ELECTRONOTES

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ENWN-47

EVIDENCE FOR INTERNAL SOURCE OF “THE HUM”

We have previously posted here [1-9] considerable discussion of the phenomenon of the Hum.

Evidence of an internal source will be elaborated here. Four topics are discussed:

1. No direct evidence of an acoustic existence
2. Personal interruption
3. Glen’s negative Deming box
4. Pitch matching distribution

1. NO ACOUSTICAL BASIS OF HUM

Most of us (all of us?) who do hear the Hum (sometimes said to be only 2% of the population) likely first supposed (generally with little doubt) that it was actually an ordinary sound. It sounded like a sound!!! Surely a diesel engine idling up the road, a sewer-line pump behind the house, a generator, an airplane engine; something like that.

I am reminded here of a ***Peanuts*** (Charles Schulz) cartoon where Lucy sees what she supposes is a yellow butterfly on the ground. She postulates and convinces herself that it flew in from Brazil. Linus points out that it is not a butterfly at all, but a yellow potato chip. Lucy is left to wonder how a potato chip got there from Brazil. A categorical change of identity does not change her imprinted notion of origin. (Schultz's cartoon characters have taught us most of what we need to know about human nature and philosophy!)

When we transition from the impression that the Hum has origins in a true sound source (vibration of air molecules) that seems **big and far away**, to it not even **being** a sound, the big and far away attribute persists. Those familiar with audio may transition to radio (or some other supposed mode of transmission). But, much as potato chips do not fly by themselves, radio waves do not become audio without some (almost always man-engineered) demodulator. Often the words "somehow" or "anomalous" preface a bold supposition of a natural RF-to-AF mechanism. Realistic details matter; wishful thinking and anecdotes do not. (Strong enough RF may well **disrupt** perception of any nature.)

NOT A TYPICAL HOUSEHOLD OR NEIGHBORHOOD SOUND

So my first observation is that because the source of the Hum is NOT what you would first suppose (an ordinary sound) we need to discard <u>all</u> notions related to that misunderstanding.

Here just above I have stated that the source of the Hum is not acoustic. I mean this in the sense that there is no sound in the room, the house, the neighborhood, or the extended environment. (There may be sound-like vibrations in the middle/inner ear).

How dare I claim no physical sound? This is proven <u>first</u> by tests most folks can do, and <u>ultimately</u> by engineering measurements.

TESTS WE ALL CAN DO

By "tests most folks can do" I mean first just noticing weird things about how the Hum behaves as compared to familiar sounds. It follows you about the house. Usually, it follows you as you move or travel – but you can't really seem to move closer or further from it. It gets louder when you close a window (yet you know it's not from inside – you checked every corner). And you generally don't hear it as well outside. [As we will discuss in detail below, it tends to be interrupted by personal physical actions.]

In addition to the tests that are just <u>concentrating on</u> ordinary observations, anyone can do certain experiments. Notably we naturally and automatically <u>try to block</u> the Hum, perhaps mainly for relief, by ear plugs or pillows. If we lie quietly at night, perhaps hearing crickets, an occasional car, and the fridge; in addition to the hum, we can do the experiment of wrapping pillows over our ears and the crickets and cars and fridge get muffled, but the Hum does not.

ELECTRONIC MEASUREMENTS

– SEEKING AN AUDIO "HUM" SIGNAL

More scientifically, using engineering procedures, we can try to electronically observe the Hum. Normally we might suppose we just record it and play it back. In actuality, no one has ever recorded the Hum. (If you think otherwise, please do provide a citation). Why not? It is first the case that recording a low pitched low level sound is already difficult. Most home recorders are not designed for this. Secondly, if it really is the case that there is no physical audio, it is obviously impossible to record it. So we ask if we can "display" the Hum waveform. A so-called "oscillogram" (like on an oscilloscope face). With some effort [3] expended, this has given only negative results. Nothing is seen, although artificial "control" (real) sounds with properties (frequency and amplitude) adjusted to well-approximate the Hum as a perception, are easily displayed.

2. PERSONAL INTERRUPTION OF THE HUM – AND WHAT IT MUST MEAN

Shortly after my first hearing of the Hum (perhaps an hour after) [1] I noticed that it was unlike normal sounds in that it could slip away briefly – in particular when I tried to speak, or even just made a head shake. It only went away for about a half-second, which made its disappearance difficult to notice – the return being somewhat more noticeable. Since I have worked with audio (and synthesized sound) for 45 years, this was easy for me to hear and describe. Considerable discussion of the "Interruption" has appeared in these Webnotes [6, 7, 9] and a good number of other hearers concur that it is a characteristic, diagnostic feature of the standard Hum (along with the "diesel engine idling in the distance" attribute). This is a personal interruption.

