

A SHORT HISTORY OF THE DANGERS OF INFRASOUND.

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1 ABSTRACT

There are clusters of people round a few wind farms in various parts of the world who are ill with a wide range of symptoms that we can call wind turbine syndrome (WTS). Many neighbours believe this to be due to infrasound but in reality it is a consequence of annoyance related to the turbines generally.

To try and understand how infrasound has got this reputation, this paper looks at the history of the infrasound myth. It traces the mysterious effects of infrasound from the fall of the walls of Jericho, through the prototype six-foot long police whistle that killed the first person to blow it stone dead on the spot. The paper looks at more modern mysteries of infrasound including sick building syndrome and wind turbines.

Hopefully there is a lesson to be learned from looking at this history for those who want to listen. But it is important to realise that those who are ill in these circumstances are genuinely ill and need treatment.

2 INTRODUCTION

There is a substantial body of opinion amongst wind farm neighbours in some parts of the world that infrasound from turbines causes a wide range of illnesses. Most of these illnesses can be conveniently called Wind Turbine Syndrome (WTS) though there are some direct physical effects (DPE) that are alleged. There is some support in places from acousticians and medical specialists. With one or two exceptions the mechanism for infrasound causing these illnesses has not been explained and even where an explanation is suggested no proof has been put forward. There is certainly no agreed causal route.

Infrasound has often been the subject of mystery and accusation and a look at the history of attitudes to infrasound may help us understand why it has become a factor in turbine noise. In the Bible, Joshua's Israelite army broke down the walls of Jericho using the sound of trumpets. It has been suggested that the mechanism for this was infrasound. Perhaps the psychological effect on the inhabitants of the city was also a factor.

Around the 1960s and early 1970s there was a number of reports of infrasound being responsible for a range of effects or conditions. Around this time there was a rise in the prevalence of Sick Building Syndrome (SBS) perhaps because of the number of new commercial buildings and in particular open plan offices with modern ventilation systems. Infrasound was suggested as a possible cause of SBS. It was also the height of the cold war and then the Vietnam war and the use of infrasound as a weapon was discussed.

3 VLADIMIR GAVREAU

No paper about infrasound would be complete without mentioning Vladimir Gavreau. There are so many conflicting stories about Gavreau that it is difficult to know what is the truth but I will attempt to set out what I think is the most likely truth, based largely on his own writing [1]

Gavreau worked for the Centre National de la Recherche Scientifique (CNRS) in Marseilles. We know he was there over the period 1948 to 1966 because the CNRS made numerous patent applications over that period naming him as the inventor (or one of them). The content of the patents gives us an insight into the work he was doing¹. From the beginning he was interested in sound and particularly ultrasound to assist in industrial processes. The purpose of Patent FR1131551A (applied for in 1955) for example was to produce high power ultrasound and audible sound to assist industrial processes such as the coagulation and precipitation of mists, fumes and dust. Some patents are related to work in robotics or to general mechanical matters.

At some date around the mid-1960s people in his lab became ill for an unknown reason. People were nauseous and could not concentrate. A lot of mystery subsequently developed round this story, but enough to say that he eventually discovered that the problem was a faulty ventilation fan in an adjacent building which produced vibration at 7Hz. This vibration seems to have driven the walls of his laboratory and produced infrasound. With many patents to his name and clearly a bit of a showman, Gavreau was obviously not one to miss a possible development when he saw one. He and his colleagues set about trying to build a machine for producing high levels of infrasound believing that they could be used to make people ill and perhaps be used as a weapon of war.

