THE ERA OF MEGAPHONICS: ON THE PRODUCTIVITY OF LOUD SOUND, 1880-1930

by

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ABSTRACT

This thesis examines a cultural interest in loud sound as a productive force between 1880 and 1930. Recent historical scholarship on sound at the turn of the 20th century has given substantial attention to noise abatement movements and their efforts to control public space. In shifting the focus towards a significant collection of people interested in the generative aspects of sonic power and its ability to paralyze the body, empty the mind and even threaten life is to suggest ways in which idealist or utopian hopes were interlaced with an idea of sonic agency. This thesis looks at three aspects of the megaphonic: firstly, the push to build the world's loudest instrument, a pipe organ; secondly, the proliferation of powerful fog-signalling along North American coastlines; and lastly, the development of shock-wave science and the increasing understanding of sound as a physical and mortal force.

Cette thèse examine un intérêt culturel pour le son fort comme force productive entre 1880 et 1930. De récentes recherches historiques sur le son au début du 20e siècle ont accordé une attention considérable aux mouvements d'atténuation du bruit et à leurs efforts pour contrôler l'espace public. En déplaçant l'accent vers un important groupe de personnes intéressés par les aspects générateurs de puissance du son et leur capacité à paralyser le corps, vider l'esprit et même menacer la vie suggère des façons dont certaines aspirations idéalistes ou utopiques ont eu une dimension sonore. Cette thèse porte sur trois aspects du mégaphone: d'une part, la pression de construire l'instrument au son le plus puissant du monde, un orgue à tuyaux, d'autre part, la prolifération de puissants signaux de brume le long des côtes nord-américaines et, enfin, le développement de la science de l'onde de choc et la compréhension croissante du son comme une force physique et mortelle.

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Canit
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R.I. Semp Augustū
Felix Cheurier del.
G. Ana. Wolfgang f.

INTRODUCTION

Hark! A new birth-song is filling the sky ! —
Loud as the storm-wind that tumbles the main
Bid the full breath of the organ reply, —
Let the loud tempest of voices reply, —
Roll its long surge like the earth-shaking main!
Swell the vast song till it mounts to the sky! —
Angels of Bethlehem, echo the strain!

–Oliver Wendell Holmes, "A Hymn of Peace" [1]

In 1869, a very large musical celebration took place in Boston, Massachusetts. The National Peace Jubilee, as it was called, was a gathering of some 11,000 singers from some 100 choral groups with over a thousand-piece orchestra section. It was then proclaimed to be the "greatest musical enterprise of modern times." If that wasn't quite true, it was still one of the largest gatherings to showcase a distinct blend of celebratory patriotism and spiritual revelation. Spectacles such as the "anvil chorus," which swung one hundred anvils in unison, reportedly "gave an impression of sublimity more than noise."[2] The massive, sprawling *History of the National Peace Jubilee* text referred to the crowd as solemn and oceanic. Fitted especially for the occasion, its custom-built pipe organ delivered music of "thunderous" quality. The music amidst the crowds was described as an overwhelming force of divine power, but also one that invoked storms and madness. Yet the experience was also perceived by some as a let-down. Despite cannons exploding on cue with the music, as well as thousands of voices singing to note and anvils clamoring in unison, to some visitors it was a disappointment of the promise of transcendental power that was *not* achieved. One reviewer in attendance remarked on this underwhelming power:

[1] Patrick Sarsfield Gilmore, *History of the National Peace Jubilee and Great Musical Festival: Held in the City of Boston, June, 1869* (Boston: Lee and Shepard, 1871), 295.
[2] Patrick Sarsfield Gilmore, *History of the National Peace Jubilee and Great Musical Festival: Held in the City of Boston, June, 1869*, 563.

> And now rises such a volume of sound as never before greeted human ears. It has a mystic puissance that cannot be analyzed. Its extended source destroys the sense of locality. It fills the air with its new vibrations that bring to us a novel emotion of universality. It mounts with a grandeur that gives us a new sensation. There are no favored registers heard, no individual voices; everything personal, trivial, local, is drowned out in the majestic flow of this grand chorus. Having felt the first effects of the combination, having remarked that they have touched the auditory with the new potency, as the ear becomes accustomed to the surging and swelling of the tide, we become, too, calm enough to perceive that it is not the bulk of the sound that is effective; indeed, a very general disappointment was felt that the united forces produced no louder music. People had expected a concussion of the air; they were surprised that the building did not tremble and that the music could not be heard four or five squares off. They found that in the ratio of size there was new smoothness, a new solemnity; instead of being volcanic, it was aerial. They were disappointed in the loudness, but moved by the majesty.[3]

[3] Patrick Sarsfield Gilmore, *History of the National Peace Jubilee and Great Musical Festival: Held in the City of Boston, June, 1869*, 516.

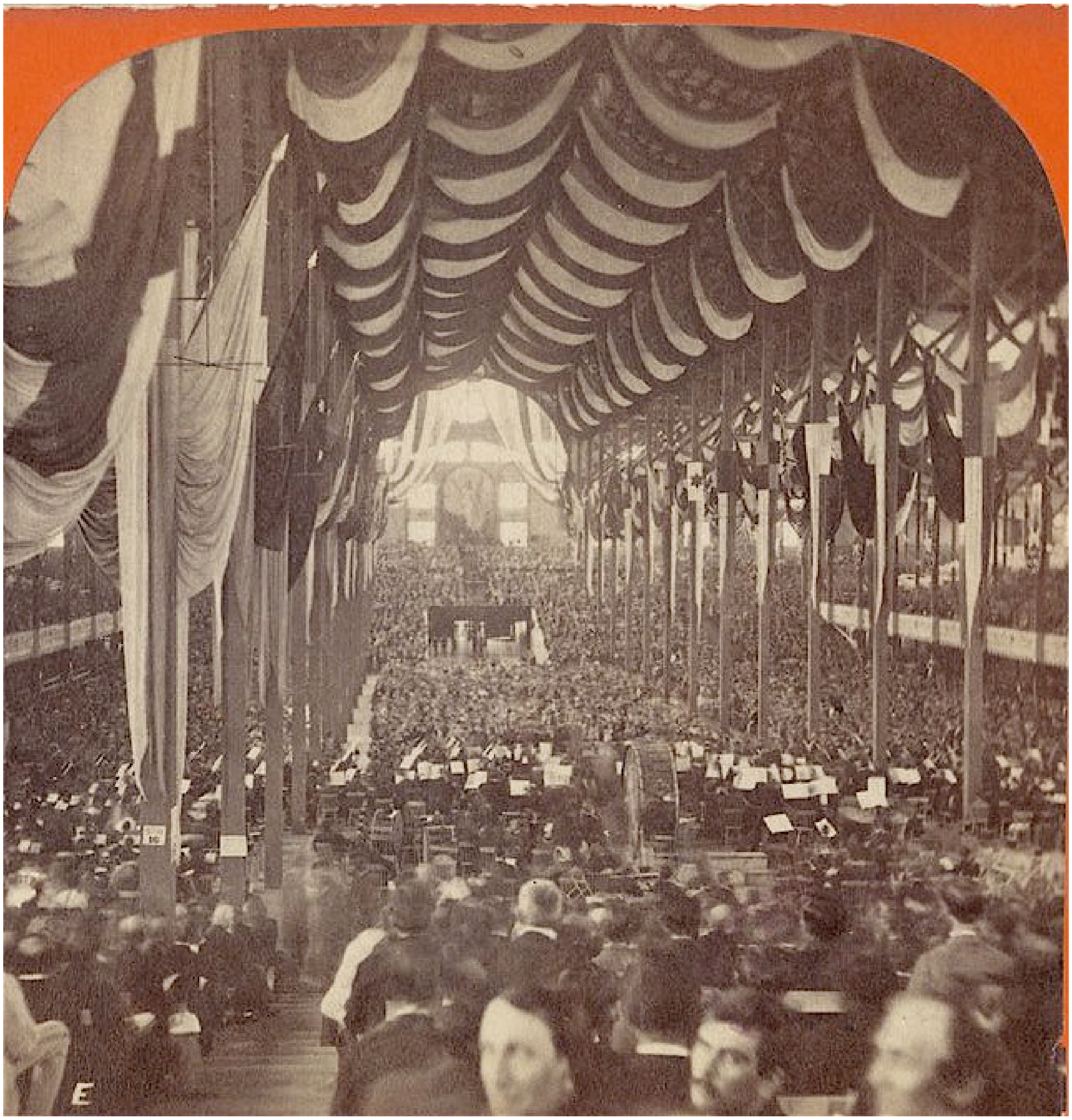
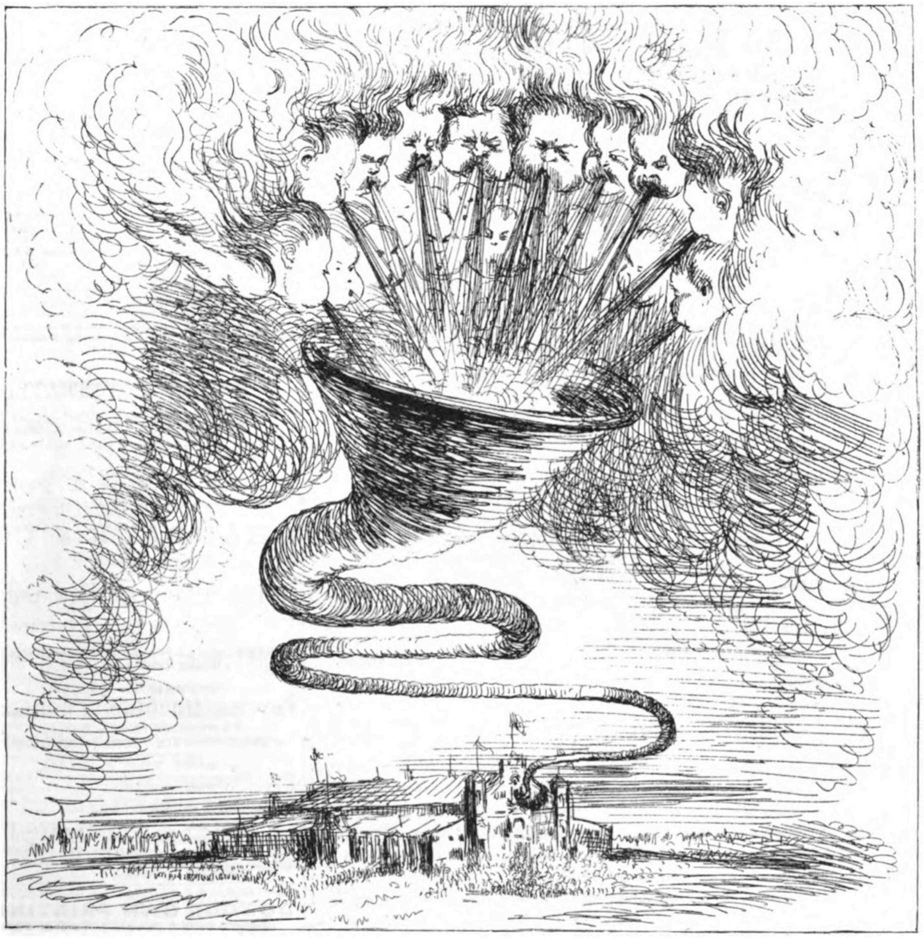


Figure 1. A Crowd Almost Dwarfed by Performers, National Peace Jubilee, Boston, June 1869



UNLIMITED SUPPLY OF POWER FOR THE JUBILEE.

Figure 2. Promises for the 1872 Jubilee (Jubilee Days)

Those who had truly expected a concussion of the air may have tried their luck again three years later at the 1872 Boston Jubilee, which featured over double the musicians and 20,000 singers. The festival boasted all the modern amenities, including globally connected telegraph systems for visiting foreign dignitaries. It was an escalation of technology and scale that would take on the apparent logic of an acoustic arms race.

But it was not the first of its kind either. In 1794, French composer Etienne Méhul's *Fete de l'etre Supreme* devised a scheme for the performance for 300k voices. It entailed the vast rolling of 200 drums to be heard alongside artillery fire out of a desire for "music of an almost religious character, exalted, pompous and impressive."[4] Another seeking sonic power was the 17th century Jesuit scholar Athanasius Kircher, one of two people claimed to have invented the technology of the megaphone. His "tuba stentorophonica" was described in his publication *Phonurgia Nova* as a "trumpet with a strong sound" that purportedly had significant sound emission potential. Kircher's other interesting work involved the implementation of acoustic signaling that served as an early system prototype for very fast network communication.[5] The phenomenon of loud sound was tied up with the possibility of transcending distance by acoustic force. Through networks of acoustic signaling, messages could be carried over hundreds of kilometers in just minutes instead of the wilting lag of ground-based message carriers.

The power of loud sound was appealing for many reasons, be it narcotic, communicative, or musical. To return for a moment to the expressions of disappointment at the perceived insufficiencies of the 1869 Jubilee, this thesis picks up on the perception of lack expressed above. In the image shown in *Figure 2*, in which the faces in the sky blow downward into a funnel attached to the festival building, reveals a snapshot of how acoustic power was characterized by the dreamers involved in the series of Jubilees: the wind of the heavens which could be channeled into acoustic force. This study charts the transformation and escalation of that characterization from the romantic wind of the divine to an electro-mechanical force capable of nefarious results. The Jubilee organizers intuited that the power of sound was not what it could be. Celebrations could be louder. Music could have more impact. The walls could shake more. Sound could travel farther. This document dedicates over two hundred pages to the inquiry of this almost mystic quest.

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[4] Arthur Ware Locke, *Music and the Romantic Movement in France.* (Freeport, N.Y.: Books for Libraries Press, 1972), 66.
[5] Athanasius Kircher, *Phonurgia Nova* (New York: Broude Brothers, 1966).

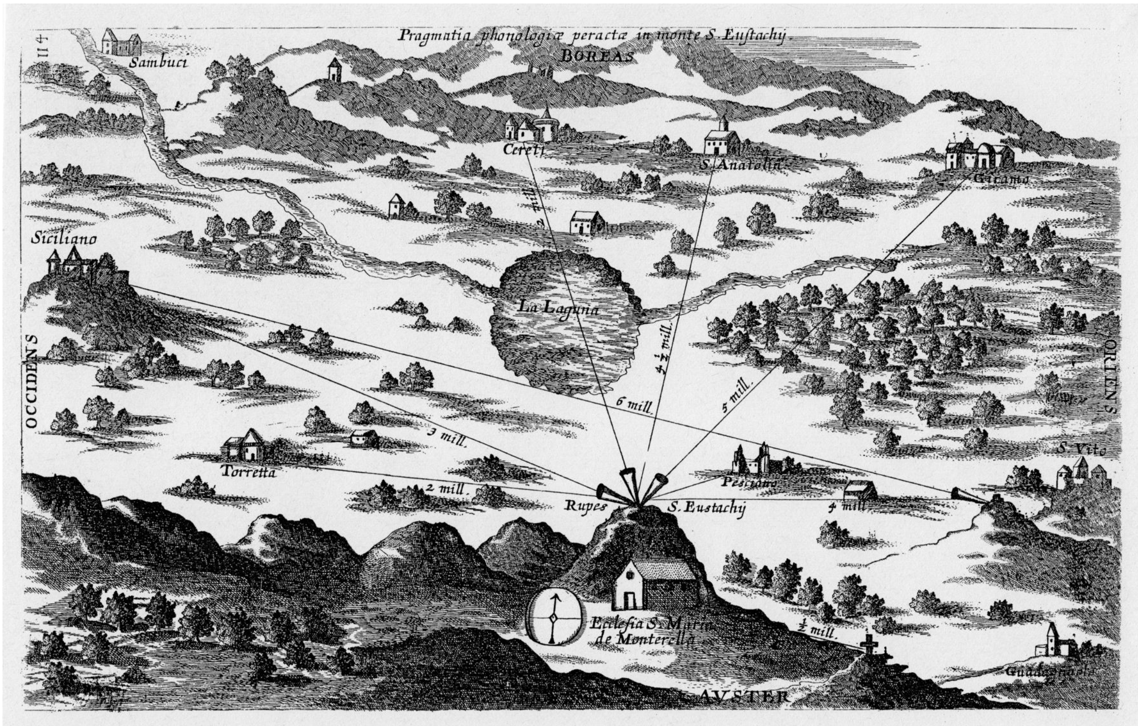

Figure 3. Acoustic Network Signaling in Kircher's Phonurgia Nova (1673 Facsimile)

The Megaphonic

This thesis is primarily interested in examining the question of "megaphonics" roughly between 1880 and 1930. That is to say it is interested in examining the curiosity, the obsessions, and the dread surrounding the possibility of loud sound as a productive and material force. Throughout this study, the term "megaphonics" will be employed to refer to sound intensity and the perception of that sonic intensity, loudness. "Megaphonics" has greater precision than the oft-utilized term "noise" which will still be used in limited contexts when appropriate. The term "megaphonics" was once used by scholar Steven Connor as a title of a radio essay largely ruminating on the poetics of noise, yet he actually didn't use the term in substance.[6] "Megaphonics" has Greek roots in *phōnē,* largely denoting the voice. To shift the discussion surrounding loud sound away from "noise" and towards the rubric of megaphonics, I seek to open a space for inquiry at a breathable distance from academic discourse on noise as unwanted sound. Gunpowder, foghorns, and pipe organs will all be portrayed as megaphonic technologies rather than social blights. In the same light, massive explosions, infernal organ concerts, and supremely-powered nautical signalling can all be said to yield megaphonic affect. Megaphonics, for the purposes of this dissertation, are that which present sound intensity as a productive force.

In discussing megaphonics it is important to delineate "sound intensity" from "loudness." "Intensity" is an objective, measurable reading of the power of acoustic phenomena whereas "loudness" is a subjective and internal experience of external acoustic phenomena. They do not always necessarily correspond: "Intensity", notes Greg Milner, "is what makes our eardrums vibrate, but when those vibrations are translated into electrical impulses in the cochlea and sent to the brain, the magic of psychoacoustics takes over… intensity 'is correlated with what happens outside our ears, but loudness exists only inside our heads.'"[7] Loudness will generally mean to be the quality of a sound that is essentially a psychological correlate of physical sound intensity. It is a subjective term through and through. It suggests the perception of abundance.

Though this dissertation is essentially a cultural history of megaphonics, a separate history could be conducted on the varying associations with the term "loudness." For Hermann von Helmholtz, loudness was the actual physical process of the excitement of a large area of the basilar membrane in the human ear. Each string or fiber of the membrane

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[6] Steven Connor, "Noise / Megaphonics," http://www.stevenconnor.com/noise/noise5.htm (accessed 13/07/2013.

[7] Greg Milner, *Perfecting Sound Forever: An Aural History of Recorded Music*, 1st ed. ed. (New York: Faber and Faber, 2009), 248.

was attuned to a particular frequency of sound wave. A sensation of loudness was produced when an increased number of fibers were activated: greater the number of fibers activated, greater would be the experience of sound wave intensity.[8] This discussion will be carried further on in chapter 3, which deals with shock wave theory, the work of Ernst Mach, and the domain of psychophysics.

There is considerable back-and-forth between the *psychological* experience of loudness and the *physical* process of heavy acoustic wave propagation. However, these terms have often been used interchangeably and this work on megaphonics recognizes an inherent degree of slipperiness between the two. "Loudness" can be used to mean intensity. This study deals with technologies of sound intensity — pipe organs, foghorns, electrical amplification and explosions — in light of both senses of the term, but also the effect of that intense (or what I often call loud) sound: immersion, dissolution of subjectivity, experiences of the sublime, transcendentalism, and sensory transmutation. Psychophysics weighs important in this discussion, as the human experience of loudness also points to the temporary obliteration of the distinction between inside and out, that of external reality and the internal psyche.

A strictly external, physical measure of sound intensity is a difficult phenomenon to objectively measure and quantify. It almost evades metrics. The genesis of the current metric of sound intensity, the decibel (dB), points to the historical inseparability between loud sound and early networks of long-distance communication. In the 1920s, researchers at Bell Telephone Labs were attempting to measure the amount of decay in signals over long distances of telephone wire. In comparing the power of the input signal to the power of the output signal, they created a new unit of measure, which was named the "bel" in honor of

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8 Edwin Boring, "Auditory Theory With Special Reference to Intensity, Volume, and Localization," *American Journal of Psychology* 37, no. 2 (1926), 106.

Alexander Graham Bell.[9] As a standard unit for comparative sound level, it measures the ratio between two sound intensities. Thus, standard measurements of sound intensity utilize a relative rather than absolute value. Other metrics exist in an effort to more objectively measure intensity, but the most ubiquitous one is far from objective. Not only are metrics for loudness and intensity for the most part relational, the actual experience of loudness also varies based on tonality. Another seminal piece of work from the Bell Labs from Fletcher and Munson in 1933, showed that low-frequency sounds are perceived to have a greater intensity than high-frequency sounds.[10] For example, a 1,000Hz tone at 50dB sounds as loud as a 100Hz tone at 60dB. This discrepancy decreases with increased intensity.[11] The history of acoustic measurement is rife with competing units of measurement, such as the "phon", the "sone" or the "wien" and unresolved debates regarding the use of those units raged until an eventual standardization.[12]

Part of the work that took place at the Bell Labs during this fruitful period was dedicated to the science of sound, including work on sonic amplification. Amplification is the process of making an acoustic signal louder, most commonly through processes of electrical enhancement. Not only is this the act of megaphonic sound generation by making something louder, but it is also the rendering of the unheard into the heard. The achievements of making atoms and electrons audible to the human ear was first reported in a December, 1924 edition of *Science News-Letter*. Later, General Electric's laboratory reported

[9] W. H. Martin, "Decibel—The Name for the Transmission Unit," *Bell System Technical Journal* 8, no. 1 (1929).
[10] Fletcher and Munson, "Loudness, Its Definition, Measurement and Calculation." *Journal of the Acoustical Society of America* 5 (1933): 82-108.
[11] See H. M. Halverson, "Tonal Volume as a Function of Intensity," *The American Journal of Psychology* 35, no. 3 (1924): 360-67., S. S. Stevens, "The Volume and Intensity of Tones," *The American Journal of Psychology* 46, no. 3 (1934): 397-408., Gilbert J. Rich, "A Preliminary Study of Tonal Volume," *Journal of Experimental Psychology* 1, no. 1 (1916): 13-22.
[12] Karin Bijsterveld, *Mechanical Sound: Technology, Culture, and Public Problems of Noise in the Twentieth Century*, Inside Technology (Cambridge, Mass.: MIT Press, 2008), 105-10.

making electrons able to be heard through a “hundred-thousand fold” amplification via vacuum tube radio amplifiers: "The rain-like blows of many electrons on the plate of the tube produced a roar that sounded like Niagara in the distance."[13]

The seduction of amplification was also an interest of the symphonic concert world. Using the power of amplification and the relay capabilities of telephone lines, a Stokowski-conducted performance of Wagner's work was given greater range, both in terms of dynamics and actual physical distance:

> "Wagnerian music was played with whispering pianissimi and thunderous crescendos hitherto unheard by human ears. Stokowski by the turn of a control knob could subdue his orchestra, isolated in another part of the theater, to a mere trickle of sound or he could build up their music to the sound of two thousand musicians at a peak of output."[14]

The idea of taking of one of the great, most emphatically loud pieces ever composed in the classical canon and broadcasting it, while giving the conductor control over the volume knob instead of a baton, is an emblematic act of the megaphonic imagination at work. It was also an intersection between telephone technics and musical megaphonics. Seductions of sonic powers were widespread. This history of megaphonics covers an era of crowds seduced by electronic loudspeaker amplification, of dreamers who built the world’s loudest and largest musical instrument ever made, and philosopher-scientists who built contraptions to freeze shock-waves as photographic proof of the materiality of invisible waves.

This thesis is not specifically a study of technologies of loud sound propagation nor is it an examination of its related scientific fields. It is much more a cultural cartography of idealist and utopian approaches to the power of sound at a time when sound was seen to be

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[13] *Science News Letter*, Volume 5, Number 191, December 6, 1924, p. 5.
[14] *Science News Letter*, Volume 23, Number 628, April 28, 1933, p. 243.

infinitely capable, technologically unbounded, and even mortally dangerous. Specifically, it examines instances between 1880-1930 where loud sound was viewed as having a generative or productive power. This productivity was the belief in the power of loud sound as an agent of transcendence, otherworldliness, safe navigation, hysteria or even death. A history of megaphonics such as this is not a triumphalist narrative of the immense march of technology and culture upwards and onwards. It is a snapshot of a rogue consensus that proposed, albeit for a prolonged moment, the near-limitless nature of acoustic intensity. It is the documentation of an arc whereby sound's limits were circumscribed: be it in the eventual diminution of public interest in live organ concerts before the dawn of recorded media, or the end of the belief in foghorn trustworthiness at the moment radar navigation was adopted. This era also points forward towards developments as wide-ranging as the deployment of acoustic weaponry to the loudness wars in music production.

As noted, this dissertation will primarily focus on a 50-year period between 1880-1930. The rationale for this periodization is multi-pronged. This era was the period in which an interest in the power of loud sound formed and took hold across a broad set of domains and instances. It was not the genesis of interest in megaphonics per se, but a catalytic epoch where its tenets began to matter significantly for domains as wide as musical expression, nautical communication, psychology and medicine. This emergence of an interest in loudness occurred, not surprisingly, alongside modern approaches to noise abatement. Significant historical work has been done regarding quests to eradicate "unnecessary noise" but little focus has been given to those who were seduced by its apparent wide-spanning possibilities.[15] Lastly, this timeframe allows for the study of megaphonics to dovetail against one standard periodization of "modernity", and thus engage with numerous claims pertinent

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[15] See Karin Bijsterveld, *Mechanical Sound: Technology, Culture, and Public Problems of Noise in the Twentieth Century.* (Cambridge, Mass.: MIT Press, 2008).

to the subject including Gustav Le Bon's argument that modernity was "the era of crowds", Emily Thompson's qualitative assertions around the "modern sound", and Hillel Schwartz's claims about noise being essentially constitutive of modernity's "essence".[16] Yet also quintessentially "modern", for example, is the brutal reality of early twentieth-century mechanized warfare. The characterization of the apocalyptic clamor of modern warfare captures one aspect of the megaphonic sublime through the writing of Ernst Junger:

> Ahead of us rumbled and thundered artillery fire of a volume we had never dreamed of, a thousand quivering lightnings bathed the western horizon in a sea of flame. A continual stream of wounded, with pale, sunken faces, made their way back, often barged aside by clattering guns or munitions columns heading the other way.[17]

Junger's work suggests a battlefield landscape of death that was also a miserable world of sonic shock.

Why Study the Megaphonic?

> *This offends you? You hiss at me? ... Louder!—I missed the insult! Louder! What's that? Ambitious? ... By all means! We're ambitious men, we are, because we don't wish to rub against your smelly fleece, O reeking, mud-colored flock, driven down the ancient streets of the Earth. But 'ambitious' is not the exact word! We're more like young artillerymen on a toot!—and you, however you may hate it, must get used to the thunder of our cannon!*
>
> - Marinetti, 'Lets Murder the Moonshine', April 1909[18]

Despite gaps in historical scholarship around the productive powers of loud sound, an impressive and growing body of literature already exists on the relationship between noise

[16] Gustav Le Bon, *The Crowd: A Study of the Popular Mind* (Mineola, New York: Dover, 1895), x. Emily Thompson, *The Soundscape of Modernity: Architectural Acoustics and the Culture of Listening in America, 1900-1933* (Cambridge, Mass.: MIT Press, 2002), 11. Hillel Schwartz, "Noise and Silence: The Soundscape and Spirituality," http://www.nonoise.org/library/noisesil/noisesil.htm..
[17] Ernst Junger, *Storm of Steel* (New York: Penguin Books, 2004), 91.
[18] Filippo Tommaso Marinetti, and R. W Flint, *Marinetti; Selected Writings* (New York: Farrar, Straus and Giroux, 1972), 46.

abatement and modernity.[19] These studies have done much to shed light on completely understudied corners of cultural history as recently as a decade ago. However, as useful, pertinent and erudite much of this scholarship has been at this time of writing many more questions are left lingering than are answered. Questions like why the largest and loudest musical instrument ever made was a product of the early twentieth-century, or why the late nineteenth-century witnessed the construction of a fog horn over twenty feet wide in diameter. What was it about these points in time that facilitated these technological and creative forays into sonic power? Neither noise abatement histories nor conventional narratives of avant-garde musical practice answer these questions. Instead of simply listing the litany of sound histories of the period, this introduction will outline some of the concerns stemming from existing literature.

Filippo Tommaso Marinetti's equivocation of the work of the Futurists with the loud assault of heavy artillery was also a provocation against a form of staid, old-fashioned, calm bourgeois artistic and intellectual culture. The embrace by Futurists of progressive technology, radical art and literature, as well as militarism and an ascending fascist politics in Europe, was also an embrace of a shock tactic where loudness was a metaphor for flushing out the old and for ending morbid calmness. Sonic intensity, shock, and assault were foundational to Futurist aesthetics. Yet, discourses in particular around the question of loudness in music are a subject that leaves more questions than it provides answers. Studies around noise music often conflate noise as something both sonically intense and subjectively unpleasant. A significant number of texts on the subject of noise music utilize historical narratives almost always linked back to Luigi Russolo and the Italian Futurist movement.

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[19] See for example Karin Bijsterveld, *Mechanical Sound: Technology, Culture, and Public Problems of Noise in the Twentieth Century*, and Emily Thompson, *The Soundscape of Modernity: Architectural Acoustics and the Culture of Listening in America, 1900-1933*.

Russolo's work celebrated the noises of the machine and the dynamic cacophony of modern urban life. He was noted as both an aesthetic and political ideologue as well as a composer bent on a new approach to composition. As a birth almost akin to an immaculate conception, Russolo's *The Art of Noises* and his noise symphony are seen as year zero of a radical form of immense cacophonous city symphonies.[20] This aesthetic valorization of noise in music has been consistently supported by a wide range of historical scholarship.[21] While not suggesting that we revise the place of Futurism in the history of musical culture, I would like to insert some space for another angle of inquiry by arguing that the Futurists were not necessarily singular avant-garde anomalies, but rather products of an era in which loud sound was a subject of broad concern. By looking at musical dreamers and technological inventors of loudness in music by, for example, examining the rise in compressed air pipe organs (which is still the loudest instrument ever built), will be to paint the era of the early twentieth-century as a widespread culture of clamor. This is to show that noise music did not congeal out of thin air with the creation of the Italian noise *Intonarumori*, but rather suggest that it emerged from a deeper and more complex web of cultural, social, and technological intermediations. One could just as easily point towards the Shaker sect's practice of boisterous transcendentalism or the use of the diaphone's ability to shatter glass in organ-based musical concerts, as one could preference a small avant-garde Viennese café circle's ability to dominate cultural discourse. One aim of this thesis is that it provides suggestions for other historical attributes expressed in actual events and occurrences that

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[20] Luigi Russolo, *The Art of Noises*, Monographs in Musicology (New York: Pendragon Press, 1986).
[21] See, for example, Karin Bijsterveld, *Mechanical Sound: Technology, Culture, and Public Problems of Noise in the Twentieth Century*, 141. Douglas Kahn, *Noise, Water, Meat: A History of Sound in the Arts* (Cambridge, Mass.: MIT Press, 1999), 56. Emily Thompson, *The Soundscape of Modernity: Architectural Acoustics and the Culture of Listening in America, 1900-1933*, 136. Paul Hegarty, *Noise/Music: A History* (New York: Continuum, 2007), 5. R. Murray Schafer, *The Soundscape: Our Sonic Environment and the Tuning of the World* (Rochester, Vt.: Destiny Books, 1993), 110.

contribute to an enduring cultural interest of sound intensity, distortion, and overload in the musical aesthetics of the twentieth-century.

Noise Histories are not Loudness Histories

As mentioned, a significant body of literature on "noise" has appeared over the past decade. Much of this literature has in part been interested, in examining efforts made to quell a perceived rise in urban sound levels in the early twentieth-century across major North American cities. These studies share an understanding that the ascent of urban noise was a salient feature of modernity. They also share the assumption that sound levels of cities have indeed risen—I will argue this is a tacit argument throughout this body of literature. Karin Bijsterveld, for instance, has written extensively on the nerve-wracking "diabolical symphony" of the modern city between the late 19th and early 20th centuries.[22] Coming from the perspective of science and technology studies, Bijsterveld is interested in the importance of noise as a key aspect of technological culture. Her 2001 article, "The Diabolical Symphony of the Mechanical Age" looked at the intersection of early 20th century noise abatement campaigns and what she refers to as the "symbolism of sound." In essence, Bijsterveld argues the technological field of the era contributed to a transformation of the sonic environment of modern society, and the underlying meaning-structure within which the noises of the city were categorized was itself a dynamic system. She argues that the category of noise was subject to cultural hierarchies that were not at all static, that biases and preferences towards which loud sounds were preferable or not was itself a shifting system of meaning. In so doing, Bijsterveld charted the rise of noise abatement campaigns

[22] Karin Bijsterveld, "The Diabolical Symphony of the Mechanical Age:: Technology and Symbolism of Sound in European and North American Noise Abatement Campaigns, 1900-40," *Social Studies of Science* 31, no. 1 (2001): 37.. This work is expanded significantly in, Karin Bijsterveld, *Mechanical Sound: Technology, Culture, and Public Problems of Noise in the Twentieth Century*..

and their efforts to catalogue the realm of "necessary" versus "unnecessary" noises. These biases of sound led to efforts in which city noise could be measured, resulting in policies and technological solutions aimed at the eventual abatement of those unnecessary sounds. Of course, despite the sophisticated decibel meters and steely determination, the majority of these initiatives produced far less of a quiet outcome than their proponents hoped for.

Emily Thompson approaches noise from a similar perspective to that of noise abatement, avant-garde music, and technological management. In *The Soundscape of Modernity*, Thompson portrays shortcomings of noise abatement not exactly in terms of its failure, but in the case of early twentieth-century noise abatement in New York City, charting the rise and fall of a noise-abatement organization that was successful in transforming public perceptions of the problem. The power and pervasiveness of the problem was laid out through scientific measurement and technological documentation.[23] In a discussion ranging from the early complaints of Dr. J. H. Girdner in his 1896 article "The Plague of City Noises" to the dissolution of the New York Noise Abatement Commission in 1932, as well as a discussion of noise in musical practice during the period, Thompson contextualizes noise abatement within the broader subject of a technicized culture of listening and sound control in the early twentieth-century. As a result, noise abatement is situated as a programme of public space reform and a byproduct of a cultural context of efficiency, as a Taylorist culture of scientific management and industrial productivity—not as a precursor to an environmental notion of "pollution." Among the other relevant claims in Thompson's text, it is suggested that between 1896 and 1925 a remarkable shift in the subjectivity of noise occurs, that noises of concern at the start of the era are distinctly different from those at its end. Traditional, "organic" nuisance sounds of 1896 give way to the annoying

[23] Emily Thompson, *The Soundscape of Modernity: Architectural Acoustics and the Culture of Listening in America, 1900-1933*.

predominantly inorganic sounds of mechanical life in 1925. What annoys us is by no means constant in different epochs.

The annoyances of noise also took root well before early twentieth-century modernity. Emily Cockayne, for example, has written a miserablist take on pre-Industrial Revolution England by focusing on the crowded, reeking, filthy, and indeed noisy city life. Annoyances were very much prevalent in the seventeenth-century, when the sounds of pigs within the city walls competed with the din of blacksmiths to produce annoying daytime soundscapes. As night fell, the raucous spillover within and outside alehouses was a cause of lost sleep. One could argue that one of the first noise abatement regulations was issued in 1596, a Lawes of the Market bylaw, which among other things restricted Londoners to avoid beating their wives after the hour of nine o' clock.[24]

Distinctions of what constituted noise versus what constituted cultured music were also being debated far before the late nineteenth-century criterion advanced by Hermann von Helmholtz. John Picker has written about noise in the context of Victorian intellectuals' quest for a quiet, contemplative space of work. The quest for the "soundproof study" was also to demarcate a professional, class-based identity against the migrant working-class din of street musicians.[25] The organ grinder was above all the source of much anguish—an ambient music of the 19th century metropolis relegated to the status of meaningless, annoying noise.

As alluded to above, most histories of noise thus far have accepted as fact the proposition that noise is always getting louder. It is presented usually as self-evident and mostly in absence of any empirical proof. Some authors merely present this argument as a

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[24] Emily Cockayne, *Hubbub: Filth, Noise & Stench in England 1600-1770* (New Haven: Yale University Press, 2007), 115.
[25] John Picker, *Victorian Soundscapes* (New York: Oxford University Press, 2003), 41-81.

perpetual truth shared by subjects of their historical inquiry; some smuggle the argument in as one they also accept. Apparently late seventeenth-century London was already perceived to be getting increasingly louder.[26] While there is little evidence to dismiss the claim, it should merely be pointed out that this stands as one of the greatest untested truisms of discourses on noise. If anything, other scholars who have been suspicious of this claim side in favour of a more cyclical approach to an urban loudness.[27]

It is also worth pausing at this point to note that the current body of historical literature, with its priority on discourses of noise abatement, suggests an overly naïve representation of the acoustics of nature. As an antidote to the perceived inferno of raucous urban life during the late nineteenth and early twentieth centuries, writers have often referred to an almost Rousseauian idea of nature as romantic, meditative retreat from a metropolitan hell. These references to the "still" and "calm", pastoral therapy of silence are a commonplace characterization of nature. In his famous 1916 tract *City of Din,* Dan McKenzie, a key noise abatement advocate, writes of nature being the antithesis of the loud city:

> Unlike the world of men, the world of Nature is not noisy. It is, on the contrary, quiet. Quietness is of course a relative term. There is sound in the world of Nature. But the sounds we hear there are not noisy. Indeed they are pleasant. Many of them are musical, and each one of them, yes! each one is pleasant.[28]

This late romantic view of nature, as a peaceful and meditative retreat of quiet sounds, was echoed in numerous other texts during the era.[29] A significant counterpoint to this viewpoint exists in discourses of the acoustics of the sublime, which will be touched upon below. The

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[26] Emily Cockayne, *Hubbub: Filth, Noise & Stench in England 1600-1770*, 129.
[27] Hillel Schwartz, "Noise and Silence: The Soundscape and Spirituality."
[28] Dan McKenzie, *The City of Din, a Tirade Against Noise* (London: Adlard and Son, 1916), 1.
[29] Rev. E. Cobham Brewer, *Sound and Its Phenomena* (Boston: Oliver Ditson & Co., 1885), 17.

acoustic patina of nature is also one of mortal threat, which also carries the possibility of an abyss. Filmaker Werner Herzog's contrasting take on the wild is particularly poignant here: "Nature here is vile and base… I would see fornication and asphyxiation and choking and fighting for survival and growing and just rotting away…The trees here are in misery and the birds are in misery. I don't think they sing, they just screech in pain."[30]

While the majority of the issues raised above are ones this thesis will sidestep from, not all of this literature review is negative positioning. There have been significant precursors calling for more work on the understudied historical subject of megaphonics. In 1996, Victorian historian Peter Bailey published a prescient essay on noise that calls for historical work of the "means, type and volume" relating to the subject of noise. Bailey was addressing what was then the neglected realm of sound and the necessity for historical work on sound, listening, and aural culture. He was among the first of recent contemporary historians to write about noise in terms of the nearly-physical valences of loudness, the idea that sound had the power to terrify, embarrass, even foster transcendence. He noted a far more ambivalent relationship between rural citizens and natural sounds, suggesting the sonics of nature was more of a loud, violent clamor than that of pastoral communion. This serves in some ways as encouragement of the fact that noise is not solely a delegate of the realm of annoyance, an object of public space rationalization, nor merely of narrow interest to institutional power. Bailey argued that a history of tone and decibel, despite the reservations about its importance advanced in certain quarters, was precisely the biggest gap in scholarship on noise.[31] This work is based on that essential hunch.

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[30] Werner Herzog. *Herzog on Herzog.* (London: Faber and Faber, 2003), 163-64.
[31] Peter Bailey, "Breaking the Sound Barrier: A Historian Listens to Noise," *Body & Society* 2, no. 2 (1996), 55.

Some Interpretations Against Meaning

The French philosopher Michel Serres offers a noteworthy theoretical approach in his deployment of metaphors of sound. Throughout his wide body of work, Serres advances the idea of noise as a constitutive aspect of communications, be it electronic or interpersonal. To him, noise, portrayed in terms of a background "envelope," is actually the fabric of existence and the foundation upon which communication takes place. Noise fills all space occupied by life. It is the background din, the murmur which fills silences, pauses, and awkward moments. He notes noise has the ability to mask meaning: "to communicate orally is to risk losing meaning in noise…such communication is a sort of game played by two interlocutors considered as united against the phenomena of interference and confusion."[32] Perhaps it is a fluid substance that fills spaces, but it is also a void where meaningful signals can dissolve into meaninglessness.

More importantly, Serres speaks about noise as a tactile material and sonic affect. In his work *Genesis*, which he admits elsewhere should have been entitled *Noise,* is a work concerned with the insufficiency of rationality in encountering the raucous, chaotic world of multiplicities and disorder.[33] Serres was an influence on writers and thinkers such as Gilles Deleuze, Felix Guattari and Bruno Latour. One of Serres' key arguments is that the ocean of multiplicities which constitute the world, while ungraspable by *reason* alone, can in fact be *sensed.* In his privileging of the senses, sound has a key role. In particular, noise stands-in as a weathervane of multiplicity and chaos. Yet noises are not simply registers of that chaos, they are generative sonic forces, turbulences in and of themselves. So for example in crowds, the perfect multiplicity, their noise is not only an indicator of fury and intensity, but rather a

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[32] Michel Serres, *Hermes--Literature, Science, Philosophy* (Baltimore: Johns Hopkins University Press, 1982), 66.
[33] Michel Serres, *Genesis*, Studies in Literature and Science (Ann Arbor: University of Michigan Press, 1995).

generative force in that fury. Loud crowd noises point towards a ripe, even urgent domain of further historical inquiry:

> Georges Dumzeil is right, one must start with the fury, one must, truly, start with the noise, battle and racket, but one must, furthermore, start from the fury of multiplicities…. Background noise is the first object of metaphysics, the noise of the crowd is the first object of anthropology. The background noise made by the crowd is the first object of history. Before language, before even the word, the noise.[34]

Certain aspects of this dissertation will be, in effect, an attempt to apply some of Serres' ideas, particularly regarding megaphonics, to a historical examination. To write about the noise of crowds, or foghorns blasting against the noise of nature is to conduct, according to Serres, a history of the first object, a history of an understudied field of invisible forces.

A shift in focus from histories of "noise" as public annoyance towards issues of megaphonics also assists in sidestepping some vexations around hermeneutics. A history of noise as "unwanted sound" encourages one to chart the varying, contradicting, and overlapping systems of meaning which lay the foundation for distinctions of wanted versus unwanted sound, or institutional concerns around "necessary" versus "unnecessary" noises. Some scholars have successfully shown that meaning systems that dictate the definition of "noise" is historically conditioned and socially constructed.[35] Furthermore, what actually qualified as unwanted sound was a rotating set of criteria that were under perpetual recalibration.

Michel Serres has referred to noise as an abundance or excess of meaning. Others have seen noise as that which is outside meaning—the sonic representation of meaninglessness. This thesis prioritizes the pulsating physicality of loudness as a way to

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34 Michel Serres, *Genesis*, 54.
35 Hillel Schwartz, "Noise and Silence: The Soundscape and Spirituality."

eschew the demand of historical scholarship being primarily one of meaning excavation. The approach of this dissertation is partly influenced by scholars such as Hans Ulrich Gumbrecht, who have encouraged a partial shift from hermeneutics to questions around presence.[36] This dissertation is not post-hermeneutic by any means — indeed, a large portion is textual interpretation. Yet approaching sound itself allows for the scholar to de-emphasize analysis based on the meaning-systems of historical actors, or archival work as semiotic excavation. The human experience of loud sound suggests a landscape where meaning systems take a backseat to the physical immediacy of invisible phenomena. Gumbrecht would call this a surplus of presence-effects, where something like the musical force of a pipe organ, the public spectacle of a massive explosion, or the foghorn-induced suffering of a lighthouse keeper all share *the material impact of sound as force.* These moments are often moments of liquidation of the self, of the dissolution of ego, or of bone-rattling de-subjectivation. In this case the responsibility of the scholar isn't so much to itemize symbols, meanings, or significations as much as it is to chart an alternate constellation of excesses, voids, and irrational quasi-narcotic obsessions.

Framing the Period

> *I hate Wagner, but I can no longer endure any other music... Wagner sums up modernity. There is no way out, one must first become a Wagnerian.*[37] – Nietzsche

As mentioned, this thesis follows a historical periodization that could be said to be at the crux of modernity as it is often framed in media-studies. The use of the term "modernity" has its limits, however. In certain contexts the term "modernity" has served as an indicator

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36 Hans Ulrich Gumbrecht, *Production of Presence: What Meaning Cannot Convey* (Stanford, Calif.: Stanford University Press, 2004), 49.

