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# SURFACE WAVES*

# AND THE 'CRUCIAL'

# PROPAGATION EXPERIMENT

by

K.L. Corum,† Brigadier General (Ret.) M.W. Miller, Ph.D,† and J.F. Corum, Ph.D.†

Texzon Technologies, LLC
202 I-35 N., Suite C
Red Oak, TX 75154

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* The Texzon technology described herein is Patent Pending.
† info@texzont.com

# SURFACE WAVES and *THE* 'CRUCIAL' PROPAGATION EXPERIMENT*

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***"This letter is to point out an <u>error</u> in sign in Prof. Sommerfeld's 1909 paper."*** **K.A. Norton, (1935)[1]**
***"There is <u>no sign error</u> . . . The famous 'sign error' is a <u>myth</u>."*** **R.E. Collin, (2004)[2]**

ABSTRACT

We consider a certain radial ground current distribution and, by employing a Hankel transform, derive the Zenneck surface wave (a non-radiating guided wave mode). We also report on its use in replicating the *'crucial'* Seneca Lake experiment of 1936, which had been used to vindicate the Sommerfeld sign error myth.

The two quotes above, separated by almost 70 years, draw attention to *"the great 20th century radio propagation controversy"*, and illustrate a striking flaw that many of us had believed and taught throughout our professional careers! While the confusion was resolved *analytically* by Professor R.E. Collin,[2] a seminal *experiment* had justified K. Norton's flawed analysis.[3] The experiment was conducted in 1936 by Dr. C.R. Burrows[4,5,6,7,8] of Bell Labs, and is, itself, famous as *"<u>the</u> crucial radiowave experiment"*.[9,10,11] It has demonstrated some surprises of its own. Details of this intriguing history are documented elsewhere.[12,13]

In 1907 Jonathan Zenneck took radiowave propagation into the 20th century by providing the first exact solution of Maxwell's equations in the presence of a lossy interface.[14,15] While Zenneck's field solution is exact, no source was specified and for many years it was considered to be spurious.[16,17,18,19] However, in 1979 Hill and Wait[20,21] analytically found an aperture distribution *that excites a pure Zenneck surface wave with <u>no</u> radiation field.* It excites the discrete mode of the Green function that launches a Zenneck wave (a transmission line mode) without exciting the radiation field! While Hill and Wait used an infinite vertical sheet of y-directed magnetic current on the y-z plane, we will employ a radial electric current in the cylindrical ρ-φ plane. Consider a radial surface current (parameters defined below),

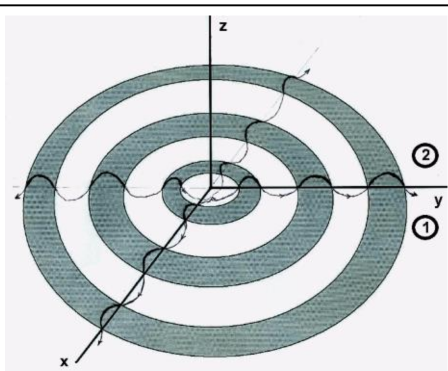


**Figure 1. Radial wave of surface current on the x-y (or ρ-φ) plane.**

$$J_\rho(\rho',\phi',0) \;=\; A\, H_1^{(2)}(-j\gamma\rho')\;\;\delta(z') \qquad (1)$$

($e^{+j\omega t}$ time variation). Let us assume that such a current density has been set up along the surface of the Earth, emanating from some injection point as shown in Figure 1. (This condition has been established in practice with the use of Texzon's field-matched surface wave probes.) By the generalized form of Ohm's law, such a current creates a *radial* electric field, over an equivalent circular aperture of infinite radius on the x-y plane, in the form $E_\rho(\rho',\phi',0) \;=\; Z_S\; J_\rho(\rho',\phi',0)$. The magnetic field for z ≥ 0 may be obtained by performing a <u>Fourier-Bessel</u>[22] (or Hankel[23,24,25]) transform of this circularly symmetric aperture distribution,[26,27]

$$H_\phi(\rho,\phi,z) \;=\; \frac{\gamma_o}{Z_o}\int_{\rho'=0}^{\infty}\int_{\lambda=0}^{\infty} J_1(\lambda\rho)\; J_1(\lambda\rho')\; e^{-u_2 z}\;\frac{E_\rho(\rho',0)}{u_2}\;\rho'\,d\rho'\,\lambda\,d\lambda \;,$$

