmony, later criticism of the idea presents the dissatisfaction with not only the pitch-color analogy and its implementation but provided one framework for the oncoming debate between value for imitation and harmony (design) and the primacy of sound as musical material.

Johann Gottfried Herder's *Fourth Grove* provides a clear view of such a shift later in the 18th century. Herder goes to great lengths to define the arts specifically in relation to one sense per art form: to sculpture he designates touch as the delineator of space and

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[11] Louis-Bertrand Castel, "Clavecin pour les yeux, avec l'art de Peindre les sons, & toutes sorts de Pièces de Musique," trans. Emily Dolan in *The Idea of Timbre in the Age of Haydn* (PhD diss., Cornell University, 2006): 25. Originally Published in *Mercure de France* (November 1725) 2552-2577.

[12] Emily Dolan, *The Idea of Timbre in the Age of Haydn* (PhD diss., Cornell University, 2006): 44.

form and distinguishes this from sight as a sense only appropriate for viewing surfaces or perspectival reductions. As such, he argues that to view sculpture only gives the illusion of form as a projection of touch created by the mind piecing together the various two-dimensional surface views of the eyes. Thus the realm of sculpture is spatial form and that of painting is the ability to contemplate multiple elements in a two-dimensional plane. Herder is opposed to the idea of the ocular harpsichord first on these grounds:

> The color clavichord is accordingly an absurdity. All objects of sight originally appear alongside one another; this allows the eye, which is always bedazzled at first, the time and space to sift through and observe them. To begin with, the eye only gapes; but if it is to enjoy fine art, it must see, and to that end Nature paints her beauties alongside one another. And now someone appears who wants to turn things upside down, to turn coexistence into succession, eye into ear. What? If he does not give the eye time to observe, if the eye has only a moment to gape at something, then all refined pleasure—indeed, ultimately all pleasure—is forfeit and we are left with a painful, perpetual numbness.[13]

He posits that time is essential for both the experience of painting and music—it is what allows the viewer to not simply "gape" but to truly "see"—but to be effective the object of view must be static. His critique of numbness of sensation is not limited to sight or even physical senses alone. He suggests that the usefulness of language lies in instruction but warns that simply adopting the language of knowledge without understanding its concepts and subjecting them to scrutiny debases the human soul and mind: "Every inherited concept deadens a nerve by which the soul might have discovered it for itself, benumbs our power to understand the concept as inwardly as if we had discovered it by ourselves."[14] As Jean-Luc Nancy would later connect the philosophical understanding to the extending of the ear Herder suggests that close attention to the

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[13] Herder. "Critical Forests," 226.
[14] Ibid., 213

senses is analogous to the search for understanding as a continuous process. He later extends this metaphor to the sense of hearing as a dichotomy between sound and tone rather than hearing and listening. After praising physicists' and mathematicians' "perfection" of acoustics to describe sound in measurable quantities based on physical characteristics of vibrating bodies he suggests that "they explain nothing of the simple tone, nothing of the energy it exerts on the hearing, nothing of the charm it possesses both in isolation and in succession; these relations explain none of this."[15] He does not yet elaborate on what this energy or charm might be but it is certainly not harmonic relations. Herder goes on to criticize Rameau's explanation of the "relation of the overtones" as having nothing to do with the affect on the soul of such simple tones:

> Even if Rameau's account were, in and of itself, as true as it today perhaps appears to be false, for the philosopher of tone-pleasure, it is a dry, one-sided, sterile experience. Chords are mere resonance, and all harmonies of chords are mere resonance; […] Students of tone-pleasure, do you thereby comprehend even the smallest part of the inner being of a tone? Of the power of a single accent over the soul?[16]

In contrast to Nancy's inner description of resonance, Herder uses resonance to describe only the acoustic phenomena as it exists outside the body—once it enters the soul it becomes pleasure and affect. It is not harmony as derived from Rameau out of the harmonic series which gives tones this power:

> It is well known that certain simple tones, independently of their pitch, loudness, or duration but according to their intrinsic nature, make different impressions on us. One strikes us as it were, more smoothly and brightly, another more roughly and obscurely. One seems to rouse and lift our nerves, the other to depress and benumb them. One causes them to

[15] Ibid., 236.
[16] Ibid., 238.

> contract in astonishment, another to melt in gentle languor—this we know from experience; let it also be our principle.[17]

The intrinsic nature Herder refers to her must be timbre as what is leftover after pitch, loudness and duration, as the essence of music. Castel is not mentioned here, but Herder clearly finds timbre to lend isolated sounds their expressive power in contrast to another criticism of color music by Rousseau, who, in contrast to the individual identity of the colors ("Yellow is yellow, independently of red and of blue. Everywhere it is sensate and recognizable."), claims that the sound "has no absolute character by which it is recognizable. It is hard or soft, has an acute or grave accent in relation to another."[18] After continuing to wax poetic over different sounds and their effect Herder asks:

> Who is so deaf that he could not feel this variety of sounds? […] If he admits the variety of whole sounds, and sound is nothing but an obscure aggregate of tones, then he must acknowledge that this variety must also obtain among the tones, and obtain properly and originally among them because they are the essence of sound. […] Let us therefore consolidate our second observation: sound and tone are not identical; the former is only an obscure form of composition; the latter is the essence of music.[19]

The difference between sound and tone is a confusing distinction to modern ears whose concept of timbre is ingrained in the idea of sound as a raw material for music that can be constructed out of an infinite number of sinusoidal waves but Herder seems to define sound as the sum total of the layers that add up to a musical texture and simple tone as the smallest unit of timbre that contributes to this overall musical texture.

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[17] Ibid., 241
[18] Rousseau, "*On the Origin of Languages*" in *On the Origin of Language* ed. and trans. by John H. Moran and Alexander Gode (New York: Frederick Ungar Publishing Co., 1966) 63.
[19] Herder, "Critical Forests," 242-243

Furthermore, as he discussed earlier in terms of sight and understanding, Herder takes this contrast of listening for sound vs. listening for tone and suggests that not only does timbre constitute the essence of music, but the act of listening to timbre allows the music to penetrate most deeply to the inner being of the soul. In much the same way he suggested that the ocular harpsichord was absurd because the eye needed time and "coexistence" to not simply gape, the ear needs simple tone so that it can resonate inside the listener as a sympathetically vibrating string. He derides those who hear only sound:

> Accustomed since youth to hear, as it were, heavy masses, which, composed of the most dissimilar parts, only murmur, only produce a din that the ear cannot purify, which therefore also appears as sound before the soul […] They will make every effort to reinforce the effect of a tone they think too weak by playing another simultaneously or rather by destroying the delicate single moment of its essence in the most brutal harmonic fashion.[20]

The numbness he spoke of earlier returns as deafness caused by the din of sound. He goes on to suggest that they are highly competent in composition and harmony and the practice of making music, but their competence ultimately destroys their ability to "feel the simplicity of tone even in the unharmonic melodies of the nightingale and all the singers of the skies; and in the unharmonic accents of Nature's every passion, with each new and lovely twist and variety, he will, like a delicate string tuned to the same pitch, inwardly recognize it and sympathetically repeat it and let it tremble within him forever."[21] Here he invokes Nature as a counter to the din of modern compositional technique of heaping up harmony onto sound. Though Rameau suggests the universality of tonal harmony with his theory connecting it to the overtone series, Herder seems to reason that an

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[20] Ibid., 248.
[21] Ibid.

opening of the ear to include the music of Nature as embodied by birdsong as a way of counteracting the loss off hearing to the artifice of modern composition (including harmonic motion) and allowing the for the ever-present resonance of the world within him.

Emily Dolan traces the emergence of the term *Klangfarbe* (first printed in 1834 in a book on organ building[22]) from this discussion of the lack of power of the individual tone and the need for imitation to lend emotive power to music to the later conception of timbre as a metaphor to color, thereby solidifying its small victory as a sonic attribute in its own right on the level of pitch. She notes the importance of the aforementioned earlier debate between 16th century Italian painters as a convenient metaphor for discussing emerging Italian instrumental music in the early 18th century whose "bold contrasts, sudden changes of mood, and an increased focus on surface details"[23] invited criticism suggesting that they were vapid or worse: nothing but noise—equating the compositions to a canvass with paint indiscriminately thrown all over it, appealing only to a tickling of the ears (*Ohrenkitzeln)*[24] rather than a compelling work of art (this would be cited again by conservative contemporaries of Mahler in their critiques of his Symphonies as lacking in unity[25]). Thus, says Dolan, critics of such instrumental music "assumed that design—whatever its musical equivalent was—was superior to color. Musical "color," therefore, became whatever part of the music was being employed or enjoyed superficially."[26] The

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[22] Dolan, *The Idea of Timbre*, 100.
[23] Ibid., 45
[24] Karen Painter, "The Sensuality of Timbre: Responses to Mahler and Modernity at the 'Fin de siècle'" *19th-Century Music,* Vol. 18, no. 3 (Spring, 1995), 237.
[25] Ibid.
[26] Dolan, *The Idea of Timbre*, 46.

idea of instrumental timbre advanced from a vague notion of such superficiality to the specific assignments of colors to instruments in JL Hoffman's *Farbenharmonie* from 1786: "Dark blue from well-prepared indigo; Lasur-blue from Lapis Lazuli and light blue from the ultramarine of silver can justifiably represent violoncello, viola and violin."[27] Hoffman dictated colors for a number of instruments in this manner; the clarinet was yellow and the trumpet scarlet.[28]

By the time Berlioz completed his orchestration treatise (published in its entirety for the first time in 1844, shortly after the emergence of the term *Klangfarbe*) the notion of instrumental timbre exhibited extensive development from Hoffman's now seemingly arbitrary assignments of color or the imitative text painting from baroque song settings. His examples from the classical orchestral repertoire such as Gluck and Mozart indicates the growing love of timbre as mediated by the growth and popularity of the orchestra in the late 18th and early 19th centuries. The book would remain a central text on the subject well into the 20th century. He writes ecstatically on the effect of instrumental sounds on the imagination of the listener. For example, following an explanation of notating

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[27] JL Hoffman, *Farbenharmonie* trans. Emily Dolan in *The Idea of Timbre in the Age of Haydn* (PhD diss., Cornell University, 1991), 103.