37 Friedrich Wilhelm Nietzsche, and Walter Arnold. Kaufmann, *Basic Writings of Nietzsche*, Modern Library ed. ed. (New York: Modern Library, 2000), 612.

of sweeping epochal change, other times as a historical delineation of rupture. Above all, modernity has been a term that represents very real experiences such as the strange, uncanny, or transformative cultural developments in the nineteenth and early twentieth centuries. Yet the period is also comprised of a bundle of contrasts and counter-pressures. Including the tensions between nihilism and civilization – or *moderne* and *neuzeit* – modernity's confusion extends to literally all corners of its characterization. It is literally a grab-bag of phenomena and qualities including: a history of an escalating state of crisis; a rebellion against tradition; processes of social fragmentation and division; the coalescence of enhanced mass movements and social consciousness; the development of mass communications; the rise of the autonomous, individuated, self-conscious individual; the categorical rejection of the example of antiquity; secularization; the death of god; the rise of utopianism; assertions of the autonomy of art; aesthetic modernism and experiments in formal abstraction; trajectories towards integrated capitalist economies; industrial cultures of mass production; Weberian bureaucratic rationalization; scientific knowledge; romantic expression; the belief of participating in revolutionary history and the development of a quintessentially modern era.[38] What this resembles best is a jumbled knot of contradictions. It is not entirely clear how modernity functions sufficiently as an explanatory framework for a history of loudness, nor how a history of loudness might further arguments about the grand period of modernity. Is Emily Thompson correct in suggesting that the quintessentially "modern" sound is a tight, reverb-controlled sound space, or is Schwartz correct that modernity is exquisitely portrayed as the cacophony of city life? It would appear that both are, but nevertheless raises the question of how prevalently should modernity function as an overarching historical

[38] Marshall Berman, *All That is Solid Melts Into Air: The Experience of Modernity* (New York: Simon and Schuster, 1982), 16. Henri Lefebvre, *Introduction to Modernity: Twelve Preludes, September 1959-May 1961* (London: Verso, 1995), 168-238. Matei Calinescu, *Five Faces of Modernity : Modernism, Avant-Garde, Decadence, Kitsch, Postmodernism* (Durham: Duke University Press, 1987), 13-92.

framework. My intention will be to keep this relationship loose and somewhat distant.

The historical approach or method I intend to employ will be a balance between historical "poetics" and an archival excavation that forwards concrete historical arguments. This is similar to what Hayden White was referring to as a means of historical explanation that "need not be assigned unilaterally to the category of the literally truthful on the one hand or the purely imaginary on the other, but can be judged solely in terms of the richness of the metaphors which govern its sequence of articulation."[39] This approach does not strive for a totalistic account of the phenomenon in question during a particular era, but is rather one way among many of disclosing aspects of the field. It is also in spirit of what Giorgio Agamben called a "paradigm" as an approach to historical explication. Instead of assembling particulars into a generalized concept (induction) or transversing a narrative from universal to particular (deduction), his paradigm was "defined by a third and paradoxical type of movement, which goes from the particular to the particular."[40] While admittedly close to tautology, for my purposes this is the assertion of the de-emphasis of generalities and universals in favor of the local and the pragmatically circumscribed. It is a method of historical work that is a point-to-point cartography, where universals are impressionistic and evasive but possibly present, much like apparitions in the fog on the chapter on marine navigation at night.

This method is employed in the spirit of allowing a space for conducting creative yet anchored historical work that does not treat science and art as an unbridgeable chasm. I will look at some technologies of loudness as well as the scientific deployment of noise in experiments while congruently considering the vague aspirational dreams of loudness in the

[39] Hayden White, *Tropics of Discourse: Essays in Cultural Criticism* (Baltimore: Johns Hopkins University Press, 1985), 46.
[40] Giorgio Agamben, *The Signature of All Things: On Method* (New York Cambridge, Mass: Zone Books, 2009), 19.

artistic use of sound as a potential route to transcendence. The result will present one way of many of looking at this era of megaphonics, while at the same time tabling defendable arguments and positions regarding its emergence and historical importance.

Despite its muddy borderlines, this study still considers modernity to be an important framework because the emerging modern technologies of sound propagation were a major condition upon the forming of a megaphonic culture. Studying loudness at the turn of the twentieth-century forces one to address the colliding movements of spiritualism and an ascending scientific culture. Between the antagonism of spiritualism against materialism, or science versus superstition, this study lands firmly *in medias res*. Both poles are crucial, but the technological condition firmly matters. The difference at this point in human history was that people believed they had access to exponentially greater physical power they had even 10 or 20 years before. The sheer sonic force that a single device could produce was crucial in fostering these senses of wonder, awe, and terror regarding the power of sound as a field of potential.

It is argued that the qualitative nature of sound was changing during the period of this study. A photo of a fifty-foot long foghorn stands as irrefutable testament to this reality. However, a culture obsessed with loud sound didn't emerge out of thin air. As mentioned, megaphonics has a deep history going back to antiquity. Just as the massive explosion of Hell Gate, New York in 1885 is predated by almost three hundred years of science as public spectacle, the difference here is scope. A massive dynamite explosion of the late nineteenth century had an intensity that invoked powers of the deities. It was a bone-chilling, life-taking thunder that terrified most that witnessed it. Sonic power was a precondition for megaphonic culture.

On the surface it would appear that this story is one of a predominantly a male culture mostly conducted for male experience. If Susan McClary's oft-cited charge is correct that the bombast of the first movement of Beethoven's Ninth Symphony is one of masculine pent-up rage, then there are grounds for a legitimate critique of the entirety of this body of work as patriarchal domination through the quest for sound amplification.[41] However, most likely a more nuanced reading of the complexities of gender associations might be found in the relationship between loud sound and the raging sea, much like Klaus Theweleit's 1930s German association with femininity and tides or floods.[42]

Other paths of interpretation are also possible. As Zoe Sofia argues, a simplistic reading of skyscrapers as masculine ignores the interpretation of this essential containment technology as a "womb with a view".[43] Pipe organs or sonic power are subject to a similar degree of ambiguity and complexity in this regard. The point is that while much of late nineteenth-century language is masculinist in frame, actual gender significations are much more ambiguous. This is not the project of this thesis, but it is recognized that these questions warrant further study.

Theweleit's notion of sound as an enveloping, invisible flood on the body that evaded all borders and limitations was a romantic notion that was under constant attack by scholars. However, sound's metaphorical history as an evasive, invisible power yielded eventually to visible photographic proof of its undeniably physical, thus real, force. It is a tale of two Ernsts, so to speak—the waves of sound that yielded forms on Ernst Chladini's plates were also eventually the waves that would be frozen in the high-speed photography of Ernst Mach. The clouds of romanticism slowly blew away and sound's ethereal, seemingly metaphysical presence became documented as a material, pliable force. This thesis is one

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41 Susan. McClary, *Conventional Wisdom : The Content of Musical Form* (Berkeley: University of California Press, 2000).
42 Klaus. Theweleit, *Male Fantasies* (Minneapolis: University of Minnesota Press, 1987).
43 Sofia, Zoë. "Container Technologies." *Hypatia* 15 (2000), 188.

chapter of this tension where sound's new physical reality suggested a furthered attempt to enact mastery over nature.

Loudness and the Sublime

To be certain, a certain romantic sensibility never quite disappeared in this era despite increased claims of empirical truth around matters previously deemed ethereal. A foundational component of the experience of loud sound was rooted in its association with the shock, awe, or wonder that has for centuries been referred to as the sublime. The essential claim of the sublime has generally entailed the stark recognition of "human" limitations through an environmental experience or aesthetic expression. What this means exactly has been the matter of great debate. The sublime is an essential framework through which to examine both the impetus and perception of megaphonics in the late nineteenth and early twentieth centuries. Perhaps it is best associated with the awestruck wonder of rugged nature or the terrifying threat of storms, but loud sound is uncannily emblematic of the "invisible immense power" referred to in eighteenth-century descriptions of the sublime. James Usher's 1769 text *Clio, or a Discourse on Taste* referred to this association with sound, a pressure of unknown power:

> We are terrified and silence into awe, at the vestiges we see of immense power; ... The same mixed sensation weighs upon us, when we see an ocean disturbed and agitated in storms; or a forest roaring, and bending under the force of the tempest. We are struck by it with more calmness, but equal grandeur, in the starry heavens: the silence, the unmeasured distance, and the unknown power united in that prospect, render it very awful in the deepest serenity. Thunder, with broken bursts of lightning through black clouds; the view of a cataract, whose billows flight themselves down with eternal rage; or the unceasing sound of the falling waters by night; the howling of animals in the dark: all these produce the sublime, by

> the association of the idea of invisible immense power.[44]

Eighteenth-century debates on the sublime spanned a wide variety of fields, from epistemological psychology to landscape aesthetics. There was hardly any bias with respect to the sublime being an attribute of visual perception rather than aural. References to sound abound throughout the body of literature. Hugh Blair's 1783 *Lectures on Rhetoric* emphasizes this:

> From this some have imagined, that vastness, or amplitude of extent, is the foundation of all sublimity. But I cannot be of this opinion, because many objects appear sublime which have no relation to space at all. Such, for instance, is great loudness of sound. The burst of thunder or of cannon, the roaring of winds, the shouting of multitudes, the sound of vast cataracts of water, are all incontestably grant objects. 'I heard the voice of a great multitude, as the sound of many waters, and of mighty thunderings, saying Allelujah.[45]

However, it is certain that sound, in historical relationship to the sublime, is significantly under-theorized and under-studied in general. Despite a few books which relate it to musical experience, it is nearly unexamined. For the purposes of this study, one of the more significant texts on the sublime in relationship to literary criticism was Theodor Weiskel's 1976 *Romantic Sublime*. Weiskel provides an interesting discussion on Immanuel Kant's concept of the sublime, which generally is a development of Edmund Burke's simpler understanding of the sublime as that which provokes terror.[46] Kant was more interested in the rational response to that which cannot be properly understood by the

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[44] James Usher, "Clio, Or a Discourse on Taste (1769)," in *The Sublime: A Reader in British Eighteenth Century Aesthetic Theory*, ed. Andrew Ashfield, and Peter de Bolla (Cambridge: Cambridge University Press, 1996), 148-49.
[45] Hugh Blair, "Lectures on Rhetoric and Belles Lettres (1783)," in *The Sublime: A Reader in British Eighteenth Century Aesthetic Theory*, ed. Andrew Ashfield, and Peter de Bolla (Cambridge: Cambridge University Press, 1996), 214.
[46] Thomas Weiskel, *The Romantic Sublime : Studies in the Structure and Psychology of Transcendence* (Baltimore: Johns Hopkins University Press, 1976), 23.

human mind—a failure or inability to represent boundlessness or the vastness of nature.[47] Two dimensions of this inability included the failure of representation and also the failure of reason to capture that boundlessness fermenting within an individual's imagination. Weiskel purged Kant's account of idealist metaphysics into an almost realist or psychological account of the sublime. Sonic experience of the sublime is largely a psychological reaction to this abundance of the excess of loudness, the inability to hide from it or to close ones ears. Adding the concussive force that sometimes comes with the shock of thunder leads to an understanding of its perennial importance.

David Nye's theory of the technological sublime is also of relevance here. Moving from distinctly North American "natural" experiences such as Niagara Falls or the Grand Canyon to the artifice-induced technological works of the Golden Gate Bridge or the Hoover Dam was a core feature of the early twentieth century sublime.[48] Weiskel agrees that natural wonders weaned with time:

> …the sublime must now be abridged, reduced and parodied as the grotesque, somehow hedged with irony to assure us we are not imaginative adolescents. The infinite spaces are no longer astonishing; still less do they terrify. They pique our curiosity, but we have lost the obsession, so fundamental to the Romantic sublime, with natural infinitude.[49]

Alongside this shift towards an increasingly technological culture arose an increased interest in new artifice-induced experiences of abundance, excess and shock. Sound was also subject to these shifts. Where this study documents an interest in megaphonics, which could also be sub-titled as an interest in the sonic sublime, it is also the employment of a history that puts increased belief in the power of instruments, amplification, and shock waves to provide

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47 Immanuel Kant, *Critique of Judgement* (London, UK: Macmillan and Co, 1914), 102.
48 David E Nye, *American Technological Sublime* (Cambridge, Mass: MIT Press, 1994).
49 Thomas Weiskel, *The Romantic Sublime: Studies in the Structure and Psychology of Transcendence*, 6.

experiences of wonder in an increasingly secular age.

There are many possible sublimes of sound, but this thesis focuses on a cultural interest in the belief that technologies of loud sound propagation could create new means of navigation, new types of musical rapture, new states of anxiety, even new forms of mortal threat. This was an epoch that suffered through new blistering noises of aerial bombardments, mechanized warfare and amplified music. Blisteringly loud foghorns exhaled dire notes of nautical warning amidst the fog while pipe organs screeched attempts at musical transcendence. The sublime is referenced in different chapters in distinct ways to accommodate the subject under examination. For example, a form of musical transcendence from a pipe organ is different from the physical menace of gongs, artillery fire, or even foghorns. One is a moderately pleasant form of going beyond, the others invoke an acoustic index of threat or harm.

Secular Transcendental Experiences and the Dissolution of Self

One of Weiskel's most interesting ideas was that the sublime's persistence was guided by a concurrent retreat of the prevalence of organized religion in Western society. He argued that the sublime revives as theology withdraws from an immediate participation in individual experience. The Romantic sublime was "an attempt to reconfigure the meaning of transcendence precisely when the traditional apparatus of sublimation—spiritual, ontological, and (one gathers) psychological, and even perceptional—was failing to be exercised or understood."[50] It is a helpful construct for example in understanding the tensions which led the rise of culture of high-powered pipe organs performing predominantly secular musical pieces. Yet early twentieth-century pipe organ culture for example witnessed lingering

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[50] Thomas Weiskel, *The Romantic Sublime: Studies in the Structure and Psychology of Transcendence*, 4-5.

theological vagaries despite the uptake of civic participation. The pipe organ inhabited a dualism of both being an increasingly secular musical object with lingering sacred hermeneutics within those secular forums. Indeed it makes sense as the church was increasingly seen as a place of refuge from the noise of a society increasingly drunk on loud, clanking industrial capitalism. Civic organs in secular spaces became perhaps unsurprisingly a new locus of thundering music experience.

William James wrote about new forms of silent spiritual practice. In a slant similar to Michel Foucault's concept of "technologies as self," James wrote in his *Varieties of Religious Experience* about new forms of spiritual practice as retreats from loud society. However, instead of entering into churches for silent sanctuary, one enters into themselves: "The time will come when in the busy office or on the noisy street you can enter into the silence by simply drawing the mantle of your own thoughts about you and realizing that there and everywhere the Spirit of Infinite Life... is guiding keeping, protecting, leading you...."[51] James had interesting ideas around drawing curtains in busy office buildings so one could retreat into their own psychic auras, much like they were alone in "some primeval wood." As a type of move that predates the New Age culture of self-help, the dispersion and dilution of techniques of spiritual practice amidst a culture of noise was emblematic of both the wane of monolithic Western religion and indicative of the ways people sought the means to go beyond the mundane and material.

A new type of secular transcendental experience was moving from the margins to mainstream society during this era. It replaced the theological promise of music being a vessel of the divine with a secular one in which loud, electrically amplified sound might yield a "thunder of melody" similar to that of the Peace Jubilee concert. This was a route to the

[51] William James, *Varieties of Religious Experience* (Oxon, UK: Routledge, 2008), 295.

dissolution of self amidst frenetic urban life, in an era seen as one with the promise of nearly unlimited musical power. The situation was akin to that described by Hans Heinz Stuckenshmidt's "The Mechanization of Music" (1925) which envisaged a rise in mechanical instruments that could replace and overtake the symphonic experience. With a "strength of sound" that had no limits arose the possibility of new forms of musical composition and new means of musical subjectivity.[52]

Perhaps core to this entire thesis is the belief that megaphonic sound was most impressive and important as an agent of the dissolution of subjectivity. At its limits, loudness does more than suggest the unfathomable infinitude of nature or the endless possibilities inferred from a state of technological hubris. It suggests the possibility of a person to lose themselves, either for a moment of musical overload or for a lifetime, through the damage of shock waves. George Santayana is helpful in this regard, partly because his *Sense of Beauty,* first published in 1896, in part described the "self-assertion of the soul" against the threat of its dissolution through external force. It implies a sort of voyeuristic fantasy of ones own destruction in the face of immensity:

> The emotion [of sublimity] comes not from the situation we observe, but from the powers we conceive; we fail to sympathise with the struggling sailors because we sympathise too much with the wind and waves. And this mystical cruelty can extend even to ourselves; we can so feel the fascination of the cosmic forces that engulf us as to take a fierce joy in the though of our own destruction... Lord, we say, though thou slay me, yet will I trust in thee. The sense of suffering disappears in the sense of life and the imagination overwhelms the understanding.[53]

Elaine Scarry suggested that the very sensory act of audition is fundamentally one of an experience of disembodiment. She argues that sound is often so bound up with its own

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[52] Harry. Haskell, *The Attentive Listener: Three Centuries of Music Criticism* (London: Faber, 1995), 276.
[53] George Santayana, *The Sense of Beauty* (New York: Dover, 1955), 184.

acoustic object of dissemination, its own source, that this dissolution of the body occurs through hearing a displaced object, be it distant thunder, a nearby alarm, or a very loud sound system. She argues this is

> …either because one seems to have been transported hundreds of feet beyond the edges of the body out into the external world, or instead because the images of objects from the external world have themselves been carried into the interior of the body as perceptual content, and seems to reside there, displacing the dense matter of the body itself.[54]

Loud sound appears to enhance this experience of the dissolution of self in the face of its totalizing and often debilitating force.

Whether or not one believes the philosophical position that audition requires an act of transposition of the body, the question of hearing and subjectivity in musical contexts is arguably more stark. Be it through the concussions of noise music, or the liquid waves of the Beyruth's *mystic abyss*, music provides an enduring narcotic effect that is enhanced through the effects of amplification of sound. It is something akin to what Heidegger, in his lectures on Nietzsche, referred to the relationship of rapture and subjectivity in art:

> …rapture as a state of feeling explodes the very subjectivity of the subject. By having a feeling for beauty the subject has already come out of himself; he is no longer subjective, no longer a subject. On the other side, beauty is not something at hand like an object of sheer representation. As an attuning, it thoroughly determines the state of man...[55]

Heidegger continues along a fruitful musical thread on the writing of Nietzsche where he calls for the domination of art as music, and thus the domination of a "pure state of feeling." This is a state of tumult and "delirium" of the senses and absorption in the

[54] Elaine Scarry, *The Body in Pain : The Making and Unmaking of the World* (New York: Oxford University Press, 1985), 165.
[55] Martin Heidegger, and David Farrell Krell, *Nietzsche: Volumes One and Two* (New York: HarperOne, 1991), 123.

"bottomless sea of harmonies" that induce states of feeling as redemption. A (loud) Wagnerian orchestra in this light is:

> the basis of infinite, universally common feeling, from which the individual feeling of the particular artist can blossom to the greatest fullness: it dissolves to a certain extent the static, motionless basis of the scene of reality into a liquid-soft, flexible, impressionable, ethereal surface, the immeasurable ground of which is the sea of feeling itself.[56]

In this sense, desubjectivity through musical sound is an essential megaphonic experience.

This dissertation proceeds with the assumption that loud sound has the ability to produce effects on the body, from the temporarily narcotic to forces of sheer obliteration. Few forces were more obliterating than the early twentieth-century battlefield. Ernst Junger described how the noise of twentieth-century battlefield also destroyed subjectivity:

> And now it is 5:05 A.M.! A flickering light enters the mouth of the tunnel, followed by a unanimous, unheard of shouting, which immediately grows to extreme intensity, like a giant engine whose individual vibrations can no longer be distinguished... Here the only way of surviving is to let go and allow oneself be molded by the hand of the world spirit itself.[57]

No lone voice can ever be heard over the din of modern warfare. This thesis was set-up such that it ends up on the battlefield. While the period ends in the early 1930s, it points the way towards the nihilistic antagonisms that would help foster the temperamental environment of the Second World War, with its unfathomable military marches, the hunger of mass crowds nourished by barking public address systems and the War's eventual inevitably brutal physical contestations.

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[56] Martin Heidegger, and David Farrell Krell, *Nietzsche: Volumes One and Two*, 85.
[57] From *Feuer und Blut* as translated in Hans Ulrich Gumbrecht, *In 1926: Living At the Edge of Time* (Cambridge, Mass.: Harvard University Press, 1997), 327.

Outline of Chapters

Chapter One examines the early twentieth-century pipe organ as a quintessential megaphonic technology. The chapter discusses the rise of a culture of pipe-organ builders who shared an interest in creating intensely loud versions of this musical instrument. The pipe organ was believed to be a means of experiencing a form of the technological sublime in music. Through focusing primarily on the work of organ builder Robert Hope-Jones and the ramifications of his short period of activity on the organ-building field in the United States, this chapter charts the rise and fall of the pipe organ as form of civic entertainment characterized by the "thunder of tone". Also, by examining the rise of two specific technological innovations in organ design—diaphonic pipe organ stops and high wind pressure—this first chapter studies the temporary wane of Romantic notions of instrument construction and points to the dynamic forces of what by the early 1930s would become the world's loudest musical instrument. The fleeting public interest in early twentieth-century American monster pipe organ was both the product of and an active agent in an emerging culture of loudness. It was a musical technique of sonic excess. Amidst the backdrop in a declining interest in organized Christianity, the divine breath of God increasingly became represented as a force of mechanical pneumatics. This is to say that the monster pipe organ of the early 20th century would offer a form of secular transcendental experience which in many ways mirrored and mimicked the decaying vestiges of sacred music within a novel civic context.

Chapter Two departs with the understanding that Hope-Jones' diaphonic organ was designed as a dual-use instrument to service both as a musical resonator and a nautical signalling device. This section examines the precarious faith that was placed on the ear as a tool of last resort in aiding dangerous ocean travel in storms and at night. The late nineteenth-century witnessed a large-scale increase in both the number of foghorns built along the coastline of North America, but also the strength of the acoustic signals they produced. Despite their assistance in aiding safe travel along coastlines, numerous crashes very close to powerful foghorn stations revealed a curious acoustic phenomena called “zones of silence.” Because of certain mysterious environmental factors, powerful horns would disappear into an acoustic black hole. While efforts were made to create even louder horns capable of blasting through the void, they ultimately were not successful. This chapter looks at the temporary, fleeting faith in loud sound as a beacon of safe harbour in the era before radar-based navigation.

Chapter Three examines loudness through the cultural interest in shock waves as a source of intrigue and stupefaction. The shock of a fourteen-inch artillery shell was believed to be one that could foster madness but, increasingly without qualification, could also cause death. This chapter on sonic shocks will examine another valence of the cultural concern surrounding loud sound, explosions, and the quest to understand the physics of sonic power. It was an intrigue about the confounding distances explosive sound waves could travel and a morbid fascination regarding the damage such shock might inflict on the human body. It begins with the work of Mach and how the emerging practice of psychophysics became a fertile terrain regarding the study of loud volume. Mach's strident position of “anti-metaphysics”, one which resisted the purported enigma of sound as invisible phenomena, was forwarded through revealing photographs of a high-speed bullet breaking the sound barrier. The chapter then examines the enhancement of ballistics and ordinance technologies, with its related attempts to extend and document long-distance sound propagation. Lastly, attention turns towards interest in the effects of concussive sonic experience on the human mind and the animal body. Loud sound was not only increasingly seen as capable of overloading the human mind, but also one of which could render bodily injury or even death.

CHAPTER 1

The Megaphonics of Music: Secular Transcendentalism and the Modern Pipe Organ

The power of a symphony to 'absorb' its parts into the organized whole depends, in part, upon the sound volume. Only if the sound is 'larger,' as it were, than the individual so as to enable him to 'enter' the door of the sound as he would enter through the door of a cathedral, may he really become aware of the possibility of merging with the totality which structurally does not leave any loophole. –Adorno, "The Radio Symphony", 1941[58]

Here you have built organs greater than may be seen elsewhere...

Above, twelve bellows are set out in a row;

While fourteen lie below.

Their alternating blasts supply vast quantities of wind,

Worked by the might of seventy strong men,

Labouring with their arms, running with sweat...

Like thunder, the strident voice assails the ear,

Shutting out all other sounds than its own;

Such are its reverberations, echoing here and there,

That each man lifts up his hands to stop his ears,

Unable as he draws near to tolerate the roaring

of so many different and noisy combinations.

The music of the pipes is heard throughout the town,

And their winged fame goes forth through the land. - Wulstan, ca 966 AD[59]

In the year 1932, the city of Atlantic City, New Jersey harbored an unfathomably monstrous

[58] Theodor W. Adorno, et al., *Essays on Music* / Theodor W. Adorno; Selected, With Introduction, Commentary, and Notes By Richard Leppert; New Translations By Susan H. Gillespie (Berkeley, Calif.: University of California Press, 2002), 256.
[59] Jean Perrot, *The Organ, From Its Invention in the Hellenistic Period to the End of the Thirteenth Century* (London; New York: Oxford University Press, 1971), 230.

musical apparatus lurking within its newly constructed Convention Hall. Technically it was a pipe organ, but to organ traditionalists it was an abomination. The instrument was a work of modern electronics and industrial manufacturing comprising of over 33,000 pipes fed by a wind system capable of providing exceedingly high pressure. A common rumour surrounding the organ was that the owners of this musical instrument needed to phone the local power company in advance of turning it on out of fear of shutting down the regional power system.[60] The rumour wasn't true, but it does represent a general view of the instrument's perceived capabilities. Over three years in development, nearly bankrupting the local treasury and bankrupting the Midmer-Losh Company who was responsible for building the instrument, this sonic apparatus was concealed within the walls of the World's Largest Convention Hall, its console set beside the World's Largest Stage. It should be no surprise then that it was also the World's Largest Musical Instrument, a title it still holds to this day. An object of absurd proportions that was capable of rendering extremes from lush symphonic sounds to pummeling imitations of thunder and storms, Atlantic City's Midmer-Losh pipe organ is the apotheosis of musical megaphonics, an example of grand architectural edifice as a resonant musical instrument. It was also an extreme example of a monster pipe organ and an endpoint of a curious cultural obsession with power in musical instrument building.

This chapter will examine the push to build monster pipe organs at the turn of the century and the rise of a broad fascination shared by organ builders, organists, and the general public towards loud sound in musical performance. Pipe organs are an under-appreciated realm of musical expression and sonic experience. They straddle a vague and fluid terrain that confuses strict definitions of musical instruments and electrical media.

[60] Interview with Carl Loser and Harry Bellangy, Atlantic City, NJ, June 16, 2009.

Organs blur the distinction – if one could be said to exist – between instruments, machines and architecture. The writer Philip Wirsching pushed this fluid distinction even farther by referring to the organ as “melted architecture.”[61] At their loudest, as was achieved during the early twentieth-century, organs were capable of obliterating individual subjectivity and easy distinctions between music and noise. They comprise a significant and early instance of extreme volume in musical expression. As discussed in the introduction, organs challenge the conventional histories of “noise-music” as beginning with Luigi Russolo's *Intonarumori* or the works of composers such as Igor Stravinski or Henry Cowell. While organs have been often used for fairly conservative artistic repertoire, many pipe organs built in the United States were also far *louder* than any of the aforementioned instruments or works. Thus, the infernal sonic power produced by early twentieth-century pipe organs is an important precursor to the ensuing widespread popularization of loudness in music, much of which relies on qualities of overbearing immensity as a virtue in compositional practice and listener experience.

The early twentieth-century pipe organ is a quintessential megaphonic technology. It is the crystallization of a wide range of musical and scientific cultures all sharing a common interest in the productive power of loud sound in musical experience. The result, if for a short while, was the development of a novel form of technologically mediated transcendental experience that was affordable to a greater range of the general public than symphonic music — a public which was increasingly secular in character. That is to say, the fleeting example of the early twentieth-century American monster pipe organ was both the product of and an active agent in an emerging culture of loudness. Sonic excess, a recurring manifestation of the sublime in music, was seen as a force of collectivity and the dissolution

[61] *Diapason*, Volume 1 Number 2, Jan 1910.

of the self. This force was understood as an almost physical, vibrational musical power that mimicked divine presence within secular fora. The divine breath of God increasingly became a force of mechanical pneumatics.

This chapter uses the pipe organ as an entry point to examining the technological sublime in music, secular transcendentalism, and musical megaphonics more generally. The focus is on the work of Robert Hope-Jones and the ramifications of his short period of activity in the organ-building realm of the United States. Originally trained as an electrical engineer in England who progressed from a tinkering hobbyist into a full-time organ builder, he was also a source of contempt, inspiration, and misunderstanding. He is presented in this study as an emblem of a broad interest in the possibilities of immense volume that could be achieved through musical instrument design. This section will also touch on earlier historical epochs similarly concerned with both the material and immaterial effects of sonic power in acoustic instruments. From that point, discussion will shift toward aspects of musical immensity and sonic power crystallized in organ-building reforms beginning in the late nineteenth-century. By charting the development of two specific technological innovations in organ design —"diaphonic" type organ stops and high wind pressure —the chapter observes the eclipse of Romantic notions of instrument construction and how two versions of the organ would compete for the claim of the world's largest and loudest musical instrument by the 1930s. The technology of the diaphone would not endure in organ design; it would instead find greater use as a foghorn than as a resonant musical device. Yet the monster pipe organ of the early twentieth-century did offer a new calibration of sublime musical effects in the form of secular transcendental experience which, in many ways, mirrored and mimicked the decaying vestiges of sacred music within a novel civic-based concert fora. Loud sound rendered by the honking, blasting, shimmering, and sometimes thunderous pipe organ offered the opportunity of losing oneself, if for a short period, through the power of its enveloping material force.

A Deep History of the Organ as an Instrument of Sonic Immensity

Historically, pipe organs are most commonly linked to their longstanding role in Western Christianity. Organs have lingered under the dominion of Christian theology for over a thousand years, but support of the Church towards the organ has been neither absolute nor without pause. The instrument exceeded the Church — before, during, and after its reign of influence. Prior to its adoption in roughly the 8th century, the instrument was viewed by Church Fathers with mistrust as an instrument of pagan culture.[62] The apparently unbreakable relationship between the organ and the church as a divine instrument – the breath of god – ignores the multitude of contexts in which the organ thrived, beginning with its early secular pagan uses until it made an eventual return as an instrument of civic mass spectacle in the early twentieth-century. It was firmly outside the realm of the Church, where the limits of musical instruments were most vividly pursued. The late nineteenth-century interest in organ power that this chapter discusses was only the latest of numerous instances of focused interest in loud musical organs over the preceding millennium.

More than just an instrument of soothing tones suggesting the comfort of divine presence, the organ has also been devised for use in the most nefarious of contexts. Perhaps the most compelling example is a war organ, the Horn of Themistius, believed to have been devised between the ninth and twelfth centuries. In his examination of the Arabic text *Kitaby al-siyasa*, Roger Bacon noted a described organ designed to be heard at up to an unfathomable distance of sixty miles. While designed with the possibility of musical tone,

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[62] Bernard Sonnaillon, *King of Instruments: A History of the Organ* (New York: Rizzoli, 1985), 18.

the organ is better described as a violent siren made to trigger terror and bodily harm:

> …it is a terrifying instrument used for various purposes. Because it will enable you to summon the whole district, and even your kingdom, and assemble the military officers the same day or more speedily or in any way that is required in a large and numerous army, for the sound of this instrument carries sixty miles...In time of war it convokes an army for sixty miles, and the horn is manipulated by sixty men on account of its bulk and enormous structure.[63]

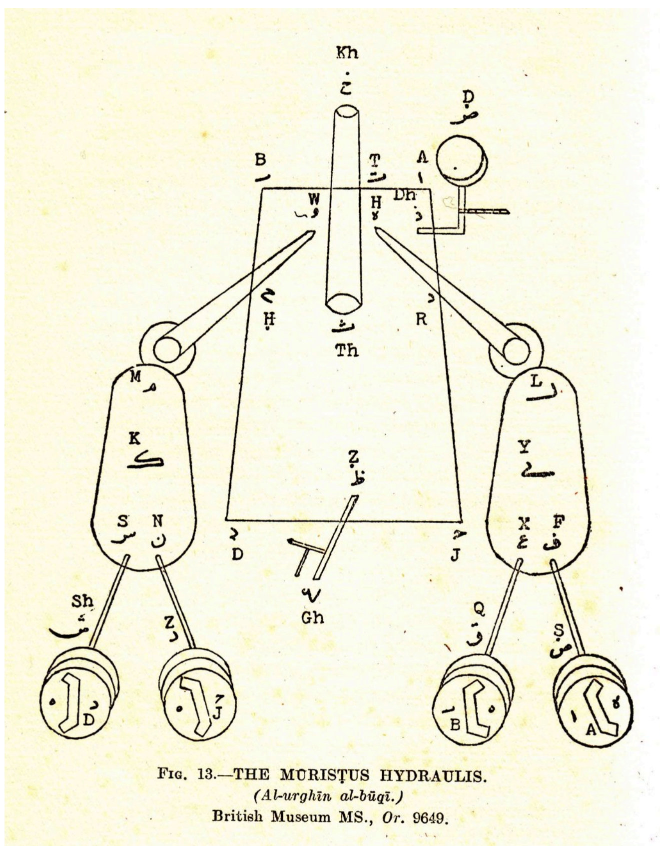

Figure 4. Illustration of a War Organ

63 See Henry George Farmer, *The Organ of the Ancients, From Eastern Sources* (London: W. Reeves, 1931), 123; Roger Bacon, et al., *Secretum Secretorum: Cum Glossis Et Notulis : Tractatus Brevis Et Utilis Ad Declarandum Quedam Obscure Dicta Fratris Rogeri* (Oxonii: E Typographeo Clarendoniano, 1920), V5, p. 151.

The unrivaled power of the siren-organ was such that the sixty people required to operate it needed to have their ears stuffed with cotton and covered with wax so that "their sense may not depart" when using the organ. This monster pneumatic instrument is more than an esoteric relic of the Middle Ages. It is a deep historical example of an enduring human interest in exceedingly powerful (musical) sonority and a continuing source of curiosity since its alleged reign of devastation. For example, the Themistius war organ was of interest to early work on acoustics and amplification, particularly to the work of Athanasius Kircher in his *Phonurgia Nova* of 1673.[64] It also functions as a paradigm, in the sense of Giorgio Agamben's interpretation of Foucault's historical method in *The Order of Things*, as an example that derives a rule from the singularity of its example alone.[65] Its very existence sets the groundwork for a general rule. The paradigm of the war organ is that it straddles the threshold between a musical instrument (it had the ability to play three or four harmonic tones) and a fear-inducing siren. This duality of linking immense musical sound with communication technology, as well as being a tool of obliterating power capable of rendering subjects physically and psychologically captive, is uncannily similar to the diaphonic-related organs and sirens that were to come at the turn of the 20th century. The paradigm of the musical horn of terror, with its purportedly unfathomable levels of extreme loudness, is a model that returns at different periods, including late nineteenth-century developments in megaphonics. It was an ancient instrument fostering a taste of the sublime *avant la lettre*. Nothing comparable to its alleged existence would be built again until the year 1932.

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64 Roger Bacon, et al., *Secretum Secretorum: Cum Glossis Et Notulis: Tractatus Brevis Et Utilis Ad Declarandum Quedam Obscure Dicta Fratris Rogeri*, V5 p. lviii.
65 Giorgio Agamben, *The Signature of All Things: On Method* (New York Cambridge, Mass: Zone Books, 2009), 22.

As organs had the ability to span massive distances in displays of awe-inspiring power, they were also believed to have the ability to coalesce ethereal vibrations into material edifice. The idea of building a sound palace out of music was a common theme to many writers: the vision of a palace built out of organ music in *Paradise Lost;* Keats' *Lamia*; and the dome built "in the air" of "music loud and long" in *Kubla Khan* [66]. It is almost an inversion of Schelling's comment about architecture as "frozen music"; rather organs were seen as a form of liquid architecture. Perhaps most interesting is the work of Georg Joseph Vogler, a late eighteenth-century composer, organist, and writer who was known for a particularly odd approach to the organ. He was a traveling virtuoso and organ tinkerer who developed a style of popular organ performance akin to "pictorial improvisations" which lured audiences from across Europe[67]. Robert Browning made reference to Vogler as another emblem of sonic palace building, a practitioner of music who made sound capable of carving out etheric solids: "Would that the structure brave, the manifold music I build; Bidding my organ obey, calling its keys to their work; Claiming each slave of the sound, at a touch, as when Solomon willed; Armies of angels that soar, legions of demons that lurk..."[68]. Organ music was repeatedly seen as aspiring towards a state of material edifice. As I will argue, organs began to merge with the buildings that hosted them in attempts to turn architectural structure into resonant instruments.

It was commonly the enlargement of material edifice that gave justification to organ expansion. Churches, the primary domain of the organ for most of the nineteenth-century in the United States, were in a period of expansion due to a population growth in the eastern

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[66] Milton, *Paradise Lost, Book I*: 705-32
[67] Peter F Williams, *A New History of the Organ From the Greeks to the Present Day* (Bloomington: Indiana University Press, 1980), 153.
[68] Robert Browning, *Abt Vogler*, ca 1864

United States alongside significant westward migrations. Due in part to an expanding number of Irish and German immigrants, stress was placed on congregation capacity. Many churches were forced to expand their premises. From this came a knock-on effect on the organ building business—bigger organs, and more of them, were in demand.[69]

Yet things were spiraling out of hand. The amount of volume coming out of organs was already a concern by the mid-nineteenth century. Nathaniel Gould was complaining that organ expansion, driven at this point more by overzealous organists than organ builders, led to a preference for louder and more raucous organs than the gentle singing-style of the past:

> By and by all restraint was thrown aside, and the struggle was for the organ of the greatest power. The small organs were set aside to make room for thunder tones, still more and more powerful, till an organ was *worthless* that would not make the granite walls of a church tremble, at times, when used in full strength...This may satisfy those who are more pleased with *noise* than *sense*.[70]

An ongoing state of contestation and conflict would endure around claims regarding sufficient acoustic power. This was a battle that, for a period of time, became increasingly dominated by those espousing organ loudness.

By the late nineteenth-century, organ loudness was not an issue that arose suddenly. It had been present in periods throughout recent history. Monster organs were a subject of significant of interest at the 1851 Great Exhibition at Crystal Palace featuring the earliest iteration of electric organ building and a bizarre idea of installing eight facsimiles of the most celebrated organs controlled by one central console.[71] The idea for a monster organ at

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[69] Orpha Caroline Ochse, *The History of the Organ in the United States* (Bloomington: Indiana University Press, 1975), 103.
[70] Nathaniel D Gould, *History of Church Music in America* (Boston: A.N. Johnson, 1853), 179.
[71] J. W Hinton, *Story of the Electric Organ* (London: Simpkin, Marshall, Hamilton, Kent & Co., 1909), 22.

Crystal Palace surfaced again in 1854, which was quickly dropped.[72] The 1869 National Peace Jubilee in Boston featured what was then one of the world's most powerful organs, played alongside an ensemble of a 100 anvils, 1,000 instruments and 10,000 voices. It was an effort that would dwarf later monolithic modernist efforts by composers such as Gustav Mahler:

> The scene from the balcony was one to remember for a lifetime. As the chorus stood up, tier after tier, and the steady stroke upon a hundred anvils mingled with the avalanche of voices and instruments, the ear was deafened with the noise and the eye was dazzled with the sight...Nothing like this has ever been heard in music before...The organ is the best for the purpose I have ever heard, not excepting the one used at the Sydenham Palace or the great one at St. George's Hall, Liverpool. Its tones were heard and felt clear over and through the host of voices and instruments. At times it seemed to overshadow all, and its thunder tones shook the building.[73]

The dream of having the largest pipe organ appeared to be a common thread across secular and sacred lines. For some churches, a loud prominent organ was an index of its eminence and modernity. Along secular lines it was an indicator of technological mastery amidst a cultural condition increasingly electrical in nature. Many priests and church leaders approached organ builders with the specified goal of building the largest organ in the country, as the parish priest of Notre-Dame Basilica in Montreal was reported to have done in 1885. *The American Organist* took a historical overview of a 1972 New York Church which professed to have the "most powerful organ in the world", describing an organ of high wind pressure of "such penetrating power that the tone is actually felt as well as heard."[74] Through the vibratory force of high volume, churchgoers felt the presence of the divine. In

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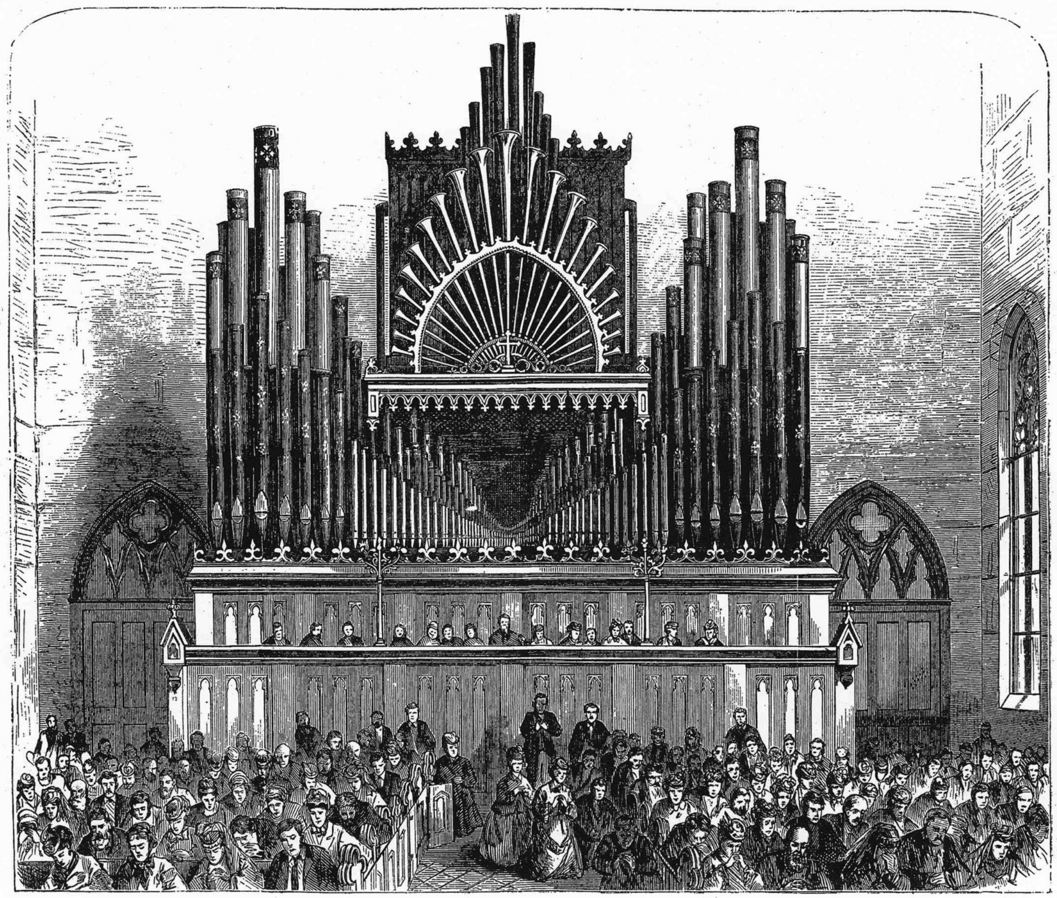
72 *New York Times*, April 18, 1854.
73 Patrick Sarsfield Gilmore, *History of the National Peace Jubilee and Great Musical Festival: Held in the City of Boston, June, 1869* (Boston: Lee and Shepard, 1871), 511.
74 "In 1872", *American Organist*, August 1930, Volume 13:8, p. 475-77.

fact, pipe organs assisted in authenticating whichever institution it inhabited. This "authenticating function" would operate primarily upon the basis of its sonic attributes — what for the church opened a channel to the divine through music, would for secular institutions be a reflection of their technical modernity and civic pride. An organ's loudness was a source of institutional authenticity and legitimization.



WHAT ORGANS (AND CHOIRS) LOOKED LIKE IN 1872 IN NEW YORK

Figure 5. A Church Congregation Adrift in Organ Sound, ca. 1872

Due in part to technological developments, it became increasingly possible to realize an organ of mammoth proportions. Some of the most prominent organs that were built in the late-nineteenth to the early-twentieth century were also organs that were unfathomably loud. This period was dominated by an organ building culture obsessed with power, volume, and immensity. It was a competitive arena of expertise dominated by a few builders. One of the key organ builders to emerge during this period would employ his experience in electrical engineering at the service of musical immensity.

