THE
"PHILADELPHIA EXPERIMENT"

by

Anonymous, Ph.d's. *

"Can we learn to think in 4-dimensions? This, and *negative time*, involve dreaming of the wildest sort, with no support whatsoever as yet from anything we see or record on our delicate instruments."

Vannevar Bush,
March 2, 1967

"Gentlemen,.... we are facing a crises such as the world has never seen before [WWI], and until the Situation clears, the best thing we can do is to devise some scheme for overcoming the submarines, and that is what I am doing now. (Applause)"

* Ph. d's who wish to remain anonymous

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ABSTRACT

In this paper we follow the thread leading from Tesla's spinning "***Egg of Columbus***" demonstration, through his proposal of a large rectangular helix disposed about the hull of a ship for U-boat detection, to Arnold Sommerfeld's discussion of magnetically biased ferrite's creating electromagnetic stealth for WW-II submarines. By calculation, the required magnetic field to reduce a ship's radar reflection to less dm 1%, at L-Band (1.5) GHz, is in excess of 15,000 A/m. Fields of this order of magnitude would appear to fulfill the requirements of a "Philadelphia Experiment". Such intense fields would create a green mist and cavities in salt water, and magnetophosphenes and Purkinje patterns in humans, particularly if driven at frequencies in the range of 10 - 125 Hz, as was available from the synchronous generators on WW-II electric drive ships. It can be concluded that with the knowledge available, the DSRB (under Vannevar Bush) would have been derelict not to have conducted such an experiment.

Finally, we present speculation on temporal bifurcation's. Assuming Hehl's hypothesis that localized Cartan Torsion tensors are generated by ferromagnetic spin, we propose two physical experiments, which distinguish temporal anisotropy arising from anholonomity (the Sagnac effect) from that arising in the torsion of the 1929 version of the unified field (Eddington's "crinkled manifold").

Disclaimer

This paper stands unique among our publications both on Tesla and on the conventional aspects of electromagnetism and relativity. In this regard it is partly speculative. (And, only partially at that, since we report on some of our experimental findings that can be verified by independent laboratory examination). Before wading too deep into a controversial subject like that before us, it is common for respectable folk to acknowledge their limitations. We need to make some kind of professional "disclaimer". Let us express it this way: we offer this little study in the spirit of an engineer and some physicists having some fun [in the sense of Arthur Eddington, [1] [2] Joseph Slepian, [3] Jearl Walker, [4]** Edwin Abbot, [5] George Gamow, [6] or even Arthur C. Clark], looking at published statements, attempting to stay within the bounds of engineering technical propriety, and saying, "What if ... ?" Since the theoretical analyses make specific physical predictions, it follows that our assertions can be experimentally examined by disinterested (but technically qualified) third parties, and that we haven't strayed too far from the scientific method in our amusing pastime. Taken in that spirit, our passing entertainment should also provide recreational diversion for skeptics, grad students, the lunatic fringe, engineers, and men of honor.

* Slepian wrote a delightful series of "Electrical Essays" for engineers. Start with the one cited and read either forward or backward several years.

** Walker wrote about physics problems, "I am not so interested in how many you can answer as I am in getting you to worry over them."

RADAR AND ROTATING FIELDS

INTRODUCTION

During the 1992 International Tesla Symposium, the authors took the opportunity to once again visit the site of Tesla's Colorado Springs laboratory and nearby Prospect Lake, where many of Tesla's experiments were conducted in 1899. While walking around the Monument in War Memorial Park our conversation turned to the book by William Moore and Charles Berlitz on the Philadelphia Experiment. A colleague at Battelle had introduced us to the story in fall of 1989. One of the presentations at the last ITS Symposium concerning the topic, and as we walked we began to ponder out loud how we might rationally and explain such an experiment.

The following is the result of our reveries:

The world of magnetics, today is extremely complex. During the 1940's and 50's high field magnetics became "big physics", and it would be impossible for the authors in this small space to even attempt a modem analysis of this topic. Instead, we believe that there is some merit to employing the sort of physical arguments, both classical and relativistic, that would have been available by scientists of the decade preceding the Philadelphia Experiment. This is not a discussion of anything even remotely like the Navy's new "Sea Shadow". [(7)]

It has been asserted that the initial Philadelphia Experiment took place "sometime between July 20th and August 20, 1943." [(8)] Simply put: in the experiment(s) a big coil of wire was wrapped around a large ship, the ship became invisible in a foggy green mist, and a lot of people on board were hurt. (Some thought they went through a rip in the fabric of the space-time continuum, were teleported from the Philadelphia shipyards to Norfolk Virginia, and saw alien humanoids). The respected names identified with the experiment include:

Albert Einstein (1879-1955)
* Rudolph Ladenburg (1882-1952)
John Von Neumann (1903-1957)
David Hilbert (1862-1943), (John Von Neumann's Gottingen dissertation advisor)
Nikola Tesla (1856-January 7, 1943),
Oswald Veblin (1880-1960),
Burtrand Russell (1872-1970),
Gabriel Kron (1901-1968),
Vannevar Bush (1890-1974)

As well as, a host of other recognized men of renown, whose common interest seems to include, among other things, a historical association with things of interest to the Navy, and submarine detection in particular. The Department of the Navy has officially identified the experiment as mythical, having its genesis in a 1955 book on UFO's, [(9)] not Naval science. [(10)] Perhaps the story really was mythological. However, if that's the case, then our hats are off to the brilliant scientists that spun this gossamer web of fantasy for no ordinary laymen could have done it.

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* Einstein served as a consultant for the R&D Division of the US Navy Bureau of Ordnance from May 31, 1943 ~ June 30,1946. Interestingly, according to the FBI, Einstein file [QC 16 ESU55; OCLC #13720407; Title #3892869], Einstein was in Philadelphia during the time of the alleged Philadelphia Experiment. (On the evening of August 10, 1943 he spoke before the Philadelphia section of the "Friends of Soviet Russia".)

Why Tesla?

It is now common knowledge that Tesla had attempted to market his radio controlled craft (the "telautomaton"; Patent* 613,809) to the US Navy.** [(11)] [(12)] Tesla was the first to advocate the electric drive for naval vessels. [(13)] He was the first to suggest that electric drive war ships could be used in peacetime to supply shore power during emergencies. [(14)] (They were, of course; See the comments below). And, as is evident from Tesla's quote at the top of this article, he was again dealing with the Navy during World War I. It was during this time that he met in Washington with Assistant Secretary of the Navy Franklin Delano Roosevelt.

Roosevelt's mentor, Josephus Daniels, was Secretary of the Navy.*** (It was also during this time that adversity professor and future Director of OSRD (Office of Scientific Research and Development), Vannevar Bush, was just starting research on submarine detection for the Navy.) From Tesla's files, we know that a few years later, during 1929, the Navy in Philadelphia (specifically John B. Flowers, Electrical Engineer), was examining Tesla's work. Anderson has noted that, "Tesla was engaged... at the E.G. Budd Mfg. Co. in Philadelphia from 1925 ~ 1926."[(15)] And, we also know that when Tesla died in 1943, Naval Intelligence officers accompanied NIT EE Professor John G. Trump (a Bush colleague also in the employ of OSRD), as he secretly examined Tesla's papers.

We think that not only can the Philadelphia Experiment be tracked to statements, which Tesla published during World War I, and were grasped by men like Bush, but that the physics of the experiment can actually be traced back to Tesla's invention of the rotating magnetic field. Furthermore, to us there appears be a legitimate link between Tesla's rotating fields and the Torsion tensor, which appears in Einstein's 1927-29 Unified Field Theory publications. This connection was first identified and published by Gabriel Kron at GE (Schenectady) during the 1930's.

Return with us now to 1887 and Tesla's first rotating field patent (#381,968; Applied for October 12, 1887; Issued May 1, 1888).

Polyphase Currents and Rotating Fields

The creation of the rotating magnetic field was "purely the work of scientific imagination". It has been identified as the greatest creation of the human mind since the invention of the wheel. Tesla's discovery of polyphase currents and "an invisible wheel made of nothing but a magnetic field" (the phrase is due to Reginald Kapp) [(16)] this was the turning point from the past, into the 20th century. Tesla stands at the focal point of the important electrical discoveries of the 20th century. At the conferral of the AIEE's highest award of honor, B.A. Behrend remarked;

> *"Were we to seize and to eliminate from our industrial world the results of Mr. Tesla's work, the wheels of industry would cease to turn, our electric cars and turns would stop, our towns would be dark, our mills would be dead and idle."* [(17)]

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* For which Tesla has been identified as the Father of robotics.

** In 1916 Tesla said, "I vainly attempted to persuade them to accept. I perfected the machine in 1898, and tried everything in my power, to have it adopted... After the patent expired a few months ago Congress appropriated [$750,000] and I have now the pleasure of simply looking on while others are using my inventions, which I could not persuade people to adopt. This is usually so." [Anderson, 1992, pg. 19.] "I tried to persuade the Navy... it was absolutely impossible to find listeners..." [Anderson, 1992, pg. 158.1

*** Both Daniels and FDR advocated absolute legal control of the electromagnetic spectrum by the Navy.

When Tesla died in 1943, Yale University EE professor Charles F. Scott observed;

> *"The evolution of electric power from the discovery of Faraday in 1831 to the initial great installation of the Tesla's polyphase system in 1896 is 'undoubtedly the most tremendous event in all engineering history."* **[18]**

And, the connection to the relativity of rotation (an issue still not put to rest today) was not overlooked: Yale physicist Leigh Page once said;

> *"The rotating armatures of every generator and every motor in this age of electricity are steadily proclaiming the truth of the relativity theory to all who have ears to hear."* **[19]**

Let us follow this central thread that runs through Tesla's professional career back to its origin.

While Tesla had constructed the first rotating field apparatus in the summer of 1883 (one year before both he, and the Statue of Liberty, arrived from France), it was not until 1887 that a company was formed to exploit the phenomenon. However, Tesla was unable to raise capital to commercially introduce his invention. (The enterprise was 'undercapitalized.) He finally found a skeptical Wall Street lawyer that was somewhat interested, and this is the conversation as Tesla retells it.

> **Tesla:** *"Do you know the story of the Egg of Columbus? ... Well, what if I could make an egg stand on the pointed end without cracking the shell?"* "If you could do this we would admit that you had gone Columbus one better." "And would you be willing to go out of your way as much as Isabella?" "We have no crown jewels to pawn," said the lawyer, who was a wit, "but there are a few ducats in our buckskins and we might help you to an extent."* **[20]**

Tesla arranged for a demonstration the next day. He placed a copper-plated egg on a wooden plate above his rotating magnetic field (there is a photograph of the apparatus in the Secor article). As soon as the windings were energized the egg began to spin. [Tesla's spinning egg is, in fact, a macroscopic analog of the Einstein-de Haas effect investigated almost thirty years later. The materials in Einstein's WWI experiments spin because of molecular 'amperian currents' (although later Einstein did suggest using a high frequency *'rotating magnetic fields'* to Barnett). In Tesla's experiments they spin because of induced eddy currents. [See part V below]

> "... to their astonishment, it stood on end, but when they found that it was *rapidly spinning* their stupefaction was complete*... No sooner had they regained their composure than Tesla was delighted with their question *'Do you want any money?'...* That started the ball rolling. Tens of millions of horsepower of Tesla induction motors are now in use all over the world and their production is rising like a flood... Rotating fields of 15,000 horsepower are now being turned out... and ship propulsion by Tesla's electric drive which, according to Secretary of the Navy Daniels' statement, has proved a great success." **[21]**

The electrical circuit, which Tesla employed for the egg of Columbus used two phase AC energizing the coils in quadrature and the source frequency was varied from 25 to 300 cycles, *"the best results being obtained with currents from 35 to 40 cycles."*** The story was also mentioned in Fleming's eulogy of Tesla. **[22]**

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* As Columbus had done when getting Queen Isabella to pawn her jewels for three ships to sail in

In 1893, 6 years after demonstrating the egg of Columbus to the attorneys and business investors in New York, a large egg demonstration was constructed for Tesla by Albert Schmid and Charles R Scott, at the time both of Westinghouse. (Scott, subsequently an EE professor at Yale, served as President of both the AIEE and, later, the IRE.) The egg occupied part of the Westinghouse exhibit in the Electricity Building at the great Chicago Worlds Fair. The 1893 Fair celebrated the 500th anniversary of Columbus' discovery of the New World and, ostensibly, it was intended to launch society into the 20th century. There is a photograph of Tesla's exhibit in the Martin book. [23] This was only a few months before Lord Kelvin was to choose the Tesla polyphase system for Niagara Falls, and 3 years before the first Niagara Falls plant was turned on.

While Tesla had been active in RF generation in the early 1890's, the close of the decade saw him making great strides in the realm of high voltage RF power processing. These experiments culminated in a cluster of patent applications and the construction of the Wardenclyffe laboratory. Mention should also be made of his turbine development and intense engineering consulting practice just prior to WW-I. From the comments above it is clear that he was actively promoting his patented ideas.

Tesla's Reflections on Radar and Ships Wrapped in Coils of Wire

Just after receiving the AIEE's Edison medal (May 18, 1917), Nikola Tesla granted an interview to H. W. Secor of the Electrical Experimenter magazine. (Secor's article was published in August of 1917.) The topic of discussion turned to the detection of German U-boats (U-boat = Unterseeboot = submarine), which had caused so much distress to the allies. The United States had entered the war in April of 1917. Tesla's concerns centered around the detection of submarines, in particular the possibility of non-ferrous hull detection. Listen as, filtered by the pen of a journalist, Tesla narrates the electrical preparation of the ship:

> *"Now, suppose that we erect on a vessel, a large rectangular helix or an inductance coil of insulated wire. Actual experiments in my laboratory at Houston Street (New York City), have proven that the presence of a local iron mass, such as the ship's hull, would not interfere with the actions of this device. To this coil of wire, measuring perhaps 400 feet in length by 70 feet in width (the length and breadth of the ship*) we connect a source of extremely high frequency and very powerful oscillating current."* [24]

We think that Vannevar Bush was aware of this suggestion, and it is our thesis that these words are the seed that later blossomed as the "Philadelphia Experiment". The article then goes on to describe an RF technique, which subsequently became quite popular (though not on such a grand scale) for metal detectors and for tuning the reactance of RF coils in transmitters and receivers. Upon further prodding by Secor, Tesla discussed a high peak power *microwave radar* for operation at wavelengths" ... of but a few millimeters". (X-Band radar at 10 GHz has a wavelength of 30 mm.)

Tesla desired that the ship be able to provide sufficient electrical power, and he states this in the interview; *"The average ship has available from say 10,000 to 15,000 HP.... The electric energy would be taken from the ship's plant for a fraction of a minute only, being absorbed at a tremendous rate by suitable condensers and other apparatus, from which it could be liberated at any rate desired."*

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* The language used to describe the staking effect his 1892 lecture-demonstration had on the Royal Institution in Londor4 was, "The scientists simply did not know where they were when they saw it." (Anderson, 1992, pg. 95)

****** Note that Tesla has recognized that he can characterize different spinning eggs with certain gyromagnetic resonance frequencies!! This was in 1887.

Clearly, Tesla was contemplating the use of pulsed currents* in the coils around the ship. Remarkably, vessels wrapped in coils were observed during WW-II (per-haps for mine sweeping or even degaussing studies).

[According to Moore, Francis Bitter, of MIT, recalled witnessing "a relatively large ship carrying ... a bar magnet going from the bow, to way aft. This bar magnet had coils wound around it, which passed current produced by big motor generators." [(25)]] By the way, the Eldridge's generator was rated at 4,600 kVA and could deliver 6,000 HP. Two generators, as described in the book, could deliver more than 12,000 HP (almost 9 Mw).

It is not clear that Mr. Secor even fathomed what Dr. Tesla was speaking about. How much of what was published in the article were Tesla's ideas and what was added (or deleted) by Secor is not transparent. (We have the same problem with O'Neill's colorful biography.) After Tesla's brief discussion of sonar, Secor mixes together the RF magnetic detection process and the "electric ray" radar technique. While Secor's version of Tesla's disclosures might sound, today, like oversimplified impractical popularization's, Secor was quick to conclude his 1917 article with the disclaimer, …..several important electrical war schemes will shortly be laid before the War and Navy Departments by Dr. Tesla, the details of which, we naturally cannot now publish" [(26)] Margaret Cheney has observed that, at the time, Thomas Edison;

> "*... had been named to direct the new Naval Consulting Board in Washington, with the primary job of finding a way of spotting U-boats. Tesla's idea, if even brought to Edison's attention, would almost certainly have been discounted."* [(27)]

It should also be noted that Vannevar Bush was involved in the same endeavor;

> *"During 1917-18 [Bush] was engaged in research on submarine detection in connection with the United States Navy special board on submarine devices. "* [(28)]

In 1917, Bush fresh out of graduate school,* was a newly appointed assistant professor of electrical engineering at Tufts College in Medford, Massachusetts and consulting for the American Radio and Research Corporation. [AMRAD was a J. P. Morgan venture, built on the Tufts campus, which manufactured "thousands of transmitters and receivers" during WW-I. [(29)]] Bush was one of the guiding lights for a spin-off company which, in 1925, was renamed Raytheon.** (In 1941, Raytheon became the prime source for the new Navy Search Radar. [(30)])

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* According to Jane's Fighting Ships (1967-68, pg. 408), the Eldridge (DE-173) was 306 feet long by 37 feet at the beam, and had a draft of 14 feet. Its main engines were GM diesels, electric drive, 2 shafts, 4.5 Mw.

* "I will tell you the secret of all these wonderful displays. ... Consider a large gun, which hurls a projectile of a ton a distance of 18 or 20 miles. If you figure the horsepower at which the gun delivers energy, you will find that it amounts to from 6 to 12 or 15 million horsepower. ... With the methods, which I have devised, with my transformer, it is not at all difficult to get rates of energy many times that. ... in the plant on Long Island, if I wanted to operate, I could have just reached a rate of 1 billion horsepower. ... That wonderful thing can be accomplished through a condenser. The condenser is the most wonderful electrical instrument ... You store less energy in the condenser than in the gun, but whereas a gun will discharge ... in 1/50 of a second, a condenser can discharge the energy in 1 millionth of this time. ... all these effects which elicited great wonderment of the profession, were always produced by damped waves, because with the undamped waves it would not have been possible to attain any such activities." [Tesla on His Work With Alternating Currents, by L. .I. Anderson, 1992, pp. 112-113.1

Bush joined the MIT EE Department faculty (his specialty, initially, was electrical power and subsequently operational calculus and analog computers (the famous network analyzer)) and became Dean, and then Vice-President of MIT in 1931. *** He accepted the position of President of the Carnegie Institution of Washington in 1938 (and held the position until 1955). He was Science Advisor to the President and was appointed by Roosevelt as chairman of the National Defense Research Committee (July, 1940), *** as director of OSRD - the Office of Scientific Research and Development (1941), and as Chairman of the Joint Committee on New Weapons and Equipment of the Joint United States Chiefs of Staff (1942). [(31)]

Vannevar Bush guided much of the Nation's weapons research during WW-II. According to Frank B. Jewettt* (President of the National Academy of Sciences), as head of OSRD Bush;

> *"... directed the mobilization of the entire civilian scientific and technical power of the nation and welded it together into the military establishment in the greatest industrial research and development man has ever known."* [(32)]

Recall that Vannevar Bush, while Vice President of MIT, had sent Tesla birthday greetings in 1931;

> *"Dear Dr. Tesla ... I wish to join to my own tribute of admiration for your unique career the congratulations of the Massachusetts Institute of Technology, where the contribution which your original genius has made for the benefit of mankind is fully appreciated."* [(33)]

In 1943, Bush like Tesla in 1917, received the AIEE's highest honor (at that time the Edison Award). Bush held about 50 US patents for various inventions. Let us move ahead from Tesla's suggestion to place coils of wire on a ship, to radar and radar counter-measures (stealth).

Radar

It seems to be broadly recognized that, although Heinrich Hertz bad observed RF standing waves resulting from metallic reflections, it was Nikola Tesla, in 1900, who was the first to propose the concept of radar. [(34)] According to NRL radar pioneer R. M. Page, it was Tesla who first "... suggested the use of electromagnetic waves to determine the relative position, speed, and course of a moving object." [(35)] The earliest patent issuing for radar appears to have been the British patent granted to German engineer Christian Hulsmeyer. [(36)] Certainly, Tesla's interview with H. W. Secor appears as an added note in the radar lore. [(37)] The acronym *radar* was an official code word adopted by the US Navy in November of 1940, the same month that the MIT Radiation Laboratory was organized for the exploitation of the microwave region for radar.

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* Bush received a BS and an MS from Tufts College (1913), Doctor of Engineering jointly from MIT and Harvard (1916), and eventually 10 honorary doctorates from various colleges and universities. During his remarkable career, he was science advisor to several Presidents. He was Vice-President and Dean of Engineering at MIT in 1931, the year that he wrote to Tesla.

** Raytheon, in fact, (with 25% of the EE department involved) came to be known by the grad students at MIT in the late 1920's as "an extension of the Electrical Engineering Department." (See Reference 29.)

*** Ever the entrepreneur, when Bush heard A. F. Joffe, of the Polytechnic Institute of Leningrad, present his ideas on a new super-dielectric for HV insulation, he rallied his investor friends and went to Leningrad and Moscow (As described in his autobiography, Pieces of the Action (Morrow, 1970), the enterprise resulted in failure.)

**** Recall that John G. Trump, accompanied by three Naval personnel, examined Tesla's personal papers when he died in January of 1943. Trump was Secretary of the Microwave Committee of the National Defense,.Research Committee from 1942 until 1944 when, as a member of General C.A. Spaatz's Advisory Special Group on Radar, he went to Europe as the Director of the British Branch of the (MIT) Radiation Laboratory. (See Electrical Engineering, Vol. 80, No. 5, May, 1961, pp. 364-365.) [General Spaatz, by the way, was Air Force Chief of Staff and headed the "very secret" committee on UFO's. According to Irving Langmuir, (Physics Today, October, 1989, pg. 48) Spaatz had confided, "You know it's very serious. It really looks as though there is something there." (Also see Physics Today, March 1990, pg. 13 and April, 1990, pg. 13.]

Sommerfeld on Electromagnetic Stealth During WW-II

In his authoritative two volume radar cross section handbooks George Ruck has pointed out the desirable features of radar absorbers.

> *"The search for suitable Radar Absorbing Materials (RAM) was initiated in the early 1940's both in the United States and Germany. Ideally, the optimum RAM would be a paint-like material effective at all polarizations over a broad range of frequencies and angles of incidence.*
>
> *Unfortunately, such a material does not exist and the probability of its being developed is rather remote."* **(38)**

Arnold Sommerfeld (1868-1951) presents a surprising discussion of German war research on stealth and radar absorbing materials in the optics volume of his famous lectures on Theoretical Phvsics. **(39)** He relates that the case where the magnetic permeabilities between two media (air and target) are unequal $(\mu_1 \neq \mu_2)$ is "of some historical interest".

During the war the problem arose to find, as a counter measure *against allied radar*, a largely nonreflecting ("black") surface layer of small thickness. This layer was to be particularly non-reflecting for perpendicular or almost perpendicular incidence of the radar wave. In this case the angle of incidence and the angle of transmission are both almost equal to zero. The problem is solved by making *the ratio of the two wave impedances* equal to unity:

$$m_{12} = \frac{E_1 / H_1}{E_2 / H_2} = 1 \qquad \textbf{(1)}$$

The criterion is, thus, not the index of refraction but the ratio of wave impedances." Sommerfelds suggestion is similar to the idea of making the radar target surface a "conjugate match" to eliminate radar reflections. If one could make the impedance of the second medium be the same as free-space, the target would become radar invisible. He continues;

> *"In order to "camouflage" an object against radar waves, one must cover it with a layer for which this ratio of wave resistances has the value* ***1*** *in the region of centimeter waves. According to [the law of refraction and the boundary conditions] this means that if we call the constants of the desired material ε and μ and those of air ε_0 and μ_0, then*
>
> $$\frac{\varepsilon}{\varepsilon_0} = \frac{\mu}{\mu_0} \qquad \textit{(2)}$$
>
> *Hence, the problem concerns not only the dielectric constant but also the relationship between the dielectric constant and the permeability. A substance must be formed whose relative permeability $\mu_r = \mu/\mu_0$, is of the same magnitude as its relative dielectric constant $\varepsilon/\varepsilon_0$."*

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* Edison Medalist in 1928. (Eleven years after Tesla.)

This case is discussed by Ridenour in Volume 1 of the famous MIT Rad Lab series, [(40)] and in a well known analytical reference by Weston. [(41)] Sommerfeld continues;

> *"But the problem is not yet solved. For at its black surface the layer borders on the object (metal), which is to be camouflaged, and this second surface still reflects strongly. Hence, the further condition must be imposed that the layer should absorb sufficiently strongly. This requires a complex rather than a real dielectric constant and because of the requirement (Eq. 2) a corresponding complex permeability. The material must, therefore, be ferromagnetic and must possess a strong hysteresis or a structural relaxation that acts correspondingly. Thus, a difficult technological problem was posed, which though not unsolvable, required extensive preparatory work.*
>
> *Because of the urgent war situation, the solution which had to be used resulted from the following considerations ..."*

Somrnerfeld then changes the course of his ideas. He proceeds to describe the reduction in radar reflection by a rather conventional means that does not build upon the requirement of **Equation (2).** Instead, what he discusses next is covering the surface with layers of lossy *dielectric* material, each strata being less than $^1/_4$ wavelength thick, neglecting entirely any effects attributable to μ **.** ("In this manner the reflected intensity could be reduced to 1% of the value given by Fresnel's formula ... " [(42)]) After the war, a number of papers were published by Sommerfeld's colleagues at Gottingen and Munich, in Zeitschrift fur Angewandte Physik, on the topic of radar absorption. (Just scan the magazine's annual index for 1956-1959.) Presumably, after the war the German workers were less constrained in publishing their research on the topic of RAM than Allied scientists.* Even at this late date most significant western RAM publications are classified, particularly those related to the stealth bomber technology.