[28] This alludes to John Locke's story in his 1690 *Essay Concerning Human Understanding* of a blind man who came to believe that he understood the color scarlet because it was signified by the sound of the trumpet to demonstrate how people could believe they understood a concept which they had never truly encountered: "A studious blind man, who had mightily beat his head about visible objects, and made use of the explication of his books and friends, to understand those names of light and colours which often came in his way, bragged one day, That he now understood what scarlet signified. Upon which, his friend demanding what scarlet was? The blind man answered, It was like the sound of a trumpet." Herder briefly alludes to this as well in the *Fourth Grove* in his discussion of the separation of certain types of sensory information to specific senses. John Locke *Essay Concerning Human Understanding* (Kitchener, Ontario: Batoche Books, 2001), 346.

harmonics for the violin he discusses the timbre alone: "On the other strings harmonics are purer and thinner the higher up you go. This characteristic, as well as their crystalline timbre, makes them suitable for what I call 'fairy' chords. These are chordal effects which draw the listener into ecstatic dreams and carry the mind away to the imaginary delights of a poetic, make-believe world."[29] Where Castel hardly admitted that an isolated sound could even be agreeable a century earlier Berlioz finds a material of nearly hallucinogenic capabilities. Even Herder's poetic and aggressive arguments for the inner resonance of tone pale in comparison to this seemingly unavoidable force. The visual mapping of timbre onto sight is still present in the evocation of dreams but it extends beyond color to form a spatial concept of an imaginary utopia of spirits. The role of instrumental timbre also grows from its subservient role to pitch content as a means of highlighting melody in orchestral scores to enacting its own character roles. In the chapter devoted to the clarinet he describes first the general character of the sound:

> The character of the clarinet's intermediate register, marked by a certain haughtiness with intimations of tenderness and nobility, equips it well for the expression of the most poetic thoughts and feelings. Only frivolity – and perhaps naive joy too – seems to suit it not at all. The clarinet is not made for the idyllic, it is an instrument of the epic, like horns, trumpets and trombones.[30]

The sound of the instrument not only evokes an image or concept of human personality but embodies these characteristics itself. As the personality and vocal style of an operatic singer might lend itself to the portrayal of a dramatic personality so the clarinet is deemed appropriate for certain types of expression. Berlioz continues:

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[29] Hector Berlioz, *Berlioz's Orcestration Treatise: A Translation and Commentary*, ed. and trans. Hugh Mcdonald (Cambridge: Cambridge University Press, 2002), 23.
[30] Ibid., 122.

> Its voice is the voice of heroic love, and if the massed brass in large military bands bring to mind a regiment in shining armour marching to glory or to death, massed clarinets in unison playing with them seem to evoke the loved ones, wives and sweethearts, whose proud eyes and earnest passions exult to the sound of arms, who sing as they enter the fray and who crown their conquering heroes or die with the defeated. I have never been able to hear the distant sound of military bands without being profoundly moved by this feminine quality in the clarinets and filled with images of this kind, as from reading the epic poetry of the ancients.[31]

Here the clarinet not only embodies human characteristics but enacts a performance of the people themselves. The use of clarinet in tandem with the *idée fixe* in his *Symphonie Fantastique* clearly makes use of this particular comparison in his portrayal of the beloved of the protagonist in the program. The final movement's distortion of the *idée fixe* to portray her as a twisted witch is accompanied by a distortion of clarinet timbre by way of the Eb clarinet's blaring trills. This practice continued in orchestral writing, particularly in the 20th century as the clarinet's non-classical contexts provided a convenient well-recognized symbol for specific personas without the need for explicit program notes—Gershwin's use of the clarinet in "Rhapsody in Blue" clearly invokes the instrument's new identity as a jazz instrument while Kodály continues the tradition started by Liszt of using the clarinet as an embodiment of Hungarian folk song in his "Dances of Galanta."

As the orchestra grew through the 19th century to Mahlerian proportions in order to provide more potential for timbral variation critics continued to expand their accusations of the tickling of the senses to an indictment of the symphony as a representation of the moral degradation of modern society, as Karen Painter discusses in

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[31] Ibid.

her essay "The Sensuality of Timbre: Responses to Mahler and Modernity at the 'Fin de siècle'" The effect of Mahler symphonies was experienced and described so vividly bodily that critics equated it with the false thrill of narcotics, returning to the age-old idea that pitch and not timbre constituted the mark of musical creativity. Such a focus on outward sensuality rather than inner content also drew the criticism that it represented the degradation of women through the loosening of societal sexual boundaries.

These historical formulations of timbre do not die with their writers but rather build up a common (albeit generally subconscious) conception of the word which is highlighted by its various contextual uses. The modern conductor commonly communicates timbral issues to the orchestra through both personifications (referring to the character of contrasting material in a work) or color (Simon Rattle recently devoted a documentary to the idea that 20th century orchestral music primarily focused on developing musical color) while not only philosophers of aesthetics but those studying music cognition and cultural perception explore Herder's inner resonance of tone in addition to more outward looking studies of acoustics. These accounts then do not simply highlight the seemingly immature notions of a past age but serve to reveal the scaffolding on which a delicate notion of timbre teeters, always awaiting perceptual expansion rather than formal contraction.

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2. Multiphonic Production in the Clarinet

In 1967 Bruno Bartolozzi published the first edition of his book *New Sounds for Woodwind* in which he states "there are no longer 'false' notes now that the electronic sound spectrograph has allowed the frequency of any sound to be determined, so there are no longer sounds which are 'ugly', 'unpleasant', 'hard', etc. Rather are there only sound phenomena which are useful to how much they lend themselves to organized musical usage."[32] He suggests that electronic measurement and reproduction of sounds has led to the shift in musical attitudes from "tuneful" sounds produced by traditional means to any conceivable sound that could be reproduced in a musical context. He goes on to detail the production of a number of sounds including description and instruction of a number of multiphonics for each of the orchestral woodwind instruments.

Many notable performers and composers had pioneered the use of such sounds which he clarified and catalogued. Jazz musicians such as Eric Dolphy and John Coltrane used these in an improvisatory context before early notated examples: John Cage wrote "undertones" into his Concert for Piano and Orchestra from 1957-8 and William O. Smith used controlled multiphonics in his Five Pieces for Flute and Clarinet from 1961.[33] By 1982 Salvatore Sciarrino wrote his beautiful "Let Me Die Before I Wake" almost entirely for delicate trilled multiphonics. The use of such sound production is now commonplace to create textures from the raucous to the sublime. A basic

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[32] Bruno Bartolozzi. *New Sounds For Woodwind.* Trans. Reginald Brindle. (London: Oxford University Press, 1967), 5.
[33] Philip Rehfeldt. *New Directions for Clarinet*. Rev. ed. (Berkeley and Los Angeles: University of California Press, 1994), 41.

examination of the acoustics of the clarinet can give some insight into this mode of production: I will first discuss the influence of three major parts—reed, cylinder, and tone-hole lattice—on what is termed the "regime of oscillation" in the clarinet in order to eventually describe the type of "regime" that could give the effect of two or more notes sounding at once. I also argue that a knowledge and practice of using such sounds have not supplanted the old "tuneful" playing alluded to by Bartolozzi but instead have provided clarinetists with specific tools to teach and perfect such technique.

