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The Hum: An Anomalous Sound Heard Around the World

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Abstract—The Hum is a mysterious and untraceable sound that is heard in certain locations around the world by two to ten percent of the population. Historically, the area that has been most affected by the Hum is the United Kingdom, where reports have been frequent since the early 1970s. In the United States, Hum reports date from the early 1990s, with the two most publicized locations being Taos, New Mexico, and Kokomo, Indiana. The source of the Hum has never been located. The Hum does not appear to be a form of tinnitus and may not be an acoustic sound. More than just a noise, the Hum is also capable of manifesting as vibrations felt throughout the body and is often accompanied by a suite of physical symptoms that includes headaches, nausea, and pain in the ears. Analysis of the largely anecdotal data that are available at the present time suggests that the most probable explanation is that some people have the capability to interpret radio transmissions at certain wavelengths as sound. It is well established in the scientific literature that people can hear electromagnetic energy at certain frequencies and peak power levels. Previous studies have found that a subset of the population has an electromagnetic sensitivity that is significantly greater than the mean. Several hypotheses are considered and discussed as possible sources of the Hum. These include cellular telephone transmissions, LORAN, HAARP, and the TACAMO aircraft operated by the US Navy for the purpose of submarine communications.

Keywords: Hum—TACAMO—HAARP—sound—Kokomo—Taos

In 1992, media in the United States reported that the tranquil community of Taos, New Mexico, had been perturbed by a mysterious and annoying sound that only a minority of the population heard. The reports began when Catanya Saltzman wrote a letter to the local newspaper complaining about the sound. Saltzman's letter was met by a "deafening" response from other people in the community who had been suffering but had been reluctant to be the first to come forward (Lambert & Haederle, 1992).

Although the reports from Taos were the first significant media notice in the United States, an unexplained low-frequency sound had plagued certain locations in the United Kingdom since at least the early 1970s. This sound is often referred to as the "Taos Hum" or just "The Hum"[1] (Figure 1). Subsequent reports have increased in recent years. The most notable recent occurrence in the United States occurred in Kokomo, Indiana, starting in 1999.

Fig. 1: *The Torment of the Hum*, by Rosemarie Mann.

Although this phenomenon has been annoying a significant number of people in the United Kingdom and elsewhere for thirty years or more, there have been few serious scientific investigations. Only a handful of articles have been published in the scientific literature (Broner, 1978; Cowan, 2003; Fox, 1989; Leventhall, 2003; Mullins & Kelly, 1995, 1998; Hanlon, 1973; Vasudevan & Gordon, 1977; Wilson, 1979), so I am forced to rely mostly on anecdotal reports.[2]

History and Occurrence

Corliss (1983: 178) provided a bibliography of reports in the scientific literature of "unidentified humming sounds" that dates back to 1830. Corliss (1983) identified five reports in the nineteenth-century literature, but the first twentieth-century reference is dated 1970.

Nineteenth-century reports of anomalous sounds appear to be distinctly different from the Hum, and Corliss (1983) placed them into a separate category. Nineteenth-century reports describe a sound that is like "the humming of apparently a large swarm of bees" (Corliss, 1983: 179). But twentieth-century reports of the Hum describe "a constant throbbing hum, something like the bass frequency of a heavy lorry with its engine on idle" (Corliss, 1983: 179). The latter sound is the classic description of the Hum.

The Hum is a worldwide phenomenon. Reports have come from the United Kingdom, Australia, New Zealand, Canada, the United States (Brooker, 1994), Japan (Stedman, 2003), and Germany (Oeder, 2001). Leventhall (2003: 43) listed a "Bristol Hum (England), Largs Hum (Scotland), Copenhagen Hum (Denmark), Vancouver Hum (Canada), Taos Hum (New Mexico, USA), [and] Kokomo Hum (Indiana, USA)."

The oldest and most frequent reports have been from the United Kingdom. These reports may go back as early as the 1940s and 1950s. "More than 2000 people in the London and South Hampton areas of Great Britain have reported hearing sounds dating back to the 1940s" (Donnelly, 1993). In 1995, a Scottish newspaper, the *Sunday Herald*, reported that the Hum was "first reported in the late 1950s when people in Britain began to report hearing a most unusual noise—a combination of a humming, droning and buzzing sound" (Anonymous, 1995).

Mullins and Kelly (1998: 121) stated that annoying low-frequency sounds have been reported in Great Britain since the mid 1960s. In 1989, the *New Scientist* reported the case of an individual who started to hear the Hum in 1967 (Fox, 1989). A case history reported in the paper by Griggs (1990) may originate from the same individual.

Reliable and widespread reports of the Hum date from the early 1970s. In 1970, a letter published in the *New Scientist* complained of a humming noise "only heard inside buildings" (Wallace, 1970). In 1973, the *New Scientist* reported the existence of "50 cases of people complaining about a low throbbing background noise that no one else can hear" (Hanlon, 1973: 415). Bristol, a port city in southwest England, has been plagued by the "Bristol Hum" since 1971 (Davies, 1996). In 1994, *The Independent*, a London newspaper, declared "Over the past three decades, reports of the Hum have become more frequent and widespread" (Brooker, 1994).

The first notable Hum reports in the popular media began with three stories printed in the *Sunday Mirror* (United Kingdom) in 1977 (Walford, 1983).[3] Following the publication of this report, the *Sunday Mirror* was deluged with 768 letters from readers who reported hearing the Hum (Broner, 1978; Martin & Barker, 1977; Wilson, 1979).

The first scientific study of the Hum of which I am aware was published in the journal *Applied Acoustics* in 1977 (Vasudevan & Gordon, 1977). The investigators concluded:

> The phenomenon of low frequency throbbing noise which has been the subject of annoyance to a small but earnest number of people in the geographical area studied is very probably a real phenomenon and not imagined or self-generated (Vasudevan & Gordon, 1977: 66).

Walford (1983) states that the "first laboratory contact" with people who hear the Hum was reported by Coles and Thornton (1973). Coles and Thornton (1973) never used the word "Hum" but described a phenomenon that appears to be the Hum.

> Most bizarre perhaps are those persons who hear noises in their surroundings, even in our electromagnetically screened anechoic chamber, but nevertheless forcefully assert that somebody or something is creating some new kind of vibrational energy which is perceptible to them as an audible sound (Cole & Thornton, 1983: 320).

People living in Largs, Scotland, a coastal town about 31 km west of Glasgow, have been bothered by the Hum since the 1980s (Mcquillan & Martin, 2001). Largs appears to be one of several coastal towns in the west coastal area of Scotland that have been affected since about 1980 or earlier (Sieveking, 2001: 31). In 2001, the Hum was also reported at Whitehills, Scotland, a small town on the northern coast (Mcquillan, 2001). Sieveking (2001: 31) reported that in the 1970s citizens in Rome, Italy, were plagued by a "throbbing, repetitive noise" that kept them awake at night. The noise apparently vanished and did not recur.