In his 1947 MIT Rad Lab Volume, Ridenour comments that;

> *"Absorbent materials have been produced in Germany for the radar camouflage of U-boats. The type of absorber that was actually put into service was of the interface kind. The dielectric constant and permeability were produced by a high concentration of spheroidal metal particles (carbonyl iron). The concentration of metal was 80% by weight, and values of dielectric constant and permeability were* $\varepsilon = 7$*, and* $\mu = 3.5$ *.*
>
> *An absorber of the second kind was also developed in Germany. It consisted of a series of layers whose conductivity regularly increased with depth. The layers were separated by foam-type plastic whose dielectric constant was close to 1. The absorption was excellent from 4 to 13 cm [2.3 ~ 7.5 GHz]. However, the complete absorber was a rigid structure 2.5 inches thick, and it was never actually used."* [(43)]

Is there any connection between the remarks of Sommerfeld and the supposed German version of the "Philadelphia Experiment", which has been rumored to have occurred at the Kiel Shipyards 'in Germany during World war II? Surprisingly, after hinting at ferromagnetic materials, Sommerfeld did not tell us how to produce magnetic radar camouflage. We will try our hand at supplying the missing details below. But first, we review conventional linear RAM.

Ferromagnetic Radar Absorbing Material

The more-or-less conventional approach to radar stealth is to either employ "shaping" of the target (use GTD to greatly reduce the RCS), or to utilize the microwave absorption properties of the complex dielectric constant and complex permeability constant. In lossy dielectric and ferromagnetic* matter

$$\varepsilon(\omega) = \varepsilon'(\omega) - j\varepsilon''(\omega) \qquad \textbf{(3)}$$

$$\mu(\omega) = \mu'(\omega) - j\mu''(\omega) \quad \textbf{(4)}$$

and from Poyntings Theorem, the time average power dissipated is given by [(44)]

$$P_d = \frac{1}{2}\iiint \left[(\sigma + \omega\varepsilon'') E^2 + \omega\mu'' H^2\right] dV \quad \textbf{(5)}$$

The imaginary components of ε and μ arise from hysteretic losses and appear in a standing similar to frictional dissipation** The one-way propagation attenuation in lossy simple media can be found from which would occur

$$\alpha = \text{Re}\{\gamma\} = \text{Re}\left\{\sqrt{j\omega\mu\sigma - \omega^2\mu\in}\right\} \quad \textbf{(6)}$$

in the use of an imperfect conductor that is thick enough to sufficiently attenuate any reflections from its back surface at the frequencies in question. Making use of the conductivity term gives the dissipation mechanism for "space cloth" (which has a wave impedance of 377 ohms/square) and carbon/graphite composite materials. The real part of **ε,** and μ lead to reactive fields, and to capacitive bypass and inductive choking, respectively. Ferromagnetic loading dissipation occurs in the imaginary component of the magnetic terms. Modeling targets as distributed transmission lines and resonators demonstrates that material impedance loading of RF "hot spots" detunes the target structure and decreases RF reflections significantly.

Ferromagnetic materials with very low conductivity are called ferrodielectrics, or ferrites. Kraus notes that;

> *"A lossy mixture of highs (ferrite) material and a high-* ***ε****, (barium titanate) material can be used effectively for wave absorption with both* ***μ*** *and* ***ε****, being complex and with ratio* ***μ / ε****, equal to that for free space* $(\mu_r / \varepsilon_r = 1)$*. Although the mixture constitutes a physical discontinuity, an incident wave enters it without reflection. The velocity of the wave is reduced, and large attenuation can occur in a short distance."* [(45)]

As an example, Kraus considers a solid ferrite-titanium slab, for which $\mu_r = \varepsilon_r = 60(2 - j1)$ at 100 Mhz, and finds that the wave mipedance $Z = \sqrt{(\mu/\varepsilon)} = Z_0$, which is the characteristic impedance of free space, and the attenuation constant is $\alpha = 126 Np/m = 1092 dB/m.$ A 10 mm thick slab of this material, backed by a perfectly conducting sheet, attenuates the propagating signal 11dB each way and reduces the radar backscatter by 22 dB. ("'The reflected power is less than 1/100 of the incident power.")

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* The American scientist of German origin, quoted by Dr. Rinehart in the Moore-Berlitz book (pp. 202-203) was clearly mistaken in his assessment of German military spirit.

Let us now turn to the situation where a magnetic bias is applied to a ferromagnetic material in order to "tune" the reflectivity of the medium to be a minimum for centimeter wavelength radar signals.

Magnetically-Biased Radar Camouflage

"You want camouflage, gentlemen! Give me a ship and I'll show you perfect camouflage. " (p. 125).*

Returning to Equation (1), we ask if there exists any phenomenon by which power line currents in a large coil around a steel (or ferromagnetic) body could somehow bring about a reduction in the reflection of microwave energy from the steel body. *Is there a phenomenological principle that may have appealed to those that conceived and designed the "Philadelphia Experiment"?* (Where were the JASON's in those days?) It turns out that there is an interesting candidate which may, indeed, explain the *motivation* for the experiment.

In Appendix I, we determine the surface impedance of a ferromagnetic slab that is immersed in a constant magnetic field oriented parallel its the surface. This would simulate the situation of a destroyer escort, with coils wrapped around it, illuminated broadside by microwave radar pulses. The normally incident, monochromatic, horizontally polarized,** plane wave reflection from the target's surface can then be calculated by using the surface impedance

$$Z_{zz} = (1+j)\sqrt{\frac{\omega \mu_0 \mu_e}{2\sigma_3}} = R_S(\omega) + j\,X_S(\omega) \qquad \textbf{(7)}$$

(see Appendix I) in the expression for the field complex reflection coefficient at the interface where the characteristic impedance of free space is taken as $\mathbf{Z_0 = 377\Omega}$. What is of interest is that the reflection

$$\Gamma(\omega) = \frac{E_{reflected}}{E_{incident}} = \frac{Z_{zz}(\omega) - Z_0}{Z_{zz}(\omega) + Z_0} \qquad \textbf{(8)}$$

coefficient can be timed to make the radar reflected power drop below 1/100 of the incident power by varying the current in the wires around the ship. Finally, we determine the magnetic biasing required to make the radar reflection, discussed by Sommerfeld, vanish at centimeter (radar) wavelengths.

In Figures 1 through 7 below, we calculate and plot the set of parameters derived in Appendix I, and the target reflection coefficient $\mathbf{\Gamma(\omega)}$ for various physical constants. A wide range of assumed physical constants are listed in Table I for the variety of examples, which we ran analytically. The electrical conductivity of steel is typically on the order of $\mathbf{10^{6}}$ **mhos/m** ***at DC***, and in Examples 1 and 2 we have assumed an RF value somewhat less. The applied field strengths are those necessary to raise the ferromagnetic resonances to the **L** and **X** Bands. With the substantial values of $\mathbf{H_0}$ involved for microwave resonances, we suppose that significant physical nonlinearities come into play. As a result, we must say that the assumed values of $\mathbf{X_0}$ are open to question. [However, there seems to be some latitude here. We found that the theory predicted similar resonances if, in the model, we employed conductivities as low as **70 mhos/m**, but in that case $\mathbf{X_0}$'s of 1620 (L-Band) and 11 (X-Band) would be required for radar reflection elimination.]

---

* Ferromagnetic substances are those, which when immersed in an external magnetic field, become strongly magnetized in the direction of the immersed field, and which exhibit retentivity and hysteresis. Iron, nickel, cobalt and gadolinium are the only ferromagnetic elements at room temperature.

** In ferromagnetic materials μ is a nonlinear function of the applied magnetic field strength, **H**

Figure 8 is a plot of the radar reflection coefficient of Example 6 verses frequency as the bias magnetic field strength is "tuned".

TABLE I – Electrical Specifications

PARAMETER→		$\sigma_3(f_0)$	H_0	ω_r	X_0
		(mhos/m)	(AmpTurns/m)	rad/s	rad/s
↓EXAMPLE	1. LBand	$0.5x10^{6}$	15,000	$3x10^{9}$	$1.15x10^{7}$
	2. X-Band	$0.5x10^{6}$	271,000	$5x10^{9}$	$7.91 x10^{4}$
	3. L-Band	70	15,000	$3x10^{9}$	1620
	4. X-Band	70	271,000	$5x10^{9}$	11
	5. L-Band	45	50,000	$3x10^{9}$	1000
	6. X-Band	6400	271,000	$5x10^{9}$	1000
	7. UHF	103	15,000	$2.7x10^{9}$	2200

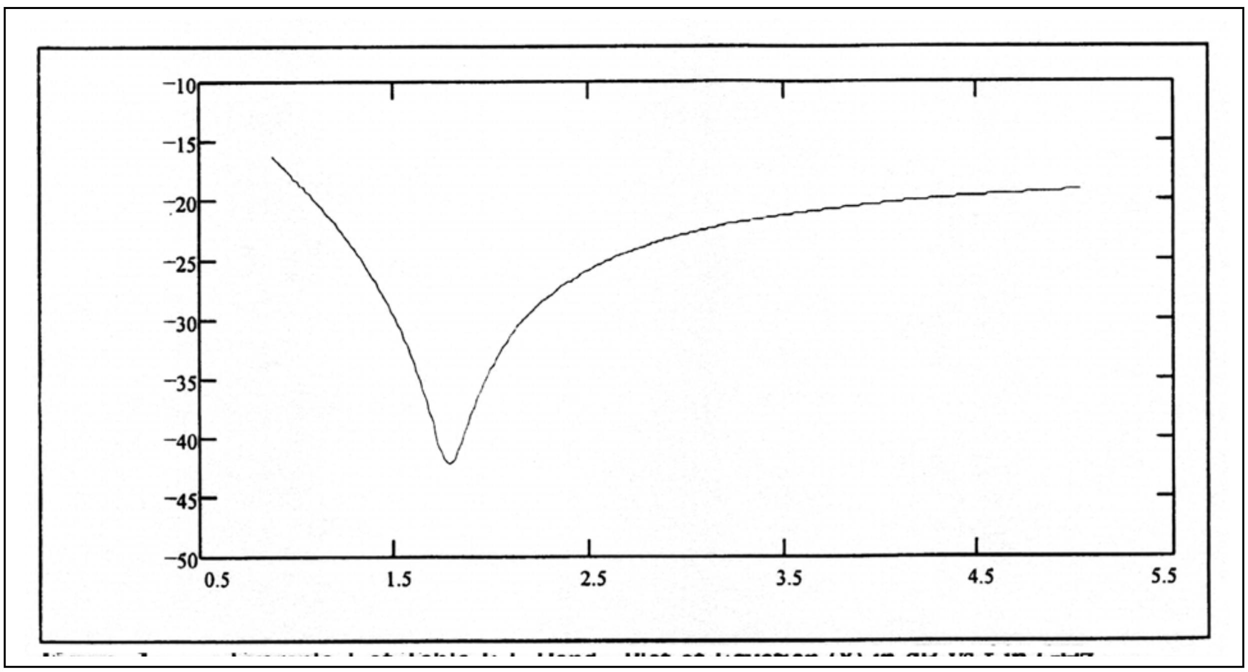

Figure 1
Example 1 of Table 1: L-Band. Plot of Equation (8) in dB vs. f in GHz.

* The PhiladeIphia Experiment, by William L. Moore and Charles Berlitz, Ballantine Books, 1979.

** Horizontally polarized for an 'L-coil' helix about the ship. and vertically polarized for an 'M-coil' helix about the ship. See the comments on degaussing below.

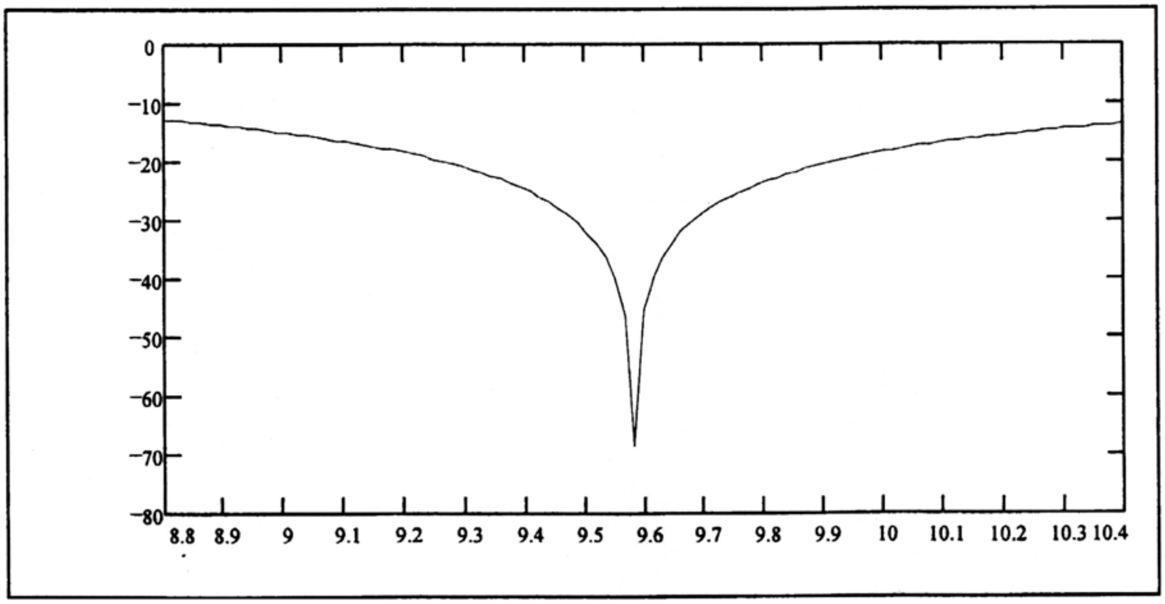

Figure 2
Example 2 of Table 1: X-Band. Plot of Equation (8) in dB vs. f in GHz.

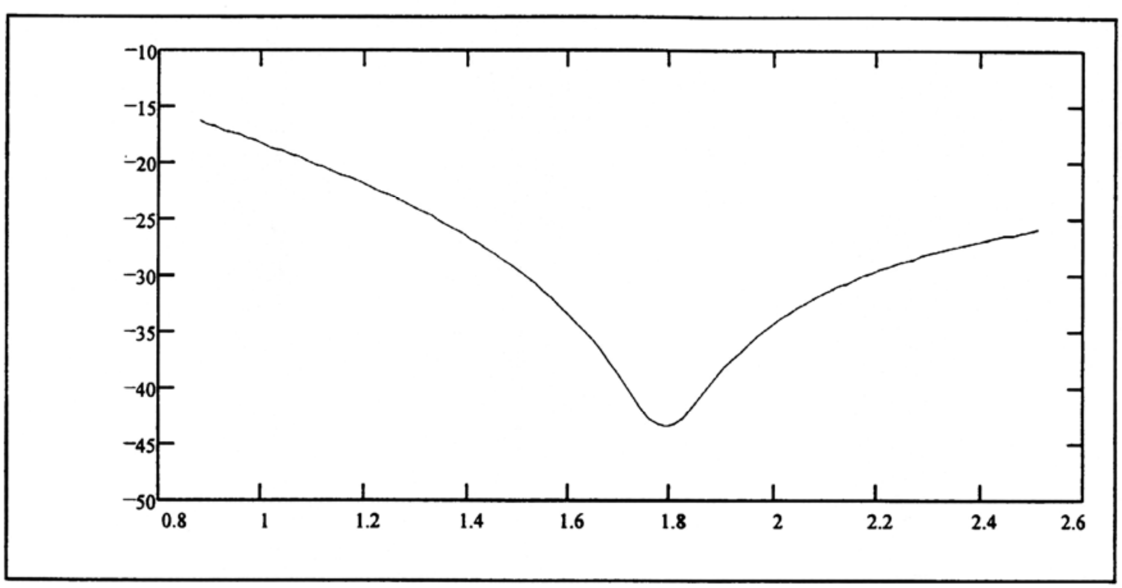

Figure 3
Example 3 of Table 1: X-Band. Plot of Equation (8) in dB vs. **f** in GHz.

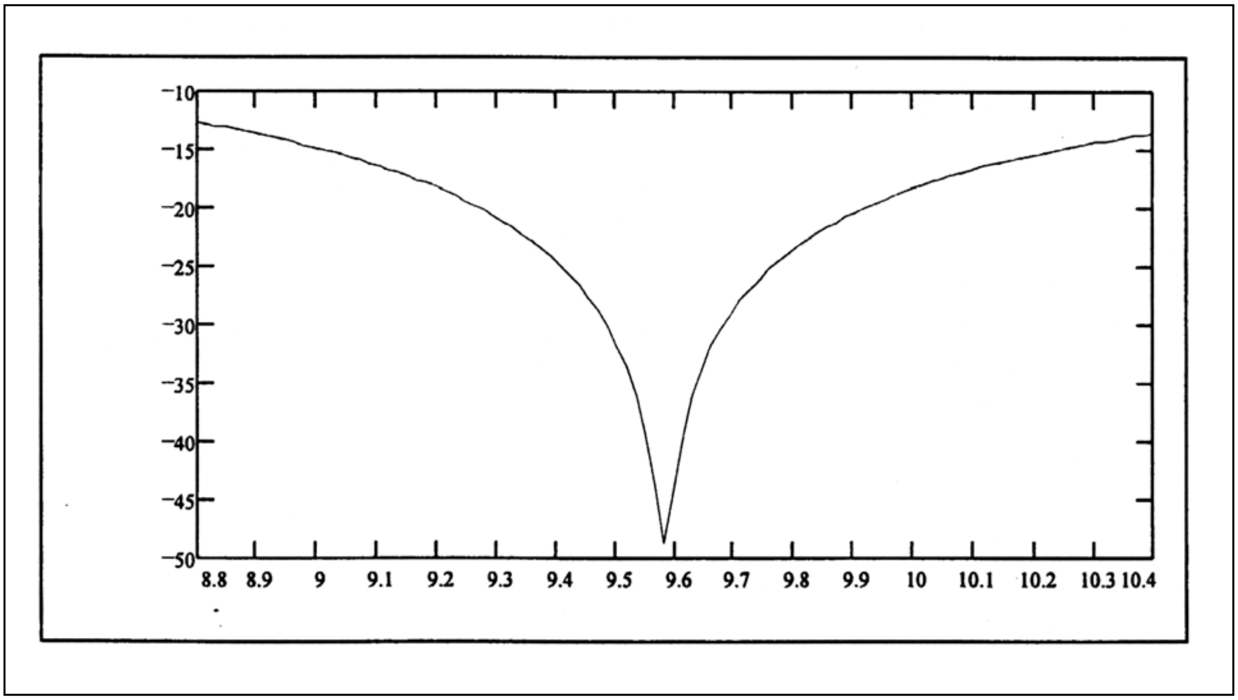

Figure 4
Example 4 of Table I: X-Band. Plot of Equation (8) in dB vs. f in GHz.

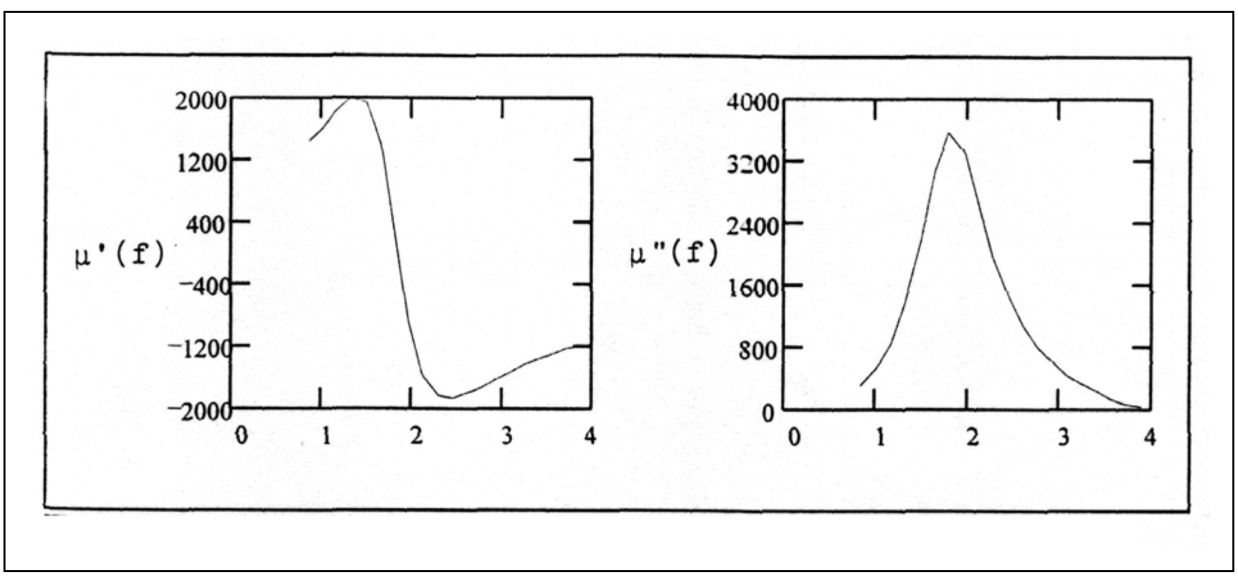

Figure 5.1

Real and imaginary parts of the permeability vs. **f** in GHz for Example 5.

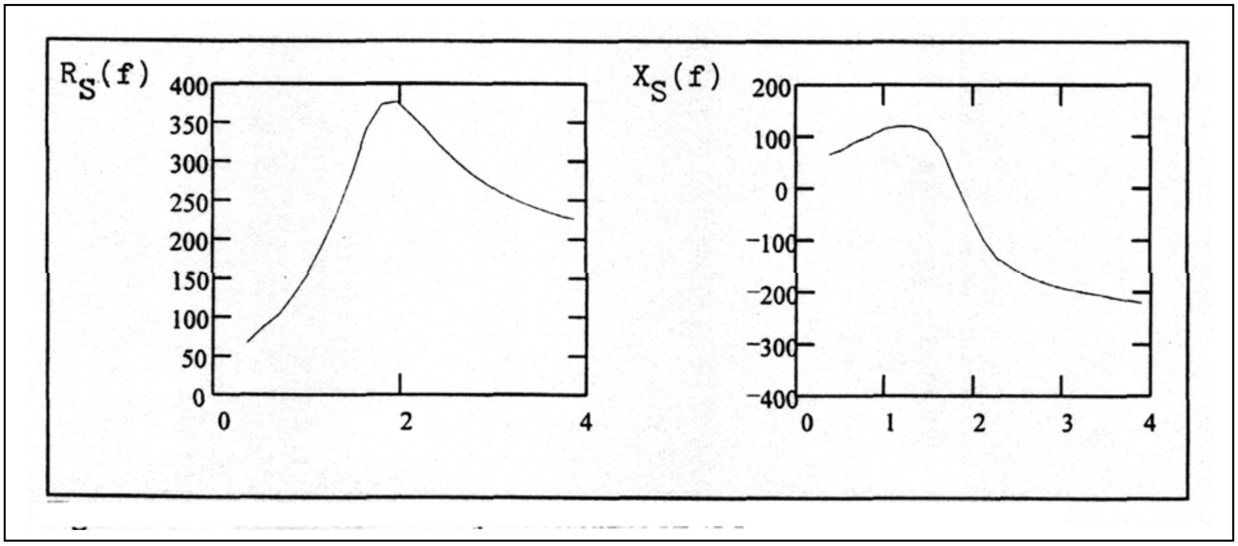

Figure 5.2
Surface resistance $\mathbf{R}_S$ and reactance $\mathbf{X}_S$ vs. $\mathbf{f}$ in GHz for Example 5.

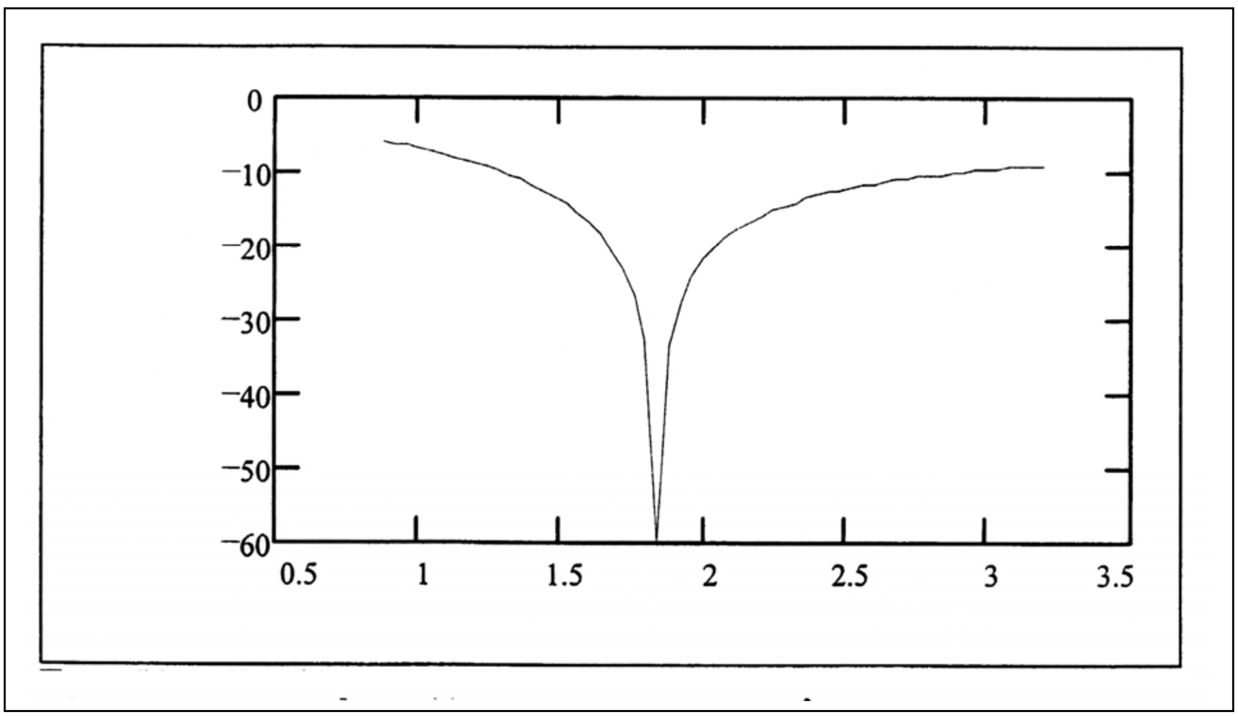

Figure 5.3
Plot of Equation (8) in **dB** vs. **f** in GHz for Example 5: L-Band.