Figure 1. (Backus 807)

2.1 Acoustic Properties of Multiphonics

Though clarinetists may never stop debating the physical attributes of a good reed, acousticians define its role simply as a flow-control device. In a manner similar to that of the vocal folds or the lips of a brass player, the reed allows puffs of air to enter the instrument to start the generation of sound waves in the tube by pushing and pulling towards and away from the lay of the mouthpiece. Without dampening of the action of the reed it would vibrate at approximately 2 to 3 kHz, but this is not commonly heard in the normal production of clarinet sound for reasons I will discuss in tandem with the properties of the clarinet tube itself. Backus clearly described the motion of the reed using an apparatus to artificially play the clarinet.[34] As air was blown through the clarinet by a vacuum connected to its end a light was shown down the bore and a phototube recorded the opening and closing of the reed. The resulting graphs (see fig. 2.1) show that

[34] Backus, John. "Vibrations of the Reed and the Air Column in the Clarinet," *J. Acoust. Soc. Am.* 33.6 (1961): 806.

at soft levels the reed appears to vibrate in a sinusoidal fashion without touching the mouthpiece. As the player increases the volume with higher air pressure the reed actually touches the mouthpiece and at loud levels is held against the mouthpiece for about half of its cycle.

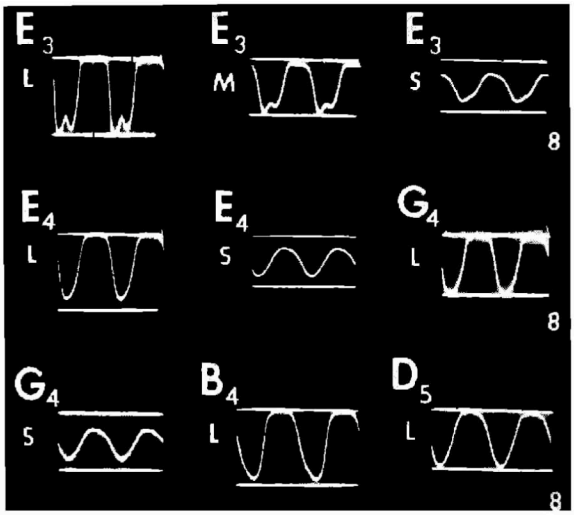

Figure 2.1: Vibrations of a reed by John Backus[35]. Air volume is indicated by L for loud, M for medium and S for soft. The top horizontal line indicates the reed closed against the mouthpiece and the bottom lines indicate the reed open away from the mouthpiece.

At the most basic level the clarinet can be thought of as a cylindrical tube closed at one end and open at the other. The vibrational modes of this type of tube will occur only at odd ratios (ie. partials start at 3, 5, 7). In a fashion similar to the way a string harmonic is played by dampening the vibration at a node causing the string to vibrate in a higher mode, the clarinet can be made to play in a higher mode, or register, with the use of a register key which releases the moving air and thus removes the pressure in the tube at the point of the greatest pressure of a lower mode, causing the perceived sound to be the next harmonic up (in the case of the first to second register, the first to the third

[35] Backus, "Vibrations of the Reed", 807

harmonic, or a twelfth). Instead of using a second register key farther up the instrument to facilitate the next mode of vibration, the clarinetist lifts their first finger to simulate its function.

Before discussing the addition of the rest of the holes to this tube we can already see how the reed and a cylindrical air column will interact as air is blown into the clarinet the reed begins to close which creates a pulse of high pressure air moving down the tube. Once it reaches the end the difference in the pressure in the tube and the pressure of the atmosphere causes most of the energy of the pulse to be reflected back towards the mouthpiece as a negative pressure pulse. This negative pulse returns to reinforce the closing of the reed and as no air can enter the mouthpiece to create a positive pressure pulse this series of events starts over in the opposite manner, with a negative pulse now traveling down towards the end of the tube as the reed pulls away from the mouthpiece and is soon pushed away by the positive pulse returning from the end of the tube. In this way a standing wave is set up in the tube by the phase locked action of the pipe and the reed. In this way the reed does not vibrate at its natural 2-3 kHz frequency but rather the frequency determined by the time it takes for the wave to reflect at the end and return to the mouthpiece. Occasionally an experienced player attempting to play high partials or simply make a very focused sound can activate this reed frequency and a listener will hear a distinctly muffled sound which seems to come out of the nose of the player. If the pipe resonates well at the harmonics corresponding to the fundamental frequency of the tube it will be easy for the player to hold a strong pitch as the resonances will reinforce

the oscillation of the fundamental. In this way a "regime of oscillation"[36] is set up in which each resonance creates a standing waves in the tube which "vote" for or against a mode of vibration.

This tube is greatly affected by the addition of a series of holes which allow the clarinet to sound the chromatic pitches (and more with the usage of less standardized fingerings). This series of holes is called the tone-hole lattice. It affects not only the pitches which will sound when the air column is set into oscillation but the timbre of the instrument as well. This is due in large part to their effect on what is called the instrument's cutoff frequency. If, for example, several holes at the top of this lattice are covered and the rest are left open, the standing wave created by the first vibrational mode of the tube will end at the location of the open hole: the tube will appear to be the length of the bore down to the first open hole because it will be reflected back up the tube at this point. As the tube is excited at the second and third modes of vibration, however, the standing waves end farther down the tube: in other words, higher frequencies are affected less by the open holes and therefore cause the effective length of the tube to be longer than the distance from the closed end to the first open hole. At yet higher modes of vibration the standing waves show no inhibition by the open portion of the tone-hole lattice and thus end at the open end of the bore of the instrument as if no holes were open. The frequency at which the tone-holes no longer reflect the wave back up the tube defines the cutoff frequency.

Resonance curves of such tubes can be made by graphing the acoustic impedance

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[36] Benade, Arthur H. *Fundamentals of Musical Acoustics*. (New York: Oxford University Press, 1976), 394.

of the tube. Acoustic impedance is defined as a ratio of the acoustic pressure to flow. If this value is measured at the mouthpiece of an instrument it will indicate the resonances of the system under playing conditions. Such a curve clearly illustrates the effect of the tone-hole lattice. In a resonance curve of a clarinet pipe without holes the harmonics drop away in amplitude from the highest peak ad infinitum, but on the curve of a tube with a tone-hole lattice, the cutoff frequency is shown as the point where the resonance peaks suddenly disappear as the upper partials are completely radiated out of the tube (see fig. 2.2).

