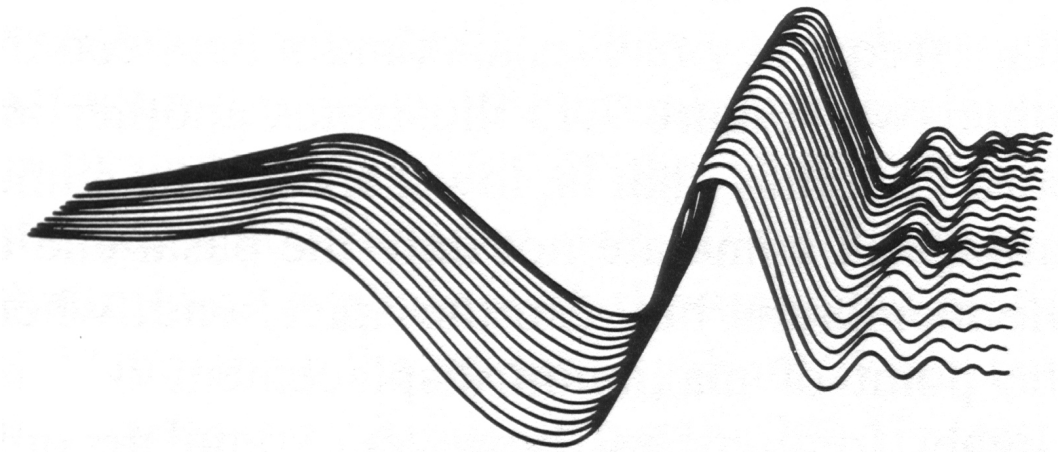
Acoustic Trauma : Bioeffects of Sound



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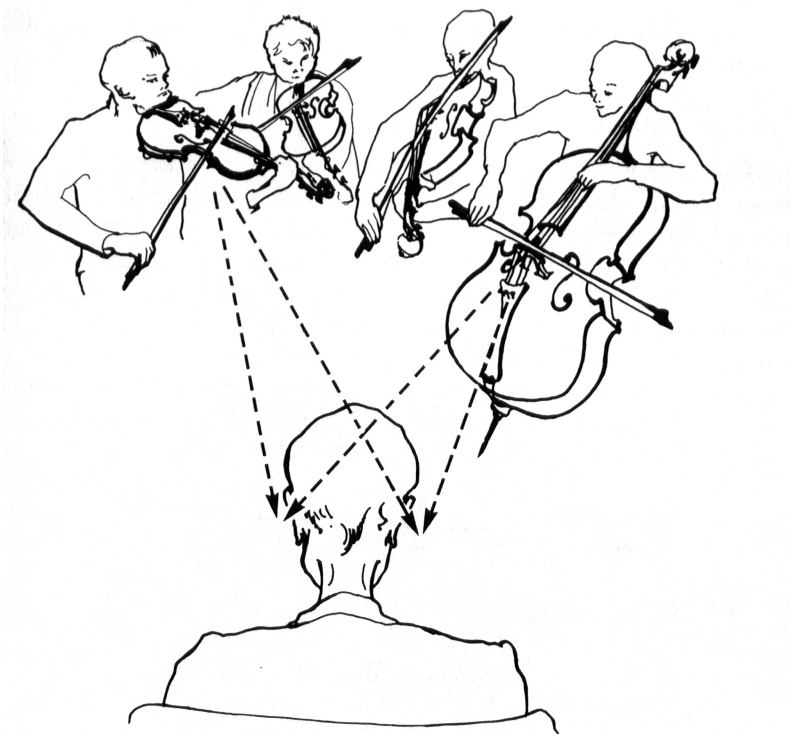
"…any unwanted sound, soft or loud, sweet or nasty, creates a multidimensional envelope that does more than intrude - it takes over not only your acoustic space, but your mind space as well. Acoustic intrusions reduce your freedom of thought. There is no escaping sound. It meets your body and forcibly enters your mind, not just through your ears but also via your bones, your flesh, and your body cavities."[1]

The work is an investigation into the effects of low frequency sound and infrasound via the design and construction of experimental acoustic emitters. Once installed in a particular space the work will have a profound effect on the surrounding sonic environment and the physiology of human subjects present. This is achieved by the resonant interactions between the subject's body and the acoustic space.

It is beyond the limited scope of this paper to explore the physicality of sound and psychoacoustics in its entirety due to the vast nature of the subject area. However, this paper will investigate various key facets of the field relating to the work.

[1]Pellegrino, Ron, *Loud Music And Hearing Loss*, http://www.microweb.com/ronpell/LoudMusicNHearingLoss.html

Human Auditory Perception



Human Auditory Perception

It is important to give some technical insight into the nature of sound in order to gain an understanding of the concerns and issues raised in this paper.

It is generally accepted that sound is perceptible to humans in the range of 20hz to 20khz (1Hz is one complete cycle per second of a sinusoidal wave). Although this is the accepted human auditory range most people, depending on age and gender, cannot hear sound above 14 to 18Khz.[2] Contrary to popular assumption, careful measurements have shown that hearing does not abruptly stop at 20 Hz but the ear is capable of registering infrasound as low as 1Hz if sound pressure is sufficient[3]. Frequencies above 20 kHz are considered ultrasound whilst frequencies beneath 20Hz are considered infrasound.

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[2]Yost, William A., *Fundamentals Of Hearing*, Academic Press, Inc., USA, 1994 p.151
[3] Altmann, Jürgen, *AcousticWeapons – A prospective Assessment*, Universität Dortmund / Institut für Experimentalphysik III April 1999 p.16

The range of audible sound is also differentiated into 3 main categories. Subsonic or low frequency sound is defined in the range of 20Hz to about 500Hz. Midrange frequencies inhabit the realm of 500Hz to 6KHz (6000Hz) with high frequency sound defined in the remaining 6KHz to 20KHz. [4]To give these figures some relevance to tangible notions of sound, the musical tone of Middle C is 261.6 Hz[5].

Although acoustic energy in all areas of both audible and non audible frequencies display intriguing biological effects, the particular regions of sound that the work focuses on is in the subsonic and infrasound region.

There are two other key aspects of low frequency sound and infrasound that are worth noting. The first is that low frequency sound has a relatively long wavelength and low material absorption rate, hence has the ability to travel vast distances. These properties make it possible to achieve a profound effect on vast tracts of acoustic space with the production of high sound pressure level (SPL) acoustic waves.[6] The second issue regarding low frequency sound is that it is very non directional in it's propagation and therefore has the effect of enveloping the individual without any discernable localized source.
The opposite of these properties is characteristic of high frequency sound which can readily be absorbed by materials and is highly directional and as such has been an asset in the design of acoustic weapons[7].

The perceived loudness of a sound is measured in a unit called the decibel (dB). The decibel utilizes a logarithmic scale rather than a linear one, as the human ear perceives loudness in a similar manner[8]. A 3dB increase equates to an actual doubling of the sound level. However, perceptively, a 10dB sound level increase is considered to be about twice as loud.Frequency and perceived loudness are intrinsically linked, with greater intensity sound being required at low frequencies to produce the same amount of perceived loudness.[9]

All objects have a property known as resonant frequency. Resonance involves the "re-enforcement of vibrations of a receiving system due to a similarity to the frequencies of the source".[10] One of the most famous examples of natural resonance is Tacoma Narrows Bridge at Puget Sound Washington. After being exposed to gusts of wind the bridge began to vibrate at its natural resonant frequency and subsequently began to swing wildly and finally shake itself to pieces[11].