The first media reports of the Hum in the United States began in 1992. Hearers in Taos, New Mexico, reported that they began perceiving the Taos Hum around May of 1991 (Baker, 1993; Begley & Meyer, 1993; Donnelly, 1993; Farley, 1993; Haederle, 1993; Lambert & Haederle, 1992; Pressley, 1993). Although the Taos Hum received more media attention, it was preceded by several months by reports from Hueytown, Alabama (Haddad, 1992; Newman, 1992; Olinger, 1992; Smothers, 1992).

Researchers in Taos, New Mexico, circa 1993–1995, said they received letters from "all over the country describing a similar phenomenon" (Mullins & Kelly, 1995: 3). Hearers in Taos reported that the Hum was more prevalent during nighttime hours and that it was persistent, although not on an around-the-clock basis. About 80 percent of hearers reported hearing the Hum at least once a week (Mullins & Kelly, 1995: 5). In Norman, Oklahoma, I have heard the Hum since 1994.

In 1996, the *Boston Herald* reported a Hum heard by residents in the small communities of Hull and Nahant, Massachusetts. Hull and Nahant are located on peninsulas projecting into the Atlantic Ocean, about 13 km east of Boston. Reports described the noise as the classic sound of an engine idling in the distance and included accounts of picture frames vibrating and windows rattling (Weber, 1996: 23).

In 1997, the *Caledonian Record*, a small newspaper published in St. Johnsbury, Vermont, reported that some local inhabitants had heard a humming sound. One hearer stated that he had heard the Hum since 1989 (Montany, 1997).

The most recent incident to attain notoriety and widespread media attention was the Kokomo Hum, which began in 1999, and was first reported in 2001 (Albrecht, 2002; Falda, 2002; Fountain, 2002; Huppke, 2002; Kozarovich, 2001, 2002; Lewis, 2004; Sharpe, 2001; Sink, 2003; Stuteville, 2002).

Reports of a Hum problem in Southwest Germany began appearing in the media in 2001 (Oeder, 2001). In 2002, the *Times Colonist* in Victoria, British Columbia, reported that a small group of people in Victoria had heard the Hum as early as 1994 (Glen, 2002).

There are other cases of humming noises being reported around the United States, but the reports are too sketchy and inconclusive to classify as the Hum. In August and September of 1985, there were reports of mysterious humming noises in San Francisco, California, and near Seattle, Washington (Associated Press, 1985; Rubenstein, 1985). But these disturbances seem to have been short-lived.[4]

Symptoms

Although the phenomenon has acquired the name of the "Hum", in most cases the sound that is perceived is not a "hum", as commonly defined. The dictionary definition of "hum" refers to a continuous sound that is low in tone. But the classic sound of the Hum is that of a diesel engine idling in the distance. Succinctly put, the Hum is not a hum. Leventhall (2003) described the Hum as:

> . . . a steady hum, a throb, a low speed diesel engine, rumble and pulsing. A higher pitch . . . is sometimes attributed (Leventhall, 2003: 43).

In tests in which hearers were asked to compare and match what they heard to musical tones, people in Taos, New Mexico, matched the Hum to tones in the range of 40 to 80 Hz (Mullins & Kelly, 1995). Higher-pitched tones are also possible—I have heard them myself. Hearers of the Hueytown (Alabama) Hum compared the sound to that made by a dentist's drill or the sound made by a fluorescent light bulb near the end of its life. Hearers in Kokomo, Indiana, reported both the classic sound of an engine idling as well as a "droning" noise (Kozarovich, 2001).[5]

In 1996, the *Daily Telegraph* reported that the Bristol Hum was heard by about two percent of the population (Davies, 1996). In an effort to determine what percentage of the population was affected by the Hum, researchers in Taos, New Mexico, sent 8000 questionnaires to residents within a 40-mile (64 km) circle of Taos. They obtained 1440 responses, including 161 from people who were classified on the basis of their responses as "hearers". Assuming that everyone who heard the Hum responded, this sets a lower limit of two percent on the proportion of the population affected. If hearers were equally well represented among non-respondents, then the percentage of hearers may be as high as eleven percent (Mullins & Kelly, 1995).

Hearers typically must travel several tens of kilometers to escape from the Hum. The range of the sound was reported by Lambert and Haederle (1992) to be 30 miles (48 km) and by Mcquillan (2001: 9) to be 45 miles (72 km).

Women may be more susceptible than men, but data and anecdotal reports are inconsistent. Palfreyman (1999: 29) reported that of 2000 Hum reports made to the British Low Frequency Noise Sufferer's Association, 75 percent were made by women. Leventhall (2003: 43) stated "Hum sufferers tend to be middle aged and elderly with a majority of women". However, Mullins and Kelly (1998: 121) found that in Taos, New Mexico, the mix of hearers was 52 percent male and 47 percent female. Hearers also tend to be disproportionately concentrated among older people. Barton (2001: 16) reported that "the majority of Hum sufferers tend to be female and over 50 [years of age]".

Hearers typically go through phases. At first, they search for the source of the noise inside their homes. Internal sources are usually eliminated by shutting off all electrical power to the home. The next phase is to conduct searches for the source of the sound by walking or driving through neighborhoods late at night or early in the morning. These searches are always in vain; the source of the Hum is never found.

There are a variety of physical symptoms associated with the Hum. These include pain in the ears, headaches, discomfort, trouble sleeping (Lambert & Haederle, 1992); balance problems and anxiety (Baker, 1993); chronic stress (Brooker, 1994); fatigue, headaches, nausea, and muscle pain (Stedman, 2003); headaches, nosebleeds, and dizziness (Crenson, 1994); insomnia, headaches, a sensation of pressure in the head, and nausea (Palfreyman, 1999); sickness and nosebleeds (Mcquillan & Martin, 2001: 3); nausea, ringing in the ears, chronic joint pain, dizziness, depression, and diarrhea (Kozarovich, 2001).

Some of the preceding manifestations are similar to radiofrequency radiation sickness syndrome, a set of symptoms that include "headache, ocular dysfunction, fatigue, dizziness, and sleep disorders" (Liakouris, 1998: 236). Radiofrequency radiation sickness syndrome is supposed to result from chronic, low-intensity exposure to electromagnetic radiation at radio frequencies. It was first identified by Soviet researchers in the 1950s, but its existence is controversial among the United States medical establishment (Liakouris, 1998).

