TESLA'S BIG MISTAKE?

Sept 1999 William Beaty

While experimenting with a long, thin Secondary coil from Tesla Coil, I suddenly connected up several things in my mind which had been separate up to that moment. After years of messing with Tesla Coils, I finally see what Tesla was up to with single wire transmission, with resonant coils, and with longitudinal waves. See if the following doesn't make sense.

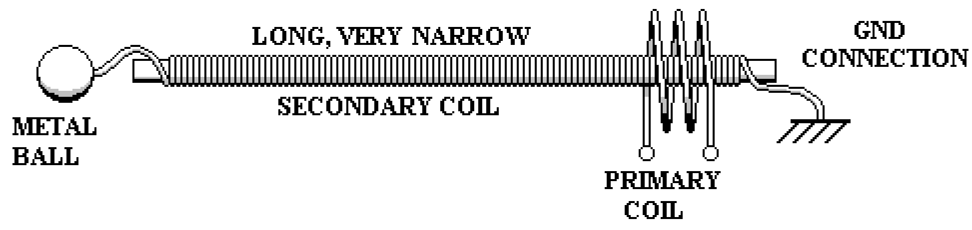

fig. 1 A typical Tesla coil

If we wrap a single-layer coil of wire upon a very long plastic tube, we have a Tesla resonator as in Fig 1. In essence, this is an an electrical transmission line. We can inject AC into one end using a little primary coil wrapped around. Now examine Fig 2 below. We've placed a *second* "primary coil" at the far end of the long coil. This second coil acts as a "receive coil," and will collect the energy we had injected into the "transmit coil" at the other end. Since our long thin coil is actually a single piece of wire, we've managed to send electrical energy along a *single wire.* There is no electric circuit involved! This only can work because the long, thin coil will support slowly-moving electromagnetic waves, and the electron-sea within the metal of this coil behaves as if it's become compressible.

Now we put a metal sphere on either end to prevent corona from spewing out of the dangling wire tips, and we've built a simple electrical power system. Inject some high-freq AC power into the first "primary coil", and the same AC power comes out of the second "primary coil" at the far end. If we choose the correct value of load resistor for the "receive" coil, then all of the electromagnetic energy flowing along the long thin secondary will be absorbed by the receive coil without reflecting.

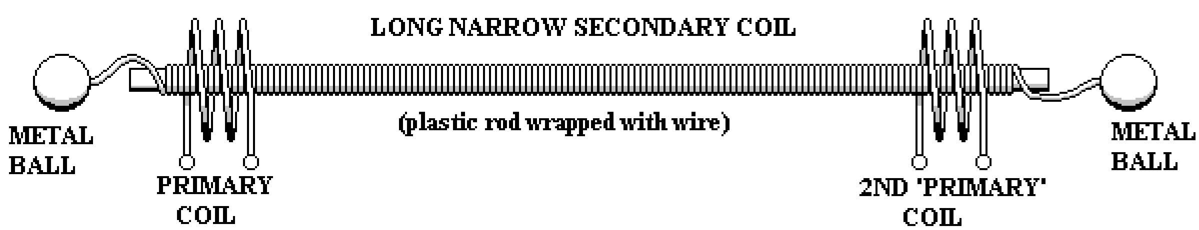

fig. 2 A single-wire transmission line

This is the infamous *single wire* transmission line. It apparently uses *longitudinal waves*! However, there is nothing crackpot about it, since it obeys conventional physics: the propagating electric and magnetic fields are at 90 degrees to each other. Successive globs of positive and negative charge-imbalance are moving along the coil, and these globs/waves are linked to each other via the surrounding EM fields. The EM fields are transverse. And the only thing which acts like a "longitudinal" wave is the density of free electrons in the wire. Is this crazy stuff? Nope. All circuits have longitudinal waves in their charge density. It's not much difference than a coax cable. Within a normal piece of coax, the electrons of the metal move as part of a compression wave, even though the EM fields within the cable's dielectric remain part of a transverse wave.