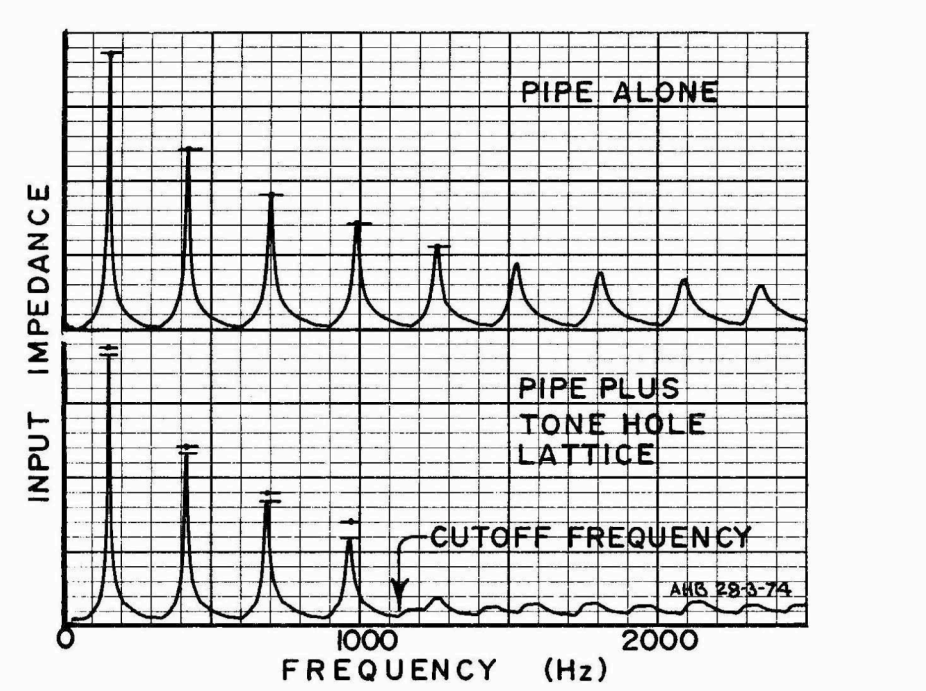


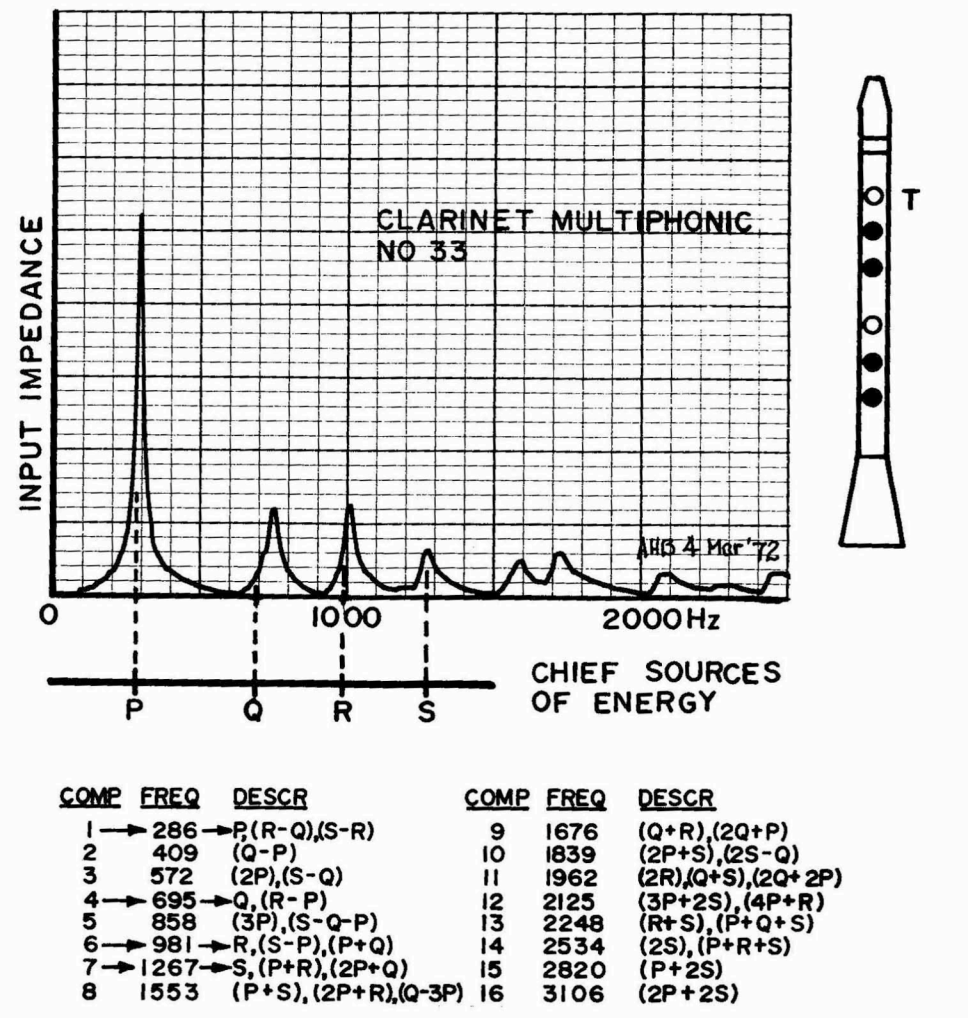
Figure 2.2: Input Impedance curves by Arthur Benade.[37]

Input impedance graphs of normal tones and multiphonics show important differences between fingerings which are typically used to play a clear single pitch and fingerings which allow the player to player more than one pitch simultaneously. In the

[37] Benade, Arthur H. *Fundamentals of Musical Acoustics*, 435.

graph of the single notes we see a series of peaks which correspond to a single harmonic series. All of these peaks add up to a sound which is heard by the ear as a single pitch due to this harmonic relationship. In a resonance curve of a fingering which produces multiple tones we see not a harmonic relationship between all of the peaks in the graph but a heterodyne relationship. This means that the frequency of each peak can be described accurately by mathematical relationships between them. One such graph by Benade shows the impedance curve and the mathematical relationship of each peak to the lowest, tallest peaks (see fig. 2.3). These contribute most heavily to the regime of oscillation present in the tube during such sound production. An examination of the fingerings involved generally shows that they mimic the reflection of waves at different positions along the tube thereby allowing multiple standing waves. More difficulty is inherent in maintaining such oscillations for the clarinetist because the resonance peaks do not reinforce each other as they do with single pitches on a well designed instrument. The player must make subtle changes in the pressure of the lip on the reed and the shape of the oral cavity in order to do so.

The heterodyne nature of this regime makes the perception of pitch much more subjective than in their harmonically related counterparts. For single pitches the brain can easily group all of the harmonics into their ratio components to the fundamental pitch and identify it with little error. In multiphonic production the brain still tends to group partials that appear to be harmonically related as a single tone but the overwhelming number of partials in any given regime of oscillation these can be interpreted into more than one possible configuration.



COMP	FREQ	DESCR	COMP	FREQ	DESCR
1 →	286 →	P,(R-Q),(S-R)	9	1676	(Q+R),(2Q+P)
2	409	(Q-P)	10	1839	(2P+S),(2S-Q)
3	572	(2P),(S-Q)	11	1962	(2R),(Q+S),(2Q+2P)
4 →	695 →	Q,(R-P)	12	2125	(3P+2S),(4P+R)
5	858	(3P),(S-Q-P)	13	2248	(R+S),(P+Q+S)
6 →	981 →	R,(S-P),(P+Q)	14	2534	(2S),(P+R+S)
7 →	1267 →	S,(P+R),(2P+Q)	15	2820	(P+2S)
8	1553	(P+S),(2P+R),(Q-3P)	16	3106	(2P+2S)

Figure 2.3: Input Impedance and multiphonic fingerings: curves by Arthur Benade indicating heterodyne nature of multiphonic harmonic content.[38]

2.2 Pedagogy and Composition

Although the register keys described earlier lend immense help in playing and tuning pitches in the upper registers of the clarinet a practiced player can sound any partial above a first register fingering by changing their embouchure alone. A teacher can often amaze young clarinet students by demonstrating this fact as it initially seems to go against all they know about playing the clarinet--suddenly it appears to be more like a

[38] Benade, Arthur H. *Fundamentals of Musical Acoustics*, 435.

trumpet with keys when in fact the beginner probably does this constantly in the form of "squeaks". A young player will most likely not produce activate the reed frequency in a true squeak. Rather these are unintended jumps up a few partials accidentally caused by a change in playing such as the volume of air, the position of the teeth and the lips, the position of the tongue or the soft palate on the roof of the mouth. The lack of visibility of these elements of the embouchure in addition to an underdeveloped awareness of moving such small muscles creates much of the difficulty in teaching and learning to play the clarinet.

Practicing playing through the spectrum can help solve a number of basic playing issues in addition to being the first step in controlling all multiphonics. For standard playing these higher partials act as a concrete goal that confirms they have made the right physical change. This helps overcome nebulous discussions of the embouchure. For example, clarinetists commonly assume that in order to play higher pitches the player needs to exert more force by pressing their lower lip into the reed via their jaw. It is possible to play this way but the excessive dampening of the reed that this also accomplishes will choke the sound and the highest registers require so much force that it becomes painful to play. Instead, students can be taught to amplify the upper partials with the oral cavity and air direction rather than relying on the register key and brute force to change the pitch. Initially these may come out as "split tones"--harsh sounding two pitch multiphonics which consist of the fundamental and any other partial as dictated by the position of the players mouth. These have often been used in compositions (Xenakis' 1971 clarinet and 'cello duo "Charisma" is a notable early example) as they are the most universally known and predictable multiphonics. These can be satisfying to

perform but students should learn the difference in playing which allows one to also simply play pure partials to learn the voicing that will allow for more fussy multiphonics, very quiet playing in the upper registers and generally the ability to control timbre. An understanding of the acoustics of the clarinet can help older students visualize this: If one knows that both the fundamental and all available harmonics are always present at varying volumes within the regime of oscillation they can visualize playing high notes as simply increasing the relative volume of the needed partial rather than forcing the higher partial to speak. This type of teaching is a common practice but I have added another level of specificity to the exercise by creating a chart which shows the available spectrum above each note (see figure 2.4). This removes some of the ambiguity of manipulating the invisible embouchure. This chart will be shown to be useful not only as a reference for students learning to produce basic pitches but for players searching for new sounds and describing old sounds and composers using multiphonics in their writing.

In describing the sound of the instrument clarinetists often refer in indirect terms to the spectral content which contribute most directly to that sound through terms such dark, round, focused, warm and clear for desirable tone which may be contrasted with bright, hollow, thin and airy. Some of these can be quickly traced to a variance in the spectral content of the sound: dark may indicate a lower prevalence of upper harmonics while thin may indicate a general lack of anything other than the fundamental. An emphasis on different parts of the spectrum can be used to vary the timbre for expressive or ensemble purposes. For instance, an orchestral player will likely attempt to focus the sound and bring out the higher end of the spectrum to cut through a string section during a forte solo then relax it to emphasize the lower end during a brooding woodwind tutti