There are even anecdotal reports of hearers being driven to suicide (Brooker, 1994). "Some sufferers have committed suicide because they could not bear the noise any longer" (Palfreyman, 1999: 29). A hearer in Whitehills, Scotland, described her experience:

> You get the feeling your head is going to explode . . . there was one night when I felt like my head had been in a spin dryer all night–like my brain had been vibrating in my skull (Mcquillan, 2001: 9).

In 1992, a sufferer told a British newspaper:

> Last year it [the Hum] almost drove me to suicide, it completely drains energy, causing stress and loss of sleep. I have been on tranquilizers and have lost count of the number of nights I have spent holding my head in my hands, crying and crying (Long, 1992).

The only possible relief from the annoyance of the Hum is through some type of masking noise. Most commonly this is accomplished by an ordinary electric fan. The sound of a compressor (on an air conditioner or refrigerator) running is even more effective at masking the Hum, but these devices cannot be conveniently run at all times of night and day. There are a few anecdotal reports of individuals who succeeded in diminishing or blocking the sound of the Hum with earmuffs or plugs. But these devices are usually completely ineffective. The Hum is usually perceived as louder indoors than outside, an attribute most likely explainable by the presence of more masking noises in the outside environment.

The sound of the Hum can be accompanied by perceived vibrations (Stedman, 2003). There have been times in Norman, Oklahoma, when I could have sworn that my entire bed was vibrating, yet no objective movement can be seen or felt. Sieveking (1996: 17) reported "it makes doors and windows shake", but sound recording equipment picked up nothing. Describing the despair of a British couple affected by the Hum, Palfreyman (1999: 29) wrote "It is so bad their house vibrates". Yet apparently the perception of vibration is entirely subjective. There are no reports of any successful measurements of vibrations or sound associated with the Hum that cannot be attributed to ordinary industrial or environmental noise.[6]

There are also anecdotal reports of what can only be called "electrical effects" associated with the Hum. A sufferer in Germany related:

> I feel as if my bed were electrically charged. The pillow, the mattress and my whole body vibrate (Oeder, 2001).

In Kokomo, Indiana, residents reported seeing dead tree leaves move for no apparent reason.[7]

> Truck driver Billy Kellems says there are days when he can sit on his back patio and watch dead leaves dance on the ground, cracking and popping like butter in a skillet (Albrecht, 2002: A-1).

There were also reports from Kokomo of electrical appliances turning themselves off and on and light bulbs quickly burning out or exploding. In Norman, Oklahoma, I was awakened late one night by a light bulb that had exploded for no apparent reason. At other times, smoke detectors in different parts of my house have simultaneously emitted short warbling tones, although no smoke was present.[8]

There may be an acclimation period associated with perception of the Hum. There are anecdotal reports that when Hum hearers move to a new area, they do not hear the Hum until they have been there for approximately two days. Similarly, when hearers return to their homes they often find the Hum to be gone, only to reappear within a few days.

Causes and Hypotheses

Delusion

The first possibility that should be considered with regard to the Hum is that it is simply a delusion. One person reports hearing an extraordinary sound and writes a letter to the local newspaper. The tabloid is subsequently flooded with similar reports, all resulting from the power of suggestion.

Human history is full of accounts of extraordinary mass delusions. Some of the most vivid narratives are found in Charles Mackay's classic book *Memoirs of Extraordinary Popular Delusions and the Madness of Crowds*, first published in 1841. Perhaps the most profound and unfortunate historical delusion was the Witch Mania that gripped Europe for 250 years, reaching its height during the fifteenth and sixteenth centuries.

> In France, about the year 1520, fires for the execution of witches blazed in almost every town ... So deep was the thraldom of the human mind, that the friends and relatives of the accused parties looked on and approved (Mackay, 1980: 482).

The total number of people executed for witchcraft in Europe was approximately four million (Long, 1893). Today, the absurdity of this craze seems self-evident. Yet that was certainly not the case at the time.

Mass delusions are usually promulgated by some social or psychological expediency. Prosecution of the Witch Mania in Medieval Europe reinforced the authority of the Christian Church and provided a means whereby undesirables could be eliminated from society. The Inquisition was also doubtless invigorated by the practice of confiscating the property of the convicted. It is a historical fact that witches and heretics tended to be less numerous in poor districts. Papal bulls urging the suppression of witchcraft and sorcery had the opposite effect of lending credence to the practice. People reasoned that if the Pope himself denounced witchcraft, it must be real. The ignorant and gullible thus became convinced that the practice of witchcraft was an efficacious means of obtaining personal power.

However, people who report hearing the Hum experience no social or psychological benefit. In addition to the nuisance and pain associated with the phenomenon itself, those who report hearing it—while others cannot—risk social ostracism and ridicule. Reports of the Hum do not appear to spring from psychological or social pressures; rather, hearers seem to act contrary to these factors. Hearers may accept extraordinary costs to escape from the nuisance. In Kokomo, Indiana, Diane Anton quit her job and abandoned a house valued at $180,000 (Huppke, 2002).

The hypothesis of "delusion" is also terribly convenient. It is possible to explain any unexplained phenomenon or perception as a delusion. As Karl Popper pointed out, a hypothesis that explains everything in fact explains nothing (Magee, 1973).

Confounding Factors

In the developed world, most people live in cities in which there are innumerable sources of low-frequency noise. These include industrial machinery, air conditioning and refrigerating equipment, boilers, compressors, electrical transformers, traffic noise, ventilation fans, tunneling operations, trains, and aircraft (Howell & Weatherilt, 1993). Thus, any attempt to measure the Hum invariably picks up normal low-frequency environmental noises.

An acoustic consultant hired to track down the source of the Hum in Kokomo, Indiana, found low-frequency noise coming from a compressor and a cooling fan. After these noise sources were abated, the press promptly declared that the source of the Hum had been found (Associated Press, 2003). But a follow-up revealed that the Hum had not been diminished. People who heard the Hum still suffered (Lewis, 2004). The acoustical consultant also noted that there were "non-acoustic" issues involved that went beyond the industrial noise he had located (Cowan, 2003).

> The sounds that our instruments cannot measure, while they are real sounds in people's heads, are not generated by acoustic mechanisms in which measurable pressure waves travel through the air to be sensed by our ears. It is also worth noting that people from areas far away from Kokomo have reported the same types of sensings. These people have contacted us from both ends of our continent and from other areas of the globe ... These issues are not local to Kokomo, and need to be addressed on a national, if not global, level (Cowan, 2003: 14).

In the absence of an answer provided by science, Hum hearers tend to find an explanation and hang onto it, sometimes even in the face of strong contradictory evidence. Human beings seem to have a psychological need for answers even if the answers are wrong. Every hearer has a theory.