In conventional cables there are two conductors, and the voltage between them forms the "E" part of the EM wave. In the above one-wire coil device, the voltage between the travelling lumps of net-charge distributed along the long thin coil forms the "E" part of the wave. The single wire acts as its own "circuit." The motion of the net-charge is an electric current, and this creates the "M" part of the EM wave.

Interesting? A single wire transmission line! It doesn't violate the rule forbidding longitudinal EM waves. However, it violates the fundamental rule regarding electric circuits in that there *is* no circuit here. The two ends of the system are connected by a single wire. The charges within the coil flow back and forth, while the electrical energy flows along the coil from source to load.

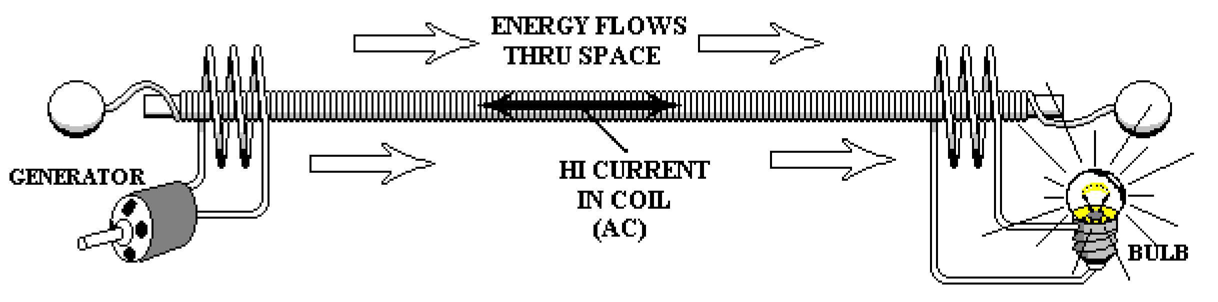

fig. 3 An AC generator lights a bulb

HOWEVER, this is not unique. Once long ago I encountered an article about a single-wire transmission line. This had nothing to do with Tesla; it was about an old microwave transmission scheme called a Goubau transmission line or "G-line." The article was in an old copy of QST magazine (amateur radio mag) in the 1960s or '70s.

It turns out that you can send microwave or UHF signals along a *single* wire as long as that wire is coated with a dielectric. To do this, you start out with a normal coaxial cable. You strip the shield from a central section, then solder on a pair of large, cone-shaped copper horns which attach to the coax shield at either end of the coax cable. The dielectric-coated single wire extends between the ends of the coax. Sort of like this:

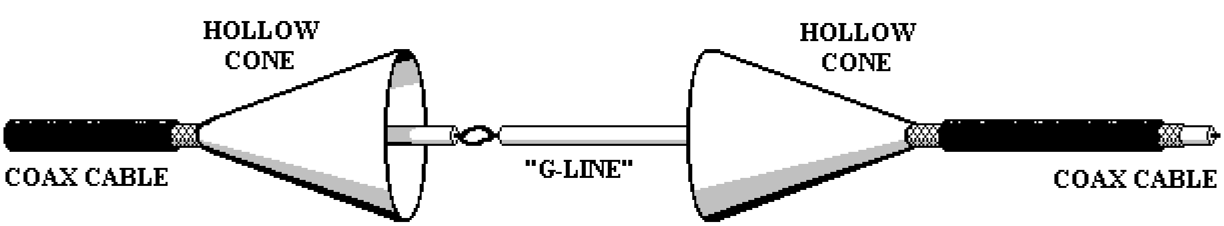

fig. 4 The Goubou or "G"-line

In the above diagram, the single-wire section between the two hollow cones can be as long as desired, but it must be fairly straight. Those cone-shaped parts must be about one wavelength across (or was it 1/2 wavelength? I don't remember exactly.) The metal cones act as "wave launchers" or "wave catchers". As the EM waves come out of the coax cable, the cones allow the waves to spread out and attach to the "G-line" part. There must be a plastic coating on the "G-line" wire, otherwise the waves will not lock onto it, and they will tend to wander away into space. The plastic tends to slow the waves below "c," so they bend slightly inwards towards the wire. The article noted that you *could* put a bend in the G-line, as long as it was a long, smooth bend of large radius. Because of the plastic coating, the waves would follow the bend. If there was no plastic coating, the waves would miss the bend and go straight out into space, missing the "catcher cone" entirely.

