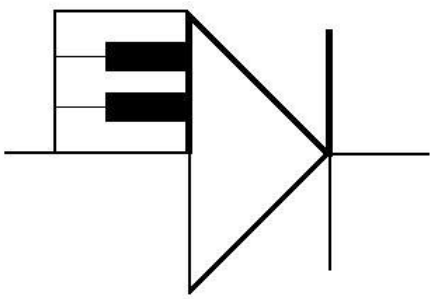

ELECTRONOTES

WEBNOTE 31 2/13/2016

ENWN-31

OH - HUM

-by Bernie Hutchins, February 13, 2016

WE CAN HEAR IT - CAN'T WE ?

Back in the time frame of 1995-2000 (or so) I know that two thing happened. I became aware that something called the "Taos Hum" was in the news, and I heard a humming sound late at night in my home. I don't remember which came first – I guess the sound.

The hum I heard seemed familiar enough. It sounded like a truck engine idling out on the road, or up the road a bit (traditional description). That is, the pitch (RPMs) was right for a stationary running engine, and it was slowing and surging like one would expect if the vehicle was not progressing. It was not very loud. I could easily become distracted from it, or just ignore it. In fact, except for the fact that my wife and I were reading and had no TV or other audio, and that the fridge was not running, I likely would not have heard it this time. Except for the time of night. Except that it was there for a long time. And something about it was strange as well, which I later identified. The details and order of events is not clearly remembered by me. It may have been that first night, or perhaps a later evening that I did look along the road expecting to see a utility truck working on some repair. Nothing. It bothered me a little.

As the hum continued, perhaps that first night, or perhaps later (I don't remember), I mentioned the "truck" to my wife. What truck! I knew it wasn't as though the truck was about to come through the front wall, but I was surprised she didn't hear it. (Except that all my life I have heard (at least noticed) sounds others often don't. Why did a family member keep jabbering when it was clear to my ear that people were walking along the (very rural) road? Why did not everyone stop to assess the potential invasion? Why did a cow keep bellowing? Was it our cow or someone else's?) "**That truck**," was my reply, inviting silence.

She still did not hear anything. Now the amplitude was going up and down a bit (surging engine effect) – roughly once a second. So as it approached a peak in loudness, I said (sharply but softly), "there." Wouldn't you know it, as soon as I said "there" it dropped way down. It came back up after a second or so. I waited again and a few seconds later said "there" again and again it dropped down. What bad luck. After about three more instances of the same thing, I got the message. If this was a truck outside, I somehow had a mysterious power: I could control the truck by simply saying something softly inside my own home. This seemed unlikely! So now there was this disconcerting suggestion that the "sound" was somehow "inside" me.

At that time I still suspected that the hum was a real acoustic signal, but very weak. I supposed that when a room (and the persons in it) were absolutely quiet, the ears cranked up what is effectively an AGC (Automatic Gain Control) to "scan for" and pull in the weak signal. Now, any sort of additional input would be, relatively speaking, louder and shut the AGC back down. This I supposed (or had read) was actually a matter of some protective muscles in the ear mechanism tightening up in response to a large input and then relaxing, with a time constant of about a second. I understood that the protection onset was quite sudden, but the refractory recovery to full gain was slower. Makes sense. [A also had understood that the protection was not quite fast enough for full protection against a very sudden loud noise such as a gunshot. Hence earplugs – but they didn't really work either. Evolution had perhaps optimized this mechanism long before any sharp, loud sounds were common to our ancestors.]

So I took it to be an interaction of something of low frequency and low amplitude (but acoustic) with the ear's ability to search for interesting signals. About that time I also read about the "Taos Hum", so I was not alone.

FOLLOWING UP

Elephant Infrasound

Also roughly 25 years ago I became involved with elephant infrasound communications, and designed and built some simple-minded equipment to record and detect the very low frequency sounds (about 20 Hz) that elephants use to communicate (at least keep in contact) over distances of many miles. This work, assisting my friends Katy Payne (book ***Silent Thunder*** [1]) and Bill Langbauer, both at the Laboratory of Ornithology (!) here at Cornell, was very interesting [2, 3].