In a similar manner sound may be exploited and tuned to particular resonant frequencies inherent in humans. It is this way that sound can be utilized to provide a diverse range of psychophysiological effects.

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[4] Davis, Gary & Jones, Ralph, *Sound Reinforcement Handbook*, HP, USA, 1989. P5.
[5] Torp-Olsen, Eric, *Whistle Physics,* http://www.geocities.com/SoHo/Museum/4915/02.HTM
[6] For example, Low frequency sound in the region of 10Hz-15Hz has the capability of propagating over several hundred kilometers. Swezey, Stuart, *Amok Journal – Sensurround Edition*, Amok, USA, 1995, p.407
[7] The highly directional properties of high frequency sound have successfully been utilized in such devices as 'The SquawkBox' where the effective beam width is so small that it can be directed at specific individuals in a riot. Other individuals present are unaffected "except by panic when they see people fainting, being sick, or running from the scene with their hands over their ears"
Rodwell. R., *Army tests New Riot Weapon*, New Scientist, UK, 20th September 1973
[8] Davis & Jones, *Sound Reinforcement Handbook*, p.19
[9] Tuzin, Donald, *Miraculous Voices- The Auditory Experience Of Numinous Objects,* Current Anthropology 25 (5), USA, 1984 p.6
[10] Pellegrino, Ron, *Sound Deserves its Own Pollution Category,*
http://www.microweb.com/ronpell/NsNSndPltnFndmntPrncpls.html/SndDsrvsOwnPltnCtgry.html
[11] It has been known that large groups of soldiers are capable of producing similar effects when marching over bridges and subsequently fall out of step whilst crossing.
Woodward, David, *The Tarcoma Narrows Bridge Disaster,*
http://www.davidwoodard.com/tacoma.html

Physiological Effects of Sound

Physiological Effects of Sound

Any severe extreme imposed on the sonic environment has a profoundly destabilizing effect on the individual. This becomes evident in both the areas of high intensity acoustic energy and also its complete absence. Anechoic chambers, which create an environment void of sound, have the ability to produce similar feelings of disorientation and disturbance that are evident with high intensity sound. The silence envelops the individual in a suffocating manner causing both psychological trauma and also physiological disturbance in the form of balance and other related body function.

It is clearly apparent that the human organism is in an extremely delicate state of equilibrium with the sonic environment and any profound disturbance of this system will have subsequent ramifications on the individual.

Although various facets of acoustic ecology have been examined there is little publicly available material on the effects of low frequency sound on humans. Thus, speculation and unsupported allegations related to the field have become prevalent. This lack of available research material is predominantly due to the fact that the Department Of Defense and related private research organizations conduct the majority of experimental research in this arena and hence the material is often of a restricted nature. Jürgen Altmann conducted the only extensive survey of the area in 1999 although this was of a purely theoretical nature without any experimental research.[12]

What also becomes apparent after a survey of the literature is that much of the material available is conflicting in nature. This adds further to the general mystery and confusion surrounding the area and promotes the rapid spread of mythologies and misinformation on the subject, highlighting an obvious need for a current comprehensive experimental study to be undertaken.

References to sound as a violent entity date from the biblical trumpets that brought down the walls of Jericho to current trends in acoustic weapons research including the work conducted by organizations such as Scientific Applications And Research Associated Incorporated (SARA)[13]. Various musicians such as The Halfer Trio and Throbbing Gristle have utilized these assaultive sonic properties in live performances with alleged degrees of success.[14] Entire musical compositions have been composed around the manipulative qualities of sound[15].

In a 1973 article in Crawdaddy ,William Burroughs[16] discusses such notions with Jimmy Page of Led Zeppelin fame. He asked Page about the potential of using infrasound to enhance the musical experience and produce euphoric effects. However, the article tends to deliver broad and hazy allegations regarding low frequency sound such as 'he (Vladimir Gavreau) had an infrasound installation that he could turn on and kill everything within five miles. It can also knock down walls and break windows. But it kills by setting up vibrations within the body'. Such statements are typical of the alleged effects of low frequency and infrasound on the body[17]. Where Burroughs obtained such a figure from is unknown as no reference was made to such a device or physiological effect in Gavreau's own writings[18]. Statements like the one above continue to propagate rumors, and in a similar manner to 'Chinese whispers' these are slowly distorted over time.

The pinnacle of sensational notions related to low frequency and particularly infrasound came after the publication of Gavreau's findings in Science Journal in 1968. At this time a variety of unsubstantiated and sensational reports appeared in the media, such as the Miami Herald's article relating to Gavreau's work entitled 'Sound Ray Developed as A Killer – French Working On A War Machine' ,and the London Observer's report on the 7th January 1968 "Sound As a Weapon Of War". Perhaps the most sensational and absurd effects attributed to infrasound was reported in the Melbourne Sunday Press (7th September 1973). Entitled "The Low Pitched Killer", the article is concerned with the lethal effects of infrasound generated by open car

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[12] Altmann, *Acoustic Weapons - A Prospective Assessment*
[13] Scientific Applications And Research Associated Incorporated (SARA), *Technologies*, http://www.sara.com/Capability/Tech.html
[14] Neal, Charles, *Tape Delay*, SAF Publishing LTD, UK, 1987 p.56
[15] T.A.G.C., Meontological Research Recordings Teste Tones, Soleilmoon Recordings
[16] Burroughs himself had a pronounced interest in the area of psychological influence that was demonstrated by his involvement in the development of the legendary "Dreammachine" with Brion Gyson. Swezey, *Amok Journal – Sensurround Edition* p.372
[17] Ibid., p. 375
[18] Gavreau did however state that 'presumably if the test had lasted longer than 5 minutes internal hemorrhage would have occurred' in regards to exposure to 196Hz at 160dB.
Gavreau, Vladimir, *Infrasound*, Science Journal 4 (1), USA, 1968 pp. 33-37

windows[19]. This document, as well as "Does Infrasound Make Drivers Drunk" published in New Scientist 1972, claimed that infrasound generated by automotive travel is responsible for a variety of dubious physiological effects including 'motorway madness'.[20]

Typically sensational, the article states:

"But much more sinister are the unnoticed effects of infrasound at lower levels: in an ordinary car travelling at speed the infrasound noise is more than enough to mimic the effect of drunkenness in the driver. With the sense of euphoria that infrasound also induces, it may therefore be responsible for many inexplicable crashes."[21]

It is no wonder that with absurd statements published in respected journals such as New Scientist, these ideas are evident within the population.[22]Though these effects could perhaps be attributed to vibratory effects generated by automobiles, due to the large impedance mismatch, low frequency sound at such levels would have an insignificant impact at such levels.[23]

Although there is no doubt that the sonic environment has considerable impact on the individual, it is quite evident with comprehensive theoretical analysis that the majority of claims in the area are sensational.[24]

Audible Sound
Audio in the region of 20Hz-20Khz can create psychological disturbance in individuals at levels substantially below those required for bodily discomfort or trauma.[25]
From the thunderous hypnotic drumming of Zulu warriors to riot police beating their batons on shields whilst marching towards confrontation, the psychological effects of sound have been used extensively throughout history as a warfare device. Noise has always been experienced as 'destruction, disorder, dirt, pollution, and aggression'.[26]
All cultures associate noise with the idea of the weapon, blasphemy and plague. "Behold, I will bring evil upon this place, the which whosoever heareth, his ears shall tingle" (Jeremiah 19.3)". "When the drums of the resurrection sounded, they filled the ears with fear" (Al-Din Runir, Diavani, Shansi Tabriz).[27]

Recently, psycho-acoustic warfare was allegedly used in the Waco siege at the Davidian compound in Texas, where it is said that the FBI used sounds of babies crying, dentist drills and a variety of other unpleasant sounds to mentally influence their opponents. The Waco compound was allegedly bombarded for long durations by these sounds via large public address systems.

