

DID TESLA'S WARDENCLYFFE TOWER GENERATE SQUAREWAVES?

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Here's a "lost concept" which I noticed while reading lots of Tesla material. Suppose we drive a Tesla coil using a low power RF source which is weakly coupled? And the coil has very high "Q?" What happens?

In that case the coil's RF output voltage will ramp up slowly, as if the oscillating coil was a kind of "capacitor" being charged up. The secondary coil is an energy storage component. But it's being charged up with AC high frequency, not with DC! Doesn't this mean we can treat our coil much like a capacitor? We could discharge it with a very short spark-gap placed across its terminals. If we keep driving it via loose coupling, the spark gap should start firing slowly and periodically, since the coil loses half or more of its stored energy each time it's shorted out by the gap. It ramps up with AC oscillations, then sparks over. It should go "snap-snap-snap-snap" just like a DC capacitor spark-gap system, yet it's entirely AC.

Here's another odd concept. In the above AC device, suppose we place a large capacitor in series with that spark gap. Let the discharge drive a capacitor. What will happen? Usually nothing strange. The high-freq AC signal just thinks the capacitor looks like a good conductor. It's invisible, it just looks like a short circuit for the high frequency. However, if we can adjust the spark gap so it quenches quickly, then whenever the gap fires, it will produce a pulse of a single polarity, and will deposit a large DC potential across our added capacitor. During the spark the oscillating coil dumps a sine half-cycle, a DC surge. Doesn't this mean that we've invented an 1890s-style AC-to-DC converter? With no diode? Yes, but I'm just getting started!

To do this the spark gap would have to quench fast; quench after a single half-cycle of the RF ringing (or more easily done: quench after an odd number of half-cycles.) In addition, during the next firing of the gap, *the capacitor DC polarity should reverse!* After all, the gap fires at maximum voltage, and once the capacitor was previously charged, the gap voltage will be at maximum when the instantaneous coil voltage is *opposite* to the previous DC polarity left sitting on the capacitor. It only fires when the AC voltage happens to be backwards. So, during each slow triggering of the gap, the capacitor polarity gets reversed. As the spark gap slowly goes snap-snap-snap, the capacitor's DC voltage goes pos-neg-pos-neg. And most important, the output voltage might not be too

much smaller than the Tesla Coil's HV output. So if we built a multi-megavolt Tesla coil, we could use it to create slow, multi-megavolt square waves.

So, by taking a conventional Tesla coil and adding to it's output terminal, one spark gap and one H.T. capacitor, perhaps we can STEP DOWN the coil's output frequency to a very low value. We feed it high-freq AC, and it outputs such a low frequency ...that Nikola Tesla might call it "electrostatic." Or, if seen from another angle: we've just built simple a sawtooth relaxation oscillator, but it's a strange version where both the power supply and the slow ramp are made of AC oscillations, and the output is not a brief spike, instead it is a square wave.

Nikola Tesla owned no "Tesla Coils"

Where did this idea come from?

Well, think about it: Tesla wasn't working with "Tesla Coils." He didn't call them that. To us, Tesla Coils are those famous vertical-coil lightning machines. But to Tesla they were just one more electrical component, one more useful tool among many he'd invented.

To him they were just power supplies.

If we have an AC high-voltage power supply kicking around the lab, what might we use it for? Well, if you're Tesla, you can hook it in series with a spark gap, then route the enormous discharge pulses through a resonant circuit. That's right, use a Tesla coil *as the power supply for a Tesla coil*. Aha, the two frequencies need not be the same.

So what happens if we use a Tesla Coil as a power supply for a very low-freq resonator: use it to power a long wave VLF spark transmitter? Tesla mentions the parts of the process: when an Extra coil is driven with CW, its oscillations ramp up over time, and if its output is suddenly shorted by a spark gap, brief pulses of stunning power are produced. Initially the TC secondary acts like a slowly charging "capacitor," then it gets periodically "discharged" by the spark gap. But unlike modern energy-storage caps, this "AC-storing capacitor" could easily be charged to megavolts, and most important: it could be recharged in tiny fractions of a second.