The recording aspects were, as a matter or economy, to amplitude modulate four channels (microphone locations) of the low frequency sound (audio carriers modulated by the sub-audio infrasonic elephant sounds) so that they could all be added and recorded on the second track

of a VHS video, (the normal audio behaving much like the “ether” of radio broadcasting) avoiding expensive FM recorders, and making audio/visual synchronization automatic. This was successful, although perhaps responsible for an immense amount of data!

The second invention was a wearable infrasound detection device, and that was a failure. The idea was that the researchers would be alerted to the presences of inaudible events by a “translated” audio frequency event. The approach was extremely simple. Since we expected elephant calls between roughly 15 Hz and 30 Hz, this octave band could be filtered (selected). The output of this input filter was roughly a sinusoidal, and if squared up, was a square wave (rich in odd harmonics). This square wave could then be octave-band filtered for a harmonic multiple of the input VLF. For example, the 7^{th} harmonic was banded from 15×7 = 105 Hz to 30×7=210 Hz. Sounds logical.

Two things wrong. First, the “elephant detectors” were built into wearable “worm boxes” which were relatively small plastic containers with belt loops intended for fishing bait (thus worms). Once constructed and tested, it became clear that you couldn’t move without generating some output (scratching against clothing, etc.). So the “wearable” aspect was not possible. The second thing wrong was that the infrasonic world is noisy although this fact is hidden from us. Even with the box stationary, it went off fairly often. Of course there were no elephants in Ithaca, but there was plenty of low-frequency noise. I never identified a source of even one beep. I had supposed that car tire rotation could have a VLF fundamental. Cars went right by – no beeps. At the same time, Bill suggested that they did not absolutely have to be alerted in advance, as VHS tapes being relatively cheap, they intended to record whenever elephants approached.

So with regard to the hum phenomenon, I learned that the VLF range was noisy. Who knew or even suspected. You didn’t hear anything!

Hum as marginal audio – “Edge Pitch”

If the Hum is acoustic, it could be hard to hear for three reasons: (1) it is already at a low amplitude, (2) it is at a low frequency where the ear’s sensitivity is vastly decreased (see Fletcher-Munson curves) [4], and (3) it is “masked” by louder and higher frequency sounds (let alone “ignored” as a static and uninteresting irrelevant noise).

The hum being at perhaps 50 to 60 Hz, is in a range where the ear’s sensitivity is something like 1% of what it is for normal sounds (speech, music, street noise). People often say they are bothered by “60 Hz hum”, and this is familiar, like the residual sound of a stereo amplifier absent any program, of the “buzz” when we touch the plug of an audio input with a finger (testing to see if it is live). What is called 60 Hz hum is largely due to naturally occurring

harmonics such as 120 Hz, such as we have with a full-wave rectified power supply. You have to try very hard to hear 60 Hz (or 50 Hz) with a signal generator to a speaker. That is, you have to turn the volume way up. A sine wave of 100 Hz or 120 Hz is much easier to hear (still the response is about 1/18 the middle range). Possibly an element in our insensitivity is our expectation that there is nothing to hear there.

This puts the Hum frequency of 50 Hz in the region where the human ear, evolutionarily speaking, is giving up. (We don't hear as low as elephants do, or a high as bats do.) Since we are attributing a "pitch" to the Hum it may be useful to be aware of "Edge Pitch" [5]. We know we often need to discuss the ear/brain and not just the ear. With perception, edges tend to engage the brain's pattern-seeking predilection. Many pages of our Electronotes literature have been devoted to pitch perception and pitch-perception literature, particularly as they relate to "pitch extractors" and "pitch-to-voltage converters".

The "edge pitch" as mentioned by Houtsma (in his 1995 review, apparently from a book) says that if we filter broadband noise, we can (weakly?) identify pitches associated with the edges of the band (not the center of the band, for example). Here we can (weakly!) argue as follows. Listening in a quiet room probably (obviously?) still involves at least some small levels of broadband low-frequency noise. These pass through the bandpass filter representing the frequency range of the ear, the lower edge being at roughly 50 Hz. Thus we should hear a vague pitch about there. Further, the overall phenomenon likely involves the processing by the brain. Houtsma mentions the edge pitch effect surviving binaural presentations. I'm not pushing this too far!