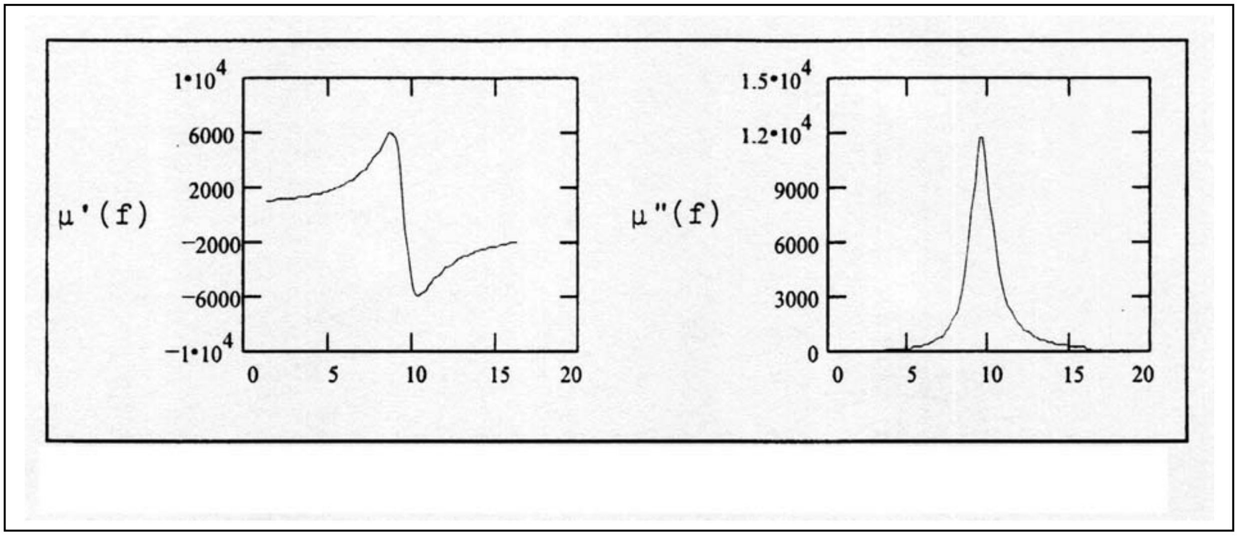

Figure 6.1
Real and imaginary parts of the complex permeability vs. frequency in GHz for Example 6 of Table I: X-Band.

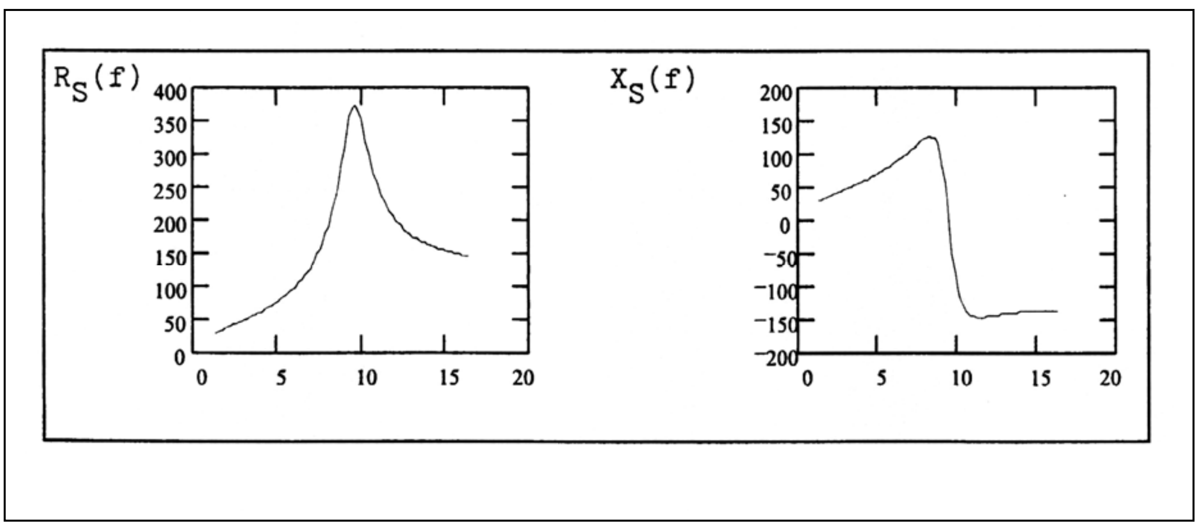

Figure 6.2
Surface resistance $\mathbf{R}_S$ and reactance $\mathbf{X}_S$ vs. frequency in GHz for Example 6 of Table I: X-Band.

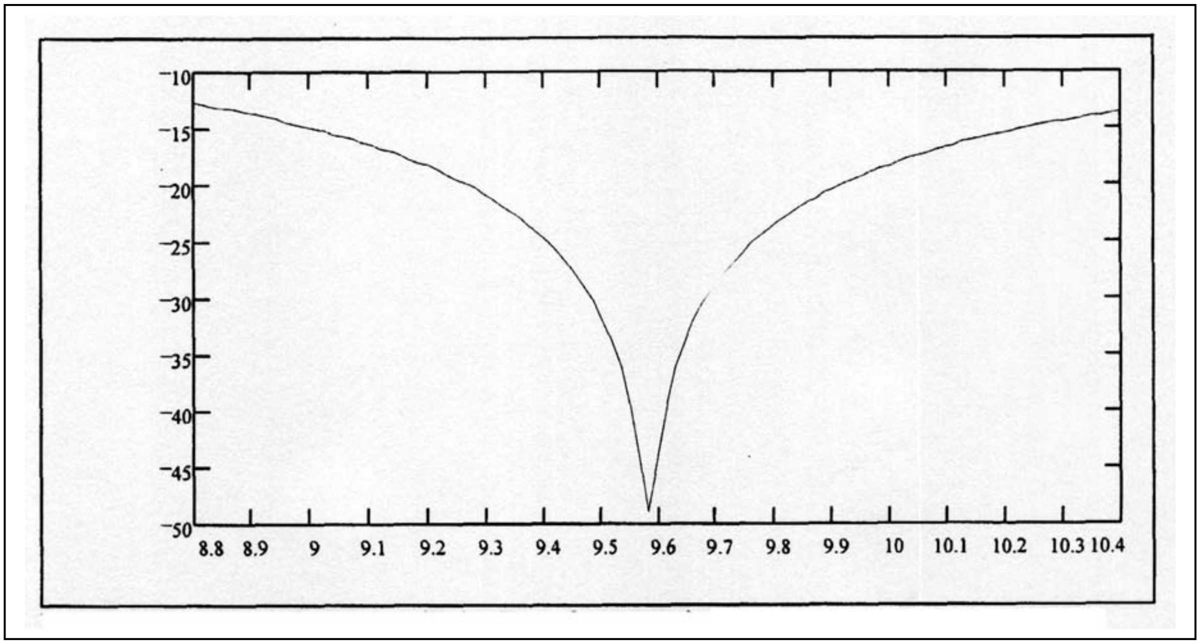

Figure 6.3
Plot of equation (8) in **dB** vs. frequency in GHz for Example 6 of Table I: X-Band.

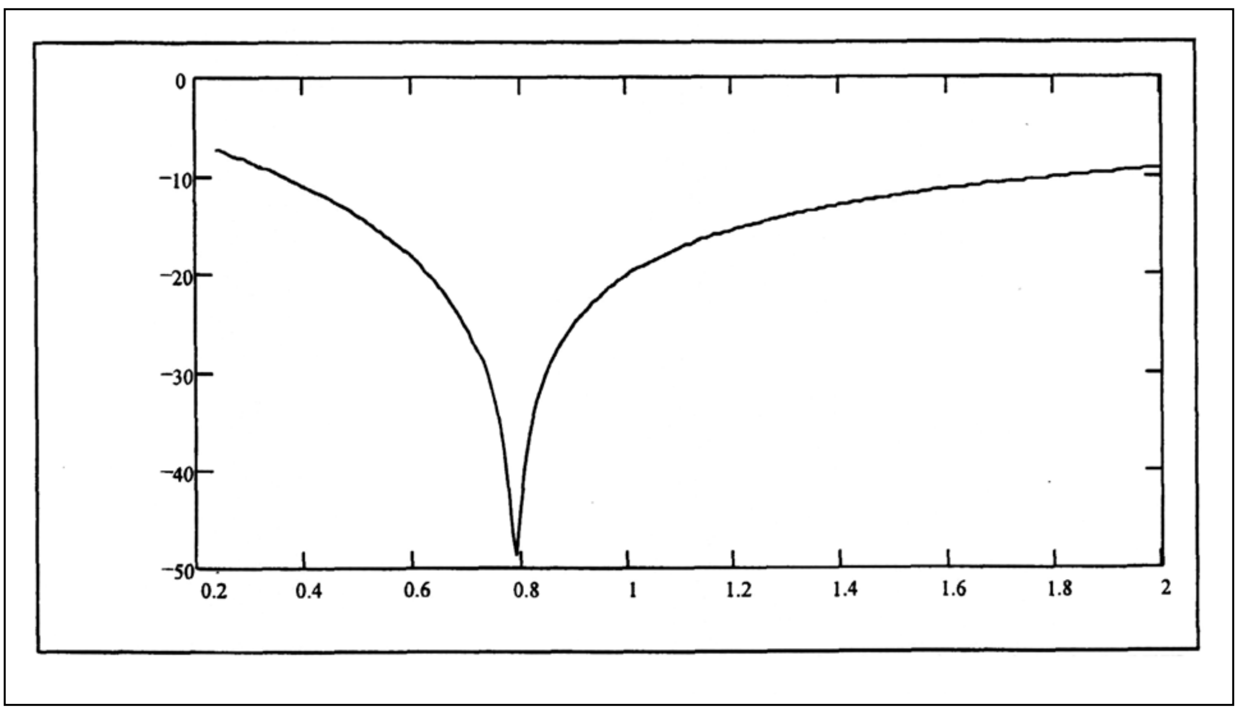

Figure 7
Plot of Equation (8) in **dB** vs. frequency in GHz for Example 7 of Table 1: UHF.

"A man went to the Navy and said, 'You want camouflage, gentlemen! Give me a ship and I'll give you camouflages'   (Moore and Berlitz, pg. 125.)

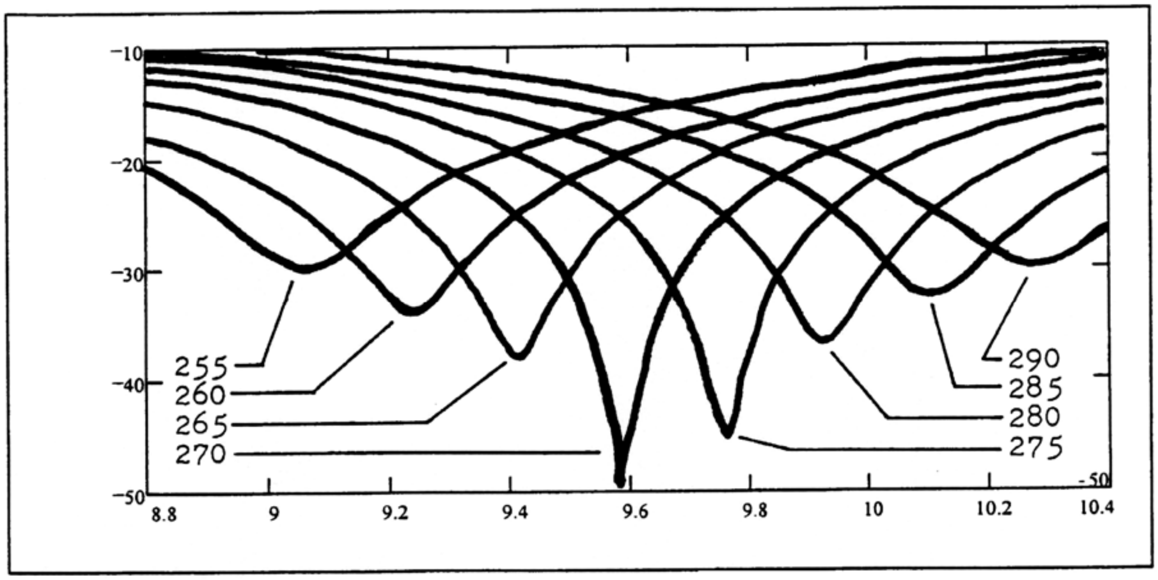

Figure 8
Plot of $\Gamma(f)$ in **dB** for Example 6 as $\mathbf{H_0}$ is varied from 255 to 290 kA/m.

The bottom line on all this is dial the surface impedance has a parallel resonance character, with the effective permeability and the surface impedance both peaking at resonance frequencies determined by the selected values of the current in the helical coil surrounding the ship. The magnitude of $\Gamma(\omega)$ and the gyromagnetic resonant frequency can be "tuned" by varying the **DC** bias field $\mathbf{H_0}$!!   In particular, at least for the fanciful values which we assumed for the ship's hull, one can bring the surface impedance to equal the characteristic impedance of free space, and thus significantly reduce radar reflection over a useful band of frequencies.   One can notch out a depression in the radar return in excess of 20 dB, 500 MHz (or more) wide at either L-Band (UHF-2 GHz) or X-Band (8~12.5 GHz).   More than probable, a 1943 “Philadelphia Experiment” would have been carried out at L-Band.

Equation (2) above can be satisfied at L-Band if $\mathbf{H_0}$ is "tuned" to 15,000 A/m.   That is to say, if there is 1 turn/m around the ship carrying a current of 15,000 amperes, the ship's radar reflection will drop to a fraction of its zero current value at 1.5 GHz. This would seem to fulfill the requirements for a "Philadelphia Experiment”. (Surprisingly, there also seems to be another modest resonance in the upper infrared, although this may possibly be a glitch in our computer code.) To be sure, we do not claim that any material is capable of such deep nulls in the radar reflection, or is tunable over such broad bandwidths. However, the evidence meager though it is, appears to indicate that the radar reflection can be minimized and the use of electronic camouflage would probably have been studied experimentally. Surely these things were taken under consideration at that time.

Small Scale Laboratory Experimental Verification

Armed with this theoretical knowledge, we thought it might be circumspect to attempt a small scale laboratory experiment to verify the effect of $\mathbf{H}$ on $\Gamma(\omega)$ at X-Band for ordinary steel.   (From the book it appears that the Navy also conducted scale model experiments.*)   In fact, we performed two experiments with our "egg of Columbus" apparatus,** which we think have bearing upon our “Philadelphia Experiment” discussion. In the final Part of this paper, we will propose two more experiments.

1) **RCS Modification.** In order to attain very large currents from a modest supply we took our ‘egg of Columbus’ toroidal steel core (as a radar target simulating the ship's hull) and used an 8 kV, 10 μF capacitor discharge pulse through the windings, which were arranged in series. [The surge current would appear to have been on the order of

$$I_0 = \frac{V_0}{\omega L_T} = \frac{8{,}000}{2\Pi \bullet 72 \bullet .5} = 35 \quad \textbf{Amps} \qquad \textbf{(9)}$$

which would imply a peak magnetic field strength on the order of **< H $_\phi$ > ≈ (120 Turns/quadrant), (4 quadrants), (35, amps/Turn) / (2 Π • 6"/39.37) = 17.5 kA-T/m]** The transformer steel was illuminated broadside to the doughnut with a small pyramidal horn-mounted Raytheon CK-109 X-Band klystron (100-250 mW at 9.98~11.98 GHz), and the radar backscatter was observed with an HP X-Band crystal detector, as shown in Figure 9. It would not be unreasonable to suppose that this is the sort of experiment that Tesla could easily have performed during, or even well before, the 1930's. (He probably would have used UHF or L-Band, with a somewhat lower power level.) *In fact, it would be surprising if he had not examined this configuration.*

A distinct difference between the magnetic bias-on and bias-off target backscatter was observed, clearly Tesla would have observed this phenomenon!

2) **Brine Displacement.** We immersed the 'egg of Columbus coil' in the bottom of a plastic tub of water and rocksalt. When the coil was energized the water 'flew out of the tub' (literally)! At lower power and the apparatus placed outside and under the tub, the salt water in the tub swirls around. (One of the authors saw a version of this, with a 'pickle jar' about 1/3 full of mercury, demonstrated at the Serbian Academy of Sciences and Arts' 1993 Tesla Symposium last September at Novi Saad.

Clearly, with up to 4.5 MW available, eddy currents in salt water would not only burrow out a hull-shaped hole in the water, but would probably levitate the ship somewhat. As a homework assignment, the reader is invited to perform the calculation for his amusement.

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* [Dr. R-F. Rinehart], "I recall some computations about this in relation to a model experiment, which was in view at the time.,, (P. 187)

** Our core was made of spiral wound steel strap, giving a core 10" ID, 14 " OD, and 2 " thick. There were four coils, each 120 turns of # 12 enameled copper wire.

CONCLUSION

The analysis would appear to lend credence to the hypothesis that something more than mythology is involved, and it renders plausible the conclusion that sufficient motivation existed to actually conduct a "Philadelphia Experiment" to examine radar stealth on ships with electric drives. Independent of whether our assumed values are practical or not, the analysis, which uses no phenomenology that wasn't known subsequent to 1938, would probably have brought WW-II Naval investigators to the point of radar stealth experimentation. In fact, it would have been derelict behavior for the Defense Science Research Board *not* to have conducted such experiments if it were aware of this phenomenology (as it must have been) in 1943. Such an approach to stealth, however, is impractical and certainly would be of little interest, as such, to the military today.

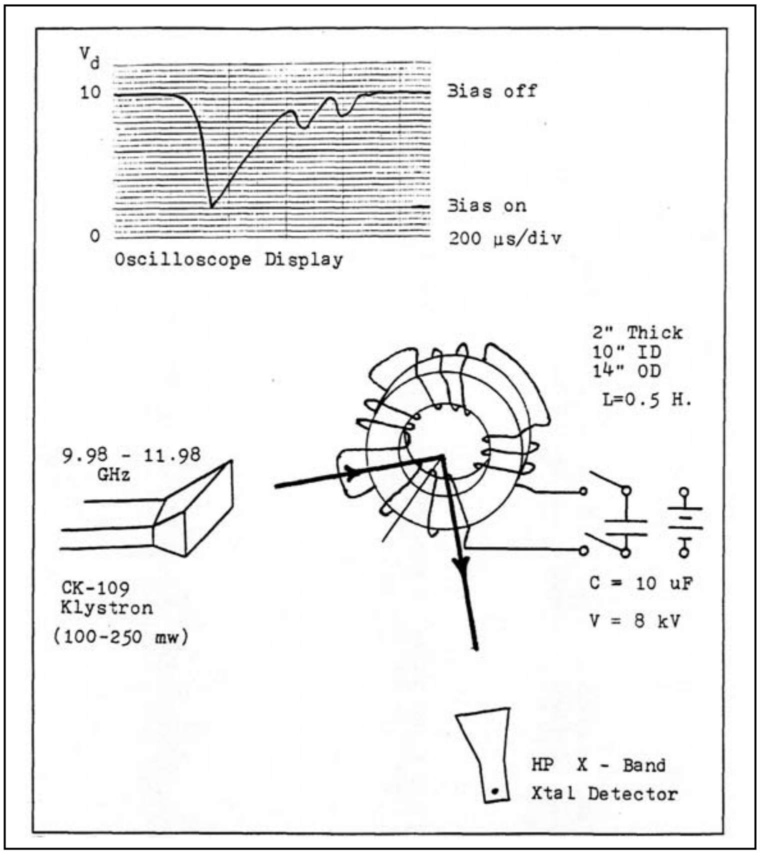

Figure 9
Experimental setup for radar backscatter from an 'egg of Columbus' apparatus.

THE EXPERIMENTAL PLATFORM

There probably exists a technical discussion of the "Bostwick" Class of Destroyer Escorts some place in the engineering literature. From Janes Fighting Ships we know that the Bostwick class, of which the DE-173 (the Eldridge) was a member, had the following properties: [(46)]

Practical Information About Destroyer Escorts

Displacement, tons	1240 standard; 1900* full load
Length, feet (meters)	306 (93.3)
Beam, feet (meters)	37 (11.3)
Draft, feet (meters)	14 (4.3)
Guns, dual purpose	3-3 in (76 mm) 50 cal.
Guns, AA	2-40 mm
A/S	Fixed hedgehog; **DCT**
Main Engines	GM diesels, electric drive
	6000 bhp; 2 shafts (4.5 MW)
Speed, knots	19
Radius, miles	1,500 at 11 knots
Oil fuel (tons)	300
Compliment	150 (accommodation 220)

And, it was transferred to Greece in 1951. Several photographs of other Destroyer Escorts of the same class are also provided. Interestingly, there does exist a descriptive level discussion of the use of destroyer escorts for providing shore power from their propulsion generators.

In a remarkable 1948 paper for engineers, Anderson and Fifer describe how electric propulsion ships were pressed into service to supply electric power to areas where the retreating enemy had destroyed existing shore plants. "During World war II, there were constructed a large number of AC turbine electric propelled vessels which had possibilities for supplying shore power." [(47)] (The DE's delivered substantial power and, according to F.M Starr of GE Schenectady, "were best suited to small diversified loads" [(48)] because they could be operated in parallel at a number of nominal output voltages at 50/60 Hz.) This is consistent with Tesla's 1917 suggestion for peacetime uses, as referred to above.

Anderson and Fifer even show photographs of two Destroyer escorts, tied up side by side at a dock, delivering power to Portland, Maine (instead of two, a third ship between them, as occurred in one "Philadelphia Experiment" reported by More and Berlitz*) during harvest-time after a severe drought had left the city without hydroelectric power in fall of 1947.

Their photographs show details of the method used to connect power between the vessels and land, the cable gantries required because of the high tides at Portland, and even the propulsion controls and the power controls, which were located in the forward engine room and the after engine room. (This is better than the movie!) There is a close-up view of the side of a Destroyer Escort showing the cable reels and unit substation.

* According to Moore and Berlitz, "The Eldridge was laid down on February 22,1943, at Federal Ship building and Dry Docks, Newark, NJ, and had a displacement of 1,240 tons standard and 1,520 tons full load." (pg. 158)

It would seem reasonable to assume that the “Philadelphia Experiment” would have used huge power cables much like those shown in these pictures. Anderson and Fifer tell us that the destroyer escort propulsion generators operated at 1,500 volts, 25-135 Hz, and, "The power output from the two vessels was about 9,000 kW." (49) This would seem to imply RMS generator currents on the order of 3,000 Amps - slightly below the $10^4 \sim 10^5$ order of magnitude required for the experiment. (See "Resonance" comments below.)

Shipboard Degaussing Installations

During the time of the “Philadelphia Experiment”, in late summer of 1943, the Naval Ordinance Laboratory had only two civilian scientists retained on contact John Kraus and Albert Einstein. Kraus was heavily engaged in ship degaussing. ("To reduce the ship's magnetic field we wrapped *several tons* of very heavy insulated copper wires around the ship." (50))

The same issue of the AIEE Transactions discussing supplying shore power also has an introduction to WW-II ship degaussing technology. (51) What is of special interest are the coil configurations on the ship. There were basically five different types of coil systems used on a ship. One of them, the "L-coil" was a helical solenoid with its axis parallel to the axis of the ship. "It was composed of a series loops in vertical planes perpendicular to the centerline of the ship. *The loops each ran inside the hull from the keel to the underside of the wectherdeck... The installations, with few exceptions were placed inside of the vessels. "* (52) (Early on, it was not fully appreciated that the coils placed inside the hulls could give effective protection, and so the first installations were actually made with the wires clamped outside and encircling the ship. Later, the coils were placed inside the steel hulls, the effect being reduced by about 30%, but the savings in maintenance justified the move.) Another coil configuration the 'M-coil' "encircled the ship just inside the hull in a horizontal plane approximately at the water line." (53) (Again, early on these were placed outside e ship.)

Kraus says, "The wires in each coil might make a bundle as big as a man’s wrist. Tons of copper were used on every ship, and degaussing coils became number one in our country's use of copper." (54) (About 12,000 American naval and merchant ships were fitted with a shipboard degaussing installation in early WW-II, no wonder we went to a "silver penny" one year.) Michel reports that it was not uncommon to use a multi-conductor wire bundle composed of 19 conductors of 40,000 circular mill area.* Some cables were "up to five inches in diameter and racked three and four cables together." (55)

Within this context of coil construction, one wonders. "How much current could such coils carry if pressed to the limit?" Not counting the presence of a heat sink (the hull of the ship and the sea), the maximum current carrying capacity of a wire is limited by the so called "fuzing current", which is the DC current, at which a wire will melt. For copper wire, (56)

$$I_F = 10{,}244 \ \ d_{inches}^{3/2} \qquad \textbf{(10)}$$

(A 1 " diameter copper wire melts at 10 kA, and a 5 " diameter wire at 1 14.5 kA.) So, it appears that the standard bundles could probably handle quite some current if pressed to the limit.

Michel reports that degaussing installations operated off the ships 240 volt DC supply bus through rheostats (the M-coil operated directly off a motor-generator pair) and the coils typically "produced 1,500 ampere turns". "Since the degaussing coils must produce fields extending rather long distances, the strength of the coil fields in the immediate vicinity of the cables is sufficiently high under some conditions to adversely affect the operation of other equipment." (57) Apparently even electric arc welders could be affected by the degaussing coils. ("Noticeable irregularities in the welding operation will occur." (58))

---

* “…..it concerned three ships. When they rolled the film it showed two other ships feeding some sort of energy to the central ship... After a time the central ship, a destroyer, disappeared slowly into a transparent fog..." Moore and Berlitz, P. 240.

CORRELATION WITH THE MOORE-BERLITZ BOOK

"The Philadelphia Experiment"

[All of Benjamin Franklin's electrical experiments were known abroad as "Philadelphia Experiments". However, *he himself* referred to the famous 1752 demonstration of the equivalence of lightning and frictional electricity as "*the*" Philadelphia Experiment. **(59)**]

The book by Moore and Berlitz **(60)** is a source of surprising descriptive information. Recently, one critic **(61)** examined the book and concluded, "Not only does the information presented by Moore and Berlitz in The Philadelphia Experiment fail the most fundamental test of verification, but the massive amount of evidence available has demonstrated the thesis patently invalid." **(62)** We think the contrary to be true. Not only is the phenomenology supplier but the independent statements of various witnesses corroborate the basic *technical* issues.

Moore declares that he is not a trained scientist, and it is understandable that technical testimony is often garbled. Take, for example, the interview with Dr. Rinehart (pp. 178 ~ 205). Reading between the lines, Moore (although frantically trying to record what he was being told) clearly didn't understand what Reinhart was saying. Further, given the unorthodox manner of C. M. Allen's disclosures, it is a wonder that any meaning can be distilled. This much makes sense:

Carl M. Allan

- "Electronic camouflage... Some sort of electronic camouflage produced by pulsating energy fields." (p. 19)
- "The Navy did not know that there would be men die from odd effects of hyperfield within or upon field." (p. 46)

We think the first statement is consistent with our presentation above. The second is consistent with the idea of incident **RF** interactions with the low frequency magnetically biased medium [fields (**RF**) on fields (**DC**)], just as given in Appendix I.