They started off by building a version of a Lavavasseur whistle (which normally produces HF and ultrasonic frequencies) but which they modified to produce 196Hz at a sound intensity level of 150 to 160dB. A rough translation of the effects of the sound was that “it became extremely intense and dangerous: it acts not only on the ears, but also on the internal organs; and the friction between the organs (stomach, heart, lung) causes a very strong internal irritation. Mr. Saul and Mr. Gavreau were sick for hours after experiencing this whistle for only a few minutes”. It was subsequently encased in a concrete block to prevent “stray radiation”. As a result, they ended up with practically a point source (7cm by 8cm) which produced this level of sound and “was intolerable even in buildings relatively far from our Laboratory”. Fig 1)

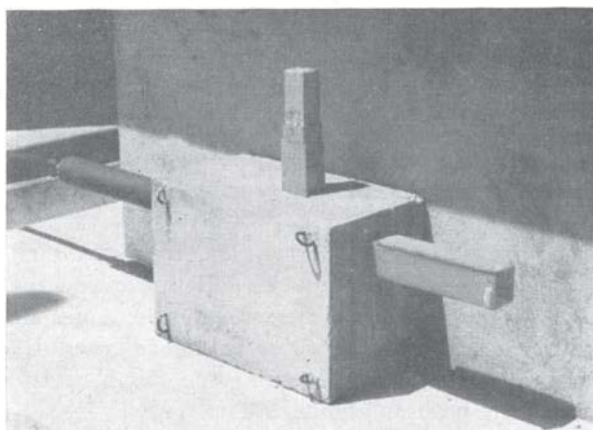


Fig 1 - The Modified Lavavasseur Whistle

Whistle number 2 was a 1.5m version of a gendarme’s whistle producing sound at 37Hz. They only ever ran it at very low power and even then it vibrated the walls of the laboratory. Geoff Leventhall tells me that he went to Marseilles and saw the buildings where Gavreau worked. They were lightweight pre-fabricated buildings.

¹ A search of the French patent records reveals that Gavreau is credited as the inventor or applicant (either alone or jointly) of 24 patents. The applications between 1948 and 1965 are all made by CNRS (Centre national de la recherche scientifique). The patents can be found listed on the INPI patents database at <https://bases-brevets.inpi.fr/en/home.html>. The patents themselves can be downloaded from: https://worldwide.espacenet.com/?locale=en_EP

To achieve 7Hz he attached a pistonphone 30cm in diameter attached to a pipe 24m long. In another experiment he put a loudspeaker in the end. This was subsequently adapted to produce 3.5Hz. Gavreau noted that, whilst the sound at 3.5Hz could not be heard, it was possible to detect it because some other sounds – such as the air jet feeding the equipment - were modulated at that frequency. There does not seem to be any evidence that these devices at 7 and 3.5Hz had any effect on people in the laboratory.

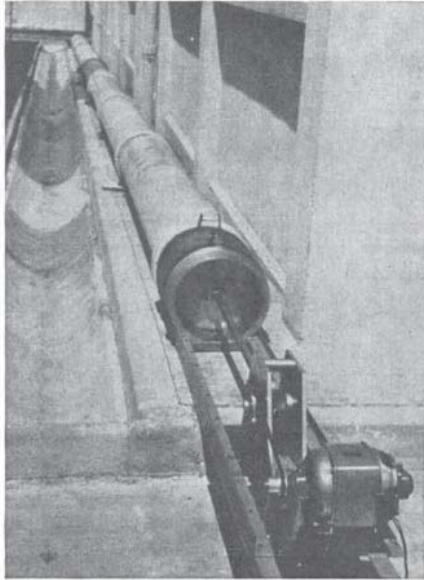


Fig 2 – 7Hz Pistonphone

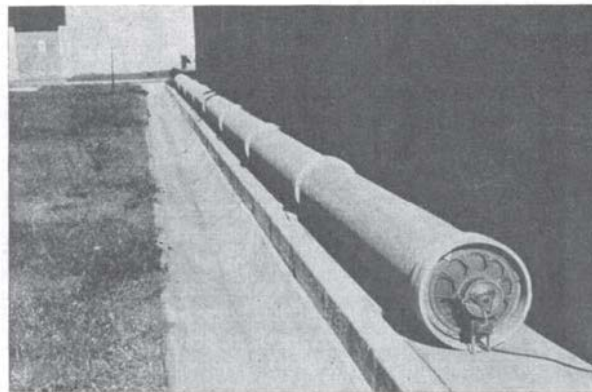


Fig 3 – 7Hz Loudspeaker drive.