An Emblem of a Culture of Musical Immensity: Robert Hope-Jones

Even a brief reading of music trade journals near the end of the nineteenth-century can paint an impression of just how fierce the competition was amongst organ builders vying for a market share amongst a growing and cutthroat organ market. For example, the pages of the British monthly *Musical Opinion & Musical Trade Review*, which was at the time the most popular forum for organ builders wanting to share insights and advertise services, hosted a debate that lasted for nearly the entire year of 1895. The debate was in part triggered by a brazen announcement by a relatively unknown builder that an organ would be designed for Worcester Cathedral in England. It would employ the most modern of electrical technologies and would achieve no less than three times the acoustic power of the cathedral's previous organ. Furthermore, the power of the new organ would derive from 100-inch wind pressure, a measurement of the maximum amount of air forced through the pipes at a given time and a general indication of relative loudness.[75] To illustrate the profundity of this ambition, it should help to note that the standard amount of wind pressure usually ranged from three to six inches. The declaration invoked the rage of fellow organ builders, most notably Thomas Casson, an esteemed and conservative organ builder. For Casson, organs were to use moderate wind pressure and eschew electricity in favour of

[75] *Musical Opinion & Music Trade Review,* Volume 18 No. 209, February 1895, p. 290.

traditional mechanical keyboard actions. Many chimed in on the debate, mostly through anonymous pen names. The Worcester Cathedral organ builder in center of the controversy was Robert Hope-Jones, an electrical engineer and dilettante organ hobbyist who was to become by far one of the most famous and controversial figures in organ building during the early part of the twentieth-century.

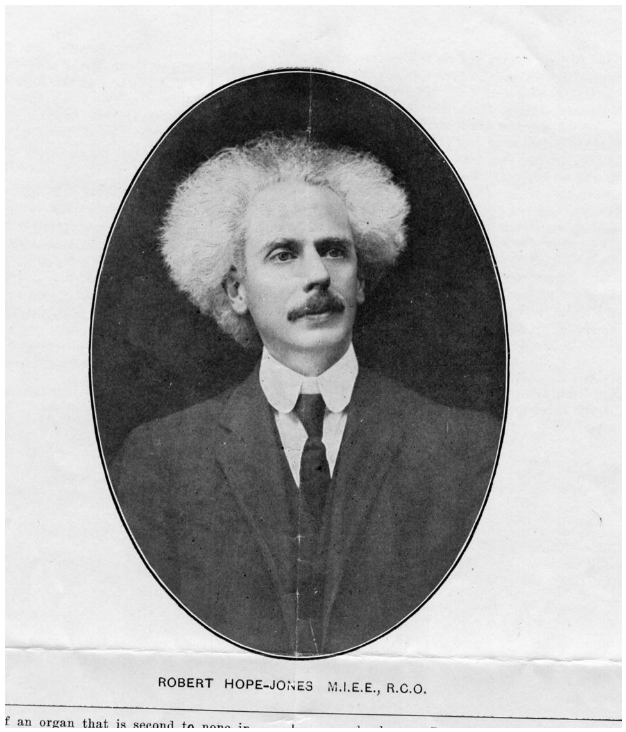


Figure 6. Robert Hope-Jones

Hope-Jones (1859-1914) was raised in England and spent his early years working as an engineer for the Lancashire and Cheshire Telephone Company. After a period of tinkering on local church organs and applying his knowledge of electrical relay systems to a variety of uses on organ mechanics, he moved to work full time in the art of organ building. As mentioned, the market for organs was a robustly expanding field. In the U.S. where Hope-Jones spent most of his productive years, the big business of organs did not peak until approximately 1927, when at its height about 2,500 organs of all types would be produced in that year alone.[76] Organ popularity was widespread, partly because it was one of the primary means of hearing full fidelity music that was affordable and accessible to many. The World's Fairs during the era often featured pipe organs as exemplars of some of the most technically complicated and sophisticated achievements on display; it was *the* instrument most emblematic of modernity in music. In fact, organs were emblematic of much of modernity's knotted contradictory characteristics: Matei Calinescu's notion of mechanized industrial capitalist modernity (as the prominent technical and financial aspects of organs); Marshall Berman's interpretation of the enveloping aesthetics of "gaseousness" as a major aspect of musical modernity (as a key metaphor of the sonic experience of those organs); and the proximity of kitsch aspects in the nature of organ concerts.[77] It was most evident in the audacious visual displays of sonic-technological prowess. The raw power of modern pipe organs was often presented with massive looming pipes exposed in an act akin to what David Nye has referred to as the technological sublime— the fusion of transcendent spirituality, technological triumphalism, and civic pride.[78] The work of Hope-Jones would come to be known perhaps as the finest exemplar of the technological sublime in musical production. His approach to organ building was distinct in a number of areas: the promotion of the electrification of the organ; trendsetting extreme wind pressures; development of the loudest, fairly radical organ stops such as the diaphone which was designed for dual-use as a foghorn; utilization of a moveable instead of a fixed keyboard console; and instigating a push against blended tones known as "mixtures" in favour of pure

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76 David L Junchen, *Encyclopedia of the American Theatre Organ* (Pasadena, Calif: Showcase Publications, 1985), 21.
77 See Matei Calinescu, *Five Faces of Modernity: Modernism, Avant-Garde, Decadence, Kitsch, Postmodernism* (Durham: Duke University Press, 1987). And Marshall Berman, *All That is Solid Melts Into Air: The Experience of Modernity* (New York: Simon and Schuster, 1982), 144.
78 David E Nye, *American Technological Sublime* (Cambridge, Mass: MIT Press, 1994).

tones. Among those advances, most importantly was the development of pipe organs more powerful than anything built by his peers or developed in recent centuries. He was a central figure in a musical culture increasingly obsessed with the power of sound in musical experience.

It must be mentioned that Hope-Jones was not the most productive organ builder, nor by far the most financially successful (most of his ventures ended in financial ruin). He is sometimes dismissed by historians as an anomaly, the supreme icon of a period of madness quickly left in the dustbin for more nuanced, modest approaches to organ building. I would argue that Hope-Jones was not an influential organ builder pushing his vision from the outside, but rather a product of a prevailing cultural condition of his age responding in part to a specific interest in organ power and sonic power more generally. The major organs he built during his productive years, including Worcester and Ocean Grove, New Jersey, are direct precursors of the world's largest instrument, the Midmer-Losh organ built in 1932 in Atlantic City, New Jersey. To assert his importance is not to advance a "great man" work of historical interpretation. One could easily focus on numerous other builders working tacitly with the same general interests.[79] But it was Hope-Jones who was the most influential and extreme proponent of the zeitgeist and the most emblematic architect of organ building during a period of indisputable decadence regarding sonic design. As organ historian Orpha Ochse remarked:

> …the desirability of loud sounds from an organ was an idea that had been growing in popularity for years. Now here was a builder who could wrest more decibels from a pipe than anyone had thought possible. Church committee members wanting to put a small, inexpensive organ in their sanctuary might well be impressed by the

[79] Relf Clark, "Robert Hope-Jones, M.I.E.E.: An Interim Account of His Work in the British Isles" (University of Reading, PhD Thesis, 1993), 141.

> amount of sound they could get per dollar...It would seem that Hope-Jones did not so much alter the course that organ design was taking as to hurry it along its chosen route. He was the supreme spokesman and the extreme exponent of the new style.[80]

As much as his work was disparaged, Peter Williams described his works as "the worst organs ever made from a careful, professional builder." Others including Ochse would agree that Hope-Jones was a key inspiration in the art of monster organ building— an arc ending with the realization of 100-inch pressure in Atlantic City, an absurd amount of pipes, and power embedded within the world's largest auditorium.[81]

With only one organ restoration under his belt, Hope-Jones approached the College of Organists in 1891 to deliver a talk on the future of electricity in organ building, flaunting some of his recent developments. He suggested that beyond merely replacing mechanical actions with electrical ones, electricity would provide the foundations for a radically new instrument that would render the entire pneumatic process of providing wind obsolete. This early vision of musical synthesis would generate tones "produced directly from electricity."[82] This was a vision of an electronic musical instrument that predates the advent of the Telharmonium in 1897.

The Secretary of the College responded by mentioning that while electricity might assist in costs, the real challenge was reigning in the trend toward large, loud, and ultimately vulgar organs. Since Hope-Jones had not built enough organs, it was far from obvious that he would become the most infamous exponent of a loud, "vulgar" style of organ building;

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80 Orpha Caroline Ochse, *The History of the Organ in the United States*, 338.
81 Peter F Williams, *A New History of the Organ From the Greeks to the Present Day*, 182.
82 Robert Hope-Jones, "Electrical Aid to the Organist," *Musical Opinion & Music Trade Review* 14: 166 (1891), 373.

he went on to develop monolithic instruments that dwarfed the concerns raised in 1891. His response was that the organ must not be seen to be an imitator of the orchestra. It was rather an instrument in its own right which required a creative approach coupling modern science and art. His training as an electrical engineer gave him a unique background to pursue such a science/art hybrid. Alexandra Hui, in *Psychophysical Ear*, describes this increasing interconnection between scientific and musical cultures at the end of the nineteenth-century that fostered inventors such as Hope-Jones.[83]

Hope-Jones began building organs as a hobbyist while working as a telecommunications engineer, but the work quickly shifted over into a full-time endeavor. While constantly derided through his career as an outsider and amateur, it was precisely his technical background that allowed for radical transformations in organ building. While other organ builders trained in the traditional techniques of mechanical actions and wind delivery, Hope-Jones was working in the vanguard field of electrical communications. The nascent domain of electrical engineering, as historian Carolyn Marvin has noted, was desperate to assert itself as an elite faction with rarified knowledge.[84] The pressure of an emerging culture of electricity and its promises of abundance were pushed upon the moldy mechanical world of organs. Hope-Jones turned a general malaise against electricity amongst organ builders into a professional advantage:

> …the Musician laughs at the production of an amateur who composes without first studying the elements of his art, and in perfect disregard of the fundamental rules of musical grammar. In the same way the Electrician is tempted to smile at the crude efforts made by those who do not even know that Electricity has a

[83] Hui, Alexandra. *The Psychophysical Ear: Musical Experiments, Experimental Sounds, 1840-1910*. (Cambridge, Mass.: MIT Press, 2013), vx.
[84] Carolyn Marvin, *When Old Technologies Were New: Thinking About Electric Communication in the Late Nineteenth Century* (New York: Oxford University Press, 1988), 15.

'grammar' far more unyielding in its nature than that of music.[85]

The grammar of electricity was deemed understood only by a specialized cadre— few in the organ building trade were capable of integrating its benefits.

The electrification of the organ, aside from creating anxiety amongst traditional organ builders, also raised the question of where the divide between an electric musical instrument and communication medium lies. It might be of little surprise to learn that the electrification of the organ was claimed to have been derived in part from interpretations of telephone relay systems. It was Hope-Jones' experience with switching in telegraph and telephone relay circuits allegedly informed his organ construction work.[86] This meant that instead of a purely mechanical act of playing an organ, triggering the opening of air to the pipes, an electrical action employed relays to trigger the same effect, albeit quicker and with less physical effort of the part of the organist. He was not the first to consider the idea, but did patent and implement the electrical action beyond anything done to that point. The link between the telegraph and the electrical organ would be made more explicit later on: "The electric action [of an organ] is really a miniature telegraph. When the organist presses a key, a tiny current of electricity is sent through a wire to the pipe."[87] This network-based approach to musical instrumentation would allow for the channeling of musical rapture to both a greater scope of ends, such as a higher number of pipes, but also though bigger, more elaborate systems— much akin to the increasing scope of telegraphic systems. As the self-styled "inventor of the megaphone", Hope-Jones pushed a prescient and almost cybernetic understanding of an organ partly predicated on the miniaturization of the orchestra and functioning as a scaled-

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85 Robert Hope-Jones, *Electricity and Organ Building* (OHS Archive Pamplet, 1891).
86 CE Ramsbottom, and AJ Ramsbottom, "Development of the Electric Organ and the Significance of the Contributions of Robert Hope-Jones, Miee," *IEE Proceedings A Science, Measurement and Technology* 136, no. 6 (1989), 324.
87 *Modern Mechanics*, January 1915, Volume 30: 1, p. 32.

down version of contemporary telecommunications systems. It was an aspiration of constructing an organ which would seek to absorb the most affecting elements of Wagnerian orchestral immensity while drifting along the line between musical instrument and telephonic device.

Worcester Cathedral, Diaphonics, Wind Pressure, off to America

Hope-Jones was not to remain in England for long, but during his time there most of his success came from his work on the Worcester Cathedral in 1896. The organ, his magnum opus in England, was declared to contain three times the power of his previous 1874 organ which was already big; considered, in fact, to be a "monster organ" due to its immensity and power.[88] Yet, the instrument was insufficient; the organ was scrapped in favour of an even bigger, louder, more advanced work of modern science. Once again it was argued his outsider background was root of his unique perspective and an opportunity:

> 'How can an electrical engineer like Hope-Jones give us anything new in organ tone? He was not apprenticed to the organ building trade?' Well, a reliable electrical organ was bound to come sooner or later; if not from Hope-Jones, then from someone else, and new stop and tone producers also. The time is ripe for a tremendous advance in quality and power of organ tone, and the man is sure to be there when the right time comes for his appearance.[89]

The organ was a test run for two of his signature ideas: 100-inch wind pressure, and his newly invented organ stop, the "diaphone", a novel means of sonic resonance.

As much as the organ began to resemble an electrical telecommunications system,

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[88] Relf Clark, "Robert Hope-Jones, M.I.E.E.: An Interim Account of His Work in the British Isles," 2.

[89] *Musical Opinion & Music Trade Review*, Volume 18 No. 210, March 1895, p. 359.

individual pipes were developed based on the same technology employed in nautical acoustic signalling systems. The diaphone was novel because it contained mechanical aspects of traditional organ pipes, but was designed with a potential for such enormous power that its use would exceed strictly musical contexts. Diaphones were constructed similar to traditional reed-type stops but contained an attached circular valve that functioned as a resonator. Air is admitted to the pipe not by a continuous stream of air, but a series of pulses formed by the circular valve beating at a fixed periodicity. The pitch of the pipe, normally a function of wind pressure, was unaffected by the pressure of wind put through the diaphone.[90] In short, this meant that the pipe could afford high wind pressures that served to generate rich harmonic content in addition to the nearly unlimited power it could produce. It was a form of acoustic pulse-based resonation that provided remarkable power. It was this enormous carrying capacity in which Hope-Jones saw a multiplicity of uses—early patents were specifically devised to cater to the "numberless forms" the diaphone could take.[91] But it was specifically its dual use as both a musical tone generator and a signaling device that would be explained at length in early patent applications. Baynton Taylor, writing about the diaphone, described its foghorn application as yielding "the most appalling of terrible loud sounds. Fortunately these can be tamed when required to give beautiful high musical notes."[92] General opinion was that the power needed for the diaphone to yield sufficient harmonic complexity also meant that it was too loud for musical use. It was a sound source that threatened to envelope every other sound in its wake, as a commentator wrote regarding the sonic effect of the diaphone in Worcester Cathedral:

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[90] David H Fox, *Robert Hope-Jones* (Richmond, Va: Organ Historical Society, 1992), 130.
[91] See British Patent No. 14,473, applied for 30th June 1896.
[92] Baynton Taylor, "Origin & Construction of Diaphones," *Musical Opinion & Music Trade Review*: 297-298 (1902), 677.

> …it is possible to have too much of a good thing. The organist was playing a fugue, and in the middle of it put on the diaphone—the result was that everything but the bass part was utterly overwhelmed…[T]he diaphone triumphed over all else. This seems to me to be a mistake...the impression left on my mind was that the magnificent bass—which is able to fill a nave twice as large as that of Worchester—is too powerful for the rest of the organ, and needs to be used with very great care.[93]

The diaphone was, arguably, a foghorn disguised as a musical resonator, but in either case it problematizes the divide between the two. The organ's uncanny resemblances to media stretched from the intricate network of telecommunications to the blunt force of acoustic signalling in fog. Yet it was a musical instrument, what George Laing Miller claimed to be the most powerful producer of musical sound known at that point.

Two years after his arrival in the U.S., the feature of Robert Hope-Jones' work in the *New York Times* focused specifically on his diaphone. Noting that traditional organ pipes employed reed-like or flue-based means of resonance, his work on the diaphone pushed aside these prosaic techniques in favour of "springs, valves and cylinders"—an approach merging modern engineering with an understanding of sound's very materiality.[94] This was the recognition that the diaphonic action was the result of waves possessing weight and momentum produced by the beating of a circular valve. The fact that the diaphone produced nearly overwhelming power was of little concern to Hope-Jones. He viewed this "heavy foundational presence" of the organ as the trump card which would elevate it above the orchestra as the instrument of grandeur, dignity, and immensity. Yet his exerted efforts to also patent the diaphone as a technology of nautical communication suggests he put more stock in its future elsewhere. He had succeeded in procuring a license to the Canadian

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[93] *Musical Opinion & Music Trade Review*, Volume 20:230, November 1896, p. 95.
[94] *New York Times*, 26 March 1905.

Government for its use as a fog signal by the turn of the century. But as a musical tone-generating device, it would become less common as time passed, showing up only in the most monolithic of organ construction projects.

Powerful new organ stops like the diaphone required a concurrent revolution in wind pressure to deliver sufficient volume of sound. As well, more traditional, "quieter" organ stops needed greater wind pressure to compete with the louder new additions to pipe organ ensembles. The development of electric-powered high-pressure wind blowers was perhaps the most important factor in the shift between late-nineteenth and early-twentieth century organs in the United States. Wind pressure was essentially synonymous with organ loudness. High-pressured wind was the breath of early-twentieth century musical megaphonics. While wind pressure has remained important from at least the Romantic period onwards, the technological capacity began to surpass any builder's needs during this period.

Prior to the end of the nineteenth-century, organs were built on relatively low wind pressure. A common pipe organ might be considered to have a pressure of approximately three inches, the standard measure of organ wind pressure meant to indicate the height of water displacement via air in a tube. Air was often provided firstly through manual bellows, then increasingly via mechanical means. By the turn of the century, organ builders were turning towards electricity to power wind turbines. Three-inch pressure would give way to organs of twelve, twenty-five, and with the work of Hope-Jones, fifty inches. Proponents claimed it provided richer harmonic tone aside from the obvious interests in power. Hope-Jones of course argued that this "revolution in wind supply" was a trend of his own design, one which was increasingly adopted by organ builders. He even held a lecture to publicly belittle those that did not: "In spite of continued opposition in certain quarters, it must be growing clear to all of you that the old order of things has passed and that the organ of the future will be a high pressure instrument."[95] For Hope-Jones, wind pressure, the primary domain of organ power, was destined for a future where organs would serve in primarily secular contexts. A near-infinite stream of air could be channeled into any creative musical composition imagined, rather, into any context that needn't remain overshadowed by a sacred choir or a reverential sermon.

Electric blowers, the breath of modern musical rapture, were turning into a significant business not only for new organ construction, but by also retrofitting old mechanical bellows. The Organ Power Company, one of the dominant blowers in the early twentieth-century, invented the "Orgoblo" in 1904. The company advertised itself as an efficient, reliable source of wind provided to "practically all the largest organs in America."[96] Particularly telling is the way in which organ wind companies visualized the turbines— not lurking invisible in the basement of churches or auditoriums, but illuminated and showcased as the secret heart of a robust bellowing organ. Because the wind turbines provided an abundant source of pressure they also generated a great deal of noise. Their concealment, often in crypt-like spaces deep below the level of the organ, was necessary to mask one noise so that another could flourish unimpeded. This was a hidden cinema projector of sound.

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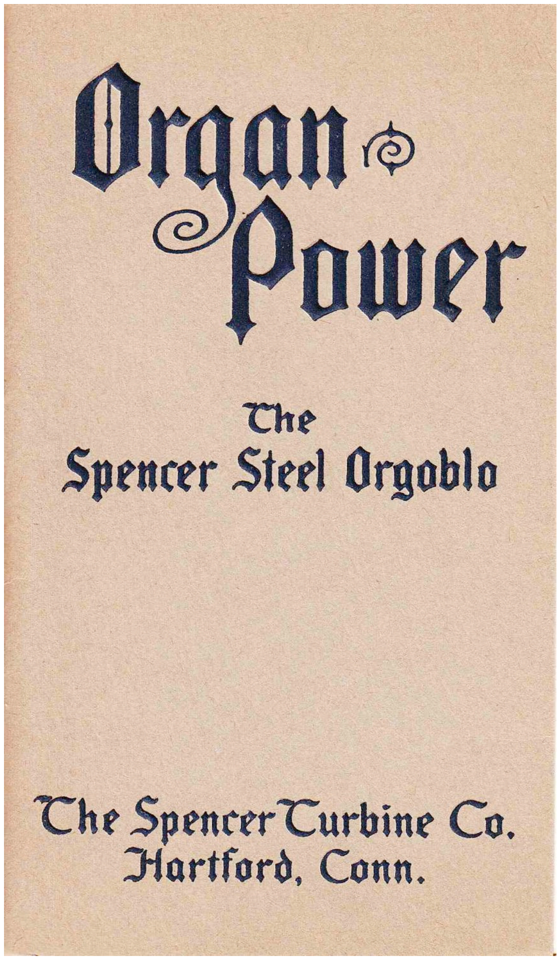
[95] Robert Hope-Jones, *Recent Developments in Organ Building* (OHS Archive: Undated Wurlitzer Pamphlet, 1910).
[96] OHS Archive: *Organ Power Company catalog,* 1918.



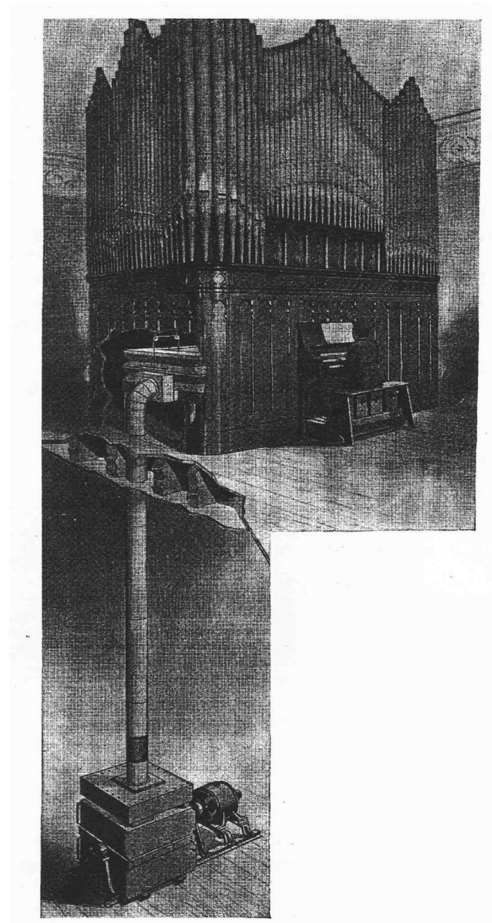


Figure 7. Depiction of Organ Blower and Promotional Material

The power of early twentieth-century U.S. organs was also a source of great national pride and an indicator of its comparative technological mastery:

> It requires but a visit to France to make the modern American organist realize what the modern organ blower means to his comfort and success. When Widor, Vierne, or Dupre wishes to practice he must first make sure some trusty husky men are at hand to supply the wind. When an American wishes to practice he presses a button.[97]

Carolyn Marvin discussed the symbolism of "the button" and how at the turn of the century

[97] "The Blowing Plant", *American Organist*, Volume 5: 10, October 1922, p. 439.

meant different things to different social groups, from visions of armchair utopias to dread of obsolescence. In the above quote, it represented a utopian fantasy of the organist; the promise of easily accessible acoustic power at levels hitherto unimagined.[98]

Hope-Jones dreamt of achieving a 100-inch pressure in his Worcester Cathedral, yet it was an utter failure. The 100-inch zenith would not be reached until the early 1930s by another builder in Atlantic City. It was still extraordinarily powerful. For many church-goers, and a large group of church organists who had a chance to hear the Worcester organ, this was truly an ungodly tone. "Unchurchly…foreign to the spirit of the organ" was the general impression of organists.[99]

Other organ builders knew him better as "Hopeless-Jones". George Audsley, Hope-Jones' greatest critic, was polemically in opposition to nearly everything he had done, describing his work as a type of "mile away sound annihilation" mistakenly seen as the acme of perfection.[100] Audsley was staunchly opposed to overly loud instruments, which he saw as noise rather than music, recalling similar distinctions by Helmholtz. The high pressure proposed in Worcester was a grave situation: "even too serious to be treated with the ridicule it deserves. Steam whistles will be the next suggestion; for noise at any price must be the master idea of its proposer."[101] For Audsley, Hopeless-Jones' "Tuba Mirabilis" on 100-inch pressure became a dreary and bloated *Tuba Miserabilis*.

Interestingly, both Hope-Jones and Audsley would flee England to develop organ building careers in the U.S., achieving their most esteemed works there. Hope-Jones arrived

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98 Carolyn Marvin, *When Old Technologies Were New : Thinking About Electric Communication in the Late Nineteenth Century*, 124.
99 Robert Hope-Jones, *Recent Developments in Organ Building.*
100 George Ashdown Audsley, *The Art of Organ-Building* (New York: Dodd, Mead, 1905), 232.
101 George Ashdown Audsley, *The Art of Organ-Building*, 567.

in 1903, fleeing from what appeared to be a sexual scandal, thrown directly into a culture where organ power was already coming into vogue. America at the turn of the century was the indisputable epicenter of the technological sublime. Bridges and skyscrapers were being built on a monumental scale not seen elsewhere. Musical spaces were not immune to this spirit of modernization. Various cathedrals, and increasingly civic spaces, were vying to host the largest instrument in the country. The title of having the largest organ was fleeting and impossibly competitive. Size and power were characteristics in abundance. For example, writer Frank Norris described his impression of a newly erected monster organ at a San Francisco church, circa 1896, worth quoting here at length:

> It was just sound, sound, sound—waves upon waves of it, sound that you could feel thrilling the air about you, sound that you could almost see streaming up from those thousand upright pipes. As Mr. Eddy played, the volume increased, the clamor became terrific. The drums of one's ears quivered and shrank under the shock of that ocean of sound-waves. The blinds of the swell boxes, opening to their limit, disclosed panel-like vistas of the church far below. To be here, here high up in this tiny swell-box, alone with this thundering monster, struck one with a feeling of awe, of positive, downright fear—the intuitive fear of all things huge. Suddenly the bourdon began, the open diapason, the vast thunder of that lowest octave of the great pedal-organ. Everything shook, wood, iron, and all quivered as the quaking of the earth. It was the thunder of artillery, the bellowing of a tremendous surge, the prolonged crashing of a Niagara, terrific beyond words.[102]

Norris was describing perhaps the definitive experience of sublime, de-subjectifying organ power. There are many other instances of where organ loudness was prevalent, like at an Albany, New York cathedral that could be heard over distant hills:

[102] Frank Norris, et al., *The Apprenticeship Writings of Frank Norris : 1896-1898* (Philadelphia: The American Philosophical Society, 1996), 221.

> The great power of the organ is astonishing. Its thunderous tones were shown in the opening blasts of the introductory selection. The great cathedral trembled with the mighty sounds and it is said that the organ can be heard a half mile distant, on the hills opposite to the east.[103]

Robert Hope-Jones had arrived at a sympathetic forum in which to flaunt his greatest strengths— his earliest promotional brochures savvily featured comments placing his work as synonymous with organ power.[104] He arrived not as an electrician and hobbyist organ-building hack, but rather a rarified organ builder with the most modern knowledge of electricity, one who claimed to have invented ninety percent of innovations introduced to the pipe organ at the turn of the century.

Meanwhile the organ was departing from its past naturalist or spiritualist associations with the breath of nature or the divine. This association was encapsulated in the image of the Grand Jubilee of 1872, discussed in the introduction, where wind power was a force channeled from the sky. Instead, it was increasingly viewed as a musical technology of sonic immensity revered for its power and clarity. Pipe organs were the site of a variety of progressive technologies and techniques, showcasing a wide variety of domains including acoustics, electrical engineering, pneumatics, metallurgy, and industrial production. Most of all, it was revered as an awe-inspiring modern machine as much as it was a musical instrument, as the *New York Times* reported on Hope-Jones' work in 1905:

> …he has procured the beating and puffing of the air current necessary to sound the great notes of the organ by a device that reminds one of a piston on an engine. Under the influence of an electrical blower on the one hand and his other mechanical devices, this piston works up and down, alternately admitting and excluding

103 *Schenectady Evening Star*, (November 17, 1904).

104 "Some Recent Opinions Regarding Hope Jones Organs", OHS Archive, 1904.

air current.[105]

The result was a raw, “pure”, powerful tone; a blast of diaphonic musical force which was the sonic equivalent of the great mechanized assemblages of the day. As can be imagined, it was a departure as far from the gentle “signing style” reeds of the past as would ever be realized. The double helix of diaphonic tone combined with the power of high-wind pressure would be pushed even farther in what many would consider to be Hope-Jones' masterwork, an organ for the Auditorium Hall of the seaside resort of Ocean Grove, New Jersey in 1908. These two extreme tendencies in musical instrumentation would crescendo again.

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105 *New York Times*, (March 26, 1905).

Figure 8. Ocean Grove, NJ, ca. 1907

An Era of High Wind Pressure: Ocean Grove

When a misty Christian seaside resort in New Jersey called Ocean Grove was planning to build an organ for their Auditorium, they turned to Hope-Jones to transform their barren architecture into resonant music. The Auditorium was constructed in 1894 with a capacity of 10,000. It was large for such a small resort town, which was mostly empty for much of the year. Their ambition with respect to their musical agenda was common to many other institutions of the time, which was to build the greatest organ devised— an organ especially designed for a musical program that was highly secular despite the Christian nature of the organization. Ocean Grove was a religious-associated institution that performed a surplus of secular, nationalist pieces. After bouncing between various companies throughout most of the decade, Hope-Jones landed a project that would allow him the nearly unfettered ability to construct an organ that matched his (personally invested) monumental aspirations. He would convince Auditorium staff that they needed, amongst other things, a set of diaphones powered on fifty-inch wind pressure. The "great weight" of the diaphonic tone would be further amplified by the ceiling of the building, a varnished wood surface of curved shape designed specifically to amplify the room's acoustics. The result was nearly too much power.

The organ built for Ocean Grove represented a clear instance where acoustic power trumped the desires of tonal quality. It wasn't that richness in tone was not a concern— it certainly was. But what made the organ special, and mirrored the interest of other organ builders and commissioners who desired the grandest organ across the land, was the scope of sonic power that remained latent within the instrument itself. An organ was desired which could venture from a gentle whisper to a trembling, unleashed thunder of tone. Thunder was a key metaphor at Ocean Grove indeed. The triumph of power over tone was evident in the announcement made by the association responsible for contracting the organ— they were confident it would become the greatest organ in the world, or more specifically by guaranteeing it "to be the most powerful of any in the country."[106] The greatest organ, at least in the eyes of the Ocean Grove Association, was not necessarily achieved through building the *biggest* organ, but the most *powerful* one. George Laing Miller, complimented the tonal characteristics of the organ which were comparative to the great

[106] Ocean Grove Camp Meeting Association, *38th Annual Report*, 1907, OHS Archive, p. 123.

organs of the world and notably "surpasses them in power."[107] It was celebrated as having five times the wind pressure of the ordinary organ, using electric turbines to provide an "immense volume of tone" that could only be constrained via swell shutters that attenuated the volume by boxing in the pipes at various degrees.[108] This allowed it to become quiet enough to accompany a human voice. However, the exceptional capacity for high volume placed in the wrong hands could turn quickly into a painful display of vulgar noise. Hope-Jones scolded overzealous organists a few years later: "having multiplied the powers and range of expression twenty-fold you must use them with care and discretion."[109] The torrent of sound lying latent in the chambers of Ocean Grove was something to evoke with discretion and tact.

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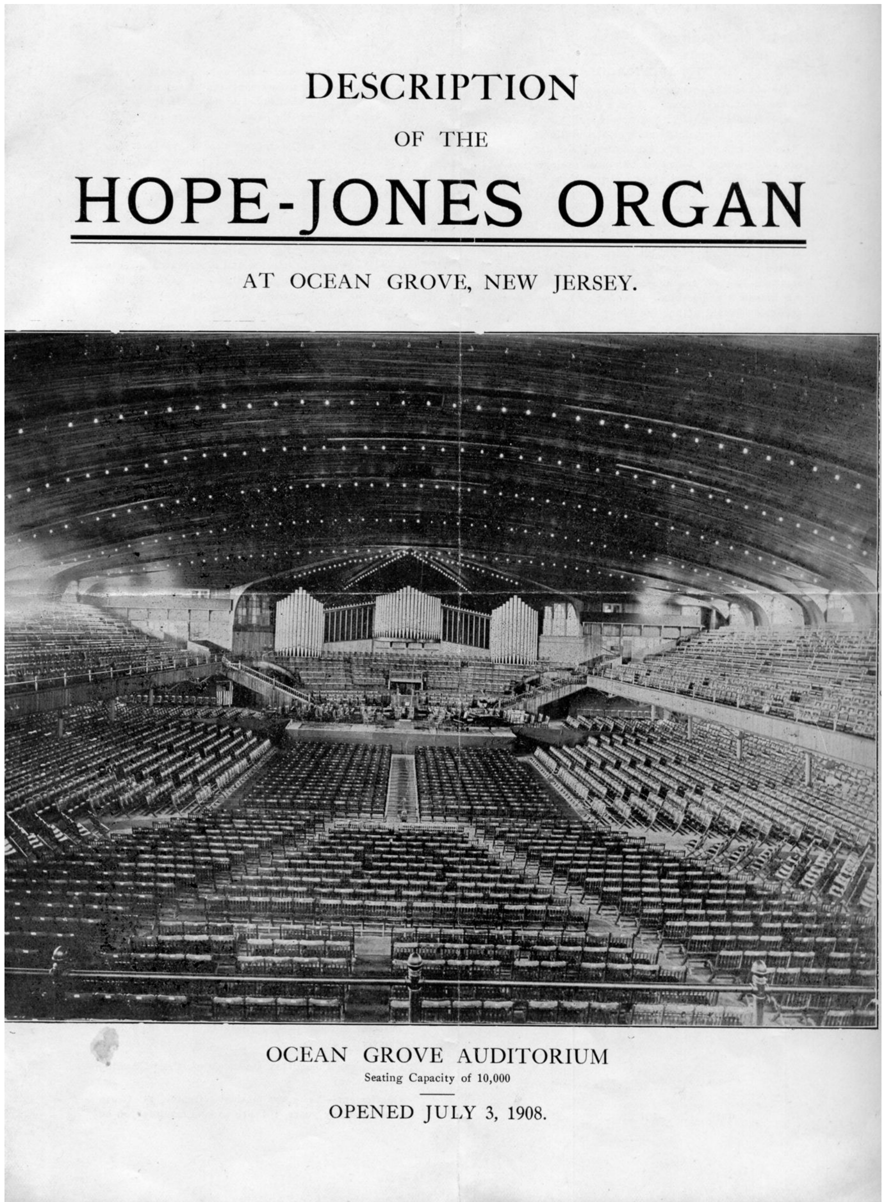
107 "The Great Auditorium Organ", published by the Ocean Grove Camp Meeting Association, 1995, OHS Archive

108 "Description of the Hope-Jones Organ at Ocean Grove, New Jersey", 1908, OHS Archive.

109 Robert Hope-Jones, *Recent Developments in Organ Building*.


DESCRIPTION

OF THE

HOPE-JONES ORGAN

AT OCEAN GROVE, NEW JERSEY.

OCEAN GROVE AUDITORIUM

Seating Capacity of 10,000

OPENED JULY 3, 1908.

Figure 9. Depiction of Ocean Grove Auditorium, 1908

Despite being likely the most powerful organ in the world at that point, it was not the largest such organ. The power came from a combination of stops such as the diaphone, high wind pressure, and the nature of several of the buildings acoustic characteristics, including a cement parabolic sound mirror designed to amplify and diffuse the organ's tone. Organs could become physically smaller while providing greater volume. In fact, Ocean Grove suggests a decoupling from the size of the instrument and the amount of tone that it could produce. The miniaturization of the organ could be seen in the reported promise that despite being the most powerful organ in the world "it will not be the largest, because of improvements in recent years not so much space will be needed."[110]

Just one organ stop, a tuba mirabilis, "could exceed in power the whole of any organ hitherto built." Of course for Hope-Jones' critics like George Audsley, that stop was a honking, shrieking "tuba miserabilis", and Ocean Grove was not much but one big thundering monstrosity. In a letter to Philipp Wirsching, Audsley wrote about being called in to examine the new Auditorium organ by Hopeless-Jones: "The tone is a roar of musical noise" he exclaimed.[111] Others were more thrilled about the promises of sonic abundance. The philanthropist and organ aficionado Andrew Carnegie reportedly informed Hope-Jones when visiting Ocean Grove that he wanted "to have an organ overwhelm [him] with the feeling of how miserable a sinner" he was.[112] Carnegie's interest and opinion of organ power is important as he financed nearly 9,000 pipe organs across the United States as a charitable act of public works.

The repertoire chosen to perform in the Auditorium on the Ocean Grove organ is interesting. Despite being a Christian institution, the programming was highly secular and often featured compositions employing thunder and storm effects. It was unique in comparison with organ repertoires in other parts of the country. Tali Esen Morgan, the musical director, had composed a populist piece entitled 'The Storm" to be played for visitors on the organ. It was used as both a lure to bring in the crowds and as a bait-and-

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110 *New York Times*, (4 January, 1908).
111 Letter from Audsley to Wirsching, dated July 16, 1908: OHS Archive.
112 *Elmira Daily Advertiser*, (16 March, 1908).

switch move— the organist would subject the audience to recitals of classical music after playing the "Storm" piece. It was a novelty trick and yet a major attraction. Storms could be simulated on organs through a variety of strange methods, including by shaking a large sheet of metal via pneumatic motor. Some organs were built with a dedicated "Orage" (thunder) stop. To obtain tones of thunder on the Ocean Grove organ, the method was to open up all the stops, in particular the 32' diaphone, and step on the pedal keys furiously. Perhaps it was no coincidence that the diaphone, partly devised to communicate in fog and storms, was itself a means to conjure up such imagery through music. The evocative power of musical thunder was used fairly commonly. The famous English organist Edwin Lemare employed a thunder effect during a concert stop in Sydney in 1903. During one recital the thunder effect was so intense an elderly lady ran from the hall. City staff forbade later performances with thunder effects for fear that the plaster ceiling would fall.[113] A year later, plaster did fall from the ceiling during a concert at the 1904 World's Fair in St-Louis, from an organ which would find its final resting home at the Wanamaker store in Philadelphia, Pennsylvania. In Ocean Grove, thanks in part to its varnished wood ceiling, there were no such problems when evoking their own rendition of thunder.

Ocean Grove was Hope-Jones' major achievement during his tenure as an organ builder. It represented the realization of many of his obsessions around the power of musical sound. It was also in some ways the realization of the long-aspired dream of the palace of sound built by organ music shared by a wide-assortment of writers from Milton to Robert Browning. In another sense, Ocean Grove was an attempt to return to what Nietzsche called the Dionysian in music— a condition of immersive sonic experience that didn't encourage order or staid contemplation, but rather through an infernal acoustic

113 Nelson Barden, "Edwin H. Lemare, Part Two," *American Organist* 20:3 (1986), 53.

overabundance implicitly aspired towards transcendence, excess and the dissolution of the self. Heidegger saw this Nietzschean notion of Dionysian abundance in the exposure to force and plenitude that facilitates states of rapture and the crumbling of subjectivity.[114]

As loud sound, music and its enclosing space could furnish this state through such force and plenitude. Ocean Grove may not have matched the Wagnerian rapture of Bayreuth, but the organ remains as a testament to the development of an edifice where musical transmission aspired to carve out etheric solids through a musical apparatus firmly entombed within the building. The organ was embedded with the bricks and mortar of the auditorium, but it was more than simply a shelter or a space to congregate. It was an *apparatus* that aspired towards a liquid architecture of transcendence, similar to what was dreamt in *Kubla Khan:* "with music loud and long, I would build that dome in air."

Hope-Jones would move afterwards to the Wurlitzer company where he worked until the last of his years. His focus shifted towards the lucrative "theatre organ" business that made instruments to be used, among other things, to accompany silent cinema. But these organs would not match the acoustic power of the organ in Ocean Grove. In fact, as business became strained with the Wurlitzer company, the owners put Hope-Jones under increasing pressure to cut costs, particularly to cut back on some of the more impressive stops and expensive higher pressure wind blowers that generated "carrying" capacity.[115] The organs built during this period were infuriatingly weak. By moving to Wurlitzer, Hope-Jones had lost the business domain of the "great auditorium" organ to his competitors. Others would pick up the mantle over the next two decades, but Hope-Jones would take his own

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114 Martin Heidegger, and David Farrell Krell, *Nietzsche: Volumes One and Two* (New York: Harper One, 1991), 98.

115 See letters between Hope-Jones and Fanny Wurlitzer between February 8 and April 23, 1912, OHS Archive.

life in 1914. It was ironic that even though he fought for the cause of electricity most of his life, the means of his ending was also thwarted by it— he had apparently planned to gas himself with an elaborate system using a gas lamp behind the organ console he built in a Rochester church. Only, on arrival, he found that the church had recently switched to electric lighting. Alas the deed was done in a hotel nearby.

The Organ from a Vessel of the Divine to Medium of Secular Transcendentalism

Hope-Jones casts a deep shadow across the field of organ building, particularly in the U.S. from the 1890s until the early 1930s when organ building took a decided turn away from the honking monolithic organs of power. His sphere of influence goes well beyond the technologies of loudness he developed; he made a case for the pipe organ to move beyond its recent theological past towards a future of secular entertainment. He also argued, repeatedly, that the organ must do more than merely imitate the orchestra— it should develop as an instrument in its own right. And in certain ways it did, becoming widely adopted as a form of mass public musical spectacle in an era where recording fidelity was poor and amplification insufficient. In short the powerful new civic organ provided a unique form of secular transcendental experience to a public that was, for a time, increasingly interested in organ music. It was a form of mass musical charm before the proliferation of high-fidelity audio recordings and electrical amplification; it also drew larger and more varied audiences than orchestral performances during the period.

By 1910, the organ builder Philipp Wirsching had recognized that organ production was increasingly becoming a civic-minded endeavor. Organ building, once the domain of ascetic monks, had moved into the secular realm of modern technics:

> As a professional manufacturing business, organ building has gradually developed from the work of these monks of the middle ages until today is an important industry in both the old and new world...the organ at the present time is an adjunct to the auditorium, concert room, theater, fraternity lodge room, hotel and residence.[116]

But historically speaking, organs were not the sole domain of a theological apparatus. As mentioned, before adopted by the Christian church they were mostly secular instruments of modest proportions. As the organ rose in prominence as a secular instrument during the second decade of the twentieth-century, it wasn't as much a turn from religion as it was that the organ outgrew the constraints of the church. A multiplicity of contexts for organ installations emerged. In the sonic abundance of high-powered pipe organs, builders like Hope-Jones saw an opportunity to create a new instrument. A self-proclaimed leader in the field of the secular organ, Hope-Jones laid claim to the movement in a speech a few years before his death at the 1910 National Association of Organists, held in Ocean Grove of all places:

> I frankly declare myself in favor of the bold introduction of the organ into the secular field. With the advantage of these great powers of flexibility and expression that I have described and with the new range of tone colors now available, there is no reason why the instrument shall not be modified and introduced freely into public halls, theatres, hotels, restaurants, parks and other pleasure resorts. But gentlemen, if we are going to do this we must frankly set on one side all our conservatism— all our traditions born of church use and we must approach the modified organ as a new instrument. We have heard much said against 'degrading the organ' and 'prostituting our art'— I cannot see the matter in this light. Such remarks are indeed forceful when applied to the Church organ, but I fail to see their applicability to a new instrument

[116] *Diapason*, Volume 1, Number 2, January 1910.

avowedly designed for amusing a large section of the public[117]

The demand for pipe organs exploded over the coming two decades as a wide assortment of secular contexts took up interest for a variety of reasons, as will be discussed shortly. But insights into the uses of powerful organs in secular contexts do not reveal all. The paradigm of the War Organ still lurks in this new instrument. This modern secular organ would embed traditional theological notions of divine presence into secular musical experiences of enchantment and desacralized transcendence. A vague, loose conception of divine presence would often remain common amongst self-proclaimed secular exponents of organ music. As discussed in the introduction, transcendental aspirations endured despite increasingly secular contexts, such as the changing context of the pipe organ.

Organ power was a concern for many churches during the early twentieth-century, but not for all. Most commonly, the organ's function was secondary support for the choir in divine service. In this service, the organ was not to overcome the choir but rather to merely accompany it. It was not to be the center of attention. But for Ernest Sheppard writing in 1919, the choir was often steamrolled by the modern acoustic Horn of Temistius: "The greatest fault is Noise…Many organists have large organs at their command, and in their eagerness to give the best of their instruments, forget the poor choir struggling to be heard beneath the thundering chorus of mixtures and reeds."[118] His message was to back off the thunderous tones— the church was a shelter from the anxieties of modern life, not an amplification of them. For others, organ power was in sympathy with God's work. Certain

117 "Pleads for Modern Devices and Work in Secular Field," *Diapason,* Volume 1, Number 11, October 1910.