Commander X

(A scientist in the WW-II Navy radar program)

- "I heard they did some testing both along the [Delaware] river and off the coast, especially with regard to the effects of a strong magnetic force field on radar detection apparatus." (P. 169)

Though hearsay evidence, this is also consistent with the idea of a magnetically biased radar absorber. We have much more to quote, but will present it with discussion, below.

Resonant Magnification

One of the issues raised above was how could they step up the current from the generator by an order of magnitude. The large $\mathbf{H}_0$ required for magnetic biasing will result from a large current in the coils. Obviously, they could use a power transformer to step the current up (and voltage down). They could, in fact run high current with a low duty cycle and pulse the coils at very low frequencies.

---

* This would be about 3.8 inches in diameter. $\left(d_{in} = 0.001\sqrt{A_{CM}}\right)$

(Not so good for power transformers.) Or, they might employ the resonant rise in circulating currents, which occurs in a “Parallel Resonant Tank Circuit”. Although DC magnetic biasing was assumed for the $\mathbf{H}_0$ field in Appendix I, this was not necessary, and low frequency pulsations may even be employed. It is only required that the frequency of the magnetic bias field ($\mathbf{H}_0$) be mucl-4 much less than the radar carrier frequency (adiabatic invariance), but low enough for saturation to occur.

Dr. R. F. Rinehart

"I think that the conversation had turned at this point to the principles of resonance and how the intense fields which would be required, for such an experiment, might be achieved using this principle." (p. 191)

"I feel confident that the idea of producing the necessary electromagnetic field for experimental purposes by means of the principles of resonance was also initially suggested by Kent* - possibly as a result of these discussions with Professor Allen**." (p. 187)

Dr. Valentine

"The experiment [Dr. Jessup] said had been accomplished by using naval-type magnetic generators, known as degaussers, which were “pulsed” at resonant frequencies so as to create a tremendous magnetic field on and around a docked vessel." (p. 130)

In Appendix II of the book on Vacuum Tube Tesla Coils [63] and in Appendix II below, it is shown that if they had placed a capacitor in parallel with the ship's coils (as Tesla suggested in the 1917 interview above) and brought the system to parallel resonance at the ship’s generator frequency, then the circulating current in the coils would be stepped up by the $\mathbf{Q}$ of the parallel resonant system. This means that, the AC current circulating in the tank circuit coil is larger than the input current by the amount where $\mathbf{I}_T$ is the terminal point input current (the

$$I_{coil} = I_T \sqrt{1+Q_T^2} \qquad \textbf{(11)}$$

generator current in this case), $Q_T = \omega_0 L/R$, $R = (R_{coil} + R_{coupled})$, and $R_{coupled}$ is the effective load resistance coupled in (due to eddy current loss in the ship and sea water). In the older literature this is called a "current amplifier" or "current magnifier". [64] The circulating reactive kVA in the tank circuit is $\mathbf{Q}$ times the real component of the generator power into the tank. (Power is conserved of course, there is no magic going on.) By the way, “pulsing” a tank circuit is the fundamental idea behind the original class **C** oscillator. At full power, a tank circuit could provide a resonant rise of the current to levels sufficient to support the L-Band experiment discussed above. (A higher $\mathbf{Q}$ or pulse power processing might support the X-Band experiment.)

The use of low frequency AC pulsations for biasing is similar to the use of raw AC for class **C** oscillator driven Tesla coils. In the optical case it would, more than likely, lead to the "shimmering" situation discussed by Dr. Rinehart (pp. 198-199).

---

* Robert Harrington Kent.

** Professor Charles Metcalf Allen of Worcester Polytechnic Institute.

OBSERVABLE RAMIFICATIONS

Next, we would like to examine the collateral effects that one would not be surprised to observe accompanying such an intense magnetic experiment. There would be phenomenological effects and physiological consequences.

Phenomenological Effects

Low Frequency Magnetohydrodynamics in Salt Water:

1. Green fog and mist;

   "After a time the central ship, a destroyer, disappeared slowly into a transparent fog until all that could be seen was an imprint of that ship in the water. Then, when the field, or whatever it was, was turned off, the ship reappeared slowly old of thin fog." (p. 240).

   "I saw, after a few minutes, a foggy green mist arise like a thin cloud. " (p. 110).

   "suddenly, the green fog returned... " (p. 249).

2. A cavity in the water;

   "The men on the ship were apparently able to see one another vaguely, but all that could be seen by anyone outside of the field was 'the clearly defined shape of the ship's hull in the water " (p. 88).

   "I watched as the DE 173 became rapidly invisible to human eyes. And yet, the precise shape of the keel and underhull of the ship remained impressed into the ocean water as it and my own ship sped along somewhat side by side and close to inboards. " (p. 110-111).

   " The field was effective in an oblate spheroidal shape, extending one hundred yards out from each beam of the ship… Any person outside that could see nothing save the clearly defined shape of the ship's hull in the water."* (p. 41).

Sea water $(\sigma \approx 5\ \Omega/m \text{ at ELF})$ is no superconductor. However, a time varying magnetic field, via Faraday's law, generates eddy currents in salt water, which in turn react back on the magnetic source opposing any changes in the source field. Consider the following description due to Feynman.

> "If we have a sheet of a perfect conductor and put an electromagnet next to it, when we turn on the current in the magnet, currents called 'eddy currents' appear in the sheet, so that no magnetic flux enters. The same thing happens if we bring a bar magnet near a perfect conductor. This makes it possible to suspend a bar magnet in air above a sheet of perfect conductor... If the conductor is not quite perfect there will be some resistance to flow of the eddy currents. The currents will tend to die out and the magnet will slowly settle down. The eddy currents in an imperfect conductor need an EMF to keep them going, and to have an EMF the flux must keep changing.

---

* A ship's "beam' is its width at the widest point.

The flux of the magnetic field gradually penetrates the conductor... In a normal conductor, there are not only repulsive forces from eddy currents, but there can also be sideways [drag] forces [which prevent lateral motion]." **(65)**

The circulating AC eddy currents would agitate the sea water, at acoustical frequencies, (pumping the salt water, making steam, mist, and fog) and, in all probability, hollow out a cavity under the magnet. (Consider what happens with a high current AC electromagnet in a plastic tub of salt water.) [It's even more exciting with polyphase AC and a rotating magnetic field!]

"If, instead of dragging a conductor past a magnet we try to rotate it in a magnetic field, there will be a resistive torque from the same effects. Alternatively, if we rotate a magnet near a conducting plate or ring [or conducting egg], the ring [or egg] will be dragged around; currents in the latter will create a torque that tends to rotate it around... A field like that of a rotating magnet can be made with an arrangement of coils [on an iron torus]... we have a 'rotating' magnetic field.... The [rotary drag] torque produced on a conductor by such a rotating field is easily shown by standing a metal ring on an insulating table just above the torus. [Feynman here shows a ring hanging by a string over a table above a three phase toroidal transformer.] The rotating field causes the ring to spin about a vertical axis." **(66)**

Feynman has just described the Egg of Columbus to his Cal Tech students, - without ever mentioning its inventor. It's too bad - for the students, that is. (They're the actual loosers.) Tesla didn't even have to use a string to hold up the egg, like Feynman (80 years later) does!]

Well, how much green fog and mist could you make with a nine megawatt AC generator? How big a cavity could you funnel out of the sea? It would be fascinating to calculate this out as another appendix.

3. Unsettled Conditions:

"….a boiling of the water, ionization of the surrounding air, and even a 'Zeemanizing' of the atoms... The ioniz6tion created by the field tended to cause an uneven refraction of the light… The result would not be a steady mirage effect, but rather a moving back and forth displacement caused by certain inherent tendencies of the A C field... We felt that with proper effort some of these problems could be overcome and that a resonant frequency could probably be found that would possibly control the visual apparent internal oscillation so that the shimmering would be at a much slower rate….." (pp 198-199).

One might expect power dissipation in the water, due to circulating eddy currents in the sea, to heat the water, perhaps to the level of steam. Also, the sea would be a heat sink for any heating of the hull; "Zeemanizing" is discussed elsewhere. There would be a good deal of turbulence near the ship (as demonstrated by the second of our experiments described above).

Ionization in the air could result as follows. Large magnetic fields rapidly changing in time can cause an ionizing breakdown of air. **(67)** The idea stems from Joseph Slepian's pioneering patent **(68)**, which resulted in D. W. Kerst's creation of the Betatron accelerator in 1941. **(69)**

If a nonsinusoidal waveform were used to drive the ship's bias coils, say a low duty-cycle, pulse train (as in a class **C** oscillator), or a capacitive discharge directly into the coil, then large spikes in $\mathbf{E}_{\phi}$ would result from the rapid $\partial H_Z / \partial$ (make/break). In the language of jumped circuits, $V_{coil} = L\, di/dt$ has spikes. For a cylindrical solenoid, Faraday's Law gives:

$$E_{\varphi}(r) = \frac{\mu_0 r}{2} \frac{\partial H_z}{\partial_t} \quad \textbf{(12)}$$

If $\mathbf{E}$ should rise to near 200 kV/m (well below air breakdown at 3 MV/m) incipient atmospheric Trichel pulses would be emitted from every sharp object on the ship and extensive corona would ensue. Clearly, a fast rising pulse would not be a good choice of waveform.

4. Acoustic whine and hum:

> *"I felt the push of that force field against the solidness of my arm and had outstretched into its humming, pushing, propelling flow."* (p. 110)
>
> *"In trying to describe the sounds that the force field made as it circled around the DE 173…. it began as a humming whispering sound, and then increased to a strongly sizzling buzz, like a rushing torrent."* (p. 111)
>
> *"A special series of electrical power cables had been laid from a nearby power house to the ship. When the order was given and the switches thrown 'the resulting whine was almost unbearable.* (p. 248)

It would seem reasonable to assume that the media immersed in the bias coil's low frequency magnetic fields (the ship and the sea water) would respond with mechanical vibrations, much like the acoustical hum of conventional power transformers for example. (The ship and sea water have become the output of an *acoustical transducer,* driven by the bias coils.) More than likely, the power content of harmonic spectra would be substantial well into the ultrasonic region, (think of all the electrical, mechanical, and physiological nonlinearities present), accounting for the perception of 'unbearable whine.

Biological (Physiological) Effects

While on earth our physical bodies move about in relatively weak background magnetostatic (**1/4** gauss), fair weather electrostatic (**100** V/m), acoustical pressure (**1/2** dyne/cm ^{2}), RF, and gravitational fields. This experiment would have meant total immersion in an unusual set of electromagnetic and acoustical fields. While people have been subjected to fairly large **DC** magnetic fields, [70] the "Philadelphia Experiment" probably used intense low frequency pulsating fields, which could lead to a novel set of recognized perceptual phenomena.

One might expect peculiar responses from the nervous system, visual system, auditory system, and respiratory system, as well as, general mental and perceptual confusion.

> *" We couldn't stand the effects of the energy field they were using... It affected us in different ways. Some only saw double, others began to 1augh and stagger like they were drunk, and a few passed out. Some even claimed that they had passed into another world and had seen ad talked to alien beings."* (p. 19).
>
> *"Any person within that sphere became vague in form but he too observed those persons aboard the ship as though they were of the same state, yet were walking upon nothing."* (p. 41).
>
> *"As he stood there trying to comprehend what had happened, and looking for his ship, he watched indistinct figures in motion, whom he could not identify as sailors and some other shapes 'that did not seem to belong on the dock, if that is where I was"*. (p. 248).

Let us zero in on perceptual effects, which we would expect under such circumstances:

Magnetophosphenes and Purkinji figures. A phosphene is a sensation of light produced by physical stimuli other than light. A magnetophosphene is one stimulated by time-varying magnetic fields. What about Purkinji patterns?

Johannes Purkinji, the renowned Czech physiologist of the 19th century once said, "Deceptions of the senses are the truths of perception." By this he meant that, "Illusions call our attention to the workings of the visual system, whereas normal perception falls to do so." [71] Perkinji was famous for studying a number of variously shaped, subjective optical patterns that can be excited by electrical stimulation. In 1819, he put a circuit interrupter (a chain) in series with a battery and electrodes across the face, and saw different shaped geometrical patterns when he wiggled the chain (The phenomenon goes back (again) to Benjamin Franklin and to Allesandro Volta.)

Following on the clue that a low frequency electromagnetic pulse spectrum was involved, Knoll and Kugler, in Germany (at Munich), investigated the excitation of “Purkinji patterns”. [(72)]

(Apparently, similar patterns have been observed during brain surgery by direct electrical stimulation of the visual cortex at 60 Hz.) [(73)]

> "It has been found that (besides flicker), a whole “spectrum” of subjective abstract light patterns can be excited in the brain by using temporal electrodes and pulses of a few volts within the encephalographic frequency range. While shapeless flicker covers a large frequency range, patterns are excitable mostly within the range of 5-35 pulses/second. The number of subjective patterns excitable in each individual was longer for mental patients than for technical students... Most patients with beta-encephalographic activity showed pattern excitation frequencies greater than 50 pulses/second. " [(74)]

They observed many light patterns such as stars, wheels, asterisks, bright dot patterns, moons, “smiley faces” and other geometrical shapes.

Fascinating surveys have been published by Becker, who specifically reports on “magnetophosphenes” (magnetically stimulated phosphenes), [(75)] and by Oster. [(76)] Becker relates that;

> "'The intensity is greatest between 20 and 30 Hz. Above 90 Hz the phenomenon becomes less evident... As the field strength is increased, the luminosity appears to involve more and more of the visual field... No subjective sensations of any ape were noted during steady field applications, but phosphenes were experienced during 'make' and 'break' of the coil current.” [(77)]

(Apparently the original data were obtained by placing the subject's head in a large solenoidal coil.) The results would seem to illustrate the importance of an intense low frequency *time varying* magnetic field.

Oster suggests that Phosphenes "may well constitute the fact behind reports of phantoms and ghosts.” [(78)] He points out that alcohol and hallucinogenic drug can induce phosphenes. However, "Pulses in the same frequency range as brain waves (from 5 to 40 Hz) were most effective in producing phosphenes." [(79)]

Oster did something else that was particularly interesting. He looked for beats.

> "Using two electrically independent generators and four electrodes, we have applied pulses of two different frequencies at the same time. Each is just above the critical point [upper cutoff frequency] and would therefore produce no phosphenes by itself. Together they generate beats, which are seen as undulating phosphenes, that move slowly across the field of view. It would appear that some neural mechanism mixes the two signals, which interact periodically to produce a beat." [(80)]

(A phosphene superheterodyne, no less: use one generator as a signal, link couple the other into the head as an injected Local Oscillator, and let the brain do the **IF** filtering, processing and detection! They could probably have searched for third order intermodulation distortion products, gotten the image frequency rejection ratio, and a host of other radio characterizations.)

The medical industry, at one time, thought that electrically stimulated phosphenes might bring about artificial vision for the blind. [(81)] [(82)] Jearl Walker [(83)] discusses phosphenes and states that not only are they poorly understood ("There has been almost no work published on modeling the phenomenon."), but also the physical source has not even been identified.

We think that visual distortion magneto-phosphenes and Purkinji patterns (whether they were the alien humanoids reported as being seen by some sailors, or not) would certainly have accompanied the experiment.

Such cerebral cortex stimulation (time varying magnetic flux producing induced electrical voltage stimuli along the visual and nervous systems) would probably also play a role in the "blanking out" experienced by some participants, even after the fields had been turned off. The "blanking out" and "frozen" episodes may have followed as a result of simple nonlinear responses of the nervous system. Furthermore, because the permitivity for brain tissue is complex $(\varepsilon = \varepsilon' - j\varepsilon'')$ with an effective conductivity $(\sigma_e = \omega\varepsilon'')$, one would expect AC (diathermy or "diatheretic") dielectric heating of the tissue, with ensuing mental and neurological complications.

Summary Remarks - Leading To Another Question

All this leads to a relatively unpretentious question. If the physics of the experiment is so easy to explain, and the physiological symptoms so easy to rationalize, then why would there be such a shroud of mystery in the Navy, and such unwillingness to acknowledge it? (Surely, with the National debt the size it is, they must have figured this all out years ago.) The military have conducted many experiments that went awry and where people were seriously injured. Why cover up this one?

The reluctance implies deeper issues. It would seem to suggest that something of an unusual nature occurred during the experiment. What was it?

TORSION TENSOR CONJECTURE

"The views of space and time, which I wish to lay before you.... are radical. Henceforth space by itself, and time by itself, are doomed to fade away into mere shadows, and only a kind of union of the two will preserve an independent reality."

Hermann Minkowski, Cologne, 1908* **(84)**

At this point, not only are the authors going to go out on a limb but, metaphorically speaking, we also will saw the tree off. Listen to the bizarre testimony presented by those involved in the experiment.

"The experimental ship also somehow mysteriously disappeared from its Philadelphia dock and showed up only minutes later in the Norfolk area. It then subsequently vanished again only to reappear at its Philadelphia dock. Total elapsed time - a mater of minutes. " (p. 89).

"Suddenly, the deep fog "flashed off", leaving Silverman in a very confused state and wondering, "what in the world I was doing in Norfolk." He said he had recognized the place as Norfolk "because I had been there before to the ship's other dock there." Then just as suddenly, the green fog returned; it lifted again and Silverman found himself back at dockside in the Philadelphia Navy Yard " (p. 249).

"One day, looking at the harbor from the dock, [five British merchant seamen in Norfolk, VA] were understandahly amazed to see a sea-level cloud suddenly form in the harbor, and almost immediately dissipate,, leaving a destroyer escort in full view, which stayed but a few moments before it was covered by a cloud and vanished again. " (p. 250).

These quotes sound like the unmitigated blubbering's of some science fiction writer. Look, you can't do a macroscopic job like this with quantum mechanics, or even general relativity. Nine megawatts is one bodacious rate of energy delivery, but (worm holes, black holes* and "zitterbewegung" notwithstanding) it's not enough to distort Schwarzschild's metric, or Kerr's metric, or anybody else's solution to the extent that something like this could happen, even in a small locality. The obvious rational explanation would be that some people that saw it, were confused or intoxicated. Certainly one might expect the former to be the case for those sailors immersed in the intense fields of the experiment. But still, one wonders...

Now we ask, "What about time-travel and teleportation?" How could these topics become part of the associated lore? [To this point, we've been having fun at the Joseph Slepian - Jearl Walker level. Now we'll have to join Edwin Abbott, Sir Arthur Stanley Eddington, [85] and George Gamow, or Philip (teleportation) [86] and King Hezekiah (time travel). [87]] Let us have some history, and attempt speculative conjecture on these topics while striving to maintain mathematical sensibility.

Spin, Torsion, and a Crinkled Space-Time

"I do not think it is too extravagant to claim that the method of the tensor calculus is the only possible means of studying the conditions of the world which are at the basis of physical phenomenon."

Sir Arthur Stanley Eddington**

---

* An English translation, accompanied by Arnold Sommerfeld's notes and commentary, is referenced.

** To make a black-hole with a null surface (absolute event horizon) the size of the ship's beam **[R_S = ($2GM/c^2$ = 5.5 meters]** would require an energy of **3.34×10^{44} Joules**.

*** The Mathematical Theory of Relativitv, Cambridge U. Pr., 1923, pg. 49.

Relation of Gyromagnetic Phenomena to the Production of Torsion

During the course of our investigation of the "Philadelphia Experiment" we examined the hypothesis that quantum mechanical spin such as found in ferromagnetic materials, may affect the structure of space-time. We were intrigued by a remark that Friedreich Hehl and his colleagues published;

> *"One finds that distant observers, who measure only the metric field, cannot distinguish between a (ferromagnetically) polarized source of spinning matter (which causes torsion locally) and a rotating distribution of matter with the same total angular momentum (which nowhere causes torsion)."* **[88]**

What was meant by ferromagnetic generation of localized torsion? This, and the fact that torsion permits temporal displacements of magnitude

$$cdt = dx^4 = 2\left|S^4{}_{ab} - \Omega^4{}_{ab}\right| dx^a dx^b \qquad \textbf{(13)}$$

drove us to pursue even wilder musings than presented above. Could it be possible that, as a result of magnetically biasing the ship to radar stealth, torsion deformations were excited in the fabric of space-time itself? (We told you that we were going out on a limb, in this section.) Were that possible, then there might be teleportation and time-travel without the crushing effects of gravitational curvature, or squeezing through the Schwarzschild radius down the throat of a black-hole, or thoughts of bubbling out through a white-hole at some unknown place in the universe, or $\mathbf{10^{44}}$ **joules** required to make the machine run. The torsion technique might even be within reach of pre-WW-II electrical engineering. If the spin were right, one might leap ahead along his world line (or perhaps even backwards) without travelling all the distance in between. What an enchanting idea!

In the pursuit of this hypothesis, we came across a very extensive literature on the relationship between quantum mechanical spin and space-time torsion. (This seems to be the present employment of Einstein's 1929 UFT (Unified Field Theory) space with torsion.) Based on this research, we provide below an heuristic and speculative account of the affect of quantum mechanical spin on the structure of space-time and also propose a new theory of the Aharonov-Bohm effect with an outline for an experiment to verify our theory. We also propose a classical experiment utilizing the conventional Sagnac Effect and photon gyros to distinguish between temporal jumps due to "Anholonomity" and jumps due to "Torsion". Since the concepts of anholonomity and torsion are central to our discussion, we will begin by illustrating what these terms mean.

Torsion and the Anholonomic Object

In a considerable volume of the literature, the concepts of torsion and anholonomity are mingled and confused. They are distinctly different, anholonomity being frame dependent and torsion being a true tensor field quantity. Imagine a reference system of coordinates that you carry around with you to make measurements. This reference system consists of a field of orthogonal basis vectors that span three (3) space dimensions $\mathbf{e}_1$, $\mathbf{e}_2$, $\mathbf{e}_3$, and time $\mathbf{e}_4$. (We use boldface for vectors.) These are Einstein's "**n-Bein**", or "**tetrad**" fields. Now, using this reference field of frames, you can make measurements, which can be transmitted to a second observer, who can transform your measurements into his reference field of frames using his own set of orthogonal basis vectors ($\mathbf{e}_1'$, $\mathbf{e}_2'$, $\mathbf{e}_3'$, $\mathbf{e}_4'$). (We could say this much more elegantly, but for the present audience and the limitations of space, please permit us to be vigorous instead of rigorous. Those that understand the formalism can supply their own rigor.)

In flat space-time (where the Riemann curvature tensor is zero), each observer can relate his reference frames (determined by his set of orthogonal basis vectors) to another observer's reference frames via a simple Lorentz transformation, provided that no forces are acting on the observers (observers are moving inertially).

In the case when observers are not moving inertially, relating the reference frames of the observers can be greatly facilitated by employing the mathematical machinery of torsion and the anholonomic object as we show in the following.

Now imagine two separated observers (observer 1 and observer 2) who wish to compare measurements (we do not assume the observers are moving inertially). In order to do this they must determine how their reference frames differ. The only way to compare reference frames is to transport observer one's set of basis vectors to the same location as observer 2 and see how they differ when compared with each other at the sane location. (See Figure 10 below)

Let $\mathbf{e}_i$, be one of observer one's basis vectors at $\mathbf{P}_0$, and let $\mathbf{e}_i'$ be one of observer two's basis vectors at $\mathbf{P}_1$ (we will use Latin indices throughout this paper with values 1, 2, 3, for the spatial dimensions and 4 for time). $e_i(P_0 \to P_1)$ is the value of observer one's $\mathbf{e}_i$ basis vector after it has been parallely transported to $\mathbf{P}_1$ (to parallel transport a vector means to move it without changing its length or angle). $\mathbf{De_i}$ is the difference between observer one's parallely transported basis vector and observer two's basis vector. This gap defect $\mathbf{De_i}$ between the two basis vectors is due either to a change in the coordinate basis between observer 1 and observer 2, in which case it can be mathematically transformed away, or it was due to deformations in the path it took between $\mathbf{P}_0$ and $\mathbf{P}_1$, in which case the gap defect cannot be transformed away, or a combination of both.