> [Some Hum hearers] are convinced aliens or secret military installations are to blame (Palfreyman, 1999: 29).
>
> Hummers ... have blamed defence radar systems, air conditioning, water pumps, factory noises, microwave levels, high pressure gas transmission pipes, seismic fault lines, [and] residual noise left over from the big bang (Sieveking, 1996: 17).

A German website (http://www.igzab.de/English/FAQ/faq.html) devoted to the Hum relates the story of a woman who is firmly convinced that the Hum she hears is caused by engines idling at a nearby airport. It is a reasonable conclusion. But in defiance of all logic and common sense, the same individual remains convinced that she is correct even when she hears the Hum at a location hundreds of kilometers from her home.

Internal or External?

When consulted, most physicians invariably diagnose the Hum as tinnitus because it is the only option known to medical science. Walford (1983: 74) subjected 23 people who heard the Hum to a battery of tests and concluded that 10 of these "definitely have low-frequency tinnitus". However, his methodology was badly flawed. Walford (1983: 73) assumed that any perceived sound associated with the Hum that could not be blocked by earmuffs must be internally generated and therefore tinnitus. But if the Hum were due to some type of electromagnetic radiation, the source could be external and the earmuffs would have no effect. Walford (1983) attempted to control for radiofrequency hearing by wrapping subjects' heads in ordinary household aluminum foil. Conductive metal of this thickness may be effective in blocking out electromagnetic waves in the higher frequency ranges (e.g., microwaves), but it is completely ineffective at shielding low-frequency signals. Walford (1983) evidently did not understand the concept of *skin depth* (see below) or how the shielding efficiency of a conductor depends on frequency.[9]

Hum symptoms are distinctly different from classic tinnitus. Tinnitus is typically a high-frequency ringing sound—not a low-frequency rumble.

> Most individuals with tinnitus match what they perceive to [be] a tone between 3000 to 6000 Hz, and rarely, if ever, does a tinnitus sufferer match to a tone below 1000 Hz. Why should such a phenomenon skip from regions of the cochlea where the lowest frequencies are represented (Mullins & Kelly, 1995: 6)?

There are also a suite of symptoms associated with the Hum that bear no apparent relationship to tinnitus. These include physical illness (headaches, nausea, etc.) and perceived vibrations.

> [She] knows it isn't tinnitus because the humming is so strong she gets vibrations through her body (Palfreyman, 1999: 29).

Being internally generated, tinnitus is not dependent on the location of the hearer. But people who hear the Hum are occasionally able to find relief in certain locations.

> There have been reports of Hummers [Hum hearers] going into deep limestone caves ... when the noise completely ceases ... (Sheppard & Sheppard, 1993: 115).

If the Hum were due to tinnitus, it should be distributed more or less proportionately throughout the population regardless of location. But that is not the case. There are some striking discrepancies. For example, the small coastal town of Largs, Scotland, with a population of 12,000, is infamous for its Hum problem (e.g., Mcquillan & Martin, 2001). Glasgow, 31 kilometers inland from Largs, has a population of 1.1 million. If the Hum is due to tinnitus, the total number of cases in Glasgow should be 92 times the number of reports from Largs. Yet there are no reports in either the popular or scientific literature of any significant Hum problem in Glasgow.

I have noted that when I listen to loud music through headphones, there is a sensitizing effect. When I remove the headphones, the Hum is louder but fades in a few minutes to a normal level. The aural stimulation of listening to music through headphones seems to enhance perception of the Hum. This strongly suggests that the Hum is a form of tinnitus and is not due to an external source. However, if the Hum is not otherwise present, aural stimulation has no effect. There are distinct times when I can remove my headphones and listen in vain for the Hum. Yet it is not there. The source, therefore, must be external.

There are anecdotal reports that people tend to hear the Hum after first stepping out of their cars. This may happen because the vibration and sound associated with automobile travel has an aural stimulation effect.

Is the Hum an Acoustic Sound?

The bulk of the evidence suggests that the Hum is not an acoustic sound. This is indicated by the simple fact that most people do not hear it. Investigators in Taos, New Mexico, tried to measure the Hum with a custom-built microphone they described as "an ultra-sensitive, low-frequency sound detector" (Mullins & Kelly, 1995: 3). But they found nothing and concluded "there are no known acoustic signals that might account for the Hum" (Mullins & Kelly, 1995: 4).

In Kokomo, Indiana, an acoustic consultant located two industrial sources of low-frequency noise, a compressor and a cooling fan. But after the noise was abated, Hum sufferers received no relief (Lewis, 2004).

Another facet of the Kokomo investigation pointed away from acoustic sources (at least stationary ones). A plot of Hum complaints in Kokomo showed no simple relationship to a source. If the Hum was generated by an industrial noise source, complaints should have been clustered around the source (or sources). But hearers were distributed randomly throughout the city (Cowan, 2003: 3).

There are anecdotal reports of the Hum being present in wilderness areas, far from any conceivable anthropogenic noise source. For most people, earmuffs and plugs bring no relief from the Hum. Nearly all hearers report that the Hum is louder indoors than outdoors and is louder during night hours compared to day. The Hum is typically said to be loudest in the hours between midnight and dawn. These observations may simply reflect the fact that many of the ordinary masking noises that are present during the daytime are absent at night. During the day, a typical household in an industrialized nation may have a television or radio playing, and a washing machine or dishwasher may be running. Traffic noises are also greater during the daytime. A refrigerator is opened more often during the day, and thus the compressor is more likely to be running than late at night. Similarly, in hot weather, central air conditioning is more likely to be running during daytime hours.

Can Electromagnetic Energy be Detected as Sound?

If the Hum is not an acoustic sound, then it is possible that it is caused by some type of electromagnetic signal that some people have the capability of detecting and interpreting as sound. The first individuals who reported hearing radar signals in the 1940s were initially considered to be mentally ill. However, research in subsequent years has established that human beings have the ability to hear radio waves under certain conditions (Elder & Chou, 2003).

The first person to investigate and report the auditory perception of radio waves was Allan Frey in 1962. Frey (1962) showed that the perception of acoustic sound could be induced by radio waves in the microwave range. The phenomenon occurred in people who had normal hearing as well as in deaf individuals. Frey's experiments were done with microwaves in the range of 425–1310 mHz at average power densities of 275 mW/cm^2.

> . . . the perception of various sounds can be induced in clinically deaf, as well as normal, human subjects at a distance of inches up to thousands of feet from the transmitter (Frey, 1962: 689).

Subsequent research has repeatedly confirmed human auditory perception of radiofrequencies from 2.4 to 10,000 MHz (Elder & Chou, 2003). The key factor in effecting an acoustic perception is not the average power level, but the peak power. Radiofrequency energy can be detected as sound at average power levels as low as 0.001 mW/cm^2 if a pulse in the range of 2 to 20 μJ/cm^2 is delivered over 10 μs (Elder & Chou, 2003: S163).