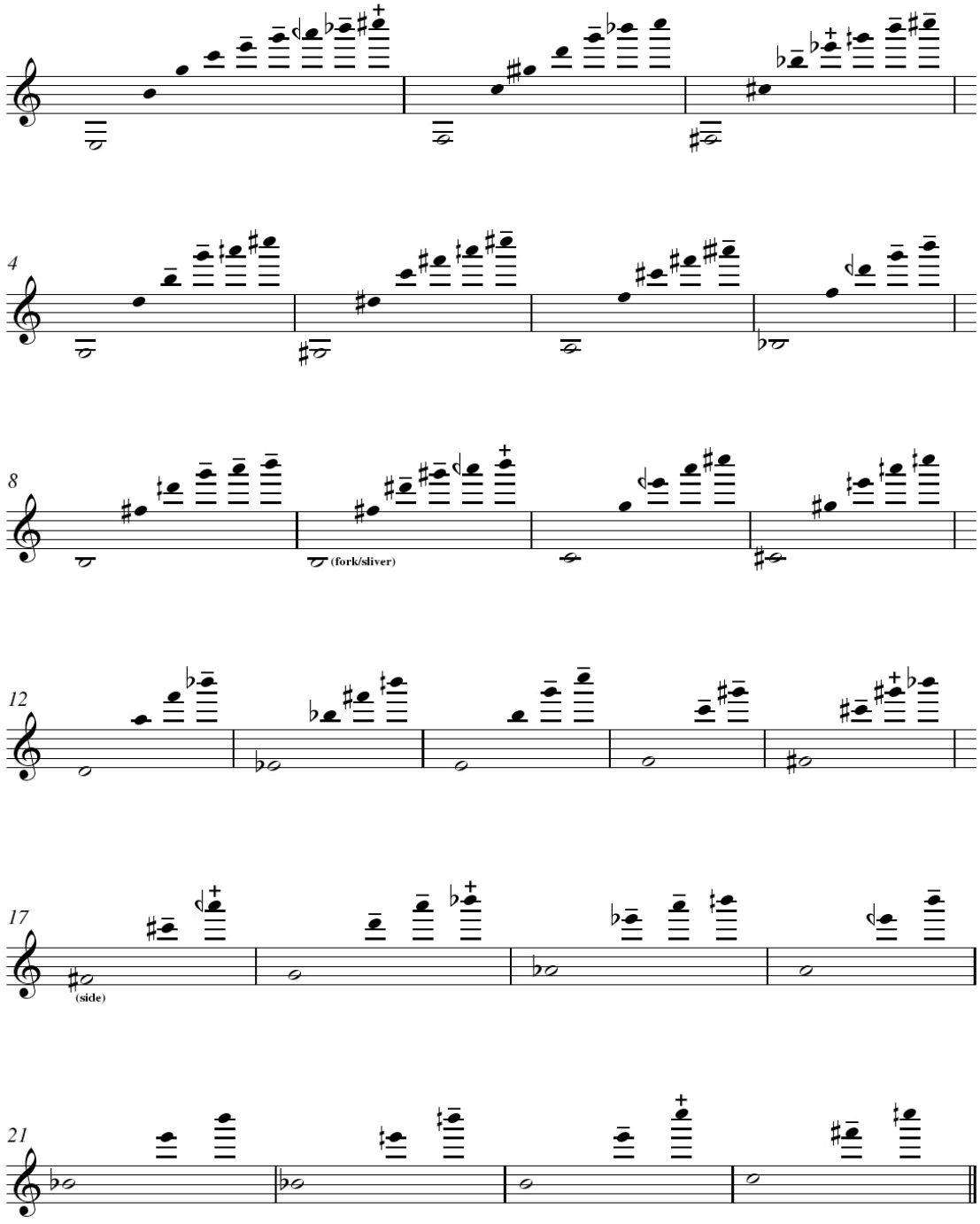


Figure 2.4: Possible partials above fundamental pitches in the lowest register, notated in Bb. The intonation of each note is approximately notated with + and – signs indicating a deviation of less than a quarter tone.

section to simply fill out the sound and blend. If the player has great control over the pitch material in the chart I've included here they could refer to the embouchure required to create these timbres specifically by partial. For example, a very focused sound might require an embouchure similar to that which would allow them to play the 7th partial C of the lowest fingered E.

Many publications, starting with the aforementioned Bartolozzi book, give listings of multiphonics with at least the approximate pitch content and the fingering used to achieve them just as beginners are provided with a fingering chart of the chromatic pitches. Often they accompany these fingerings with either a description of the difficulty or ease of response of the multiphonic, the quality of the sound (e.g. loud/soft, calm/beating) or occasionally a recording of a clarinetist performing them. These charts can provide a good starting point for experimenting clarinetists or composers interested in using such sounds but often cannot replace a collaborative process between composer and clarinetist. Every combination of instrument, mouthpiece and reed can result in slightly different sounds, but more importantly the skill of the clarinetist varies widely as the techniques require their one distinct skill set from normal training. It also poses problems for the composer: without hearing the sounds performed in context there is a tendency to use the sounds in a manner which may seem to be effective in theory but may be disappointing in practice. The multiphonic charts create the illusion that one will hear chords which could be potentially used with a distinct harmonic language but the aforementioned difficulty for the mind of determining pitch generally prevents this. This difficulty of composing without hearing first should not be surprising as few would compose for the standard notes of the clarinet without first having a good idea of what the

instrument sounds like in multiple contexts. For the performer a quick glance at the chart could be enough to learn the fingering for an effect but the chart can't show the changes in the embouchure required to make the sound speak--especially without a reference for the sound they are attempting to make. Knowledge of the pitches available in the spectrum of each normal note fingering greatly simplifies the collaboration as a starting point for both discovering possible note combinations and how to produce them.

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3. A Realization of Cornelius Cardew's *Treatise*

The content of my realization of a few pages of Cornelius Cardew's massive graphic score *Treatise* derives from ideas percolating through my mind over the course of late summer and fall of 2010 while preparing for the performance and learning to program the electronic portion of the realization in the Pure Data programming environment. As many facets of the work developed simultaneously over several months they represent both an interconnected whole and a hodgepodge. An attempt to elucidate each element's role runs the risk of ignoring the resulting layers of meaning that naturally develop in such a process. Here instead, outside of some basic rules which governed my interpretation of *Treatise*, I intend to explore one line of reasoning that runs through the piece: an attempt at representing an experience of campus protest through the recontextualization of the 1970's protest anthem "Here's to You."

As a first encounter with the interpretation of Cardew's work I interpreted each visual element on its own in as straightforward a manner as possible. With this in mind I focused on pages which contained a small number of such elements, namely circles (p. 3, see fig 3.1) and long lines stretching over many pages (pp. 7-14). Some of these lines appear drawn with a straightedge while others Cardew drew free hand and waver considerably. The straight lines of pages 7-14 immediately struck me as equivalent to the unwavering sine tone and the free hand lines an exaggeration of long tones played on acoustic instruments whose ability to constantly control pitch in minutiae prevents the same constancy of pitch achieved by electronic means. Circles implied cycles to me which varied in some way by size and location on the page: more specifically, each

constitutes a cycle of sound events of any kind and the size indicates both the volume (larger circles I considered more diffuse and thus quieter) and length of time in which the given cycle would continue (read as in proportional notation such that smaller circles last for less time). As I generally chose to read the score from left to right in time as a standard manuscript the score dictated everything except the specific sounds and durations in the case of circles, and pitches in the case of lines.

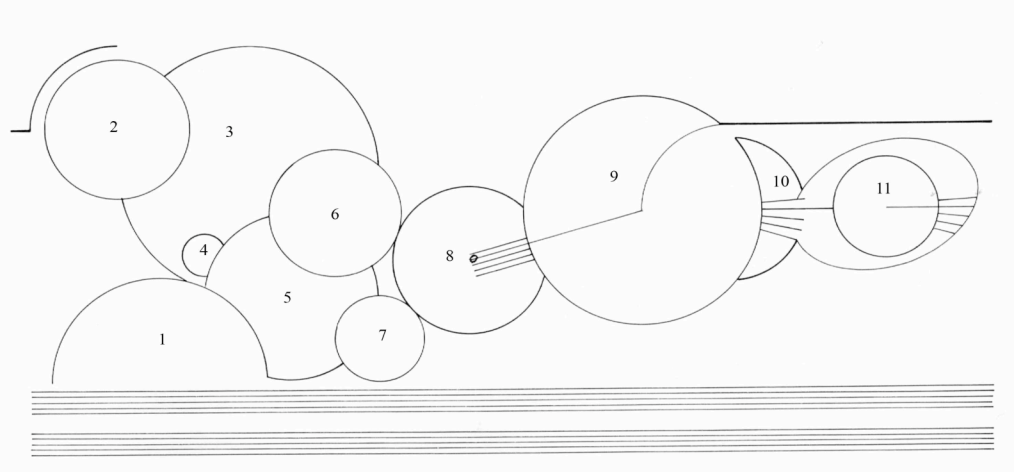

Figure 3.1: Altered page 3 of *Treatise*[39]. All numbers have been added to facilitate labeling of additional performance score (see Appendix).

Many UCSD students may remember 2010 by the many protests concerning both the economic future of the institution and several shocking racist incidents highlighting both student ignorance and institutional racism. I attempted to use the experience of taking part in these protests as fodder for the piece rather than commenting directly on the issues at stake in these student reactions. Part of my experience as a participant consisted of a concern over both the exciting (albeit disconcerting) power of a huge number of people apparently acting in concert and the feeling of powerlessness of rehashing techniques commonly associated with political statements of college students

[39] Cornelius Cardew, *Treatise* (Buffalo, New York: Gallery Upstairs Press, 1967), 3.

during the Vietnam War era or the civil-rights movement. There is a collective memory of this time period that individuals reshape in accordance with their involvement in the actual events. Activists who participated directly clearly have a memory dictated by their experience and the other memories of the time period of their life that frame it and lend it its nostalgia. For many young adult students this memory has been transferred through public education fairly early (starting with Martin Luther King Jr.'s "I have a dream" speech in grade school), often through the depiction of the era through film and television and—most importantly for my realization—through the popular folk and rock music that now tends to signify the spirit of these student movements. This music can replace the lack of personal memories of young adults to the extent that it renders the nostalgia without the participation. This can powerfully influence how they react when they witness seemingly similar injustices in the present. These same memories can work against them when witnesses of their protests against current issues disregard them by failing to register the event as important due to a perception of overuse. A relative of mine (a San Diego resident) put this to a fine point when he responded to the news of the student actions that "college students are always protesting about *something*," implying not only that the "something" in this case should not be taken overly seriously but that we need not concern ourselves with the specifics of the fact as it would simply be encouraging a commonplace overreaction to a problem considered solved long ago.