Although this type of sonic assault can have a profound emotive effect on individuals, it relies heavily on the individuals particular experiences. This is where the actual physiological effects of sound are unique. Physiological changes in the body only

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[19] Reproduced in Broner, N, *The Effects Of Low Frequency Noise On People – A Review,* Journal Of Sound And Vibration 58 (4), England, 1993.pp 483-500
[20] Ibid., pp.483-500
[21] Bryan, Michael and Tempest, William, *Does Infrasound make Drivers "Drunk"?*, New Scientist 16th March 1972.pp 584-86
[22] The Internet also contains a predominance of sensationalist literature on the subject with few objective examinations. See http://www.borderlands.com/archives/arch/gavreaus.htm for a typical example. Being such an easily accessible resource, misinformation can be readily disseminated
[23] Altmann, *Acoustic Weapons - A Prospective Assessment,* p.22
[24] For Comprehensive calculations regarding this see Altmann, *Acoustic Weapons - A Prospective Assessment* and Broner, *The Effects of Low frequency Noise on People- A Review.*
[25] Altmann, *Acoustic Weapons - A Prospective Assessment,* p.52
[26] Attali, Jaques, Noise – The Political Economy Of Music, Manchester University Press, UK, 1977.pp.26-7
[27] Jacques Noise p.27

start to occur at greater sound pressure levels. At about 120 dB discomfort begins in the ear and pain occurs when levels reach approximately 140dB.The eardrum subsequently ruptures at levels of about 160 dB. Pain becomes evident when the middle ear system is mechanically displaced beyond its normal operational limits [28]

These acoustic effects are only apparent on the ear mechanism. The ear is a very easy structure to attack. Due to evolutionary processes the ear is particularly sensitive to midrange frequencies inherent in the human voice[29]. Subsequently, all that is needed is an increased sound intensity at these frequencies for the threshold of pain to be readily reached. This is also related to the properties of the acoustic reflex in which a small muscle in the middle ear pulls the stirrup back from the oval window and subsequently reduces the amount of acoustic energy transmitted to the middle ear. [30] This however only has a significant impact at frequencies lower than about 1000 Hz so that frequencies between 500 to 4000 Hz, the range at which the auditory center is most sensitive, are largely unaffected.[31]

The acoustic effects on the body are more complex. Research has concluded that with low frequency sound in the region of 50 – 100Hz at levels of 150dB or more, intolerable sensations in the chest and thoracic region can be produced—even with the ears protected. [32]

Other physiological changes that occur include chest wall vibration and some respiratory-rhythm changes in human subjects, together with sensations of hypopharyngeal fullness (gagging). The frequency range between 50-100Hz also produces mild nausea and giddiness at levels of 150-155 dB, at which point subjective tolerance is reached. At 150 to 155 dB (0.63 to 1.1 kPa); respiration-related effects include subcostal discomfort, coughing, severe substernal pressure, choking respiration, and hypopharyngeal discomfort.[33]

Vladimir Gavreau, who worked extensively with high SPL low frequency sound at the Centre National De La Recherché Scientific states, after being subjected for five minutes to an acoustic emitter producing 196Hz at levels of 160 dB, "we became aware of a painful resonance within our bodies-everything inside us seemed to vibrate when we spoke or moved." These feelings subsequently disappeared after a period of three hours.[34]

At medium to high audio frequencies the pronounced visceral effects that are evident with low frequency vibration are absent. However, disturbance of the equilibrium can be achieved at levels above 140 dB for unprotected ears. At even higher levels,

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[28] Broner, N. *The Effects of Low frequency Noise on People- A Review*, *Journal of Sound Vibration* 58 (4) (1993), pp483-500.
[29] Tuzin, Donald, *Miraculous Voices- The Auditory Experience Of Numinous Objects*, p.6-7
[30] The acoustic reflex takes approximately one tenth of a second to take full effect after the onset of a high intensity sound. Therefore it would provide little protection from impulse noise devices which can attain such levels in a substantially shorter time. Campbell, Murray, *The Musicians Guide To Acoustics*, Dent, England, 1987 pp. 44-8
[31] Tuzin, *Miraculous Voices- The Auditory Experience Of Numinous Objects*, pp. 6-7
Long term physical damage in the form of permanent threshold shift (PTS) is more likely to occur at rock concerts where the acoustic reflex affords little protection to the relatively broad frequency distribution of the sound. This is contrary to the electronic music present at 'Rave Parties' and clubs in which the majority of the acoustic energy lies predominantly in the low frequency range. Campbell, *The Musicians Guide To Acoustics*, p.23
[32] Altmann, *Acoustic Weapons - A Prospective Assessment,* pp. 18-21
[33] Ibid., p.20
[34] Gavreau, *Infrasound*, pp. 33-37

tickling sensations and heating may occur in air-filled cavities such as those of the nose and mouth and gaps between the fingers. A 7kHz acoustic beam at a level of 165 dB produced the sensation of strong heating between the fingers of the subject that were being held close together. This was due to the high degree of friction that was created although the effect vanished when the fingers were subsequently opened apart.[35]

High audio frequencies (above 10 kHz) and ultrasound (above 20kHz) have no pronounced effect on the individual unless the level is in the range of 140dB with more prominent effects of heating of air cavities, hair and textiles becoming apparent at levels of 160dB.[36] Various assaultive acoustic devices have been designed to operate within this audio region. Most of these devices utilize a sonic property called heterodyning in which 2 differing frequencies combine to form the sum and difference of the initial frequencies.[37]For example, the frequencies of 16000 Hz and 16002 Hz can be combined in the ear to form 32000Hz and 2Hz[38]. Devices operating in the ultrasonic region in this manner also have the added advantage of operating in a very directional and focussed manner at an imperceptible frequency region.