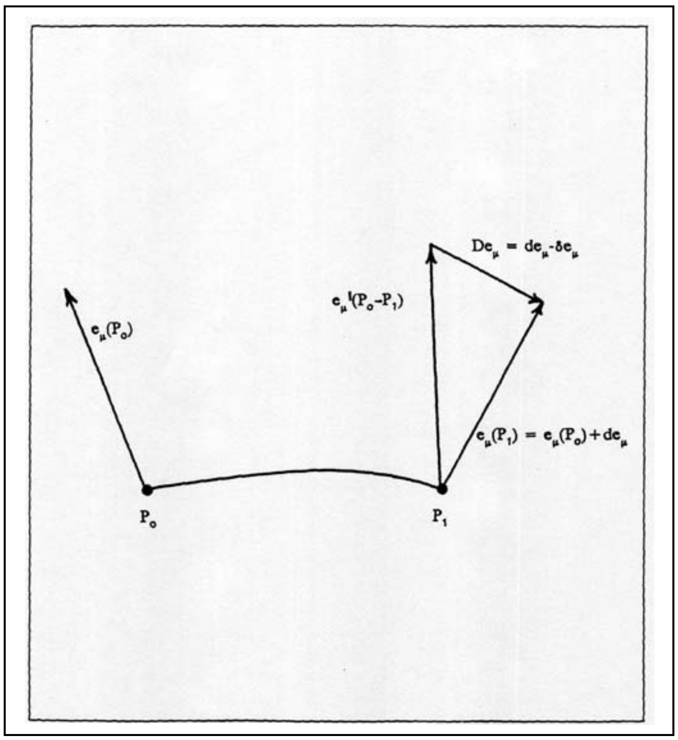

Figure 10
Parallel transport of a vector from $\mathbf{P}_0$ to $\mathbf{P}_1$

To see this more clearly, let us move observer one's set of basis vectors over two different paths. Parallel displacing an incremental vector $dx^b e_b$ from the point **P_0** along the basis vector **e_a** over an infinitesimal distance **dx^a** to the point **$P_1 = P_0 + dx^a$** gives the vector

$$dx^b \vec{e}_b(P_0 \rightarrow P_1) = dx^b \vec{e}_b(P_0) + \Gamma^c{}_{ba}\, dx^a dx^b \vec{e}_c \qquad \textbf{(14)}$$

Similarly, parallel displacing the incremental vector $dx^a e_a$ from the point **P_0** along the basis vector **e_b** over an infinitesimal distance **dx^b** to the point **$P_2 = P_0 + dx^b$** gives the vector

$$dx^a \vec{e}_a(P_0 \rightarrow P_2) = dx^a \vec{e}_a(P_0) + \Gamma^c{}_{ab}\, dx^b dx^a \vec{e}_c \qquad \textbf{(15)}$$

The gap defect between the parallely transported vector at **P_1** and the actual value of the vector $dx^b e_b$ at **P_1** is

$$dx^b D\vec{e}_b(P_1) = dx^b \left(\frac{\partial \vec{e}_b}{\partial x^a} \right) dx^a - \Gamma^c{}_{ba}\, dx^a dx^b \vec{e}_c \qquad \textbf{(16)}$$

Likewise, the gap defect between the parallely transported vector at **P_2** and the actual value of the vector $dx^a e_a$ at **P_2** is

$$dx^a D\vec{e}_a(P_2) = dx^a \left(\frac{\partial \vec{e}_a}{\partial x^b} \right) dx^b - \Gamma^c{}_{ab}\, dx^b dx^a \vec{e}_c \qquad \textbf{(17)}$$

The total gap defect between the two vectors is

$$dx^b D\vec{e}_b(P_1) - dx^a D\vec{e}_a(P_2) = [\vec{e}_a, \vec{e}_b] dx^a dx^b + [\Gamma^c{}_{ab} - \Gamma^c{}_{ba}] dx^a dx^b \vec{e}_c \qquad \textbf{(18)}$$

where the commutation and anholonomic object are given by [(89) (90)]

$$[\vec{e}_a, \vec{e}_b] = \left(\frac{\partial \vec{e}_b}{\partial x^a} - \frac{\partial \vec{e}_a}{\partial x^b} \right) = -2\Omega^c{}_{ab}\, \vec{e}_c \qquad \textbf{(19)}$$

As Eddington and Schouten recognized in the 1920’s, parallelograms (composed of parallel transported vectors) don't necessarily close (either because of anholonomity or because of torsion). [91] [92] [93] [94]

> *"Einstein's world geometry may be briefly described as a geometry in which there are parallels but not parallelograms. Thus he admits the existence, even at great distances, of a line CD equal and parallel to AB; but the line through B parallel to AC fails to cut CD. (We are dealing with at least three dimensions, so that lines are not necessarily coplanar.) The geometrical idea of an abortive parallelogram which fails to close up at its fourth comer, does not carry us very far, and it is necessary to proceed analytically."* [95]

This is not an effect attributable to curvature. Furthermore, while the anholonomic object can be transformed away by a coordinate transformation, this is not the case for torsion.

One interpretation of a coordinate transformation is that it simply means to relabel the coordinate basis of one frame into that of another. For example, the point **P** is located in one coordinate system by the points **x, y**. In another coordinate system, which we will call the prime coordinate system, the same point is located by the points **x, y**. If the coordinate transformation (the relabeling process) between the two is holonomic then

$$dx' = \left(\frac{\partial x'}{\partial x}\right)dx \qquad \textbf{and} \qquad dy' = \left(\frac{\partial y'}{\partial y}\right)dy \qquad \textbf{(20)}$$

and the coordinate differentials are integrable into coordinate curves. If the coordinate transformation is non-holonomic then the above relations do not hold (this is known as Pfaff 's problem) and the prime system uses basis vectors, which are not tangent to the coordinate curves of any coordinate system. The anholonomic object, as we have seen, measures the discrepancy between the basis vectors of two different coordinate systems that have been caused solely by the mathematical machinery (the coordinate transformation) that relates the two coordinate systems; remember the commutation operation $[\mathbf{e}_a, \mathbf{e}_b]$ from above. Consequently, what has been created mathematically can be dissolved mathematically and the anholonomic object can be transformed away by an appropriate change in the choice of coordinates.

We do not wish to imply that the anholonomic object is a mathematical artifact with no physical consequences. Failure to take into account anholonomity inherent in the twisting of the tetrads in some reference systems can have dramatic consequences. [96] [97] [98] [99] (Thomas precession, the Sagnac effect, the Oppenheimer-Schiff paradox, the Feynman Paradox, etc., are all classic examples of the effects of anholonomity.) In relativistic rotation one desires to describe what's happening in the rotating (anholonomic) frame, not in the holonomic (non-rotating) frame!

The components of the torsion tensor $S^c{}_{ab}$ are obtained from [100] [101] [102] [103] [104]

$$S^c{}_{ab} = \frac{1}{2}\left[\Gamma^c{}_{ab} - \Gamma^c{}_{ba}\right] \triangleq \Gamma^c{}_{[ab]} \qquad \textbf{(21)}$$

Torsion, unlike anholonomity, is due to changes in the properties of the underlying manifold and cannot be transformed away by a change in the coordinate basis**.** Torsion is a measure of how much the manifold is crinkled or folded, and such geometry's can be made anholonomic Riemannian by tearing, as discussed in great detail in the publications of Gabriel Kron. It should also be noted that the principle of equivalence does not hold in spaces with torsion. [105]

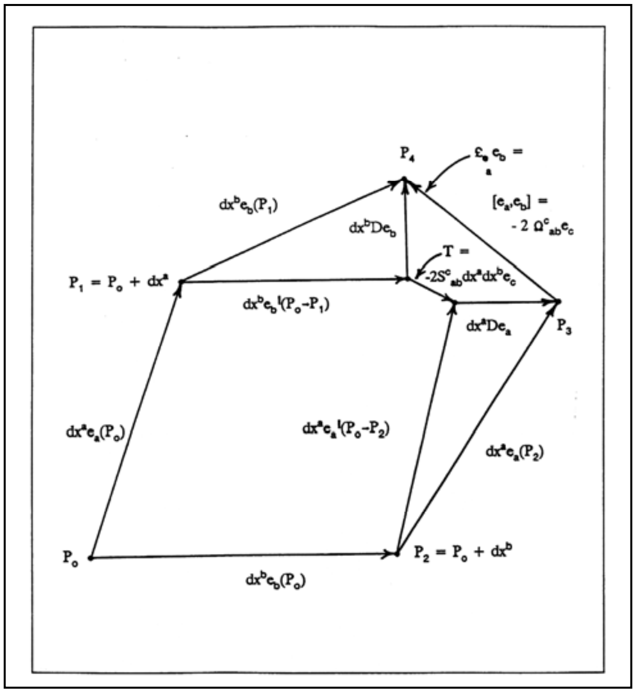

Figure 11
The non-closure of the outside quadrilateral depends upon Anholonomity. The non-closure of the inner pentagon depends on the Torsion of the manifold.

A simple picture might help to illustrate torsion: imagine a folded towel. Start at a point underneath the fold and trace a circle so that you cross over the fold. The point where you return after tracing the circle is on the fold above the point where you started. If there were no torsion, i.e., no fold, you would have returned to the same point where you started. (Do not confuse this with curvature. What we are discussing is distinctly different from Riemannian curvature!) The torsion component

$$\vec{T} = 2S^{c}{}_{ab}\, dx^{a}\, dx^{b}\, \vec{e}_{c} = \left[\Gamma^{c}{}_{ab} - \Gamma^{c}{}_{ba}\right] dx^{a}\, dx^{b}\, \vec{e}_{c} \qquad \textbf{(22)}$$

measures the gap across the fold from where you started to where you finished. The distinction between gap defects arising from anholonomity and from torsion is shown in Figure 11 below, which is self explanatory. (Look, for **c = 4** we're talking about a "time machine".)

Perhaps one more sketch will help clarify all this analytical machinery. Consider the 'crinkled manifold represented in Figure 12 below. The affine connection is asymmetric: $\Gamma^{c}{}_{ab} \neq \Gamma^{c}{}_{ba}$. Consequently, parallel transporting the two vectors at **P $_0$ (t=O)** leads to the discrepancy, or gap defect vector shown. In spaces with torsion, an observer in space can be transported forward in time by the amount

$$cdt = dx^{4}\, \vec{e}_{4} = 2\left[S^{4}{}_{ab}\, df^{\,ab}\right] \vec{e}_{4} \qquad \textbf{(23)}$$

Similarly, as shown on the left, an observer may jump through the space gap **dϕ (**with **dt =0),** the gap being given by

$$d\varphi = dx^3 \vec{e}_3 = 2\left[S^3{}_{ab}\, df^{ab}\right]\vec{e}_\varphi \qquad \textbf{(24)}$$

In spaces with anholonomity (but no torsion), the gaps are actually measured as the Sagnac effect and Thomas precession respectively. The former is of considerable interest to GPS receivers and photon rate gyros.

As we have seen, anholonomity is a mathematical creation caused by a choice in coordinates or resulting from noninertial motion. It's a twisting of the coordinate surfaces used an observer. Torsion, however is caused by a folding of the space-time manifold itself. What could cause a folding or crinkling of the space-time manifold and so create torsion? Is there a way that we could actually build such a 'time machine' out of magnets and coils and capacitors and stuff? We look at one answer to this question "in the next section".

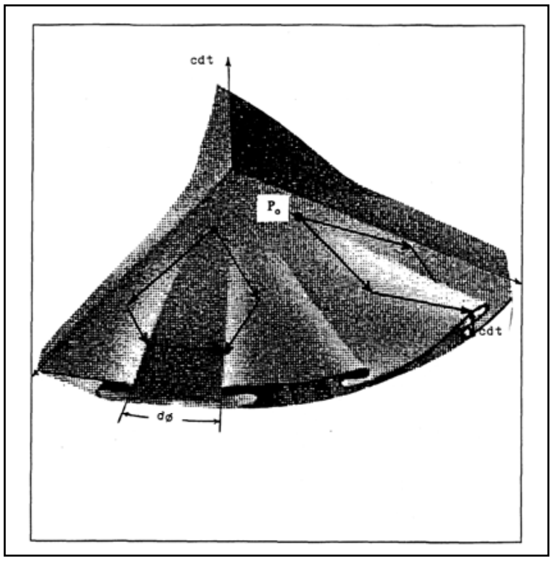

Figure 12

A "crinkled space modeled as a pleated fabric". The jumps are due to Torsion if $S^c{}_{ab} \neq 0$ and due to Anholonomity if $\Omega^c{}_{ab} \neq 0$.

Spin and Torsion

Spin

Is defined as the angular rotation of an object about one of its axis is a concept for which we are all familiar.

Quantum mechanical spin

Is defined as the internal angular momentum of a quantum mechanical particle is a more elusive concept. Recent work [106] , however, has brought to light an old suggestion [107] that quantum mechanical spin may be regarded as an angular momentum generated by a circulating flow of energy in the wave field of the quantum mechanical particle. With this concept of quantum mechanical spin in mind, we will proceed to discuss how quantum mechanical spin may create torsion in the space-time manifold.

In the previous section, where we heuristically demonstrated the concepts of torsion and the anholonomic object using parallely transported basis vectors, we found that when we compared the parallely transported basis vector to their actual values at a point some infinitesimal distance away, there was a gap defect due to the misalignment of the respective basis vectors. This misalignment can be corrected by simply rotating the parallely transported vector until it aligns with the actual value of the vector at the destination point. The rotation that caused the misalignment of the basis vectors consists of two parts: one part proportional to the anholonomic object, which can rotate the transported basis vector on a Riemannian (torsion-free) manifold; and the other part due to torsion, which provides another independent rotational degree of freedom. Now let us see how the extra degree of rotational freedom associated with torsion can be related to quantum mechanical spin.

Assume that a material system can be described in terms of a Lagrangian density **L**. Then the energy-momentum tensor T^{ij} of the material system can be described by

$$T^{ij} = \frac{2}{\sqrt{-g}} \left(\frac{\delta L}{\delta g_{ij}} \right) \qquad \textbf{(25)}$$

where g_{ij} is the metric of the underlying manifold and g is its determinant.

Metric specifies the scaler product between two basis vectors, which lie in the tangent space above the manifold and is used to determine distance and angle on the manifold. Because metric is used to define distance, a variation in the metric δg_{ij} determines a variation in the distance on the manifold.

Analogous to the definition of the energy momentum tensor stated above, it has been shown that a dynamical definition of spin can be related to variations in the contortions of space-time

$$\tau_k{}^{ji} = \frac{1}{\sqrt{-g}} \left(\frac{\delta L}{\delta K_{ij}{}^{k}} \right) \qquad \textbf{(26)}$$

where $\tau_k{}^{ji}$ is the spin angular momentum and $K_{ij}{}^{k}$ is the contortion tensor [108].

The contortion tensor is related to the torsion tensor by [109]

$$K_{ij}{}^{k} = -S_{ij}{}^{k} + S_{j}{}^{k}{}_{i} - S^{k}{}_{ij} \qquad \textbf{(27)}$$

Consequently, a variation in the contortion tensor implies a variation in the torsion and in the affine connection. We can see this more clearly by defining an affine connection for spaces with torsion in anholonomic coordinates as [110]

$$\Gamma_{ijk} = g_{ki} \Gamma^{1}{}_{ij} = -\Omega_{ijk} + \Omega_{jki} - \Omega_{kij} - K_{ijk} \qquad \textbf{(28)}$$

and in holonomic coordinates as [111]

$$\Gamma^{k}{}_{ij} = \left\{ {}_{i}{}^{k}{}_{j} \right\} - K_{ij}{}^{k} \qquad \textbf{(29)}$$

where $\left\{ {k \atop i \; j} \right\}$ is Christoffel's symbol of the second kind. As mentioned above, this idea can actually be traced back to Schouten and Cartan in the 1920's.

Thus, we see that a variation in the contortion tensor $K_{ij}^{\;\;k}$, varies the torsion space-time connection and leads to a twisting of the parallely transferred orthogonal basis vectors.

We have passed through some rather subtle mathematics here, and lest the reader think that this is, to quote some anonymous wag, the product of the leisure of the theory class, let us state in the strongest terms possible that what we have just said lies at the bedrock foundation of electrical engineering! Perhaps some history would be in order before proceeding.

A Short History of Successful Unified Field Theory Applications

Historically, the idea of an unsymmetric affine connection was first discussed in a 1921 footnote by Arthur Eddington. (112) He conceived that such a manifold would be "infinitely crinkled".

This can be visualized as a geometrical manifold constructed as a folded or pleated sheet of cloth as mentioned above. Any attempt to extrapolate out away from the contact point of reference $\mathbf{P}_0$ will lead to unanticipated results. Infinitesimal parallelograms are discontinuous as one approaches a pleat from above the fold or from under the fold. If the discontinuity is due to actual folds in the manifold, the resulting pentagon is due to torsion and the discontinuity, is of magnitude $S^c_{\;ab}\, dx^a dx^b e_c$. If, however the jump discontinuity is due to folds in the choice of coordinate surfaces, the resulting pentagon is due to anholonomity and the coordinated time correction required is of magnitude $2\Omega^c_{\;ab}\, dx^a dx^b e_c$. This is the case for the Sagnac effect and it is clearly observed with the GPS (Global Positioning Satellite) system, and especially with global time dissemination.

The torsion tensor was introduced almost simultaneously in 1922 by Eli Cartan (113) (1859~1951) and in 1923 by Jan Schouten (114) (1883~1971). Subsequently, from 1925 to 1931 Einstein employed affine connection asymmetry in speculative generalizations of relativity theory. (115) (116) (117) (118) (119) (120) He had hoped to link the four vector potential $(\mathbf{A}_a)$ to a contracted torsion tensor field $(\mathbf{S}^{\mathbf{b}}_{\;\mathbf{ba}})$. He seems to have had difficulty recognizing the distinction between anholonomity, which depends on the commutation of the basis vectors, and torsion, which depends solely on the asymmetry of the affine connection.

Norbert Wiener was the first to recognize that Einstein's distant parallelism gave the possibility of comparing "spins" at different points.

> *"The notion of a parallelism valid for the whole of space and of Einstein's **n-uples** enables us to carry over the **Dirac** theory into general relativity almost without alteration... the quadruples need not be integrable so as to furnish us with a co-ordinate system throughout space... This seems to us the most important aspect of Einstein's recent work ... "* (121)

Wiener saw the tetrad approach of Einstein's as providing a bridge between the macroscopic world of mechanical bodies and the microscopic world of quantum mechanics, and a way to compare the distant interaction of spins. Perhaps the curious issues which Dr. Eric Laithwaite* has raised concerning "spin radiation" from gyros may be resolved in this manner.

> *"….it should be possible to cause one force-precessed wheel to transmit a torque through space to another spinning wheel. If that be true, it is extremely likely that this kind of [non-electromagnetic] radiation is bombarding the earth from outer space and should be capable of collection."* (122)

Modem work on unified field theories is concerned more with the identification of torsion with spin, which was not Einstein's stated purpose in the 1920's versions of the Unified Field Theory.*

Einstein's labors with unsymmetric connections were again taken up after 1945. [(123) (124) (125)] In the latter reference he points out, in fact, that

> *"... at first the Riemannian metric was considered the fundamental concept on which the general theory of relativity, and thus the avoidance of the inertial system, was based. Later, however, Levi-Civita rightly pointed out that the element of the theory that makes it possible to avoid the inertial system is rather the infinitesimal displacement field* $\Gamma_b{}^a{}_c$ *. The metric, or the symmetric tensor field* g_{ik} *which defines it, is only indirectly connected with the avoidance of the inertial system in so far as it determines a displacement field."* [(126)]

(The "at first" that Einstein uses refers to the 1916 classical general relativity, now so familiar. The "later.... Levi-Civita" comment refers to a famous 1930 paper. [(127)] Apparently during the late 1920's Einstein was somewhat touchy about Cartan's priority with the torsion tensor, as can be seen in his 21 letters to Cartan on the topic of "Fernparallelismus". [(128)] It should be clear that Einstein had independently created a Riemannian geometry with torsion. [(129)]

Perhaps the most unexpected application of Anholonomity and the Torsion tensor is in the area of electrical machinery and electrical circuit theory (dating, in fact, back to Tesla's "egg of Columbus" and his creation of the rotating magnetic field). With the appearance of Einstein's unified field work of the late 1920's, Gabriel Kron discovered a remarkable unifying role for these concepts in the generalized theory of electrical machines. [(130)] During his lengthy career at General Electric, Kron published a long series of contributions formally employing geometrical concepts from Einstein's so called "Unsymmetric Unified Field Theory" to successfully explain complex mutual interconnections of electrical networks and machinery in terms of tensors. [(131) (132) (133) (134) (135) (136)]

* 1984 IEEE Tesla Medalist, and Professor at Imperial College, London.

** As a side note, it was also during this time in the 1920's that Einstein and Dr. Leo Szilard (1898~1964) filed 16 joint patent applications (ostensibly for an electrodynamic pump).

Einstein patented a gyrocompass and with Rudolph Goldschmidt (1876~1950), Einstein received a joint "hearing aid" patent. Goldschmidt is famous in radio history as the inventor of the high frequency RF generator utilizing groups of rotating coils for harmonic generation, and resonance for CW production. Goldschmidt's apparatus was used in the first wireless link between Germany and the US in 1914.

Nominated for his pioneering contributions by Paul Langevin (who first recognized the importance of de Broglie's work), Kron received the Montifiore Prize in 1936. MIT mathematics professors Struik [(137)] and Wiener [(138)] were both interested in Kron's application of Einstein's Unified Field Theory to electrical machinery. The application to electrical systems should not be surprising since the unified field theories were framed to describe situations which involve physical coordinates (space and time), gravitation, and electrodynamics. Kron's approach however, was to employ the same mathematics to describe interconnected systems with physical coordinates, mechanical energy, and electrical energy. (This application has enjoyed remarkable success in industry and presently, it is extensively employed by electrical utilities and heavy electrical equipment manufacturers around the world, in the analysis of interconnected power systems.) Kron's approach is a tensor theory and consequently invariant. [The popular state variable approach is not, and therefore it is doomed to failure, in the general case. It cannot be a fundamental electrical theory. (Try it on a curved manifold, or even one with torsion!) It is a matter of invariance; sooner or later, the geometers will even win the political battle being waged by the algebraic topologists in the fight over electrical circuit pedagogy!]

The mathematical analogy to Einstein's work is only formal, of course, since, as Kron points out, mechanical energy is not the same as gravitational energy. (139) However, the practical utility, *success* (the actual words used by Banesh Hoffmann* were "experimental confirmation" (140)), and *the wide-spread use of the 1929 Einstein unsymmetnc unified field theory in electrical power systems usually comes as quite a surprise to most physicists,* and even to some electrical engineers with narrow training. It should not be surprising that Tesla's polyphase system of rotating electromagnetic fields would have lead to this path. Kron once said,

> *"The equations of rotating electric machinery are formally analogous to those used by Einstein... In fact, the equations of a rotating machine plus a transmission line are far more complicated [geometrically] than those I have yet seen used by those long-haired physicists or still longer-haired mathematicians... You may laugh on hearing that a really scientific analysis of a synchronous machine implies the introduction of such unearthly concepts as nonholonomic reference frames, or multidimensional non-Riemannian spaces, or the Riemann-Christoffel curvature tensor... [but] that's where the electrical power engineer must look for new ideas and new inspiration... What's more, he has no other choice!"* **(141)**

Because of the complex phase or nature of electrical quantities (voltages and currents), and with special interest in polyphase systems, Kron's research labors led him to complex (in the sense of **R + jX**) manifolds with many degrees of freedom. From the work of Veblen and John von Neumann **(142)** he observed,

> "In establishing the equivalent networks for electrical machines, there are at least three types of transformations used.
>
> 1. Coordinate transformations
> 2. Spin Transformations
> 3. Gauge Transformations
>
> Coordinate transformations are used in passing from stationary to rotating axes. Spin transformations are used in introducing the hypothetical symmetrical component frames.
>
> Gauge transformations enter in eliminating phase shifters..." **(143)**

The method of symmetrical components, as every sophomore electrical engineer student knows, is based upon Fortescue's theorem. **(144)** Any unbalanced polyphase system of vectors can be resolved into three balanced systems: A positive-sequence system (the three-phase vectors have the same phase sequence as the original unbalanced system), a negative sequence system (the three-phase vectors have the opposite phase sequence to the original unbalanced system) , and a zero-sequence system (three equal magnitude in-phase vectors). **(145)**

Is it any wonder that Kron would have seized upon John von Neumann's work on complex domains. Further-more, his original investigation of zero-phase sequence waves in synchronous machines led him to conclude that, "The most general representative machine must have an infinite number of coordinate axes representing a space with an infinite number of dimensions." **(146)** The geometrical treatment of harmonic waves in unbalanced polyphase

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* The cryptic remark was written by Hoffmann in 1943. Hoffmann was an assistant to Professor Oswald Veblen at Princeton University, where he received his Ph.D. Subsequently, he was a member of the Institute for Advanced Study, working with Einstein, Infeld, and Veblen.

windings requires, as Kron pointed out, the introduction of Hilbert Spaces. In the analysis of time-varying systems, Kron makes use of "tearing" and of John von Neumann's work on an asymmetrical form of the wave equation. [147] (It should not be thought that the method of diakoptics was merely a computational technique for handling large matrices - this would be to have missed the entire purpose of diakoptics and the geometrical foundation of electrical theory!)

With regard to experimental verification, Kron wrote in 1936,

> *"While the equations of the Unified Field Theory are not amenable to experimental verification (hence the large variety of theories and equations) all tensor equations developed in this serial can easily be checked by other well known methods of analysis or by tests on actual machines."* [148]

In spite of the remarkable applications to electrical machinery, [149] crystals, [150] plasticity, [151] and even nuclear reactors, [152] recent activity concerning spaces with non-zero torsion has centered in the particle physics community. A lengthy review has been prepared by Hehl, et. al. [153] From an engineering perspective, however, most of the modem work m geometries with torsion appear to be more-or-less academic, with no practical applications for technology.

This is not the case with anholonomity. Indeed, Berry's discovery of a path dependent geometric phase, or anholonomic shift in the overall phase of an energy eigenfunction, has now appeared in a broad variety of applications, both quantum and classical: Aharonov-Bohm effect, Hall effect, Thomas precession Sagnac effect, polarization rotation in optical fibers, rotation rate gyros, and a host of others. Some of the recent literature on Berry's phase, however, does not distinguish between effects which are due to curvature (a property of the manifold) and those which arise from anholonomic constraints. Having said this, let us return to our "Philadelphia Experiment" thesis.

Spin and Magnetism

Magnetism in ferromagnetic materials is due to an imbalance in the electron spins in the partially filled atomic shells of the ferromagnetic material. A group action among many of the atomic magnetic dipoles causes the moments to align and produce macroscopic ferromagnetic domains. The large permanent magnetic field characteristic of ferromagnetic materials is due to the collective orientation of the dipole moments in the material's many domains, which we can describe by;

$$\vec{M} = N\vec{m} \tag{30}$$

where **M** is the magnetization in amperes/meter, **m** is the average magnetic dipole per atom and **N** is the number of atomic magnetic dipoles all aligned in the same direction in a volume element **dV**.

The vector potential **A** for a magnetized material can be calculated from

$$\vec{A}(\vec{r}) = \frac{\mu_0}{4\pi}\int_S \frac{\vec{J}_s}{R} dS + \frac{\mu_0}{4\pi}\int_V \frac{\vec{J}_v}{R} dV \tag{31}$$

where

$$\vec{J}_S = \vec{M} \times \vec{n} \tag{32}$$

is the equivalent surface current density and

$$\vec{J}_v = \nabla \times \vec{M} \tag{33}$$

is the equivalent volume current density. We can describe the collective action of the atomic spins in terms of a surface current density $\mathbf{J}_S$ and a volume current density $\mathbf{J}_V$. Consequently, we have a circulating flow of energy and momentum built up from the collective action of the aligned spins, which are themselves individual circulating flows of charge in the wave field of the electron. Since the momentum circulates it is an angular momentum.