There were "side effects" associated with Frey's experiments.

> With some different transmitter parameters, we can induce the perception of severe buffeting of the head, without such apparent vestibular symptoms as dizziness or nausea. Changing transmitter parameters again, one can induce a "pins-and needles" sensation (Frey, 1962: 689).

Frey (1962: 692) found that the sensitive area of the human head for detection of sound from microwave radiation was an area over the temporal lobe of the brain. He also found that the sound could be blocked with an ordinary piece of screen wire two inches square (5.1 cm).

There is also some evidence in the scientific literature that low-frequency electromagnetic radiation can induce the perception of sound in people. Anomalous sounds have been reported as coincident with large-scale electromagnetic emissions associated with the Aurora Borealis and the passage of large meteors through the Earth's atmosphere.

One of the most spectacular natural phenomena on Earth is the Aurora Borealis, or the Northern Lights. The classic auroral display is a shifting curtain of whitish-green or red light that appears occasionally at high latitudes during the night. The aurora is caused by charged particles from the solar wind entering the Earth's atmosphere along lines of magnetic force and colliding with molecules in the atmosphere. It is the molecular collisions that generate light. The aurora also generates radio waves over a wide range of frequencies. The emissions are especially intense in the neighborhood of 500–1600 kHz (Akasofu, 1979: 66).

There are anecdotal reports of people hearing sounds attributed to the aurora.

> Many people have reported hearing a crackling or hissing sound coming from the aurora on occasion (Akasofu, 1979: 66).

However, no one has ever been able to record an acoustic sound generated by an auroral display.

For hundreds of years, anomalous sounds associated with the entry of large meteors were attributed to a psychological effect. This attribution occurred even though there were well-documented cases of a sound perception occurring before the visual sighting of a fireball.

The first physical explanation for the strange sounds associated with some meteors was provided by Colin Keay in 1980. Keay (1980, 1992) theorized that large bolides generated electromagnetic radiation in the extreme low-frequency (ELF)/very low-frequency (VLF) range of 1–10 kHz with power outputs on the order of megawatts. Subsequent measurements confirmed that large bolides emit radiation in this range (Keay, 1998).

It is not clear if hearing related to meteors takes place by electrophonics, the direct perception of electromagnetic radiation as sound, or if radiation generates acoustic signals by exciting transducers in the environment. Keay (1980) exposed 44 subjects to radio transmissions in the 1–8 kHz range. He found that three of them (seven percent) "exhibited heightened awareness of sounds from an electric field varying at audio frequencies" (Keay, 1998: 10). Interestingly, Keay (1980: 14) also found that sensitivity to electrophonic perception varied by at least a factor of 10^3 between individuals.

Leitgeb and Schröttner (2003) tested the ability of people to detect a 50-Hz electric current applied on their forearms. They found that sensitivity has a log-normal distribution, but women are more sensitive than men. They also documented the existence of a subset of the general population that has a significantly greater sensitivity.

Cellular Telephones

Cellular telephones in the United States have proliferated over approximately the same period of time during which media reports of the Hum have appeared. From 1985 through 2001, the number of cell phone users in the United States increased from 500,000 to 120,000,000. Cell phones also operate at frequencies in the neighborhood of 800–900 mHz, within the range covered by Frey's experiments.

However, there are a number of logical problems in attributing the Hum to cellular telephone transmissions. Reports of the Hum in the United Kingdom date back at least to the 1970s, predating the proliferation of cellular phones. If cell phone towers were the cause, Hum reports should be concentrated in high-population urban areas. Yet the two areas in the United States that have had what appear to be the highest concentrations of Hum hearers are small cities. The population of Taos, New Mexico (year 2000) is 4700; the population (year 2000) of Kokomo, Indiana is 46,113.

Hearers of the Hum should find an inverse correlation between distance from the nearest cell phone tower and magnitude of the sound. Yet there have been no such reports of any correlation. The source of the Hum is notoriously difficult to trace. In fact, no investigation has ever found the source. As Frey (1962) reported, microwave radiation is easily shielded with thin metal sheets or screens. Yet I am aware of anecdotal reports of unsuccessful attempts to shield the Hum with similar materials.

LORAN

In 1999, Arthur Firstenberg suggested that the Hum could be caused by LORAN (Firstenberg, 1999). LORAN is an acronym for ‘‘long range radio navigation’’. The LORAN system consists of a network of powerful radio transmitters that continuously broadcast signals at a frequency of 100 kHz. LORAN signals are used to find location by comparing differences in arrival times from three or more transmitters. There are 25 LORAN transmitters located in the United States (including Alaska); their broadcast power ranges from 400 kW to 1600 kW. In comparison, commercial AM radio stations in the United States broadcast in the range of 535–1605 kHz with a maximum power of 50 kW.

There are some difficulties with the LORAN hypothesis. Although there are some anecdotal reports of people hearing the Hum 24 hours a day, in most areas the Hum is intermittent. LORAN broadcasts, in contrast, are continuous, except when stations are shut down for maintenance.

If LORAN broadcast towers were the source of the Hum, there should be a correlation between LORAN broadcast locations and Hum reports. Yet no such correlation exists. Consider the case of Kokomo, Indiana, the site of well-documented Hum reports in 2001 and 2002 (Albrecht, 2002; Fountain, 2002; Huppke, 2002; Kozarovich, 2001). The closest LORAN broadcast tower to Kokomo is about 138 km to the east in the small town of Dana, Indiana, near the Indiana-Illinois border. If the LORAN tower were the source of the Kokomo Hum, there should have been similar reports from people living closer to the LORAN facility in Dana. Yet no such reports exist. The town of Terre Haute, Indiana, lies 40 km south of Dana and has a population (year 2000) of 59,614, higher than Kokomo’s population (year 2000) of 46,113. Assuming an inverse-square relationship, the effective radiated power from the LORAN station at Dana is more than ten times greater in Terre Haute compared to Kokomo. Yet even after media reports of the Kokomo Hum appeared, there were no similar reports from Terre Haute.[10]

HAARP

HAARP is an acronym that stands for High Frequency Active Auroral Research Program. The HAARP facility is located in the small town of Gakona, Alaska, 294 km northeast of Anchorage. HAARP was originally promoted by Ted Stevens, US Senator from Alaska, as a method of harnessing the vast energy of the Aurora. But this application was never considered by physicists to be practical, and was ridiculed as ‘‘sky-powered toasters’’ (Cohen, 1991).