Infrasound
The threshold for infrasound is around 140dB at 20Hz increasing to about 162dB at 2 Hz and to 175-180dB for static pressure.[39]Due to the ethical issues regarding testing human subjects, experiments on dogs were conducted at levels of 170dB at a frequency of 0.5 Hz. Curiously the dogs stopped breathing because of lung ventilation due to the high intensity pressure changes, although the 0.5 Hz frequency of the sound acted as an artificial respirator and the dogs showed no ill effects afterwards.[40]Many of the most profound effects of sound are attributed to infrasound in the region of 7Hz. This corresponds with the median alpha-rhythm frequencies of the brain.[41]It is also commonly alleged that this is the resonant frequency of the body's organs and hence organ rupture and death can occur at high intensity exposures.[42]

Impulse noise
Shock waves from explosive blasts produce varying and perhaps the most dramatic effects in the realm of acoustic devices. At moderately high levels in the region of 140 dB temporary hearing loss occurs, which can become permanent at higher values. At acoustic levels above 185 dB the tympanic membrane begins to rupture.
At acoustic levels of about 200 dB, lungs begin to rupture, and above about 210 dB some deaths will occur.[43]

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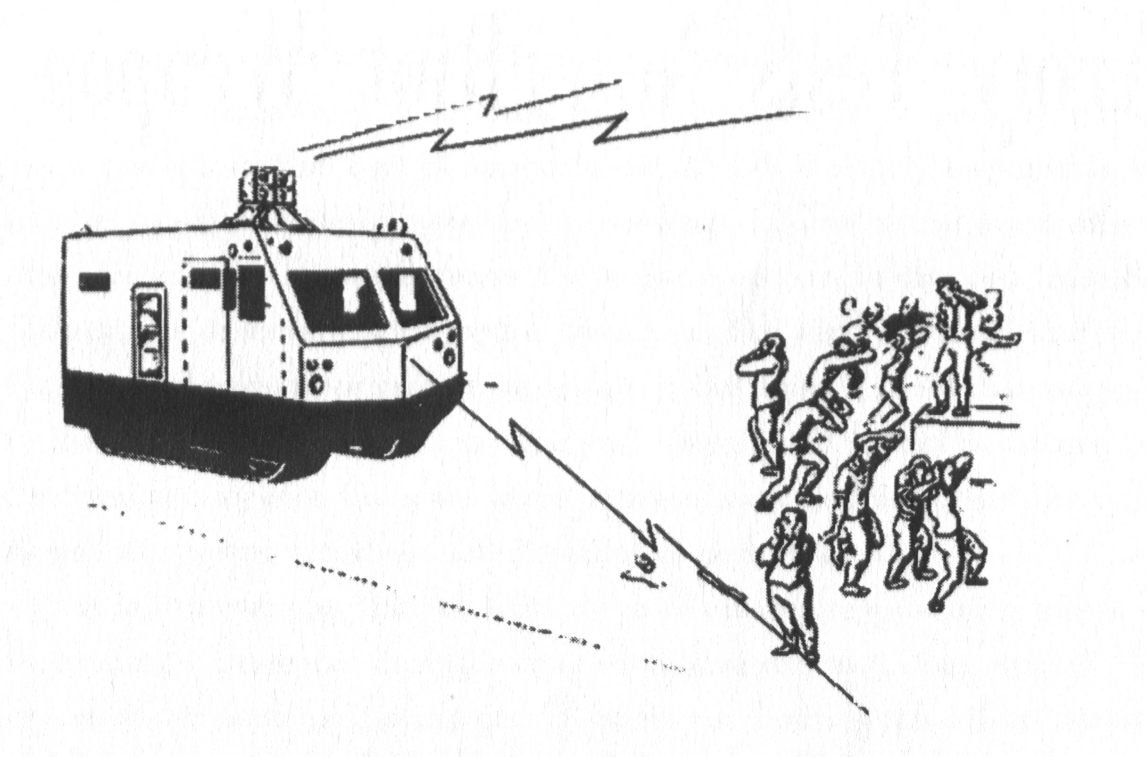
[35] Altmann, *Acoustic Weapons - A Prospective Assessment*, p.56
[36] Ibid., pp.27
[37] Pellegrino, Ron, *Loud Music And Hearing Loss*, http://www.microweb.com/ronpell/LoudMusicNHearingLoss.html
[38] These two frequencies were utilized in the Squawk Box utilized by the British Army against protesters in Northern Ireland. See Note 8, Rodwell. R., *Army tests New Riot Weapon*, New Scientist, UK, 20th September 1973
[39] Broner, *The Effects of Low frequency Noise on People - A Review*, pp.483-500
[40] The Lancet December 15, 1973, Republished In Swezey, *Amok Journal – Sensurround Edition,* p.391
[41] Swezey, *Amok Journal – Sensurround Edition*, pp. 408-9
[42] Ibid., p.408
[43] Altmann, *Acoustic Weapons*, p.58

Sonic Violence



Sonic Violence

"Noise is violence: it disturbs. To make noise is to interrupt a transmission, to disconnect, to kill."[44]

An acoustic attack works on several levels. The first is physiological changes that take place within the body. These vary and are directly relational to the frequency of the sound and the intensity. Next is the isolation of the individual from the environment. Not only would high intensity sound effectively mask all other sound thereby rendering the user deaf to the immediate environment, but it would also make him/her powerless in the realm of vocal communication. With the loss of effective speech comes feelings of helplessness and confusion. Humans are able to selectively filter various aspects of their immediate sonic environment to extract particular fragments from the soundscape. Such auditory filtering systems inherent in human sound perception would be rendered useless as the individual is enveloped by high intensity sound.

Low frequency sound and particularly infrasound have intrinsically mysterious effects as they generally bypass the ear mechanism and are predominantly felt and not heard. This coupling of sound directly to the body may be responsible for feelings of anxiety due to a lack of cognitive resolution within the individual.

Psychotropic Warfare
It is the human condition to try and find answers for inexplicable events or phenomena. Sonic weapons are often embraced in this capacity, as they are not only often imperceptible to the ear in their operation but also are capable of extensive physical and behavioural control. As a result sonic violence has also become a prevalent theme in the area of conspiracy theorists and 'mind control' victims.[45] This has lead to the loss of credibility in an area that has an extremely significant impact on the human organism.

The aims of such systems are to influence and manipulate neural activity or to confuse or destroy the signals that normally keep the body in equilibrium. One such group of devices are silent communication systems in which non-aural carriers in the infrasound or ultrasound range are propagated acoustically or vibrationally for inducement into the brain.
They may be used to "artificially implant negative emotional states - feelings of fear, anxiety, despair and hopelessness."[46]Such a device is outlined in the 1992 US Patent #5,159,703.

The American Defense news in 1993 describes "acoustic psycho-correction" experiments carried out by the Russians from the mid 1970's which "could be used to suppress riots, control dissidents, demoralize or disable opposing forces". The device which operated by the "transmission of specific commands via static or white noise" showed "encouraging results after exposure of less than one minute" and operated without the upsetting of other intellectual functions.[47]Operating as an infrasound

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[44] Attali, *Noise – The Political Economy Of Music*, pp.26-7
[45] See http://members.aol.com/_ht_a/ultra21753/ for a typical survey of the area.
[46] Wall, Judy, *Military Use Of Mind Control Weapons*, USA, Nexus October / November 1998
[47] According to Tactical Technology magazine the Russians discussed a demonstration of this technology where a group of workers were outside a hospital working on the grounds. The staff sent a psycho-correction message via their machine to the workers telling them to put down their tools, knock on the door of the hospital and ask if there was anything else they could do. The workers did just that.

device the acoustic psycho-correction message is transmitted via bone conduction. Due to this insidious facet, earplugs prove fruitless in protecting the individual, as whole body protection is needed. Further developments of such devices utilizing sonic communication directly to the temporal lobe may produce the most striking and profound acoustic attack. Literature by Silent Sounds, Inc. indicates that it is now possible to analyze human emotional EEG patterns and replicate them, then store these "emotion signal clusters" and, at will, "silently induce and change the emotional state in a human being".[48]

Again, in much the same manner as the alleged effects of infrasound and low frequency sound, misinformation and sensationalism shroud data in this arena. Perhaps even more so in the case of psychological assaults, as notions of control over the will of other individuals has been sought since the dawn of humanity. One cannot help but think in the following statement that profound psychological disturbances are present when common individuals appear to be victims of extensive mind control harassment. It is apparent that the sensationalist public opinion regarding acoustic weapons and control devices is being readily drawn upon by individuals to justify and explain maladies and aberrations of the body and mind.