I based my use of Joan Baez and Ennio Morricone's 1971 song "Here's to You (Nicola and Bart)"[40] on this concern over these recontextualizations of such memory.

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[40] Ennio Morricone and Joan Baez. "Here's to You," *The Life Aquatic with Steve Zissou*. CD. Hollywood Records 2061-62494-2. 2004

The song has been repackaged many times in the last 40 years from its original role as part of the soundtrack to the film "Sacco e Vanzetti" about a pair of Italian immigrants and anarchists--Nicola Sacco and Bartolomeo Vanzetti--controversially convicted for a double homicide in 1920 and executed seven years later. The song was then adopted by activists in the civil rights movement as a protest anthem, used for a soundtrack again in 2004 in the Wes Anderson film *The Life Aquatic with Steve Zissou* following the death of a central character and most recently (and ironically) as the ending theme to the 2008 third person shooter video game *Metal Gear Solid 4: Guns of the Patriots*. The song's use in *The Life Aquatic* is in itself nostalgic as the movie uses many distinctly child like or perhaps fairy tale like elements: the rich, bright colors of the cinematography and direct, understated dialogue contrast with the adult thematic material concerning a documentary filmmaker, Steve Zissou, who must deal such as the death of his longtime filmmaking partner, the potential loss of his acclaim as a filmmaker, and his struggling marriage and a pirate attack on his ship. Each of these varied uses retains the names of the original eulogy (Nicola and Bart) but clearly refers to those lost in the conflict at hand.

By providing my own new context for the song amidst soft cycles of trichords I further decontextualized the song to this emotionally distant (or at least ambiguous) form which evokes the sounds world of composers such as Morton Feldman. Without knowledge of the performance history of the work an audience will read into the use of the song whatever associations have managed to reach them and if they've never heard the song before it will simply be pleasant and cyclical. The lyrics remain the same just as in the previous contexts of the song but now no plot or social context serves to give a new

identity for Nicola and Bart and they simply become anonymous names. Constant quiet oscillating sounds calls to an audience to appreciate each sound carefully as it comes just as a whisper beckons the listener to lean in and focus their intent. Placing the song in this context then causes a loss of syntactical meaning of the words in deference to their basic timbral beauty. The pitch content of the page 3 circles was unified by my use of the (013) pitch class set with one of the pitches voiced up an octave as an outlier (see appendix 3.1). The resulting sixth lends this voicing a serenity lightly tempered by the fluttering insinuation of the half step/whole step cluster of (013) and at quiet dynamics sounds familiar and comforting yet mildly alien. These are used in two ways, the first being entirely on one instrument such as circle 1 performed on bass clarinet with one pitch played normally while the other two pitches are traded back and forth by the clarinetist singing through the instrument. The interference between the voice and the normal playing creates a muddy sound contrasting with cycles such as circle 2 in which the horn trades quietly trades pitches with double bass double stops.

Circle 10 emerges from behind the quietly intoned Baez: the visceral satisfaction from singing and playing a fifth and resolving to a wide open authentic cadence to the point of hoarseness. The student taking their turn at the megaphone with "the people united..." doesn't care about the originality of their declaration as long as it allows them to embody the voice of the entire group—both the present gathering and past victims of injustice.

I interpreted the five evenly spaced lines of pages 7-14 as a series of stacked perfect fifths create the basic framework for latter half of the performance (see Appendix for Pd patches). On page 8 of the score Cardew wove a circle into these long lines. I

took advantage of this as a moment in which I could recontextualize yet again the Baez work, this time by means of fading in and out a fragment of the original recording. Here, amongst the pure and exacting music of numbers, the fragment intrudes rough and overly familiar like a comic book character suddenly appearing in a Mondrian painting. This also serves to unify the work by revealing the source of the song in page 3. It is united again in the final moments of the realization through a sine tone cluster resembling the (013) collection from earlier created by a series of 12:11 intervals rather than semitones. The pitches enter during the fifths as one 12:11 above, one below the lowest tone of the fifths and one more below that (121/144 below the original tone). The resulting three pitches consist of a narrow perfect fourth divided into a narrow minor third and a narrow major second which create an unfamiliar yet pleasant flutter before cutting off unceremoniously.

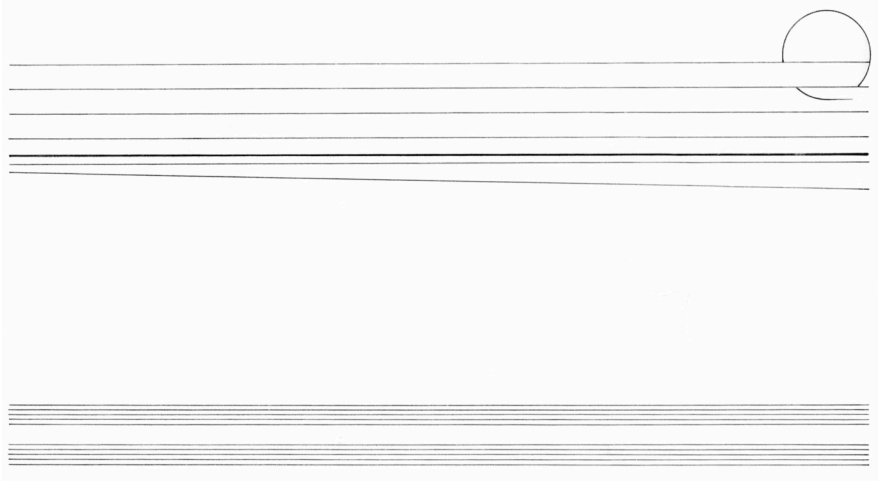

Figure 3.2: Page 8 of *Treatise* showing circle interpreted as a literal Baez sample.

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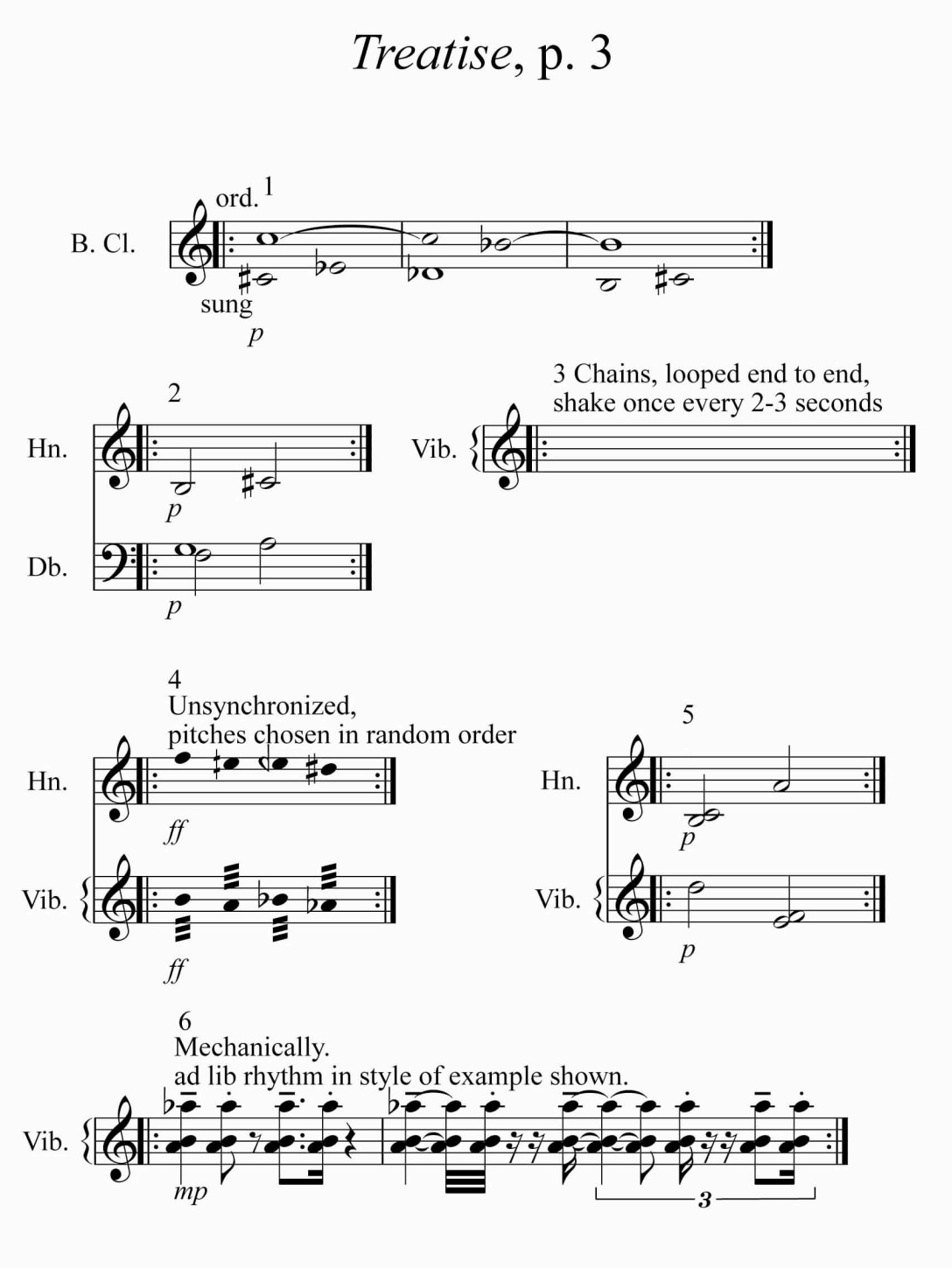