The stated purpose of HAARP is to transmit high-frequency radio waves into the Earth's ionosphere for the purpose of heating the ionosphere (Mintz, 1995). The Earth's ionosphere begins at an altitude of about 70 kilometers; the name is derived from the fact that this region contains a significant number of charged particles or ions. Natural electric currents are induced in the ionosphere by the solar wind, a plasma stream of charged particles ejected by the sun.

The apparent rationale behind HAARP is that the beaming of energy into the ionosphere can be used to control and alter the large electric currents that exist there. These currents in turn can be used to generate low-frequency electromagnetic waves for purposes such as submarine communications, terrestrial tomography, and possibly even as a shield against incoming missiles (Mintz, 1995).

Although the HAARP transmitter operates on a frequency range of 2.8 to 10 MHz, it has the potential to induce secondary radiation at both very low (0.001 Hz) and very high frequencies (>1 GHz).

> By exploiting the properties of the auroral ionosphere as an active, nonlinear medium, the primary energy of the HF transmitter, which is confined in the frequency range from 2.8 to 10 MHz, can be down-converted in frequency to coherent low frequency waves spanning five decades, as well as up-converted to infrared and visible photons . . . As a result, the HAARP HF transmitter can generate sources for remote sensing and communications spanning 16 decades in frequency (Naval Research Laboratory, 1998: 6).

The HAARP facility has considerable potential for long-distance low-frequency communications capable of penetrating both earth and water to significant depths.

> [HAARP] can be used as a low-frequency transmitter or radio system that is tunable continuously over the range from 0.001 Hz to 40 kHz . . . [HAARP-generated] waves can propagate with low attenuation over thousands of kilometers, guided by the waveguide formed by the ground and the ionosphere, in the manner that many low-frequency communication systems are used by the Navy (Naval Research Laboratory, 1998: 8).

Experimental studies of ionospheric heating conducted in Alaska, Norway, and Puerto Rico date back to the late 1960s (Naval Research Laboratory, 1998: 8). In 1991, the *Washington Post* reported that a three-year experiment involving the beaming of energy into the ionosphere had been under way in 1988, suggesting that activity at the current HAARP site in Alaska could have begun as early as 1985. Early research was aimed at generating ELF waves for the purpose of submarine communications, and was funded by the US Office of Naval Research (Cohen, 1991). Large-scale funding of HAARP began in 1990 (Danitz, 1996).

Although the acronym HAARP refers to a "research program", it was apparently also developed for applied purposes. At a planning meeting held in 1990, HAARP was conceived as a practical device for modifying the ionosphere, not solely a tool for pure research.

> The scientific field was ready to make the transition from pure research to applications in the civilian and military arenas . . . The workshop endorsed the HAARP transmitter as the

cornerstone of the transition from ionospheric research to technology and applications (Naval Research Laboratory, 1998: 8).

From the beginning, HAARP has been surrounded by controversy. Initial criticisms of HAARP focused on characterizing the project as wasteful pork-barrel spending (Cohen, 1991). In recent years, the HAARP project has been surrounded by secrecy and rumors.

HAARP technology is based on three US patents held by physicist Bernard J. Eastlund (Lomas, 1999) and assigned to a company named Advanced Power Technologies, Inc. (APTI). The Eastlund patents are:

- 4686605: Method and apparatus for altering a region in the earth's atmosphere, ionosphere, and/or magnetosphere.
- 4712155: Method and apparatus for creating an artificial electron cyclotron heating region of plasma.
- 5038664: Method for producing a shell of relativistic particles at an altitude above the earth's surface.

Eastlund's patents appear to be related to ideas originally proposed by the eccentric and brilliant Nikola Tesla (1856–1943). Lomas (1999) described Eastlund's third patent (5038664) as identical to "Tesla's Death Ray", a reference to a legendary invention that Tesla claimed he could build. On September 22, 1940, the *New York Times* published an article titled "Death Ray for Planes". The author wrote:

Tesla ... stands ready to divulge to the United States Government the secret of his "teleforce", with which, he said, airplane motors would be melted at a distance of 250 miles, so that an invisible Chinese Wall of Defense would be built around the country against any attempted attack by an enemy air force, no matter how large (Laurence, 1940: D-7).

In 2002, *The Observer* reported that the Russian Parliament had made demands that construction on HAARP be stopped. The demands were based on the analysis of a Russian scientist who warned that:

[HAARP could] trigger chaotic changes in weather patterns, cause permanent environmental damage ... influence the mental and physical health of people across regions, lead to a new arms race, and undermine the strategic stability of the world (Walsh & McKie, 2002: 22).

Some of these claims appear to be substantiated by the text of the Eastlund patents.

... by appropriate application of various aspects of this invention at strategic locations and with adequate power sources, a means and method is provided to cause interference with or even total disruption of communications over a very large portion of the earth. (US Patent 4686605)

This invention has a phenomenal variety of possible ramifications and potential future developments. As alluded to earlier, missile or aircraft destruction, deflection, or confusion could result, particularly when relativistic particles are employed . . . Weather modification is possible by, for example, altering upper atmosphere wind patterns or altering solar absorption patterns by constructing one or more plumes of atmospheric particles which will act as a lens or focusing device. (US Patent 4686605)

The plasma will be confined between adjacent field lines and will form a shell of relativistic particles there . . . the shell so formed may be used as an anti-missile shield. The high energy, relativistic particles in the shell will collide with any missile passing through there to give up energy which, in turn, will damage or destroy the missile (US Patent 5038664).

The holder of the Eastlund patents, APTI, developed HAARP for the US Navy and Air Force. In 2001, *Commerce Business Daily* reported:

The Office of Naval Research has a requirement for continuing the development of HAARP . . . the Government intends to negotiate with only one source, Advanced Power Technologies Inc. (APTI). APTI was the sole offeror under the original competitive procurement and has completed the demonstration prototype phase of this program. Under this phase, a functional research instrument of 960 kilowatts power was developed, and is currently being used to pursue research objectives within its capability. The proposed action is for continued development of the facility toward its final planned configuration with 3.6 megawatts power (Anonymous, 2001).

At the present time it would appear that the HAARP facility in Alaska is in an intermediate stage of development. In June of 2004, DRS technologies received a $23.3 million contract to provide transmitters for HAARP. The applications outlined in the Eastlund patents are ambitious, and the degree to which they can be realized is unknown at the present time.

HAARP is invoked perhaps more often than any other single hypothesis as a cause of the Hum. One Hum sufferer describes himself as "HAARPooned". However, there is a significant problem in attributing the Hum to HAARP: reports of the Hum predate HAARP. There are reliable reports of the Hum in the United States in 1991, 1992, and 1993 (e.g., Taos, New Mexico) and well-documented reports in the United Kingdom that go back to at least the early 1970s. Although research into ionospheric heating dates back to the 1960s, the HAARP facility itself does not appear to have been fully operational until the mid-1990s.