"Don't EVER let a psychiatrist tell you voices in your head must indicate mental illness any more! Voice to skull radio transmission is now a de-classified documented reality".[49]

Psychotropic acoustic violence may not only work on direct speech /sound to skull transmissions but also on the manipulation of various brain functions. This psychophysical principle is called entrainment and acts on both subtle and pronounced ways. Entrainment is the foundation of music for dances, marches and work songs. Society often looks upon sound and the acoustic environment as a form of wallpaper yet rarely considers the myriad of psychophysiological influences always present.[50] Trance inducing properties are evident at 60 beats per minute with a frequency of 72 Hz, corresponding to the frequency of human heartbeats. Frequencies corresponding to the Alpha, Beta and Theta brain rhythms have been utilized in similar manners to influence neural activity. This is perhaps why the fabled infrasound frequency of 7 Hz is so notorious as it is the median frequency of the brain's theta rhythms. This frequency is most prominently associated with moods concerned with fear and anger. Incidentally psychopaths have a general dominance of theta rhythms.[51] It is also allegedly the average resonant frequency of the body's organs and hence excitation would cause organ rupture and death.[52]

Keith, Jim, *Mind Control World Control – The Encyclopedia Of Mind Control*, Adventures Unlimited Press, USA, 1997 pp. 218-19

[48] Wall, *Military Use Of Mind Control Weapons*

[49] http://www.raven1.net/tactics.htm - A "list of recommended tactics which can be used when dealing with skeptics or psychiatrists and other mental health officials"

[50] Pellegrino, Ron, *Sound Deserves its Own Pollution Category,* http://www.microweb.com/ronpell/NsNSndPltnFndmntPrncpls.html/SndDsrvsOwnPltnCtgry.html

[51] Sikorsky, *Smurfing On Sine Waves*, NoiseGate #3 http://www.rfbaker.demon.co.uk/noisegate/articles/ngsmurf.html

[52] Report To United Nations CCD/575, *Working Paper On Infrasound Weapons*, August 14 1978, Republished in Swezey, *Amok Journal – Sensurround Edition* p.408

Acoustic Ecology

Acoustic Ecology

"Noise becomes a parasite which threatens to dominate the environment in the same way as weeds choke a vacant block"[53]

Natural Sources of Low Frequency Sound:
Ever since the dawn of life on earth organisms have been exposed to low frequency sound and vibration. Though ever present, the effects of such environmental sound would not begin to have a profound impact on the acoustic ecology and inhabitants until the advent of the industrial revolution. It was only then that sounds of extremely high intensity became prevalent. Prior to this these sounds were the consequence of remarkably rare environmental events.

There are several predominant sources of naturally occurring low frequency and infrasound in the environment. The entire globe is in a continual dynamic state of enveloping low frequency sound. Sources of such low frequency sound range from atmospheric winds in the range of 30 to 40 Hz to those produced by the ocean and other turbulent bodies of water. Ocean waves produce sound with a mean frequency of 16Hz. These frequencies can become more pronounced if unique geographical conditions are present and the frequency produced by the water is the same as the resonant frequency of the environment such as in bays. The thunderous crashing torrents of water in waterfalls are strong emitters of infrasound as is the gigantic shearing and fracturing of icebergs. It has been said that such low frequency tones have a continuing effect on those inhabiting such environments.[54] Deep seismic shocks produced by earthquakes send strong infrasonic impulses to the surface of the earth[55]. Animals are notoriously sensitive to such vibrations displaying erratic and anxious behavior well before any human perceives the impending chaos.

The explosive force of Krakatoa in August 26 –27 1883 produce massive intensities of low frequency sound and is in fact considered to be the loudest noise on earth in living memory. The apocalyptic blast was heard over nearly one – thirteenth of the entire surface of the globe at a distance of nearly 4500-Km.[56]

Though these sounds are ever-present in the acoustic space that individuals inhabit on a day to day basis, their influence on the individuals psychological and most certainly physiological state are subdued when compared to the influence of machines.
The advent of the industrial revolution has promoted a flourish of diverse interest in acoustic ecology and the subsequent effects on society and the individual. This period has proved to be a truly unique era in acoustic ecology as sounds generated by

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[53] Madsen, Virginia, *Notes Towards Sound Ecology In The Garden Of Listening*, Essays In Sound 2, Technophobia, Australia, September 95, pp.12-13
[54] Cody, John, *Infrasound*, http://www.borderlands.com/archives/arch/infra.htm
[55] An attempt was made to simulate the visceral sonic effects of earthquakes in 1970's disaster movie earthquake. Under the name Sensurround Universal Studios teamed up with speaker manufacturer Cerwin-Vega and after analyzing tape recordings of the 1971 Sylmar earthquake to ascertain frequency distribution developed a theater system that could produce bass frequencies down to 16 Hz at a level of 110 decibels. Although it was claimed that this was structurally safe as buildings have a resonant frequency of 6 Hz during the initial test at Grauman's Chinese Theatre in Hollywood a net had to be erected to catch the ornate ceiling moldings that fell from the roof. Swezey, *Amok Journal – Sensurround Edition* pp. 373-4
[56] Schaefer, Murray, *Soundscape*, Cultures 1 (1), UNESCO, 1973. pp. 8-9

machines powered by inhuman sources has meant that sounds readily exceed conventional human limits. Machines also have the unique properties to produce sounds that force human systems to resonate in inhuman ways. [57]

Individuals exploring this area range from John Cage to Russulo and the Futurist Artists. Cage, generally renown for his interest in miniature sound also examined the nature of loud sounds. When asked in a 1977 interview for radio France whether there were any 'poisonous' sounds Cage responded "I haven't heard any. And I have been searching. I even made the experience to hear a very loud sound".[58] Cage refers to an incident whilst attending a concert of the Spanish group Zai. He "sat in front of the speaker for an hour turning first one ear and then the other towards it". When it stopped he states, "my ears were ringing. The ringing continued through the night, through the next day and through the next night".[59]

Although society and the individual have embraced the machine and the industrial revolution and although utilized, it is indeed rare that a fondness for such sounds is present. Machine noise is responsible for the greatest intensity of sonic pollution present in society. Contrary to the aversions of society in general the Futurist musicians such as Russulo and Marinetti joyously embraced the noises of war. Building devices called Inonarumori to simulate these horrific sounds, musical works were constructed with these psychologically unpleasant noises.[60]
Prior to this, in a musical context, loud sounds were traditionally "generated by the lungs and limbs of performers grouped together in massive numbers."[61]Now however machines could be utilized as instruments. One such mechanical performance is highlighted in a disastrous rendition of George Antheil's Ballet Mechanique in 1927.