Obviously this can only work with AC. There is no electric circuit, instead we have waves of "electron compression" which propagate along a single wire. Let's briefly look at a fluid analog. The fluid analogy of a*conventional* electric circuit is a closed *loop* of water-filled hose. To send energy to any part of the loop, we simply force the water in one part of the loop to begin flowing, and all the water in the entire loop must therefore flow as well. It acts like a drive belt. Might it be possible to break the circuit and use a straight-line hydraulic system? Can we send compression waves through the electrical "water" in the "hose" made of wire? Sure! That's what the G-line does. If we have a long hose with closed ends, we can send "sound waves" through the "water" of the hose, although we cannot create constant flowing DC as we can with the closed circuit hose-loop. These single-wire systems are inherently AC systems. They are analogous to sending sound energy along a fluid-filled tube.

Because there is only one conductor in the G-line, the "E" part of the EM wave must extend between successive lumps of net-charge which propagate along the wire. The "voltage" on the transmission line extends outwards as radial e-field flux, but rather than the flux connecting with a coaxial shield as it does in a normal cable, it curves around and connects with the opposite flux-lines which extend from another spot on the wire. The "M" component of the wave acts like the magnetic field around any normal wire: acting like circles which surround the wire. The energy flows lengthwise along the wire as is commonly shown by Poynting's vector (E x B).

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fig. 5 The e-field of the "G-Line", extending between propagating regions of opposite surface charge

So, here we have a one-wire transmission line based on transverse EM wave in space, and electron density waves within the wire. Inside the metal surface of that single wire, the electrons wiggle back and forth while the EM wave propagates outside at about the speed of light. It's almost like sound waves moving on the string of a tin-can telephone, but electrons take the place of those cellulose fibers, and the sound waves are replaced by transverse EM waves. But in the case of the "G-line," the energy gets stored in the EM fields connected to the electrons, rather than being stored in the kinetic energy and potential energy of the string.

How does this relate to Tesla? Well, once we have the ability to send energy along a single wire, we should also have the ability to send energy along any conductor at all, as long as that conductor has a dielectric coating. Like this:

fig. 6 "G-line" with large conductive lump

Any large, metallic hunk could be stuck in series with the "G-line". Yes, there might be wave-reflections where the thin wire connects to the big metal hunk. But that's beside the point. With the above setup, we can send waves along the surface of a conductive object, while within the object itself the "electron sea" vibrates longitudinally. Hmmm. Where have I heard *that* before? I know. Nikola Tesla's "World System," in which he intended to transmit usable electrical energy to any receiver anywhere on the Earth.

In the above diagram, suppose the "hunk of conductor" is the entire planet Earth! Suppose the "cone shaped" launchers are replaced with an elevated sphere which supplies a "virtual ground" reference capacitance? Suppose the frequency of the waves is below the UHF band in frequency? The entire Earth will then behave as a "G-line" single wire transmission system.