In his patent FR1437460A published in 1966, he says the invention relates to infra-sound generators of very high power, or synchronised piston-phones. “We know” Gavreau says, “that infra-sound physiological effects are remarkable: even at low intensity (barely perceptible vibration of the needle of a barometer), they radically prevent any mental work such as a calculation and quickly cause fatigue, nausea and vertigo”. He went further: “It is an effect on the semicircular canals of the ear (sense of equilibrium) which is absolutely analogous to that produced by low frequency oscillations ("seasickness"). With a slightly stronger intensity, they provoke an irresistible panic: one has the impression that "the head will burst"; At very high intensity, they act directly on the internal organs: heart failure becomes possible . . the loss of sight and hearing is almost certain”.

The only evidence that he quotes however is the faulty fan at 7Hz. If the sound was moving the needle of a barometer that might suggest a change of approaching 100Pa (1mb in atmospheric pressure) or just over 130dB.

Thereafter the patent applications were mostly related to sound insulating and absorbing materials and most were applied for directly by Gavreau, sometimes with Henri Saul. None of them seems to have had anything to do with infrasonic weapons. It does seem that Gavreau and his team believed there might be something worth pursuing, perhaps in terms of weaponry but at least in terms of investigating unknown impacts. As Broner [2] said in 1977 with regard to possible health impacts of infrasound “The speculation mainly began following the publication by Gavreau, Condat and Saul and Gavreau of certain statements, one of which, for example, was that infrasound was “certainly one of the many causes of allergies, nervous breakdowns and other ‘unpleasant phenomena of modern life’ found in industrial cities”, which the authors made without having any scientific basis”.

4 REACTION TO GAVREAU

People love conspiracy theories and a “silent killer” has all the elements of a spy drama. Perhaps this is part of the reason that much of Gavreau’s work became embellished and exaggerated.

William S Burroughs, the author of “Blade Runner” gave a series of interviews to Daniel Odier which were collected in a book in 1969 [3]. He related Gavreau’s work on infrasound reasonably accurately but he then goes on to quote Gavreau who said that “it works directly on the the internal organs. There is a rubbing between the various organs because of resonance.” The impression, then, of this writing is that infrasound at inaudible levels directly affects the internal organs, whereas the real story is that such effects were related to sound at 196Hz at a level of 150 to 160dB, well above the threshold of pain. According to Burroughs, in summarizing Gavreau’s work, the policeman’s whistle principle could be developed to, perhaps, eighteen feet across and could be blown with a fan driven by a small aircraft engine. This will produce an all-destroying 10,000 acoustic watts and kill a man at five miles.

According to Lyall Watson in 1973 [4] Professor Gavraud (yes, with a “D” and now a professor) almost gave up his post at the institute in Marseilles because he felt ill all the time. Watson’s description of events was that he built a six foot long police whistle with a pea in it. The technician who gave the whistle its first trial fell down dead on the spot. A post mortem revealed that “all his internal organs had been mashed into an amorphous jelly”. Where that story came from is a mystery, but it is interesting to note that another source attributes a similar event to Levevasseur when he developed his whistle². Watson goes on to relate how Gavraud did his next test outdoors more carefully and the observers were in a concrete bunker. “They turned the air on slowly – and broke the windows of every building within half a mile.” And that “waves of low frequency can be aimed and that two generators focussed on a particular point even five miles away produce a resonance that can knock a building down as effectively as a major earthquake. These are Frequency-7 machines and you can get a copy of the patent from the French patent office”. This may be a highly embellished version of Gavreau’s invention which is the subject of French patent 1.437.460 applied for in 1965 by CNRS. This describes a bank of synchronized pistonphones in 24m long tubes intended to generate and focus 7Hz infrasound. There is no evidence it was ever made let alone tested. Fig 4 may be Gavreau with a model of the device.

Gerry Vassilatos in Lost Science in 1997 also relates the Gavreau story. He describes Gavreau’s tests on the 24m pipes. *“The main resonant frequency of these pipes occurred in the ‘range of death’ found to lie between three and seven cycles per second. These sounds could not be humanly heard, a distinct advantage for a defense system. The effects were felt however. The symptoms came on rapidly and unexpectedly, though the pipes were operating for a few seconds. Their pressure waves impacted against the entire body in a terrible and inescapable grip. The grip was a pressure which came in on one from all sides simultaneously, an envelope of death. Next came the pain, dull infrasonic pressure against the eyes and ears. Then came a frightening manifestation on the material supports of the device itself. With sustained operation of the pipe a sudden rumble rocked the area nearly destroying the test building.”* Funny Gavreau never mentioned that.