118 Ernest H. Sheppard, "Misuse of the Organ in Service," *American Organist* 2:2 (1919): 54-55.

churches valued the "majestic volume of sound."[119] The organ's potential for immensity could be used to help in sensing the presence of the divine— God's presence could be physically felt through the thunder of the organ. These features would remain tacitly integral to the secular organ, without the choir, the litany, or even the church.

For the philanthropist and organ financier Andrew Carnegie, music itself was a religion.[120] He financed over 8,800 pipe organs installed in schools, churches, and civic institutions during the late nineteenth and early twentieth centuries. A lover of organs, who reportedly was awoken each day with a pipe organ being played in his Manhattan home residence, he furnished U.S. cities with musical instruments in a policy of arts patronage that is nearly unsurpassed. His generosity had an undeniable effect of the culture of civic music, among other things the development of a new position in many municipalities: the city organist.[121] Organ historian Orpha Ochse noted that this push to develop municipal organ programs was widespread across the U.S. in the second decade of the twentieth-century.[122] The U.S. was to become furnished, unlike perhaps any other country, with a national arsenal of pipe organs, many of which were built during the period when organ loudness was in vogue.

During the early twentieth century, the orchestra was the sole competitor to the pipe organ as the most prominent form of mass musical spectacle. It was a point of great debate as to whether organs should be designed on the basis of mimicking the orchestra or to develop into an instrument of its own right, severed from orchestral imitation. In 1891,

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119 Peter Christian Lutkin, *Music in the Church* (Milwaukee: The Young Churchman Company, 1910), 101.
120 Craig R Whitney, *All the Stops: The Glorious Pipe Organ and Its American Masters*, 1st ed ed. (New York: Public Affairs, 2003), 29.
121 Orpha Caroline Ochse, *The History of the Organ in the United States*, 196.
122 Orpha Caroline Ochse, *The History of the Organ in the United States*, 329.

Hope-Jones was lectured by head of the College of Organists, arguing "the orchestra should be the model" for organ design.[123] He would retort that the organ could not be seen merely as the imitator of the orchestra, that it was its own instrument. Henry Hiles wrote that while perhaps the organ began as a "compact orchestra", its power would outgrow even a 60-person orchestral pit:

> Modern organs are, to a great extent, compact orchestras; brought under the control of one executant, who is invested with much of the power of a conductor without being troubled by the insubordination or incompetence of his assistants... And this compact orchestra is a high-pressure instrument so complete and powerful in itself that it refuses to bend to the rule of any ally or associate…[it] has more power than the whole band[124]

This singularity of the organist would become almost the composite of conductor, performer, and in an increasingly desacralized musical fora, a quasi-spiritualist reverend. The organist of this "new" instrument would have at hand an acoustic abundance that could go beyond orchestral mimesis. Not satisfied with creating distance from the orchestra, builders like Hope-Jones would go as far as to propose pipe organs as a cost-saving rationalization for replacing over-paid union theatre orchestras. The promise was they were cheaper, easier to maintain, and could easily match the volume of a sixty-piece orchestra.[125]

This "new instrument" emerged at a time when broad swaths of the population took up an interest in organ performances. During the second decade of the twentieth century, with the development of municipal organ programs, increasingly large crowds were attending civic organ concerts. The city of Portland, Maine, for example, claimed to have built the first "municipal organ" in 1912. After the first year of organ recitals there,

123 Robert Hope-Jones, "Electrical Aid to the Organist."
124 Henry Hiles, "Organ and Orchestra," *Musical Opinion & Music Trade Review* 18:208 (1895), 230.
125 *New York Times*, 16 August 1911.

attendance was alleged to have reached a total of 225,000. Openings of municipal organs were "an occasion of major importance."[126] The interest in organ concerts was partly because it was an affordable means of hearing full-fidelity music at a robust volume. Orchestras, conversely, were for the relatively wealthy, and radio and audio recordings were both in their infancy and incapable of providing quality, loud sound.[127] At this time, music was still an evanescent phenomenon that could not really be stockpiled and enjoyed at a later date— it needed to be appreciated at the site of its originating source or not at all.

One of the world's most famous organists of the era was Edwin Lamare. An undisputed populist, he rendered transcriptions of works from Wagner, Brahms, and Dvorak into "stunning transcriptions of original scores" performed on some of the biggest organs in the world.[128] His audience was comprised of a more a general and heterogeneous notion of the public compared to the elite modernist realm of the orchestra, and were often largely uneducated in the ways of symphonic music. He often produced a trick similar to the "bait and switch" of *The Storm* in Ocean Grove, where he would lure people into his concerts by playing popular music of the time, performed with "soul". Often mid-concert he would switch channels and move into more difficult, more brooding work such as Wagner.[129] Lemare was important because he was arguably the most popular organist, performing to perhaps some of the largest musical crowds assembled, but who did so with the view that organ power could provide a vaguely spiritual experience in a largely secular context.

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126 Orpha Caroline Ochse, *The History of the Organ in the United States*, 329.
127 See Craig R Whitney, *All the Stops: The Glorious Pipe Organ and Its American Masters*, 28. And Evan Eisenberg, *The Recording Angel: Music, Records and Culture From Aristotle to Zappa*, 2nd ed. (New Haven, CT: Yale University Press, 2005).
128 Nelson Barden, "Edwin H. Lemare, Part One," *American Organist* 20:1 (1986), 61.
129 Nelson Barden, "Edwin H. Lemare, Part One," 61.

Wagnerian immensity was a great inspiration to Lemare. During a trip to Bayreuth, Lemare began to realize the musical potential that existed between Wagner's compositions and the pipe organ as a means to render those compositions. For Lemare, it was from deep inside Bayreuth's famous "mystic abyss", the orchestral pit, that symphonic immensity actually appeared to mimic the power of the organ. This uncanny reversal of that conventional symphonic mimesis was instead the discovery that a symphony might aspire to the state of singular and powerful pipe organ. Lemare found this nowhere but in Bayreuth.[130] But organ power could do more than mimic the symphony— it was a unique instrument that had the power to evoke a distinct type of spiritualism. For Lemare, powerful musical sound could evoke a type of "spirit" in the form of a psychological state of disembodiment or desubjectification that flirts with the remnants of traditionally theological spirituality but in an oblique fashion:

> The appeal is fundamentally spiritual, or emotional. The normal listener of music doesn't listen to an organ recital as he listens to an orchestral concert. The latter challenges his attention. The former woos it. There is that in an organ which passeth understanding. It is persuasive, spiritual and golden. It is never merely pretty. It should be the musical center of the city, because it can be heard by the greatest number at the smallest cost. It must never be played in connection with any affair other than one which is essentially and intrinsically musical. There should surround it, at all times, the suggestion of the spiritual…the point is to get from the diapasons the deep, fundamental and reverberating suggestion of things divine.[131]

Lemare was making a claim for a secular notion of transcendental musical experience that remained in a knotted interrelationship with the vestiges of sacral organ music it apparently

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[130] Nelson Barden, "Edwin H. Lemare, Part One," 63.
[131] *San Francisco Chronicle* (11 March, 1917).

superseded. The Divine was still suggested but never explicitly; it would lurk as a spectral association. Just as Nietzsche would charge Wagner's music with carrying an implicit, underhanded Christianity, organ music would never cut the link completely from sacred associations, no matter how secular the musical context.[132]

Figure 10. Civic Auditorium Organ Concert. San Francisco, April 1917

Less an experience of bringing the individual closer to god and more one that brings people closer to each other, modern loud organ concerts were often events that fostered some of the most profound instances of collective experience. Secular organ concerts drew in increasingly large groups interested in affordable and powerful music. Elias Canetti saw concert crowds as caught in a sort of paradox of conformity: the implicit promise of musical concerts was an abundance of affect. But any sound made by registering such states of musical feeling was considered highly taboo. So a dichotomy existed between "the stillness

132 Friedrich Wilhelm Nietzsche, et al., *The Will to Power* (New York: Vintage Books, 1968), 442.

of listeners and the din of the apparatus inflicting itself on them."[133] Given the often abundant volume and the large crowds the dichotomy wherein sitting, still crowds are delivered overbearing musical force reveals indisputable political valences. Not surprising then that the politics of the pipe organ was also used in the deployment of nationalist sentiment. On Easter Sunday, 1917, Lemare was giving an organ concert to inaugurate a new organ for San Francisco's Civic Auditorium. War and nationalism were in the air. President Wilson had just delivered his "stirring war message" to a massive crowd through the novel means of electrical amplification via a public address system only days before. The crowd in the Auditorium, estimated at 14,000, who might have been expecting a repertoire of religious music given the holiday were instead subjected to a pummeling rendition of secular nationalist musical themes. As Lemare worked his way into the *Star Spangled Banner*, he opened up nearly all of the organ stops, including the high-pressure tubas for an effect that "must have been overwhelming."[134] It was a massive gathering and suggests the widespread capacity for crowds to absorb a wide range of affect from the trembling tones of divinity to the nationalist chords of state politics. Over the coming years, the style of monster pipe organs developed by Hope-Jones would be pushed far beyond his already wild imagination, and crowds assembled to hear highbrow civic musical enjoyment in numbers that would dwarf previous attendance. The organ in question still to this day holds the title for not only the largest musical instrument ever devised, but also the loudest instrument ever built.

133 Elias Canetti, *Crowds and Power* (London: Penguin Books, 1973), 41.
134 Nelson Barden, "Edwin H. Lemare, Part Four," *American Organist* 20:8 (1986), 47.

Architecture as Infernal Musical Instrument: Atlantic City

By the early 1930s, the shifting American metropolis and the broader cultural condition of modernity were having an impact on the once coddled domain of the pipe organ. The cover of the February 1932 edition of *The American Organist* displayed the situation in a compelling fashion: the quasi-pastoral environment past organists enjoyed was no longer. Instead, a monstrous urban skyline loomed on the horizon that could eclipse the sun. It was an omen of the impact of technics on musical life and perhaps an underhanded plea to a return to a simpler time. The metropolis of early twentieth-century modernity was commonly seen as a having the attributes of a dynamic force. The architect Le Corbusier famously complained a few years earlier of being driven off the once pedestrian-friendly boulevards of the Champs-Elysées by the force of brutish automobile traffic.[135] Musical instruments were being built with a scope and intensity that mirrored the brutish and spectral dynamic forces of the encroaching megalopolis. That same year, an organ by the Midmer-Losh Company was being completed in the Atlantic City Convention Hall that would dwarf any musical instrument ever built. It would set a benchmark that has never been surpassed since. This infernal organ was itself an apex of musical technics, representing a terminal endpoint of the culture of high wind pressure championed by Robert Hope-Jones.

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[135] Marshall Berman, *All That is Solid Melts Into Air: The Experience of Modernity*, 165.

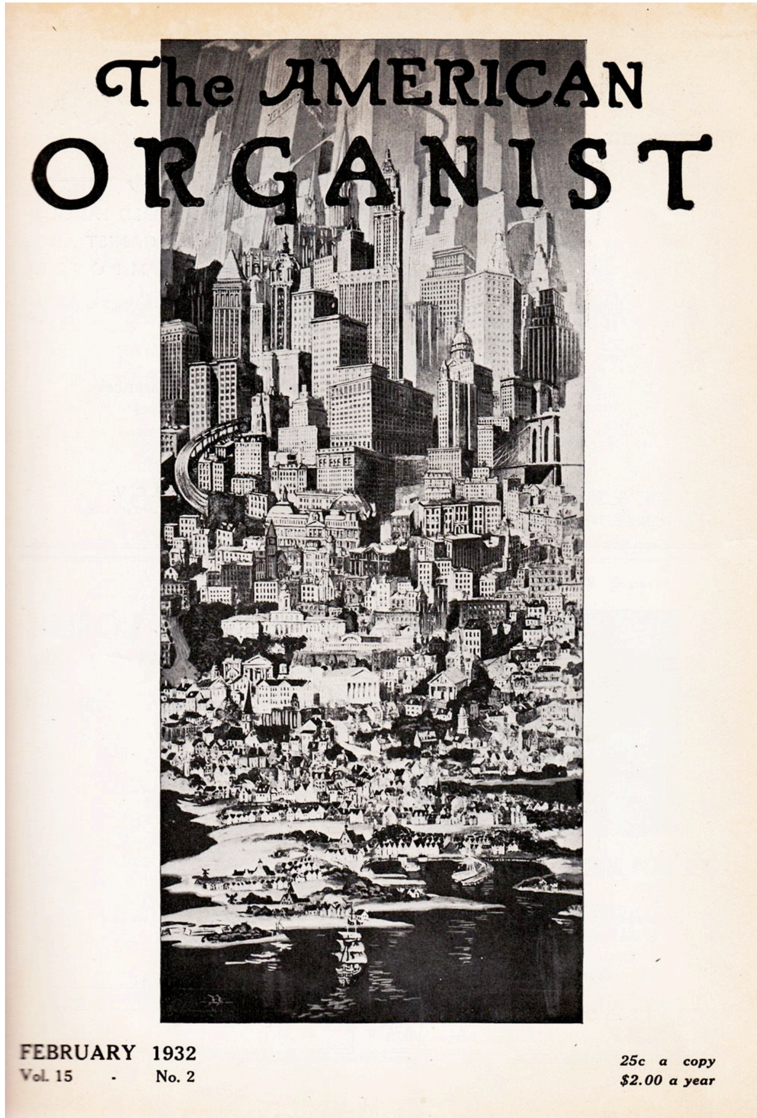

Figure 11. Cover of American Organist, February 1932

For a period of time, Atlantic City was considered one of the premier leisure destinations on the Eastern seaboard of the United States. In 1926 the city was building a new convention hall in an effort to capture and amplify that popularity. It was not a modest nor average hall— the intention was, in fact, to build the largest convention hall in the world. It would boast a more than robust capacity of 40,000 people and met numerous other feats such as the largest stage in the world, "the most powerful public speaker system in the world", and the promise of being able to transmit "perfect sound".[136] The inauguration of the building in 1929 was similar to the opening of the San Francisco Civic Auditorium in 1917 in that it was an event exploited by nationalist and militarist sentiment. The USS Wyoming, a battleship waiting offshore fired its 16-inch artillery and shortly after a military airship floating above triggered an acoustic siren from above. A mysteriously named "electric ear" was reported to have detected the siren calls and automaticaly turn on the building's lighting system.[137] A strange, raucous beginning for the life of an edifice of monumental proportions which was once described by its builders as sitting on the Atlantic City beach sand with the same enduring heft as the Pyramids or even the Parthenon.

Figure 12. Atlantic City Convention Hall, Atlantic City NJ, ca. 1929-32

[136] Stephen D Smith, *Atlantic City's Musical Masterpiece: The Story of the World's Largest Pipe Organ* (Portsmouth, N.H: Published for the Atlantic City Convention Hall Organ Society, by Peter E. Randall, 2002), 18-21., and *The American Organist*, Volume 13 No. 7, July 1930, p. 409.
[137] *New York Times,* May 20, 1929 and Stephen D Smith, *Atlantic City's Musical Masterpiece: The Story of the World's Largest Pipe Organ*, 16.

The builders of the hall decided that such a monumental building needed a monumental music system to accompany it. In fact, two separate organs would be built for the building: one for the main hall and one for the ballroom. After a competitive bidding process, the contract to build the main organ was given to the Midmer-Losh company being the lowest bidder— it was a fatal low-ball strategy that would bankrupt the firm. Announcing the imminent construction of the instrument, the American Organist gave the Midmer-Losh organ a long feature in 1929, calling it the "greatest organ ever projected."[138] According to the publication it constituted the singularly greatest event in twentieth-century organ building. The specifications of the organ itself were titanic; plans for the organ ranged between 29,000 and 43,000 pipes spread out throughout eight clusters embedded in the walls of the giant convention hall. In opposition to earlier overt visual displays of acoustic prowess where pipes were presented prominently in the foreground, the unrivalled power of the Midmer-Losh would be recessed within the building's veneer. Confident in its capabilities, the organ was less a separate musical instrument as it was a resonant architectural edifice. In effect, the building was the instrument. It was an architecturally embedded version of immense surround sound avant la lettre. Every form of reed and flue pipe would be represented, some voiced on wind that would finally be delivered through the holy grail of 100-inch pressure.

While the *power* of pipe organs is usually denominated in the metrics of wind pressure, the *size* of organs are most often the tally of their pipe counts. The absurdly large pipe counts planned for the Midmer-Losh were not culled out of thin air, rather they were based on a strategic calculation to supersede the Wanamaker Grand Court Organ, an organ installed in a Philadelphia department store. The Wanamaker organ, built for the 1904

[138] *American Organist,* May 1929, Volume 12, Number 5, p. 273.

World's Fair, resided in numerous places before settling into a life inside the department store. Designed by Hope-Jones' nemesis George Audsley, it boasted a pipe tally that grew through the era to around 28,000 and was described as a billowing and opulent "niagara of sound."[139] Yet its power would be constrained because of its commercial-oriented location. Its function in the store was to be "entertaining without distracting." The same constraints would not be placed in Atlantic City. But the builder of the Convention Hall organ, Senator Emerson Richards, still wanted to go beyond the Wanamaker organ. It was competitive ambition above all else— a nearly unachievable scenario akin to Werner Herzog's *Fitzcarraldo* where the builders were not prepared to deal with the fact of its near impossibility:

> When Senator Richards got the idea into his head that Convention Hall would have an organ, he never considered what the weather and the fact that the hall is unheated most of the time would do. He didn't think that the Depression would come on and turn what should've been a six-month job into three years. He just wanted this to be the bigger than Sam Wanamaker's in Philadelphia.[140]

What was contained in the final plans, despite cutbacks forced by the looming Depression, was an organ both bigger and louder than any that had come previously.

Many organ builders denounced the organ as a stunt of imperial ambition. For others it was hubris or even "a circus effort to beat the world on the largest organ mania."[141] Richards would dispute that the scope of the organ was overkill, arguing that the space in which the organ needed to fill demanded a colossal force of tone. His position was that an "engineering and scientific standpoint" demanded the enormous level of organ power.[142]

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139 Craig R Whitney, *All the Stops: The Glorious Pipe Organ and Its American Masters*, 42.
140 Former organ custodian Dennis McGurk, *New York Times*, December 27, 1998
141 *American Organist*, May 1929, Volume 12 Number 5, p. 273.
142 *American Organist*, May 1929, Volume 12, Number 5, p. 277.

Other factors such as competitive civic pride or a combination of arrogance and experimental curiosity seem to be more convincing explanations. But for Richards it was acoustics foremost—a space of such tremendous size required a level of instrumental power not yet realized, or at least so he argued in public. It was obvious the nearly obscene potential for loudness in Midmer-Losh organ was dictated by more than purely acoustic exigencies. It should be clear from the experience of Robert-Hope Jones that claims to engineering or scientific knowledge do no render specific guidelines for appropriate organ loudness; it was too subjective a domain to have any agreement whatsoever. These discussions also predate the common use of the decibel as a useful measurement. However, it is certain that those closest to progressive quasi-scientific approaches in organ building at the turn of the century were also the same people who pushed loudness beyond the threshold of comfort.

If any ghost might haunt the modern technological console of the Midmer-Losh organ in Atlantic City, it would certainly be that of the spirit of Hope-Jones. The Convention Hall organ is the culmination of many of the ideas Hope-Jones worked to develop over his relatively short career, among others being: the most extreme wind pressure ever achieved in a working organ, the use of some of the largest, most unconventional organ stops such as the diaphone, and a robust employment of sophisticated electrical technologies. The Midmer-Losh organ was to be voiced on 100 inches of wind pressure— a "pet scheme" of Richards' and something Hope-Jones never achieved but finally became realized after all. The numerous wind blowers were housed deep within the basement vaults of the Hall. The functional requirements of 100-inch pressure was such that an air compressor-type of apparatus was necessary instead of the more traditional high-pressure wind blowers.[143] Hope-Jones would have been honored to see his beloved diaphone stop employed in one of the rare instances after his death— in fact a 64-foot long version was built for the Midmer-Losh. The result was an organ stop with capabilities beyond anything of musical use, power beyond anything previously achieved in a musical instrument, and yet another ceiling falling apart from organ loudness:

> …the 64-foot set up quite a vibration. When we first played it, a lot of the sound absorbent bricks dropped right out of the ceiling - not in the chamber, but out there in the hall...And there was a terrible noise from one of the steel beams up in the middle of the auditorium ceiling; a rattling noise like a machine-gun that started fast and slowed down, then started up again.[144]

The diaphone, an organ stop originally devised by Hope-Jones to provide both "fundamental organ tone" and nautical acoustic signalling functions, was employed in the Atlantic City organ as a terrifying fountain of sonic power, a trembling low-frequency instance of musical sublime. By 1930, the publication *Diapason* purported the organ was offered nothing less that the "possibilities for the education and uplift of humanity which very few musical instruments, if any have as yet possessed."[145]

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143 Stephen D Smith, *Atlantic City's Musical Masterpiece: The Story of the World's Largest Pipe Organ*, 69.
144 Stephen D Smith, *Atlantic City's Musical Masterpiece: The Story of the World's Largest Pipe Organ*, 179.
145 *Diapason*, (November 1930), p. 44.

Figure 13. Two of Atlantic City's Electrical Wind Blowers

Figure 14. Building the 32-foot Diaphone, Atlantic City

By late 1932, the organ was built. The *American Organist* devoted its entire August 1932 issue to the organ, referring to it as the greatest organ in the world, an "epoch making acquisition in the realm of the musical arts."[146] What was constructed over a period of three years was an instrument beyond the physical scope and sonic capabilities of any instrument ever realized. In six basement vaults, high-pressure wind was fed to a network of over 33,000 pipes embedded in clusters throughout an enormous building controlled by a console using advanced electrical engineering and an unfathomably immense system of electrical wiring. As such its historical importance has been grossly understated, its ongoing decline a tragic tale of neglect; it is the victim of shifting tides of popular taste and inadequate custodial funding. There is no better musical example of the type of technological sublime discussed by David Nye— it was a musical instrument equivalent of the Golden Gate bridge, which at the time appeared beyond debate. Like the awe-inducing power of Niagara Falls to nineteenth-century visitors, experiences of the Midmer-Losh organ were similarly liquid and encompassing. An "unprecedented flood of tone" which provided "a tonal energy far surpassing anything hitherto considered possible" was how one visitor explained it.[147]

Indeed the organ had so much power that it was considered nearly an embarrassment to the Midmer-Losh Company. George Losh believed that showing the organ to potential customers made them lose out on a number of contracts. This soon-to-be bankrupt company took steps to avoid unleashing the monster of tone when giving tours: "We had prospective customers who were quite shocked by the volume of tone that came out. They did not believe that a voicer who had produced such tremendous volume could adjust the

[146] *American Organist*, August 1932, Volume 15, Number 8, p. 469.
[147] *American Organist,* April 1930, Volume 13, Number 4, p. 228.

loudness of tone to fit their building and needs."[148] It was also a veritable health hazard to be near the high-pressure stops. Organ tuners would work with cotton in their ears. One of the most recent organ curators is deaf in one ear from working on it. It would sometimes be too much for audience members; complaints about its loudness were common. At a climatic passage of a rendition of Wagner's *Tannhauser*, an audience member approached the organist pleading to play quieter.[149] A familiar secular-emphasized organ repertoire would be the employed in the Hall triggering trembling thunder pieces such as *The Storm* composed for the Hope-Jones organ in Ocean Grove and other nautical pieces including the quasi-sailor song *Return of the United States Marines.*

Figure 15. Relative Scale of the 32-foot Diapason

[148] Stephen D Smith, *Atlantic City's Musical Masterpiece: The Story of the World's Largest Pipe Organ*, 69.
[149] *Diapason*, November 1930, p. 44.

Of all the high-pressure stops in the Midmer-Losh organ, the highest-pressure wind of 100-inches was reserved for the *Grand Orphicleide* 16', a shrieking trumpet-like stop of ear splitting volume. It continues to be recognized as the loudest organ stop in the world. Its loudest notes sit at a higher register in the frequency spectrum than the Diaphone, which resonates most powerful at nearly inaudible low-frequency bass notes. During a visit to the organ I had an opportunity to play both the Diaphone and Grand Orphiclede. Despite the organ being in a state of total disarray due to a variety of factors (only one chamber of the eight embedded in the Convention Hall currently "works"), both the Orphiclede and Diaphone manage to still emit sound, continuing to be a nearly brutal form of acoustic power however misaligned and malfunctioning. The Orphiclede, on 100-inch pressure, is a rattling and skull vibrating tone and the Diaphone, at its lowest 64-foot tones, is essentially sub-sonic. A frequency of eight Hertz could be said to be a vibration that is pre-tonality; it is possibly the closest a musical instrument comes towards a material force.[150] I was shocked from this experience and given its limited functionality could only imagine the force provided when fully functional. In the past, impressions of the 64-foot Diaphone have been occasionally to describe its sound as that of a helicopter hovering in the building.[151] Indeed during the 1970s a helicopter would manage to fly within the enormous enclosed space of the auditorium—as part of a test to conduct the world's first indoor helicopter flight.

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150 Goodman, Steve. *Sonic Warfare: Sound, Affect, and the Ecology of Fear*. Cambridge, Mass.: MIT Press, 2010, 18.

151 Stephen D Smith, *Atlantic City's Musical Masterpiece: The Story of the World's Largest Pipe Organ*, 179.

Figure 16. Helicopter Sound Both Literal and Metaphorical, Atlantic City Convention Hall ca. 1970

The Atlantic City Convention Hall Organ, inaugurated in 1932, would remain as the apotheosis of both organ power and musical instrument building likely not bettered since. The proclaimed "new era" of organ building that was to be ushered in by its presence never occurred. Public winds would irrevocably turn on the question of monster organs during the Depression— large organ projects were at first no longer financially possible and later no longer desirable. The pipe organ, once an object close to the center of American musical life, would fall irreparably out of vogue. Tastes changed, the fidelity of recorded media improved to the point that it wasn't as enticing to hear an imitation orchestra when a reproduction of the real thing could be heard in the comfort of one's own home.[152] The organ-building world itself was in the midst of a throwback movement. The "organ reform" movement, which picked up steam in the 1930s, sought to get rid of the excesses of recent organ

[152] Craig R Whitney, *All the Stops: The Glorious Pipe Organ and Its American Masters*, 49.

building in favour of a more Baroque approach to instrument craft. An instrument's worth returned to the benchmark of its ability to perform Bach. Robert Hope-Jones was reduced to a caricatured emblem of all that went wrong with the organ building trade. In short, organ power dropped out of favour; orchestral mimesis was gauche. The changing tides were reflected by G. Donald Harrison's remarks to the 1933 National Association of Organists convention: "There is a tendency to use lower wind pressures, and extreme tones are being eliminated. The old singing quality is coming back… A good tonal ensemble does not necessarily mean a very loud ensemble."[153] The era of high-pressure pipe organs was over. Organists like Edwin Lemare, ones who garnished international fame by being able to tame big infernal organs, found their services of little interest in the great halls of performance.

The early twentieth-century high-powered pipe organ remains as a quintessential megaphonic technology and a resolute example of monumental artifice in musical experience during the era. An arc of work spanning from Hope-Jones' late nineteenth-century organs to the 1932 Midmer-Losh in Atlantic City reflects the compelling ways in which the power of sound was seen as a catalyst for transcendent experience and modern musical rapture. The fact that these organs were influential and important, if only for a fleeting period, suggests some broader linkages of how loud sound can be construed as more than merely noise in need of abatement—these organs offered the ability to experience quasi-sacred music in secular venues. One could consider it as a return of sonic power in music not seen since the Babylonian War Organ, the Horn of Themistius. In terms of musical instruments, nothing louder has really come since. In the 1970s the Atlantic City Convention Hall apparently hosted a competition against a rock band to see who could be

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[153] Harold Cobb, "The Influence of Robert Hope-Jones on the American Organ" (Thesis: OHS Archives, 1934), 60-61.

louder inside the hall. Even in its state of decay by that time, the Midmer-Losh organ still easily triumphed against the band.[154] This should come as no surprise.

[154] Anecdotal evidence provided in an interview between author and organ officials Carl Loeser and Harry Belangy, 2009.

CHAPTER 2

Diaphonics of the Void

> *"Oh, why this fog, so thick and dark for five long days and nights? It seems as though kind Providence has veiled the heavenly lights. That he who seeks his life to save shall live the tale to tell. Of drunken mobs and demon cries, like legions just from hell."* - Hunted Down, or Five Days in the Fog, H. H. Granice, 1875[155]

In the spring of 1900, the *Chicago Daily Tribune* published a story about a newly installed foghorn on the shore of Chicago that was "wearing on the nerves" of a young woman living close to the horn. While complaining to her husband about the inundating din, he offered to take her for a walk along the fog-engulfed shore so she would see "why it is necessary to keep [the horn] going."[156] What started as a gesture of paternalist education turned into near-nightmare as the couple became quickly swamped by the miasma of a classic Chicago fog. Not able to see more than a foot ahead of themselves they were enveloped by a cloud of mist that obfuscated everything and denied the very possibility of vision itself. The couple feebly groped their way across a landscape rendered unknown and unseen. Mysteries unfolded: a sea-crusted mariner passed by them with a lamp on the right; a small dog whisked by on the right. They were lost in fog.

The problem of the persistent fog on the shores of Chicago was compounded by the fact that the city lies in front of a major nautical port. For mariners trying to navigate in fog, the blindness meant but one option for safe passage— acoustic signaling, the dubious act of navigating via the ear and broadcasting via pneumatic-based sound. For an acoustic signal to transmit effectively, it was believed that sufficient power was needed to overcome distance

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[155] Granice, H. H. *Hunted Down: Or Five Days in the Fog.* (San Francisco, CA: Woman's Publishing Co, 1875).
[156] "Found in the Fog", *Chicago Daily Tribune*. April 24, 1900, p. 6.

and obstacles to efficient transmission. This chapter charts the rise and fall of the belief in loud sound as an effective way to provide safe harbour for marine navigation.

Fog signals are more than simply a beacon for wayward sea travellers. They also represent a sort of guardian against the void, or rather a type of acoustical index which demarcates multiple voids— the borderland between governed land and the ungovernable infinitude of the sea, as well as the void of visuality in which sight no longer provides any answers. Left with no other option for the helpless mariner, it was only the blunt force of cultivated acoustic power that could blanket the coastlines of North America with an aura of nautical safety.

To elaborate on the productive loudness of acoustic signaling during this period, it would help to step back and consider the significance of fog itself in the context of modernity. Like crowds and other seemingly liquid-like phenomena, fog was an emblematic fixation of modernity itself. Much akin to being lost in a mob or a crowd, the denial and confusion that a fog rolling into a major city in the late-nineteenth or early-twentieth centuries almost mimics some of the more general confusion and bewilderment which characterized the experience of modern urban life during the period. Marshall Berman described the vortex effect of capitalism, industrialism, and urban development on late nineteenth-century subjects as a melting of societal norms that were once stone-like and permanent into vapor.[157] Living in a large city during this period often afforded the experience of ambiguity, formlessness, and perpetual flux. This was considered the "condition of modernity"— the cultural, political, and economic condition of perpetual vertigo brought on by a new velocity of modern life which had the effect of disorientation and anxiety amidst the vaporousness.

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157 Marshall Berman, *All That is Solid Melts Into Air: The Experience of Modernity* (New York: Simon and Schuster, 1982), 92-93.

Figure 17. Georges Seurat, Au Divian Japonais 1887-1888

It should come as little surprise then, that fog itself was an endemic metaphor during the period, particularly in late nineteenth-century aesthetic practices in visual art. One thinks immediately of the soft-focus emphasis of impressionist painting for example, or the obfuscations inherent in the emergence of the pointillist technique in the late nineteenth-century. Artists such as Claude Monet and James Whistler went as far as to celebrate the aesthetics of fog and smoke. Monet celebrated the various colored fogs in his painted tables and one stated, "without the fog London would not be a beautiful city."[158] Georges Seurat's charcoal-based drawings are a prime example of a visualist-based practice that attempts the

158 Thorsheim, Peter. *Inventing Pollution: Coal, Smoke, and Culture in Britain Since 1800*. (Athens, Ohio: Ohio University Press, 2006), 55.

delicate dance between form and formlessness, an aesthetic of veils that reveals form amidst the denial of intelligibility.

Allusions to fog were also common in literature. Charles Dickens depicted London as a city mired in a glum fog in *Bleak House*, using fog as a metaphor for the obfuscation endemic to multiple aspects of London life. Towards the late nineteenth century there was an increasingly large glut of books set amidst the fogs of the many modern metropolises, particularly London. The famous "London Fog", while not known at the time, was not always mist but often in fact polluted air— a by-product of widespread coal burning. It was a type of pollution so thick that it was referred to as having the consistency of pea soup; only through touch one could navigate given the denial of vision. It was an experience which forced you to mistrust all of your senses, short of touch:

> A London fog, solid, substantial, yellow as an old dog's tooth or a jaundiced eye. You could not look through it, nor yet gaze up and down it, nor over it; and you only thought you saw it. The eye became impotent, untrustworthy; all senses lay fallow except that of touch; the skin alone conveyed to you with promptness and no incertitude that this thing had substance. You could feel it; you could open and shut your hands and sense it on your palms, and it penetrated your clothes and beaded your spectacles and rings and bracelets and shoe-buckles. It was nightmare, bereft of its pillows, grown somnambulistic; and London became the antechamber to Hades.[159]

As a prelude to the looming idea of environmental pollution, urban fog was seen as something distinctly out of place. It somehow did not belong in the modern city, a space often seen as increasingly managed, controlled, and rationalized. When a fog rolled in, not only did it force one to abandon vision as a conduit of certainty, navigation, or even truth,

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159 Harold MacGrath, *The Voice in the Fog* (Indianapolis: Bobbs-Merrill Company, 1915), 1-2.

but it also had the ability to amplify the sense of futility around efforts to control public space. Fog almost encapsulates some of the contractions inherent to the historical condition of modernity itself— the regimes of public order which were fostering an accelerating industrial capitalism could not fully control the visual or sonic environments which they considered to be their dominion. Fog and noise were the foils of urban environmental normalcy, which undoubtedly also encouraged gauzy aesthetics.

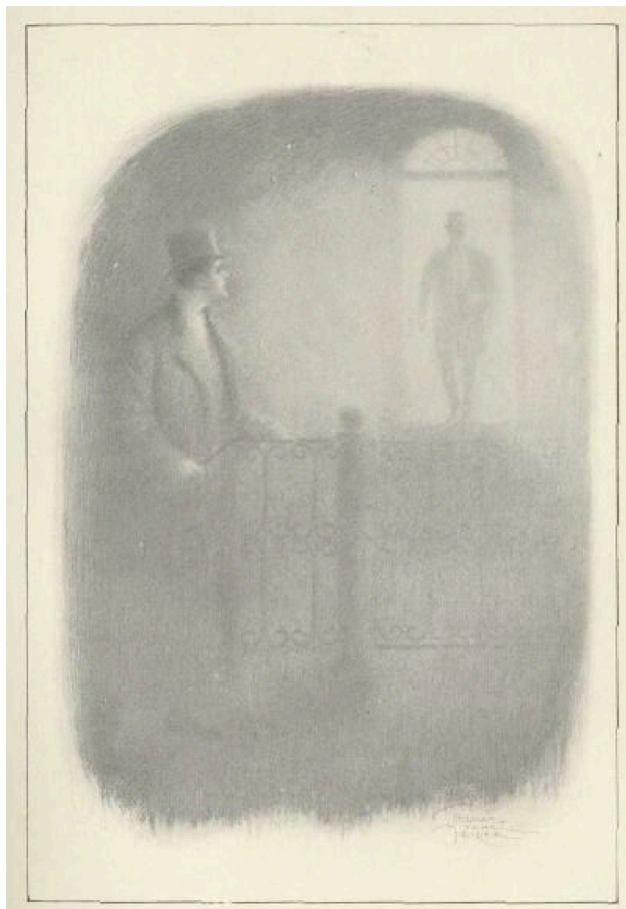

Figure 18. From In The Fog (ca 1901)

The risk of miasma was abundant even for the genteel city dweller, as described in the following 1901 neo-romantic novel entitled *In the Fog*:

> At sea a fog is a natural phenomenon. It is as familiar as the rainbow which follows a storm, it is as proper that a fog should spread upon the waters as that steam shall rise from a kettle. But

> a fog which springs from the paved streets, that rolls between solid house-fronts, that forces cabs to move at half speed, that drowns policemen and extinguishes the electric lights of the music hall, that to me is incomprehensible. It is as out of place as a tidal wave on Broadway.[160]

Fog in the city was repeatedly presented as a state of pure hell. For the all of the portrayals of "helpless women" confused and paralyzed by the mist, there were tales of heroic chivalry in which male bravery was on par with *Knights of Days Gone By*. Such a narrative was made explicit in the *Boston Globe* article of 1905 titled "MEN LOVE DARKNESS: Knight-Errantry as it is Today Shown in a London Fog" in which a noble gentleman predictably helped a helpless woman lost in fog.[161] In Chicago, a fog in 1911 was reported with the byline: "Fog Descends Upon City; Women ask for Police Escorts."[162] The article portrayed a city of nervous women, frozen in stone awaiting rescue. But more generally, the city was seen as frozen itself, the familiar beacons of arc-lights appeared through the "gummy atmosphere" of a misty infernal haze of impressionistic red globes. Other stories of experiences in Chicago describe the effect of paralyzing fog on afternoon shopping excursions and other tales of "darkness, after the style of ancient Egypt, shroud[ing] Chicago for hours."[163] Fog, we were told, spoils everything: it saturates clothes with cold humidity, it engulfs buildings, it devours familiar landmarks and renders them alien once again in a mist of confusing vapor. Above all, it means that once again the fog signal shall commence its booming and incessant noise.

If one agrees that fog is inherently unnatural in an urban setting, it would seem intuitive that the experience of fog at sea is more comfortable or natural. To the mariner this

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160 Richard Harding Davis, *In the Fog* (New York: R. H. Russell, 1901), 31.
161 *The Boston Daily Globe*, February 26, 1905.
162 *Chicago Daily Tribune*, September 11, 1911.
163 *Chicago Daily Tribune*, December 20, 1895.

would likely be farthest from the truth. All the emotions of the city slicker lost in the fog, such as the mild anxiety or disorientation, are amplified considerably in the situation of the mariner. Mariners lost in fog had only their ears— a form of desperate listening for the orientation provided by a sound signal. These sound signals had numerous impediments to being successfully heard. They needed to pass unabated though zones of silence or even transcend the noise of the sea itself. A ship could be meters away from razor sharp rocks that would spell a sure death in the dark of the night. The loudness of the sea, itself an alien landscape to the mariner, required that sound signals must create more noise than sea noise for the transmission to be successful. The French philosopher Michel Serres makes the case quite explicit in his text *Genesis*:

> The silence of the sea is mere appearance…How much noise must be made to silence noise? And what terrible fury puts fury in order? Noise cannot be a phenomenon; every phenomenon is separated from it, a silhouette on a backdrop, like a beacon against the fog, as every message, every cry, every call, every signal must be separated from the hubbub that occupies silence, in order to be, to be perceived, to be known, to be exchanged.[164]

So to a certain extent the noise of the sea required an even greater noise to be able to override the sounds of the sea in order to be heard in storms or the veiling effect of fog. This was a crucial precondition for megaphonic sound as it was another instance of the escalating acoustic logic of modernity. Former U.S. lighthouse official A.B. Johnson described this cruel type of listening forced upon the "tired ears" of the mariner, who had to discern crucial fog signals from "the shrieking of the wind, the creaking of the cordage, the rattle of the machinery and the roar of the surf."[165]

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164 Michel Serres, *Genesis*, Studies in Literature and Science (Ann Arbor: University of Michigan Press, 1995), 13.

165 Arnold Burgess Johnson, "The Cruise of the Clover—Further Remarks on the Aberrations of Audibility of Fog Signals," *Science* 23: 570 (1894), 6.

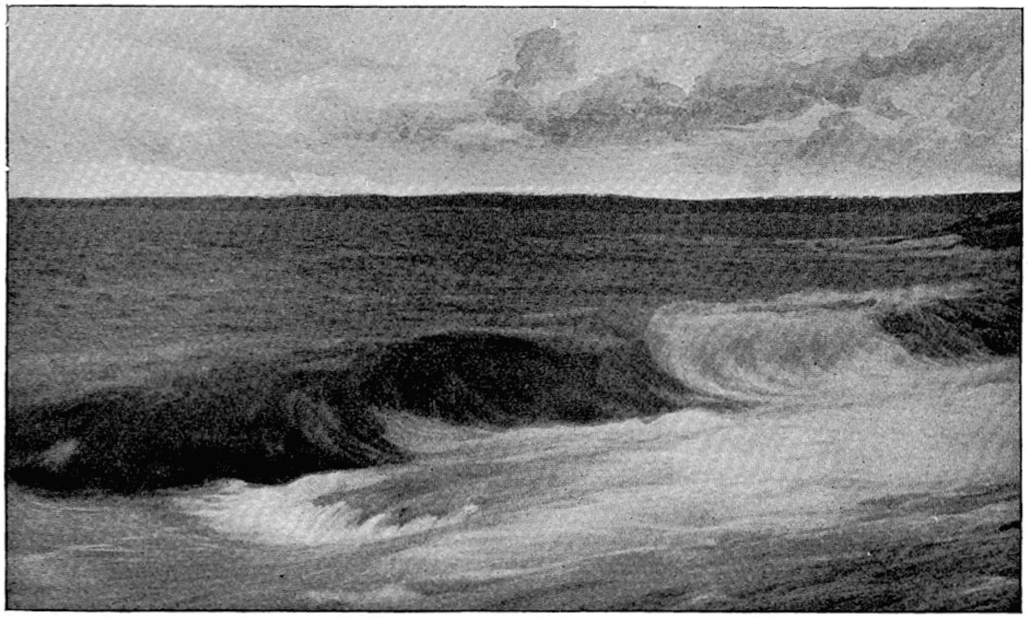

Figure 19. The Sea's Lonely Roar, New England Magazine (1897)

Examples of this type of precarious listening in literature abound. A late nineteenth-century tale of a young man whisked out to the open sea, in fog at night, summarizes the horrors of being lost: the anxiety of blindness, the noise of the sea, and a type of difficult listening that was required to attempt safe harbour. This tale of Tom, the unwitting sea-goer documents the shuddering fear of an enclosing fog, a blanket which "extinguished the glimmering stars. It threw a veil over the receding shores. It drew its folds around him closer and closer, until at last everything was hidden from view."[166] As the small craft was shuttled out to the void of the open sea, the sea noise consumed everything. Tom's only answer was to listen closely:

> …by incessant attention to the monotonous sounds, they ceased to be altogether monotonous, but seemed to assume various cadences and intonations. His sharpened ears learned at last to

166 James De Mille, *Lost in the Fog* (Boston, MA: Lee and Shepard, 1871), 92.

> distinguish between the dash of large waves and the splash of small ones, the sighing of the wind, the pressure of the waters against the boat's bows, and the ripple of eddies under its stern...[167]

It was an almost cultivated form of audition that would allow him to recognize a signal amidst a catalogue of sea noises. Finally, Tom hears a foghorn he refers to as the voice of an old friend calling him. It would provide a beacon in the right direction back to the shoreline. This young mariner achieved safely and escaped the nether regions of the open ocean because of close listening and the acoustic power of the fog signal itself. Yet foghorn power was still at its infancy.

This chapter charts the rise of a tenuous faith in exceedingly loud forms of acoustic signaling in marine navigation. The turn of the twentieth-century was a period that fostered megaphonic approaches to nautical communication. Until roughly the early 1920s, it was a marked belief that louder acoustic signaling could provide both greater safety to mariners and also overcome dreaded "zones of silence"— spaces that sound could not penetrate. Zones of silence were pockets of ocean where sound seemed to disappear or was not audible, even if the sound source was very close by. The problem of zones of silence, made starkly evident by the discrepancy between megaphonic long-distance sound transmission and the elusive, unreliable nature of these pockets of silence, was a problem addressed by the most revered acoustic scientists of the time. One answer was the development of a diaphone-based foghorn and the utilization of louder forms of sound signaling. Recognized for its unsurpassed sonic power, the diaphone was a quintessential megaphonic technology at the turn of the century— an understanding of loud sound as a productive force of safe harbour when used in abundant quantity. For this to happen the diaphone needed to

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[167] James De Mille, *Lost in the Fog*, 94.

override the raging sounds of the sea, itself increasingly viewed as a terrain of noise. Noise could be deployed at the service of another noise.