* The Texzon technology described herein is Patent Pending.

which is a superposition of cylindrical wave equation eigenfunctions.[28] Rewriting Equation (2) gives

$$H_\phi(\rho,\phi,z) \;=\; A \int_{\lambda=0}^{\infty} \int_{\rho'=0}^{\infty} J_1(\lambda\rho)\, J_1(\lambda\rho')\, e^{-u_2 z}\, H_1^{(2)}(-j\gamma\rho')\,\rho' d\rho'\,\lambda\, d\lambda \;, \tag{3}$$

where the vertical and radial wave numbers, index of refraction, and characteristic impedances are: $u_2^2 = \lambda^2 + \gamma^2$; $\gamma = \dfrac{j n k_o}{\sqrt{1+n^2}}$; $n = \sqrt{\varepsilon_r - j\sigma/\omega\varepsilon_o}$; $Z_o = \dfrac{k_o}{\omega\varepsilon_o}$; $Z_S = \dfrac{u_2}{j\omega\varepsilon_o}$. Recall that a Hankel function with a complex argument may be expressed in terms of the *modified Bessel function of the second kind*, so that the ρ' integration reduces to a tabulated integral.[29] We are then left with the following expression

$$H_\phi(\rho,\phi,z) \;=\; \frac{-2A}{\pi} \times e^{-u_2 z} \int_{\lambda=0}^{\infty} J_1(\lambda\rho)\; \frac{\lambda^2}{\gamma(\lambda^2+\gamma^2)}\; d\lambda \;. \tag{4}$$

Sommerfeld pointed out that such integrals, "… suffer from a certain *'mathematical inelegance'*: they are integrals with the fixed initial point λ = 0, not integrals along closed paths in the [complex] λ-plane, which, due to their deformability, would be much more useful."[30] Following Sommerfeld, this flaw is removed by employing the reverse identity[31,32,33] $J_q(\lambda\rho) \;=\; \frac{1}{2}\left[H_q^{(1)}(\lambda\rho) \;+\; H_q^{(2)}(\lambda\rho)\right]$, to give

$$H_\phi(\rho,\phi,z) \;=\; \frac{-A}{\pi} \times e^{-u_2 z} \int_{\lambda=-\infty}^{\infty} H_1^{(2)}(\lambda\rho)\; \frac{\lambda^2\, d\lambda}{\gamma(\lambda^2+\gamma^2)} \;, \tag{5}$$

which is an integration from -∞ to +∞, thus satisfying Sommerfeld's "elegance" criterion. (The path of integration on the complex λ-plane can now be deformed into a semi-circle of infinite radius.) The integrand of Equation (5), call it *f(λ)*, is a function of the complex variable λ, with singularities (the roots of the denominator are simple poles, $\lambda_s$) at $\lambda = \lambda_s = \pm j\gamma$. One may use Cauchy's Residue Theorem and integrate over a semicircle of infinite radius on the lower half plane with the straight path along the real axis. See Figure 2. The contour direction is clockwise for causal waves with $e^{+j\omega t}$ time variation and Cauchy's Residue Theorem gives the value of the integration as -2πj times the sum of the residues, where the minus sign is present for a clockwise integration contour in the lower half plane.[34,35,36] For simple poles the Residue of the complex pole of the integrand at $\lambda = \lambda_s$ is $\text{Res}\,(\lambda_s) = \left[(\lambda - \lambda_s)\, f(\lambda)\right]_{\lambda=\lambda_s}$. The residue at the integrand's pole, λ = -jγ, gives the surface-guided *wave mode*

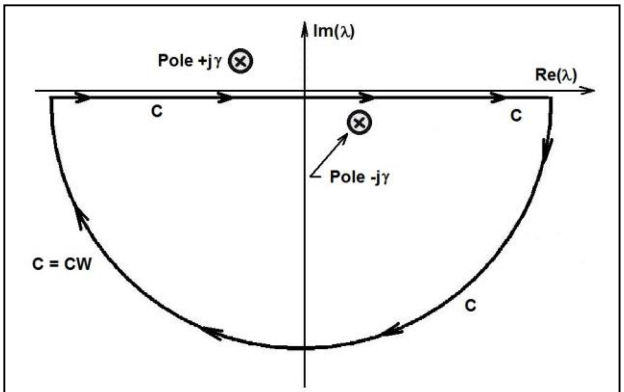


**Fig. 2. Integration contour C on the complex λ–plane for $e^{+j\omega t}$ time dependence.**

$$\text{Res}\,(-j\gamma) \;=\; H_1^{(2)}(-j\gamma\rho)\; \frac{(-\gamma^2)}{\gamma(-2j\gamma)} \;=\; \frac{1}{2j} H_1^{(2)}(-j\gamma\rho) \;. \tag{6}$$