There is an additional logical problem in attributing the Hum to HAARP-generated low-frequency radio waves. These waves apparently can travel for "thousands of kilometers" without significant attenuation, yet the Hum appears to be a local phenomenon confined to several tens of kilometers.

TACAMO

TACAMO is an acronym that stands for "Take Charge and Move Out". The term was first coined in 1961 when the idea of using aircraft to communicate with submarines was proposed as an interim solution until a permanent land-based facility that could survive a nuclear attack was built. As time passed, it became clear that survivability depended on mobility, and TACAMO aircraft became an essential component of submarine communications (Anderson & Day, 1996).

The function of TACAMO aircraft is to relay messages to submarines using transmitters on the VLF band. The first generation of TACAMO planes were Lockheed EC-130s, into which VLF transmitters had been loaded. The first plane became operational in 1963. By 1971, TACAMO aircraft had undergone four generations of improvements and incorporated a 200-kW transmitter. TACAMO aircraft broadcast by deploying two trailing wire antennae while flying in a circular orbit. The shorter antenna is about 1500 meters in length, the longer is about 8500 meters long (Nordwall, 1990).

Starting in 1989, EC-130 aircraft were phased out and replaced by sixteen modified Boeing 707 designated the E6-A (GAO, 1987). The upgrade in ‘‘airframe, avionics and mission equipment’’ was substantial and completed in 1992 (Anderson & Day, 1996). Current transmission power and frequency range of TACAMO transmitters are unknown.

Starting in 1998, E6-A aircraft were upgraded to the E6-B. The E6-B planes continued the role of submarine communications but also took over the communications operation formerly performed by the United States airborne strategic command post known as ‘‘Looking Glass’’ (Rudney & Stanley, 2000). The name ‘‘Looking Glass’’ derived from the fact that it mirrored a land-based command center (Gertzen, 1995). The first Looking Glass airplane took off on February 3, 1961. One of seven Looking Glass aircraft remained continuously airborne until Cold War tensions eased on July 24, 1990 (Anonymous, 1990).

TACAMO’s home base is Tinker Air Force Base (AFB) in Oklahoma City. From there, crews are deployed to Travis AFB, 69 km northeast of San Francisco, and the Naval Air Station at Patuxent River, 85 km southeast of Washington, DC (Proctor, 1996).

VLF transmissions from TACAMO planes are complemented by ELF (30–3000 Hz) signals from transmitters in Wisconsin and northern Michigan. A drawback to the ELF facility is that the low frequency limits the rate at which data can be transmitted. It takes about 20 minutes to transmit a short, coded message via ELF frequencies (Fairhall, 1988). Because of the limited data transmission rate, ELF transmitters are only capable of relaying simple messages, such as a three-letter code instructing a submarine to approach the surface and deploy an antenna for additional instructions (Sullivan, 1981). In 1988, the *Guardian*, a London newspaper, reported that the Soviet Union had three land-based ELF transmitters in operation (Fairhall, 1988).

The US Navy also maintains permanent, land-based VLF transmission stations in Australia, Japan, Hawaii, and the west and east coasts of the US (Meyer, 1984). The US Navy VLF-transmitters at Cutler, Maine, and Jim Creek, Washington, are the most powerful radio stations in the world, transmitting at a power of more than two million watts (Littleton, 1988).

Radio frequencies in the VLF band of 3–30 kHz are used for submarine communications because lower frequencies penetrate deeper than higher ones.

The degree to which electromagnetic waves are attenuated in a conductor like seawater is described by the concept of *skin depth*. The skin depth is the depth at which an electromagnetic wave is attenuated to $1/e$ of its surface magnitude, where e is the base of the natural logarithms ($e = 2.7183\ldots$). Skin depth d is inversely proportional to the square root of frequency f.

$$d = [1/(\mu\pi f\sigma)]^{1/2} \tag{1}$$

where μ is the magnetic permeability, f is frequency, and σ is electrical conductivity. For seawater, the following values are good approximations: $\mu = 4\pi \times 10^{-7}$ N/A^2 and $\sigma = 5$ (ohm-m)$^{-1}$ (Griffiths, 1981, p. 326). Substituting these values into Equation 1 yields:

$$d = [1/(1.974 \times 10^{-5})f]^{1/2} \tag{2}$$

Equation 2 gives the approximate skin depth d (in seawater) in meters for a radiofrequency f in Hz. Thus, the skin depth for 30 kHz is 1.3 meters; the skin depth for 3 kHz is 4.0 meters.[11]

To receive transmissions in the VLF band, submarines tow an antenna with a buoyant casing that places a 61-m–long antenna about 12 meters below the surface. The tow line itself is about 500 meters long, enabling a submarine to remain concealed at depth while receiving VLF signals (Sullivan, 1981).

TACAMO aircraft and associated VLF transmissions are in many ways coincident in time and space with Hum reports. For security reasons, the precise areas in which TACAMO aircraft operate are classified. The only public information that the US Navy provides is that one squadron of planes is deployed to cover the Atlantic Ocean, the other to cover the Pacific. Historically, the area with the most Hum reports is the United Kingdom. A prime operating area for US submarines—especially during the Cold War—would have been the North Atlantic, with the United Kingdom a logical base of operations for communication functions. Although it may be possible that Hum reports in the United Kingdom date back to as early as the 1940s, widespread reports appear to date back to the early 1970s or mid 1960s. This is about the same period of time that TACAMO aircraft first became operational.

With some notable exceptions, Hum reports appear to be concentrated near coastal regions where TACAMO aircraft operate. Of course, the population of the United States is also concentrated near the east and west coasts. However there are some fascinating cases that illustrate how the Hum seems to be peculiarly prominent near seacoasts. In 1996, the *Boston Herald* reported that inhabitants of the tiny peninsular towns of Nahant (year 2000 population 3632) and Hull (year 2000 population 11,050) were bothered by the Hum (Weber, 1996). Yet there were no reports from the major city of Boston, located 13 km to the west with a population (year 2000) of 589,141. Similarly, reports in Scotland seem to come from small coastal towns such as Largs (population about 12,000), while major cities which are further inland, such as Glasgow (population 1.1 million), are quiet (Mcquillan & Martin, 2001). If the Hum were due to tinnitus or were a byproduct of an industrial infrastructure, reports should be more numerous in major population centers. Yet that does not seem to be the case.

The extent to which TACAMO aircraft operate over the continental United States is unknown. Presumably when TACAMO took over the Looking Glass mission, deployment over the continental United States was concomitant. In 1997, *Defense Daily* reported that TACAMO training flights take place over the Gulf of Mexico (Breen, 1997).