However, the era was increasingly marked by a decidedly precarious and almost suspicious relationship with the ear as a tool in maritime navigation. With each increase in the acoustic power of nautical signaling, the assertion that sound was a reliant means of safe navigation was cast increasingly in doubt. The main point of the chapter is that for a period of time (roughly between 1880-1920), a widely held belief in the productivity of megaphonics was sustained as a tool of marine navigation. Yet this period ended due to a variety of factors: the enduring problem of zones of silence despite increases in power (casting doubt on the reliability of human ears), noise abatement concerns (increasingly railing against diaphonic incursions) and an increased mastery over more trustworthy higher-frequency forms of communication. As the ear could not be relied upon, the field of marine navigation essentially abandoned the auditory sphere— an ascension out of the range of the untrustworthy ear and up into the inaudible domain of ultrasound.[168]

Basic Nautical Navigational Concerns: A Necessary Faith in the Ear

What did fog mean to the world of late nineteenth-century science? As a physical phenomenon, fog was described at various points as a consequence of the fact that both the air and sea could carry water. Humidity was the invisible, yet material presence of water droplets in the air. Fog was the visible manifestation of that physical presence of water. Thus this premise appeared in some navigational manuals presenting the air above the sea was

[168] This claim recognizes that sonar technology was implemented right at the period of the decline of bare acoustic forms of navigation. Sonar relies on an electronic intermediary to interpret location. This discussion is primarily around bare audition of loud sound.

seen as an atmosphere of water.[169] This transparent, invisible vapor could be rendered visible by two main scenarios:

> …when warm air saturated to the 'Dew-point' passes over cold water, the temperature of the air is reduced, its moisture in condensed, and fog is the consequence. On the other hand, when a cold wind blows over relatively warm water, the invisible vapour rising from the water is chilled, with precisely the same result.[170]

Different areas experienced varied ways in which fog was produced. For example, the fogs which blight Northern California for extended periods without respite stem usually from the first situation: the mixture of warm air currents with frigid water. Other areas experience similar dense, ongoing fog seasons, such as parts of the Banks of Newfoundland and various areas along the coast of New England. Other areas are surprisingly fog-free most of the time, such as the U.S. South Atlantic and the Gulf Coast areas.

For mariners, understanding the science of fog was important, as once a fog settled it would turn a routine act of navigation into a perilous journey saturated with mortal threat. In fog you were lost "almost at once."[171] Vision, the main means of navigation, became utterly useless. Fog is in essence the ultimate source of dread for the mariner, as this 1913 text on lighthouses attests:

> …notwithstanding the wonderful ingenuity that is displayed in the concentration of light into powerful beams, these all count for nothing when fog settles upon the sea. The ray of 1,000,000 candle-power is almost as futile then as the glimmer from a tallow dip. Fog is the peril of the sea which the mariner dreads

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[169] Edmund M. Blunt, *The American Coast Pilot: Containing Directions for the Principal Harbors, Capes, and Headlands on the Coasts of North and South America.*, 20th ed. ed. (New York: E. and G.W. Blunt, 1864), 13.
[170] Thornton Stratford Lecky, *Wrinkles in Practical Navigation.* 15th. ed., rev. and enl. by William Allingham. ed. (London: [s.n.], 1908), 305.
[171] Paul E. Wylie, *The Essentials of Modern Navigation* (New York, NY: Harper & Brothers, 1941), 72.

> more than any other. The blanket of mist, descending upon the water, not only shuts everything from sight, but deadens every sound as well. The sea is absolutely calm, so that no intimation of danger ahead is conveyed by the breaking of the waves upon rock, shoal, sandbank, or iron-bound coast. It is in times of fog that the navigator must be given the greatest protection. As this is impossible to accomplish visually, appeal must be made to his ear.[172]

Indeed, in the period before radio-assisted navigation, sound was the main means of navigation in fog or storms. It was far from ideal, but through the development of cultivated techniques of listening, it was believed safe passage could be achieved by being able to discern auditory signals. Navigation-based listening practices were just one of a number of nineteenth-century techniques of focused listening.[173] Almost invoking Caliban's claim for the pleasantries of noise in *The Tempest*, the following passage indicates the plenitude of voices present at sea which provide both terror and welcoming delights, thus requiring discernment: "as the mariner is guided by lighted buoys by night, so is he guided in fog by buoy bells, chimes, horns, or whistles. The silent fog-ridden sea becomes alive with voices, notes, sweet and raucous when a ship nears danger spots and harbor entrances."[174] But sound was also a dreaded technique, a last resort far more dire than the comfort, clarity, and precision afforded by vision. Increasingly, sound signaling techniques became standardized and mariners were burdened with specific methods to make sound and more importantly, to listen for sounds. In 1895, the *Boston Globe* published an article informing readers of the techniques in which mariners sound out to hear one another— a specific numbers of sound blasts from ships based on direction at specific intervals were general standards by which

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172 Frederick Talbot, *Lightships and Lighthouses*, vol. Conquests of science (London: W. Heinemann, 1913), 57.

173 See Sterne, Jonathan. *The Audible Past: Cultural Origins of Sound Reproduction*. (Durham: Duke University Press, 2003), 87-177.

174 Jim Gibbs, *Sentinels of the North Pacific: The Story of Pacific Coast Lighthouses and Lightships* (Portland, Or.: Binfords & Mort, 1955), 97.

vessels could locate and keep distance with other.[175]

A set of cultivated listening techniques emerged in the late nineteenth-century for the mariner, all of which required a tenuous faith in the art of audition. It was a type of listening altogether peculiar— a method of guidance that required an attuned ear for vague or buried sounds amidst the cornucopia of sea noises. It was a situation in which failure meant certain death. Guidebooks for mariners during the period often stressed the importance of listening closely, while at the same time maintaining a degree of suspicion. Familiarity with a wide assortment of types of sounds and differences in sound blast duration all signaled different issues of concern for navigators. The utterly essential late nineteenth-century tract on all aspects of navigation, *Wrinkles in Practical Navigation*, described some of the clues the ear could provide for the astute mariner while "groping" along a rocky shoreline:

> …a good look out either the roar of the surf, the 'booming' of the waves against the cliffs, or the echo of the steam-whistle will be heard in sufficient time to warn of danger. Indeed, sometimes, after groping carefully along, it is only by the cessation of sound showing a break in the coast-line, that it is to know that the vessel has reached the entrance of the port.[176]

The fact that before the development and standardization of sound signaling devices a large percentage of accidents were due to fog-related issues suggests that there was a marked benefit to the use of the ear in navigation. Yet it was a less than ideal bargain. This dubiousness of the use of sound in navigation would not become entirely clear until the work of acousticians Tyndall and Rayleigh on "zones of silence" along major navigation routes, which will be discussed below. In the meantime, acoustic signaling was being

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[175] *Boston Globe*, Nov 1, 1895 p. 5.
[176] Thornton Stratford Lecky, *Wrinkles in Practical Navigation.* --., Rev. and enl. ed. ed. (London: [s.n.], 1884), 215.

developed with an emphasis on powerful transmission underscored by an unqualified belief that loudness could blast through problem spots along the shorelines.

The first fog signal installed in the U.S. was at Boston, also the place of the first light signal, in 1719. "A Great Gunn to answer Shipps in a Fogg," was the promise of the Boston signal— a booming note assured by the fact that it was a canon generating the sound. Artillery and canon fire were standard methods of acoustic signaling at light stations up until at least 1860.[177] Artillery fire had multiple functions, for example "minute guns" were used to demark funerals. In the late nineteenth-century a very similar technique to send signals from light stations was used to honor the dead with the heavy melancholic thunder of weaponry discharged into the air. The *New York Times* claimed there was "nothing more solemn than [a minute gun's] slow booming [sound]."[178] As will be discussed below, this linkage with signal-based weaponry and affective states like melancholy is also a relationship that includes the whole gamut of nautical signaling devices. From the sad notes of the lonely whistling buoy, floating alone off the coast to the diaphones tuned in minor-key resonances; sea-based acoustic signals fostered an assortment of affects upon land-based citizens, lighthouse keepers, as well as sailors. The dreary, melancholic association with coastlines and fog literally stem partly from the dreary tones that dot the shore.

Firing weapons on a regular basis was an impossible trend to maintain for nineteenth-century light keepers. Repetitive, morose, nearly cruel in its requirements, it was often too much for those workers. One keeper in California, a retired Army Sergeant, was required to fire his cannon for a period of three days without rest. Despite the battle

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177 Dennis Noble, *Lighthouses and Keepers: The U.S. Lighthouse Service and Its Legacy* (Annapolis, MD: US Naval Institute, 1997), 165.
178 *New York Times,* (23 September, 1881).

hardness he gained from war it was still no match for the fogs of San Francisco.[179] It was an unsustainable technique, especially given the looming fruits of pneumatics and mechanical automation. Other downright silly techniques were either unreliable, complicated, or ridiculous. For example, horses were experimented with in the early to mid-nineteenth century by either walking up a ramp that forced compressed air into a holding tank or by walking in a circle similar to a hamster-cage wheel.[180] The idea, while it lasted, was that horses could power foghorns.

As efforts to move away from artillery-based signals escalated, researchers found that louder fog signaling devices could be developed through the use of steam-based forms of power— a clear step up from the horse-on a treadmill approach! Steam boilers were the basis of rudimentary forms of compressed air delivery, a method that could power horns to achieve impressive levels of power. The shape and mechanism of the horn was a subject of great investigation.

Not surprisingly, efforts were made to expand the size of the horn to near ludicrous proportions. Sandy Hook, New Jersey, a place host to many megaphonic experiments in the late nineteenth and early twentieth centuries, began tests with sirens in 1868 which utilized a very large cast iron horn fed by 70 pounds of steam pressure. This experimental horn was dubbed the "Daboll Trumpet", a huge megaphone large enough for one to stand inside. Other models of the Daboll Trumpet were installed in Maine and Rhode Island. While these experimental models were not implemented anywhere else, the existence of a massive Daboll Trumpet was an clear indicator that sonic power was a desirable quality and should be enhanced in order to protect lives at sea.

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179 Elinor De Wire, *Guardians of the Lights: The Men and Women of the U.S. Lighthouse Service*, 1st ed. ed. (Sarasota, Fla.: Pineapple Press, 1995), 70.
180 Dennis Noble, *Lighthouses and Keepers: The U.S. Lighthouse Service and Its Legacy*, 166-67.

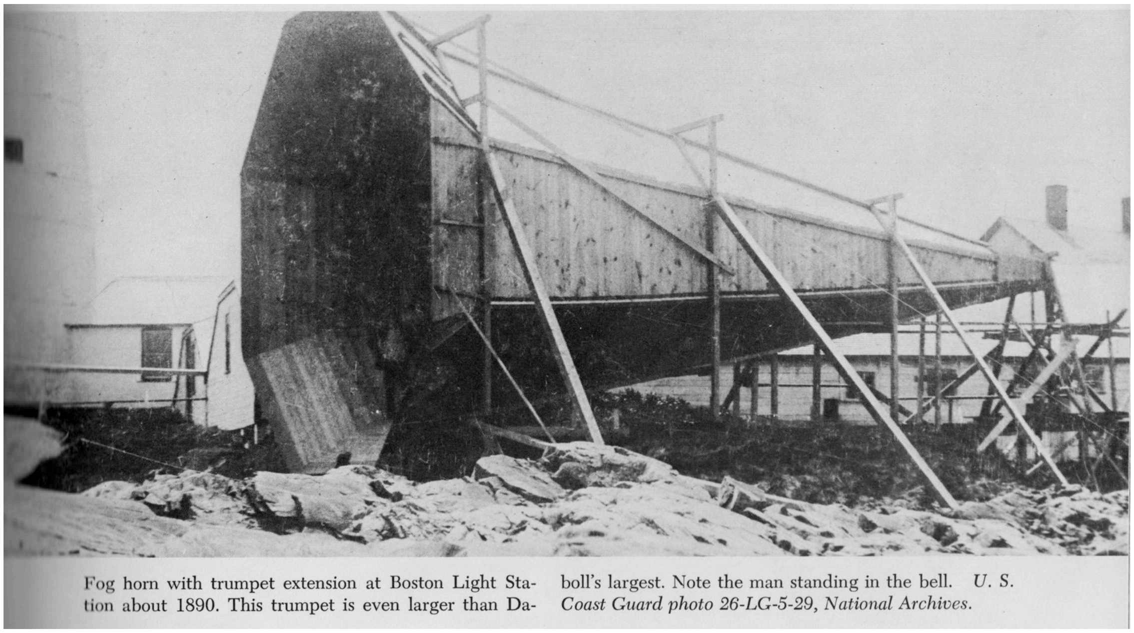

Figure 20. Example of Daboll Trumpet Experiments, ca. 1890

Yet it is important to note that the fog signal itself, until at least the eve of its redundancy, was an object of widespread derision. The foghorn's dire status within the world of lighthouse aficionados and keepers further reinforces a sort of visualist bias in comparison with the proverbial gleaming tower of crystal-refracted light above: "ugly, least featured, least romantic aspect of the light station—the fog signal. Such mechanisms have been the bane of lighthouse keepers, an irritation to the general public and the target of more profanity, more frustration and more resignations than could ever be recorded."[181] The fog signal itself was often hosted in a small non-descript building close to the tower. It was an unassuming profile in contrast with often imposing or majestic lighthouse towers, almost as if the visual sphere's very ascendancy over the sonic realm is embedded within the hierarchy in nautical communication.

Lighthouse keepers often despised the acoustic signals they were forced to maintain

181 Jim Gibbs, *Lighthouses of the Pacific* (West Chester, Pa.: Schiffer Pub., 1986), 251.

for reasons beyond the obvious duress of living beside a shrieking noisemaker; operating these devices entailed backbreaking upkeep and maintenance. The drudging upkeep meant dragging heavy sacks of coal or wood to feed perpetually hungry steam boilers and lugging large drums of fuel oil.[182] It was the worst of work on a remote lighthouse lifestyle already loaded up with solitude, misery, and toil. Yet this form of mechanical toil lasted only for a period of time as steam-powered signaling began to give way to louder and more automated forms of electric-based compressed air delivery. Slowly, beginning mostly at the beginning of the twentieth-century, oil-powered boilers were replaced by electric ones. This meant a quicker start up time and liberation from the drudgery of loading coal into a boiler.

The need for ships to communicate with the assistance of powerful sound signals was becoming increasingly evident in the late nineteenth-century. In 1873, George Elliot, then Engineer-Secretary of the U.S. Lighthouse Board, departed the U.S. to visit the well-known acoustician Lord Tyndall and other lighthouse researchers in UK and Europe. En route through one of the densest fogs of the Grand Banks off Newfoundland, his vessel came across another steamship. The only safety device which helped avert a catastrophe was the fact that the two vessels were sounding out their locations so that a collision might be avoided. For Elliot, even in 1873, this run-in stressed "the importance of powerful fog-signals."[183] Acoustic power quickly became a major mandate for the Lighthouse Board, which sponsored investigations into the ability of sound to project distance and to overcome obstacles to the successful projection of sound. Furthermore, a network of sound signals was envisaged.

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182 Jim Gibbs, *Lighthouses of the Pacific*, 251.
183 George Elliot, *European Light-House Systems: Being a Report of a Tour of Inspection Made in 1873* (London: Lockwood & Co., 1875), 16.

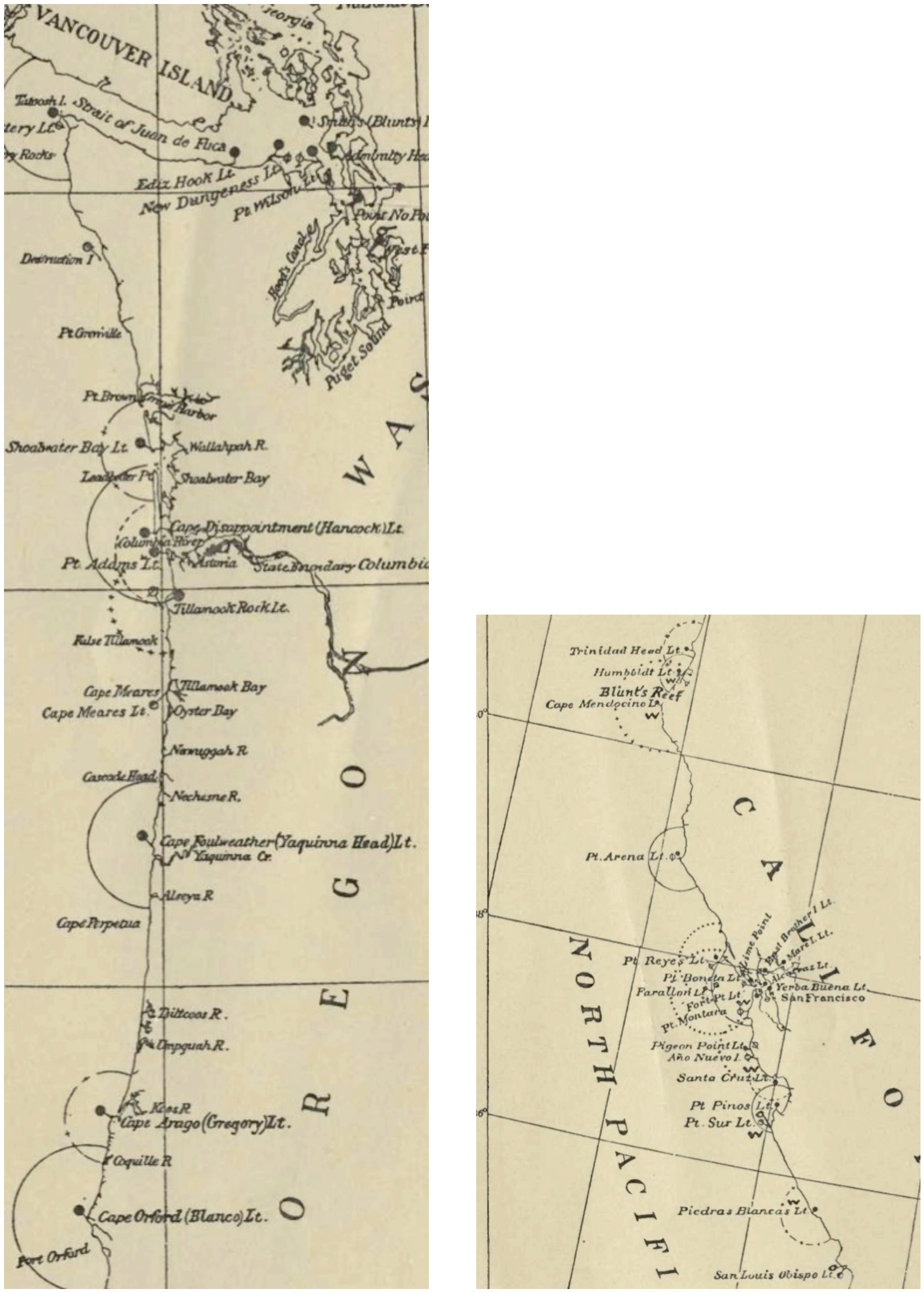

Figure 21. 1888 Map of Expanding West Coast Foghorn Network

Two major changes were occurring between 1880-1900: there was increased debate as to what constituted the correct type of acoustic signal while, at the same time, the network of sound signals along the coasts of North America was expanding greatly. One of the realizations of Secretary Elliot in his 1873 trip to Europe was the belief that the coastlines should be blanketed by the secure tonalities of nautical signals. Over the next fifty years the number of signals in service substantially increased. By 1884, astute mariners were well aware of this changing fact, as the handy guide *Wrinkles* explained: "Within the past few years many of the more prominent head-lands and turning points have been marked by the establishment of fog signals."[184] This expanding network of acoustical signals was promised as being for the "greatest possible service."

The type of signal deployed was also changing. From roughly 1880 onward, the dominion of whistles, gongs, and canons was giving way to the pneumatic majesty of sirens. Bells were "not sufficiently powerful for use on the seacoast."[185] Smaller horns were deemed not suitable to stand guard on outer coastlines. Because of their weak carrying capacity, such horns needed to be replaced with newer technologies of sound projection. Numerous types of siren emerged at the end of the nineteenth-century, from the monstrous Daboll trumpet to the deceptively compact diaphone. Their commonality was the ability to deliver unheralded acoustic power and capability of projecting signals upwards of twenty miles at sea. Yet some visions for louder forms of acoustical signaling were not solely the domain of siren-based creations. Audio reproduction technologies also permeated the isolation of lighthouses. Of all the dreams pinned on the phonograph, a most curious one was the idea, circa 1900, that it could be used as a siren and replace foghorns at lighthouses:

> It is claimed that under favorable circumstances they [phonograph-siren transmissions] might be easily heard by persons on a vessel fifteen miles out at sea. If such a remarkable efficiency of sound transmission can be maintained, the phonograph placed on a lighthouse or lightship could give a verbal warning that would be vastly more effective than that of the foghorns and detonators

[184] Thornton Stratford Lecky, *Wrinkles in Practical Navigation*, 217.
[185] *The Rudder*, Volume 32, 1916, p. 304.

> now in use.[186]

From all earnest attempts to confirm, this publicized fantasy-invention did not materialize in any significant way. But louder, more capable sirens were being developed which would far surpass the hopes of this fantasy device.

New forms of megaphonic acoustic signaling were receiving attention from the press and neighbors alike. These strange new horns were usually noted in particular for their shuddering, brute power. The following report of a new device in 1904 carried with it the promise of being able to destroy nothing short of the atmosphere itself:

> Another new method for sending a mighty voice across the sea involves the use of a diaphragm which is made to vibrate by electricity. To this are attached two huge megaphones which emit a deafening roar that can be heard for many miles.... The terrific blast that burst from the gaping mouths of the twin horns, each of which is 15 feet long, can be heard above the noise of the fiercest gale. It literally shatters the air.[187]

A horn in Maine was reported to be able to knock seagulls out of the air.[188] San Francisco Bay was described as a jungle cloaked in mist, with its groaning and rumbling foghorns. When a new foghorn was installed in New York Harbor in 1905, a local journalist described it in floral prose as "an army of panthers...the roar of a thousand mad bulls...with intermediate voices suggestive of the wail of a lost soul, the moan of a bottomless pit and groan of a disabled elevator."[189] An encounter with this new type of sonic force was most often a conveyance of a feeling of estrangement and wonder best considered in terms of the sublime.

What occurred by the early twentieth-century was both the expansion of the number

186 "Loud Phonograph - A Machine that Can be Heard Twelve Miles Away." *Los Angeles Times*, August 21, 1900.
187 *Boston Daily Globe*, (August 21, 1904).
188 Elinor De Wire, *Guardians of the Lights: The Men and Women of the U.S. Lighthouse Service*, 77.
189 Elinor De Wire, *Guardians of the Lights: The Men and Women of the U.S. Lighthouse Service*, 77.

of acoustic marine signals and a marked increase in their carrying capacity. It reflected the belief, that while far from ideal, sound signaling was the best option available to sailors in times of navigational duress— in essence there was a dubious faith placed on the ear as a conduit to safe harbor. By 1910, the coasts of North America were believed to be under a shield of safety thanks to acoustic signals, with 146 fog signals in the United States alone protecting the most hazardous points along the shore. But doubts lingered, as the *Los Angeles Times* reported in that same year. Modern high-powered signals are the products of some of the most inventive minds, operated by some of the most fiercely trustworthy guardians of the coastline, capable of "tremendous blast of sound which, in some cases, have a range of audibility as great as twenty-eight miles."[190] Yet this overabundant power could be utterly useless and at other times, nefariously deceptive by luring sea-goers into danger.

Newspapers and mariner publications were strewn with tales of astute, diligent, mariners drawn into duress—most particularly and curiously was the oft-repeated theme of navigators being deceived by their ears while approaching harbors. Take for example, the disaster of the steamship *Rio de Janeiro* in 1901, in which the vessel disappeared while approaching San Francisco in fog. The pilot reported hearing a fog signal and then suddenly nothing. A "deep, uncanny silence" fell upon the ship at sea. The pilot listened multiple times, even employing a whistle to check for echoes. It was clear that the ship had encountered what was termed a "ghost". Forty minutes later, the steamship was at the bottom of the ocean, along with it 130 of its passengers including its Captain. All of this occurred within close range of a fog signal deemed to have been in continuous operation.[191] Stories similar to this abound. A crash in 1901 near Captain's Island, Connecticut bears a

190 *Los Angeles Times*, (November 20, 1910).
191 *Los Angeles Times*, (November 20, 1910).

similar debate: was the fog signal not working, or was the captain not listening attentively?[192] To be sure, most often both the fog signal was operating and the navigator was listening attentively.

This enduring "ghost" of audibility was the blight of mariners and the main reason for suspicion of the entire practice of acoustic signaling. The frequency of which these black holes of sound were appearing was not on the decline. Despite the increase in power and number of acoustic signals, the number of shipwrecks was not abating by any significant amount. In the years between 1893 and 1902, it was estimated that 900 to 1000 vessels were wrecked by "aberrations of sound or by being drawn on a false course by the echo."[193] The significant loss of life and property due to the vagaries and dangers of navigating in fog was serious challenge to the notion that an "enhanced" acoustic signaling system was of use in North America. A profound skepticism flourished around the idea that high-powered sound could assist in transcending the "ghost" out at sea. Yet it was not for lack of effort— it was also the subject of some of the most progressive avenues of acoustics research during the era.

What Loudness Could Not Overcome: Zones of Silence and the Cradle of Acoustics Research

If mariners did choose to read the passages on acoustic signaling in nautical manuals they would often be faced with a confusing paradox— they would learn that sound signals were essential in times of constrained vision but they did not always work. "Ever Beware of Fickle Sirens," was the cautionary slogan of the widely read *Wrinkles in Practical Navigation*. The manual continued:

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192 *Boston Daily Globe*, (July 8, 1901).
193 *Los Angeles Times*, (November 20, 1910).

> …it is important to know that sound is conveyed in a very capricious way through the atmosphere…Apart from wind of *visible obstructions*, large areas of silence have been found in different directions and at different distances from the origin of a sound, *even in the very clearest of weather*, and under a sky absolutely cloudless.[194]

This was a shuddering conclusion for those that chose to absorb the information. What confounded sailors the most was that claim that it was often on the clearest days that the ghost most often chose to appear. Sailors were also mostly under the assumption, even common today, that a visually clear day meant as well a sonically clear day— the opposite is most often the case.

This fact left sailors in a position of helpless anxiety if they knew better, or a cultivated state of willful ignorance if they chose to deny the ghostly specter of what was increasingly known as *zones of silence*. Essentially, a zone of silence is a phenomenon that contradicts the common assumption that sound diffuses equally in all directions. What experience at sea and experiments along the shoreline made clear was that in certain conditions this belief was far from the truth, that in certain instances sound sources could be in fact completely inaudible even at very close proximity to the source in question. The conditions which would trigger these zones, or the "ghost", was a source of debate amongst mariners, lighthouse bureaucrats, and acoustic scientists until the early-twentieth century. It took a monumental accident, the 1880 crash of the *Rhode Island* steamer off the eastern U.S. coastline to trigger awareness to this phenomenon. That wreck, one of the most serious of the era both in life and property lost, made it clear that the usual source of blame was insufficient. What was insufficient was the standard claim that a fog signal was not working— something else was obviously occurring. Those in charge of the ship signed

194 Thornton Stratford Lecky, *Wrinkles in Practical Navigation*, 308.

affidavits that the mariners responsible were "anxiously listening" for a sound signal when apparently there was none.[195] Other lighthouse operators confirmed that they heard the signal in question operating at the time of the accident. Something was absorbing or deflecting the powerful signal coming from the lighthouse. As emphasized in 1889, the wreck of the *Rhode Island* made clear that the power of sound did not always have an effect on the success of its transmission:

> …indeed it would be heard faintly where it ought to be heard loudly, and loudly where it ought to heard faintly; that it could not be heard at all at some points, and then further away it could be heard better than near by; that it could be heard and lost and heard and lost again, all within reasonable ear-shot, and all this while the signal was in full-blast and sounding continuously.[196]

If a fog signal is audible upwards of twenty miles at sea and yet is inaudible in areas of four or five miles close to the shore, it was information nearly impossible to fathom for sailors.[197] They were left with little choice but carry on course in fog, as dropping anchor meant running the risk of being run-down by another boat and the option of reducing speed to avoid the danger of collisions often mean being more subject to swerving and disorientating cross-currents.

This section focuses on the rise of a vanguard edge of acoustical science that emerged amidst a growing skepticism around the senses, and the ear specifically, as a trusted instrument of navigation. Zones of silence were a foil to the concerted effort to make rugged, dangerous coastlines safe by means of progressive technology and human diligence. As North American coastlines increasingly were blanketed under the aura of sound signaling

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195 Arnold Burgess Johnson, "The Cruise of the Clover— Further Remarks on the Aberrations of Audibility of Fog Signals," 3.

196 Arnold Burgess Johnson, *The Modern Light-House Service* (Washington, DC: Government Printing Office, 1889), 74.

197 *Los Angeles Times*, (November 20, 1910).

systems in the late-nineteenth to early-twentieth century, the shortcomings of the system became apparent as the network expanded. Fog signals were of great significance for navigators for the most part, but they could not mitigate risk in places where sound transmission functioned as a black hole. Skepticism around sound signals was also moving beyond the narrow domain of knowledgeable seafarers. An 1895 news report outlined a situation regarding a whistling buoy that had escaped from its anchor near Boston. The buoy was cut loose from its demarcation of danger, now announcing danger where there was none, "floating about the Atlantic sending out its dismal notes of warning where no danger was near, and frightening ships from their true course, and thus becoming a teller of falsehoods in this language of the sea."[198]

Fog signals truly became a source of wariness for mariners, a suspicious "teller of falsehoods." By 1910, the *Los Angeles Times* was prematurely preparing an obituary for the fog signal: "as if the humane object [the fog signal] had been labored for in vain, that thousands of dollars in coal consumption were annually blown into the fog for naught."[199] Yet the end of fog signals was not quite near by then. In fact, the early twentieth-century was a sort of apex period for the fog signal, both in terms of the sheer amount of fog signals in operation as well as the highest levels of acoustic strength. The power of these devices, coupled with the mysteries of sound diffusion which power apparently could not solve, attracted the scrutiny of some of the most distinguished acoustics scholars. Readers of editions of *Wrinkles* published in the first decade of the twentieth century were informed that this subject was of concern to luminaries including Lord Tyndall and Rayleigh, two of the most professionally esteemed acoustics scholars of the era.

Tyndall, a devoted materialist and anti-metaphysical skeptic similar to his

198 *Boston Globe*, (November 1, 1895).
199 *Los Angeles Times*, (November 20, 1910).

contemporary Ernst Mach, was well placed to approach and extinguish any notion of the "ghost" that was haunting the practice of nautical signaling. A denier of miracles and otherworldly phenomenon, Tyndall believed the source was something as simple as invisible clouds reflecting sound waves upwards. Gillian Beer described his approach to sound as essentially an exercise which requires an authoritative act of revelation, one which is equivalent to a thorough demystification: "the universe is full of unexpected and hidden phenomena for which authoritative interpretation is required."[200] Zones of silence were such a "hidden phenomena" due for a course of demystification. Tyndall's work on aberrations of audibility in acoustic signaling mostly took place in England during the early 1870s, but was essentially the foundation upon which other researchers built. His investigations centered on the question of which conditions fostered zones of silence. The first answer was refraction: that sound could be deflected first upwards by different air currents of varying temperature and then defected downwards farther on by another air current. Yet this did not explain why the same condition might exist when the wind did not blow. His major theoretical finding and conclusion was the understanding that these "acoustic clouds" served to obstruct waves of sound in the atmosphere but more importantly reflected those waves upwards. He claimed that such clouds consisted of air of different density and humidity that existed in both clear as and foggy weather. It was a theory of sound being deflected out of the range of audition by spherical clouds that were invisible, and as of yet unpredictable.

[200] Gillian. Beer, *Open Fields: Science in Cultural Encounter* (Oxford [England]: New York: Clarendon Press; Oxford University Press, 1996), 252.

Figure 22. Depiction of Tyndall's Acoustic Fog Signal Experiments

One of the major revelations that came out of Tyndall's foghorn experiments on the south coast of England was the debunking of the theory of optical equivalence. "Optical equivalence" is the belief, still common today, that an optically clear situation is also a condition for ideal sound dissemination; in other words, the notion that a clear sky is one which is perfect for listening and on the inverse, more critically, that foggy conditions also dampen sound. The fallacy that fog dampens sound goes back to the investigations of the English naturalist philosopher William Derham. While being astute in certain areas, for example he was the first to roughly estimate the speed of sound, Derham was totally wrong in his assertion in 1708 that "fog is a powerful damper of sound." His belief was that fog was a mixture of air and globules of water and thus since when sound encountered these globules, a portion of these vibrations were reflected and lost. The conclusion, as George

Elliot summarized,

> …follows that the greater the number of the reflecting particles the greater will be the waste of sound. But the number of particles, or, in other words, the density of the fog, is declared by its action upon light; hence the optical opacity will be a measure of the acoustic opacity.[201]

In Derham's view rain obstructed sound and snow did so even *worse* than fog.

This assumption, captured in Derham's *Philosophical Transactions* of 1708, remained unchallenged until the late nineteenth-century. Tyndall believed that the main culprit in heterogeneous sound diffusion, these zones of silence, was not from suspended water droplets, but actually water in its vaporous form such as patches of humidity. Most interesting is that his conclusion regarding how to overcome the condition of the ghost was through an appeal to the potentialities of megaphonics, as though the acoustic force of high-powered sirens might overcome these voids:

> The real enemy to the transmission of sound through the atmosphere has, I think, been clearly revealed...That enemy has been proved to be not rain, nor hail, nor haze, nor fog, nor snow—not water in either a liquid or solid form, but water in a vaporous form, mingled with air so as to render it acoustically turbid and flocculent. This acoustic turbidity often occurs on days of surprising optical transparency. Any system of measures, therefore, founded on the assumption that the optic and acoustic transparency of the atmosphere go hand in hand must prove delusive. There is but one solution of this difficulty: it is to make the source of sound so powerful as to be able to endure loss by partial reflection and still retain a sufficient residue for transmission. Of all the instruments hitherto examined by us, the syren comes nearest to the fulfilment of this condition; and its establishment upon our coast will in my opinion, prove an incalculable boon to the mariner.[202]

Yet sirens were not quite powerful enough at that point to sufficiently overcome the

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[201] George Elliot, *European Light-House Systems: Being a Report of a Tour of Inspection Made in 1873*, 52.
[202] John Tyndall, "Transparency and Opacity in the Atmosphere," *Philosophical Magazine and Journal of Science* 47 (1874), 383.

limitations of zones of silence. It was a marker for future investigation and a hypothesis that would be attempted time and again for the following fifty years. Despite monstrous experimental models like the Daboll Trumpet, acoustic signals were not capable of fully blasting through the ghost.

In the end Tyndall did not really leave the mariner with much of anything in terms of practical guidance. His investigations in the 1870s demonstrated that these zones of silence existed, but his work offered nothing in terms of solutions— no law was tabled which would predict the appearance of these acoustic clouds, their duration, nor location. There was good reason his work was not common knowledge with the seafaring community.

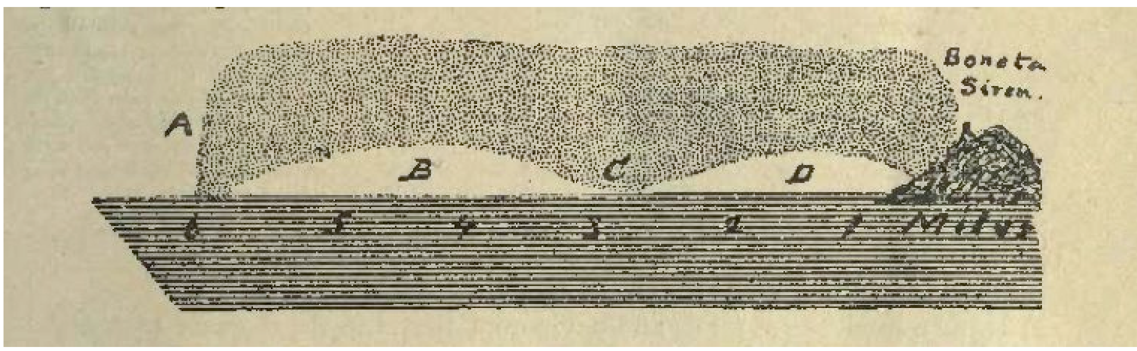

Figure 23, Depiction of Zone of Silence (1888)

The Foil of Aural Immensity: Zones of Silence and Rayleigh's Work

Research on zones of silence in the period after Tyndall shifted from concerns around understanding the theory and categorization of sound shadows towards an interest in the measurement and optimization of loud fog signal transmission. It was almost as if scientists had given up on understanding conditions upon which mariners could predict such aberrations. Instead, energy was focused on means of better penetration and coverage through enhanced sound projection techniques. In 1887, Lord Rayleigh followed Tyndall to take up the post of Professor of Natural Philosophy at the Royal Institution and also to the same position Tyndall had held at the British Lighthouse Board, Trinity House.[203] Rayleigh's research on the subject comes out of questions surrounding some of Tyndall's observations. Rayleigh was not convinced by Tyndall's belief in the reflection of sound sources. He thought the refraction of sound energy from encounters with vaporous air was more likely than reflections off "acoustic clouds." Some scientists during the period went the other direction— retreating to the bogus notion that fog absorbs sound, a view commonly encountered to this day. Research would show that fog most often enhanced the projection of sound as opposed to inhibiting it.

In the lead up to Rayleigh's trials in 1901 at the St. Catherine's lighthouse in England, research thus far had been of nearly zero-use to the mariner: no clues on how to predict sound shadows, no standards regarding appropriate fog signal types or techniques to enhance dissemination of sound sources. As fog signal historian Alan Renton indicates, there was no certainty on issues such as siren size, type of signal port, speed of siren rotation, air pressure, or air volume.[204] Predictably, mariners at that point were weary of how much help a fog signal could be in times of need. "Don't Believe Your Ears: They Are Often Deceptive, Especially in Dense Fogs," warned the *New York Times* in 1891.[205] The article cited the famous *Rhode Island* crash of 1880 and that it appeared that even eleven years later, little had changed to give solace to the mariner at sea.

The aim of the St. Catherine trials was to determine the "most effective way of protecting a large sea area."[206] Its means was primarily though testing a battery of different sirens to see which projected the farthest and was most consistent regarding possible sound shadows. A huge "Rayleigh Trumpet" was tested, among others, which is reminiscent of

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[203] Alan. Renton, *Lost Sounds: The Story of Coast Fog Signals* (Latheronwheel: Whittles, 2000), 93.
[204] Alan. Renton, *Lost Sounds: The Story of Coast Fog Signals*, 94.
[205] *New York Times,* (February 22, 1891).
[206] Alan. Renton, *Lost Sounds: The Story of Coast Fog Signals*, 98.

other monster trumpets like one tested at the Boston Light Station in the early 1890s. Despite the hopes that bigger is better, what was clear according to the tests was that increasing the air pressure of a horn became pointless after a limit of 25 pounds per square inch.[207] While the results were somewhat discouraging for those holding the belief that more power is the answer, it would hardly hold back future pursuits in this area. From the tests in St. Catherine's was a set of maxims hardly divergent from Tyndall's conclusions, and again of little use to the mariner.[208]

Research on zones of silence would tail off in the early to mid-twentieth century as nautical signaling shifted to radio-based methods of transmission. However the last main push in understanding zones of silence was the work of McGill University-based scholar Louis Vessot King, who was working at the intersection of shock wave theory and acoustic measurement. One of the issues fairly well known but insufficiently examined by the turn of the twentieth-century was that explosive sounds were measured to travel at as much as two and a half times the velocity of "normal" sound waves. Stemming particularly from the work of French scientists Pierre Duhem and Paul Vielle, King believed that sirens' sound propagation functioned closer to explosive sources than normal ones.[209] His efforts went into mapping out the efficiency of high-pressure siren blasts along the coast of the Saint Lawrence River. Through techniques of phonometric analysis and measurement, the acoustical science of foghorn operation became better equipped to understand the most efficient ways to achieve powerful sound propagation. King's work also informed some of Paul Sabine's groundbreaking research on reverberation tails inside buildings.[210] Again, what

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207 *Encyclopedia Britannica*, 11th edition, Volume 16, 1911, p. 648.
208 See summary of conclusions of Rayleigh's experiments in Louis Vessot King, "On the Acoustic Efficiency of Fog Signal Machinery," *Journal of the Franklin Institute* 183 (1917), 261.
209 *United States Naval Institute Proceedings*, Volume 43, Number 7, July 1917, p. 2069.
210 Paul Sabine, *Acoustics and Architecture* (New York: McGraw-Hill Book Company, 1932), 8.

it didn't provide is any better assurances on how to navigate through zones of silence.

Sound shadows— these dark recesses of marine communication which the concentrated efforts of acoustical scientists could not address in any substantive fashion— were an ongoing source of anxiety for navigators. Ironically, the phenomenon was of use to Theodor Reik, a psychoanalyst who trained with Freud. He saw these zones of silence as a metaphor for the dark recesses of the human psyche:

> Experts have established that certain conditions of ebb and flood as well as certain directions of wind often create a 'zone of silence' … in which not the slightest sound from the outside can be heard. A ship which finds itself in this zone, which is many kilometers wide, is completely shut off from sounds of the external world. We believe that what is unconsciously repressed comprises such a 'zone of silence' in emotional life. In neurosis this zone expands and deepens. The silence that we mean here is not merely muteness; it is rather pregnant with unsaid words...Psychoanalysis signifies the first breakthrough in this zone of silence of the individual being.[211]

The metaphor serves an apt parallel to the estrangement of the mariner in this acoustical void. Lost in the fog, at night with a no location capabilities aside from an utterly trustworthy method of listening almost mirrors the ascendant psychological states of anxiety and neurosis. By the early twentieth-century, the limitations of navigating by sound was becoming all too apparent. While perhaps the erosion of trust in foghorns was well underway, the failure to predict zones of silence repeatedly led to a flailing response: the often reiterated hope that increased power would transcend the void. A megaphonic solution was an escape route of last resort for the foghorn.

[211] Theodor Reik, "The Psychological Meaning of Silence," *Psychoanalytic Review* 55, no. 2 (1968), 185.

Ascent of Diaphones in Nautical Communication

Similar to tests in the UK, numerous experimental trials were conducted in the U.S. to test out various foghorns. In the summer of 1893, the Boston Light Station was equipped with a battery of different "criers", an arsenal consisting of steam and air sirens, steam whistles, trumpets, and 4000-pound bells. Certainly the most remarkable of the horns assembled was a giant horn dubbed the "Zylophonorous Trumpet"; over two stories high at the opening of the horn, it was also fifty feet long.[212] Little is known about the design of the horn aside from photographs documenting the design, which depict a horn unfathomably large (see *Figure 4* above). An emerging sense of understanding regarding zones of silence at the time was a classification between two types of "acoustic clouds." One was believed to be permanent condition of the area, the other a movable, transient phenomena. Writing about the 1893 tests, one newspaper summarized the rationale of the monster trumpet as an attempt to blast though these transient clouds through sonic power—an attempt to evaporate the clouds through sound. The rationale was quintessentially megaphonic:

> …why not penetrate the acoustic cloud by force. It meant an instrument so large and powerful that its sound waves would defy differences in air density and humidity, and one of the most powerful trumpets was therefor equipped with a great extension or megaphone, fifty feet long and eighteen feet in diameter at its bell.[213]

The volume that emanated from the horn was reported to be "tremendous." It was claimed to have the effect of blasting through zones of silence. But the trumpet tested at the Boston Light Station was not a device with any sort of practical application. It was too big, too prone to destruction through the elements and too costly to construct. A new type of

[212] Dates vary regarding the occurrence of these tests, which range between 1880-1884. Most sources point to 1893. Dennis Powers, *Sentinel of the Seas* (New York: Citadel Press, 2007), 64.
[213] *Los Angeles Times*, (November 20, 1910).

sound-producing mechanism was needed— one which was both powerful and efficient in a compact design.

Towards the turn of the century a new standard emerged in foghorn construction. It was the return of the diaphone, a device that began life in a vulgar and marginal role in certain pipe organs. Out at sea it was to have a fuller life as the de facto siren of the early twentieth-century. As discussed in Chapter One, the original inventor of the diaphone, Robert Hope-Jones, had envisaged a dual role for his invention patented in 1896. This role was both as a musical resonator and a nautical signaling device. As a fog signal, the diaphone was a device that differed from traditional reed or horn type of sirens. The diaphone was a hollow piston-type of device fit inside another cylindrical chamber. The hollow piston contains numerous lengthwise slits. When air is admitted through the outer casing, the piston drives forwards and backwards rapidly. The mechanical/pneumatic process was described as one where "the air effects its escape through the orifices, when they come into line, in intermittent puffs."[214] These puffs were of low, "grunting" character, capable of travelling great distance. Because of the mechanism its selling points were numerous: it was less prone to damage or wear, it produced an even pitch that did not vary due to air pressure, and the instrument was undeniably efficient in that it provided unsurpassed carrying capacity with a relatively low level of air pressure require to drive the sound.

Upon arrival in the United States, Hope-Jones sold the rights to the diaphone patent in 1902 to the Canadian John Northey. Northey established the Diaphone Signal Company the same year, shortly after acquiring those rights. As discussed in Chapter One, Hope-Jones carried on with his pipe organ work, drifting from company to company building some of the most eccentric and loud devices ever made. Northey was far more organized and

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[214] Frederick Talbot, *Lightships and Lighthouses*, 67.

entrepreneurial. He quickly convinced officials in the Canadian Government to utilize the diaphone as the main type of siren along the eastern coast. He introduced seven different sizes and further improved the efficiency of the device, reducing the required sounding pressure from 90 to 30 pounds per square inch. By 1903 the Canadian Department of Marine and Fisheries "had been sufficiently impressed by the diaphone to adopt it as the standard fog signal at Canadian lighthouses."[215] By 1912, there were 82 diaphones in operation along Canadian coastlines, with more on the way. A great number were clustered along the St. Lawrence River, including those used in the experiments of Louis Vessot King.