This effect can be demonstrated by means of the Einstein-de Haas effect: a freely suspended body begins to rotate upon being magnetized. Macroscopically, Tesla's "egg of Columbus" exhibits an analogous behavior. (In the latter, the magnetization is due to induced eddy currents, not molecular "amperian currents".) Einstein and de Haas performed these famous experiments in 1915 and 1916 (twenty-eight years after Tesla) to demonstrate the existence of Ampere's "molecular currents", and they determined the gyromagnetic ratio in a ferromagnetic substances such as iron. [154] [155] [156] [The Barnett effect is the dual phenomenon: a rotating ferromagnetic rnedium becomes magnetized by a molecular gyroscopic action. Apparently Einstein later suggested to Barnett that he should examine the effects of an impressed polyphone rotating magnetic field. Again we see the footprints of Dr. Tesla, his rotating magnetic field, and the "egg of Columbus". Even Professor Bloch took interest in this experiment. Frequencies as high as 30 kHz were used. [157] [158]]

The electromagnetic vector potential $\mathbf{A}$ describes the circulating field momentum built up by the atomic spins. The fact that the vector potential $\mathbf{A}$ is a field momentum can be clearly seen when one writes the Hamiltonian $\mathbf{H}$ for a charged particle in a magnetic field;

$$H = \left(\frac{1}{2m}\right)\left(\vec{p} - q\vec{A}\right)^2 + q\Phi \tag{34}$$

where $\mathbf{m}$ is the mass of the charged particle, $\mathbf{q}$ is the charge, and $\mathbf{\Phi}$ is the electrostatic potential. The total momentum is

$$\vec{P} = \vec{P}_k + \vec{P}_f = m\vec{v} + q\vec{A} \tag{35}$$

where $\mathbf{P}_k = \mathbf{mv}$ is the kinetic momentum and $\mathbf{P}_f = \mathbf{qA}$ is the field momentum. The expression

$$\left(\frac{1}{2m}\right)\left(\vec{P} - q\vec{A}\right)^2 = \frac{1}{2}mv^2 \tag{36}$$

gives the kinetic energy of the charged particle and shows that the magnetic field does no work on the charged particle.

Torsion and the Electromagnetic Field

The electromagnetic field tensor F_{ij} in spaces with torsion and using holonomic coordinates is given by [159]

$$F_{ij} = \nabla_j A_i - \nabla_i A_j \tag{37}$$

where

$$\nabla_j A_i = \frac{\partial A_i}{\partial x^j} - \Gamma^k_{ij} A_k \tag{38}$$

and

$$\Gamma^{k}{}_{ij} = \left\{ {k \atop i\ j} \right\} - K^{k}{}_{ij} \tag{39}$$

Thus

$$F_{ij} = \nabla_j A_i - \nabla_i A_j$$

$$= \left(\frac{\partial A_i}{\partial x^j} - A_k \left\{ {k \atop i\ j} \right\} \right) - \left(\frac{\partial A_j}{\partial x^i} - A_k \left\{ {k \atop j\ i} \right\} \right) - A_k S^{k}{}_{ij} \tag{40}$$

$$= \left(\frac{\partial A_i}{\partial x^j} - \frac{\partial A_j}{\partial x^i} \right) - A_k S^{k}{}_{ij}$$

Covariantly differentiating with respect to only the Christoffel symbols of the second kind $\left\{ {k \atop i\ j} \right\}$ and not the affine connection $\Gamma^{k}{}_{ij}$ would mean that photons would be decoupled from torsion. [160]

It has been shown that gauge invariance and minimal coupling (the replacement of partial differentiation by covariant differentiation using $\Gamma^{k}{}_{ij}$) can be satisfied in spaces with torsion [161]. Two experiments now come to mind: one involves the Sagnac Effect and the other involves the Aharonov/Bohm effect. A third (Thomas precession) could also be examined, obviously, but space does not permit a discussion in this paper.

A Sagnac Effect Experiment

In extensive publications over the last 20 years, the authors have shown that the Sagnac effect arises from the anholonomic nature of the relativity of rotation. The interested reader is referred to these papers. [162] [163] [164] [165] [166] A photon gyro may be constructed by splitting a coherent light beam and sending it in a clockwise and in a counterclockwise direction around a closed path on a circular platform. When the platform is at rest the beams produce no beat frequency when combined. However, when the platform rotates, the co-rotating beam shifts upward in frequency and the counter propagating beam shifts downward in frequency, with the result that when the beams are combined they heterodyne and produce low frequency beats directly proportional to the rate of rotation of the platform. (Rotation with respect to what? This is a trick question, with profound implications.) The formula for time difference with respect to an observer fixed on the platform (one half of the reciprocal of the beat frequency) is given by

$$dt = \frac{dx^4}{c} = -\frac{2}{c}\Omega^{4}{}_{ab}\, df^{ab} \approx \pm \frac{2\omega A}{c^2} \tag{41}$$

where ω is the angular velocity of the platform, the $\pm$ is taken for beam propagation with (+) or counter (-) to the platform rotation, and df^{ab} is the differential area (**A**) enclosed by the optical path.

However, the general case, when torsion is present as well as rotation, is described by

$$cdt = dx^4 = 2\left[S^{4}{}_{ab} - \Omega^{4}{}_{ab} \right] df^{ab} \tag{42}$$

The question we ask is, "If the platform had gyromagnetic spin and produced a torsion tensor in accord with Hehl's assertion above, could one fool the photon gyro?" Could you turn S^4_{ij} on, and make the gyro on a non-rotating platform think that Ω^4_{ij} had arisen? (One normally turns Ω^4_{ij} on, merely by spinning the table.) Alternatively, could you turn on S^4_{ij} and cancel out the Ω^4_{ij} term and make the gyro on a truly rotating platform think that it was at rest. (There is probably a military servo-system application here.) And so, you see, we have proposed a simple experiment, with two parts, that can be performed in a thousand laboratories before tomorrow evening. We have a second experiment to propose.

Aharonov-Bohm Effect

The Aharonov-Bohm effect is one of the outstanding puzzling effects of quantum theory. In classical physics one can write an equation describing the force **F** acting on a charged particle in an electromagnetic field as

$$\vec{F} = q\left(\vec{E} + \vec{v} \times \vec{B}\right) \qquad \textbf{(43)}$$

This is the Lorentz force law, where **q** is the charge on the particle, **v** is the particle's velocity, **E** is the electric field strength and **B** is the magnetic induction. Let us consider the case where we only have a static magnetic field present: $B = \nabla \times A$ and in regions where **B = 0** there is no magnetic force on the particle. This situation occurs outside an infinite solenoid of radius a:

$$A_\varphi(r) = \begin{cases} \dfrac{Kr}{2} & r < a \\ \dfrac{a^2 K}{2r} & r > a \end{cases} \qquad \textbf{(44)}$$

$$B_Z(r) = \frac{1}{r}\frac{\partial\left(r A_\varphi\right)}{\partial r} = \begin{cases} K & r < a \\ 0 & r > a \end{cases} \qquad \textbf{(45)}$$

[For an infinite solenoid wound with n turns/meter, **K = μ n I**.] In spite of the fact that **A ≠ 0** outside the solenoid there appears to be no classical force on the particle that can be attributable to **A**. Consequently, **A** was not considered to be a physical field in classical electrodynamics. In quantum mechanics, however, it was observed that in regions where there was no magnetic field present **B = 0,** the interference pattern caused by the wave fractions of electrons shifted due to the presence of **A**. This is the Aharonov-Bohm effect. We will borrow from Feynman [(167)] the following illustration of the Aharonov-Bolun effect using Figure 13.

We call Θ_1 the phase of an electron wave function moving along path 1, Θ_2 is the phase of an electron wave function moving along path 2. We call Θ_1 **(B = 0)** the phase of the electron wave function along path 1, when the magnetic field inside the solenoid is zero (likewise for path 2). Note that both paths are located in regions where **B = 0.** When the magnetic field inside the solenoid is turned on, **B ≠ 0** inside the solenoid but still **B = 0** outside the solenoid along paths 1 and 2. However, the vector potential **A** is nonzero outside the solenoid when the solenoidal field is on. Consequently, along path 1 the total phase shift will be

$$\Theta_1 = \Theta_1(B=0) + \frac{q}{\hbar}\int A \bullet d\,\vec{S}_1 \qquad \textbf{(46)}$$

Similarly, the phase of an electron moving along path 2 will be

$$\Theta_2 = \Theta_2(B=0) + \frac{q}{\hbar}\int A \bullet d\,\vec{S}_2 \qquad \textbf{(47)}$$

Consequently, the interference pattern at the detector is shifted by an amount proportional to $\delta\Theta$.

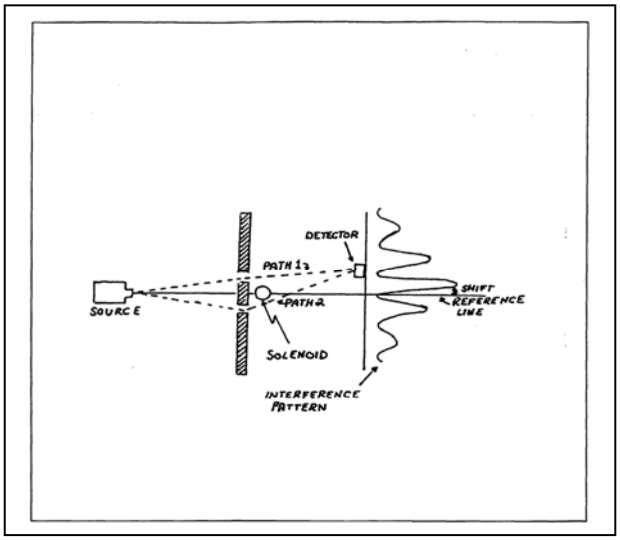


Figure 13
Aharonov-Bohm experiment configuration. (Feynman's Fig. 15-7)

$$\delta\Theta = \Theta_1 - \Theta_2 = \Theta_1(B=0) - \Theta_2(B=0) + \frac{q}{\hbar}\left(\int A \bullet d\,\vec{S}_1 - \int A \bullet d\,\vec{S}_2\right) \qquad \textbf{(48)}$$

This means the electrons were influenced by the vector potential to depart from the path they would have taken if the solenoidal field had not been turned on. This influence is the quantum mechanical analogue to the Lorentz force we discussed earlier; so, how can the vector potential influence the electrons?

If we recall that the vector potential for a magnetized material is a circulating field momentum created by the collective motion of atomic spins, which are themselves made up of individual circulating flows of charge, then we may formulate the following hypothesis;

> The atomic spins create a torsion field, which is coupled to the vector potential **A**. Particles such as the electron with intrinsic spin couple to the torsion field and are deflected providing us with the interference shift.

Let us examine the last equation we wrote and see how torsion may play a role in the Aharonov-Bohm effect. The integrals

$$\frac{q}{\hbar}\left(\int A\bullet d\vec{s}_1-\int A\bullet d\vec{s}_2\right) \quad \textbf{(49)}$$

can be expressed as one integral around a closed path

$$\frac{q}{\hbar}\int A_i dx^i \quad \textbf{(50)}$$

Using Stoke's theorem this integral can be rewritten as

$$\frac{q}{\hbar}\int A_i dx^i=\left(\frac{q}{2\hbar}\right)\iint\left(\nabla_r A_k-\nabla_k A_i\right)df^{ik} \quad \textbf{(51)}$$

where we have transformed an integral over a four dimensional closed curve, into an integral over a surface area spanning the curve. Remembering that

$$\nabla_i A_k=\frac{\partial A_k}{\partial x^i}-\Gamma^j_{ik}A_j \quad \textbf{(52)}$$

is the covariant derivative, the integral

$$\left(\frac{q}{2\hbar}\right)\iint\left(\nabla_r A_k-\nabla_k A_i\right)df^{ik}=\left(\frac{q}{2\hbar}\right)\iint\left(\frac{\partial A_k}{\partial x^i}-\frac{\partial A_i}{\partial x^k}\right)df^{ik}+\left(\frac{q}{2\hbar}\right)\iint\left(\Gamma^j_{ki}-\Gamma^j_{ki}\right)A_j df^{ik} \quad \textbf{(53)}$$

where, 'in the last term, use may be made of the fact that

$$\left(\Gamma^j_{ki}-\Gamma^j_{ik}\right)=2\left(\Omega^j_{ki}-S^j_{ki}\right) \quad \textbf{(54)}$$

where Ω^j_{ki} is the anholonomic object and S^j_{ki} are the components of the torsion tensor. Note that

$$\left(\frac{\partial A_k}{\partial x^i}-\frac{\partial A_i}{\partial x^k}\right)=\begin{cases}B_Z & \text{within the solenoid}\\ 0 & \text{outside the solenoid}\end{cases} \quad \textbf{(55)}$$

The term

$$\left(\frac{q}{2\hbar}\right)\iint\left(\frac{\partial A_k}{\partial x^i}-\frac{\partial A_i}{\partial x^k}\right)df^{ik} \quad \textbf{(56)}$$

represents the magnetic flux enclosed by paths 1 and 2. In fact the integrand vanishes for **r** greater than the radius of the solenoid (or whisker) in the Aharonov-Bohm experiment. Exterior to the solenoid, the integral term simply gives a number equal to the enclosed flux density, times the cross sectional area of the solenoid (i.e., the enclosed flux). A conventional quantum interpretation of the Ahwonov-Bohm effect attributes phase shift, not to the interaction of the charge with the magnetic field at the field point (it's zero where the charge is), but to the non-local field **B**, which is enclosed by the two paths. [168] The electron wave function is not exposed to the **B** field since it travels in regions where **B** is zero. Therefore the conventional explanation employs action at distance to account for the interference effect.

The torsion theory leads directly to a local "torsion field" interaction, which depends upon the expression

$$\left(\frac{q}{2\hbar}\right)\iint\left(\Gamma^{j}_{ki}-\Gamma^{j}_{ik}\right)A_j\,df^{ik} \qquad \textbf{(57)}$$

at the field point through which the charge passes. That is, the interaction is due to the direct exposure of the electron wave function to the local torsion field created by the vector potential **A**. [By the way, the **j = 4** terms describe the "electric" Aharonov-Bohm effect [169] [170] with equal alacrity!]

An Aharonov-Bohm Torsion Experiment

As the second proposed experiment, we suggest that a demonstration be performed to determine if torsion plays a role in the Aharonov-Bohm effect. Basically the experiment would involve using a solenoid or a magnet to generate an external vector potential. The paths of the particles having intrinsic spin would again be in a magnetic field free region just as in the conventional experiment. We would then ask that the paths around the magnet (or solenoid) be rotated. (Perform the experiment on a rotating table.) The idea is that the rotating frame generates an anholonomic term that would tend to cancel the torsion term in the equation resulting in a

$$\left(\Gamma^{j}_{ki}-\Gamma^{j}_{ik}\right)=2\left(\Omega^{j}_{ki}-S^{j}_{ki}\right) \qquad \textbf{(58)}$$

change in (or even cancellation of) the Aharonov-Bohm interference pattern. Such an apparatus could, in fact, be used as a sensitive "Torsion-field strength meter" in the exploration of space-time. (Why wasn't one of these put on our Mariner spacecraft and launched beyond sidereal space?)

Speculations on Torsion and Time Discontinuities

We will close with the observation that torsion allows the space-time manifold to be folded in a manner such that the fold has a discontinuity along the time axis. That is, if we suddenly "turn on" the torsion the manifold will abruptly fold up along the time axis. See Figure 12.

Similarly, folding could also occur in the spatial hyperplane. It is interesting to speculate on what sort of spin densities would accomplish such a feat on a macroscopic scale. Some work on torsion has focused on conditions in collapsing stars where very high spin densities may exist that could cause large macroscopic effects. [171] [172]

Nevertheless, it seems to us that laboratory magnets and solenoids may provide the necessary field strengths to manifest torsion's effects at the quantum mechanical level as suggested in our proposed Aharonov-Bohm experiment. At the macroscopic level, it would be of great interest to see if the Sagnac effect can be "turned on and off" by ferromagnetic torsion, and how much magnetic field is actually needed to be able to observe this on the lab bench.

Finally, purely as an academic exercise, how much magnetic resonance driving current is required to create a torsion tensor necessary to transport a DE- 173 forward along its world line by, say, $\Delta_t = 10$ million seconds (4 months)? Are these the sort of thoughts that resulted in Dr. Valentine comment,

> "[**Dr. Jessup said**] *This use of magnetic resonance is tantamount to temporary obliteration in our dimension but it tends to get out of control. Actually it is equivalent to transference of matter into another level or dimension and could represent a dimensional breakthrough if it were possible to control it."* (pg. 130).

While it may be that what we have proposed, turns out to be totally impractical for teleportation or time travel, except for the Aharonov-Bohm effect, everything discussed above was known or available in the pre-WW-II literature. Certainly these were the kinds of thoughts and considerations that should have been going through the minds of the Einsteins, Veblens, Von Neumanns, Ladenburgs, and power engineers (like Vennevar Bush) of that era. They certainly were among the thoughts of the Gabriel Krons and Norbert Wieners. So, we're back to Tesla's egg of Columbus again.

CONCLUDING REMARKS

We started Part V with the question, "What about time-travel and teleportation?" No numbers have been plugged into these last equations. Our question has really been left as unanswered mathematical speculation. Perhaps a black-hole would have been a "more practical" machine, but we don't think so. (All the reasonably prudent folk may have gotten off the train at Part IV, anyway.) However, a physical experiment to test the hypothesis has been suggested.

This leaves the question of T. Towensend Brown's reason for being in the story. (The relevance of his "force fields" to the physical phenomenon seems spurious and unnecessary to us. Yet, it was Dr. Rinehart that inserts him into the narrative. Were his comments about Brown's radar background relevant?) Perhaps these were calculated to make the book appeal to a wider audience, or to enhance the value of the movie rights, or increase the page count by 10%. At any rate, we confess our inadequacy to appreciate the peripheral significance of these items. (Ockham's razor would seem to relegate them to the domain of excess baggage.)

As to why the government has not been forthright on the "Philadelphia Experiment", we can only speculate. To us it would (perhaps naively) seem that the reason for the apparent stonewalling was simply that certain military and civilian decision makers (travailing under "peasant knowledge"*) got in over their heads into physical wonders that they just didn't have the breadth or capacity to pull together. (Where were the engineering 'renaissance men'?)

FINAL CONCLUSIONS

The mathematical possibilities of time travel and teleportation notwithstanding, Vannevar Bush's quote at the top of this article is still a perceptive and sober observation. Perhaps an experiment, such as the simple one proposed above, will someday make it possible to "record on our delicate instruments" such wonders.

Subsequent to the original book, Moore wrote an article, in which he states the following;

> *"... Navy scientists undertook to see whether anything could be done to either disguise a ship's radar image or to otherwise confuse the offending German radar and thus render such a weapon useless ... The scientists then energized the ship's hull with tremendous pulses of low frequency electromagnetic energy."* **(173)**

We think that this assertion, at least, can be supported on technical grounds. To invert the skeptical remarks made by another critic, not only does a substantial amount of the information presented by Moore and Berlitz satisfy the most fundamental tests of experimental verification, but the massive amount of collateral technological evidence available demonstrates that the thesis *is* patently plausible. If the account, in fact, is authentic then what is disappointing and disgusting is the shabby professionalism of the pathetic leaders, administrators and scientists that took part in manipulating its wretched cover-up.

We wish to say that we enjoyed the book and would like to extend our appreciation to William Moore and Charles Berlitz for spinning a fascinating yarn. To a scientific audience wishing to scrutinize its technical merits, we hope that our little "brown study" will be no less enchanting than were the cited essays of Joseph Slepian or Arthir Eddington. This has not been a definitive study on the topic. We have, in fact, been rather sloppy on each particular point. But, except for a lack of conciseness, we think that Joseph Slepian would have been pleased.

This has been an engrossing little study for us, but this is a Tesla Symposium. We must stay focused on his remarkable career. Tesla's creative discovery of the rotating magnetic field was more far-reaching than the mere invention of the induction motor or the polyphase power distribution system, (which has so impacted the upward progress of civilization in the twentieth century). It is, in fact, interwoven with the very fabric of space-time and our material existence in the physical universe. We hope that our amusing little War Memorial reveries will not detract from the serious issues associated with Tesla's authentic work. And so, as with old Prospero,

> "Our revels now are ended. These our actors,
> As I foretold you, were all spirits and
> Are melted into air, **into thin air…"**

---

* Peasants knew their field well, from stonewall to stonewall, but had no knowledge of what lay beyond. Hence the term 'peasant knowledge', as suggested by Dr. Matthew Sandor.

** Irving Langmuir has related that General Carl A. 'Tooey' Spaatz, AF Chief of Staff 1947-1948, once confided to him about UFO's, "You know, its very serious. It really looks as though there is something there." ["Pathological Science," Physics Today, October, 1989, pp. 36-48; March, 1990, pp. 13-14, 108, 110, 112.] Recall that John G. Trump was a member of General Spaatz's Advisory Specialist Group on Radar. [Electrical Engineering, Vol. 80, No. 5, May, 1961, pp. 364-365.]

APPENDIX I

Surface Impedance for a Ferromagnetic Planar Slab

In this Appendix we present the technical features involved in obtaining the surface impedance for a magnetically biased anisotropic medium. What we get for our troubles is the functional relation between the anisotropic surface impedance and the applied magnetic field. The results are used in **Equation (8)** above and plotted in Figures (1) through (8) in the text.

The Ferromagnetic Anisotropic Permeability Tensor

Physically, a ferromagnetic medium is considered to consist of an ensemble of spinning electrons with magnetic moments. The interaction of the spinning electrons, each with a magnetic moment proportional to its angular momentum (**m = γJ**, where the constant of proportionality **γ** is called the gyromagnetic ratio), with an applied magnetic field produces a torque (**T =** $\mu_0 m \times H$ where **H** is the total magnetic field at the point), which try's to bring it in line with the applied field. This results in a temporal precession of the axes of the spinning electrons about the direction of the applied field. When the medium is saturated,***** the magnetic moments all line up in a manner similar Tesla's "egg of Columbus". Batygin and Toptygin have written **[174]**

> *"Ferromagnetic resonance is established under the following conditions: a constant magnetic field acting upon the magnetic moment of an atom or a single electron gives rise to the Larmor precession of the moment about the direction of the field. This motion is eventually damped out due to the conversion of the Larmor precession energy into thermal energy. If the external field is sufficiently large, then all the elementary magnetic moments become parallel to the external field. The ferromagnetic material is then referred to as saturated and, correspondingly, the magnetic moment per unit volume is called the saturation magnetization. If in addition to the constant field, there is also an alternating [RF] magnetic field, which is perpendicular to the constant field, then the alternating field will tend to maintain the processional motion and, when its frequency becomes equal to the processional frequency, ferromagnetic resonance will set in."* **[175]**

The processional motion of the magnetization vector **M** (the magnetic moment per unit volume) about the applied magnetic field vector **H** is described by the Landau-Lifshitz **[176] [177] [178] [179] [180]** equation:

$$\frac{d\vec{M}}{dt} = \gamma\left(\vec{M} \times \vec{H}\right) - \omega_r\left(\chi_0 \vec{H} - \vec{M}\right) \qquad \textbf{(59)}$$

where

$\boldsymbol{M_0}$ = Saturation Magnetization

$$\chi_0 = \frac{M_0}{H_0}$$

$$\gamma = \frac{\mu_0 e}{m} = 1.759 \times 10^{-11} \times \mu_0 = 2.210 \times 10^5 \qquad \textbf{(60)}$$

* 'Zeemanized! (TPE, p. 198): The Zeeman energy, $-m \bullet H$, is a maximum.

$$\omega_r = \frac{p\gamma^2 M_0^2}{\chi_0}$$

In the above, **M** is the magnetization vector, **H** is the magnetic field strength, **p** is a loss parameter, and ω_r is the natural (damped) resonant frequency.

Now consider a semi-infinite ferromagnetic medium with a uniform magnetic field $H_0 \hat{z}$ [the hull of a ship wound with a helical coil, and all the electron spins precessing around the z-axis]. When a time-harmonic radar RF field $he^{j\omega t}$ (with **h<<H** $_0$) is applied to the electron system, it causes the amplitude of the precessions to build up. The forced oscillations of the magnetization vector **M** may be found as follows. The total magnetic field intensity has components

$$\vec{H} = \left[h_x e^{j\omega t}\right]\hat{x} + \left[h_y e^{j\omega t}\right]\hat{y} + \left[H_0 + h_z e^{j\omega t}\right]\hat{z} \qquad \textbf{(61)}$$

so the solution of the Landau-Lifshitz equation will be sought in the form

$$\vec{M} = \left[m_x e^{j\omega t}\right]\hat{x} + \left[m_y e^{j\omega t}\right]\hat{y} + \left[M_0 + m_z e^{j\omega t}\right]\hat{z} \qquad \textbf{(62)}$$

As Batygin and Toptygin point out,

> *"The form of the solution corresponds to the assumption that the transient Larmor precession has been damped out and the oscillations are maintained by the high frequency forcing field. Hence, the quantities **m** $_x$, **m** $_y$, **m** $_z$, should be regarded as small (of the order of **h** or lower)."* [181]

Direct substitution of the assumed form of **M** into the Landau-Lifshitz equation, and neglecting higher order terms, gives the components of **m** as;

$$m_x = \chi_0 \frac{\Omega^2 + j\omega\omega_r}{\Omega^2 - \omega^2 + 2j\omega\omega_r} h_x - j\chi_0 \frac{\omega\omega_0}{\Omega^2 - \omega^2 + 2j\omega\omega_r} h_y$$

$$m_y = j\chi_0 \frac{\omega\omega_r}{\Omega^2 - \omega^2 + 2j\omega\omega_r} h_x + \chi_0 \frac{\Omega^2 + j\omega\omega_r}{\Omega^2 - \omega^2 + 2j\omega\omega_r} h_y \qquad \textbf{(63)}$$

$$m_z = \chi_0 \frac{\omega_r}{\omega_r + j\omega} h_z$$

where

$$\Omega = \sqrt{\omega_0^2 + \omega_r^2} \qquad \textbf{(64)}$$

$$\omega_0 = \gamma \mu_0 H_0$$

The quantity ω_0 (called the ferromagnetic resonance frequency) is the Larmor Precessional frequency of the electron in the total internal dc field $\mathbf{H}_0$. The older literature gives $\mathbf{H}_0$ in **cgs units** (Oersteds). [The conversion being

$$\vec{H}\left(\frac{Ampere-Turns}{meter}\right)=\frac{1}{4\pi\bullet 10^{-3}}\vec{H}(Oersteds) \qquad \textbf{(65)}$$

It is common to note that γ = 2.8 MHz/oersted. An internal field of 1000 oersteds gives a gyromagnetic resonance (in the lossless case) at 2800 MHz.] From Equation (6) it is clear that when ferromagnetic resonance's occur actual physical losses prevent infinite response as with the presence of resistance in **RLC** tuned circuits. It is also to be noted that the precession of the spinning electrons reinforces the original applied fields and cross-couples that field into the transverse components.