"When the conductor Eugene Goosens gave the cue, the siren player cranked and then cranked feverishly, but absolutely no sound was produced. The moment for the siren was now long past, and Goosens was turning to the last page of the score. Disgustedly the effect's man stopped turning the crank, as the last bars of the ballet crashed out. And then in the silence that followed there came the unmistakable sounds of a fire siren gathering speed. Louder and louder it came as the last noted of the ballet died away, and as Goosens turned to bow to the audience and Antheil rose from the piano, it reached it's full force. We had all of us completely forgotten the simple fact that a siren does not start making any sound until it has been energetically cranked for almost a full minute. And also we had forgotten that it does not stop shrieking simply because you stop cranking. We remembered both of these things now as the wail from the infernal red thing on the stage kept dinning in our ears, drowning out the applause of the audience, covering the sound of the people picking up their coats and hats and leaving the auditorium."[62]

The performance highlights the all-encompassing and pervasive nature of industrial sound. Matt Heckert's Mechanical Sound Orchestra provides a contemporary presence of mechanical sound art and acoustic emitters. Although Heckert's work draws upon the futurist machine music it also explores notions of the body as an instrument. One group of orchestral devices known as the 'resonators' create sonic environments that interact with the audiences body. Consisting of Cannon like pipes they are pulsed via a mechanically actuated diaphragm. The work is 'music for the body, not just for the ear or the mind'.[63] Exhibited at Biomachines, the work encouraged the audience to sit in succulent chairs and be enveloped by the variety of modulated frequencies produced.[64]

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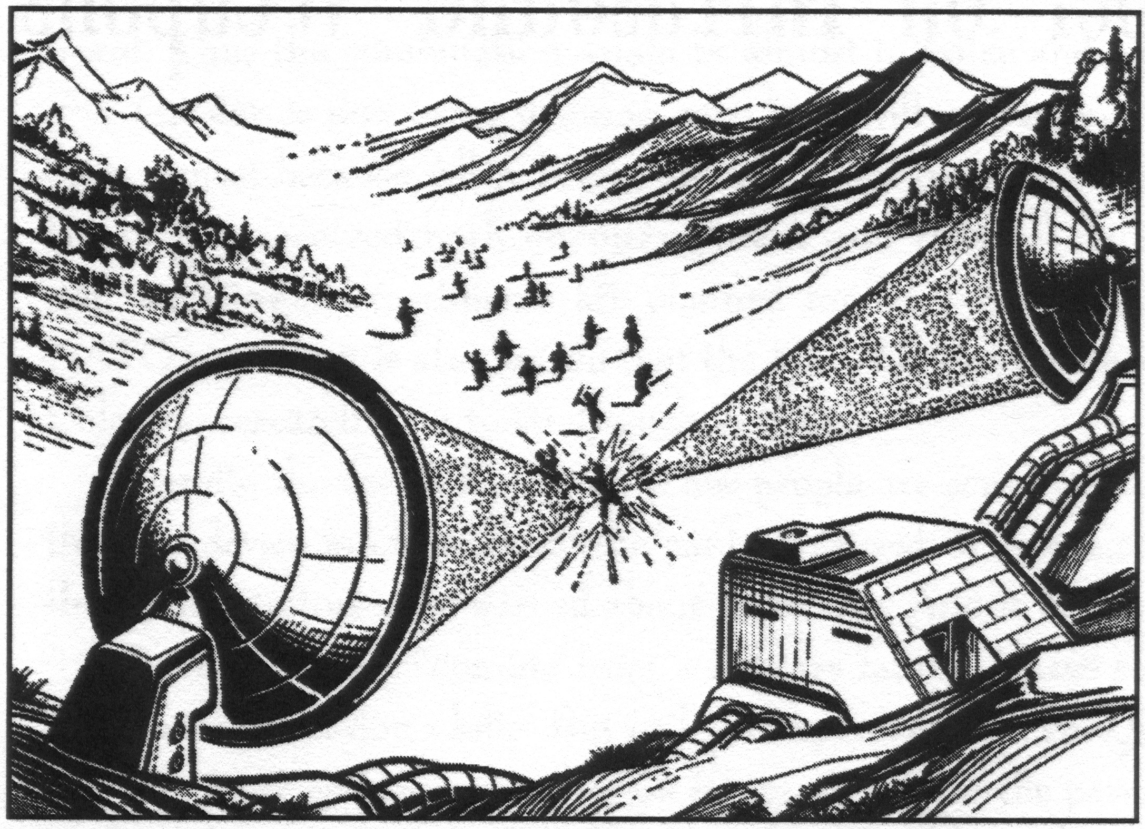
[57] Pellegrino, *Sound Deserves its Own Pollution Category*.
[58] Christophe, Charles, *Poisonous Sounds*, http://www.microweb.com/ronpell/NsNSndPltnFndmntPrncpls.html/PoisonousSound.html
[59] Kahn, Douglas, *Noise Water Meat – A History Of Sound In The Arts*, MIT Press, USA, 1999 p.234
[60] Scarbourough, Kim, *The Art Of Noises*, http://www.unknown.nu/futurism/noises.html
[61] Kahn, *Noise Water Meat – A History Of Sound In The Arts*, p.232
[62] Ibid., p.124
[63] Baker, Keneth, *Body Sound: Other Music At Artspace*, San Francisco Chronicle, 3/3/1990, Republished At http://www.MattHeckert.com/Press/SF_Chronicle.html
[64] Telstra Adelaide Festival 1999, Biomachines Event.

Similar concerns also extend to the work of Eric Hobjin with the Dante Organ. The Organ is an "installation consisting of 10 to 15 flame-throwers with pillars of fire 13 to 20 meters high, creating an environment dealing with the aesthetics of violence". The thunderous sounds produced by the pipes assault the viewer, forcing them to "abandon the pure artistic aspects of the piece to deal with the real and present danger." [65]

The use of high intensity sound in such works creates unique sonic spaces in which, as Douglas Kahn states "any performance space could be turned into a resonant chamber, much like the body of a very large instrument in which humans are played".[66]

[65] Hobijn, Eric, *The Dante Organ And The Aesthetics Of Violence*, http://flux.thing.de/parasites/Dante/
[66] Kahn, *Noise Water Meat – A History Of Sound In The Arts*, p.233

Acoustic Weapons



Acoustic Weapons

Infrasound has been used in the context of war since WW1, although at this stage it was related to sensitive devices used to measure infrasonic emissions and hence identify the location of artillery.[67] Though there are references to assultive acoustic devices being created as early as WW2 it was not until the 1960's that research in the area became more vibrant. Early references to such devices come only as fragments or hearsay. One such device is explained as follows

"... consisted of a parabolic reflector, 3.2 meters in diameter, having a short tube which was the combustion chamber or sound generator, extending to the rear from the vertex of the parabola. The

[67] Swezey, Stuart, *Amok Journal – Sensurround Edition*, Amok, USA, 1995 p.371

chamber was fed at the rear by two coaxial nozzles, the outer nozzle emitting methane, and the central nozzle oxygen. The length of the chamber was one-quarter the wavelength of the sound in air. Upon initiation, the first shock wave was reflected back from the open-end of the chamber and initiated the second explosion. The frequency was from 800 to 1500 impulses per second. The main lobe of the sound intensity pattern had a 65-degree angle of opening, and at 60 meters' distance on the axis a pressure of 1000 microbars had been measured. No physiological experiments were conducted, but it was estimated that at such a pressure it would take from 30 to 40 seconds to kill a man. At greater ranges, perhaps up to 300 meters, the effect, although not lethal, would be very painful and would probably disable a man for an appreciable length of time. Vision would be affected, and low-level exposures would cause point sources of light to appear as lines."[68]