Due largely to Northey's efforts, the diaphone was becoming increasingly integrated within the North American lighthouse network and became the *de facto* standard for fog signaling. The Canadian company solicited the device to the U.S. Lighthouse Service, who was so enamored with the device that it acquired rights to manufacture the siren in a separate New Jersey plant. Among its other apparent charms, the diaphone promised to produce deep sounds that were "population friendly" and district offices of Lighthouse Service claimed to receive fewer complaints from "the sleepless populations of maritime cities plagued by fog."[216] More on that later. At the apex of acoustic signaling in North America, the coastlines were literally blanketed in the sometimes comforting, sometimes anxiety-producing grunt of diaphonic tone. By 1930, there were 160 diaphones in Canada alone.[217] Its success in becoming the most common form of siren, aside from the impact of entrepreneurial persuasion, was from its reputation as a reliant siren with unsurpassed acoustic power.

California had its fair share of the diaphones installed by the Lighthouse Service. The

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215 Alan. Renton, *Lost Sounds: The Story of Coast Fog Signals*, 161.
216 Dennis Noble, *Lighthouses and Keepers: The U.S. Lighthouse Service and Its Legacy*, 169.
217 Alan. Renton, *Lost Sounds: The Story of Coast Fog Signals*, 162.

well-known low-toned sounds of foggy San Francisco bay are diaphonic tones, tones which carried great distances. The diaphone stationed at the foot of the Golden Gate Bridge carried enough power that it was thought to be able to trigger rock erosion, as lighthouse historian Elinor De Wire speculated:

> The deafening concussion of the Point Bonita fog signal could also cause [avalanches of rock]. The cliff here has rumbled and shuddered from numerous earthquakes, including the devastating 1906 San Francisco earthquake; but mostly it has eroded from the scouring of wind and water, aided by the intense vibrations of cannons, bells, horns and whistles. Little by little, pebble and cobble, the cliff has been crumbled away by the interminable din.[218]

Truth or not, the din of diaphone-based fog signals were of unprecedented levels. The diaphone installed at the San Pedro Entrance Light in California was reported to being heard 33 miles out at sea.[219] They were indeed “unfathomably loud.”A Toronto-based newspaper went as far as to hail the device as "the most powerful sound-producing instrument in the world."[220] Yet the expansion of the capabilities of the diaphone appeared to have no end. In 1913 another alleged plan was reported to build an even more monstrous diaphone:

> the builders of this terrible noise-producer are experimenting with an apparatus having a piston 14 inches in diameter. The sound issuing from such a huge apparatus would be almost as deafening as the report of a big gun and should succeed in warning a mariner several miles away.[221]

The lure of diaphones led to their use in other situations, such as lightships sending guidance for mariners out at sea. The magazine Popular Science reported on one lightship equipped with a diaphone which "makes sound signals that can be heard above the wildest

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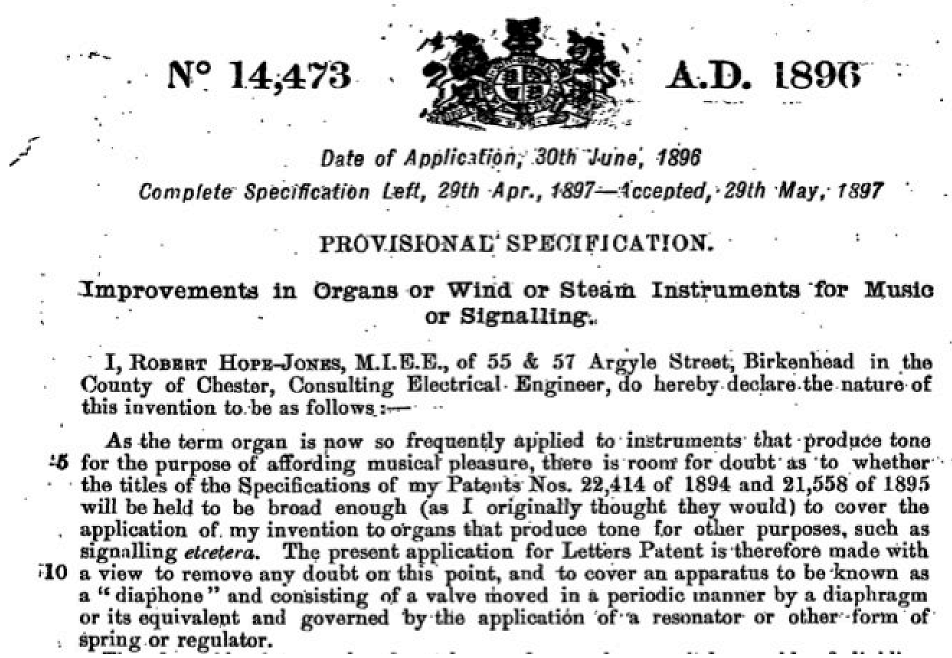
218 Elinor De Wire, *Guardians of the Lights: The Men and Women of the U.S. Lighthouse Service*, 3.
219 Jim Gibbs, *Lighthouses of the Pacific*, 44.
220 *Toronto Daily Star*, (June 25, 1908).
221 Frederick Talbot, *Lightships and Lighthouses*, 67.

Atlantic gales."[222] On land, the diaphone was later adopted as the *de facto* siren for many fire and public alert systems in US cities: "the combination of distinctive tone—a tone which cannot be mistaken for any whistle—and the great carrying power, has made this equipment a favorite with a large number of American cities and towns."[223]



Nº 14,473 A.D. 1896

Date of Application, 30th June, 1896

Complete Specification Left, 29th Apr., 1897—Accepted, 29th May, 1897

PROVISIONAL SPECIFICATION.

Improvements in Organs or Wind or Steam Instruments for Music or Signalling.

I, ROBERT HOPE-JONES, M.I.E.E., of 55 & 57 Argyle Street, Birkenhead in the County of Chester, Consulting Electrical Engineer, do hereby declare the nature of this invention to be as follows:—

As the term organ is now so frequently applied to instruments that produce tone for the purpose of affording musical pleasure, there is room for doubt as to whether the titles of the Specifications of my Patents Nos. 22,414 of 1894 and 21,558 of 1895 will be held to be broad enough (as I originally thought they would) to cover the application of my invention to organs that produce tone for other purposes, such as signalling *etcetera*. The present application for Letters Patent is therefore made with a view to remove any doubt on this point, and to cover an apparatus to be known as a "diaphone" and consisting of a valve moved in a periodic manner by a diaphragm or its equivalent and governed by the application of a resonator or other form of spring or regulator.

Figure 24. Hope-Jones' 1896 Diaphone Patent for both Music and Signaling

A major reason the diaphone is distinct, aside from its significant power, is because it was a device that blurred the distinction between signaling device and musical instrument. It was designed that way from its inception. But besides the dual use for the technology, the implementation as a fog signal brought an aspect of musicality to the solitary tones blasting along the coastline. This occurred in two senses. On one level, hearing the diaphone from ashore was deemed to be inherently musical to the listener: "diaphones make sweet music

[222] *Popular Science*, February 1931, p. 68.
[223] *American City*, October 1921, Volume 25, p. 351.

when the navigator needs their help."[224] But also, diaphones sought to differentiate different beacons by giving them identifiable tonalities. Many were tuned at the often melancholic pitch of F# which centers around the frequency of 180 hertz. The concern with musicality was such that loudness wasn't enough if it didn't help a mariner locate what signal they were hearing. As far back as 1880 Tyndall was reportedly sympathetic to the idea of creating acoustic signals which might "pronounce" the name of the lighthouse station through distinct tonality.[225]

Musicality in Fog Signaling

As Michel Serres remarked on transmissions amidst the noise of the sea: "how much noise must be made to silence noise? And what terrible fury puts fury in order?"[226] The sounds that were emitted from diaphones were more than mere brute force, they were often calibrated harmonic frequencies designed to travel great distance and be distinguishable amidst a morass of nautical noise. Thus a sort of musical form of signaling emerged with tailored sets of frequencies designed to discern "the sound from background noises," and thus improve its audible range.[227] That this form of music in the void, the harmonically tuned or dual-pitch diaphone foghorn, emerged from a musical resonator should not be surprising. In Ocean Grove, a seaside town where ocean mist and fog literally wafts into the auditorium hall, the diaphone was one of the showcase pipe sets in the 1908 pipe organ designed by Hope-Jones. The marketing of diaphones took on an almost music-like theme to how they were presented. The promise was a noble trumpet blasting through the fog, a type of "tuned resonator," an advantage being "that it automatically adjusts its note to that

[224] Paul E. Wylie, *The Essentials of Modern Navigation*, 73.
[225] *English Mechanic*, Volume 32, No. 822. December 24, 1880, p. 363.
[226] Michel Serres, *Genesis*, 13.
[227] Alan. Renton, *Lost Sounds : The Story of Coast Fog Signals*, 180.

of the trumpet"—as if to discern itself from the echoes and the noisy lies which spell instant catastrophe upon the rocky shoreline ahead.[228]

A musical diaphone might have symbolized a sort of certainty amidst the noise of the foggy sea, but as a metaphor in musical composition, fog was seen as a failure to portray any sort of clear harmonic intention. It was a compositional flaw, a lack of certainty rendered as a vague, impressionistic confusion. These were compositional techniques such as "closely-textured modulation," or other effects which obfuscated the clear distinct voice of an instrument. The critic Charles Villers Stanford saw this as a crutch, a creeping risk of musical indecision threatening the young composer:

> It is to produce a muddled effect: sometimes this is justifiable. You remember that Wagner once asked Richter if a certain horn passage would be played, and that Richter answered 'Yes, but it would sound very foggy.' 'That, is just what I want,' said Wagner. So for Wagner, in the right hands it was a impressionistic tool of power, but for young composers a crutch showing lack of clarity and knowledge of compositional rules.[229]

From the shoreline, through the fog, this new type of two-toned siren fostered of state of musical affect for citizens and lighthouse keepers. Often, the horns would be tuned in minor-key tonal associations to blast two notes in succession. Some heard mournful harmonies where others heard more uplifting or mysterious tonalities. A lighthouse historian described the state of affect from the shore:

> …certain persons found they also had romantic qualities, in fact, there is something warming and melancholy on a still, fog-filled morn when one is listening to the symphony of strange noise rising out of a mystic fog…may it be duly recorded that foghorns and music can go hand-in-hand.[230]

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228 Alan. Renton, *Lost Sounds : The Story of Coast Fog Signals*, 157.
229 Charles Villiers Stanford, "On Some Recent Tendencies in Composition," *Journal of the Royal Musical Association* 47 (1920), 49.
230 Jim Gibbs, *Lighthouses of the Pacific*, 251.

Other instruments such as gong buoys produced what was described as a "distinctive Oriental sound," a "melodious chant" that renders the dangerous sea waves as an ocean-scape of Zen bliss.[231]

But the art of seafaring was rarely an occupation that delivered states of bliss. The hazards of marine navigation were hardly being mitigated by the early twentieth-century. Despite the expansion of the network of sound signals and the enlarged projection of new types of acoustic devices, zones of silence were not being transcended in any meaningful way— ships were still crashing. Loudness was not a panacea for the risks of the ocean. In fact it was becoming clear that louder devices actually in certain conditions close to shore enhanced risk by amplifying the amount of echoes heard. The Los Angeles Times reported this fact in 1910, adding another voice to the line of unanswered questions surrounding acoustic signaling: "[the echoes] would give a false location of the signal, and therefore a false and destructive course for the unsuspecting navigator. It meant that a limit to the volume of sound existed."[232] If there was a limit to the meaningful use of loud sound it was only a question of time before acoustic fog signaling in general would be eschewed for another, more reliable means of communication.

Indeed, during the first two decades of the twentieth-century, a sort of "mistrust of the ear" was growing amongst mariners and officials alike. What began as a series of isolated doubts around the ability to hear signals in certain conditions became a widespread state of malcontent regarding the role of foghorns in sea travel. It was a metamorphosis into a device of caprice and malice. A 1916 issue of *Popular Science*, summarized the general mood with the blunt title: "The Undependable Fog Horn." In the article it summarized the

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[231] Jim Gibbs, *Sentinels of the North Pacific: The Story of Pacific Coast Lighthouses and Lightships*, 98.
[232] *Los Angeles Times,* (November 20, 1910).

problems still evident with zones of silence, now seen as “acoustic caprices,” a “poor makeshift” surely on the wane. The future was proclaimed to be with submarine and radio-based navigational assistance.[233] It would still be sonic, albeit in a mediated form.

Finally, research around zones of silence and the doubts they fostered were percolating down to the mariner in increasingly somber tones. One just has to compare changes in a local navigation manual, such as the differences between the 1906 and 1920 versions of pilot manuals for Eastern Canada. The 1906 *St. Lawrence Pilot* had warned the mariner to put “no reliance” on a possible position due to the sounds heard due to echoes and zones of silence. Further, one was not to judge location solely from “the power of the sound.”[234] The signals were suspect and not to be completely trusted. What seems apparent however is that the references to sound as a “capricious” force were increasing in number. In the late nineteenth-century, references within nautical manuals regarding how sound travelled through the atmosphere was, for the most part, predictable aside from occasional aberrations such as through zones of silence. By 1920, the transmission of sound was almost sinister, as the *Nova Scotia Pilot* informed sailors: "sound is conveyed in a very capricious way through the atmosphere.”[235] The text informed sailors to put more faith in submarine signals, a fleeting technique of nautical communication before the advent of radio signals. For some the response to this flood of doubt was towards a return to the certainties of light. A 1912 article suggested new devices of illumination will not betray like sound is prone to: "unlike sound light is not misleading in a fog. While the howling of the winds, the splashing of the waters, or the noise of an engine may drown the sound of a fog horn, these

233 *Popular Science*, April 1916, p. 576.
234 Henry Wolsey Bayfield, *The St. Lawrence Pilot: Comprising Sailing Directions for the Gulf and River St. Lawrence.* --., 7th ed. ed. (London: Hydrographic Office, 1906), 21.
235 *Nova Scotia Pilot*, 6th ed. (Washington, DC: Hydrographic Office, U.S. Navy, 1920), 14.

things cannot obscure a powerful light."[236] For most though, the answers to the problem of sound in marine navigation turned towards reinforcement of other types of signaling: the combination of acoustic and submarine signals with ship-based lookouts and wireless telegraphy. It was not through louder foghorns. Yet the diaphones installed along the shorelines of North America endured and continued operation despite questions around their use and effectiveness. They were brutal for all except the most desperate of mariners.

The Madness of the Fog Signal

A citizen must have been quite compelled by the new air siren installed at the Baker's Island lighthouse in Massachusetts to write this poem, published in the *Boston Globe* in 1907, entitled the "The Strident Horn":

> Has the old white cow a pain again,
> Or is there a fog at sea?
> But the fevered woman and restless child
> Are denied the sleep long sought,
> While the precious ships of the Standard Oil
> Come undelayed to port
> ....
> Give heed, give heed to the sailor's need
> When fogs or gales arise:
> Let horn or bell the danger tell
> In the zone where the danger lies.
> But tame the note from the brazen throat
> That it still due guard may keep,
> Yet leave once more to the sick on shore
> The priceless boon of sleep.[237]

Many of the foghorns installed during the expansion of the North American sound signal network in the early twentieth-century were close to populations that often had a deeply

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[236] *Boston Daily Globe*, (February 25, 1912).
[237] *Boston Daily Globe*, (November 17, 1907).

ambivalent relationship to the devices. Many couldn't sleep. Some claimed nerve damage. Farmers sometimes suggested they drove livestock delirious. For some it was, as mentioned, a source of romantic affect, but for most it was seen as a nuisance.

Some of the contestation around foghorn noise gives added texture to recent historical work on urban noise, but also raises questions. As mentioned in the Introduction, several historical studies have been published over the past decade characterizing the early twentieth-century as a period deeply concerned with noise abatement and control.[238] In the case of conflicts regarding fog signal noise, the answer was not to minimize the sound level of horns, since they were intentionally designed to create high levels of sound. What emerged was a stalemate between citizens and lighthouse officials where fog signals were defended as a necessary noise. An almost utilitarian argument formed around the productivity of noise, a plea for the greatest level of sonic power for the greatest good. Unlike other urban contexts where control over noise was largely endorsed by city officials, mariner safety usually trumped the needs of sleeping populations. The noise produced by diaphones and similar devices suggests a way in which loud sounds were deployed for what was believed to be productive ends.

Before the dawn of radio signaling, people living near signals had no choice but to suffer through fog spells. In 1900, a new and much more powerful fog signal was installed at Pomham Rocks Lighthouse, Rhode Island. It was deemed to be extremely bothersome to residents. A local newspaper ran a headline stating "THE GREATEST NUISANCE IN THE HISTORY OF THE STATE," describing it as "a sound to make the flesh creep,

[238] See Emily Thompson, *The Soundscape of Modernity: Architectural Acoustics and the Culture of Listening in America, 1900-1933* (Cambridge, Mass.: MIT Press, 2002). And Karin Bijsterveld, *Mechanical Sound: Technology, Culture, and Public Problems of Noise in the Twentieth Century*, Inside Technology (Cambridge, Mass.: MIT Press, 2008).

indescribably lonesome and cheerless, creepy, and dreary."[239] This creepy, dreary sound was feared to also impact real estate valuations. A proposed fog signal near Boston in 1910 was reported to threaten nearby property by as much as twenty five to fifty percent in value. The sound was so dismal it was alleged that it could be heard up to twenty miles inland.[240] Residents claimed to be physically abused by the sound. Another nearby fog signal claimed to turn its residents into shuddering, drooped phantasms of a life once lived. The archetypal resident was described as "a shrinking looking man or woman, whose hands clasp and unclasp nervously, who shivers every half minute as if from a blow, whose lips twitch and eyes roll, while the hair shows a tendency to uplift at regular intervals"[241] There were also tales regarding the punishing effect of horns on local livestock. On the Isle of Wight in England the *Los Angeles Times* reported, "no cow is free from the horn's bellow and accompanying oscillations."[242]

Some towns took it upon themselves to question the necessity of the fog signal. Citizens living nearby the new Baker's Island fog signal in 1907, perhaps under the influence of the aforementioned poet, acquired legal representation to challenge the horn's legitimacy. Residents were "much disturbed" by the noise of the new foghorn and sought the possibility of having the horn changed.[243] As will become evident, one of the sole means of both continuing the necessary sonic power while appeasing citizens was the development of custom sound "deflectors"— a type of shield intended to direct sound away from the shores

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239 Wire De, Elinor, *The Field Guide to Lighthouses of the New England Coast: 150 Destinations in Maine, Massachusetts, Rhode Island, Connecticut, and New Hampshire* (St. Paul, MN: Voyageur Press/MBI Pub., 2008), 77.
240 *Boston Daily Globe*, (January 26, 1910).
241 Michael Lamm, "Feel the Noise: The Art and Science of Making Sound Alarming," http://www.americanheritage.com/articles/magazine/it/2003/3/2003_3_22.shtml (accessed January 20, 2011).
242 *Los Angeles Times*, (November 7, 1926).
243 *Boston Daily Globe*, (August 18, 1907).

and out towards the sea. The new deflector installed in Bar Harbor, Maine was installed to appease uncomfortable summer resort residents, hoping that "the direction of the noise could be changed so as to afford material relief without lessening the warning sounded for vessels approaching."[244] The City of Milwaukee felt their foghorn was so unnecessary and unwelcome that they petitioned the U.S. Senate to "take steps…to do away with the noise and din caused by the new foghorn."[245] Most attempts at curbing foghorns were met with swift rebuttals by officials. One could question the necessity of a factory whistle, but it was beyond the pale to question the sky shattering booming of foghorns.[246] Apart from the accommodation of deflectors, citizen-led suggestions of changes to fog signals were for the most part ignored.

"Necessary Noise" and the Chicago Harbor Signal

> *Out of the fretful deeps, when the fog creeps towering in, smothering out the horizon and soaking the rigging until the drops fall like rain, masters of ships tilt a weather ear in the direction of the Chicago Harbor light and say 'That's the gol-darned best old horn on Lake Michigan'*[247]

The situation surrounding the new diaphone installed in Chicago Harbor is a case study of a "necessary noise" in an urban context. While once of unchallengeable necessity, it was true that the fate of the fog signal in general was sealed. New radio-based communications, among other factors, would help to quickly relegate sound signals to a minor role in navigation assistance. Sound signals still had a use however, as not all areas had significant problems with zones of silence. In Chicago, a case was made that the horn was a life-saving necessity. As of 1925, it was still the only possible method of warning ships on the lake,

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244 *Boston Daily Globe*, (August 1, 1904).
245 *New York Times*, (March 13, 1926).
246 *Boston Daily Globe*, (November 24, 1912).
247 *Chicago Daily Tribune*, (June 7, 1925).

according to the Commissioner of the U.S. Lighthouse Service. While fog signals had been an issue of Chicago city life for at least thirty-five years, the new diaphone installed around 1925 had triggered a new debate as to the limits of loud sound near cities. This was a debate around a view of the productivity of sound at the service of human life. The center of the debate was the life and safety of the mariner.

An article published in the *Chicago Daily Tribune* in 1925 attempted to inform citizens about the mortal risk of navigating on the lake, and in doing so presented a moral case for the new diaphone. It was drafted as an instrumental appeal for the virtues of selective applications of immense sonic power in close proximity to cities. A tract intended to enlighten the "busy business man" on nautical threats; it was an effort to silence the whines of disturbed bankers, under-slept housewives, and bleary-eyed scholars: "Think of the mariners!" was the implicit message. Addressed to the proverbial "citizen who has lost sleep over the yodeling roar from the lake," the message was to be thankful and to be silent about complaints so that these sounds of safety could be enhanced. After all, things could have been worse— the new diaphone was only a "Type F", the Type G was even louder.[248] Out on the lake, some mariners dismissed the whining bankers: "They are among those who scoff at the few hours sleep lost by the soft citizens on land and they tell tales of the lakes, and the fogs that creep in before you know it."[249]

This remarkable article visited the fog signal apparatus itself. The visual spectacle of this sonic menace did not match its acoustic fury. Its facade was dwarfed by the imposing tower of light which, in the perpetually foggy Chicago Harbor, was a mostly useless display of majesty. Readers were informed that the real demon lurked hidden below. In a small building to the side, a little diaphonic horn extended outwards, a "terror [which] looks like

[248] Chicago Daily Tribune, (June 7, 1925).
[249] Chicago Daily Tribune, (June 7, 1925).

an overgrown auto horn." The previous horn could only be heard at a paltry distance of seven miles away. Mariners interviewed felt this little menace with its capability of up to 25 miles was sweet music to the mariner. The old horn was simply not powerful enough to assure safe passage.

The real crux of the debate and the terms of the diaphonic exposure documented in the *Tribune* was a moral one, according to its authors. George Putnam, the Lighthouse Commissioner who was accustomed above anyone else to appease complaints around fog signals, saw its adoption as moral duty: "the [diaphone] is the most modern and efficient horn. To have failed to install it at this important point would have been equivalent to a soldier's refusing rifle, machine gun, and gas mask, and sticking to sword and shield."[250] His implicit message, essentially, was *stop thinking about yourself and to get used to it.* Other cities had dropped their resistance, and welcomed the signals as an offering of fidelity to the "men on the lakes." Putnam extinguished many other fires around fog signal complaints. He supported the suggestion of a journalist that the area of Russian Hill, San Francisco might take a trip out to sea:

> Russian Hill should be put to sea of a foggy night in a fisherman's boat...It should see the skipper at the helm, holding his boat to an uncertain course through the blackness of space. There would be minutes of suspense and apprehension; then out of the night would come the siren, so friendly and intimate and reassuring—almost beautiful. Then Russian Hill could go back and sleep in peace; the sire would have a sweeter tone ever after.[251]

The debate around the Chicago diaphone is notable for a few reasons. It captured a source of longstanding debate around perhaps one of the largest signals close to a major

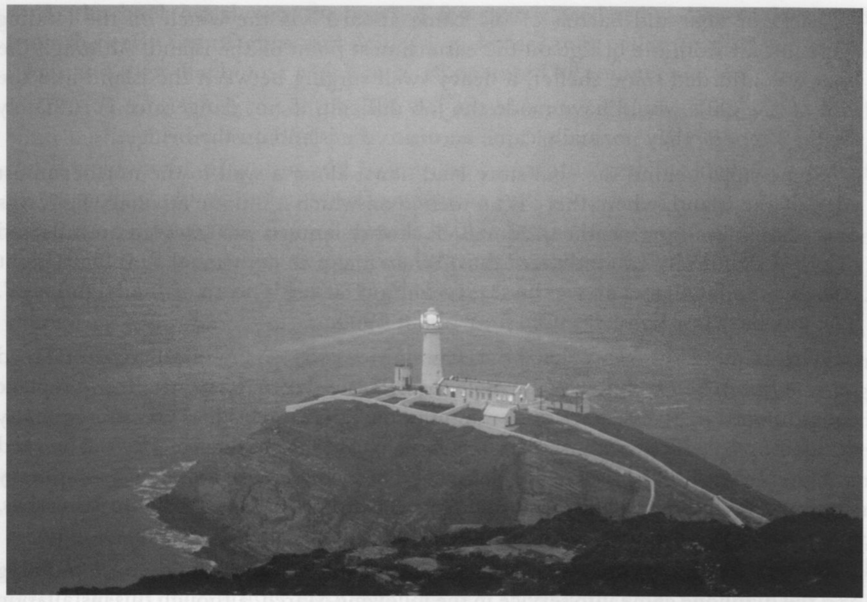
250 *Chicago Daily Tribune,* (June 7, 1925).
251 George Putnam, *Lighthouses and Lightships of the United States* (Boston, MA: Houghton Mifflin Company, 1917), 236.

metropolitan area. But more importantly, it was at a period where two key issues intersected: the increasingly organized noise abatement movement with the imminent eclipse of the diaphone as the standard of nautical signaling in hazardous conditions. The noise abatement movement was far from instrumental in the foghorn's demise, but certainly assisted in casting doubts on the justification for unencumbered sonic power.

Fade Out, or, The Madness of the Lightkeeper

As the days of the diaphone were numbered, the moral claim on behalf of the Commissioner was partly disingenuous— if one only thinks of the mariner, who will consider the lighthouse keeper? Certainly one of the cruelest occupations ever devised, the increasing enhancement of fog signals installed at lighthouses came with significant mental and physical health consequences. Sonic power was literally punishing light stations operators. With the promise of an automated system with the apparent liberation from incessant coal-powered drudgery, came a new form of domination likely far more punishing. Once described as the "mechanical tyrant" hiding in lighthouse complexes, the advent of automated fog signaling was seen as a "revolutionary transformation" of the keeper's responsibilities.[252]

[252] Elinor De Wire, *Guardians of the Lights: The Men and Women of the U.S. Lighthouse Service*, 67.



South Stack at twilight.

Figure 25. The Fog Signal at Twilight

With the transformation from a custodian—whose main job was to illuminate the light beacon each day—came the burden of an acoustic machine that few could handle. The promise of a coastline blanketed with the tones of safety came at the expense of the scarification of the lighthouse keeper. The need for supreme loudness amidst the void almost warranted a site of transmission devoid of human presence. What made fog stations uninhabitable was claimed by one historian to be

> the constant loud blasts of the foghorns. One engineer in the 1900s said, 'At short range, it would be difficult to find anything more blood-curdling than the long drawn out, trumpet-like howl emitted by one of these machines'...When the sirens blasted for protracted periods of time, the continual noise seemed to stun keepers, forcing some into zombie-like states.[253]

Tales abound of keepers severely affected by the repeated howling blasts that would often

[253] Dennis Powers, *Sentinel of the Seas*, 65.

occur for days. For some it was a type of ontological transformation through a perpetual subjection to loudness:

> Coast Guard keeper Marvin Gerbers became so accustomed to the foghorn at West Point Lighthouse in Puget Sound that he automatically paused every 27 seconds in his conversations with visitors, knowing the foghorn would drown out his words. Apparently the habit followed him even after retirement, when his new friends noted a curious but regular stop-start pattern in his speed, as if his brain were still planning for loud interruptions.[254]

It should be no surprise then that the exhausting, punishing work amidst great solitude was not appealing to many. Commissioner Putnam, while busy defending the moral rights to life of sailors, was also occupied staffing certain fog-prone light stations that were seen as undesirable for habitation and work. The Superintendent of Lighthouses in San Francisco considered the local lighthouse of Point Reyes, "the most undesirable lighthouse in his district…those [that worked there] seemed to go about their duties in a zombie-like state, stunned by the whir of wind and the oppressive clamor of the fog signal."[255] The agony of the keeper who worked in a fog-prone area was unending. Sleep was an issue, as sleep deprivation was believed to be a cause of some of the psychological conditions associated with working at certain remote stations. Perhaps its not a coincidence that researchers on sleep deprivation during a 1936 experiment on "sleep-wrecking" at the University of Chicago chose foghorns as a means of waking subjects. Sleepers were "tortured" with foghorn blasts throughout their sleeping night, and their subsequent patterns of waking were documented.[256]

Returning once again to the remarks of Serres, it would appear that the combination

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[254] Elinor De Wire, *Guardians of the Lights: The Men and Women of the U.S. Lighthouse Service*, 80.
[255] Elinor De Wire, *Guardians of the Lights: The Men and Women of the U.S. Lighthouse Service*, 78.
[256] *Popular Mechanics*, June 1936, p. 864.

storm noise and the loudness required to overcome those noises was more than too much for mariners. In one situation during a storm in Oregon in 1912, a keeper was nearly murdered by the sound of a portion of the cliff-side shearing off into the ocean below:

> The roar of the raging gale outside, the pounding seas, and the dismal foghorn, were common to his ears. Then suddenly the roar of a thousand cannons pierced his eardrums. In all the years on the rock he had never heard such a terrifying noise. He stood straight up, petrified, as if bracing himself before the lighthouse slid into the sea...[257]

This vignette is an almost apocalyptic scene where the lighthouse and noisy foghorn are no match for geological realities. The earth and the sea swallowing the noise-maker into the void is a scenario more megaphonic than any efforts of human artifice could foster.

This chapter has charted the ascension of acoustical signaling in maritime transport from the late-nineteenth-century until its decline in the early-twentieth century. The promise of sound as an aid to navigation was partly undermined through the shortfalls of what loud sound could not provide. Loud sound waves had proved to be evasive, undependable, and often utterly nefarious to the average sea-goer. Despite the hopes that the power of the diaphone would be able to overcome zones of silence, it did not do so in any consistent, predictable manner. The common assumption of acoustical scientists and lighthouse officials around the turn of the century that better and louder fog signals would provide greater certainty was a belief that ultimately bore little fruit. The proliferation of foghorns installed along the coasts of North America, some still rusted and honking on autopilot today, bear witness to this belief, and lighthouse keepers are the sacrificial bodies for this experiment in megaphonics. The increasing standards and certitudes of nautical communication meant that the exercise in high volume signals transmitted within the range

[257] Jim Gibbs, *Sentinels of the North Pacific: The Story of Pacific Coast Lighthouses and Lightships*, 84.

audible to the human ear would be a brief one. Marine navigation aids quickly departed from the audible range, as the advent of the era of radio-based navigation elevated marine communication into the more assured realm of ultrasound. Global Positioning Systems have made acoustic modes even more redundant.

Now mostly ceremonial, acoustic signaling is a boon to little more than the most desperate and low-tech of pleasure craft vessels. Foghorns and lighthouses have become little more than architectural curiosities. Some are still used in navigation, but most now serve only as a destination point for golden age travellers. An irony is that when some fog signals were recently faced with decommissions, residents objected citing a pleasant nostalgia for their melancholic tones. Perhaps they never had the luxury of living close to an infernal diaphone, close to these honking guardians of the void.

CHAPTER 3

Sonic Shocks and Megaphonic Materialities

In 1923, a massive detonation was set ablaze in Germany releasing 1000 kilograms of explosives. It was not an accident. Nor was it an act of war or research related to the science of explosions. Rather, it was triggered with the singular purpose of substantial long-distance sound propagation. Its effect was substantial—detected at a distance of 700 kilometers away, it was by far a record for the longest documented sound propagation event. The Jütebog explosion, as it was called, was an example of the extent of sound dissemination so profound that it makes the alleged 100-kilometer capability of the ancient Horn of Themestius seem absolutely quaint.

The 1923 explosion was one of many such tests. A series of explosions during the 1920s in Europe were not only a chance to assemble unheard-of amounts explosives together, but it was also the opportunity to test the thresholds of shock wave audibility across the span of countries rather than traditional challenges of propagation across valleys or regions. The late-nineteenth and early-twentieth centuries were the backdrop for a bounty of experimentation and scientific knowledge gathering around the question of the shock wave and the power of sonics. It is yet another example of the cultural obsession around the productive uses of loudness.

Shock waves were a source of intrigue and stupefaction. As an emerging field of analysis they were a source of scientific seduction and near mystical effect. Shock wave science was a point of disciplinary intersection. Also it was a meeting point for physicists, physicians, meteorologists, acousticians, and military researchers. Part of what drew so many disparate investigators was that it offered their respective fields of knowledge a scientific equivalent of a magic trick, meaning the rendering of invisible phenomena visible by techniques of measurement and visualization. Speculative, invisible powers were being pulled out of thin air and turned into the tangible, the tactile, and the understandable. Such was one of the major contributions of Ernst Mach in his efforts to capture on film the enigmatic forces which could damage windows at great distances and render bodily harm on those close enough to the path of explosions. Mach's efforts to undermine what he considered to be the "metaphysical" vagaries of shock waves led to the specialized technique of high-speed photography and compressed wave front documentation.

Out of shock wave research would emerge what was not only an unveiling of invisible force, but also a blurring of tepid distinctions between what was sound and what was not sound. Increasingly, sonic phenomena were posited not as a distinct physical set of phenomena but one subset of sensory experiences situated across a continuum of wave-based experiences. But also important were the biological and psychological effects triggered by experiences of sonic shock. The shock of a gong was believed, albeit erroneously, to induce the dubious state of female hysteria. Sound was believed to be the force which triggered an overload of the mind by concussive metallic sonority. The shock of a fourteen-inch artillery shell was understood to induce psychological distress not only from a sonic overload, but increasingly also as a material form of physical damage. The close-range experience of an artillery shell was believed to be one that could foster madness but, increasingly without qualification, could also cause death.

This chapter will examine interrelated questions around shock waves and megaphonic experience. Once again, the period was host to a multiplicity of cultural obsessions relating to the increased power of sonic propagation but was also host to the scientific and philosophical interest in the effects of those wave-based phenomena. Loud sound was emblematic of an emerging modernity—in this case a peculiar intersection of the increased capabilities of ballistics and ordinances in concert with enhanced abilities of scientific documentation. It was also an epoch interested in increased speed, whereby high-velocity phenomena were studied, measured, and explicated. The concussive forces of new thresholds of sonic power became inexorably intertwined with the truth claims of high-speed photography. The productivity of loud sound was made more certain in the evidence of frozen photographic tableaus partly ushered in by an ascendant culture of science. It was a curious confluence of weaponry, psychology, acoustics and physical science channeled into an intrigue regarding powerful sound propagation.

This section on sonic shocks will examine another valence of the cultural concern surrounding loud sound, velocity, and the quest to understand the physical mechanics of sonic power. It was an intrigue about the confounding distances explosive sound waves could travel and a morbid fascination regarding the damage such shock might inflict on the human body. It begins with the work of Mach and how the emerging practice of psychophysics found a fertile terrain in the subject of loud volume. Mach's profound "anti-metaphysics", one that resisted the purported enigma of sounds as invisible phenomena, led to the capture of revealing photographs of a high-speed bullet breaking the sound barrier. Next, the chapter will examine the enhancement of ballistics and ordinance technologies, with its related attempts to extend and document long-distance sound propagation. Lastly, attention will turn towards interest in the effects of concussive sonic experience on the human mind and the animal body. Loud sound was not only increasingly seen as capable of overloading the human mind, but also one of which could render bodily injury or even death.

Theoretical Foundations: Mach, Fechner and the Seeds of Psychophysics

While visiting the 1881 First International Electrical Exhibition in Paris, Ernst Mach attended a lecture by the Belgian artillerist, Louis Melsens. According to Mach scholar John Blackmore, he was taken aback by Melsens' theories regarding the violent, explosive impact of compressed air as an explanation for the strange crater-like wounds in victims shot by gunfire in the Franco-Prussian war. Melsens' argument was that the wounds experienced by soldiers on the field were not sufficiently explained solely by the harm inflicted from a bullet penetrating flesh—another force was inflicting damage in conjunction with the bullet itself.[258] Melsens felt an invisible force was causing damage at the point of impact. Mach had reservations regarding his argument. Upon returning to Prague, he embarked on a series of experiments that would visualize sound dissemination and shock waves as well as explain a host of phenomena associated with high-speed propagation. Melsens' claims would be rebuked by means of the scientific dazzle of high-speed photography.

Mach's work was important on numerous fronts, both in terms of the philosophical questions that propelled his experimentation and the substantive terrain of that experimentation. Sound was a long-standing interest. He was deeply curious about the physical properties of sound propagation and a maintained an ongoing fascination with the concussive force of explosions. While it is perhaps slightly dubious to anoint a singular point of origin for shock-wave research and practice, Mach was undoubtedly one of the major forces, if not the major influence. His broad philosophical concerns suggested ways in which his material scientific research would turn to focus on the enigmas of sound and shock waves. Furthermore, his philosophical work was considered of the foundational sprouts for an emerging philosophy of science. Mach was a devoted "anti-metaphysicist", an advocate

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[258] John T. Blackmore, *Ernst Mach: His Work, Life and Influence* (Berkeley: University of California Press, 1972), 105.

of psychophysics in the study of physical sensations and a general positivist-empiricist in his approach to epistemology. Both Einstein and Nietzsche read his work.

While technically an atheist, there was something of a veiled spiritualist approach to Mach's views of epistemology that was his basis in rejecting metaphysics. It wasn't a form of reactionary positivism. Rather it was a more reverential approach to knowledge that would encourage the more spectral offshoots of American pragmatism in the ensuing work of William James, for example. James would take from Mach aspects of his evidence-based skepticism with decidedly spiritualist inclinations regarding psychology, sensual perception, and the soul.

The introductory section of Mach's influential 1886 work *Contributions to the Analysis of the Sensations* was sternly titled "Antimetaphysical". Its intentions were clear: "the view, namely, that all metaphysical elements are to be eliminated as superfluous and as destructive of the economy of science."[259] This meant two things: firstly, the a challenge to the Kantian idealist sense of metaphysics being that which exists outside of experience, but also the rejection of "ideas whose source or history we could not clearly trace."[260] This wasn't a blanket realist attack, rather a mutated idealism that sought to outline scientific investigation as "the compendious representation of the actual."[261]

But it is curious why Mach did choose to devote significant time to sound, arguably one of the most metaphysical of physical processes at that time. During his era, it was an esoteric subject more commonly seen as a conduit for spirits than a rich empirical terrain of discovery. Surprisingly for Mach, sound was consistently a source of investigation he would return to, including work on: Doppler theory (1860); acoustic waves in the human ear

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259 Ernst Mach, *The Analysis of the Sensations* (London: Open Court, 1914), x.
260 John T. Blackmore, *Ernst Mach: His Work, Life and Influence*, 33.
261 Ernst Mach, *The Analysis of the Sensations*, xii.

(1863); effects of sound waves on glass and quartz (1872); and soot explosion experiments (1878).[262] It is perhaps a compelling argument that Mach could not avoid sound, as it offered the ultimate opportunity to confront the metaphysical, a chance to expose the previously enigmatic.

In fact, Mach's interest in sound's inherent physicality follows a lineage of empirical studies of sound after the work of Gustav Fechner. Fechner proposed a scientific methodology that assumed a single type of reality. This monistic singularity would apply to both physics and psychology ("psychophysics" as it was to be called) in an attempt to relate mind and body. A single type of reality in fact had two sides, an "outside" which was physical and a psychological "inside." Both functioned not through interactions, but behavior in parallel that could be expressed through mathematical formulae and functions.[263] While Mach was to question many of Fechner's assumptions, including the two-sidedness of reality, it is difficult to dispute that he was Mach's greatest intellectual influence. Almost as important, Fechner's methods, arguably the genesis of experimental psychology, were attempts to bring metrics to psychical processes.[264]

Sound was not just a sidebar subject with Fechner either. Aspects of *Elements of Metaphysics* were devoted to perceptions of tonality and issues around thresholds of audibility in the upper and lower registers. But sound perception triggered a core debate within the framework of psychophysics: what is the relationship between objective, external stimulus and its internal sensation-effects? It was commonly assumed that a linear increase in sonic intensity would foster the parallel increase of perceivable sound intensity. As E. B. Titchener remarked:

[262] John T. Blackmore, *Ernst Mach: His Work, Life and Influence*, 106.
[263] John T. Blackmore, *Ernst Mach: His Work, Life and Influence*, 29.
[264] See for Hui, Alexandra. The Psychophysical Ear : Musical Experiments, Experimental Sounds, 1840-1910. (Cambridge, Mass.: MIT Press, 2013).

> …the measurement of stimulus is simple; but sensation can be measured only by recourse to stimulus. It seems that we are involved in a circle… Fechner, however has shown us how to overcome this difficulty. We measure sensation by aid of the just noticeable difference of stimulus, which corresponds always with an identical increment of sensation, and thus furnishes us with a sensation-unit...[265]

So "Weber's Law", as was named by Fechner, declared that the perceivable difference is logarithmically related to the magnitude of the stimulus. This Weber-Fechner law took sound intensity as a core object of study to prove that, for example, a two-fold increase in emanated sound energy does not necessarily foster a two-fold increase in perceived loudness. This was fairly sophisticated work on sound intensity perception if one considers a similar contribution in the 1860s by Helmholtz. For him, intensity was a function of the physical disturbance of the basilar membrane. The force of displacement of the basilar fibres would correlate to the effect of perceived loudness. Thus experience of *loudness* depended on the extensiveness of disturbance, whereas *pitch* depends on what specific fibres were displaced.[266]

Fechner also fostered a quasi-mystical approach to sound perception that Mach was most likely be troubled by. What Fechner positively referred to as the "day-view" was an almost reverential approach to scientific methodology. It encouraged a sense of the wonder of nature in stark opposition to the dead mechanistic view of an atheistic scientism, which he called the "night-view". Perhaps foreshadowing some of the debates around contemporary scientific triumphalism, Fechner's night-view rendered the magic of the mind into a wonder-less "clump of protein called [the] brain."[267] Sound waves were profound

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265 E.B. Titchener, "Mach's 'Lectures on Psychophysics'," *American Journal of Psychology* 33:2 (1922), 215.

266 Edwin Boring, "Auditory Theory With Special Reference to Intensity, Volume, and Localization," *American Journal of Psychology* 37, no. 2 (1926), 160.

267 Michael Heidelberger, *Nature From Within: Gustav Theodor Fechner and His Psychophysical Worldview* (Pittsburg, PA: University of Pittsburgh Press, 2004), 126.

phenomena that could not be reduced from "shining, sounding vibrations" to "blind, mute waves." Science could draw closer to the natural world without necessarily emptying that natural world of meaning:

> Natural man resists the wisdom of the night view. He believes that he sees the objects surrounding him because it is really light all around him, not that the sun begins to shine somewhere behind his eyeball; he believes that flowers, butterflies and violins are as colorful as they appear to him …, in short he believes that throughout the world there is light and sound outside of himself and it pervades him.[268]

Fechner encouraged an approach to empirical evidence gathering that would attempt to reinforce a sense of natural wonder. Mach, however, would largely discard some of these soft sentiments and look for a means of rendering metaphysical sonic phenomena into provable physics through the gathering of visual evidence. This is to say that Mach was less pushed by a desire to materialize the evanescent as a way to reinforce the wonder of nature. Instead, he was furnishing a simple pragmatic approach to settling a scientific dispute that was over-saturated with mystical half-truths.

Shock Waves, Mach and the Speed of Sound

Mach's question as to whether the French had violated the ban on explosive projectiles during the Franco-Prussian War was not yet sufficiently answered. The claim of Melsens still stood unanswered—whether a small explosion on impact was the cause for the crater effect around bullet wounds. Thus a pragmatic dispute between two scientists on the nature of a flesh wound was the basis for a set of experiments that would provide more evidence than initially imagined. Two assumptions of Melsens would be refuted by Mach: (1) that a

[268] Michael Heidelberger, *Nature From Within: Gustav Theodor Fechner and His Psychophysical Worldview*, 126.

projectile is capable of *carrying* a significant amount of compressed air which is dependent on its velocity; and (2) the compressed air *precedes* the projectile, and may cause "mechanical, explosion-like effects."[269] Both assumptions would be refuted in a stunning act of scientific evidence presentation. Its important to note in passing that Mach was not the first to approach questions of shock wave phenomenon. In 1864, German physicist August Toepler noted the phenomenon in question as "spark waves" or conversely "air percussion waves."[270] Toepler was the first to experiment with and document shock waves, but the limits of his documentation went as far as sketches of the observed phenomena, as opposed to providing almost irrefutable proof via the medium of film. When he died, his wife erroneously etched on his tombstone "August Toepler— The first to see the sound." Her conflation was a confusion between shock and sound, one that symbolized both a common misunderstanding and a mutually inseparable relationship.