Note that the pole is extremely close to the real axis.* The residue at the captured pole gives only the Green function's *discrete-mode* component[37] as a φ-directed magnetic field strength (with zero radiation field[38])

$$H_\phi(\rho,\phi,z) \;=\; A\, e^{-u_2 z}\, H_1^{(2)}(-j\gamma\rho) \qquad\qquad \text{(for } z \geq 0\text{)} \tag{7}$$

*With $\varepsilon_r = 8$ and σ = 0.0006, for f = 1.85 MHz, γ = 0.0001 + j 0.037. The poles of the integrand are at λ = ±jγ. Notice how close to the real axis the critical pole at -jγ is located! Note that the real part of $\lambda_s$ is less than $k_o$ (∴ a fast wave).

which, while propagating as a *radial transmission mode*, is evanescent (exponentially decreasing) in the +z-direction: a Zenneck surface wave. The components of the electric field for z > 0 may be found directly from Maxwell's equations (actually Ampere's law for time-harmonic fields), $\vec{E} = \frac{1}{j\omega\varepsilon_o} \nabla\times\vec{H}$ , as

$$E_\rho(\rho,\phi,z) = A\left(\frac{u_2}{j\omega\varepsilon_o}\right)e^{-u_2 z}\, H_1^{(2)}(-j\gamma\rho) \tag{8}$$

$$E_z(\rho,\phi,z) = A\left(\frac{-\gamma}{\omega\varepsilon_o}\right)e^{-u_2 z}\, H_o^{(2)}(-j\gamma\rho) \quad . \tag{9}$$

Equations (7)-(9) are Zenneck's solution above ground in cylindrical coordinates.[39,40,41,42] The $E_\rho$ and $H_\varphi$ both vary as the Hankel function $H_1^{(2)}(x)$ but have a complex phase relation because of the coefficient of $E_\rho$. And, since $E_z$ varies as the Hankel function $H_o^{(2)}(x)$, it would be in simple phase quadrature with $H_\varphi$ (at least for the regions out beyond the point where large argument asymptotes predominate over small argument asymptotes). For the case of small losses (and real coefficients), Zucker has pointed out that,

> "… the first two components [$H_\varphi$ and $E_\rho$] carry all the power along the interface, while $E_z$ and $H_\varphi$ form a vertically pulsating storage field."[43]

The wave impedance is resistive for $S_z = -E_\rho H_\varphi$ and reactive for $S_\rho = -E_z H_\varphi$. The expressions for **E** and **H** are Zenneck's *surface wave*. If one can synthesize ground currents as given by Equation (1), they will launch a radially propagating Zenneck wave (a guide mode similar to the ***zero-phase-sequence*** of power transmission line experience[44]) with ***no Hertzian radiation or Norton ground-wave radiation*** *whatsoever!*

We mark the dissimilarity between the Zenneck *surface wave* (which is a transmission line mode) and the Norton *ground wave* (which is a radiation mode).* Stratton points out that they are not the same.[45] The distinction follows directly from the Green function solution of the wave equation and is related to complex-plane *singularities* and the dissimilarity between the eigenvalues of *continuous-mode* radiation fields (from antennas) and the *discrete-mode* guided fields[46,47] existing in waveguides and on transmission lines. The comments by Friedman[48] in his classic text go directly to the heart of the matter.[49,50,51]

**(1)** The *continuous* part of the eigenvalue spectrum (corresponding to *branch-cut integrals*) produces space waves (radiation).

**(2)** The *discrete* spectra (and corresponding *residue sum* arising from the poles enclosed by the contour of integration) result in traveling waves that are exponentially damped in the direction transverse to the propagation. (These surface waves are "guided transmission line modes", i.e. - *"non-Hertzian waves"* propagating *without* radiation. The only flow of energy normal to the interface is that required to supply media losses.[42])

Much more could be said at this point. But, instead we now turn to the implications for Burrows' 1936 Seneca Lake experiment and our September 2014 replication of it.