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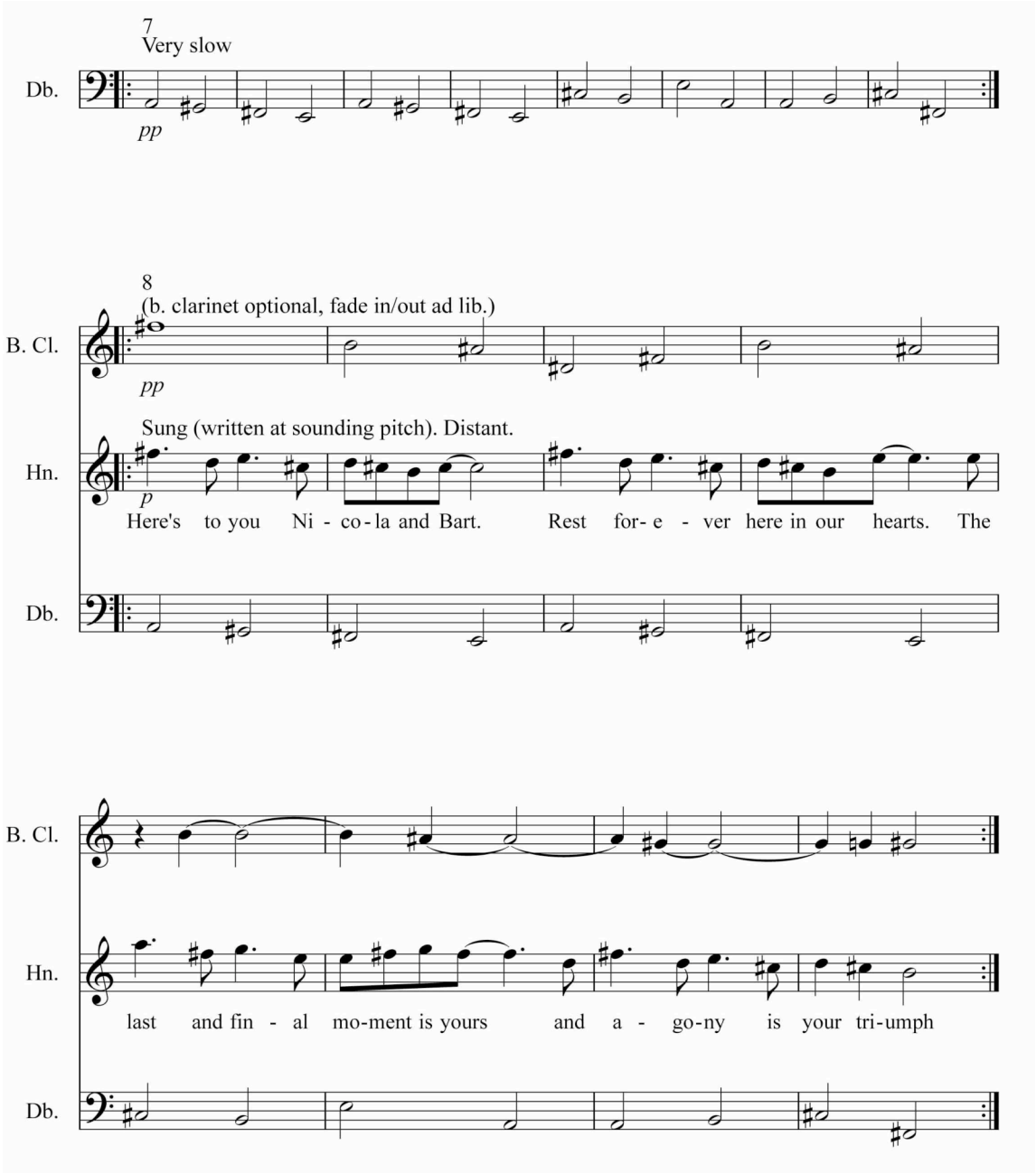

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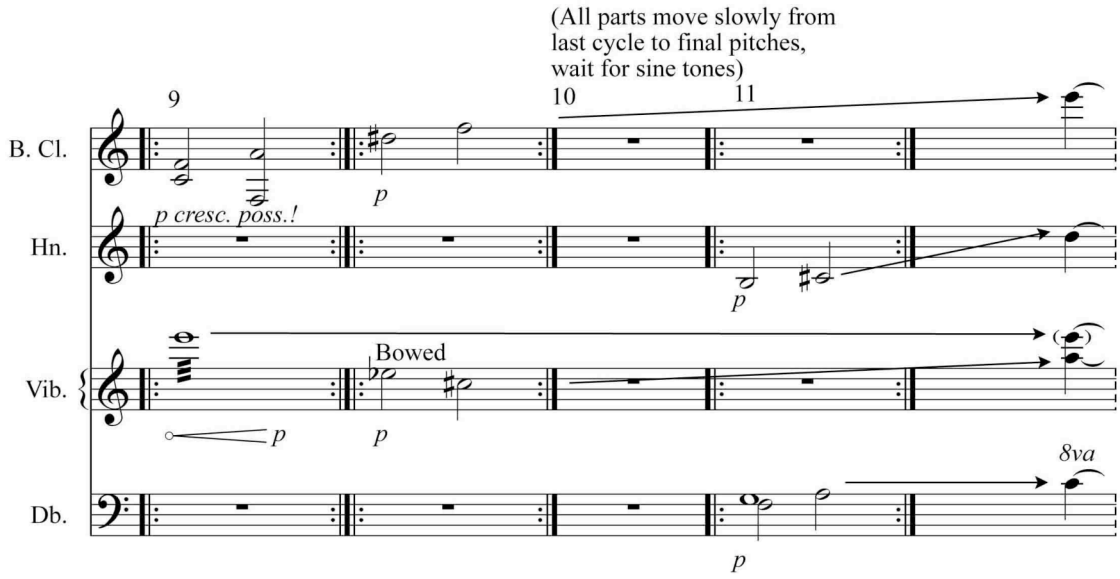
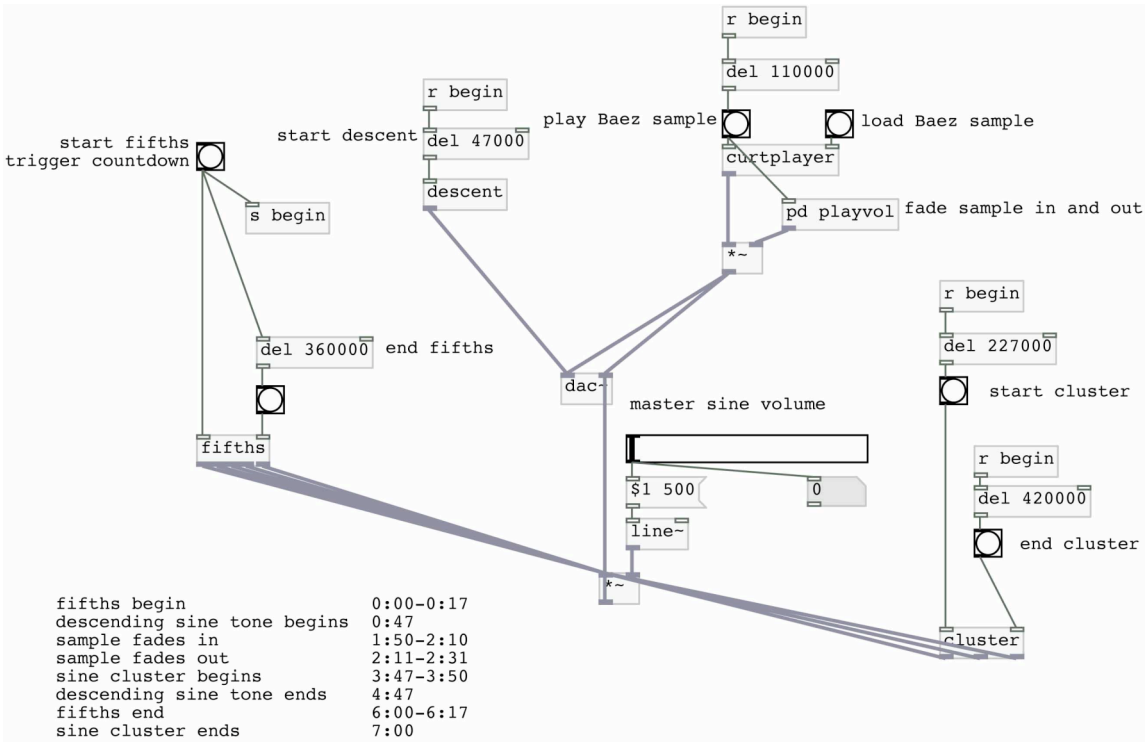
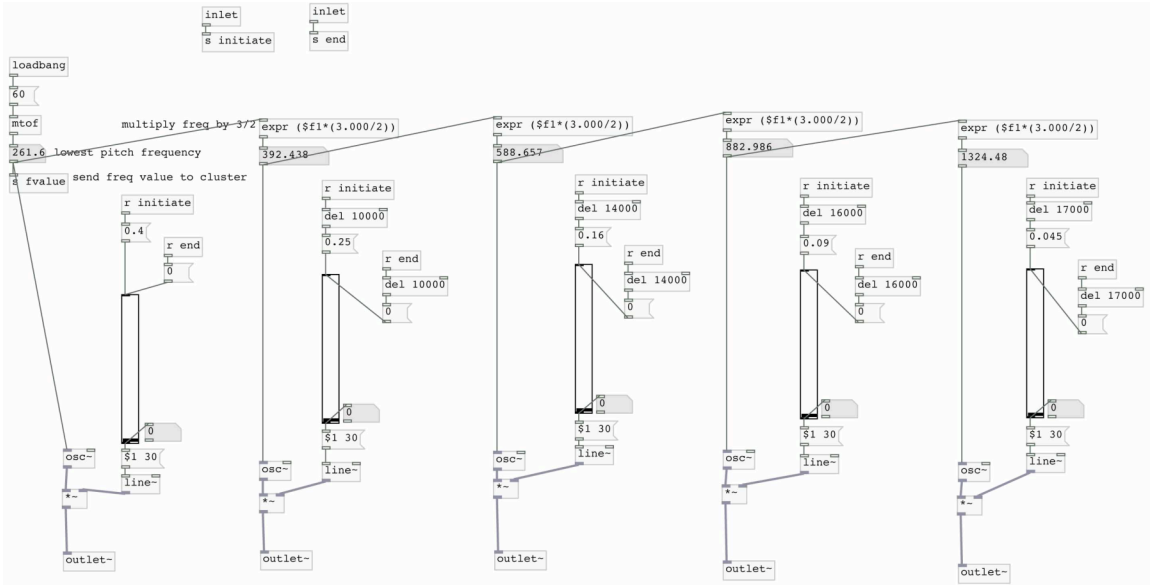