Even if Toepler essentially developed the mechanism that would allow the visualization of the bullet's waves, Mach's improvements to the method ensured that his work would receive all the attention and attribution as an effective discovery. In essence, shock waves arise when matter is subjected to rapid compression, in particular through "violent expansion of the gaseous products from a high explosive or by an object moving faster than the speed of sound in the surrounding fluid."[271] The challenge for Toepler, and what he could only represent through sketches, was the pictorial representation of that rapid shock-inducing compression of air.

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[269] John T. Blackmore, *Ernst Mach: His Work, Life and Influence*, 105.
[270] Peter Krehl, *History of Shock Waves, Explosions and Impact* (New York: Springer, 2008), 911.
[271] Peter Krehl, *History of Shock Waves, Explosions and Impact*, 72.

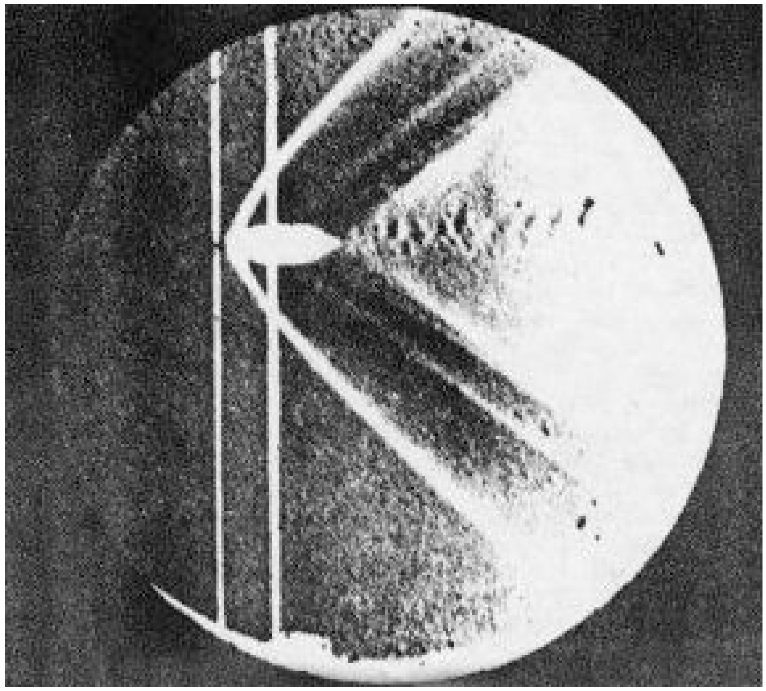

Figure 26. Mach's 1887 High-Speed Photograph of a Bullet

Mach was able to acquire high quality photographs of these shock waves. The photographs were important in different ways. Firstly, it was a technical triumph to visually capture a projectile so fast that was to the naked eye essentially invisible. Secondly, refinements to Toepler's *Schlierenmethode* by magnifying the light from spark created a shadow-effect outlining the condensed water at the front of a shock wave— this allowed for a wave-based phenomena effectively invisible would be rendered visible.

Mach's rendering of visual evidence was not a freak occurrence or the result of an outsider act of genius. It was part of the scientific zeitgeist of the late-nineteenth century, as Lorraine Daston and Peter Galison argue. They posit that a common urge of the era was to 'photograph the evanescent', to make the invisible visible and the abstract concrete through scientific observation:

> This form of image-based scientific objectivity emerged only in the mid-nineteenth century. It appeared piecemeal, haltingly at first

> and then more intensively, positioned against idealizing, truth-to-nature images that themselves never died out completely. Like the spring melt of an ice-bound northern river, the change begins with a crack here and there; later come the explosive shears that throw off sheets of ice, echoing through the woods like shotgun blasts, followed eventually by a powerful rush of water that should not, for all its drama, obscure the myriad local changes that preceded it. Objectivity entered the practical domain of scientific atlas making slowly, throughout the 1840s, then gained momentum, until it could be found almost everywhere in the rush of the 1880s and 1890s.[272]

Ernst Mach's work on the visualization of shock waves was very much part of this late-nineteenth century mad-rush of scientific evidence gathering through film-based documentation. It provided a tableau of the bullet as a means to outflank metaphysics and render sound waves visible. Mach was often as much or more concerned with the methodology of the scientific process, the techniques in gathering the images, than the results or implications of his research. For example, he devoted over 100 separate letters to a colleague regarding the proper technique of photographing a bullet as opposed to its theoretical implications.[273]

The first attempts to photograph waves fronts in 1884 did not provide any clear evidence. But by 1886, faster bullets were loaded in the pistol chamber and more discernable results were obtained. The shock waves surrounding a high-speed projectile were finally properly visualized and the arguments by Melsens regarding bullet crater wounds refuted: projectiles did not carry masses of air with them, nor were the wave fronts responsible for the enlarged wound areas. Rather, continuous disturbances of stationary air triggered by the

272 Lorraine Daston, and Peter Galison, *Objectivity* (Cambridge, MA: MIT Press, 2007), 124.
273 John T. Blackmore, *Ernst Mach: His Work, Life and Influence*, 111.

projectile were to blame. The crater wounds were the sole result of the impact of the projectiles on flesh and not an explosion on impact.[274]

The revelation of shock waves did more than the service of unveiling invisible phenomena; it also gave proof regarding the often-concussive power coupled with shock waves themselves. Shock is a process of physical force. As historian Peter Krehl notes, such waves occupy an interesting position within the more general field of dynamics. They are observable both in the laboratory and in natural processes, within macro and microscopic dimension and even in the depths of space. Shock waves and percussion processes "are discontinuous phenomena and are felt by our senses as sudden and violent events."[275] But exactly what constitutes "discontinuous" phenomena is difficult to pin down and essentially a subjective matter. The essentially physical (and often violent) force of shock waves was also deeply connected to acoustic phenomena. Mach was made profoundly aware of the menace contained in acoustic waves and their ability to destroy glass windows. It was compounded and reinforced by the discovery that shock wave fronts often carry an atmospheric density as high as fifty-times normal levels.[276]

The questions posed by Melsens also had repercussions on the understanding of sonic phenomena in association with shock waves. An inseparability between sound and shock is evident both in the inherent sound intensity coupled in the phenomena of shock, but also the fact that shock is triggered by the transgression of the threshold of the speed of sound. Later dubbed the "Mach number" by physicists, it was the multiplier that expressed extreme velocity, which was indexed solely upon the velocity of sound transmission itself. As shock wave science developed in the 1880s, aided by the capabilities of violent

[274] John T. Blackmore, *Ernst Mach: His Work, Life and Influence*, 111.
[275] Peter Krehl, *History of Shock Waves, Explosions and Impact*, 5.
[276] John T. Blackmore, *Ernst Mach: His Work, Life and Influence*, 115.

ordinances, it was not surprising that a lexicon of violence flourished to describe both the nature of the shock and its associated acoustics. An 1885 text on 'Sound and its Phenomena' by Cobham Brewer described shock waves caused by gunpowder exploding as a sonics of violence, strangely in part because of the void which it reveals:

> Many of the loudest sounds with which we are familiar are occasioned by the percussion of air against the air... The tremendous noise of exploding gunpowder or dynamite is occasioned in the following manner: certain highly elastic gases, engendered by the inflammation of the powder, are suddenly developed, press upon the air which they encounter with considerable violence and greatly condense it. This condensed air, being driven back against adjacent strata, condenses them in turn, and these latter, repelled against more remote portions, produce the same effect. In the meantime the new-formed gases either condense or diffuse themselves, leaving a vast void. The condensed air rapidly dilates in order to occupy this void; and currents flowing in from opposite sides, clash together with enormous violence, producing a new series of condensations at the very moment of their rarefaction. This latter is the cause of the peculiar roll which characterizes an explosion of gunpowder. The original sound being due to the condensation and dilation of air, as the gases develop or condense, and the rolling to the collision of opposite portions of air as they rush forward to occupy the void from which they had been dislodged.[277]

This chain reaction outlined by Brewer, as the basis of the shock-wave mechanism, outlines an acoustics of menace that has at its core a reaction as violent as the explosions that often trigger it. The very physics of the most megaphonic of all sonic phenomena in essence mirrors the reaction that takes place at the instant of exploding gunpowder.

Shock wave science, which started in the mid to late nineteenth-century as a quaint alleyway of physics, eventually grew into a complex interdisciplinary science. Shocks were increasingly seen everywhere. As Krehl argues, it was soon discovered that nearly all violent

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[277] Rev. E. Cobham Brewer, *Sound and Its Phenomena* (Boston: Oliver Ditson & Co., 1885), 15-16.

phenomena existing in nature could be explained by the blanket of shock. From terrestrial tectonics to cosmic disturbances, these disruptive phenomena are all governed by general shock wave processes. Shock-based discontinuities include,

> thunder, meteoric impacts, volcanic explosions, earth- and seaquakes, bores and tsunamis, while in the Universe they encompass stellar explosion and implosion phenomena, bow shocks and planetary shocks, comet and asteroid impacts, and galactic collisions involving tremendous amounts of energy.[278]

Leaving aside the question of galactic acoustics, large-scale earthly shock processes would also challenge basic understandings of acoustic transmission. That is to say, the louder the explosive force, the less likely related sound effects could be clearly explained by classical sound transmission theory. Intense sound propagation, in short, produces acoustic phenomena that deviate from the linearity of classical acoustics.[279] The acoustics of explosions are understood to adopt properties as unconventional as quantum physics are to classic Newtonian mechanics.[280]

Rather than getting into specifics about the physical science for interests sake, these points are mainly to emphasize the interconnection between shockwave science and acoustics, particularly in the emergence of the specialization in the late nineteenth-century. Mach's work on proving evanescent phenomena through the doubt-eviscerating lens of high-speed photography had repercussions on the understanding of sound transmission. It demonstrated that the mechanism of the shock wave and its related acoustic boom is in itself inseparable from one another. Also it became clear how integrated the nature of ordinances and ballistics science were with studies of sound propagation. As will become

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[278] Peter Krehl, *History of Shock Waves, Explosions and Impact*, 5.
[279] Peter Krehl, *History of Shock Waves, Explosions and Impact*, 72.
[280] A. L. Thuras, Jenkins, R.T., and O'Neil, H.T., "Extraneous Frequencies Generated in Air Carrying Intense Sound Waves," *Journal of the Acoustical Society of America* 6 (1935).

clear, megaphonic science relied inherently on the provisions of ballistics; once the sidebar domain of hobbyist craftspeople, it would blossom into an important component of experimental and theoretical science.

Bullets, Artillery Fire & Ordinance Fever

While Mach's work expressed a truth-to-nature claim regarding shock wave sound propagation through visualizing ballistics, it also ushered in an era that used the bullet as a gold standard in physical science investigation. As the late nineteenth-century witnessed an amplification of interest in both the ability to produce and analyze megaphonic sound, it also was the context in which a watershed of ballistics development took place. The bullet's development as the *de facto* standard for investigations into shockwaves and the velocity of sound was reinforced by the fact that only the bullet was able to cross the sound barrier in a controllable fashion. The tail end of a cracked whip was an unmanageable phenomenon. There was little else that was both fast enough and controllable—the only option was a bullet. Thus at the heart of acoustics research was a certain understated menace; late nineteenth-century acoustics and ballistics are inseparable. It should not be a surprise that the rise of supreme sound propagation capabilities during the era was matched or trumped by the rise of powerful, obliteratingly loud high-caliber weaponry.

In Dan McKenzie's *City of Din*, amidst cataloging some of the noise-based blights of urban living, devoted substantial attention in outlining some of the emerging megaphonic phenomena of the early twentieth-century. According to McKenzie, noise in cities was out of control and regulation was required to remedy the problem. But urban noise was but one subset in the greater proliferation of powerful sources of sound propagation. Weaponry was a major part of this expansion of megaphonics and explosive sound was increasingly prevalent. While it wasn't primarily an urban blight, powerful early twentieth-century weaponry was a symbolic token of the generous capabilities of modern technics able to both cause annoyance and harm. For him a new type of great explosion was emerging, described in passing as "the mountainous billow of sound that emanates from the great naval guns and monster howitzers."[281]

Not all weaponry had similar sonic properties. McKenzie differentiated between the annoying sound of machine guns versus the violent and utterly concussive sound of large artillery. It was clear to McKenzie that artillery fire was a blight both to the mind and body of soldiers: "A rapid repetition of the latter, however, as the naval battles of the Great War have proved, is probably one of the most terribly destructive to hearing of all the sounds of civilization."[282] And the range of volume-based trauma caused by modern weaponry was on the rise. The 12 to 14-inch large-shell artillery fire of WWI soon gave way to even larger mega-guns. For example, the Germans realized in WWI that cement-reinforced bunkers were too tough to penetrate with existing capabilities and sought to develop even greater penetrative power. This encouraged the development of larger, more powerful forms of bunker penetration, including the realization of monstrosities such as the "German Krupp", a 17-inch projectile also dubbed "Big Bertha" with ranges reaching up to 122 km. Larger caliber weapons required increased explosive power to propagate the projectiles sufficiently. Increased explosive power also translated into greater shock waves.

These new forms of weaponry posed obvious challenges to those in the direct proximity of a blast. As McKenzie noted:

> …there is no position in the vicinity of the gun where one can avoid it, as it spreads equally all round through a spherically-

281 Dan McKenzie, *The City of Din, a Tirade Against Noise* (London: Adlard and Son, 1916), 94.
282 Dan McKenzie, *The City of Din, a Tirade Against Noise*, 94.

> shaped area of the atmosphere, the centre of which is the mouth of the gun. Thus the noise is as great behind the gun as it is to one side of it. So tremendous in these great explosions is the condensation and rarefaction of the air that the drum of the ear may be rent by it in precisely the same way in which the closed windows of a house are shattered by heavy firing.[283]

Gunners were often advised to open their mouths in a semi-yawn like state so as to be able to absorb the pressure blasts into equalizing quickly and minimizing risk. Boom waves were not only travelling through the ear canal though, it was increasingly realized that sound waves were travelling to the ear as well through the bones of the body and skull. The human skeletal system was a resonation device as much as the ear was in the case of megaphonic blasts.

By the dawn of the First World War, it was becoming clear that there were significant physiological and mental repercussions for humans in close proximity to these new expressions in ballistics. The new condition called "shell shock" appeared to occur, at least from the outset, without any direct physical trauma. Medics and scientists were often confused as to whether it was a condition of the organs or of the psyche. Shell shock itself is emblematic of some of the unknowns of shock wave sonics. Were the blights inflicted on soldiers an effect caused by psychological disturbances from audible sonic experiences, or were they caused by physiological damage triggered by waves primarily of the infrasonic realm? In short was shock triggered by sound or "not-sound"? The work of physiologist D. R. Hooker in the 1920s would be essential in answering this question, and his findings will be examined towards the end of this chapter. But as he expressed from the outset, the confusion regarding shock waves was clear:

> The physiological effects of air concussion were studied during the period of the war because of the probable relationship of air

[283] Dan McKenzie, *The City of Din, a Tirade Against Noise*, 95-96.

> concussion to certain war injuries. Men subjected to the concussion of large shells often developed a condition of 'shock' which was unrelated to obvious traumatism since no external or internal wounds were clinically demonstrable. While it is true that subsequent investigations developed the fact that many of these instances were cases of psychoses (shell shock), nevertheless a considerable number were left, the symptomatology of which indicated some physical injury without, however, any external manifestation.[284]

The debate around shell shock was whether it was a psychological condition stemming from an audibly perceivable experience or a physiological-based trauma from physical force. It would take some years before the source of injury was properly understood as primarily psychological or physical. But during the mid-1920s it was suspected that the sometimes fatal damage would stem from injury to the physical organs; this mortal risk was encouraged by a concurrent anxiety or panic attack brought on by the exposure to unfathomable sound. Shell shock in some ways captures a key problematic of megaphonics: when a sonic "event" is deemed to be of a significant intensity, it ceases to remain within the sole domain of audition. Here the continuity of waves becomes obvious— explosive sound is not merely an isolated and solely auditory event, it is a blast that propagates waves below, above, and within the range of human audition. Shell shock was a condition of exposure to extreme megaphonic phenomena. It shuts down the mind through an overload of audition and (it was hypothesized) damages the organs because of the menacing shock of intra-sonic waves. Hooker's work on physiological damage to animal organs will be the final thematic of this chapter, an attempt to chart the sequence of events which leads to death via aerial concussions.[285]

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[284] D. R. Hooker, "Physiological Effects of Air Concussion," *American Journal of Physiology* 67, no. 2 (1924), 219.
[285] D. R. Hooker, "Physiological Effects of Air Concussion," 220.

But the sonics of modern weaponry also had a softer, less destructive side. Large guns had the capability of psychological affect. In particular, military guns were used in the service of fostering melancholic moods. Shortly after the death of U.S. President Garfield in 1881, which came weeks after an assassination attempt, it was proposed that minute guns be used to convey the solemn mood across the city of New York:

> Does it not seem proper that during the funeral on Monday afternoon minute guns should be fired from one of the forts in the harbor? This is a ceremony at which the whole Nation attends. It is a national—not State affair. A telegraph wire could be easily run to the battery to give the exact time for the procession starts for the cemetery; and the booming of the first gun from the Harbor forts would give note to all the City and for miles around it. There is nothing more solemn than the slow booming of the funeral minute gun.[286]

A loud gun booming across as metropolis was as good a device for triggering a sense of collective mourning, as it was an integrated communications device.

The flourishing of weaponry in the late nineteenth-century also encouraged a rash of imitation guns that would rely on shock sonics to trigger discomfort in the name of cheap gags. Such gun-crazy and mimetic inventions aimed to develop small-scale explosive sounds purely as entertainment. Types of explosive-imitation inventions included Frank Burn's "Toy Arm" patent of 1896 which promised "improvements in toy arms or devices from producing sounds in imitation of the explosion of cannon and other firearms... the main object of which is to produce explosive sounds by harmless means and in an economical manner.... imitation of a piece of field-artillery."[287] Pop-guns also imitated the shock-effect of weaponry for laughs. In Brewer's 1885 text *Sound and its Phenomena*, the sound of a pop-gun was analogous to many other weapons-based sonics of the time. He writes,

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[286] *New York Times*, September 23, 1881

[287] U.S. Patent 560,570 dated May 19, 1896.

> …for example: when a person draws off briskly the lid of a pen-and-pencil case, a noise is produced like that of a pop-gun. For, as the air in the sheath is more rarefied than the external air, immediately the lid is removed the external air with greater density rushes in. The encounter produces a shock, and the noise of the shock is augmented by the resonance of the case.[288]

While Mach gained recognition by succeeding at photographing a bullet in mid-flight, focusing primarily on either his work and issues pertaining to close-range projectiles would ignore some of the unique aspects of general explosive capabilities. His work on documenting bullets had the effect of freezing time and focusing on the invisible—in effect manifesting invisible phenomena as provable through its visibility. The sonic world of ordinances, however, was far more widespread and scientifically obtuse. A glut of new forms of explosive weaponry were about to be developed in the late-nineteenth and early-twentieth centuries that would help push scientific understandings of explosive sound propagation on a macro-level.

In this section the close-range effects of shell-shock or technical aspects of high-caliber artillery were touched upon as local, immediate, micro-based observations of acoustic phenomena. Bullets aside, this begs the question: what were the conditions of general explosives and their acoustic valences? What were the capabilities of new bombs as well as explosives such as dynamite and gunpowder in the context of sound wave propagation?

Long Distance Megaphonic Sound Propagation

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[288] Rev. E. Cobham Brewer, *Sound and Its Phenomena*, 21.

In 1885, a maritime passage close to New York City was plagued with an impassible reef system that caused numerous shipwrecks. Despite trying to remove the reef several times, every attempt ended in failure. Unlike the zones of silence in the previous chapter that caused numerous fatalities, tragedy from this reef could not be simply avoided through the assistance of foghorns— it was an impediment that needed to be destroyed. Thus an era of blowing things up as a method of removing obstacles was fostered in. One answer to the immovable realities of stone and tectonics was found in dynamite. The Hell Gate explosion of 1885, the celebrated spectacular removal of this rock through a massive explosion witnessed by thousands of New York citizens, signaled in the era of public explosions as spectator sport. It was both a cultural narcotic and a triumph over nature. Finally achieving success in destroying the rock was the result in increased capabilities through greater amounts of dynamite and concussive force. Publically, it was heralded as a quintessential triumph of modern technics over nature:

> The tremendous explosion of Flood Rock yesterday, which was reduced to a harmless and picturesque spectacle by the vast pressure of the waters which enveloped it, furnished a striking illustration of the mastery of man over nature. By the devices which he has contrived out of her own laboratory he is able to modify her plans almost at will to suit his own purposes. He not only spans rivers and pierces mountains when they come out his way, but he makes watercourses where there were not and regulates the drainage of continents. The paths of the ocean itself he changes when they are not sufficiently accommodated to his ends.[289]

[289] *New York Times*, (October 11, 1885).

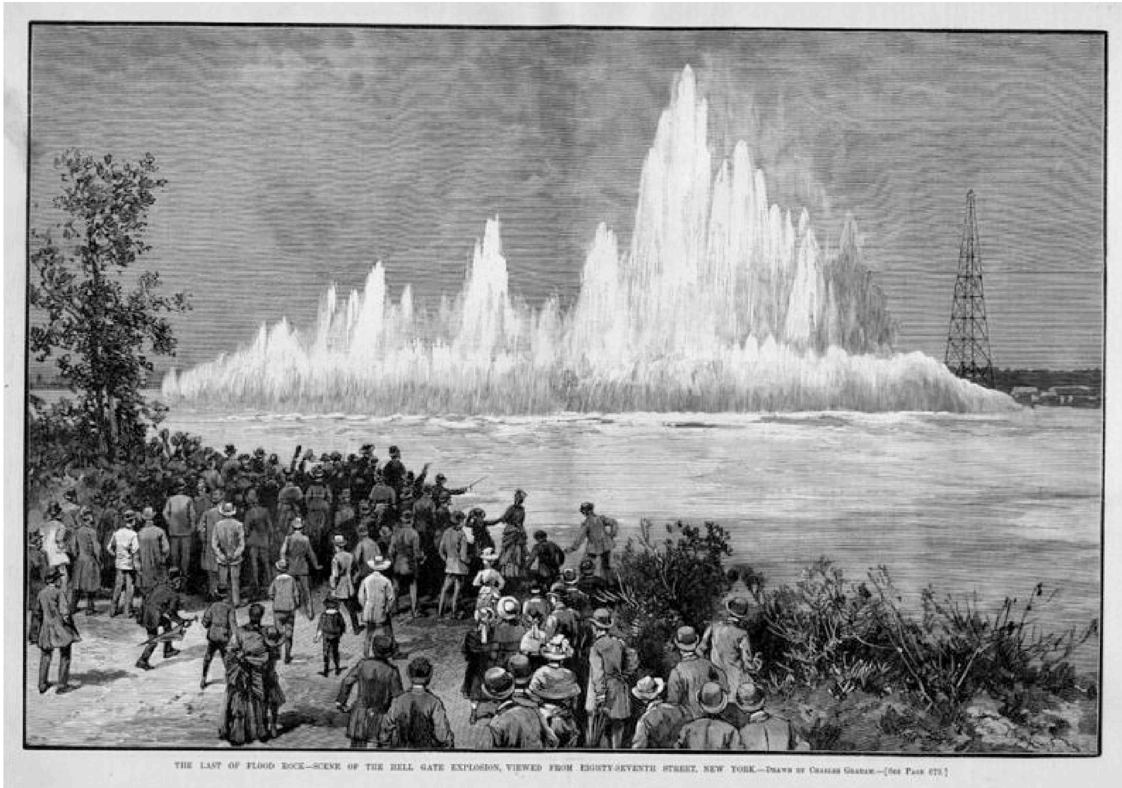

Figure 27. Spectators Watching the Hell Gate Explosion (1885)

This spectacle was one of the largest mass exhibitions of technological prowess witnessed in the nineteenth-century. An estimated 200,000 people were believed to be watching from the safe vantage point of the shoreline. Hospitals and psych wards were emptied out and the patients brought close enough to watch the explosion, both as a form of entertainment and safety precaution in the case of any collapsing walls or blown out windows due to shock. One engineer noted a significant physical sensation from the explosion and confirmed that the sound was as loud as expected. The *New York Times* reported the sound as a series of concussive waves, partly like "a loud rumble, not unlike the firing of a distant canon."[290] The Hell Gate episode was an episode of shock and destruction as public exhibition and amusement, a gentle yet powerful suggestion as to the sonic

[290] *New York Times*, October 11, 1885

capabilities of dynamite-based explosions, even if this explosion primarily occurred under water. Destroying bedrock was an explosively propagated form of domination over nature, one where the acoustic properties closely resembled that of canon or artillery fire from the depth of a river bed.

Underwater blasts are but one specific type of explosion within a spectrum of possible sonic experiences. Brewer's *Sound and its Phenomena*, published the same year as the Hell Gate explosion, attempted to catalogue the conditions which fostered the propagation of loud or intense sounds. For him, the loudness or intensity of sound was proportionate to:

> I. The force of the shock which the air receives; II. The density of the medium through which the sound-waves pass; III. The uniformity of that medium; IV. The absence of obstacles to interrupt the progress of the sound-waves; and V. The proximity of the auditor to the original source of the sound.[291]

For Brewer, the explosion that gives the air the greatest shock also produces the loudest sound. That's why a roasted chestnut exploding has no comparison to the energy or force released by gunpowder. But also on his second point, sound waves pass through denser air easier than more rarefied air at higher altitudes, so sounds are less audible at elevation. This also means that we are buffered, for Brewer, from the sounds of the universe: "no noise whatsoever proceeding from celestial bodies can ever reach our earth."[292] As well, depth is a boon to noise such as in case of a diving-bell, where if the slightest whisper is audible. Moreover valleys are louder than plains at elevation. Valleys are "speaking-trumpets, and tubes of communication." As well, sounds travel farther and with greater intensity at night than during the day.

[291] Rev. E. Cobham Brewer, *Sound and Its Phenomena*, 24.
[292] Rev. E. Cobham Brewer, *Sound and Its Phenomena*, 27.

In the October 14, 1915 edition of the journal *Nature*, an English reader wrote in claiming his wife heard the continual rumbling of guns. There was no fighting on British soil at the time. He wondered if the sounds did not originate from the battlefields of France.[293] An expert in explosive sound propagation, Charles Davison, who was consulted on the question in *Nature* reaffirmed that guns had been heard as far as 139 miles during the late nineteenth-century. He claimed it was indeed possible that the explosions taking place in France could be clearly heard at massive distances across the English Channel. Davison reported earlier that a battle in 1797 was said to have been heard as far as 200 miles away. As a matter of fact, the nineteenth-century was replete with reports of long distance gunfire audibility over distances of 100 miles or more.[294]

The research of Davison uncovered a wealth of information regarding the long-distance propagation of war sounds. During a mock battle in the French town of Cherbourg in 1900, it was also reported that the guns were heard across the English Channel. From the other side in England, the acoustic perception of that battle changed as the distance increased; that change was a waning from the audible and physical to the purely physical and not audible at all. At short distances of 70 miles, on the Isle of Wight, the sounds were “described exactly like that of heavy guns", but at greater distances, "the prominent reports ceased to be audible, and there was merely a deep monotonous throbbing noise, the pulsations recurring with great rapidity and regularity, resembling a very quick beating of a big drum far away, or the paddles of a distant and unseen steamer." At 100 miles "a most curious throbbing sensation in the air, and a dull sound like that of a distant train."[295]

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[293] *Nature*, Volume 98, No. 2398, October 14, 1915. p. 173.
[294] *Nature*. Volume 62, Number 1607. August 16, 1900. pp. 377-378.
[295] Charles Davison. *Nature*. Volume 62, Number 1607. August 16, 1900. pp. 377-378.

Distant explosions, as they dance along the threshold of audibility, become the lowest of low frequency experiences. A clergyman noting the sound of an explosion at a distance sounded "like a bomb falling on a nearby parish."[296] The megaphonics of explosions at a distance had an acoustic profile that was often indistinguishable from that of a bomb.

Explosive sound propagation was far from being a linear phenomenon. In fact its numerous aberrations in long-distance propagation that were of interest to a wide swath of scientists, meteorologists and military personnel. Scientists learned that with even the strongest, most insisting of explosives, sound did not travel in a linear or predictable fashion. It was subject to the whims of weather and humidity amongst other forces. In 1935, F. J. Whipple gave a sort of definitive lecture at the Royal Meteorological Society, titled "The Propagation of Sound to Great Distances." In it he suggested that the field of megaphonic long-distance sound transmission acoustics had its start during realizations in the UK during WWI that sound travelled with different characteristics in summer than in winter.[297] Acousticians helped formalize an intuitive truth that soldiers had known for some time, that sound travels in a far more muted fashion in frozen, snowy conditions. Sound was dampened in winter, and the sounds of war were often "smothered" by the crystals of snow as Brewer suggested in 1885:

> The British and American troops, on one occasion during the Revolution, happened to be encamped on the opposite sides of the same river. The outposts were so near to each other that a drummer on the American side was observed by the British troops moving his arms to the beat of his drum, but yet no sound

296 F. J. W. Whipple, "Autographic Records of the Air-Wave From the East London Explosion, January 19, 1917," *Quarterly Journal of the Royal Meteorological Society* 43, no. 184 (1917), 399.
297 F. J. W. Whipple, "The Propagation of Sound to Great Distances," *Quarterly Journal of the Royal Meteorological Society* 61, no. 261 (1935), 285.

> whatsoever was perceptible. A heavy fall of snow had recently covered the ground, and the air was thick with the river mist.[298]

Just as the sound of fog signals often passed through aberrations referred to as "zones of silence", explosive sound was subject to numerous other transmission irregularities that prevented it from being heard throughout a blast path. Where the acoustic science of fog signal audibility pointed towards the effects of humidity in deflecting waves above the low elevation necessary for audition, explosive sound often would draw on geological and atmospheric science to understand irregularities. The black holes of sound experienced by mariners in fog, which sometimes would prevent the possibility of hearing foghorns nearby, were of a completely different tier of blackout than the tendency of explosive sounds to deflect upwards into the atmosphere for distances of up to 100 kilometers. These were massive distances, megaphonic-based ones. Davison, writing again in *Nature,* noted a significant zone of silence that occurred during the funeral of Queen Victoria in 1901. During an interval of up to 80 kilometers, the funeral guns were not audible at all, and then distinctly reported at longer distances.[299] What happened to the sound?

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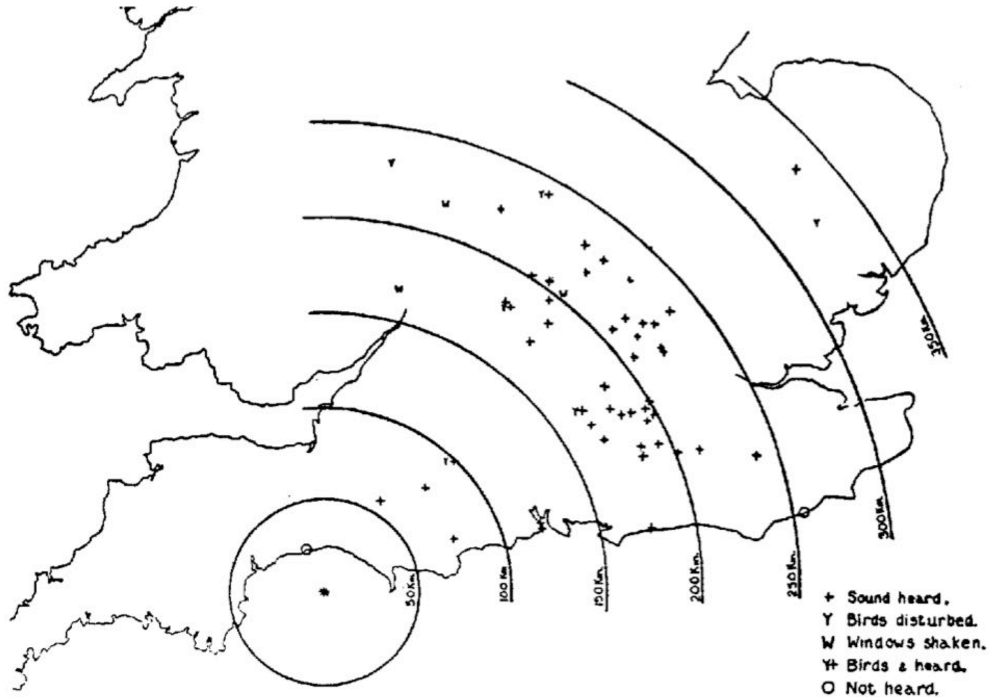
[298] Rev. E. Cobham Brewer, *Sound and Its Phenomena*, 31.
[299] *Nature*. Volume 111, Number 2778. January 27, 1923, p. 117.



AUDIBILITY OF FIRING IN WEST BAY, 1930, Nov. 1st. DURING VISIT OF THE IMPERIAL CONFERENCE.

FIG. 3.

Figure 28. Graphic Representation of Long-Distance Audibility, Whipple (1935)

As sound was demonstrated to travel through bones, it also became clear that it travelled through the ground. A particularly concussive explosion that happened in London in 1917 vexed numerous scientists and suggested the tendency of sound waves to vanish during long transmission, and then reappear suddenly at a distance. It was known as the explosion of the "Silvertown Chemical Works" where apparently a chemical factory was completely destroyed, leaving little more than a giant crater where the site once stood. Witnesses and the press referred to it as an almost material, concussive force that snapped across significant distance. Again, as in other observations of explosions, it was most often detected at a distance as a low grumbling sound akin to thunder. But not everyone in the blast path heard the sound. One observer noted, who desperately canvassed all the other workers in the building, some of which did not hear the thunder:

> I personally heard the explosion, but to me it sounded more like a peal of thunder in the distance—more of a rumbling sound than of a sharp explosion; but in the same building where I was a number of gentlemen happened to be in another room, and they did not hear any sound whatever. I have also made inquiries of other gentlemen, who state that they heard no sound at all.[300]

Meteorologists who studied the effects of the 1917 explosion noticed that in many locations it was not the audition of direct sound waves that was heard, but rather the sound diffracted towards the ground. While likely based on disputable acoustical science from a contemporary perspective, apparently this observation helped to explain why an explosion would blow open a basement door 11 miles away from the blast site but not necessarily be audible as an "explosion". Meaning, much of the higher frequencies expected from a full-spectrum sonic experience, such as an explosion, didn't transmit over the distance of 11 miles; it was only the low frequencies that could travel through the ground:

> …[the sound arrived] not by transmission in direct lines but by what is called diffraction from the broken edge of the wave front, that is to say, as the wave passed each obstacle the excess pressure at the lower edge could not be retained in the absence of suitable support; the overhead energy that survived would act as a source sending down disturbance so that the wave-front would become bent...[301]

At each point of deflection, it was believed the sound would be refracted down through geological strata. This is perhaps the best explanation why a distant basement door could be blown open without any noticeable effect on the building's upper doorways or windows.

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300 F. J. W. Whipple, "Autographic Records of the Air-Wave From the East London Explosion, January 19, 1917," 395.
301 Napier Shaw, *Manual of Meteorology*, vol. III (Cambridge: Cambridge University Press, 1945), 38.

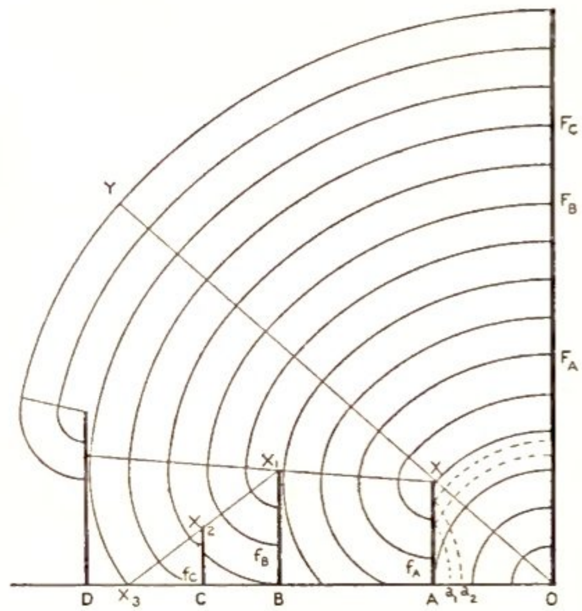

Figure 29. Diffraction of Sound Waves into the Ground Through Interference, Shaw (1937)

Another scientific opportunity arising from the 1917 London explosion was the use of industrial barometers from across the city in order to reconstruct a cartography of the shock wave. It was an air-wave map outlining the air pressure around London at one point in time. The work of F. J. Whipple in utilizing numerous pressure gauges around London that had been recording pressure at the time of the explosion graphically underlines the resolutely non-linear nature of sound transmission. His findings appeared to confirm the assumption that shock waves would disappear at given points, either by escaping upwards into the upper atmosphere or deflecting downwards into deep strata.

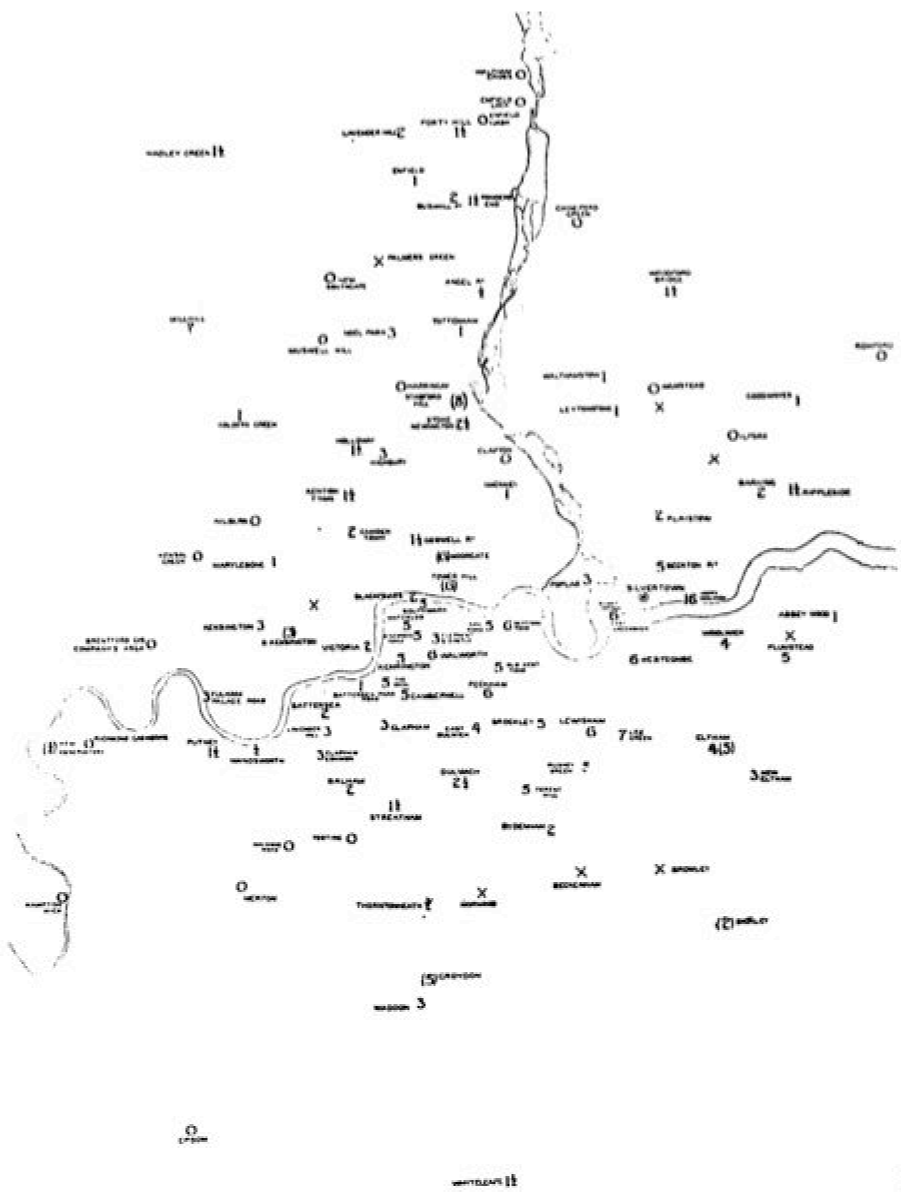

FIG. 2.—Plan showing the places from which records were obtained.
Scale—1 cm. to 2·7 km. or 1·6 mile.
The figures indicate rise of air-pressure in tenths of an inch of water. Figures in brackets refer to barographs. Crosses indicate the limits of the area in which damage was reported.

Figure 30. Shock-wave Barometer Reading as Explosion Cartography of London, Whipple, (1917)

As bullets proved essential to the visualization and magnification of invisible wave fronts, dynamite-based explosions would prove irreplaceable in the quest to extend and measure megaphonic sound propagation. A wide-ranging series of well-controlled tests would begin in the 1920s. Explosion-derived long distance sound propagation experiments, conducted largely in between World Wars, used the devices of the battlefield to test audition up to distances of hundreds of kilometers. Most of the key documented explosions took place in Germany and France in the 1920s including: Oppau, 1921; Odebroek 1922; la Courtine 1924; as well as Jüterbog on several occasions between 1923-6.[302] Such controlled and measured tests of blast-range audition could very convincingly demonstrate that significant explosive charges could be heard at distances of 300 kilometers or more. It was no longer the case where loud sound was understood to only have the ability to echo within a valley basin or across a plain of several miles. Through the collusion of modern ordinance and acoustics science, sound was increasingly understood as able to clearly transverse over massive distances and could be documented through compelling means of synchronized audition.

According to F. J. Whipple, there was little in terms of actual acoustic rules regarding megaphonic sound propagation. At distances of 200km or greater, sound transmission is anomalous or abnormal by definition: "sounds which are heard at a distance of say 200km are nearly always abnormal and it is but rarely that there is normal reception at such as distance."[303] Non-linearity is the rule. A conspiracy of humidity, weather systems, atmosphere, and geology work in unison to evade nearly any form of predictability in long-distance sound propagation, thwarting the assumptions of basic physics against an almost quantum-like system of sonic rules. A test at Jüterbog, Germany where one 1000kg explosion was set free on May 3, 1923 demonstrates the phenomenal distance sound can be tracked, and the utter irregularity of the path of which it travels. As noted in the *Manual of Meteorology* the Jüterbog explosion was clearly documented as being heard at the unfathomable distance of over 700 kilometers.[304]

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302 Napier Shaw, *Manual of Meteorology*, 45.
303 F. J. W. Whipple, "The Propagation of Sound to Great Distances," 286.
304 Napier Shaw, *Manual of Meteorology*, 47.

RESULTS OF OBSERVATIONS OF THE SOUND OF AN EXPLOSION

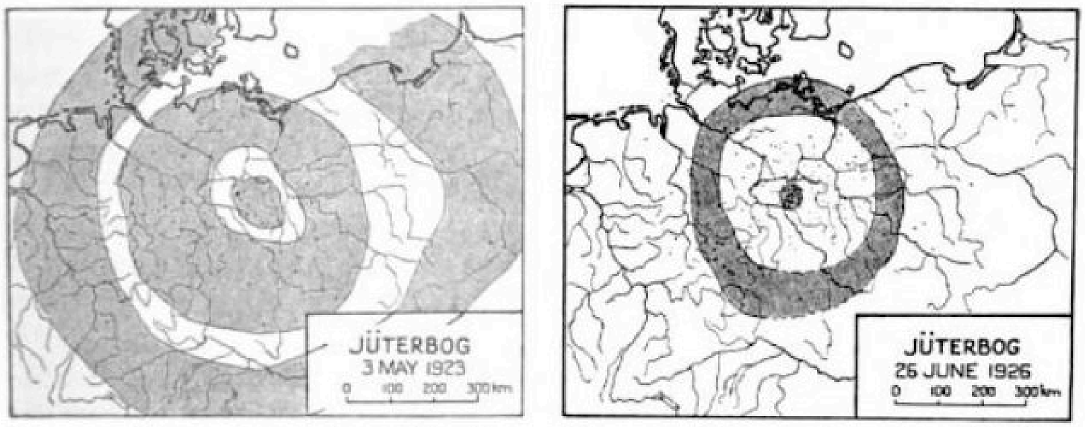

Fig. 23. Charge of 1000 kg at Jüterbog on 3 May 1923. The shaded areas show the regions of audibility.

Fig. 24. Charge not stated at Jüterbog on 26 June 1926.