² “Imagine taking the cross section of a standard referee’s whistle and the revolving it about an axis to form a toroidal shaped sound cavity - that’s what Robert Levavasseur did when he patented this whistle in 1956. Word has it that in testing a giant 6ft version of this type of whistle, the sound was so loud that it ruptured the internal tissues of Levavasseur and two of his colleagues”.
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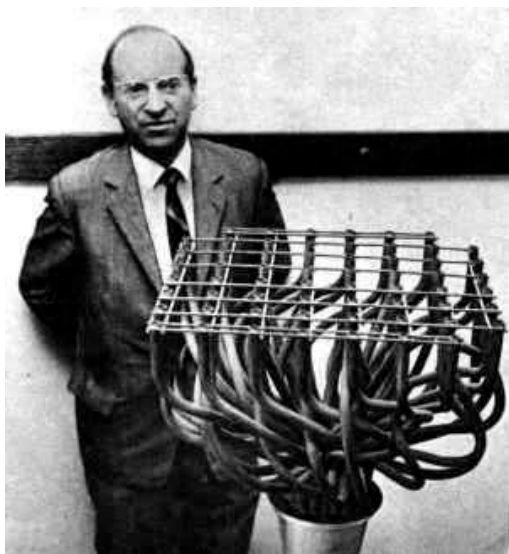


Fig 4 – Gavreau with the “Silent Killer”?

5 INFRASONIC WEAPONS.

The possibility of infrasound as a weapon has appeared elsewhere and featured in the news as recently as last year. Here are a few examples of weapons that are quoted as infrasound.

In 1973 the CIA apparently had a weapon called a Squark Box which “creates 2 simultaneously inaudible ultrasound tones at pitches of 16 and 16.002khz. These 2 ultrasonic waves of highly directional beams are aimed to coincide at the target point. This interference pattern creates a sub-beat of 2hz outside normal auditory perception and when played at immense volumes causes ears, shoulders, chest wall and buttocks to resonate. It converts the target body into a human tuning fork. Symptoms include headache, visual distortion, epidermal tinglings. The skin actually gets heated by localized ultrasound and gently cooked. Other effects are the formation of cavities or bubbles in the body, choking, excessive salivation, testicular pain, nausea and giddiness - a technological extension of witchcraft.”³ This of course is modulated ultrasound, not infrasound.

There is a device called “The Scream” which is described thus. “In 2005 the IDF started using a vehicle-mounted device dubbed the Scream. This generates a loud and piercing sound reported to cause dizziness and nausea. It has been suggested that the device causes a sort of artificial seasickness by affecting the inner ear, but there has been no independent verification of this. In any case, within days of the device being deployed, Palestinian protesters had found they could neutralize the effects of the Scream by stuffing cotton in their ears.”⁴ The Long Range Acoustic Device (LRAD) had also briefly come to prominence in November 2005 when it was allegedly used to repel pirates trying to board a cruise ship off Somalia.⁵

Like the LRAD or The Scream non-lethal sonic weapons are actually audible sound. That’s how they work – they are so loud that they frighten people with high pitched noise and cause temporary deafness. If they do have any non-audible element it will be ultrasound not infrasound because you can create a narrow beam with the former but not the latter. From press reports, the recent Cuban incident is also audible sound (they heard it). Again, the reports are of intense beaming (step out of bed and it goes away) which is high frequency, not low frequency.

³ <http://www.interwebmegalink.net/articles/darknotes/0/1>

⁴ <https://www.popularmechanics.com/military/weapons/a5853/israel-non-lethal-weapons/>

⁵ <http://www.semissourian.com/story/1125162.html>

The trouble with these weapons is that infrasound has no significant directivity. Those operating the weapons would be subject to much higher levels of infrasound than their targets. In 1972 New Scientist said that it has been estimated that to produce fatal injury at 250m an infrasonic source would have to be 198dB. Furthermore, the source would have to be 1100 meters in diameter to have sufficient directional properties.