## The Famous Seneca Lake Experiment

The formal analysis of *wire-waves* was first supplied by Sommerfeld[52] in 1899, and this laid the foundation for his famous 1909 paper on doublet radiation above the earth. The mystery to be solved was as follows:

* Following historical convention, we use the terms *"ground wave"* and *"surface wave"* to identify two *distinctly different* physical phenomena. They arise from distinctly different features of the Helmholtz equation's Green function, and are as markedly *dissimilar* as "Hertzian waves" (radiation fields) are from *transmission-line* modes (guided waves). The former fall off *geometrically*, while the latter attenuate *exponentially* (as can be seen in Fig. 4).

> "With which type are wireless telegraphy waves to be identified? Are they like Hertzian waves [radiation] or are they like [guided] electrodynamic waves on wires? . . . The main task of the present investigation is … to settle the question: *space waves* or *surface waves*?"[53]

What is intriguing though, is that a surface wave similar to that obtained hypothetically by Zenneck in 1907 appeared to emerge in Sommerfeld's 1909 paper, this time from a specific incremental radiating source geometry. In 1919 Hermann Weyl developed a propagation solution by an alternative technique which complemented Sommerfeld's 1909 solution.[54] However, while Weyl's solution, much like Sommerfeld's, can be interpreted as the superposition of a space wave plus a ground wave, Weyl's *ground wave* is not the same as the *surface wave* of Zenneck and Sommerfeld,[55,56,57,58,59] which arises from a discrete *pole* and propagates as a guided wave.[60,61,62] The integration path in Weyl's solution fails to capture the Sommerfeld-Zenneck pole and leaves only what later became known as the *ground wave* of Norton, Burrows, Niessen and Van der Pol. At intermediate ranges the predictions of Sommerfeld's 1909 formulas did not agree with either reported measured field strengths or the calculations from Weyl. The discrepancy was, according to Van der Pol ('that grand old man of radio'), *"…of foremost interest to almost every nation."*[63] A conference was held at Bell Labs in 1935 to determine which theory was correct, and the conference attendees were faced with a dilemma in that *they could find no error in either Sommerfeld's or Weyl's analysis*.

> "After a half-day conference …was unsuccessful in finding the source of any *error* in either paper [Sommerfeld (1909) or Weyl (1919)], Dr. Fry suggested the <u>experimental approach</u>."[64]

Then, in June of 1935 Norton published a letter in Nature[65] alleging that there was *"an error in sign"* in Sommerfeld's 1909 paper, which, without identifying, he asserts to have corrected. (What it did was eliminate Zenneck's surface wave from the Sommerfeld integral.) Collin's review of the assertion says,

> "In 1937 Niessen published a paper[66] in which he also claimed that Sommerfeld had made a sign error in his 1909 paper. According to Niessen, the sign error came about because Sommerfeld did not take the value of the angle of the square root of a complex number using the convention that this should always be taken to be between 0 and 2π. … *Niessen's argument was not a valid one*. … this explanation was widely accepted and has been propagated throughout the technical literature from that time forward. … *What both Norton and Niessen had observed was that by a simple change in sign* – in the square root of a parameter called the numerical distance – they could provide a ***quick fix*** to Sommerfeld's 1909 solution *that would bring his solution into conformity with that of later workers*. … From a mathematical perspective, a change in sign of Sommerfeld's closed-form expression for his solution is *not allowed*, and Norton's and Niessen's assertions are *not* acceptable."[67]

In 1936 the experiment suggested by Dr. Fry was conducted by Burrows[68] at New York's Seneca Lake.[69] A graph of the measurements did not exhibit any Zenneck *surface wave* behavior, but rather indicated that the propagation launched from a simple cylindrical antenna is a *Norton ground wave*.[70] (See curve 2 in Fig. 3.) Norton took this as an experimental *confirmation* of his Sommerfeld sign error 'discovery' and wrote,

> "Some recent experimental results obtained by C.R. Burrows and described in a letter to Nature [August 15, 1936] substantiate [my] theoretical ground-wave formulas and graphs.[71]

[According to a 1962 account by Burrows it was actually *Rice and Niessen* that discovered the mathematical error in Sommerfeld's work … and that this was done *after* the crucial experiment had been performed:

> "*Later* Rice and Niessen independently found the source of the error in Sommerfeld's work – the incorrect choice of the square root of a complex quantity in an intricate mathematical derivation."[72]

This account is at variance with the conventionally accepted story that it was Kenneth Norton (and some say K.F. Niessen) who first identified the asserted sign error in Sommerfeld's 1909 paper.]