Figure 31. Zones of Audibility Near The Juterbog Explosions of 1923 & 1926. Whipple, Shaw, 1945

Reports of long-range audibility were documented around the globe: An explosion of a train carrying dynamite in South Africa in 1932 was heard over a staggering distance of 500 kilometers, and an explosion in Boden, Sweden in 1933 was heard over 300 kilometers away from its source. F. J. Whipple's devotion to the subject encouraged the documentation of the path of audibility of a series of weapons being discharged in 1930, heard over 300 kilometers away as well.[305]

The documentary and quasi-cartographical efforts of acousticians and meteorological scientists brought forth a varied set of ways in which megaphonic sound could be represented and investigated. The British Broadcasting Corporation made an appeal to listeners in 1927 to note unusual observations regarding sound in their area at the time of the test explosion. The appeal to listeners was dropped in later tests, but the BBC did stay involved by broadcasting the actual signal of the sound of the explosion itself:

305 F. J. W. Whipple, "The Propagation of Sound to Great Distances."

> Excellent arrangements have been made, with the approval of the War Office, at Woolwich, where the officer who fires the gun simultaneously transmits the signal that is broadcast. Originally we utilized only the firing of the largest guns, 16-inch and 15-inch, but it has been found of late that the waves produced by 9.2-inch and even 8-inch guns can be recorded under favourable circumstances.[306]

So a curious intersection of artillery fire and communication technologies was deployed in the service of the metrics of megaphonic sound. Through the efforts of radio broadcasting and the far-reaching scope of mass media, citizens were made aware of the efforts to document long-range loud sound propagation. They were encouraged to assist in the reporting of the journey of sound waves.

During sound propagation experiments in the late 1920s, it was noted that there was a tendency for loud sounds to split into distinct and separate wave fronts. This notion of "pulse-splitting" was the means whereby a sonic event would become fractured into two separate fronts and would arrive at a long-distance destination at different times. One pulse may become diverted into the atmosphere or reflected down to the earth and back again. Another pulse may take a different route entirely:

> …in such cases the recorded times are consistent with the hypothesis that the waves are reflected from the ground between their passages through the upper atmosphere. The phenomenon has been observed many times in Germany: the most remarkable instance occurred on December 19, 1928, when waves from Jüterbog were recorded at Konigsberg at a distance of 578km after three reflections.[307]

As it was understood at the time that sound waves can take a decidedly subterranean route, they could also bounce between the earth and the upper atmosphere like a pinball game. 578

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[306] F. J. W. Whipple, "The Propagation of Sound to Great Distances," 290.
[307] F. J. W. Whipple, "The Propagation of Sound to Great Distances," 300.

kilometers was a massive distance for explosive sound to travel laterally, but when one actually considers the nature of that lateral transmission, that a shock wave may visit the upper atmosphere multiple times, it becomes even more curious.

The idea of pulse-splitting may have been too simple of an attempt to describe the truly chaotic nature in which loud sound travels. As an inherently "non-linear" acoustic phenomenon, the propagation of explosive sound would also be seen as more than a simple binary "split" of waves. Rather, it increasingly became clear that sound diffused into multiple, even infinite wave fronts. This emerging idea of "diffusion" was the understanding regarding a smearing-effect which was the result of sound waves encountering resistance, such as reflection off impediments be it solid material or upper-atmospheric resistance. Sound would arc towards the atmosphere, but when it would hit the upper limit it would return downward and smear in a variety of directions. These long-distance sound transmission physics were subject to a multitude of non-linear complexities that repeatedly thwarted understanding.

The Metrics of Megaphonics

Efforts to understand the *direction and distance* that sound travels (as was the case with the explosive event) is not the same as the rich body of work that has examined issues of *velocity* with respect to loud sound. Attempts at understanding the linkage between sound propagation and velocity has a history going back to ancient Greece. Surprisingly, one of the longest-held truisms of sound propagation—namely the assumption that the velocity of sound is not constant—has held up to considerable scrutiny over time. This is the assumption that louder percussive sound travels slightly faster than lower intensity sound. It was first subject to quasi-scientific scrutiny during a trip through the Northwest Passage by

English polar explorers William Parry and Henry Foster in 1824-5. While firing a gun at a distance of four kilometers, they observed the words "fire" to distinctly come shortly after the boom of the weapon, not before as would be expected.[308] So it was hypothesized that explosive sound travels faster than sound at a lower volume.

Thus another valence of the productivity of loudness emerges, that the violent concussive intensity of explosive sound travels faster than those of quiet utterances. The louder the sound, the more effective and quickly a transmission could possibly be completed, albeit a message to be communicated or a signal to be relayed. Perhaps a certain utilitarian expediency came with sonic power.

Early experiments to determine a relatively precise figure for the speed of sound go back at least as far as the early seventeenth-century. Acoustics historian Frederick Hunt argues that as early as ancient Greece, Aristotle claimed that the speed of sound varied based on the intensity of its source.[309] Pierre Gasendi (1592-1655), keen to follow the Galilean revolt of all things Aristotelian, attempted to debunk Aristotle's claim that intensity was in fact linked with velocity. Gasendi declared that the sound of artillery fire, such as the loud blast of a canon, would arrive at a distance of three miles at the exact same time as that a blast from a small weapon such as a musket.[310] Such crude efforts attempted to time the arrival of explosive blasts by the aide of a pendulum. Multiple other Italian experiments attempted the same inconclusive experiments later in seventeenth-century. It was still not even clear what a velocity of sound was at this point.

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308 Peter Krehl, *History of Shock Waves, Explosions and Impact*, 156.
309 Frederick Vinton Hunt, *Origins in Acoustics: The Science of Sound From Antiquity to the Age of Newton* (New Haven: Yale University Press, 1978), 100.
310 Frederick Vinton Hunt, *Origins in Acoustics: The Science of Sound From Antiquity to the Age of Newton*, 100.

The first attempt to scientifically predict the velocity of sound was made by Isaac Newton in 1687. Up until tests in the early nineteenth-century, the erroneous consensus, propagated by Gasendi and others, maintained that the velocity of sound was constant, irrespective of pitch or loudness. It was still believed that all sounds were transmitted with exactly the same velocity.[311] Its difficult to conclude as to what was more impressive—Aristotle's intuition that velocity is intensity dependent or the remarkable length of time an incorrect understanding was perpetuated by Enlightenment-era scientists. Shock wave historian Peter Krehl noted a comment published in 1864 on the scientific stagnation: "Some researchers, extrapolating these results without hesitation to violent sounds in general, denied any effects of sound intensity on the velocity of sound at all."[312] Otherwise questions did begin to arise as early as the Parry and Foster experiments of the 1820s. Christian Andreas Doppler in 1847 presented a paper examining some of the acoustical phenomena described as the *Doppler effect,* wherein he speculated that the propagation velocity of sound should increase with intensity. Samuel Earnshaw published his *Mathematical Theory of Sound* in 1860, which reaffirmed the intensity-dependent nature of sound wave velocity. For him, the more "violent" the sound, the greater its propagation:

> …the report of the gun, might be heard at a long distance in an inverse order i.e. first the report of the gun, and then the word 'fire.' In a slight degree, therefore, the experimental velocity of sound will depend on its intensity, and the violence of its genesis. I consider this article as tending to account for the discrepancy between the calculated and observed velocities of sound (which most experimentalists have remarked and wondered at), when allowance is made…for change of temperature."[313]

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[311] Peter Krehl, *History of Shock Waves, Explosions and Impact*, 81.
[312] Ibid, 81.
[313] Samuel Earnshaw, "On the Mathematical Theory of Sound," *Proceedings of the Royal Society of London. Philosophical Transactions* 150 (1860), 139.

Finally, the writing was on the wall for the bogus claim of the equivalence of sound propagation velocity. Earnshaw noted that "if the theory here advanced be true, the report of fire-arms should travel faster than the human voice, and the crash of thunder faster than the report of a cannon."[314] In 1863, Henri Regnault, a French researcher, proved beyond a doubt the existence of supersonic velocities through triggering small explosions in the Paris public sewage system. Through comparatively measuring the velocities of various explosive charges, Regnault argued again that shock waves and louder sound in general does indeed travel faster in relation to lower intensity sound.[315] Earnshaw had already tabled a typology of sound waves, suggesting a tripartite scheme of sound waves divided by their velocities: minute waves, ordinary waves, and violent waves.[316] Violent waves were characterized as being the fastest, loudest and most in breach of a "normal" velocity. It was clear that loud sound offered a kind of expediency or efficiency. Sound propagation was not limited by an absolute threshold of velocity; there was no invisible wall limiting the speed of sound. The experiments of Mach, Sommer, Regnault and Earnshaw all proved this point. Shock waves, according to Mach while may propagate supersonically quickly after the blast, they would approach the normalized speed of sound as distance from source increased.

If the velocity of sound was indeed dependent on the intensity of the sound propagation, what was the benchmark for a baseline speed? Of course it would have to be harmonized Western music played at a "reasonable" volume. William Jacques, a physicist and fellow at John Hopkins, published *On the Velocity of Very Loud Sounds* in 1879. Jacques experimented on phenomena that enhanced the velocity of very loud sound. He concluded

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314 Samuel Earnshaw, "On the Velocity of the Sound of Thunder," *Philosophical Magazine and Journal of Science* 20, no. 4 (1860), 41.
315 Peter Krehl, *History of Shock Waves, Explosions and Impact*, 81.
316 Samuel Earnshaw, "On the Triplicity of Sound," *Philosophical Magazind and Journal of Science* 20, no. 4 (1860): 186-92.

that musical expression of low intensity should be the benchmark for determining a baseline rate for the velocity of sound:

> It is very well known that the velocity of a musical sound is, within very wide limits, sensibly independent of its intensity and of its pitch. The experimental proof of this is that a piece of music, played by a military band at a considerable distance, comes to the ear of the observer with its harmony entirely undisturbed.... When, however, we come to the consideration of a loud and sharp shock or explosion, in which the disturbances are very violent and abrupt, we cannot be at all sure that the changes of density are negligibly small, and hence that the velocity of sound for such cases would be a constant.[317]

Somewhat similar to Helmholtz's qualification of Western-based music's harmonic structures as inherently organized and harmonious in opposition to discordant noise, here organized music would serve as a normalized standard for which the speed of sound should be indexed upon.

Loud, explosive sound was also of interest to acoustics researchers because of the resistance it posed to being quantitatively analyzed. A whole host of devices were envisaged by various researchers as means from which loudness could be measured. Dayton Miller's "phonodeik", devised around 1908 for example, was one means by which loudness could be measured and visualized. Arthur Webster also envisaged his "phonometer" during the first two decades of the twentieth-century. Its use was specific— to measure the absolute intensity of sound. Webster also proposed using the metric *phone* as a unit of sound as an "absolute measure."[318] The phonometer would be both an inscription device and device of quantification: "[it would] be capable of reproducing at any time a sound of the simplest

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317 William Jacques, "On the Velocity of Very Loud Sounds," *Philosophical Magazine Series 5* 7: 42 (1879), 219.
318 Arthur Gordon Webster, "The Absolute Measurement of the Intensity of Sound," *Transactions of the American Institute of Electrical Engineers* 38, no. 1 (1919), 701.

character and which permits the output of sound to be measured in watts of energy."[319] Despite the failure of the widespread adoption of the measurement tools and standards of the early 1920s (the *decibel* would emerge as the *defacto* standard later in the same decade), the plurality of attempts bear testament to the general interest in sound intensity.

Some of the most curious efforts in measuring intense sound propagation were directed towards quantizing the explosive power of natural sonic occurrences. In particular, analyzing the power of thunder has long interested researchers. The harnessing of natural magical phenomenon has a long history in techniques of scientific observation.[320] Thunder, in particular has a longstanding appeal.[321] In 1914, an Austrian researcher, Wilhelm Schmidt, published his efforts to measure thunder. Declaring the issue of the metrics of thunder an impoverished realm of understanding:

> …from earliest times a thunderstorm, and particularly the thunder and lightening, has made the greatest impression on man. It is therefore, all the more strange, that precisely these phenomena have remained so little studied, and that our knowledge of the sound phenomena has not been increased by more experiments that are something more than analogies.[322]

His experiments consisted of two bizarre apparatuses devised specifically for the cause: one involving a giant 200 liter vessel of water, another involving smoke rings emanating from a gramophone horn. Apparently drawn by the physicality of thunder, a source of physical vibrations could be perceived by its delicate sense of touch and through the trembling of the ground. Schmidt found that thunder-based shock waves had significant similarities with the physical properties of explosive shock waves, particularly with respect to the way air

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319 Arthur Gordon Webster, "The Absolute Measurement of the Intensity of Sound," 701.
320 Hankins, Thomas L., and Robert J. Silverman. *Instruments and the Imagination.* (Princeton, N.J.: Princeton University Press, 1995), 4.
321 Rath, Richard Cullen. *How Early America Sounded.* (Ithaca, N.Y. ; London: Cornell University Press, 2003), 11-42.
322 Wilhelm Schmidt, "On Thunder," *Monthly Weather Review* (1914), 665.

compresses along the wave front, but also its velocity of travel which initially goes faster than the speed of sound.

Schmidt's analysis emphasized the starkly violent, physical nature of thunder vibrations: "the essential constituent of thunder, however, were the yet longer vibrations, certainly far below the limits of audibility, which were rather violent pressure variations that were accompanied by "beats" of "nodes" in the thunder."[323] Like many other acoustics researchers, Schmidt also sought to understand the commonalities of natural sound like thunder and Western musical paradigms. While some of the thunder tonalities, he discovered, matched certain notes of the bass clef, thunder and music were an evasive difficult pairing. Only perhaps the non-traditionally "musical" work of someone like Luigi Russolo would have any similarities to the sound of thunder. The sonic obsessions of rogue meteorologists also led to ruminations on what the acoustic properties of incoming meteors might include. According to the research of Harry Bateman, one must speculate that a meteor follows a similar acoustic pattern to that of loud, explosive sounds. However, he lamented those speculations were not yet empirically verifiable, as in it is difficult to measure a meteor in any accurate way.[324]

Despite continuing evidence further contradicting the assertions of seventeenth-century Italian scientists like Gasendi, that sonic velocity is not related to variances in explosive intensity, a common assumption persisted that the speed of sound was constant. Related to this enduring assumption of the fixedness of sonic speed was the increasing belief in a "sound barrier", a limit threshold of which was nearly impossible to transgress. Dreams of crossing the threshold of speed of sound go back as far Jules Verne's 1872 novel *Autour*

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323 Wilhelm Schmidt, "On Thunder," 670.
324 Harry Bateman, "The Influence of Meteorological Conditions on the Propagation of Sound," *Monthly Weather Review* (1914), 258.

de la lune which details a fantasy involving three men and two dogs being shot to the moon through supersonic travel. It wasn't until roughly 1935 when the term "sound barrier" started to become widely accepted. It was based on a myth of science, the idea of an invisible limit to sound, which became widely accepted among the general public. Russians refered to it as a *sonic wall*, which suggested an even greater obstacle to overcome.[325] The term sonic wall was adopted in a variety of other languages: the German *schallmauer*, the French *mur du son*, the Italian *muro del suono*, as well as the Spanish *muro sonico*.

There was no "wall" that impeded the acceleration of velocity. Rather, there was a baseline velocity whereby a further increase of speed could trigger sonic effects later known as sonic booms— the concussive loud sound which was an ongoing series of rapid air compression effects following a projectile's movement across space. The first documented non-projectile transgression of that perceived, and erroneous, limit was the use of a whip. Measured by Otto Lumer in 1905 to be as fast as 700 meters per second, its sonic effect was the trademark cracking whip sound— a mini sonic boom of sorts. High-speed jets would also achieve sufficient velocities later in the twentieth-century, effectively harboring the ability to trigger sonic booms. Pilots would turn their bodies and vehicles into literal projectiles, hurtling through desert test ranges at unfathomable speeds, turning airplanes into concussive shock wave instruments.

Shocks and the Shaking of the Body: Tremors, Hysteria and Fear

If a test pilot going faster than the speed of sound manifests its hurtling body and vehicle into a vibration-inducing sonic instrument, what would be the comparable effects of loud vibrations on static bodies and vulnerable minds? Psychologists in the late nineteenth-

[325] Peter Krehl, *History of Shock Waves, Explosions and Impact*, 505.

century would become interested in this very question, provoking inquiry into the effects of vibration and shock on the human mind. A clinical consensus was developed that sound could indeed be a catalyst for physical and psychological dispositions. It was affirmed, for instance, that a subject subjected to a loud sound by surprise in a state of pathological investigation may induce another type of shock through loudness; that intense vibrations could have the psychophysical effect of a state of tremors, hysteria, or even anxiety. As loud sound's material, physical affects on the body will become clear at the end of this chapter, its worth looking at ways in which intense aural stimulus, as the shock of surprise, could foster states of vibrating bodies in a state of fear.

Shock waves are a continuance of airborne disturbance defined by the rapid compression of air that is caused by hyper velocity across a space. The effect of a shock wave is concussive sound and vibratory disruption. But what about the vibratory effect of sound on static bodies? And in particular how might it help crossing traditional Cartesian distinctions of body versus mind?

The effect of sound on static bodies is comprised of a psychophysical multitude of responses, from cellular damage of foundational biophysical matter to profound states of psychological duress. Among other things, sound's response to shock is a physical shaking that confuses the distinction between mind and body. Stephen Connor wrote particularly eloquently on the interrelationship between tremors and sound. The act of shaking, he believes, is but one of a number of bodily affectations where the confrontation between and active and passive source takes place. Or rather, shaking is a *site of transference* between a weakness and a strength. As he argues,

> …trembling always signifies a disequilibrium or passage of power. An object may be made to tremble as a result of a blow or a sound or some incoming influence that transmits an energy into the

> receiving object which cannot all be diffused in movement, but is, as it were, held and dispersed in the aftershock of tremor.[326]

So on a metaphoric level it makes sense to consider the act of shaking as a response to the surplus energy confronting a body that cannot absorb that energy. A strength in this case meets a weak form, which results in the deforming impact of a transference of sonic vibration into bodily tremors. Connor continues:

> The communicability of these sensations [shaking] can come about partly because shaking is an imaging of a body that is resonating or has become sonorous. The shaking body has become diffused, its mass has been volatized into process. Shaking belongs to a different universe or physical order from the universe of colliding solids announced by Newton. It belongs to a physical universe based on the principle of sympathetic resonance, in which substances and events reach into each other's hearts.[327]

Beyond the concepts of vibratory transference, it is important to realize that in this case loud sound is the perceived weakness of the receiving body, as argued by Connor most recently in a long list of the characterization of tremors as weakness. Diderot's Encyclopedia, for example, characterized tremors as an "involuntary alternating weak and disorganized movement" of bodily organs.

There is no better example of the intersection of sound and bodily tremors than the much-maligned late nineteenth-century clinical experiments of gong-induced female hysteria. Jean-Francois Lyotard, ruminating on the famous painting of Jean-Martin Charcot's clinical examination of a hysteria patient, asked in an obtuse fashion what it means to capture an image that neuters dialogue with the subject, one which silences sound of the event.[328] Charcot's method of clinical performance involved the triggering of states of catatonic

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[326] Steven Connor, "The Shakes: Conditions of Tremor," *Senses & Society* 3: 2 (2008), 210.
[327] Steven Connor, "The Shakes: Conditions of Tremor," 209.
[328] Jean-Francois Lyotard, *The Inhuman: Reflections on Time* (Stanford: Stanford University Press, 1988), 129.

female hysteria in front of audiences of colleagues or even curious onlookers. Using methods such as "ovary compression", he suspected that the female state was a stress-based reaction to the pressures of domesticity and thought it may be the effect of the female womb moving up in the body. Just as Mach sought to unveil invisible physical phenomena through the use of high-speed photography, Charcot hoped that the use of the visual documentation of esoteric, enigmatic psychological conditions would be made more concrete through imagery. Hysteria was the manifestation of a psychological state "without a clearly identifiable anatomy." What was needed, he thought, was a means of making such an evasive condition more real. Thus through the bogus means of public performance of trained clinical subjects, Charcot and his acolytes encouraged pictorial documentation of the hysteric condition through the silencing of an event with sonic underpinnings.

Most often the shock-based state of female tremors were triggered by loud sounds such as gongs being rung behind the subjects.[329] The apparent consensus within the circus-like clinical atmosphere of the Salpêtriè hospital was that loud sound was a nearly failsafe means of producing clear physical effects in hysterical patients. Patients and staff would dance in the charade of pathology to please the circus-master— and the shock of sound was one of the great displays of showmanship. As Paul Richer, a student and protégé of Charcot's would attest, sounds as benign as those produced by a tuning fork could generate altered states:

> Light is not the only agent which plunges hysteric-epileptics into states of catalepsy and lethargy; the same experiences were reproduced under the influence of sound vibrations. The patients GI and B sat on the box emanating a strong pitch, this pitch comes from a metal bell vibrating at sixty-four times per second...

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[329] James C. Harris, "A Clinical Lesson At the Saltpetriere," *Archives of General Psychiatry* 62 (2005), 471.

> After a few moments, patients become cataleptic, their eyes remain open, they appear to be absorbed, they are more aware of what is happening around them. If one briskly stops the sound vibrations, immediately it is possible to notice the noise, and patients are plunged into lethargy. Here lethargy has all the characteristics previously described above. In the middle of the lethargic state, new vibrations of the tuning fork induces catalepsy.[330]

For Richer's subjects, it was fairly easy to trigger a state of trance through the vibrations of a tuning fork. It was alleged that the same effect of catalepsy was replicated with the use of a tuning fork in the work of another Charcot disciple, Paul Regnard.[331]

Figure 32. Tuning Ford Catelepsy from Regnard's Les Maladies (1887)

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330 Paul Richer, *Études Cliniques Sur La Grande Hystérie Ou Hystéro-Épilepsie* (Paris: A. Delahaye, 1881), 373-74. Translation mine.

331 Paul Regnard, *Les Maladies Épidémiques De L'Esprit: Sorcellerie,Magnetisme, Morphinisme, Delire Des Grandeurs* (Paris: 1887), 261.

Devices far more powerful than seductive tuning forks were also employed at the service of psychological manipulation and clinical demonstration. An effect even more pronounced than the tuning fork was achieved through the intense shock of a gong. As documented in a famous drawing of a session in 1878, several hysterics were assembled in the same room. Unbeknownst to them, a large Chinese gong was hidden on the other side of the room. It was a deafening sound, one that Richer assures the reader is a sound that everyone is familiar with. The effect of the clandestine gong blow was apparently "large", Richer's study noting that one patient quickly fell into catalepsy, "immobilized in the atmosphere of fear, her body leaning with her two hands raised to the level of the ears. The catalepsy appeared more intense than normal, and the patients kept moving after the shock of the sound, but they were somewhat paralyzed."[332] The sound of the gong could demonstrate that hysterics could easily progress into paralyzed states of anxiety— a vibratory transference that in effect passes the gong's vibrations through to vulnerable shell-shocked patients.

[332] Paul Richer, *Études Cliniques Sur La Grande Hystérie Ou Hystéro-Épilepsie*, 375. Translation mine.

Figure 33. Gong-derived Caelepsy (1887)

The use of gongs also came up in Regnard's *Les Maladies*, a use dedicated to the desired effect of anxiety, dread, and catatonic paralysis through the use of sonic shock:

> It is only necessary to surprise the subject with a unsuspected noise, for example from a Chinese gong—and everyone knows how disagreeable that is: the patient shows a sign of fright and remains frozen in her place. It was possible to trigger the same effects which I will recount in a few details. Six hysterics were placed in front of a camera, and they were informed that their photo was to be taken as a group. Suddenly, a violent noise came from the other room. The patients made gestures of fear and were frozen in catalepsy with the look which the shock had produced in them.[333]

[333] Paul Regnard, *Les Maladies Épidémiques De L'Esprit: Sorcellerie,Magnetisme, Morphinisme, Delire Des Grandeurs*, 262. Translation mine.

For Regnard, Richer, and Charcot, their results were not simply reflective of the clinical documentation of the states of catalepsy induced by loud sound, but also of a staged environment specifically designed to trigger an anticipated effect. This effect was to provide sumptuous, arresting visual imagery of sonic shocks on vulnerable subjects— a sort of tableau created through the act of paralysis via sound. As Didi-Huberman argues, visual documentation, particularly photo-based recreations, was a crucial aspect of the nature of tabling proof of these pathological conditions.[334] Richer, for example, was particularly focused on documenting a sort of wasted, zombie-like state of subjects exposed to gong-based shocks. But late nineteenth-century French clinicians repeatedly described portrayal of a state not far from the shell shock experienced by those close to artillery fire. Multiple blows of the gong rendered patients even farther into a state of conscious-less, self-less mental and physical vacuity.

Psychological experiments of loudness were not an isolated occurrence limited to the clinical confines of the Saltpetriere. In the early twentieth-century, American psychologist John Watson and his assistant Rosalie Rayner were interested in ways in which "conditioned emotional responses" could be triggered in people. In their famous and now essentially discredited case study of classical conditioning dubbed the "Little Albert" experiment, the duo sought ways in which young children who are relatively void of fear-associations could be conditioned to become afraid. The problem was that the only sensory stimulation that could repeatedly and apparently reliably affect young children were loud sonic shocks. For Watson and Rayner, loud sound was a baseline, a lynchpin from which fear could be indexed to. Little Albert wasn't afraid of white rats, rabbits, dogs, monkeys, masks, or fire in isolation. But it was believed that when those visual presentations were

[334] Georges Didi-Huberman, *Invention of Hysteria* (Cambridge, MA: MIT Press, 2003), 210.

associated with the shock of loud noise, they would trigger a response of fear, panic, or anxiety. Their assumption was that the reactions of children, whenever they heard loud noises, were prompted by fear which then triggered an associated chain of dread if another item was placed at the same time as the loud sound. At only eight months of age, Little Albert was left to suffer the sonic effect of a massive steel bar, four feet in length, which was then repeatedly struck with a hammer:

> One of the two experimenters cause the child to turn its head and fixate his moving hand; the other, stationed back of the child, struck the steel bar a sharp blow. The child started violently, his breathing was checked and the arms were raised in a characteristic manner. On the second stimulation the same thing occurred, and in addition the lips began to pucker and tremble. On the third stimulation the child broke into a sudden crying fit. This is the first time an emotional situation in the laboratory has produced any fear or even crying in Albert.[335]

If a rat, for example, was placed in the room at the same time as the steel bar was struck, Watson argued that the rat would trigger an "emotional response" the next time the rat was introduced even without the sound. So a rat, something that did not on its own foster any sort of anxiety, was then believed to be the result of anxiety by association. Sound was a catalyst of fear in this case. Watson's work was often treated with skepticism, but by 1979, the assumptions and methods used were all but discredited. Harris referred to the study's "distortions" and stands as a classic example of "myth making in the history of psychology."[336]

An aim of surveying now-discredited psychological experiments of the late-nineteenth and early-twentieth centuries is not necessarily to undermine the methodologies

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335 John B Watson, and Rosalie Rayner, "Conditioned Emotional Reactions," *Journal of Experimental Psychology* 3, no. 1 (1920), 2.
336 Ben Harris, "Whatever Happened to Little Albert?," *American Psychologist* 34: 2 (1979): 151-60.

of the examiners, but to reflect on the importance of loud sound as a catalyst or wedge into the deep recesses of the human psyche. While to an extent "bogus" investigations, they are still evidence of an enduring sense of a historically specific belief that shocks were capable of profound effects on the mind. Watson appeared to understand that megaphonic experience was capable of affording psychological or physical trauma on patients; a shockingly loud sound was assumed to be about to inflict harm on a young boy's mind. As we will discuss in the next and last section, sonic shocks were also increasingly understood to be capable of obliterating the human body.

Shocks on the Body II: The End of Life by Sound

By the second decade of the twentieth-century, a consensus was emerging around loud sound's effect of the psyche that went far from the confines of the psychological clinic. A wealth of evidence was emerging from the battlefields of Europe and military experiments in North America that revealed the nature and extent of damage on the bodies and minds of solders exposed to new levels of artillery fire. Suspicions regarding the widespread effects of extremely loud sound, which first arose in the Great War, were becoming empirically validated just after the First World War. When a large caliber artillery shell was fired in close proximity of humans, the shock waves generated were understood to trigger mental conditions such as psychoses and anxiety, but also made it more difficult to discern generalized physical injuries. These injuries at first seemed to be phantom ailments— it would be some time before the actual mechanism of physical damage by shock wave was clear to scientists.

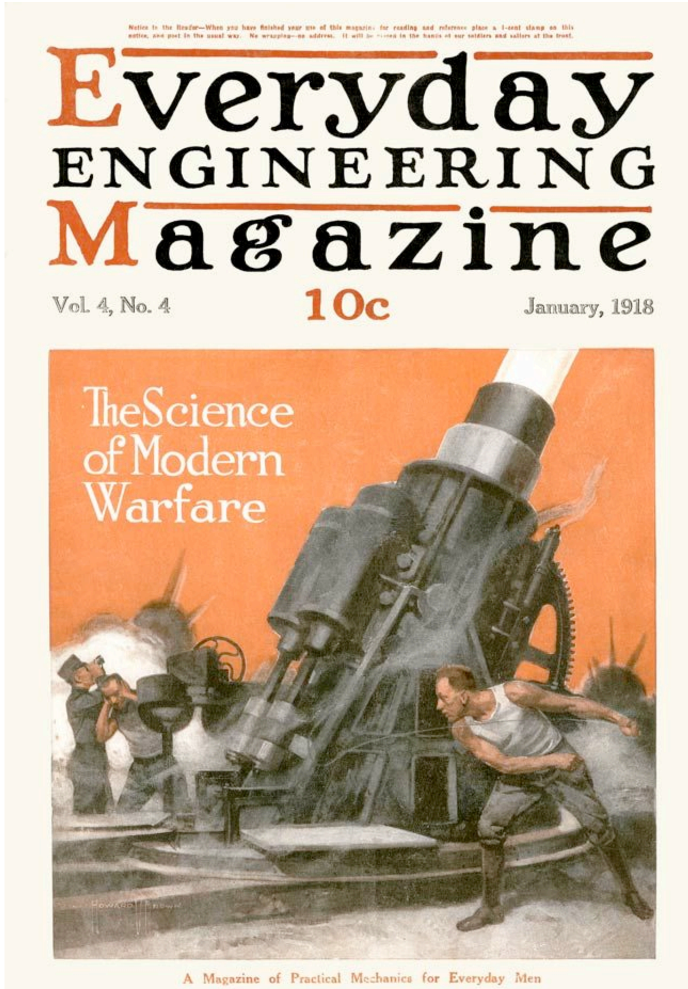

Figure 34. Depiction of Artillery Acoustwics (1918)

It is likely not hyperbole to suggest that the early twentieth-century battlefield was an acoustic terrain of transformation and increased intensification. The acoustics of war were changing. From the distant echoes of cannons and the misery of human grunting, the sound of war was becoming both increasingly mechanical and more intense. As Dan McKenzie, a key ringleader of the noise abatement movement argued about the new sounds of war in 1916:

> There is no noise or combination of noises that even remotely approaches it for loudness, for persistence, and for harmfulness both to hearing and to brain. Many men who have had to endure

> its agonies have been rendered totally deaf; many other have been driven insane, their nervous system being hopelessly and permanently disorganized by its appalling intensity and persistence. [It was described as] 'It was noise gone mad, out of all bounds, uncontrolled.'... While another, but no less expressive, observer has summed it up in the simple phrase: 'Hell with the lid off'—there is no doubt, you see, that to the modern minds, Hell is the place of noise.[337]

McKenzie was optimistic about being able to regulate the sounds in the modern city but was less than optimistic about the possibility of abating the noises of war. For him, the sounds of war were an acoustic manifestation of a universe overwhelmed. Authors like Ernst Jünger describe the battlefield of the First World War as one of clanging mechanical brutality, but also one of unbearable loudness.

The physicality of sound was made particularly obvious through examinations on the ways in which sound waves were conducted by bones. Human bodies were increasingly understood to be able to conduct sound through the skull and associated cranial bones. Hironymus Capivacci, writing in 1589, made one of the first studies of bone conduction in clinical otology. The study involved placing a rod between the teeth of a patient with impaired hearing and the other end in contact with the vibrating string of a musical instrument. If the patient heard the tone, the deafness was diagnosed as a disease of the drum membrane; if the patient didn't hear the tone it was a disease of the labyrinth.[338] Much as a hysteric could arguably be understood as the product of static body overwhelmed with vibratory force, in the 1920s the effect of loud sound on the skull was argued to vibrate in a similar fashion as the eardrum. As Banister wrote in his article "Transmission of Sound Through the Head": "the head may be made to vibrate as though it were a diaphragm...

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[337] Dan McKenzie, *The City of Din, a Tirade Against Noise*, 101-02.
[338] Noble H. Kelly, "Historical Aspects of Bone Conduction," *The Laryngoscope* 47:2 (1937), 102.

when the far tympanum, in contact with the relatively stationary air on that side, would be set in motion."[339]

Intense sound was deployed in the effort to understand the ways sound propagated through the skull. It proved ways in which "hearing" could be utilized in the absence of the normal physiology of audition. If one was technically deaf, there was the possibility of hearing vibration through the teeth or sound's passage through the skull. Numerous efforts were made to understand the ways in which very loud sound could translate into vibratory perception which might serve as hearing by other means.[340]

By no means however was the understanding of the passage of intense vibrations through the skull limited to positive findings. Studies, most of which took place after the First World War, began to question the nature of cellular damage through exposure to intense vibrations. Increasingly, soldiers were found dead with no apparent damage to their bodies, often solely as the result of being in the proximity of an explosion or shock wave. A French study in 1918 examined the mortal risk to soldiers in WWI due to exposure to artillery fire shock waves, noting the brain is not always protected by the skull. Soldiers within close-range of explosions sometimes died without "any apparent injury". And if they did survive, concussion-like effects could last easily up to eight weeks.[341] While French examinations on physical risk from shock phenomena focused on brain trauma, a key groundbreaking American study of the same era would focus on the effect of shock on the lungs.

During nearly the same timeframe as the French were conducting examinations of shock trauma on human brains, the U.S. military base in Sandy Hook, New Jersey was host

339 H. Banister, "The Transmission of Sound Through the Head," *Philosophical Magazine, Series 7* 2:7 (1926), 146.
340 H. Banister, "The Transmission of Sound Through the Head," 151.
341 G. R. Marage, "Contribution a L'Etude Des Commotions De Guerre," *Comptes Rendus* 166 (1918).

to a series of disturbing studies of the physiological effects of “air concussion”. Sandy Hook was the same naval base that hosted megaphonic experiments of massive foghorn sound propagation a few years earlier. The base is a set upon a small, isolated peninsula of land that borders New York Bay on one side and the Atlantic Ocean on the other. It was uniquely placed to afford a multitude of experiments on megaphonic sound with minimal effect to neighboring communities. D. R. Hooker’s study was one of the first to examine untraceable or unknown injury caused by explosive wave propagation. His work was set in motion by the fact that trauma from concussive shock-based experiences often show little to no signs of physical injury. Often soldiers would die while later examinations would show no detectable sign of trauma.

Yet Hooker set upon the Sandy Hook staging grounds with the prescient suspicion that the observed effects to the circulatory system and microscopic injury to vital organs could be replicated in animals. Hooker set cats, dogs and rabbits in the blast path of very large ten and twelve-inch artillery fire. Many of the animals died shortly after exposure to the shock waves. The grim research focused on transformations to blood pressure, disposition, and general observations leading to the point of death or possible recovery of the animals.[342] Experimentation with different animals yielded a few basic points about the effects of blast waves on bodies and organs: because of the rapid dissipation of the intensity of shock waves, the difference between exposure of ten feet from the blast path as opposed to twenty often meant the difference between survival or not. Also all blast victims experienced a rapid drop in blood pressure after exposure. Microscopic lesions were often detected in the lungs of animals, but Hooker assumed it was not the deciding factor between life or death.

[342] D. R. Hooker, “Physiological Effects of Air Concussion,” 229.

The general assumption from the Sandy Hook experiments on air concussion was that the effects of a shock wave are essentially akin to an invisible force of a hammer hit to the head. It was a bludgeoning, concussive force on the bleeding edge of both a sonic event and invisible hammer blow of compressed air. The macabre experiments were not an accidental occurrence or an anomalous set of rogue scientific procedures. They were very much a part of a zeitgeist, one which centered around the seduction and horror of modern wave-based phenomena. The expansion, documentation, and analysis of sonic capabilities during this time culminated in the understanding that explosions, once understood as a merely an audible sonic event, were more than that. In fact, the perceived *sound* of explosions were only one component of a wave force assault that also included infrasonic and ultrasonic dimensions. The damage rendered was no longer an unexplainable act of the mind and body giving up on life, it was the result of microscopic damage that stemmed directly from close-range exposure to intense compressed wave forces.

CONCLUSION

The concussive, violent forces unleashed by the explosions at Sandy Hook were also understood as wave fronts increasingly capable of travelling across obscene distances. Sound waves produced long-distance communicative capabilities, psychological effects, and physiological damage. They were no longer an enigma, but rather an element of an increasingly well-understood, material-based range of physical forces.

The underlying purpose of this dissertation has been to address a concern about the historical context of sound at the turn of the century. If this era truly was one in which societal reality was shaped by the experience of an increasingly and fundamentally louder city and a truly more awe-inspiring sonic technological capability, then does the current body of historical literature around noise abatement and the cultural histories of noise music satisfactorily capture this louder cultural context?

My wager has been that they do not. Many of the works discussed in the literature review of this dissertation illuminate hitherto dark but important corners of cultural histories of sound. Yet they have often failed to capture the narcotic-like hubris of inventors obsessed with sonic power, the instruments they've developed because of those beliefs, or the interests of a public that would attend something like a pipe-organ concert of thunderous tonality. The narratives presented in this study have been aligned by the underlying assumption across disciplines, institutions, and cultural contexts that loud sound has an underlying productivity— that is the ability to forget one's self for a moment, to grasp at a glimmer of a fading transcendental sensibility in an increasingly secular age, or the possibility of sound's invisible ability to inflict physical harm. Loud sound, it was widely agreed, could provide all those things. It could send messages across distances almost as fast as light. It was better than a carrier pigeon.

This thesis owes a debt to a germinal idea placed in the work of American artist Dan Graham in his 1984 video essay *Rock my Religion*. In it he juxtaposes the Shaker sect's practices of transcendental stomping with suggestions of mid-twentieth century's lingering transcendent promises latent in rock music.[343] To recover a feminine punk-rock spirit that singer Patti Smith carries forward from Shaker leader Ann Lee, is to both chart an alternate history of rock away from phallocentric capitalist logic and to explore evidence of enduring transcendental aspects of sound and music. For the Shakers their expression of transcendentalism was through cyclical, hypnotic practices of repetition, stomping, and loudness aided by dome-shaped architecture that enhanced acoustics, funneled sound into the middle of the room and amplified the dissolution of self that they were searching for. Forms of late twentieth-century electrically aided amplification carried on this essential, almost timeless function. Studying megaphonics is to carry forward this juxtaposition and advance the argument of Graham that transcendental aspirations through sound have endured for at least hundreds of years.

What this thesis leaves out, at least in my mind, is the relationship between loud sound and the rise of public address systems and electrical amplification. This was partly due to space and time constraints in developing this dissertation, but this subject area could act as gateway to readings of the megaphone and amplified power politics of Hitler, where a part of the seduction of mass crowds was through the allure of electrically amplified sonics. It should hopefully be obvious that one of the spectres that lurk behind this dissertation is the shadow of the Third Reich and World War Two. Hitler's Nuremburg rallies, particularly

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343 Dan Graham, *Rock My Religion, 1965-1990*. (Cambridge, Mass.: MIT Press, 1993).

the 1938 gathering which was attended by over a million, were sophisticated deployments of amplified sound. Hitler's voice was channeled into a megaphone which attempted to channel ancient Aryan confidence, a gesture of acoustic bombast and electrically amplified guttural rhetoric.[344] Loud sound was a productive aspect of this form of mass coercion.

Some key remnants of the megaphonic endure to this day. One of those remnants is the increased interest in acoustic weaponry. An attack on a luxury liner by Somalian pirates in November 2005 was thwarted, as *Der Spiegel* reports, by the use of loud sound. Despite being fired on by machine guns and rocket launchers under a normally routine and successful takeover of a vessel in off the coast of Somalia, this attack was thwarted by the deployment of what is called a "Long Range Acoustic Device"' (LRAD).[345] Developed initially by the US Defense Department, this device delivers a head-splitting focused beam of high volume sound. Much akin to a laser, this device delivers beams of sound with intensities of up to 150 decibels. It was enough sound to debilitate and thwart the attack. LRADs are a major new development with military, policing and civilian uses. The company has recently boasted of significant advancements in the number of deployed units. The inventor, Woody Norris, a formed executive at Sony, apparently worked on musical loudspeaker technology before the LRAD side of his business took off.

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344 See Carolyn Birdsall, Nazi Soundscapes : Sound, Technology and Urban Space in Germany, 1933-1945. (Amsterdam: Amsterdam University Press, 2012).
345 See http://www.spiegel.de/international/spiegel/the-weapon-of-sound-sonic-canon-gives-pirates-an-earful-a-385048.html. Accessed July 26, 2013.

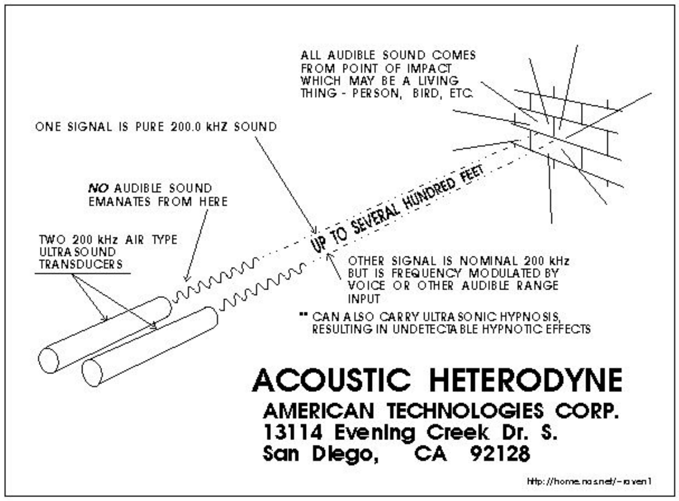

Figure 35. The Sonic Wall—LRAD Device Schematic

When it was reported that San Diego County Sheriff's Department bought a brand new LRAD in 2007 with the help of a government grant, its justification was both obtuse and blindingly clear. One captain justified it as a glorified megaphone: "'The way we always planned to use it was as a public address system,' said Sheriff's Capt. Todd Frank. 'If you have a very large group of people, you can use bull horns or maybe a public address system from a patrol car, but the LRAD is much more targeted and much better at delivering the message.'"[346] Indeed, it delivers a targeted message very well.

The deployment of modern megaphonics against piracy was one method where sound was used by the state for "behavior modification". Another example is the evidence presented by Suzanne Cusick in her study of the use of music as a weapon in the detainment and torture of Iraqi detainees in the early 2000s. This weaponization of music, like the weaponization of sound with the LRAD device, is an act of physical and psychological debilitation. Instead of an arbitrary "loud" sound at the service of rendering a subject

[346] See http://www.utsandiego.com/news/2012/Apr/20/sounds-of-success/2/?#article-copy . Accessed July 26, 2013.

compliant, "loud music" can use both "volume and the moral antagonisms of gender, religion, or sexuality to implode the life-worlds of prisoners", as in the case of Cusick's presentation of the activities of U.S. military forces in Iraq.[347]

There are gentler, less militaristic examples of the megaphonic in musical culture that endure to this day. The oft-cited "loudness wars" in musical production are one, for example. This is the general trend amongst mastering engineers to make a piece of music as loud as possible given the constraints of the digital audio medium. This means namely, the use of "brick wall" limiters that squash the dynamic range and push a piece of music up against another lingering sonic wall in the quest for body and loudness.[348] The result is often a one-dimensional sonic attack that quickly tires most listeners, but is also intoxicating during short spells of listening.

Figure 36. Grateful Dead Sound System (1973)

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347 Suzanne Cusick "'You Are in a Place That is Out of the World.': Music in the Detention Camps of the 'Global War on Terror'." *Journal of the Society for American Music* (Volume 2, Number 1 (2008)): 1-26.
348 Greg Milner, Perfecting Sound Forever: An Aural History of Recorded Music. (New York: Faber and Faber, 2009).

Through the endless waves of noise music, the ascension of overload aesthetics in musical culture, and the prevalence of and massive modern sound systems all demonstrate a continuing interest in loudness.[349] Grateful Dead's impressively large sound system used in 1973-4 concerts (*Figure 36*), with its Lego-like speakers that stack into a greater whole, is in some ways a contemporary template of what could be mimicked, enhanced, and modified in the years to come. Human interest in megaphonic experiences appears at once evergreen—stretching back as far as the ancient War Organ of Themistius and as far forward as modern sky-high stacks of Marshall amplifiers or the common high-volume "bass bins" that perpetually draw people forward, lost in the dark of a nightclub.

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[349] See, for example, Steve Goodman, *Sonic Warfare: Sound, Affect, and the Ecology of Fear*. (Cambridge, Mass.: MIT Press, 2010), 16-19.

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