It has enormous power-processing ability far beyond that of DC energy storage capacitors. Which is what Tesla said on numerous occasions!

So Tesla figured out a way to build a Tesla coil where the power supply ran at megavolt output, and then the main Wardenclyffe coil stepped it up from there. Aaaaaand... the output frequency could be low.

A small experiment

But is this actually real? How about an experiment? OK, I'll take this 1" diameter long narrow 800KHz TC secondary and drive it at resonance using my old Wavetek sig gen. It's now behaving like the Extra Coil of a Magnifier: one coil terminal is driven, and the other is left floating. The Wavetek puts out about 10Vp, and at resonance the far end of the coil is running at a thousand volts at least. (NE-2 bulbs glow!) Next I'll let the extremely tiny sparks from the far end of the coil start leaping to a metal object. What happens? *Something Very Cool!*

A low frequency SQUARE WAVE does appear on the metal object. It's HV and high-Z, so I monitor it with a nearby scope probe. It's very noisy and grungy. The origin of the square wave is obvious:

- The 800KHz Extra-coil's output rises to max volts over about ten cycles.
- the gap sparks over
- after quenching, some DC volts are left on the metal object
- the 800KHz HV ramps up again
- because there's now static HV on the metal object, this time the gap fires on the OPPOSITE POLARITY of the 800KHz wave
- after quenching, opposite polarity of DC HV is left on the metal object.
- repeat...

So it's basically a relaxation oscillator much like a NE-2 blinker. But this one is powered by AC, not DC. The slow-rising "sawtooth" waveform is an 800KHz modulation rather than a DC ramp. And the output is alternating positive and negative current spikes. Wow! Pretty cool, eh?

OK, what if I harness those slow alternating spikes? I can use them to drive a simple tank circuit. I grab an inductor and capacitor out of the junkbox and route the alternating spikes through it and to Earth. Yes! A large slow sine wave appears across this grounded LC tank. Also, the spark gap's pulses seem to "phase lock" to the LC oscillations, and the signal isn't nearly as grungy as before. On the scope it remains coherent over more than 50 cycles. Makes sense: the low-freq AC voltage on the output of the spark gap is affecting the gap timing, and it's forcing the gap to fire at just the right time to dump a single-polarity pulse that kicks the next cycle of the slow sine wave.

I check out the component values on an LRC meter and calculate that my coil/capacitor tank circuit should run at 39KHz. Those were randomly chosen components. I calculate a better freq: the AC ramp takes about 10 cycles to rise, and the pulses are half that period, so the ideal output freq would be... 40KHz?!!!!! But my RLC is 39KHz. Bizarre. Just by chance those random

component values were perfect. I love it when that stuff happens. (If I'd grabbed different ones ...would I have failed? and given up?)

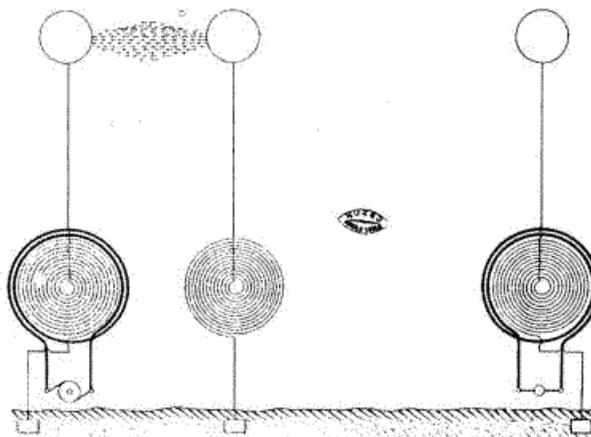
So, I now have a BACKWARDS TESLA COIL. Its CW sine-wave input drive is 800KHz, and its output is 20x lower: 40KHz. And this step-down factor depends on the Q of the Extra Coil. Instead if the Q-factor of my extra coil had been 10x higher, and it took 100 cycles for it to slowly ramp up or down, then I could have stepped the 800KHz down to 4KHz, which is well within the set of Schumann absorption lines for Earth-res. (or hook it to a high-Z piezo speaker and hear what it sounds like.)