6 OTHER STORIES

In the early 1970's there were a number of articles in the technical and general press about infrasound. In March 1972 the New Scientist published an article entitled "Does Infrasound Make Drivers 'Drunk'". Various research was reported including one experiment where subjects experienced chest wall vibration, sensation of gagging, slurring of speech, pain on swallowing, giddiness, flushing and nausea. But these occurred at level up to 150dB and the test frequencies were up to 100Hz.

In another reported research project in the same article 50% of subjects who were exposed to infrasound at 105dB had a 10% reduction in reaction time. On another measure some subjects had slowed reaction when exposed to 95dB. Test were also made of the levels of infrasound that produced balance disturbance. These levels are about 20dB above the threshold of hearing for infrasound. Levels just above this balance threshold – around 110dB at 20Hz - were created in a particularly noisy car at 60mph with the driver's window open, and this is what lead to the headline.

7 INFRASOUND AND WIND TURBINES

Out of all the events I have described above the only ones where infrasound might have had any effect are Gavreau's experience with the faulty fan which made staff nauseous at an unknown level but one sufficient to vibrate the lightweight walls of the building and the New Scientist report of noise in a car which was 20dB above the threshold of hearing. This is the basis on which the infrasound story is built. The rest is a mixture of misunderstanding and misinterpretation or just plain sensationalism.

The level of infrasound from wind turbines is well known. Fig 5 puts the situation into context. The red line is typical modern turbine noise at 125m, the yellow line typical modern turbine noise at 500m. The blue line is the threshold of hearing. The dots mark the various examples of infrasound described earlier. The red diamond is Gavreau's first experiment that made them ill. The blue circle is the noise through the open car window and the green square is my somewhat speculative estimate of Gavreau's original exposure to infrasound in his laboratory.

The infrasound we are talking about is well below the threshold of hearing and the forces involved are so small that any effect on the body other than via the ear must be so unlikely that it should be rejected even when adopting the precautionary principle. As regards a mechanism via the ear, that has been proposed by a number of people as a hypothesis. However, there are several studies that show that it is not the case including the paper by Fiona Crichton [5] and others by the same author. In fact, it has been known for at least 30 years. Henrik Møller, in his PhD thesis in 1984 [6] says "*infrasound slightly above the hearing threshold gave a feeling of pressure on the ear and it was given a high rating on an annoyance scale. The infrasound did not cause headache, nausea, tiredness or dizziness and did not influence the circulatory system. The subjects' performance differed significantly from the control in only one of nine tests. No effects were observed from infrasound below threshold*".

As engineers, we know that 70dB of infrasound represents the tiniest fluctuations of sound pressure in the air of around one tenth of a pascal. That's fluctuations in air movement that are less than the

tiniest breeze through an open window. Perhaps just enough visibly to move a candle flame but probably not. This is what our bodies are being “bomarded” with. The particle velocity is in tenths of a millimeter per second and less.