Whether such a device was truly effective can never really be known however there are currently several organizations conducting research in area of acoustic weapons. Due to this continuing research in the area one can speculate that there has never been a truly successful device. Interestingly this is also reflected in recent statements by research groups such as Scientific Applications and Research Associates (SARA) who have apparently taken previous allegations on face value when quoting the alleged effects of some of the impulse noise acoustic devices under construction.[69] Despite such extensive inconsistencies in regards to the alleged effects of acoustic energy current research still flourishes in the area. A similar, albeit more compact device to the one described above, was outlined by Primex Physics International Company in 1998. Still relying on impulse noise technology, it achieved levels of 165dB at a distance of 50 feet and "appears to have very desirable risetime and pulsewidth characteristics that are essential for optimal acoustic-psychological coupling to targets.[70]

The applications of this current research is predominantly based in the development of non-lethal acoustic devices for use in such circumstances as "embassies under siege, for crowd control, for barriers at perimeters or borders, for area denial or area attack, to incapacitate soldiers or workers."[71] Regarding to the non – lethal properties of such devices, the purported effects with respect to humans seem extremely inappropriate for temporary incapacitation with no long term side effects.

The most recent alleged effects from SARA's current research are stated as:

"Infrasound at 110-130 dB would cause intestinal pain and severe nausea. Extreme levels of annoyance or distraction would result from minutes of exposure to levels 90 to 120 dB at low frequencies (5 to 200Hz), strong physical trauma and damage to tissues at 140-150 dB, and instantaneous blastwave type trauma at above 170. At low frequencies resonance's in the body would cause hemorrhage and spasms; in the mid-audio range (0.5-2.5 kHz) resonance's in the air cavities of the body would cause nerve irritation, tissue trauma and heating; high audio and ultrasound frequencies (5 to 30 kHz) would cause heating up to lethal body temperatures, tissue burns, and dehydration; and at high frequencies or with short pulses, bubbles would form from cavitation and micro-lesions in tissue would evolve."[72]

If would be interesting if such allegations prove to be plausible when backed up by experimental data in the future however at this juncture it does not seem to be the case.

There are several possible paths that can be taken regarding the design of a high acoustic output device suited to sonic violence. Conventional loudspeakers are not particularly suitable for the task for several reasons. The primary reason is efficiency.

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[68] Simon, Leslie E., *Secret Weapons of the Third Reich*, WE Inc, USA, 1971. Republished at http://www.urbanlegends.com/death/sound_as_a_weapon.html
[69] Altmann, *Acoustic Weapons*, p.8

[70] Primex Physics International Company, *Non Lethal Defense III - Acoustic Blaster*, http://www.dtic.mil/stinet/ndia/NLD3/sze.pdf
[71] Altmann, *Acoustic Weapons*, p.7
[72] Ibid., p.7

Only about 1% -2% of energy is efficiently used in a conventional voice coil loudspeaker. Efficiencies of between 10%-50% can be achieved with the use of rear loaded exponential horn speakers.[73]Subsequently to obtain the high sound pressure levels needed for an effective unit an impractical array of speakers and amplifiers would be needed to compensate for this. The second flaw with the use of conventional speakers as a suitable emitter is the limited frequency response in the low frequency sound region. An alternate to voice coil technology is that of pneumatic emitters. These include whistles and horns. A whistle acts as a resonant cavity with a mouth similar to that found in a pipe organ. These devices are able to achieve efficiencies of up to 70% and are capable of generating frequencies well into the infrasound region.[74]

Impulse noise devices offer the capability of extremely high SPL via an acoustic shock pulse. These may be generated via any explosive mixture in the form of a fuel/air mix or explosive compound. Due to the nature of combustion however, byproducts of the ignited fuel/air mix would pollute the immediate surroundings hence necessitating an outdoor environment and loss of flexibility of the device. The pneumatic acoustic emitter is not as self sufficient as that of the combustion based counterpart as generally 3 phase power is required to provide enough energy to operate the device. The combustion-based device however may run as long as fuel is present and hence would be more appropriate for remote locations without the use of generators. A greater degree of control over specific frequency ranges is apparent in the whistle design. This enables the generation and subsequent observation of the effects of very precise frequencies in the subsonic and infrasonic region.

Humans interact with the acoustic environment in many complex ways. The human hearing system not only consists of the ear but also encompasses conduction and mediation via bones, flesh, and body cavities. Acoustic energy has the ability to profoundly influence an individual's brain waves, respiratory cycles, nervous system, muscle function, heart rate and glandular function. As such, a benign acoustic space can readily be turned to violence against the individual. Although this has been well documented throughout history a great deal of misinformation and blatant sensationalism has lead to the creation of a area still void of any concrete findings. Due to this the complex and significant pychophysiological influences still remain a mystery to a large degree.

[73] Ibid., p.41

[74] A vast device constructed in this manner in 1941 consisted of a horn that provided 37kW of acoustical power at 460Hz. With pressure levels at above 170 dB the wooden horns initially used in the first 5-minute test were destroyed and subsequently replaced with ones of steel. At a distance of 30 meters levels of 137 dB (about the threshold of pain) were achieved dropping to 127 dB at 100 meters. Ibid., p.42

Bibliography

Attali, Jaques, *Noise – The Political Economy Of Music*, Manchester University Press, UK, 1977.
Broner, N, *The Effects Of Low Frequency Noise On People – A Review,* Journal Of Sound And Vibration 58 (4), England, 1993.
Bryan, Michael and Tempest, William, *Does Infrasound make Drivers "Drunk"?*, New Scientist 16th March 1972.
Campbell, Murray, *The Musicians Guide To Acoustics*, Dent, England, 1987
Davis, Gary & Jones, Ralph, *Sound Reinforcement Handbook*, HP, USA, 1989
Gavreau, Vladimir, *Infrasound*, Science Journal 4 (1), USA, 1968
Hecht, Jeff, *Not A Sound Idea*, New Scientist, UK, 20th March 1999
Kahn, Douglas, *Noise Water Meat – A History Of Sound In The Arts*, MIT Press, USA, 1999
Keith, Jim, *Mind Control World Control – The Encyclopedia Of Mind Control*, Adventures Unlimited Press, USA, 1997
Kientzle, Tim, *A Programmer's guide To Sound*, Addison-Wesley, USA, 1998
Madsen, Virginia, *Notes Towards Sound Ecology In The Garden Of Listening*, Essays In Sound 2, Technophobia, Australia, September 95
Neal, Charles, *Tape Delay*, SAF Publishing LTD, UK, 1987
Rodwell. R., *Army tests New Riot Weapon*, New Scientist, UK, 20th September 1973
Schaefer, Murray, *Soundscape*, Cultures 1 (1),Unesco, 1973
Seashore, Carl E., *Psychology Of Music,* Dover Publications Inc., USA 1967
Simon, Leslie E., *Secret Weapons of the Third Reich*, WE Inc, USA, 1971
Swezey, Stuart, *Amok Journal – Sensurround Edition*, Amok, USA, 1995
T.A.G.C., *Meontological Research Recordings Teste Tones*, Soleilmoon Recordings USA, 1988
Toop, David, *Ocean Of Sound*, Serpent Tail, USA, 1995
Tuzin, Donald, *Miraculous Voices- The Auditory Experience Of Numinous Objects,* Current Anthropology 25 (5), USA, 1984
Wall, Judy, *Military Use Of Mind Control Weapons*, USA, Nexus October / November 1998
Yost, William A., *Fundamentals Of Hearing*, Academic Press, Inc., USA, 1994