What about Beating?

The phenomenon of "beating" is well-known but often misunderstood [6]. Beating can sometimes be measured, sometimes heard, and sometimes both. If beating is physical (as in the air) we can probably measure it and view it on a scope. If on the other hand, it is generated by the brain (after the ears serve mainly as transducers), then it would be complicated (perhaps impractical) to measure and display. Such beats are called "second-order" or "subjective" beats. The perception of such beating is a weaker phenomenon than the objective or physical beating, but is in some ways otherwise somewhat similar.

Normal beats occur when sinusoidal waveforms of very close frequencies are added. Often the amplitudes are the same, or comparable. In such a case, the waveshape of the sum shows pronounced amplitude variations. This is just the constructive/destructive interference phenomenon in every beginning physics class. Musicians use pretty much the same thing to tune musical instruments. This is familiar.

Subjective beats are different. For example, they are heard when sinusoids are not close to a 1:1 ratio but perhaps close to a 3:2 ratio (a musical fifth). Looking at a scope, no large amplitude variations are observed, and the very annoying "throbs" associated with these

variations are not perceived. Further, the “central” (i.e., brain) involvement with subjective beating is shown by the fact that the two different signals need not be mixed in the air, but can be fed in “binaurally” (one to each ear, and at low enough levels so that mixing by bone conduction is unlikely).

Now, with regard to the Hum, we see folks relating various things regarding the use of oscillators and mixing (or just comparing) generated tones with the original hum (presumably in the air). Regrettably such anecdotal accounts too often lack details or at least consistency. Sometimes they “stop” the hum, are “identical” to the hum, or “beat with” the hum. Here is all we can say.

The alleged existence of “beating” is supposed to prove that the Hum is real and acoustic in nature (a physical sound). Because of non-detailed reports, and the possibility of subjective beats, no such claim is justified. It could well be subjective beating with one external signal (through the ears from the oscillator) and one internally generated “Hum”. Further, we can not pick up and display the combined oscillator and Hum from the air. Since we can not reliably (or at all) display the Hum as picked up on a microphone (I have really tried hard to do this), any sum in the air would be even more ambiguous. Thus any perceived beating is irrelevant to the physical reality of an acoustic hum, at least baring better data.

Why This, Now?

This note was assembled in response to an overnight radio show “Coast to Coast AM” of George Noory that was aired Feb. 10, 2016 from 1AM-3AM (night following Feb. 9). I often check the schedule to see what Noory is up to. Much of what he does (paranormal junk frankly) keeps me away. On the other hand, George is an exemplary sincere, thoughtful, fair and honest individual, and he uses Bob Zimmerman (“Behind the Black” website) as a science advisor. Some gold there!

The case in point here was the Feb. 10 two hours on the Hum with guest Dr. Glen MacPherson who runs a http://www.thehum.info/ website. It seems that MacPherson is a very impressive, no-nonsense science guy – a fast informative two hours. In listening to the presentation I was mindful that I was being updated, and was paying attention to the things I knew (or at least believed I knew) about the Hum which were NOT on the show. These are noted especially in my narrative above in four places in green text. MacPherson’s site has a section to log in for visitors to answer questions about hum experiences. Since it has nearly 9000 visitors, I could only sample. The first of my green comments does appear to have been noticed by at least one person. Perhaps I am offering little new.

Given that some folks won’t be happy unless it is speculated that the hum is a pre-invasion scan by aliens from Planet X (looking specifically for YOU!), or something along those lines, we can hope the far more fascinating truly scientific investigation will eventually prevail.

REFERENCES

[1] Payne, Katherine, ***Silent Thunder: In the Presence of Elephants*** – (Simon & Schuster – 1999)]

[2] Hutchins, B., "Processing of Information-Bearing Signals for Pitch Changing, Time-Base Changing, and Information Preservation", ***Electronotes***, Vol. 16, No. 173, May 1989

[3] Here is a 2014 video of Katy
http://www.onbeing.org/blog/how-does-katy-payne-record-elephant-infrasound/3844

[4] https://en.wikipedia.org/wiki/Fletcher%E2%80%93Munson_curves
This result dates to the 1930's and there are many updates. The exact details are not too important. We don't hear low frequencies, and the cutoff is (of course) not instantaneous.