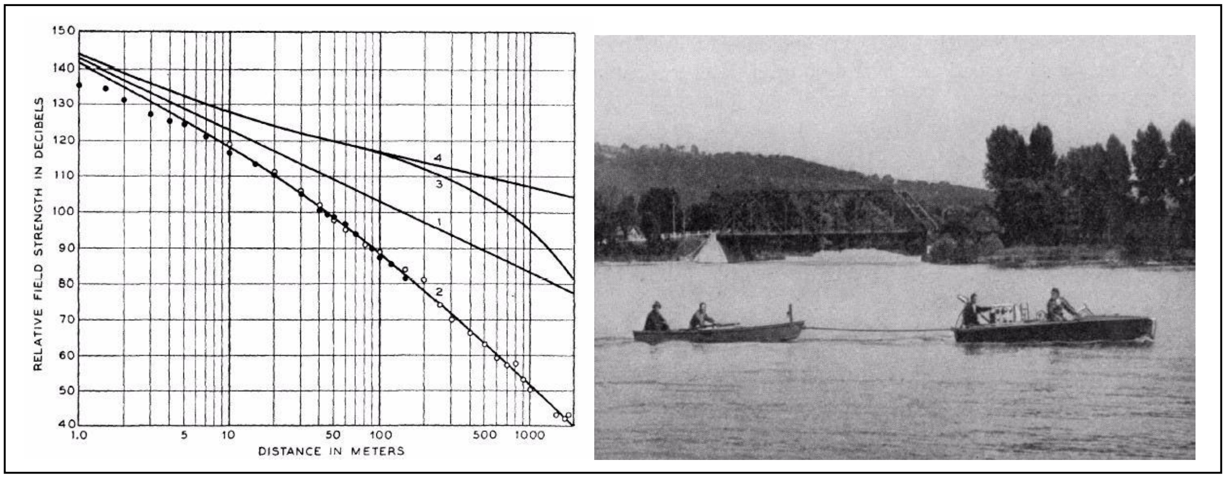


**Fig. 3. Burrows' 1936 measured Seneca Lake data over a range from 1 m to 2 km. Curve (1) is the lossless inverse field (Hertz). Curve (2) is the van der Pol-Norton *ground wave* over a lossy medium (Seneca Lake) with measured data. Curve (3) is the Sommerfeld-Zenneck *surface wave* over a lossy medium (Seneca Lake). Curve (4) is the lossless dielectric surface wave. Curve (1) (the "inverse field") varies as 1/r. Curve (4) varies as 1/√r. Burrows used a dipole antenna at 150 MHz.[73]**

In 1950, Kahan and Eckart wrote,

> "The discrepancy between the experimental points and curve 3, which is a plot of Sommerfeld's formula, is so great that there can be no doubt as to the incorrectness of the latter . . . the Sommerfeld curves predict a field strength about 100 times that measured by Burrows."[74]

With observational difference in excess of 40 dB (at 150 MHz), Burrows now seemed to have decisive *experimental* evidence to resolve the analytical dilemma. Burrows interpreted these results as follows,

> "…*the crucial experiment* showed that Weyl's formulation was correct and that the surface wave of Sommerfeld did not exist."[75]

We thought it would be constructive to repeat Burrows' experiment at Seneca Lake. When we used a conventional vertical half-wave dipole we obtained Norton's groundwave radiation curve for the constitutive parameters that we measured in situ at 52 MHz ($\varepsilon_r$ = 82.5, σ = 0.067).[*] However, when we repeated the experiment with a field-matched surface-wave probe we observed just the opposite effect, as seen in Figure 4. The dominant field contribution was consistent with that predicted by Zenneck theory *not* Norton. Our experiment was conducted on September 4, 2014 from the docks at "The Anchor Inn and Boat Rental" on Salt Point Road, two miles north of Watkins Glen on the west shore of Seneca Lake. The transmitter and antennas were set up on the Inn's wharf, and a rented motor-boat was used from which to perform field strength measurements out on the lake, just as Burrows had done in 1936. Location identification was made with a GPS receiver. We took data all over the Southern end of the lake. By making our structure very small we have averted the radiation problem in a practical sense. (The radiation resistance of our launching structure is brought as near to zero as practicable, leaving only incidental systematic resistive losses.) For us, the *Zenneck surface wave* predominates over any *Norton ground wave* (which, in fact, is barely present for short probes lacking extensive ground systems).