Basically, the Hum might have an internal source (such as a low-frequency tinnitus) or it might have an external source [such as an actual diesel engine, a pump, or even be a RF (radio-frequency) signal "somehow transduced" to seem to be audio]. In light of the discussion in Section 1 above, we tend to doubt any acoustic source, and in the need for a hypothetical "somehow transduced" we might doubt an RF source, although not rule it out completely. The idea of a distinctive personal interruption is, on the other hand, extremely strong evidence of an internal source of the Hum.

If the source were external (acoustic, RF, or something else) it would have to be large (relative to a person or building or neighborhood) and possess considerable energy. Perhaps an actual truck down the block or a VLF transmitter in Wisconsin. It is of course ridiculous to imagine that a personal grunt or head shake could shut down such a source.

Instead, one would need to postulate that the grunt or headshake interrupted the transmission link between the source and the person. It is not unreasonable to consider this possibility. The interrupt perception, while moderately difficult for a general hum hearer to master as being truly diagnostic may well become a familiar test "tool". It is clear that sounds in general are NOT interrupted, nor are low-frequency low-level audio signals that are specifically tested as "controls" for the experiment [6]. Only the Hum is interrupted – not audio in general.

It is virtually impossible to imagine any sort of mechanism by which a grunt or headshake could interrupt RF. Further, the interrupt mechanism (audio or RF) is apparently "tuned to" the Hum. How and why?

If the Hum is internally generated (an otoacoustic emission), we roughly envision it as a hearing mechanism linkage that is in "standby" and subject to random fluctuations. (Sort of like wind chimes that appear stationary but still ring.) Describing the collisions of molecules of air in the middle ear with the structures therein would hardly seem to rate a characterization as a "bombardment", and yet the ear has a dynamic range that is immense [10]. Compare to Brownian motion. The interruptions mentioned (grunts, head-shakes) are clearly mechanical.

3. IMPLICATIONS OF GLEN'S IMPORTANT NULL FINDING

Let's consider the possible implications of what Glen reported from the Deming-Box [11 - 13]. The D-Box box notion is a general attempt to block various possible sources of the Hum by constructing an enclosure and getting inside to see if the Hum penetrates. It can not be overemphasized that such enclosures are likely air tight and accordingly very dangerous unless FULL safety measures are taken. To mention that the D-Box resembles a coffin is first a useful shortcut in description of what the box in fact looks like and a sobering reminder of the danger. Further, if we think about what a fully scientific and formal study using D-Boxes (controls with boxes of various materials, involvement with human subjects, finding enough "hearers" for a statistically useful sample size) it is evident that this experiment is not going to happen. At best we hope for isolated data points.

Indeed, Glen has reported on a steel box he constructed and tried himself. This was a rigorous effort to block any RF. He "heard" no change inside the box [13], and that could mean several things. Now, if it had been the case that he heard the Hum outside, but not inside, and this result were repeated on just himself, multiple times, that might well have indicated that there was something outside (probably RF) that was blocked. However, what was observed in not such a simple result.

GENERATION INSIDE THE BOX (INSIDE THE PERSON INSIDE)

First, in the most straightforward interpretation, it could be the real case that the Hum is an internal generation (like in the middle ear). In such a case, any suspected "excitation" is irrelevant and any corresponding blockage/enhancement by the D-Box would be irrelevant. A particular RF field may or may not exist, and even if it does exist, whether or not it is blocked is irrelevant. [This internal view is strongly suggested by much non-D-Box evidence (e.g., interruptions by head shakes, air travel).]

BOX IS COMPLETELY TRANSPARENT TO A STILL UNIMAGINED CAUSE

Secondly some mysterious "excitation" might exist in the environment and cause the Hum, but if it IS blocked at all by the D-Box, not to any noticeable degree. It is obviously hard to imagine an excitation that interacts with some matter (with humans to produce an illusion of sound) and not interact with other matter (like a shield) at all!

THE BOX IS JUST NOT "THICK ENOUGH"

We could have the notion that there is an external excitation but the D-Box is not "thick enough" (or is somehow limited). This is widely discussed in fact, and correspondingly fairly well understood. That is, it is discussed that a thin layer of "tinfoil" (aluminum foil of course) is enough to block microwaves (high frequencies), but not low-frequency RF. This is correct and introduces the notions of skin-depth; and that frequency matters. It further complicates the interpretation – have we tried hard enough?