[5] Houtsma, A.J.M., Chapter 8 Pitch Perception, pg 283 (1995)
http://web.mit.edu/hst.723/www/ThemePapers/Pitch/Houtsma95.pdf

and other sources

[6] B. Hutchins," Revisiting Beating", ***Electronotes***, Vol. 22, No. 213, January 2013
http://electronotes.netfirms.com/EN213.pdf

IF IT'S ACOUSTIC, WHY NO ELECTRONIC DISPLAY

Predominantly, people who experience the Hum describe it consistently as a signal that is **heard**. This suggests that the insertion of the signal (wherever from) is through the auditory nerves, and/or that it is received by the brain in an area accustomed to receiving authentic acoustic signals. This would suggest, but does not seem to require, that there is a physical sound (vibration of air molecules) with the eardrum, inner ear, etc. all involved as with "normal hearing". Indeed, if there were such a physical acoustic signal, it should not be as difficult as it seems to be to display and record. I know of no convincing or even notable recordings (or displays) of the Hum waveform. It should be easy; it's clearly not.

One thing that would make acoustic recording/display "difficult" is if there was NO acoustic signal (my own personal view). But the audio/electronic detection could be more difficult, although not really hard, because it is not stationary (so - just use a sampling scope). Everyone agrees it surges (suggesting an engine-like sound), an amplitude modulation, and the frequency (pitch) is not clearly consistent. It is true that we humans have a difficult time hearing any frequency as low as say, 50 Hz (Fletcher-Munson curves and similar). So, do we translate our personal difficulty into assuming (in error) that the electronics has similar limitations! There should be no such limitation of our electronic devices. A low-frequency tone can be picked up and displayed on a scope. It can even be recorded, although perhaps not well with a tape recorder intended for consumer-level music recordings (or a cell phone).

Further it is a low-frequency signal most often described as an "idling engine" in the distance, and usually as a relatively low amplitude signal heard when otherwise the environment is quite quiet. There are also accounts (and attempted recordings) that are NOT this canonic phenomenon, and individuals who are interested in a fantastic, rather than a prosaic explanation. [As prosaic as one can get: I first supposed, based on available evidence, that it was a sewer "elevator" between gravity-run segments of a disposal line, one such line runs 200 feet back of my house. (Let's not speculate on whether or not this would surge!) It wasn't that – I ruled that out when I heard the same Hum at my father's home, 60 miles from my home, and his house many miles from any municipal utilities. Also, the supervisor of the line told me later they used no pumps.]

EXTERNAL OR INTERNAL

Let's suppose the "cause" or the hum is some low-frequency source which may be acoustic or perhaps electro-magnetic (somehow transduced to audio), or perhaps a radio wave that just

sneaks into the brain (not impossible I suppose). What would be some of the properties of such a source?

First, it would need to be either very powerful globally or less powerful, but ubiquitous, more locally. It is heard nearly everywhere there is a population concentration. This is significant. Secondly, it would need to fluctuate at the source, or have unreliable transmission, because at the receiver, it surges. Something quite stable (on the scale of hours, days, years) like the power grid (an obvious suspect) would not surge, I believe. Likely electronic motors would not vary much, nor would any diesel generator you would care to buy! Thirdly, there does NOT seem to be any roll-off with distance, which would seem necessary if there were relatively few lumped sources. Well, it seems that some people seem to not even hear it, while for others like myself it is weak and amusing, while still others take it as loud and annoying. Clustering of hearers seems like it is simply population based. Or else, it would need to be statistically demonstrated as being otherwise. Or, does it fall off with distance from some central strong hub not yet identified?

What if the Hum is generated internally? That is, the mechanism of our inner ear are restless and start to make things up. This seems possible, as we know that people in "isolation chambers" tend toward "hallucinations" (with no abnormal psychotic implications). That's kind of like yourself in bed in a quiet home, perhaps in the dark. Perhaps the "edge pitch" effect would even explain the general pitch.

ANY "EVENT" INVOLVED HERE?