[*] Burrows reported that $\varepsilon_r$ = 82.2 and σ = 0.045 mhos/m were measured for Seneca Lake water in the summer of 1936. Today the US Coast Guard asserts that σ = 0.065 near the north-end of the lake.

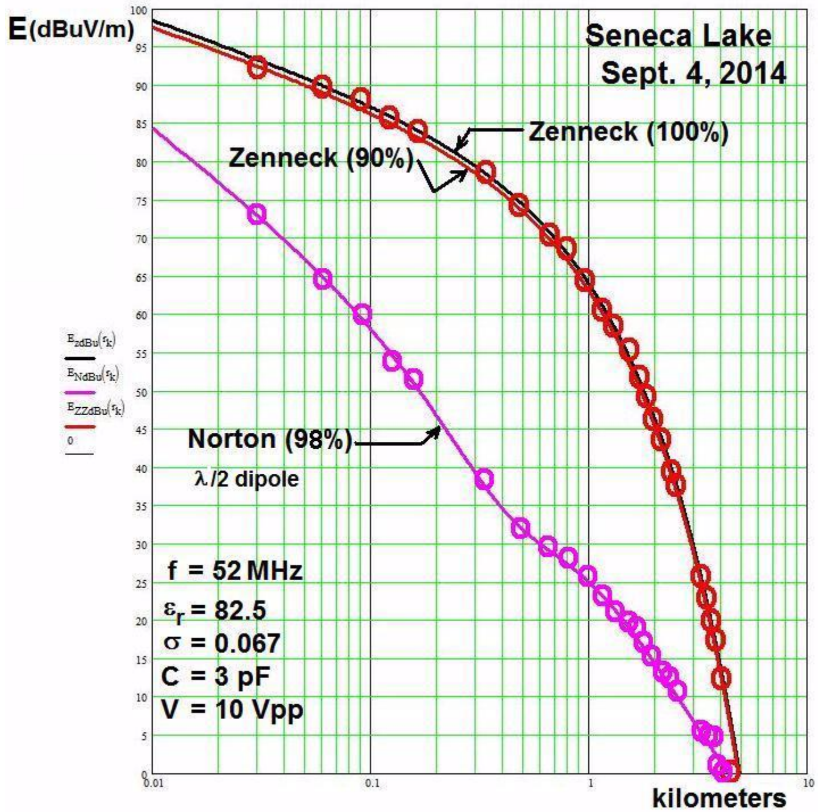


**Fig. 4. Theoretical predictions (curves) and measured data (circles) for our Seneca Lake experiment. The units are dBμV/m vs. km. [dBμV/m = 20 log $E_{mV/m}$ + 60 dB] We performed the experiment at a wavelength of 5.77 meters (52 MHz), while Burrows operated at a wavelength of 2 meters (150 MHz). Data was taken with a NIST traceable calibrated Potomac Instruments FIM-71 field strength meter.**

The Burrows/Norton opinion became a presupposition in academia, and guided 20th century scientific thought for almost 70 years. In 2004, Collin pointed out that there was no sign error, the Sommerfeld solution was correct, and even his integral approximations are fine … they just restrict application of his expressions to regions far out (at large numerical distances). And, in this region the solutions of Weyl (whose integration does not capture the discrete pole) and Sommerfeld are identical. Collin remarked,

> "… both Norton's and Niessen's manipulations of Sommerfeld's solution and *claiming that an error in sign had been made* has no merit. Sommerfeld's first solution is given by his asymptotic series plus the Zenneck surface wave. His second solution[76] is given by a power series, which is consistent with his first solution. … There are inherent *limitations* in Sommerfeld's [post-integration] solution, but they are *not* caused by a sign error."[77]

In spite of the fact that Burrows' Seneca Lake experiment did not satisfy the large numerical distance *restriction* on field strength calculations, it was *unjustifiably* used to substantiate the Norton-Niessen-Burrows assertion of a "Sommerfeld sign error". Prof. Collin has made the striking conclusion,

> "The sign error that has been claimed in the technical literature for more than 65 years *is a myth*. … in spite of the long-held belief, Sommerfeld did *not* make a sign error in his 1909 paper. … There is no sign error . . . *The famous sign error is a myth*."[77]

The tragedy is that the opportunity for practical *terrestrial* surface wave excitation and the possibilities for Zenneck wave wireless power distribution were missed altogether in the 20th century.