The notion of "skin depth" is perhaps misleading because (1) we really don't know what frequencies to consider and (2) it is only a depth for attenuation to 1/e = 0.3679… = 37%. This down to 37% amount it likely noticeable, but very far from a true blocking. For example, 7 skin depths would be $(1/e)^7$ or about 0.001, which MIGHT be excellent blocking. Still, we must be aware of Fechner's Law – essentially that human perceptions (sight, sound, touch) are logarithmic with respect to amplitudes (which is why we use dB for sound). In that view, 37% blocking might not be that evident.

Because we don't even know what VLF or ELF frequency to look at or its power on arrival (or modulation mode) we can't say much about the required thickness of a proposed shield. If a D-box does not give essentially 100% blocking, and if it is in fact the case that we are fairly sure we have not yet noticed any attenuation, there is always going to be the question as to whether we have just not tried hard enough!

EXPERIMENTS WITH ORDINARY AM RADIO.

Some 60 years (or so) ago cars had only AM radios, radio stations were not as densely spaced, and high-speed superhighways (with "underpasses") were a new adventure. In consequence, a long road-trip could begin with the radio tuned to a home station. In short order, the station would begin to dim. You started to think about looking for an alternative (likely unknown). You might be reluctant to give up. Then you went under an over-bridge, and the original signal faded completely, so you faced the inevitable. Fair enough. Steel bridges must somehow block radio signals. But with the advent of car FM radios, often a bridge enhanced a signal.

It happens that I have a steel box that is a crude approximation to Glen's D-box. It is an "equipment cabinet" that I used in the past to install many of my synthesizer circuits. It is about 19 inches by 19 inches at the base, and 7 feet tall. It is upright – my wife always called it the "phone booth". The sides are solid steel and the back is a hinged steel door with two gridded air vents. The front is sealed (or not) depending on what equipment is installed. When we last moved 20 years ago, I took out all the equipment (it is still too heavy!) and put it in the cellar, and never used it since. When I heard Glen talk about a D-box, I walked inside. The Hum went in with me. Of course the front was open, but I hauled up a 5x5 sheet of steel which had been leaning against the cabinet! Certainly still large openings and vents remained. The Hum was unchanged. Since I believed the source was not RF, this seemed consistent with expectations.

Several months ago I thought I would try the box with AM radio. I simply took a CD player with built-in AM and looked for a station. Local stations were essentially unchanged inside the box (open front). Weaker stations could fade to half or less. Because I was interested in low-frequencies (VLF or ELF) I of curse wanted something on the low end of the AM band. My radio tuned to 530 kHz and there was in fact a very weak station there (Spanish language – Cuba?). This station was completely blocked inside the cabinet, even with the front completely open!

This result at 530 kHz was significant because if it were not blocked, we would doubt that VLF or ELF could ever be blocked. The skin-depth decreases with frequency. That is, it takes a greater thickness to block low frequencies; famously a thin layer of foil blocks microwaves. Clearly, if my box blocked 530 kHz with an open front, a proper D-box would certainly also do so.

But I fear it's still not simple blocking. I tried different metal objects. Very curious. The 530 kHz was not blocked by an aluminum window screen with the radio on either side of the screen with the screen length/width perpendicular to the station direction (determined by the loop antenna) but did block it with the radio on either side with the length/width parallel to the signal direction. That is, it did not block with the screen between the station and the radio – counterintuitive. Even more interesting, when the radio was setting on a metal desktop, the signal was stronger than when it was held a few feet above. This observation is not consistent with a notion of blocking, but rather with one that masses of metal warp the strength of RF fields. Much to learn here.

4. THE PITCH OF THE HUM

A Hum has a pitch; almost by definition. It is not always possible to clearly identify a pitch that corresponds to any particular sound. Matching an oboe sound at 440 Hz is rather trivial. Matching narrow band noise is harder. It get even harder when pitches are low. The Hum has a low pitch (say 40 Hz to 120 Hz), and this is in a region where response is already attenuated on the roll-down of frequency [10]. It is not easy.

When we look at Glen's tabulation we see a column to list this pitch, so each and every person who enters the easier data such as location and age could potentially enter the pitch he/she hears. Very few people enter anything at all, and many who do type something give a range and not one number; or perhaps a clearly invalid number. Glen specifies that a tone generator be used for the match. It is true that everyone has access to a tone generator – at least online. Here is one I like fairly well:

http://onlinetonegenerator.com/

This one is nice because it can be tuned much sharper than 1 Hz (sharper than just integer values). In addition, it offers a variety of waveforms (non-sine waves are often easier to work with). Further, you can start multiple copies of the program and hear the sum. For example, start two copies at 440 Hz and then change one to 440.1 Hz. You will hear a slow amplitude variation (beat) over 10 seconds. Spend some time with this generator just for fun.