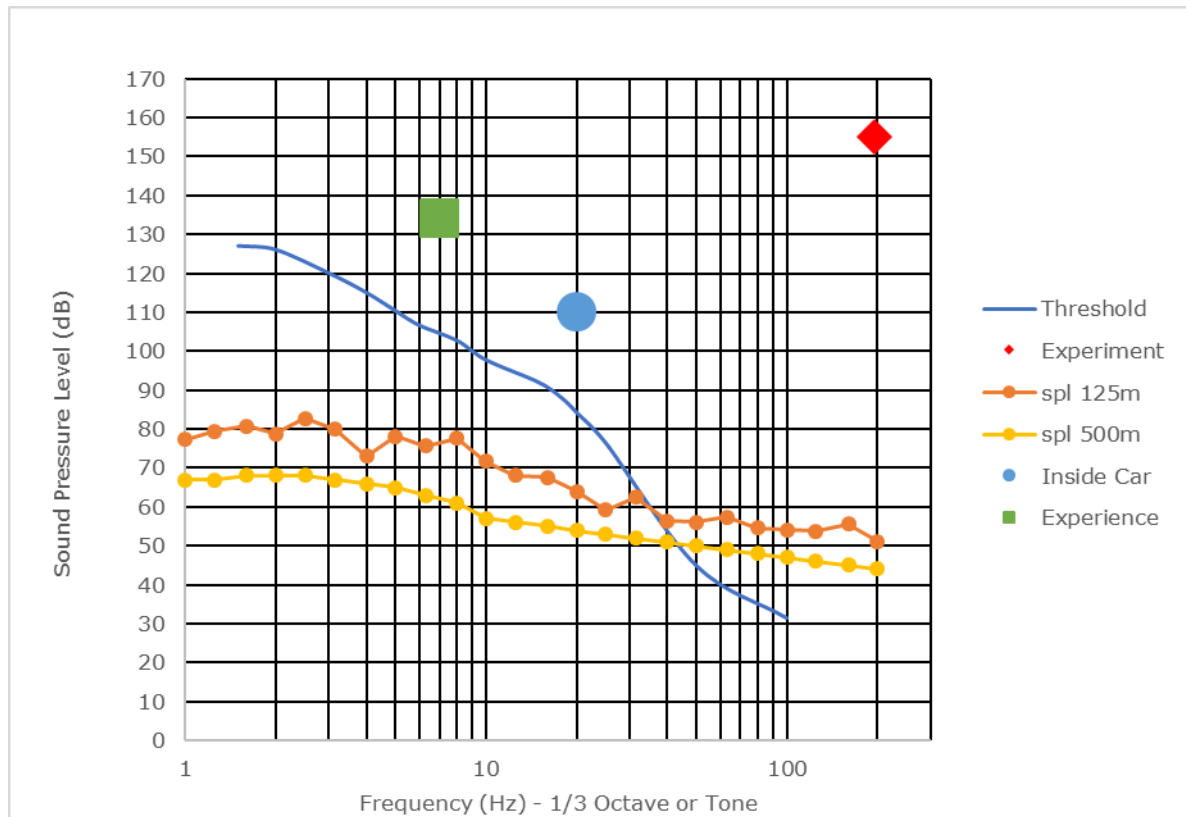


Fig 5. See text for explanation.

8 THE MODERN INFRASOUND MYTH

The allegations against infrasound from wind turbines can broadly be divided into two types. The first is WTS which is identified by a wide range of symptoms broadly similar to symptoms of stress but sometimes dominated by nausea and loss of balance. DPE allegedly causes thickening of the pericardium in humans and the death or birth with deformities of animals.

8.1 Wind Turbine Syndrome

The most common symptoms of WTS are headaches, dizziness and loss of balance, nausea, lack of concentration and sleeplessness. These occur at distances up to 5km or even more from turbines. The symptoms recede when the person moves away from the turbines or when the turbines stop operating and return again when the person is near operating turbines. Sometimes it is just one person who is affected and sometimes there are a number of people (up to about 10 in some cases) in a fairly close cluster round one wind farm or wind turbine. It must be emphasized that these illnesses are real and may well be caused in some way by the presence of the turbines. However, there is no evidence at all that infrasound is the mechanism and indeed, it will be apparent from what I have said earlier that infrasound is extremely unlikely to be the cause.

8.2 Direct Physical Effects

Some of the direct physical effects alleged to have affected animals can be found in a publication by the Independent Noise Working Group [7]. A 50% reduction in the milk yield from cows in France, goats dying in Taiwan and eggs produced without yolks in Australia. You can read these for yourself but I will just look at one in more detail which is the spontaneous abortion of mink pups in a mink farm in Denmark. This has been put down to infrasound although the mechanism has never been made clear. In fact, the mink farmer (who is still farming mink at the same address) did call the vet in the belief that wind turbines, when first commissioned 300m away, were to blame. However, the vets report recommends the animals be tested for plasmacytosis or Aleutian Mink disease which causes spontaneous abortion and death in mink. What is more, there was an outbreak of Aleutian disease in that part of Denmark at the time. Unfortunately, we do not have the results of the tests but does it not seem more likely that Aleutian Disease was the cause than infrasound?