Patents

Adams, Guy Emery, *Noise Generator & Transmitter*, Untied States Patent 4,034,741, July 12 1977
Brunkan, Wayne B., *Hearing System*, United Stated Patent 4,877,027, October 31 1989
Drewes, William, *Sonic Weapon System,* United States Patent 4,349,898, September 14 1982
Flanders, Andrew, *Psycho-Acoustic Projector*, United States Patent 3,566,347, February 23 1971
Lowery, Oliver M, *Silent Subliminal Presentation System*, United Stated Patent 5, 159,703, October 27 1992

Naff, John T., & Shea, James, *Acoustic Canon*, United States Patent 5,973,999, October 26 1999
Puharich, H.K., *Means For Aiding Hearing*, Untied States Patent 2,995,633, August 8 1961
Wilson, Joseph, *Superimposing Method And Apparatus Useful For Subliminal Messages*, United States Patent 5,134,484, July 28 1992

Internet: Note **–** All URL's referenced are current as of time of publishing however due to the dynamic nature of the Internet certain articles may not be accessible in the future.

Non Lethal Weapons

Lewer, Nick, *Forum – Nonlethal Weapons*,
http://forum.ra.utk.edu/summer99/nonlethal.htm
Murhpy, Michael, *Biological Effects Of Non Lethal Weapons*,
http://www.dtic.mil/stinet/ndia/NLD3/murp.pdf
Paternak, Douglas, *Wonder Weapon,*
http://www.usnews.com/usnews/issue/970707/7weir.htm
Welsh, Cheryl, *Nonlethal Weapons – A Global Issue*,
http://www.calweb.com/~welsh/8.htm

Acoustic Weapons & The Psychophysiological Effects of Sound

Altmann, Jürgen, *AcousticWeapons – A prospective Assessment*, Universität Dortmund / Institut für Experimentalphysik III April 1999
http://www.einaudi.cornell.edu/PeaceProgram/acousticweapons.pdf
Day, Fergus, *Deadly Silence*,
http://www.profreedom.free4all.co.uk/deadly_silence.html
King, Benson, *Nonlethal Acoustic Weapons*,
http://www.dtc.army.mil/tts/1997/proceed/king/sld014.htm
Scientific Applications And Research Associated Incorporated (SARA), *Technologies*, http://www.sara.com/Capability/Tech.html
Schewe, Phillip & Stein, Ben, *American Institute Of Physics-Acoustic Surgery,*
http://www.aip.org/enews/physnews/1998/split/pnu380-1.htm
Vassilatos, Gerry, *Hearing Through Wires: The Physiophony Of Antonia Meucci*,
http://www.borderlands.com/archives/arch/hearing.htm
Pellegrino, Ron, *The Effects Of Sound / Music On Digestion*,
http://www.microweb.com/ronpell/FXofSndMscONHumnDigstn.html
Nichols, B, *Deadly Vibrations – A Brief History Of Sonic Warfare*,
http://www.overloadmedia.co.uk/library/deadvibr.htm
Woodward, David, *Trumpets Of Jericho,*
http://www.davidwoodard.com/jericho-index.html
Vassilatos, Gerry, *The Sonic Weapon Of Vladimir Gavreau*,
http://www.borderlands.com/archives/arch/gavreaus.htm
Walonick, David, *Effects Of 6 – 10 Hz ELF on Brain Waves*,
http://www.borderlands.com/archives/arch/elf.htm
Sikorsky, *Smurfing On Sine Waves*, NoiseGate # 3
http://www.rfbaker.demon.co.uk/noisegate/articles/ngsmurf.html
Primex Physics International Company, *Non Lethal Defense III - Acoustic Blaster*,
http://www.dtic.mil/stinet/ndia/NLD3/sze.pdf
Kranidiotis, Argiris A. *Human Audio Perception FAQ*,
http://mambo.ucsc.edu/psl/audfaq.txt

Sound Art

Wendt, Larry, *Luigi Russulo And The Art Of Noise,*
http://cadre.sjsu.edu/switch/sound/articles/wendt/folder6/ng632.htm
Scarbourough, Kim, *The Art Of Noises*,
http://www.unknown.nu/futurism/noises.html
Hobijn, Eric, *The Dante Organ And The Aesthetics Of Violence*,
http://flux.thing.de/parasites/Dante/
Baker, Keneth, *Body Sound: Other Music At Artspace*,
http://www.MattHeckert.com/Press/SF_Chronicle.html

Acoustics & Acoustic Ecology

Pellegrino, Ron, *Loud Music And Hearing Loss*,
http://www.microweb.com/ronpell/LoudMusicNHearingLoss.html
Bottum, J, *The Soundtracking Of America*,
http://www.theatlantic.com/cgi-bin/o/issues/2000/03/bottum.htm
Pellegrino, Ron, *Why are Audio Engineers The Enemies of Our Ears*,
http://www.microweb.com/ronpell/EnemiesOfOurEars.html
Pellegrino, Ron, *Sound Deserves its Own Pollution Category,*
http://www.microweb.com/ronpell/NsNSndPltnFndmntPrncpls.html/SndDsrvsOwnPltnCtgry.html
Christophe, Charles, *Poisonous Sounds*,
http://www.microweb.com/ronpell/NsNSndPltnFndmntPrncpls.html/PoisonousSound.html
United States Air Force, *Sonic Boom*,
http://www.af.mil/news/factsheets/Sonic_Boom.html
Cody, John, *Infrasound*,
http://www.borderlands.com/archives/arch/infra.htm
Miller, Wreford, *Silence In The Contemporay Soundscape*,
http://interact.uoregon.edu/MediaLit/FC/readings/Thesis.pdf
Silverman, Andrew, *Acoustics FAQ*,
http://www.faqs.org/faqs/physics-faq/acoustics/index.html
Woodward, David, *The Tarcoma Narrows Bridge Disaster,*
http://www.davidwoodard.com/tacoma.html
Vassilatos, Gerry, *Nocturnal Disturbances and the Infrasonic "Hum",*
http://www.borderlands.com/archives/arch/nux.htm
Karlow, Edwin A., *Loud Music And Hearing Loss*,
http://www.microweb.com/ronpell/LoudMusicNHearingLoss.html

Torp-Olsen, Eric, *Whistle Physics,*
http://www.geocities.com/SoHo/Museum/4915/02.HTM

Psychotronic Warfare

Project Freedom, *Remote Mind Control Weapons,*
http://www.profreedom.free4all.co.uk/part1.html
White, Eleanor, *Subject Index to Articles*,
http://www.raven1.net/ravsubjx.htm
Synetic Systems Inc., *The Science of Light and Sound,*
http://www.ecst.csuchico.edu/~andrewc/synopsis_of_articles.html