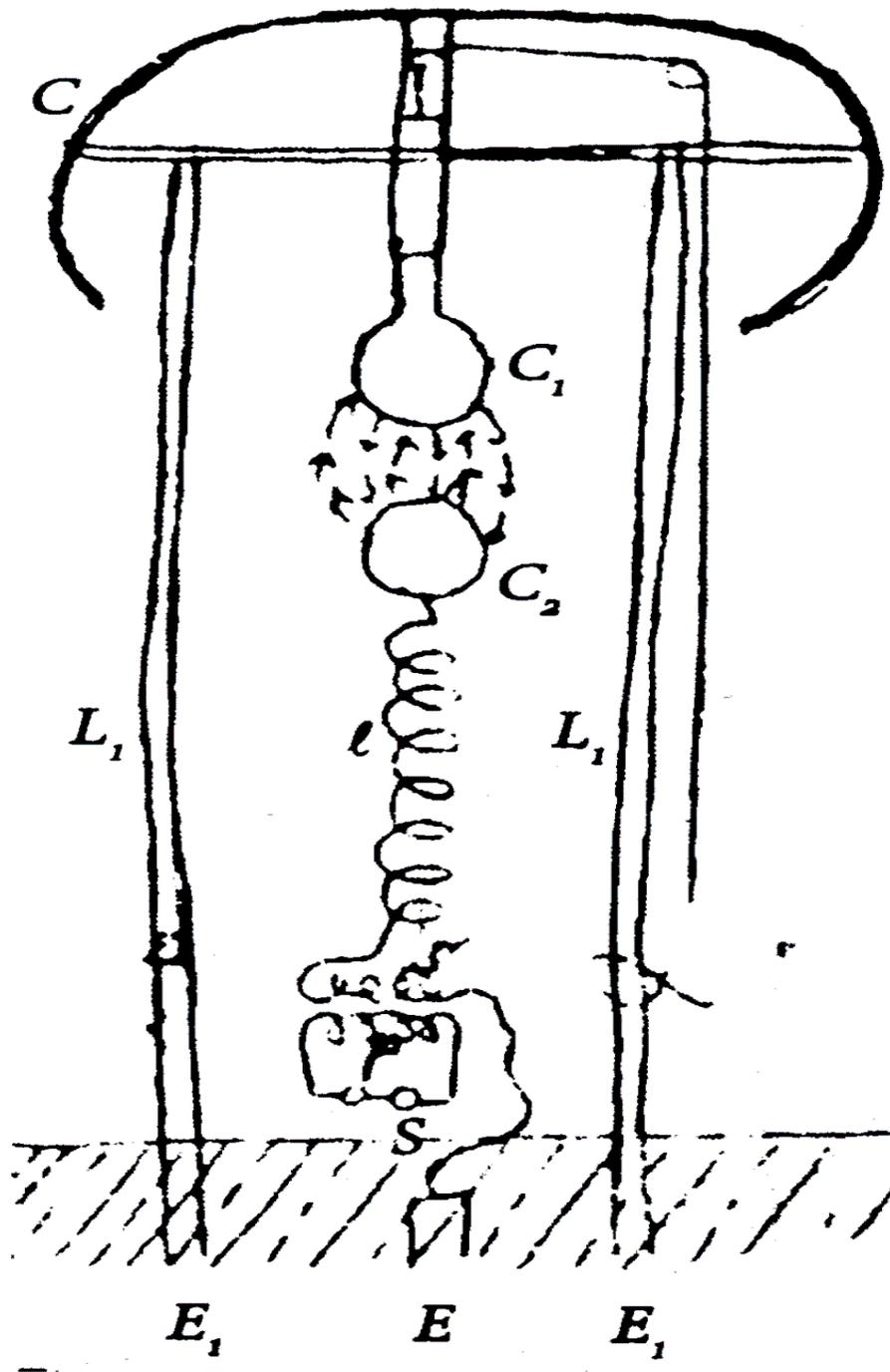
If Tesla had a huge 75KHz coil of very high Q, then the PRF of his spark gap and his transmitter output could have been far lower: down in the hundreds of Hz. The output is an alternating spike waveform, and the "tank circuit" which forms the sine wave is ...the entire Earth. As all oscillators do, it phase-locks its pulse drive to its tank circuit, so that any changes to the tank circuit's resonant frequency won't de-tune the drive pulse-rate. It will just continue oscillating at the changed frequency. And so a simple Tesla coil should be able to excite the very low Earth Resonances even though the TC frequency is tens or hundreds of times higher. (But note that this "Earth-res phase-lock" effect would only occur above a certain threshold of operating kilowatts. Those returning waves in the sky-fields which are trapped in the Schumann ionospheric duct, they must be strong enough to bias the next triggering of the spark gap.