Notably, the first reports of the Hum in the United States were in 1991, about the same time that older TACAMO EC-130 aircraft were upgraded to the E-6A. One of the most mysterious aspects of the Hum is the absolute inability of any person or investigator to locate the source. This inability could be understood if the source were on a moving aircraft subject to random and unpredictable deployments. Furthermore, investigations of the Hum in Taos, New Mexico, circa 1993 (Mullins & Kelly, 1995) and Kokomo, Indiana (Cowan, 2003), were publicized well in advance, allowing time for any mobile source to be moved. One more aspect of the Hum implicates an anthropogenic source: it avoids publicity.

> Curiously, the families who complained about the Hueytown Hum say it subsided noticeably just as national news reporters showed up to hear it (Olinger, 1992).

One difficulty with attributing the Hum to VLF transmissions from TACAMO aircraft is that there are no Hum reports near the Navy's stationary VLF broadcast stations at Cutler, Maine, and Jim Creek, Washington.

Conclusions

1. Analysis of that anecdotal evidence available at the present time tentatively suggests that the Hum is not an acoustic sound or a form of tinnitus. As a working hypothesis, it appears probable that the Hum can be attributed to electromagnetic radiation that some people have the ability to interpret as sound.

2. The source of the Hum is unknown. However, a comparison of several different sources of radio transmissions with the time and place of Hum reports seems to tentatively exclude several possibilities. Unlikely sources include cellular telephone transmissions, LORAN navigational stations, and HAARP. The hypothetical source that can be best correlated in time and space with Hum reports is the TACAMO aircraft operated by the US Navy for purposes of submarine communications.

3. Thirty years of research into the cause of the Hum have proven fruitless because of the repetitive and thoughtless use of standard acoustic techniques. Although sound measurements are an indispensable starting point, it should be clear by now that routine approaches are inadequate. Future investigations should start with some recognition that local manifestations of the Hum are only one aspect of a global problem. Ten years ago, the *British Medical Journal* noted:

> Hums are associated with noise problems that cannot be routinely solved by acoustic consultants or environmental health officers (Rice, 1994).

The global nature of the problem should be recognized and investigators should be equipped to measure radiofrequency energy into the VLF band and below. Because the source of the Hum may be anthropogenic, it may be circumspect for future inquiries to be performed surreptitiously.

4. A simple experiment could be performed to determine if the Hum is acoustic or electromagnetic in origin. A set of three boxes or enclosures large enough to contain a human body could be constructed. On the outside, each box would appear identical. But the inner composition of each box would be different. The control box might have an inner layer of air. The second box would be lined with concrete to attenuate acoustic signals. The third box would contain a conductor thick enough to significantly diminish the amplitude of most electromagnetic radiation.[12] The boxes could be transported to a location such as Kokomo and hearers asked how the perceived sound of the Hum changes inside each enclosure.

As a corollary, there should be experiments designed to determine human sensitivity to pulsed electromagnetic radiation in the VLF band and below.

5. Study of anomalies is the key to scientific discovery. If human beings have some previously unrecognized ability to detect low-frequency electromagnetic energy, there may be beneficial applications.

Notes

[1] I use the convention that the particular phenomenon referred to in this article is capitalized as ‘‘the Hum’’, while the lower case usage (‘‘hum’’) refers to the dictionary definition.

[2] I try to maintain a complete bibliography at: http://groups.yahoo.com/group/humforum/ Coming from a mainstream scientific tradition, I am uncomfortable with the use of anecdotal evidence. However, as one reviewer pointed out, ‘‘some topics are necessarily anecdotal’’, and cited ball lightning as an example. In this article I try to balance skepticism with credulity.

[3] Walford (1983, p. 83) lists *Sunday Mirror* articles appearing in 1977 on June 19, July 3, and November 20. The only one of these I have been able to locate is the July 3 story by Martin and Barker (1977).

[4] In August of 1985, a seasonal nighttime hum that had plagued people living on houseboats in Sausalito, California (the Sausalito Hum) was tracked down to the fish species *Porichthys Notatus*. The description of the sound, an underwater buzzing noise that sounded like an electric razor, did not match the Hum. See stories that appeared in the *San Francisco Chronicle* on July 29, August 7, and August 20 of 1985.

[5] I recall very well one Sunday afternoon during the summer of 1999 when the Hum manifested as a continuous higher-pitched tone in my rural home. The ‘‘sound’’ was extremely irritating. It felt like someone holding a mechanical device of some type up against my head. As an experiment, I drove a mile north of my home, stopped my automobile, and got out. The Hum was still there, absolutely unchanged. I drove over several miles in a number of

compass directions. The Hum remained undiminished as far as 5 miles from my home. Fortunately, these higher-pitched manifestations are uncommon.

[6] An acoustic consultant hired to track down the Kokomo, Indiana, Hum in 2003 measured low-frequency sound from industrial sources (Cowan, 2003). However a causal relationship between these noise sources and the Hum was never demonstrated. It is apparent that any moderately large town in an industrialized nation will have sources of low-frequency noise.

[7] A reviewer noted here that "crackling" noises from dry leaves can also simply result from air currents. The author's perspective is that the observer would have been sufficiently astute to differentiate between leaves rustling in the wind and anomalous behavior.

[8] The inference to be drawn from the smoke detectors is that the simultaneous excitation of these alarms in different parts of the residence could only have been due to some type of uncommon radiofrequency interference. One of the reviewers pointed out that smoke alarms can be set off by high concentrations of dust or humidity.

[9] Aluminum foil 0.001 inches (2.5×10^{-5} m) thick will block out 95 percent of electromagnetic radiation at a typical cellular telephone frequency of 850 mHz. But the same foil will lose its shielding effectiveness dramatically as the frequency drops.

[10] One of the reviewers noted that LORAN and other radio transmissions do not necessarily attenuate in a linear or even a regular manner with increasing distance from the transmitter. Although this is undoubtedly the case, it seems unlikely to the author that such effects could reasonably explain the marked contrast between the cities discussed. It is also striking that there are no known instances of a Hum problem adjacent to a LORAN facility.

[11] The discussion of skin depth appears extraneous, but is included to make the point that thin conductors are not necessarily effective shields of electromagnetic energy. There are anecdotal reports of sufferers being unable to block out the Hum with aluminum foil and thereby concluding that the Hum is not due to electromagnetic energy. But VLF frequencies and lower are easily able to pass through household aluminum foil without significant attenuation. For example, the skin depth for a 20 kHz wave in aluminum is 5.8×10^{-4} meters, while the typical thickness of household aluminum foil is 0.001 inches or 2.5×10^{-5} meters.

[12] A layer of aluminum one inch (0.0254 meters) thick would attenuate the amplitude of a 100 Hz wave by 95 percent.

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