Using the online generator, one can punch in various trial frequencies and iterate until a good match is achieved. This is satisfactory. A somewhat better alternative (in my opinion) is to use an analog function generator. This is an older, stand-alone instrument which has a continuous frequency dial. The advantage is that it can be adjusted very rapidly, and when you want to zero in on something, you can "ride" the frequency knob, employing tactile/aural feedback - barely moving the dial except with slight pressure, listening to the result. The main disadvantage is that the dial is not very accurate. In consequence, it is best to have a frequency-counter (digital) attached. You adjust by ear to the best match, and then read the pitch from the counter. Quite nice.

Here we need to mention beating again [14]. If you did the suggested exercises running two simultaneous online tone generators, you noticed that when the two generator were at the same frequency there was no beating. By offsetting the generators, there was an amplitude beat at the difference frequency. For example, using 440 Hz and 442 Hz, you got a 2 Hz beating. So called "zero-beating" is a classic way of matching frequencies (pitches in this case).

Why not use beating to pitch match the Hum? The parallel web-based generators sum electronically before feeding the sum to the computer speakers. With audio sources (indeed with real musical instruments) the summation is in the air. So to beat with the Hum you just play audio into the air, self-summing with the Hum, listening for beating. Well, you can't do that because the hum is not audio, as we said above.

However, something curious happens as you adjust your test audio very close to the Hum. I believe it is a classic "second-order" or "subjective" beating. There is a weak sense of a beat-like result, a quivering, but totally without the strong amplitude (first-order) beating. Just enough to be helpful in matching. The classic examples of subjective beating are to add signals not at a 1:1 frequency ratio but at something like a 3:2 ratio (musical fifth), or to feed the same frequency to separate ears.

Does this all mean anything? Possibly it means that the test audio (real sound) meets up with a false audio perception (the Hum) somewhat like two real sounds fed to different ears eventually mix in a perceptual center of the brain, while there is no summation of actual audio signals mixing. Possibly a useful observation. Here however we are just suggesting this subjective beating, if it is heard by others, as a very accurate method of pitch matching to the Hum.

Unfortunately the data are so poor as to be essentially useless. Well not quite! If the Hum were from a single source, the pitch matches would likely be tightly bunched, and they are not. This is not just because they do have a common source, but because we envision a common periodicity exciting various resonator-like receptors in the human receiver. That is, all receivers would need to be tuned to the same excitation rate, much as all radio receivers tuned to the same station's signal would have to receive the same frequency. If different hearers heard different pitches, some sort of pitch shifting (modulation) would be necessary, and no such mechanism seems remotely plausible.

Ideally we would like to have two, or as many as a half dozen or so hearers, all in one place, all of whom agree that the Hum is currently "on" and all of whom are competent pitch matchers. If all, independently tested say the pitch is the same (perhaps 56 Hz) than that would mean something and suggest a common external source. If there is scatter, perhaps from 45 Hz to 75 Hz, we strongly suspect an individual internal generation. In fact, even just two persons side by side, each with convincing evidence of an ability to hear the conventional Hum, and a demonstrated ability to pitch match, who report significantly differing pitches, would be an important indicator of internal generation. The fact that perhaps only 2% or the population hears the Hum makes this proposed experiment difficult statistically, even before we further restrict the test pool to those with the necessary audio hearing skills. So likely it's far worse than having only 2% because a reliable "talent" threshold for pitch matching needs to be present.

Accepting the formidable problems with the pitch data, it can be argued that the wide spread of pitches that occurs in Glen's tabulation is a useable result in itself. This spread supports the internal generation notion.

Before leaving this issue, we could hope for even more. Recently [8] I gave a rough suggestion that the pitch an individual hears might be associated with a hearing "edge". I hear the Hum at 64 Hz and for me this is right on the edge (frequency going down) just before the response falls off very rapidly (I can barely hear 58 Hz at the same level and 55 Hz is gone).

Suppose we have a person who reliably matches the hum to a particular pitch. If this person measures his/her low frequency hearing and finds a precipitous roll-off just below this, that would be interesting, The test would be, perhaps to start at 440 Hz as a SINE WAVE and hear it at a comfortable level. Now shift down to 100 Hz, and then to 70 Hz. Likely you will find the level at 70 Hz to be too low, and need to turn up the volume. Now try your own Hum pitch, and again, you may need to increase the volume. Then set the frequency only about 5% lower. Does it virtually disappear (and the level needs to be increased yet again)?

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