Hmmmm now, did Tesla have any plans for a giant transmitter where there was a large, CW-driven "Extra coil," but there was also an unexplained mysterious "Extra Gap" placed in series with the HV output conductor?

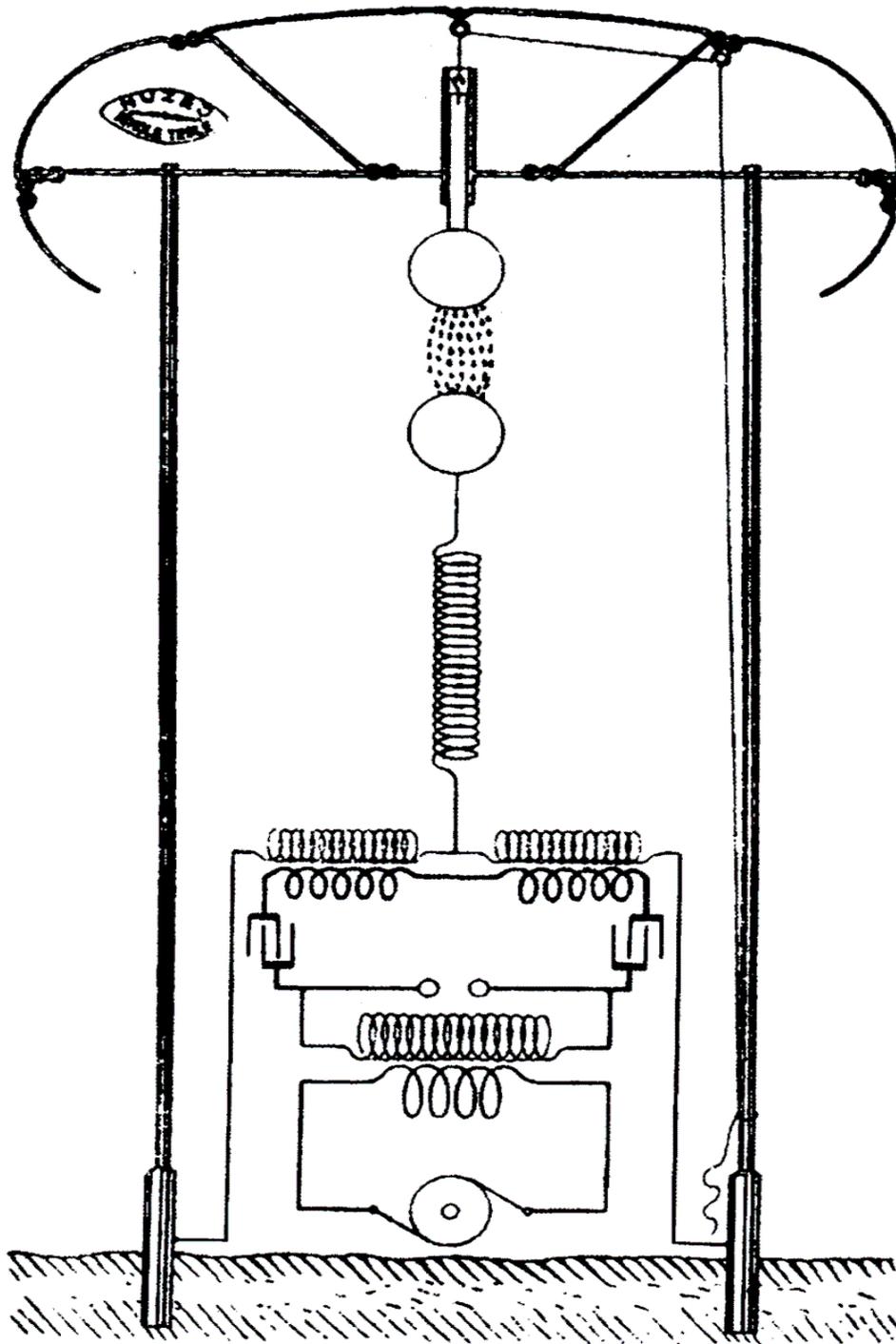
Yes. Yes he did.