If we humans generate Hum tones internally, that would explain a lot. What it would NOT explain is why the phenomenon is new, if it is indeed true that it is new. Clearly, people have not suddenly evolved to make up a Hum in their inner-ears. If we do it today, so should our ancestors of at least hundreds (probably thousands) of years ago. It is not clear why some people don't hear it. To me, it is very difficult to imagine that anyone (let alone most folks) should not hear it! [Obviously in the not too distant past, folks were indisposed to saying they "heard things", especially if it were as rare as a few percent of the population, which is sometimes suggested for hearers of the Hum today.]

Is there an event, like a technological event, that could explain at least a relatively sudden onset of the phenomenon? Like the turning on of a military VLF radio transmitter, as is often claimed? And it would seem additionally convincing that this supposed event were relevant if it did, in fact, involve a low-frequency modality, as the military VLF does, (unlike cell-towers, smart meters, etc.). So – good suspects here. This would require explaining how the "smoothness" of the phenomenon comes about, and of course, the mechanism of RF perception as audio.

But, is there any "event", of any nature, that coincides with onset of reports of hearing the Hum. YES THERE IS – the reporting of people hearing the Hum. A sociological, not a technological event. Could a natural but marginally perceptible phenomenon, as called to our attention, have become fashionable at some point in time – particularly if such notoriety was aided by expanding communications possibilities (like the Internet)? [Shades of Charles Mackay's 1841 book ***Extraordinary Popular Delusions and the Madness of* Crowds**, or of James Surowiecki's ***The Wisdom of Crowds*** (2005).] Unlike a hallucination, the hum could be in fact very real in some sense, but marginally noticeable – until someone mentions it, or as it becomes perfectly good gossip.

SUMMARY

Here is my summary of what I find most likely, in decreasing order of likelihood. I emphasize that I am just rethinking this after about 25 years, so it is, if anything, intended to provoke discussion. To the extent that it may be correct (particularly to engineers), it should not be in any way denigrating to people with contrary views, or to people who are truly bothered by the phenomenon, or to people who don't hear anything.

(1) The Hum is not real acoustically (physically – external as a sound entering the ear) but is still a real perception. It is a report to the brain in a region that normally receives real audio.

(2) The neural report is likely a restless quivering, likely spontaneous and un-driven, a rumbling of structures of the inner ear, at a level that is barely noticeable to most individuals. It is entirely natural, not a hallucination.

(3) So, many if not most people potentially could notice the Hum, if told to listen for it, although not many or all would be impressed by it. (Okay – so what – plug the fridge back in before the beer gets cold!) As a news event, a mystery, it could spread.

Bernie Hutchins: hutchins@ece.cornell.edu (comments welcome)

From “THE HUM” Website

Bernie Hutchins

February 13, 2016 at 12:31 pm Reply

Hi – Great Show. Real scientists are getting rare!

I am a retired instructor of EE from Cornell and have much experience with audio and music synthesis and some with elephant infrasound some 25 years back. I have also heard the Hum back then, and still do (virtually every night I pay attention). The C-to-C show was a great update. But there are FOUR issues I remembered that were not mentioned which I just wrote up. Here is my “webnote” just posted today. Summary of each of four issues in green text.
http://electronotes.netfirms.com/ENWN31.pdf:

I would welcome email at:
hutchins@ece,cornell.edu

Bernie Hutchins

1. **Dr. Glen MacPherson**

February 13, 2016 at 2:11 pm Reply

Bernie. I read your document thoroughly and it is one the best references that I have seen on this topic over the past several years. Your input here is very much appreciated and I look forward to a dialogue with you regarding it. Cheers, Glen.

1. **Bernie Hutchins**

February 14, 2016 at 6:26 pm

Thanks for the very kind words, Glen –

Actually I added 3 additional pages to my "Webnote 31". Now back to looking at more of your stuff.

Same URL for the webnote, and email.

http://electronotes.netfirms.com/ENWN31.pdf:
hutchins@ece,cornell.edu

Best wishes.
Bernie

2. **Bernie Hutchins**

February 14, 2016 at 7:33 pm

Sorry – the email address I wrote had a comma where it needed a dot. It should be:

hutchins@ece.cornell.edu

Bernie