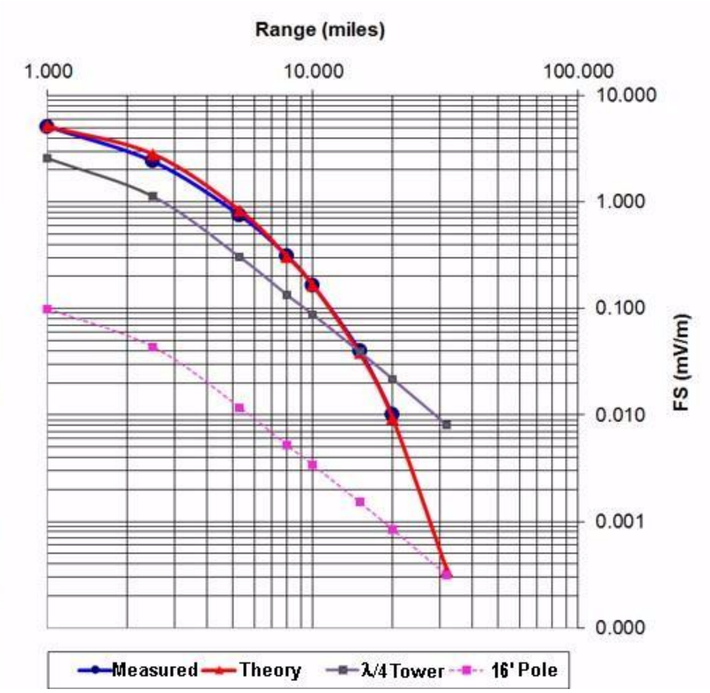


**Photo 2. The 4.9 meter 1.82 MHz surface wave probe and field strength measurements (out to 20 miles) compared with predicted fields for Zenneck, a λ/4 tower (with 120 radials), and the actual Norton vertical stub with only an 8 ft. ground rod at the base of the pole. [2/12/2016: C = 45 pF, $V_{RMS}$ = 42.4 volts, $\varepsilon_r$ = 15, σ = 0.012, $R_g$ = 35 Ω. For radiation: h/λ = 0.030, $R_r$ = 1.38 Ω, $\eta_r$ = 3.8%.]**

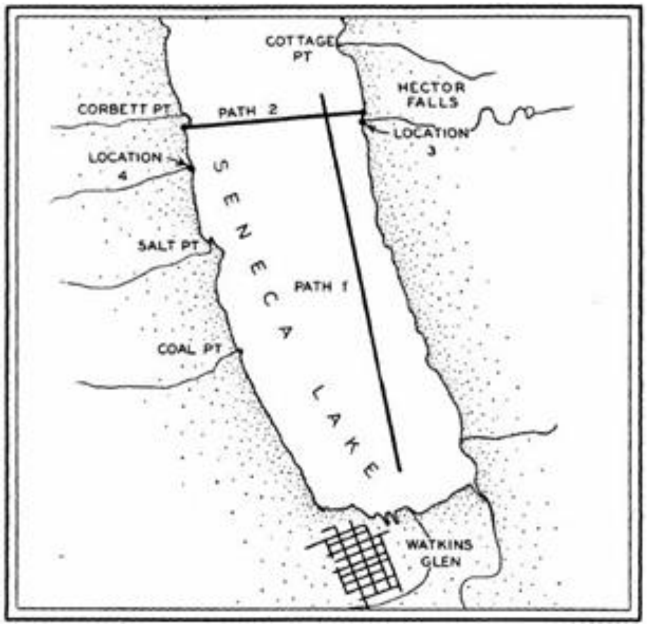


**Photo 3. Propagation paths on Seneca Lake used by Burrows in 1936. In 2014 Corum used path 1. The photo shows the Zenneck probe (the small golden doublet, left side) mounted at six feet, and the conventional 52 MHz vertical λ/2 dipole with a Guanella balun mounted at 10 feet (right side). Our 2014 data is shown in Figure 4, above. The Texzon technology described herein is Patent Pending.**