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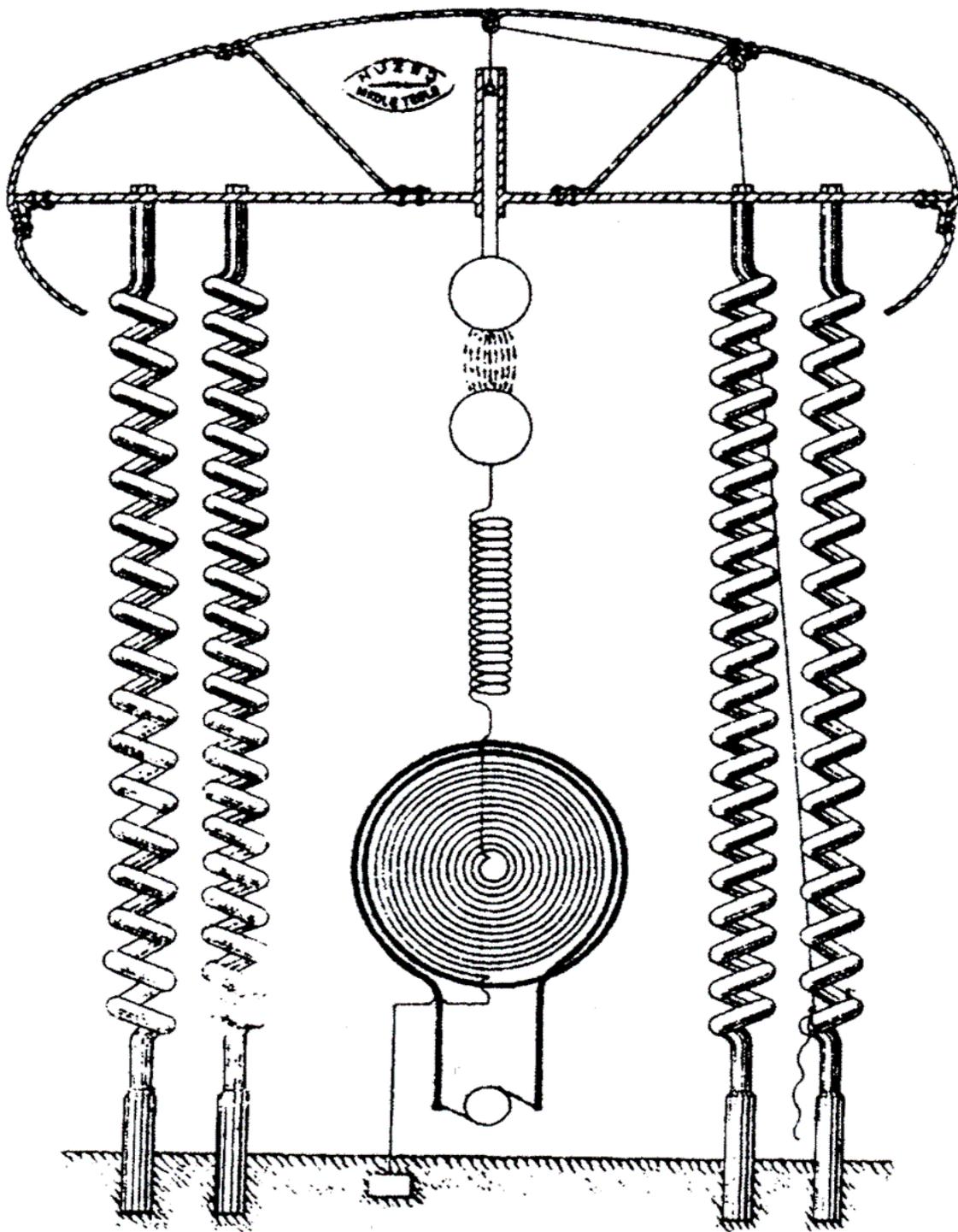