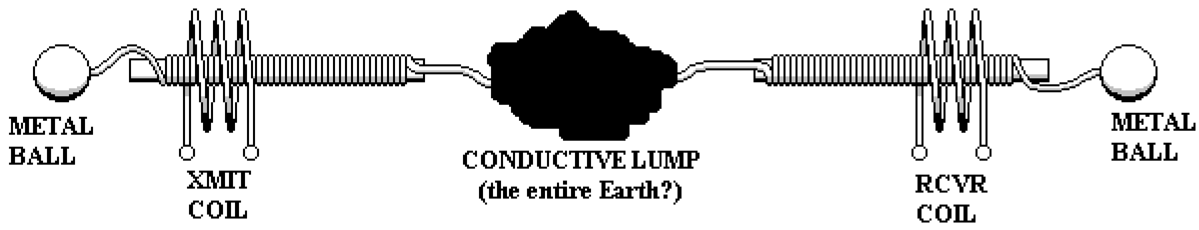

fig. 7 Tesla-coil-based "G-line" spans planet Earth

In his writings, Tesla was convinced that his devices did *not* use the same physics as Hertzian waves. He was right... and wrong. When radio- frequency energy propagates through empty space, the E and the M components are transverse, and the waves propagate at 90 degrees to both of them. However, when EM energy is sent along a cable, we also have electrons involved: the electron-sea within the metal wires. The electrons slosh back and forth in the cable while the EM waves flow along outside of the metal surfaces. Why is this important? Because the physics of a transmission line is the physics of the "near field" of a coil or capacitor, not the physics of freely-propagating "Hertzian" waves. When Tesla sent energy around the Earth, he was treating the Earth as an electrical cable. His waves were coupled to the charges within the surface of the Earth. He was not transmitting pure radio waves, even though the frequency of the wave-energy might be the same as any normal radio wave. Instead he was using a one-wire transmission system where the conductive Earth served as the wire. Tesla's technology used "near field" effects of coils, capacitors, and transmission lines, not the dipole antennas that Hertzian waves use, and in that sense his waves were "non-Hertzian."