Next, the permeability tensor for the anisotropic medium may be found for RF. Recall that, in MKS units, the magnetic flux density

$$\vec{B}=\mu_0\left(\vec{H}+\vec{M}\right) \qquad \textbf{(66)}$$

where the magnetic field strength $\mathbf{H}$ is due to free currents and the magnetization $\mathbf{M}$ is due to the superposition of all the magnetic moments (the magnetic dipole moment, per unit volume arising from "bound currents"). The magnetization is related to the magnetic field strength as,

$$\vec{M}=(\mu_r-1)\vec{H} \qquad \textbf{(67)}$$

which is sometimes expressed as

$$\vec{M}=\chi_m\vec{H} \qquad \textbf{(68)}$$

where χ_m is the magnetic susceptibility. The permeability is

$$\mu=\mu_0(1+\chi_m) \qquad \textbf{(69)}$$

Consequently, using (8) and collecting terms from above, gives the relative permeability tensor as

$$\mu_{ij}\begin{pmatrix}\mu_\perp\, j\mu_a 0\\ -j\mu_a\mu_\perp 0\\ 00\,\mu_\Pi\end{pmatrix} \qquad \textbf{(70)}$$

where we let

$$\mu_\perp=\mu_\perp'-j\mu_\perp''$$

$$\textbf{(71)}$$

$$\mu_a=\mu_a'-j\mu_a''$$

with

$$\mu_{\perp'} = 1 + \chi_0 \frac{\Omega^2(\Omega^2 - \omega^2) + 2\omega^2\omega_r^2}{(\Omega^2 - \omega^2)^2 + 4\omega^2\omega_r^2}$$

$$\mu_{\perp''} = \chi_0 \frac{\omega\omega_r(\Omega^2 + \omega^2)}{(\Omega^2 - \omega^2)^2 + 4\omega^2\omega_r^2}$$

$$\mu_{a'} = \chi_0 \frac{\omega\omega_0(\Omega^2 - \omega^2)}{(\Omega^2 - \omega^2)^2 + 4\omega^2\omega_r^2} \qquad \textbf{(72)}$$

$$\mu_{a''} = \chi_0 \frac{2\omega^2\omega_0\omega_r}{(\Omega^2 - \omega^2)^2 + 4\omega^2\omega_r^2}$$

$$\mu_{\amalg} = 1 + \chi_0 \frac{\omega_r}{\omega_r + j\omega}$$

and the $\amalg$ subscript indicates the axis along which the static field is applied. The dependence of the real and imaginary parts of $\mu_\perp$ and μ_a verses frequency shows that the imaginary parts $\mu_{\perp''}$ and $\mu_{a''}$ are maximum when $H = \omega_0/\gamma$, and the real parts $\mu_\perp'$ and μ_a' reach extremal values when $H = (\omega_0 \pm \omega_r)/\gamma$. [Microwave engineers usually fix the RF frequency, **ω**, and tune **H**. The plot of $\mu(H)$ then displays the resonance character of the permeability. See Figure I-1.]

Electromagnetic Waves in an Anisotropic Ferromagnetic Medium

Consider a planar ferromagnetic slab (the side of the ship) with the **y**-axis normal to and directed into the medium and with the **z**-axis directed along the applied magnetic field. The incident RF wave will be, as Sommerfeld suggested, normal to the slab. (This is called the "transverse dc magnetization”' case. [182]) Further, the incident fields are assumed to be uniform in **z** along the ship $(\partial/\partial z = 0)$. Using the permeability tensor of Equation (11), Maxwell's equations give

$$\nabla \times \vec{E} = -j\omega\vec{\mu} \bullet \vec{H} \qquad \textbf{(73)}$$

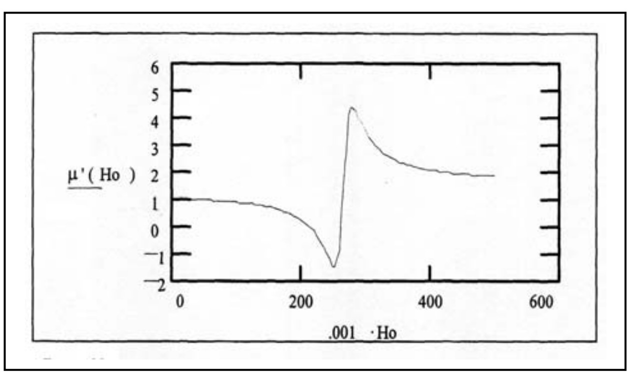


Figure I – 1 (a)

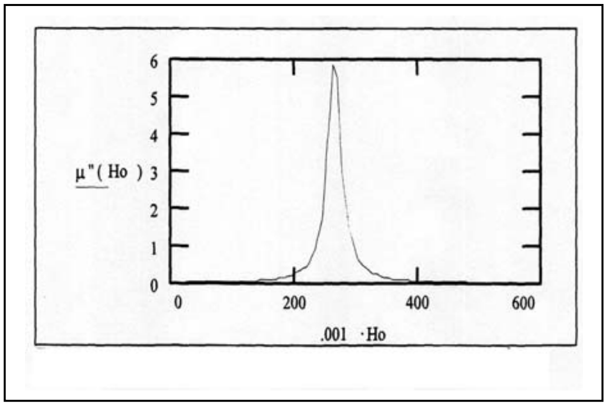


Figure I - 1(b)

Complex permeability for **f** = 9.375 GHz, $\mathbf{M_0}$ = 160 Gauss, $\omega_r = 3\times10^9$. The resonance occurs at $\mathbf{H_0}$ = 271 kA/m (3405 Oersteds).

$$\frac{\partial E_z}{\partial y} = j\omega\mu_0\left[\mu_\perp H_x + j\mu_a H_y\right] \quad \textbf{(74)}$$

$$-\frac{\partial E_z}{\partial x} = j\omega\mu_0\left[-j\omega\mu_a H_x + j\mu_\perp H_y\right] \quad \textbf{(75)}$$

$$\frac{\partial E_y}{\partial x} - \frac{\partial E_x}{\partial y} = -j\omega\mu_0\mu_{II} H_z \quad \textbf{(76)}$$

and

$$\nabla\times\vec{H} = [\sigma + j\omega\in]\vec{E} \quad \textbf{(77)}$$

$$\frac{\partial H_z}{\partial y} = [\sigma + j\omega\in]E_x \quad \textbf{(78)}$$

$$-\frac{\partial H_z}{\partial x} = [\sigma + j\omega\in]E_y \quad \textbf{(79)}$$

$$\frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y} = [\sigma + j\omega\in]E_z \quad \textbf{(80)}$$

A wave equation for horizontal $(e = E_z\hat{z})$ Polarization may be found as follows. Multiplying **15** by $j\mu_a$ and **16** by $\mu_\perp$, and adding gives,

$$j\mu_a\frac{\partial E_z}{\partial y} - \mu\perp\frac{\partial E_z}{\partial x} = j\omega\mu_0\left[\mu_\perp^2 - \mu_a^2\right]H_y \quad \textbf{(81)}$$

Repeating in reverse order gives

$$j\mu_a\frac{\partial E_z}{\partial x} + \mu\perp\frac{\partial E_z}{\partial y} = -j\omega\mu_0\left[\mu_\perp^2 - \mu_a^2\right]H_x \quad \textbf{(82)}$$

First, **Equation (22)** is differentiated with respect to **x** and second, **Equation (23)** with respect to **y**. Subtracting the second from the first and using the **z**-component of Ampere's law gives a wave equation for $\mathbf{E_Z}$, as;

$$\frac{\partial^2 E_z}{\partial x^2}+\frac{\partial^2 E_z}{\partial y^2}+\left(\omega^2 \in \mu_0 - j\omega\mu_0\sigma\right)\left(\frac{\mu_\perp{}^2-\mu_a{}^2}{\mu_\perp}\right)E_z=0 \qquad \textbf{(83)}$$

which implies that the medium has an effective relative permeability (consider, for example, the situation when the conductivity is zero) of

$$\mu_e=\frac{\mu_\perp{}^2-\mu_a{}^2}{\mu_\perp} \qquad \textbf{(84)}$$

This is the effective permeability, which the ferromagnetic medium presents to an RF field with magnetic field components perpendicular to the direction of the applied magnetic bias.

Similarly, for vertical polarization ($\mathbf{e} = \mathbf{E_X}\ \hat{x}$), differentiating (19) by **y** and (20) by **x** , and using the **z**-component of Faraday's law gives a wave equation for $\mathbf{H_Z}$, as

$$\frac{\partial^2 H_z}{\partial x^2}+\frac{\partial^2 H_z}{\partial x^2}+\left(\omega^2\in\mu_0 - j\omega\mu_0\right)\mu_{II}H_z=0 \qquad \textbf{(85)}$$

This is the case where the incident RF field has magnetic components along the applied magnetic bias. The situation for which there are different propagation constants for waves polarized with the RF electric field along the direction of $\mathbf{H_0}$ **(** $\mathbf{E_Z}$ **)** or perpendicular to $\mathbf{H_0}$ **(** $\mathbf{H_X}$ **)** is called birefringence.

By the way, an anisotropically conducting surface can be handled in a manner similar to that above. Following the same line of development, the anisotropic electrical conductivity tensor with components given by

$$\sigma_{ij}=\begin{pmatrix}\sigma_1 & j\sigma_2 & 0\\ -j\sigma_2 & \sigma_1 & 0\\ 0 & 0 & \sigma_3\end{pmatrix} \qquad \textbf{(86)}$$

leads to an effective conductivity

$$\sigma_e=\frac{\sigma_1{}^2-\sigma_2{}^2}{\sigma_1} \qquad \textbf{(87)}$$

which can be used in the expressions for impedance.

The detailed determination of the fields is rather tedious. [Assume the **y** variation of the **xz**-uniform fields is $e^{-\gamma y}$ (not to be confused with the gyromagnetic ratio used above), use the **z** component of Ampere's law to get the relation of $\mathbf{E}_Z$ to $\mathbf{H}_X$, and the **x** component of Faradays law to met the relation of $\mathbf{E}_Z$ to $\mathbf{H}_X$] It leads, in the case of a ferromagnetic medium with anisotropic conductivity, to the result that

$$E_z = \left[\frac{j\omega\mu_0 \left(\frac{\mu_\perp^2 - \mu_a^2}{\mu_\perp} \right)}{\sigma_3} \right]^{\frac{1}{2}} H_x \qquad \textbf{(88)}$$

$$E_x = \left[\frac{j\omega\mu_0 \mu_{II}}{\sigma_e} \right]^{\frac{1}{2}} H_z \qquad \textbf{(89)}$$

At this point, one can determine the surface impedance of the medium

The Anisotropic Surface Impedance Tensor

We desire the surface in@ce. Again following Batygin and Toptygin, (") we consider the case of the surface impedance of a flat fertomagnetic conductor immersed in a constant magnetic field that is oriented parallel to the surface. The usual expression of the impedance boundary condition for the interface between simple media is, as introduced by Leontovich, **(194)**

$$\vec{E}_t = Z_S \left(\vec{n} \times \vec{H}_t \right) \qquad \textbf{(90)}$$

where the unit vector is directed into the medium and the subscript **'t'** indicates the tangential components of the field vectors. However, in the anisotropic case, a surface impedance tensor must be determined. **(195)** By extension, consider an expression of the form

$$\vec{E}_{t,i} = Z_{s,ij} \left(\vec{n} \times \vec{H} \right)_{t,j} \qquad \textbf{(91)}$$

where **i,j = 1,2** .

As above, let the **y**-axis be oriented perpendicular into the surface of the metal and the **z**-axis be oriented along the applied bias magnetic field from the coils on the ship. Also assume that the incident RF wave is normal to the side of the ship. The surface impedance tensor can then be calculated as

$$Z_{ij} = \begin{pmatrix} Z_{xx} & 0 \\ 0 & Z_{zz} \end{pmatrix} \qquad \textbf{(92)}$$

where

$$Z_{xx} = \frac{-E_x}{H_z} = \sqrt{\frac{j\omega\mu_0 \mu_{II}}{\sigma_e}}$$

$$Z_{zz} = \frac{E_z}{H_z} = \sqrt{\frac{j\omega\mu_0\mu_e}{\sigma_3}} \quad \textbf{(93)}$$

Recalling that

$$\sqrt{j} = \sqrt{e^{j\frac{\pi}{2}}} = \frac{1+j}{\sqrt{2}} \quad \textbf{(94)}$$

the complex components lead to the surface impedance tensor expression

(95)

where μ_{II} and the effective permeability μ_e are as given above.

While we have only considered gyro-resonance resulting from electron spin, similar arguments lead to the idea that, as a result of domain wall motion, entire domains behave as Tesla's "egg of Columbus" and possess gyromagnetic resonance's in the VHF region. These would also contribute to the surface impedance. In this regard, the experiments of Dr. Rado** are particularly notible. [(186) (187) (188)] We leave this for the interested reader to follow up on.

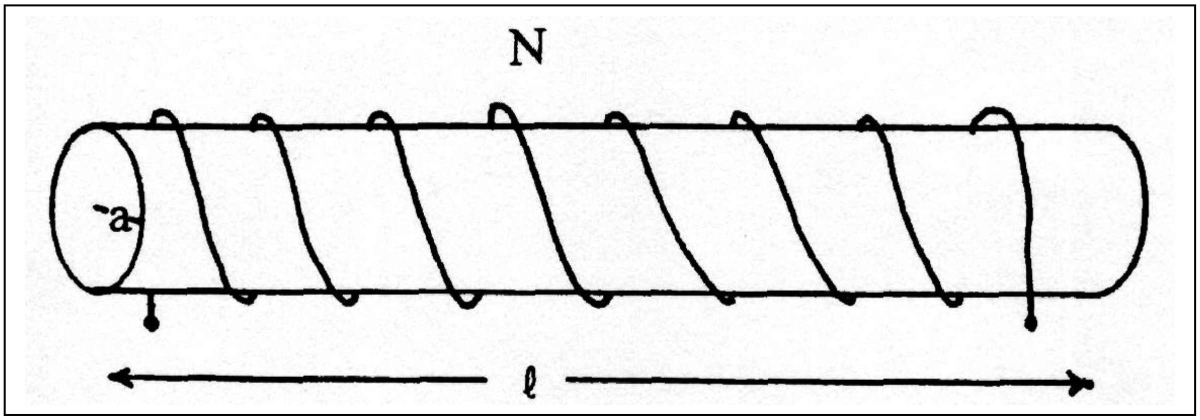
What is fascinating in all of this is that the $Z_{zz}(\omega)$ component, which depends upon both the RF frequency ω and the magnetic bias $H_0\hat{z}$, has a resonance character similar to a parallel tank circuit, and its magnitude and resonant frequency can be "tuned" by varying H_0!! We can calculate and plot this for the ship's hull. Again, there will be a resonance peak near some frequency ω_0 when H_0 is tuned to equal ω_0/γ. This leads to the notion that shipboard tuned resonance's, for incident RF fields, might satisfy Somrnerfeld's criteria for radar stealth.

** This was not Tesla's close friend, NYU Professor Dr. Paul Rado, who notified King Peter when Tesla died.

APPENDIX II

An Electrical Model for the DE 173

For simplicity, we model the ship and bias coil as a wire wound cylindrical solenoid of circular cross section, as shown.



N	=	100 Turns
ℓ	=	300 ft = 3600 inches
a	=	18 ft = 216 inches (ship effective radius)
D_w	**=**	3 inches (effective diameter of conducting wire)
ρ	=	10.37 CM-ohms/ft (resistivity of copper)

Figure II-1
Parameters for the calculation of coil inductance

1. Coil Inductance (Wheeler's Formula):

$$L_{\mu H} = \frac{a_{in}^2 N^2}{9 a_{in}^2 + 10\ell} = 12.3 mH$$

2. Total length of wire:

$$\ell_W = N 2\pi R + \ell = 11{,}610 \, ft$$

3. Wire cross section:

$$A_{CM} = (D_{mils})^2 = (1000 \, D_{in})^2 = 9 \times 10^6 \, CM$$

4. Total wire resistance:

$$R = \rho \frac{\ell_w}{A_{CM}} = 0.0134\Omega$$

To remain on the conservative side let's increase this resistance estimate by 50 % to, say, **R = 0.020Ω**

A Series Resonant Coil Driver

We are told that the diesel generators were rated at 1,500 VAC RMS and could deliver 4.5 Mw ($I_{gen} = 3{,}000A$). In the text, we needed a bias field requiring a coil current of 15,000 amperes. At 60 Hz, the inductive reactance of the above coil $\lfloor X_L = 377 \times 0.0123 = 4.64\Omega \rfloor$ would limit the magnitude of the current to only 323.3 amps - almost 50 times too small for the experiment.

If we added a series capacitor bank of 4.64 ohms reactance $\lfloor C = 1/(\omega X_c) = 572\mu F \rfloor$, then the current through the coil (and the generator) would be

$$I_{coil} = \sqrt{\frac{P_{in}}{R}} = \sqrt{\frac{4.5\times 10^6}{0.020}} = 15{,}000 amps$$

Although the generator voltage need only be

$$V = \sqrt{P_{in} R} = 300 volts$$

which may be gotten from the 1,500 volt output by a step-down transformer, this places an unreasonable requirement on the delivery system since it would require the 15,000 amps to flow either through the generator windings or through the windings of the step-down transformer's secondary. With transients, things could get pretty evil in the core. Is there another way to reasonably leverage the current up? We think that the classical "current-magnifier" circuit would be a likely candidate.

The Anti-Resonant Current Magnifier***

In Figure A.II.2 we give a summary for a *single phase* parallel resonant (or anti-resonant) current driver for the ship's coils. [(189)] [(190)] [(191)] Suppose that we assume that the ship's generators supply a rather "modest" 4,500 kVA step-up tramfonner rated at 70 kV output at only 65 amps.

In calculating the driver coil inductance, we assumed that, to first order at 60 Hz, the ship is more-or-less hollow. Using the parameters obtained above, the "Tank Circuit" terminal point **Q** is

$$Q_T = \frac{\omega_0 L}{R} = \frac{377 \times 0.0123}{0.020} = 232$$

The tank circuit input impedance at resonance will be

*** The authors wish to thank Basil F. Pinzone for collaboration on this section.

$$R_T = R\left(Q_T^2 + 1\right) = 1{,}076.5\Omega$$

The capacitor bank required for matching will be

$$C = \frac{L}{R_T R} = \frac{0.0123}{(1{,}076.5)(0.020)} = 572\mu F$$

Although somewhat large (rated at 100 kV peak), this is not unreasonable for the present application. The tank circuit's terminal point input current (required from the power transformer) is only

$$I_T = \frac{V}{R_T} = \frac{70{,}000}{1{,}076.5} = 65 amps$$

The RMS circulating current in the tank circuit is

$$I_L = I_T\sqrt{Q_T^2 + 1} = Q_T I_T = (232)(65) = 15{,}085 amperes$$

which is the desired current in the bias coils required for the Philadelphia Experiment. (Perfectly wonderful!!)

While we are at it, we might as well calculate the reactive power circulating in the tank. The circulating reactive kVA's are

$$P_{Tank} = V_T I_L = Q_T P_{in} = (232)\left(4.5\times 10^6\right) = 1.04 GVARs$$

which is indeed substantial, as was desired. The load power is found as

$$P_R = I_L^2 R = \left(1 + Q_T^2\right) R I_T^2 = I_T^2 R_T = 4{,}500 kw$$

which is, as expected, equal to the power supplied from the generator. Antenna engineers will recognize that we have used a classical **L**-Network for current magnification through the driver coils and as a matching circuit between the loss resistance and the generator at 60 Hz. Power engineers will appreciate the capacitor bank as giving unity power factor correction for the driver coil as a generator load.

Resonant Current-Magnification

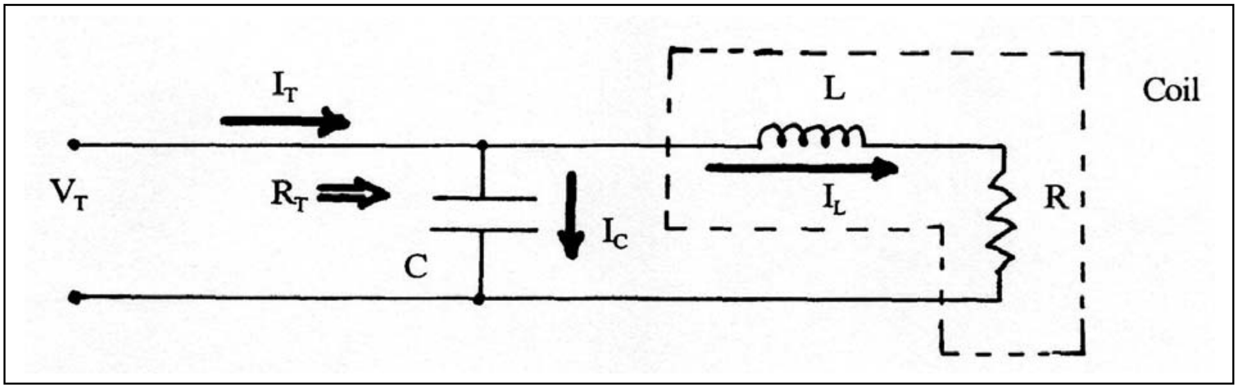


Figure II-2
Summary of the anti-resonant tank circuit. Note the terminal point impedance step-up feature and the stepped-up current pumped through the coil.

Resonant Frequency: $$f_R = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}} = f_0\sqrt{1 - \frac{1}{Q_T^2}}$$

Tank Circuit **Q** (measured at the terminals): $$Q_T = \frac{\omega_0 L}{R} = \omega_0 C R_T$$

Input Impedance at f_0: $$R_T = R\left(Q_T^2 + 1\right) = \frac{L}{RC}$$

Capacitance Required for Matching: $$C = \frac{L}{R_T R}$$

RMS Circulating Current: $$I_L = I_T\sqrt{Q_T^2 + 1} \approx Q_T I_T$$

Circulating Reactive kVA: $$P_{Tank} = V_T I_L \approx Q_T P_{in}$$

Load Power: $$P_R = I_L^2 R = \left(1 + Q_T^2\right) R I_T^2 = I_T^2 R_T = P_{in}$$

Input Admittance: $$Y_T(f) = \sqrt{\frac{C}{L}}\left[\frac{1}{Q_T} + j\left(\frac{f}{f_0} - \frac{f_0}{f}\right)\right]$$

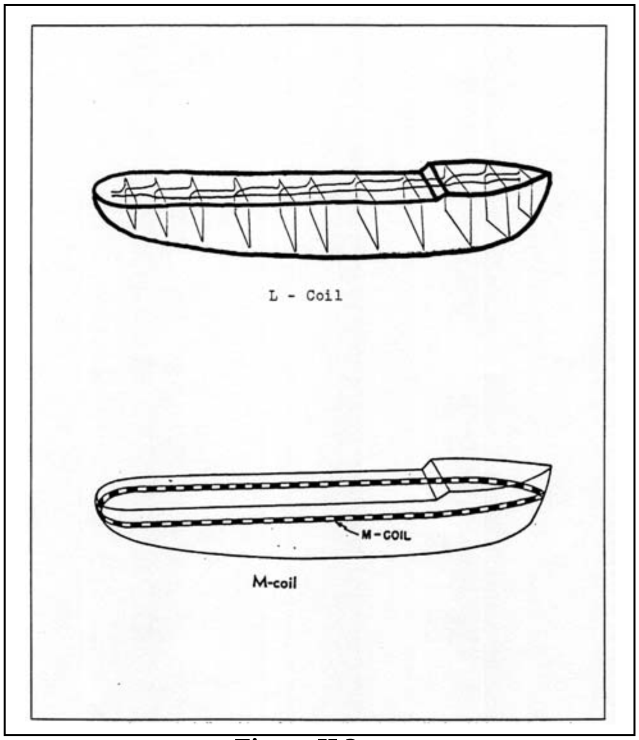


Figure II.3
Geometrical disposition of the "**L** - Coil" and "**M** - Coil" for shipboard degaussing

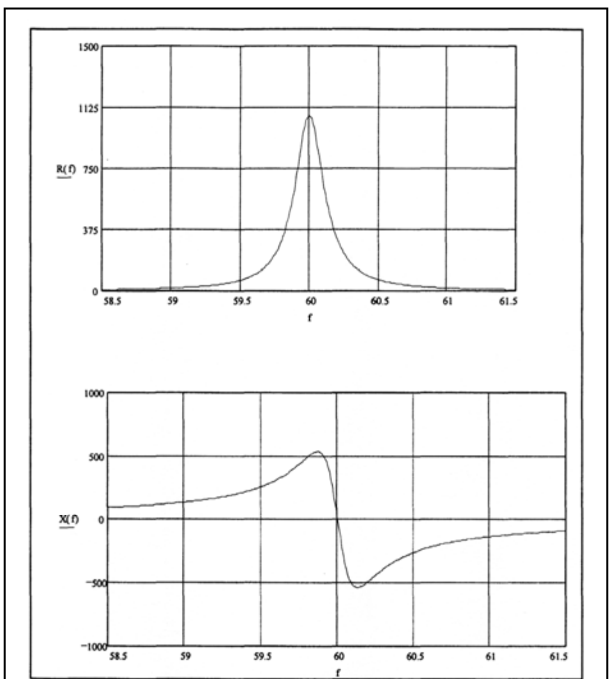


Figure II-4
Calculated input impedance $(R_T + jX_T)$ for the DE-173 driver coils as a function of generator frequency. Extra loading would tend reduce R_T.

CONCLUSIONS

Our conclusion is quite simple. While many other methods might have been employed to drive the required current through the magnetic bias coils in the Philadelphia Experiment, even a relatively modest power system could have done the job.

A whole variety of alternative options come to mind. A polyphase system could be used to drive multiple or segmented bias coils. Saddle coils could be used for biasing the hull, for stealth, under a variety of incident RF polarizations. The coils might, for example, be driven at some other pulsating low frequency. With a more sophisticated driver, employing low duty-cycle pulse power processing, one might even be able to raise the coil current to the fuzing level of

$$I_F = 10{,}244(3 inches)^{\frac{3}{2}} = 53{,}230 amps$$

If greater currents were desired, a larger wire bundle, or even shaped conductors, would have to be used (unless the effect of the seawater could hold back the overheating of the copper wire).

The limiting factor is the impracticality of this approach to stealth (you might not see the ship, but you could sure hear it coming), not the physical explanation of a "Philadelphia Experiment".

APPENDIX III

Peripheral Items of Interest

Robert Harrington Kent's obituary appears in Physics Today, July, 1961, p. 68.