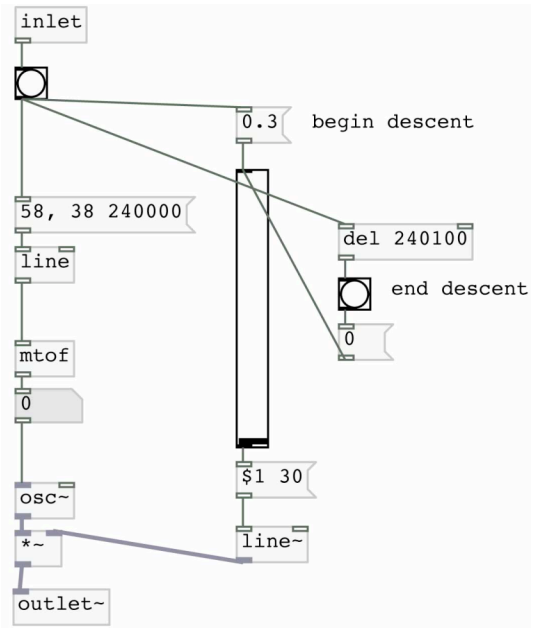
Page 3 of supplemental score.



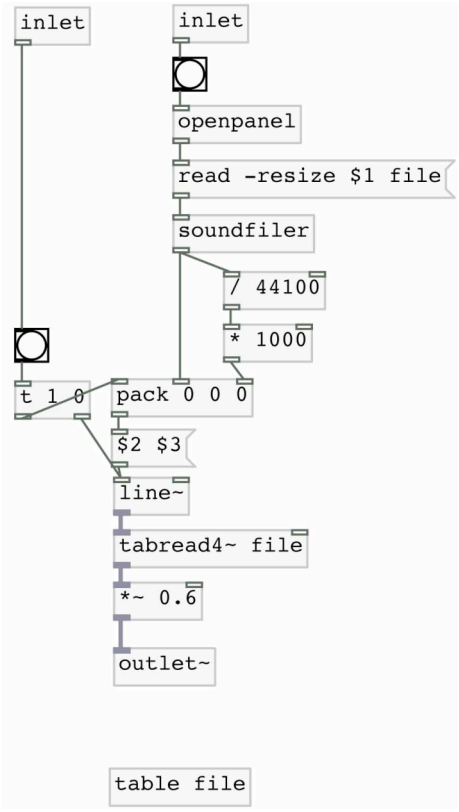
Control patch for pages 7-14



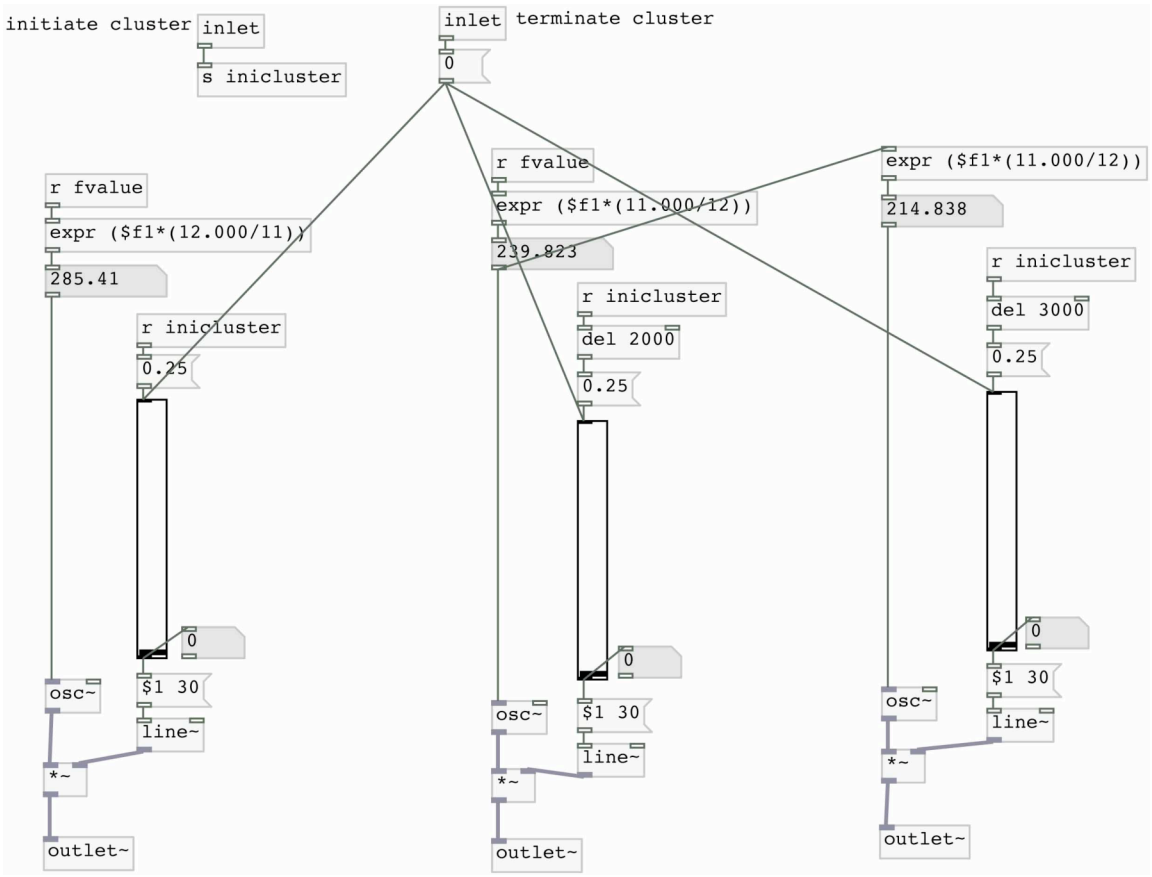
Subpatch “fifths” for five sine tones in fifths based off C4



Subpatch “descent” for descending sine tone from Bb3 to D2



Subpatch “curtplayer” to play Baez sample.



Subpatch “cluster” for final sine tones in 12/11 intervals.