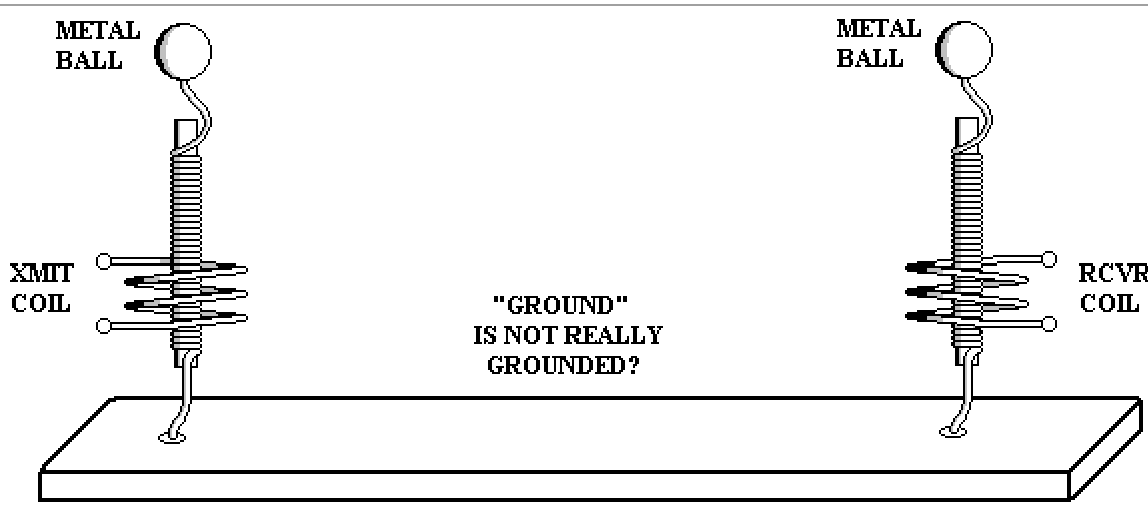

fig. 8 The ground acts as the transmission line

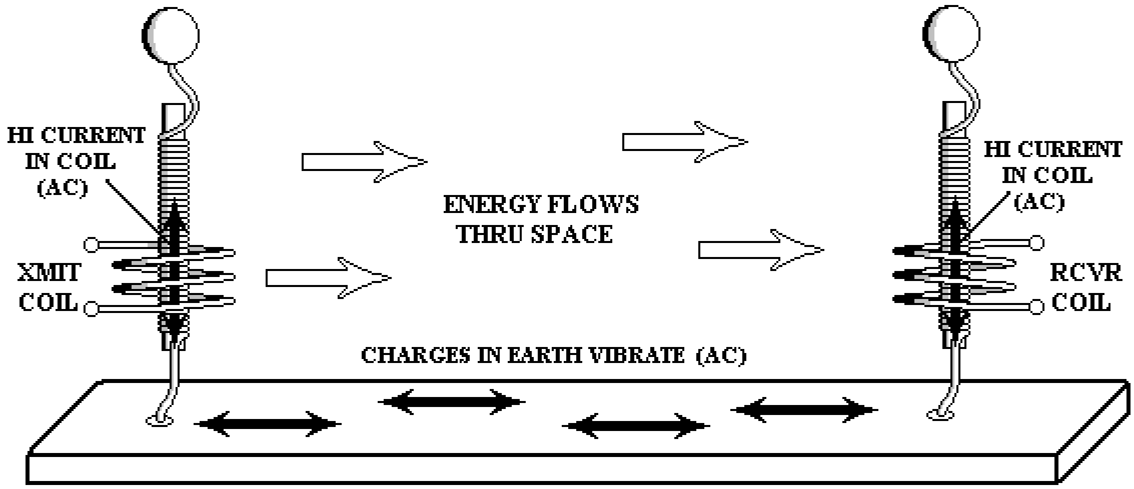

fig. 9 Charges vibrate, while energy flows sideways

But wait a minute. This stuff can only work if there is a dielectric substance coating the Earth. Without that coating, the waves will not slow and bend to follow the curve of the Earth, they will just fly out into space. The atmosphere supplies this coating, and the resistive earth also helps to slow the waves so they bend to follow the surface. And even better, there is a conductive ionosphere which will act a lot like the "shield" of a coaxial cable and force the waves to go around the Earth.

Tesla was using the ground as a transmission line. He was correct when he insisted that he was producing longitudinal waves in the "natural medium." He was correct in saying that the ground was not just a voltage reference. In this case the "natural medium" is the population of mobile ions in the dirt and oceans which cause the Earth act as a conductor. He was converting the Earth's surface into a "G-line" conductor. Any electrical device could intercept a portion of that energy, as long as that device was connected to the ground and to an elevated metal object.

So, what was Tesla's big mistake? Initially he did not realize that the Earth's atmosphere was critically important for his system to work. If the Earth had acted like a perfectly-conducting metal ball hanging in a vacuum, then Tesla's system would not have worked. The waves would have travelled along the ground and then shot straight out into space. His system would have been like a "G-line" with a sharp bend in the middle: except for a bit of diffraction, the waves refuse to follow the bend and instead go right off the cable and are lost. Because of the "dielectric" effect of the atmosphere, and also because a conductive ionosphere was present, Tesla's system was feasible. Yet any scientist of the time would "correctly" see that Tesla's system totally violates well-known theory. If Tesla had started out from known theory, he would never have pursued the path he did. Tesla actually started out with empirical observations that the Earth resonated electromagnetically like a struck bell. The atmosphere and the ionosphere made this so, but Tesla only knew that it worked, and he really did not know why, at least at first.

Tesla's other big mistake was in thinking that his wireless transmission system had nothing to do with "Hertzian" waves. In fact, the waves in a coaxial transmission line are not much different than the waves which fly off any dipole antenna connected to the end of that transmission line. Whether it is ruled by "near field" or "far field" equations, electromagnetism is electromagnetism.

Tesla's mistake was not really so big. Especially not a big mistake when compared to those contemporary scientists who were absolutely certain that the Earth *didn't* have any resonant frequencies, who *knew* that radio waves would not travel around the curve of the Earth, and who dismissed Tesla's wireless transmission system as crackpottery; as an unworkable violation of known physics. When "Schumann" VLF earth-resonance was rediscovered in the 1950s, nobody in the conventional sciences dared court the embarassment of admitting that Tesla had been right all along.

Tesla is mostly a hero among the non-scientist "underground," while in conventional circles he is still ridiculed for trying to distribute electric power without using wires, or rather, by sending it through the ground. Everyone (still) knows that this is impossible, even in theory.

Yeah, right.