The effects on humans have been set out by Mariana Alves Pereira from Lusofona University in Lisbon. The effects of infrasound are due to direct bombardment of the body by infrasonic waves. The pericardium and other internal structures of the body become thickened. After ten years exposure the person may have psychiatric disturbances, headaches, hemorrhages of nasal & digestive mucosa, duodenal ulcers, spastic colitis, varicose veins & hemorrhoids, decreased vision, severe joint pain, severe muscular pain and neurological disturbances. Again, there is no evidence that infrasound causes these things.

8.3 Assertion and Fake News

Like fifty years ago, the stories about infrasound include a mixture of distorted truth, misunderstanding and exaggeration. An infrasound proponent in a recent blog on infrasound from turbines said *"you need to understand that inaudible noise . . . below 20Hertz . . . is present. The lower the frequency the more energy it contains. How do you think low frequency weapons work. They were produced by governments to disable enemy troops? Such a weapon, tested in Germany in the 1980's inadvertently killed a herd of cows. Such frequencies are currently being blamed for the American and Canadian diplomats deafness and ill health in Cuba"*.

On another occasion I was led to a paper by Laurie, Thorne and Cooper [REF] as a detailed explanation of how infrasound makes people ill. However, the word "Infrasound" occurs only once in that article in the phrase *"The sound did not include infrasound"*. But the paper does talk about people near turbines being affected by them. The quoting of sources that are not related to infrasound is very common, even when the debate is about infrasound. Most often papers or articles refer the fact that some people near wind farms are ill, which we know to be a fact and is not in dispute.

Common to both types of effect is the response to criticism and the presentation of facts that counter the infrasound view. The first responses are to simply assert alternative "facts", quote papers and articles that often have no bearing on the matter. The second is to assert that there is a conspiracy led by the wind industry to cover up the facts. The more contrary evidence is presented to those who believe in the infrasound argument, the more entrenched they get in their views.

8.4 Conspiracy

A common theme accompanying the infrasound argument is that there has been a conspiracy of silence. A few years ago the infrasound lobby "discovered" Neill Kelley. He worked for NASA in the 1980's and discovered high levels of infrasound affecting people at considerable distances from the MOD-1 turbine. This was a downwind turbine so that the rotor passed through a dead spot in the wind as it passed behind the tower. This was presented all over the world as a conspiracy by the wind industry to hide the fact that infrasound was a serious problem. But Kelley also tested the

MOD-2 turbine which was an upwind turbine like modern ones. Kelley's conclusion to his research on the MOD-2 Turbine (in full) says "*We determined from our analysis of both the high- and low-frequency-range acoustic data that annoyance to the community from the 1983 configuration of the MOD-2 turbine can be considered very unlikely at distances greater than 1 km (0.6 mile) from the rotor plane*".

9 CONCLUSIONS

There is something about infrasound that invokes an air of mystery. Because it is not well understood it is easily sensationalized. Some of the events I have related may be amusing but people who are ill near wind farms are genuinely ill. It is a public health issue, albeit not a large one in terms of numbers but nevertheless it is one and it needs to be addressed. Focusing on infrasound is not helping those people.

10 REFERENCES

1. Gavreau V, Condat R, Saul H (1966) Infra-sons: generateurs, detecteurs, proprietes physiques. Effets biologiques. *Acustica* 17(1):1-10
2. The Effects of Low Frequency Noise on People. A Review. N. Broner. *Journal of Sound and Vibration* (1978) 58(4), 483-500
3. "The Job". Daniel Odier Penguin Books 1989. P62.
4. Supernature. Lyall Watson. Hodder and Stoughton. 1973.
5. Can Expectations Produce Symptoms from Infrasound Associated with Wind Turbines? March 2013 *Health Psychology* 33(4). Fiona Crichton et Al.
6. Effects of infrasound on man. A monograph of research carried out at Aalborg University. Møller, Henrik. 1984
7. Work Package 1 – The Fundamentals of Amplitude Modulation of Wind Turbine Noise. INWG.