## AUTHOR BIOSKETCHES

**Dr. James F. Corum** (Ph.D. in Electrical Engineering, Ohio State 1974) is a Life Senior Member of the IEEE, an Emeritus Life Member of the American Association of Physics Teachers, and listed in *Who's Who in Engineering* and *American Men and Women of Science*. He served in academia for 18 years on the engineering/physics faculties at several universities, and as Senior Scientist, Research Leader, and Chief Scientist for a number of technology corporations. He has consulted for industry and dozens of government agencies, and is currently President of National Electrodynamics. Dr. Corum is the authentic inventor of the contra-wound and cross-wound Toroidal Helix Antenna technologies (1972, 1981, 1986, 1988), the 60 Hz Ring Power Multiplier (1998, 2003, 2009, 2013), and the Polyphase Surface Wave Probe (2013, 2014, 2015), and holds several dozen patents. He has authored over 125 technical papers and reports, and his principal publications are on Antennas, Microwaves, and Relativistic Electrodynamics. While study manager for the DARPA National Panel of Radar Experts in 1990, Dr. Corum was cited as a "National Treasure" by the Office of the Secretary of Defense.

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**Kenneth L. Corum** (B.A. in Physics, Gordon College 1976; Engineering graduate studies at U. Mass.) Mr. Corum taught digital techniques, and software engineering for Compugraphics, ATEX/Kodak, Hewlett-Packard and Sun Microsystems. He was Director of the Commercial Satellite Division of Pinzone Communications in Cleveland, OH. He was Staff Consultant for Sun Microsystems (now Oracle) in Burlington, MA and taught industrial software courses in England, France, Germany, Latvia, Switzerland, the Netherlands, Russia, India, China, and Chile, as well as across the US and Canada. Mr. Corum is currently Chief Scientist for TEXZON Technologies in Red Oak, Texas. Mr. Corum holds several domestic and foreign patents. He is the discoverer of the *modulated common-mode Radar-backscatter phenomenon from baseband differential-mode nonlinear systems*. He also discovered and documented the Trichel pulse excited VCO (Voltage-Controlled-Oscillator), and the 2-frequency RF-injected parametric regenerative mixer/detector technique employed by Mahlon Loomis in his 1865 RF experiments. His fundamental work on slow-wave helical resonators and Tesla's laboratory generation of ball lightning was published in *Uspekhi* by the Russian Academy of Sciences in 1990. This electric fire-ball phenomenon was recently experimentally replicated by the Russian Academy of Sciences in Moscow and Troitsk in 2012. His most recent activity involved a modern replication of C.R. Burrows' 'crucial' Seneca Lake measurements and the experimental verification and NIST-traceable documentation of Tesla's 1897-1899 (Zenneck mode) surface wave propagation phenomenon. He spoke by invitation at Belgrade and Novi Sad as a guest of the Serbian Academy of Sciences and Arts in 1993. He is listed in *American Men and Women of Science*, and other dictionaries. He received the 1915 *Tesla White Dove Award* at the International Global Forum in Serbia.Over 100 patents are now pending or applied for on the new technology.

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**Brigadier General (Ret.) Michael W. Miller** (B.A. University of New Orleans 1981; MBA University of North Dakota 1988; Ph.D., Walden University 2011.) General Miller was commissioned as a second lieutenant in 1984. The first six years of his career were spent in the field of space and missiles. He rose through the ranks with many major awards, decorations and achievements, and was ultimately promoted to Brigadier General (USAF, 2009). General Miller has served at Headquarters Air Force Materiel Command as the Chief of Financial Management in the Office of the Command Surgeon. He has also served at Headquarters U.S. Air Force as the Chief of Medical Manpower Division as well as the Deputy Assistant Surgeon General for Medical Plans and Programs. General Miller served in the Office of the Surgeon General as the senior executive and Director of Staff. He is board certified and has achieved Fellow status with the American College of Healthcare Executives. General Miller holds a Ph.D. in Management, with a specialization in Information Systems Management. He was Assistant Surgeon General, Strategic Medical Plans, Programs and Budget, and Chief of the Medical Service Corps, Office of the Surgeon General, Arlington, Va. General Miller was responsible for the execution of the Air Force Medical Service's $5.8 billion annual budget supporting the activities of 43,000 personnel serving 2 million beneficiaries through 75 medical treatment facilities worldwide. General Miller was the senior health care administrator in the Air Force, responsible for accessions, development and management of 1,100 health care administrative professionals in the corps. Dr. Miller is now *President and CEO* of TEXZON Technologies (Red Oak, TX), Professor in the College of Business and Education at SAGU (Southwest Assemblies of God University, Waxahachie, TX), and Member of the SAGU Board of Regents.

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