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Regarding Tesla's transmitter at Wardenclyffe NJ, it's still an open question about how he was able to use a tens-KHz system to drive the Earth resonance

frequencies (which are all below 20KHz, and the best ones far lower.) To excite the Earth, a huge Tesla coil would have to have far lower resonance than usual, and so be built 20x or 50x taller than the largest ones ever made. Or, Tesla would have to have some way to step the frequency down without reducing the enormous output voltage.

Perhaps he connected a spark gap in series with his coil's output, then used this to charge a capacitor? Yes, according to unpatented drawings from his collected works, this is exactly what he was working on during Wardenclyffe years. But nobody has said why that "Extra Gap" was placed between the main coil output and the capacitive topload hemisphere. So maybe a mystery is solved, and the Wardenclyffe tower was the world's largest square-wave signal generator?

SQUARE WAVES, AND PHASE-LOCK FEEDBACK TOO

Relaxation oscillators are sensitive to environmental e-fields. After all, they're being triggered when the voltage across a spark gap reaches a particular threshold. If other external e-fields are present, these extra fields can add or subtract from that threshold. They'll cause the oscillator's pulses to come earlier or later than normal. (This is why a little NE-2 blinker circuit can detect nearby RF sources.)

If we set up Wardenclyffe to be a square wave oscillator, and then we leave it outdoors where it can be influenced by other e-fields, perhaps something very useful will happen. Perhaps the pulse-waves sent outwards by our system will race all the way around the Earth, then concentrate themselves in contracting ripples back at our location and cause our oscillator to fire early.

If such things were to occur, what does it mean? It means that our device will drive just one of the Earth Resonance frequencies. It means that if the resonance were to slightly wander because of Solar Wind or changing magnetosphere phenomena... our transmitter would still remain locked to that frequency. The system would keep oscillating even as the frequency drifted up and down. And if we attempted to set our transmitter to a much higher frequency, it would *leap discontinuously* to the higher absorption line in the Earth Resonance series. Remember that these frequencies are all in the audio range. So if the spark gap distance was made wider and wider, the noise from such a system would sound like successive notes being struck on a piano keyboard. Or perhaps sound like an air-raid siren which leaps from note to note. (Well, they'd actually be buzzing raspy, spark-gap notes!) Brrrrrrrrrrr-Baaaaaaaaaaa-BIIIIIIIII-BEEEEEEEEEN! That *may* have been the

characteristic sound of Wardenclyffe tower in operation.

This all solves another Tesla mystery: Earth Resonance frequencies are known to wander around slowly. For this reason it's supposedly impossible to strongly excite the Earth Resonances. If your VLF transmitter managed to hit the target frequency, your success would only be temporary, since the Earth system would slowly change, and you'd lose the resonance. The solution is found above: stop treating the Earth as a target frequency for your drive transmitter, but instead make it part of your oscillator. If the Earth becomes our oscillator's "Tank Circuit," then such an oscillator will always be on resonance, even if the frequency-determining components are wandering in value.

Yes, except for my 800KHz coil test, all this stuff is pure speculation. But it all hangs together SO NICELY, and explains so many mysteries, that I thought I'd post the whole mess here on my website and let the critics have at it.