Mr. F. Reno appears to have been an actual person, and not a pseudonym, for he is acknowledged for his "valuable suggestions" in a technical paper by Robert R. Kent. Dr. Kent solves the telegrapher's equation for terminated lines. [(192)]

Princeton Physics Professor Rudolph W. Ladenburg's obituary appears in Physics Today, May, 1952, p. 37.

The Code Name Dictionary, edited by F. G. Rufffner and R. C. Thomas, Gale Research Co., Detroit, Mi., (Library of Congress # PE 1693.R8) lists ***Rainbow*** as "(1) The code name for the Rome-Berlin-Tokyo axis..... (7) The code name for a military exercise."

One very distinguished Dr. Robert Fross Rinehart (b. 1907; MS '32, Ph.D. '34 from Ohio State), though presented as an pseudonym by Moore and Berlitz, actually existed. From 1942 to 1945 he was a member of the Operations Research Group of the Navy, involved with subsurface weapons and submarine warfare. From 1948 to 1950 he was on the Research and Development Board of DoD (serving as Chairman upon MIT President K. T. Kompton's resignation). Later while a Math Professor at Case Institute of Technology, he published several engineering research papers on Lunenberg Lens antennas. [(193)]

Joseph Pothier points out in his review that, "'The vessel [DE 173] was named after Lt. Commander John Eldridge, Jr., a 1927 Naval Academy graduate who was killed in action in the Solomon Islands 2 November, 1942." [(194)]

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APPENDIX IV *

The Philadelphia Experiment: Some Loose Ends

Since presenting the above paper on the Philadelphia Experiment,[(1)] at the 1994 International Tesla Symposium at Colorado Springs, we have had further thoughts concerning the following four items:

1. high voltage stealth,
2. the involvement of Thomas Townsend Brown,
3. recently published allegations that the incident was a hoax, and
4. the 1925 version of the Unified Field Theory ** and its possible relation to propulsion.

We wish to append this little addendum in the same playful spirit of speculative entertainment in which our original paper was written.

Electrostatically-Biased Radar Camouflage

Many years ago it was pointed out to us that Northrop, at the Norair Division in Hawthorne, California, [(2)] had, at one time, employed leading edge charging on wing-tip. [(3)] Ostensibly, the process was for the purpose of reducing drag and eliminating sonic boom; the upstream flow of ions sprayed from the wing tips charges the air molecules in front of a supersonic aircraft and lowers the Reynolds number for the medium. (The phenomenon was of interest to us as a component of Tesla's particle beam weapon. Without drag reduction the beam's particles burn up, like meteors, in a distance of a few kilometers. With a charged macron beam, however, the air's effective viscosity is significantly reduced and the particles can travel farther by orders of magnitude.) [(4)] But now, however, the idea of RCS (radar cross-section) reduction by using the dual process to that discussed in our "Philadelphia Experiment" paper becomes intriguing. A similar phenomena occurs as radar blackout during atmospheric reentry from space. Why not simultaneously drive the degaussing coils and employ high voltage corona for selective stealth reduction of radar backscatter?

On the Role of T. Townsend Brown

In the paper we expressed puzzlement at the introduction of Thomas Townsend Brown (1905-1985) into the narrative. But, we noted that it was Dr. Rinehart that injected Brown, and so we take it that there must have been a reason. Since then Brown's involvement has become more plausible to us. There have been many books and review articles published about T. T. Brown (primarily related to electrostatic propulsion research). Charles Yost has printed a detailed chronological chart for Dr. Brown's life and professional activities, which indicates that Brown attended Denison University, and that he and Professor Paul Alfred Biefeld collaborated over the years between 1924 and 1930. Brown's graduate work appears to have been directed toward stress in dielectrics and electrostatic propulsion.

Dr. Brown left Swazey Observatory (where Professor Biefeld was Director) in 1930 and accepted a position at the Naval Research Laboratory in Washington, DC. As a civilian member of the Navy Department, he was a staff physicist in the International Gravity Expedition to the West Indies during 1932. The following year (1933), he left NRL (as a result of budget cuts) and joined the Naval Reserve. By 1939 he was a lieutenant in the Navy Reserve, and was working as a material engineer for Martin (later Martin Aerospace) at Baltimore, MD.

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* This section added March 28, 1997.

** For complete translations of these papers, see the new book Selected Papers On 'De Early Unified Field Theories by Einstein and Others :. A Collection of Rei3rints and Translations (1921 to 1933), edited by J.F. Corum, 1997, manuscript in review.

According to Dr. Rinehart, that same year the Navy placed him in charge of magnetic and acoustic mine sweeping research at the Bureau of Ships. "This is where he got involved in [the Philadelphia Experiment] project." (6) In 1942, as a Naval Lt. Commander, he taught radar and served as Commanding Officer of the U.S. Navy's Atlantic Fleet Radar School at Norfolk, VA. "It was while serving in this assignment that he put forth some suggestions on how electromagnetic fields might be utilized to achieve partial radar invisibility." (7) According to most accounts, Dr. Brown suffered a physical collapse from exhaustion in December, 1943 and retired from the Navy. He recuperated for six months. During 1944 he took a radar consulting position for Lockheed, Vega Aircraft Corporation in CA. He went to Hawaii in 1945, where he continued his research in electrostatic propulsion. Subsequently, he spent a substantial portion of his life continuing his research on high voltage charged disk-shaped airfoils. (HV Trichel pulses: impulses yield momentum as opposed to electric wind?)

We think it startling that Brown, with such strong professional training and experience in classical electromagnetism, would have "attempted to explain his results in terms of Unified Field physics. Brown firmly believed in the existence of an observable coupling between gravitation and electricity, and that this coupling is being demonstrated by his devices." (8) In contrast to what we had previously thought about T. Townsend Brown, we now appreciate why he might have actually played quite a substantial role in the development of the Experiment. He was experienced in high field research, degaussing techniques, radar, and he had spent a considerable period of his career contemplating the classical unified field theories.

Hoax Allegations

While we were aware of the objections by Pothier, (9) which were readily dismissed, the publication by Vallee (10) was not called to our attention until only recently.***** Pothier, who is not a scientist, actually performed substantial naval document examination, and his papers should be read as supplemental nontechnical material by everyone interested in the topic. As we stated above, however, the critical issues and recitations of Pothier are readily dismissed on the basis of simple physics, and actually lead to a conclusion directly opposite to that which he states. Not only does the book by Moore and Berlitz supply the phenomenology, but the independent statements of the various witnesses, in fact, corroborate the basic technical issues, which we find astonishing since neither, Moore nor Berlitz have a scientific background. Jacques Vallee's effort to repudiate the incident, however, requires further discussion.

Witness Edward Dudgeon

Remarkably, Vallee actually produces a "witness" to the incident: a sixty-seven year old retired executive named Edward Dudgeon. Dudgeon was seventeen at the time of the experiment in 1943 and was stationed on the DE-50 (the U.S.S. Engstrom), which was in Philadelphia Harbor at the same time as the Eldridge. The witness does provide corroborating evidence for the incident. Mr. Dundgeon said;

> *"I believe that Einstein worked with the radar development group, but he wasn't involved in running actual tests."* (11)

This statement would seem to support the legend and, based on his subsequent declarations, we have no reason to doubt that Mr. Dudgeon was really there.

His testimony concerning the "tavern incident", (which he places in early August of 1943) and his explanation of the Eldridge's teleportation (disappearance at Philadelphia, appearance at Norfolk, and reappearance back at Philadelphia), are believable. To us these were not really not critical issues, and we certainly find his comments reassuring. It's far easier to believe Edward Dudgeon than Carlos Allende on these two points.

* We thank Albert Budden for sending us a copy of the Vallee paper in May, 1996.

Mr. Dudgeon noted that when the Eldridge and three other ships (including the Engstrom) were returning from Bermuda in July of 1943, they were

". . . caught in a storm that created a display of green fire accompanied by a smell of ozone. The glow abated when it started raining." [(12)]

We don't doubt the occurrence of this natural display, either. It was obviously "St. Elmo's hot fire", which is present around sharp objects whenever there exist substantial potential gradients, as in the case of some electrical storms.

His remark that the Navy personnel saying, *"Their going to make us invisible",* meant that they would be *"undetectable by torpedoes"* is certainly acceptable and consistent with our hypothesis that fields produced by the degaussing coils account for the observed physiological phenomena (Purkinji patterns, magneto-phosphenes, etc.) as reported by witnesses in the Moore-Berlitz book.

When asked about the procedure for degaussing a ship, Dudgeon responded, *"7hey sent the crew ashore and they wrapped the vessel in big cables, then they sent high voltages (sic) through these cables to scramble the ship's magnetic signature."* ***** Except for the remark about high voltages (degaussing requires very high currents at relatively low voltages), this is again what we would have expected in the account provided by a witness of the "Philadelphia Experiment", so far, so good.

However, we do have a problem with the witness credibility when it comes to the assessment of technical issues:

- Mr. Dudgeon asserts that the "Philadelphia Experiments" were *"not about trying to make the ship invisible to radar: the Germans hadn't deployed radar at the time."* [(13)] We have documented in our paper that this assertion is, by no means, accurate. Indeed, as pointed out in our paper, segments of the German physics community were (according to Arnold Sommerfeld) [(14)] intently searching for radar stealth countermeasures (as were the Allies).

- Clearly, the witness boyhood memories are also suspect. Witness Dudgeon asserted, *"When they were degaussing, you could smell the ozone that was created. You could smell it very strongly."* [(15)] Oh? You could smell it? We don't think so. The degaussing process involves the passage of high currents through low impedance coils surrounding the ship, not the employment of high voltages (as expressed above). And, certainly not voltages so high that air is ionized! (Unless there was an incredible $\partial B / \partial t$, such as is alleged to have been present during the "Philadelphia Experiment".)

  According to Mr. Dudgeon, he, at seventeen years of age, was actually an electrician's mate third class and it was his assignment at sea to speed up, slow down, or reverse the diesel generators on his ship in response to commands from the bridge. Perhaps he was referring to ozone generated by brushes and circuit breakers during switching, but certainly these had nothing to do with the degaussing physics. If the strong smell of ozone was prevalent during the operation in the Philadelphia Navy yard, then something more than simple ship degaussing was transpiring.

- Vallee asserts that, *"In conversations with the author, he [Dudgeon] cautioned that none of the electronic systems on the destroyers at that time were high-tech devices: the Navy was trying anything that could provide an advantage over German submarines."* [(16)] If there is any merit whatsoever to the conventional analysis provided in the early parts of our paper, then we concur that no sophisticated electronic systems were present (or required) on the ship for the "Philadelphia Experiment". The statement is in complete harmony with our analysis above.

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* What happens if the crew is not sent ashore?

While it is difficult to actually find a scientific witness to the "Philadelphia Experiment", we conclude that the youthful Mr. Dudgeon ("I was just a kid then.") [(17)] was not adequately trained to make technical assertions about physical phenomenology or to provide us with anything more than inexplicit and general descriptive information. Taken in context, we think that Mr. Dudgeon's testimony actually corroborates the legend of the “Philadelphia Experiment”, at least in the form as was described above.*****

Vallee's Tactic

In his paper, Vallee proceeds in another direction. He attempts to list the characteristic features associated with grand hoaxes * and identify these features with the alleged Philadelphia Experiment. His technique is that, since the features of the Philadelphia Experiment are similar to hoaxes in general, the incident must, therefore, also be a hoax. The logic fails, of course. (Post hoc, ergo propter hoc.**)

Vallee tabulates six rational countermeasures to being deceived by a hoax:

1. Disregard self described experts,
2. Disregard the media,
3. Look for logical flaws,
4. Identify and remove irrelevant drama,
5. Discover and test independent sources of information, and
6. Disregard any claims of secrecy

He identifies a bona fide feature of most hoaxes; “*7he problem with hoaxes is that they are charming, tantalizing, entertaining, and often correspond to what we would like to be true*... [18] [Nothing new here, the same can be said of most of 20th century physics!]

Vallee's article, which really contains surprisingly little about the Philadelphia Experiment, actually spends its energy attacking paranormal phenomena. In that arena, we have no experience, and no interest. We see no connection - it takes a leap of faith to identify the Philadelphia Experiment with UFOs or the paranormal. (Vallee is not alone in trying to make this connection but, unlike Vallee, most of his other bedfellows artificially invoke the paranormal as an *explanation.)* After adopting the link as part of the Philadelphia Experiment, Vallee dismisses the incident on the basis of *guilt by association. "We have seen that the Philadelphia Experiment had all of these characteristics. This hoax ... should have died a long time ago ..."* [19] In a remarkable exhibition of psychological gymnastics (rivaling even the ring antics of TV's professional wrestlers), Vallee grapples with an artificial straw man and body-slams it to the mat.

A Tragic Error

Vallee's paper exhibits a shocking lack of preparatory investigation - particularly for the strategy, which he is attempting to employ. For example, Moore and Berlitz inform us that T. Townsend Brown studied under Dr. Paul Alfred Biefeld, Professor of physics and astronomy at Denison University in Granville, Ohio. Moore and Berlitz relate that this Dr. Biefeld was a former classmate of Albert Einstein's in Switzerland (one of only eight). [20]

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* The Philadelphia Experiment: a big coil of wire was wrapped around a large ship and pulsed at resonant frequencies, the ship became invisible in a foggy green mist, and a lot of people on board were hurt.

** Vallee lists the following attributes of all great hoaxes: astonishing claims, interesting witnesses, peripheral evidence, dramatic sequels, a scientific aura, a link to reputable scientists, classified projects and government cover-ups, interest for common laymen, validation by paranormal researchers, media promotion, relevance to "believers", the presence of underdogs, and secret contacts.

*** After this, therefore on account of this.'

In an attempt to illustrate that hoaxes inject highly-visible scientists *as a* hoaxing mechanism, Vallee makes much of the fact that, *"The Berlitz-Moore book drags in Dr. T. Townsend Brown, said to be an academic protege of a “Dr. Biefield” (sic) who is said to have conducted experiments in antigravity with him ... however, only two Biefields (sic) are cited in the American Who's Who in Science. One received a degree in chemistry from Denison in 1930, the other in physical chemistry in 1948, also at Denison. Dr. Brown attended Denison in]924-*

25 and could not have been a protégé of either man." The conclusion is correct, but irrelevant! Another straw man is slammed to the mat!! (Vallee should be in theWW-I.) Vallee uses this data as evidence to bolster his argument that the “Philadelphia Experiment” was a hoax: No Biefeld, no Philadelphia Experiment!

The only problem is that Dr. Paul Biefeld really did exist, really taught at Denison, and really was an undergraduate classmate of Einstein's at Zurich in 1889. This isn't hard to check. Paul Biefeld's name tops the official list of the eight students in Einstein's second-year class at the Zurich Polytechnic Institute for 1889. (A photograph of the roster lists eight classmates including (in addition to Paul Biefeld) Einstein's first wife Mileva Maric and Einstein's subsequent collaborator Marcel Grossmann. [(21)]] Dr. Biefeld obtained his Ph.D. at Zurich in 1900. In addition to his university post at Denison University, he was also Director of Swazey Observatory in Ohio. The Denison University Biefeld’s from the 1930's and 40's were probably Dr. Biefeld's children.

As an aside, One wonders if Professor Biefeld ever discussed his old classmates with his student, T.T. Brown. It was during the time that T. Townsend Brown was with Professor Biefeld (1924-1930) that Einstein was publishing his initial papers on the Unified Field Theory. Did Professor Biefeld discuss these publications, by his old classmate, with Brown? Did Brown subsequently speak with Einstein about his former classmate (Professor Biefeld), or of student life at Zurich, of Einstein's first love, Mileva Maric (the gossip about their illegitimate child), etc. [(23)] Surely, such topics (and their common professional interest in radar) would have created a bond between Einstein and Dr. Brown, if later they actually worked together on the “Philadelphia Experiment”. Rather than a hoax gimmick, the Biefeld connection may have actually been a critical component to the subsequent execution of the “Philadelphia Experiment”, and completely bungled by Vallee.

A hoaxing mechanism? Come, come now, somebody didn't do their homework! It would appear that not only does Jacques Vallee owe William Moore and Charles Berlitz an apology, but he should find some way to correct for his public ridicule of these authors in the pages of The Journal of Scientific Exploration. How does Vallee ever repent and a rehabilitate all the poor miserable readers around the world that have been misled and deceived by his demonstrated lack of scholarship?

Which Version of Einstein’s Unified Field Theory should be used?

There were several versions of Unified Field Theories generated by Einstein over the years. The question naturally arises, "Which version of his Unified Field Theory was motivating the Navy in the Philadelphia Experiment?" Einstein was employed by the Navy (at the Research and Development Division of the Navy's Bureau of Ordnance, in the subsection on High Explosives and Propellants of the section on Ammunition and Explosives)' as a civilian consultant from May 31, 1943 to June 30, 1946, ostensibly for applied electromagnetics, (which might be related to radar, or might be related to ship degaussing, or torpedo deflection, or something else funneled through the Bureau of Ordnance). But, how does the Unified Field Theory enter the story of the Philadelphia Experiment?

The Source of the Idea

The book by William Moore and Charles Berlitz oives three separate people that inject the idea that the incident had something to do with Einstein's Unified Field Theory. First, in both of the letters to Dr. Morris K. Jessup, Carlos Allende focuses on the 1925 version of the Unified Field Theory, which was rejected by Einstein in 1927 ("primarily for humanitarian reasons, not for mathematics errors"). [(26)] He further alleges that the concepts of this version were tested by the Navy in 1943. Secondly, Dr. J. Manson Valentine asserts that, shortly before his death, Jessup believed that the explanation for the “Philadelphia Experiment”... was to be found in Einstein's Field Theory. [(27)] Thirdly, Dr. Rinehart begins his interview by William Moore with the words, "The Unified Field Theory….", [(28)] and he, too, gives it a significant role in the incident. * Dr. Rinehart also introduces T. Townsend Brown into the story. [(29)] According to Moore, Brown had a keen interest in Unified Field physics and believed in an observable coupling between gravitation and electricity. [(30)]

While the other two people just say "Unified Field Theory", it is Allende who specifically states that it is the 1925 version upon which part of the Philadelphia Experiment was based.* What curious feature of the 1925 version makes it so attractive for a Philadelphia Experiment? If it was rejected by Einstein, and subsequent versions (which were also unsatisfactory) were developed, why not use latest and best theory? Why the 1925 version? What, exactly was this 1925-27 version of the Unified Field Theory, and why was this version so prominent? What is the magic that makes it possible to subdue universal gravitation?

Some Background Information

Perhaps a little history is in order. The opinion that gravitation and magnetism are, somehow, related phenomena is as old as our knowledge of magnetism. In more recent times, Faraday (1791-1861) discusses the possibility in his research notes, and even Oliver Heaviside (1850-1925) formulated a unified field theory. [Some of Heaviside's papers on the topic were found at his Paignton, England home in 1957. Heaviside lived at Paignton from 1889 to 1897. (He superposed a gravitational flux vector onto the Poynting-Heaviside vector in flat space: $S = E \times H + G$.) [31] Interestingly, Heaviside's unpublished manuscript for a Volume FV of his Electromagnetic Theorv, including material on the unification of gravitation and electromagnetism, was loaned to NM during the 1930's for display. After WW-II it was requested that these papers be returned to England but, for some unknown reason, a "thorough search" of the Institute by the N41T President's office failed to produce the now-lost Heaviside Unified Field Theory manuscript.]

German physicist Gustav Mie (1868-1957) attempted a field theory of matter just prior to the creation of classical General Relativity. [32] [33] Gunnar Nϕrdstrom appears to have been the first to employ the term "unified field" in a modem context. [34] He also initiated the 5-dimensional pursuit. The first effort at a unified field theory based on general relativity was that due to David Hilbert (1862-1943) in 1915. [35] [36] While the odor Kaluza (1885-1954) introduced an enticing five-dimensional geometry for unifying gravitation and electricity," it was Hermann Weyl [38] [39] (1885-1955) and then Arthur Stanley Eddington [40] [41] (1882-1944) that set the stage for Einstein's labors toward a geometrical Unified Field Theory of gravitation and electromagnetism. Weyl noted that while general relativistic gravitational phenomena depend upon the sixteen components of a four-by-four metric tensor, electromagnetic phenomena are governed by a four-vector (the four-potential) and that *"so far these two classes of phenomena stand side by side, one separate from the other."* [42] He traced the root of the difficulty to the geometrical conveyance of vectors along arbitrary paths, and he probed the basis of world geometry,

> .... a geometry comes into being, which when applied to the world, explains in a surprising manner *not only the phenomena of gravitation, but also those of the electromagneticfield.* [43]

Weyl assumed that the affine connection was symmetric, and his efforts at unification soon ended in failure.

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* There is a mutual interaction here, the common acquaintance being Carlos Allende. It might be argued that Allende had acquired the idea from the lectures of Dr. Jessup. We need more information in order to isolate the witnesses.

** One might also raise the question as to how Allende, who was by no means a scientist (does he even read German, never mind understand non-Riemannian geometry?), could be aware of this feature of the incident. Was he merely garbelling together his narration of the Philadelphia Experiment and parroting back Dr. Jessup's remarks concerning the need for government funded research on Einstein's Unified Field Theory? (Allende was, of course, a common connection between the three people that have injected Unified Field Theories into the story.) Did his testimony infect the comments of the others? If this were so, and if only Allende, Jessup, and Rinehart express the explicit use of Unified Field Theories, then this whole aspect of the tale becomes suspect. To its it seems that his point requires clarification.

Unified Field Theories by Einstein

Einstein's famous General Theory of Relativity unified geometry and gravitation. [44] His passage from classical general relativity toward a geometrical theory in which gravitation and electromagnetism are supposed to emerge from a single principle may be traced chronologically as follows.

(1) In 1923, Einstein (1879-1955) trifled with the idea of a unification of geometry and electrodynamics. [45] In this primitive theory, based primarily on Eddington's 1921 notions, he obtained the result that the symmetric affine connection of space-time can be related to the metric tensor $g_{\mu\nu}$ and the electric four-current ($i_\mu = i_1, i_2, i_3; \rho$) as

$$\Gamma^{\alpha}_{\mu\nu} = \frac{1}{2} g^{\sigma\beta} \left(\frac{\partial g_{\mu\beta}}{\partial x_\nu} + \frac{\partial g_{\nu\beta}}{\partial x_\mu} - \frac{\partial g_{\mu\nu}}{\partial x_\beta} \right) - \frac{1}{2} g_{\mu\nu} i^{\alpha} + \frac{1}{6} \delta^{\alpha}_{\mu} i_\nu + \frac{1}{6} \delta^{\alpha}_{\nu} i_\mu \qquad \textbf{(1)}$$

(The affine connection $\Gamma^{\alpha}_{\mu\nu}$, prescribes how events at one point in space-time are related to events at adjacent points.) This led to the obstacle that it was impossible to derive the source-free Maxwell equations; in contradiction to experience, no electric field is possible at places where the current is zero! The same year, Dutch electrical engineer and noted mathematician J.A. Schouten (1883-1971) found a way around this difficulty, and he provided the first asymmetric affine connection Unified Field Theory. [46]

Schouten introduced the four-vector potential

$$S_\mu = S^{\nu}_{\mu\nu} = \tfrac{1}{2}\left(\Gamma^{\nu}_{\mu\nu} - \Gamma^{\nu}_{\nu\mu}\right) \qquad \textbf{(2)}$$

which is the contracted torsion tensor. In contrast to Einstein's work, he obtained the result that

$$\Gamma^{\alpha}_{\mu\nu} = \frac{1}{2} g^{\alpha\beta} \left(\frac{\partial g_{\mu\beta}}{\partial x_\nu} + \frac{\partial g_{\nu\beta}}{\partial x_\mu} \frac{\partial g_{\mu\nu}}{\partial x_\beta} \right) - \frac{1}{2} g_{\mu\nu} i^{\alpha} + \frac{1}{6} \delta^{\alpha}_{\mu} i_\mu - \delta^{\alpha}_{\mu} S_\nu \qquad \textbf{(3)}$$

Because of the presence of S_μ electromagnetic fields are now possible even in places where the electric four-current i_μ is zero. The question is why should the four-potential depend upon the torsion of the manifold (and vice-versa)?

(2) Einstein first employed the term "Unified Field Theory" in 1925, publishing the famous paper "Einheitliche Feldtheorie von Gravitation und Elektrizitat".* [47] Starting from a variational principle Einstein obtained an enchanting metric tensor that could be decomposed into a symmetric part $g_{\mu\nu}$ (which could be identified with gravitation and classical general relativity) and an unsymmetrical part $\Phi_{\mu\nu}$ (which he attempted to identify with the electromagnetic field tensor: $\Phi_{12}, \Phi_{23}, \Phi_{31}$ corresponding to the electric field-strength, and $\Phi_{14}, \Phi_{24}, \Phi_{34}$ corresponding to the magnetic field strength). The problem was that the $\Phi_{\mu\nu}$ was not exactly the curl of a four-vector, as it should be for electromagnetism, so the new "electromagnetic-like field" is going to generally have the wrong properties. However, the "electromagnetic-like field" equations which emerge in the weak field limit are, in Einstein's words, almost completely equivalent to the Maxwell equations for free space ... essentially equivalent to Maxwell's equations for free space", - but not quite. The equations fail for the existence of sources. Nothing arose to be interpreted as the electric current density standing on the right side of a

Maxwell's source equation: $\nabla_{v}\Phi^{\mu v} = i^{\mu}$. The remarkable outcome of this theory was that the symmetric part of the metric gave classical general relativity (including red shifts, perihelia precession, light bending, etc.) *plus* the unsymmetric part of the metric gave a slightly flawed version of Maxwell's equations. The implication was, if you could generate the appropriate electromagnetic fields then you would modify the metric tensor for the geometry of space-time. In this 1925 version, however, gravitation and electromagnetism are ". . . independent from one another in the first approximation." **(48)** (Interestingly, Einstein's post war attempt at a Unified Field Theory, in the final decade of his life, starts with the same variational principle as his 1925 version and delivers both an unsymmetric metric and torsion. **(49)**)

(3) In 1927, when commenting on the 1925 Unified Field Theory and his attempts to make it work, Einstein said,

> *". . . all our endeavors to attain a theory which combine the gravitational field and the electromagnetic field into a formal unification were directed along the paths embraced by Weyl and Eddington, or a similar route; through numerous failures I have now, myself, struggled through to the conviction that one does not come closer to the truth along this way."* **(50)** [Emphasis in the original.]

We take it that this was the 1927 "rejection" referred to by Allende in the quotes above.

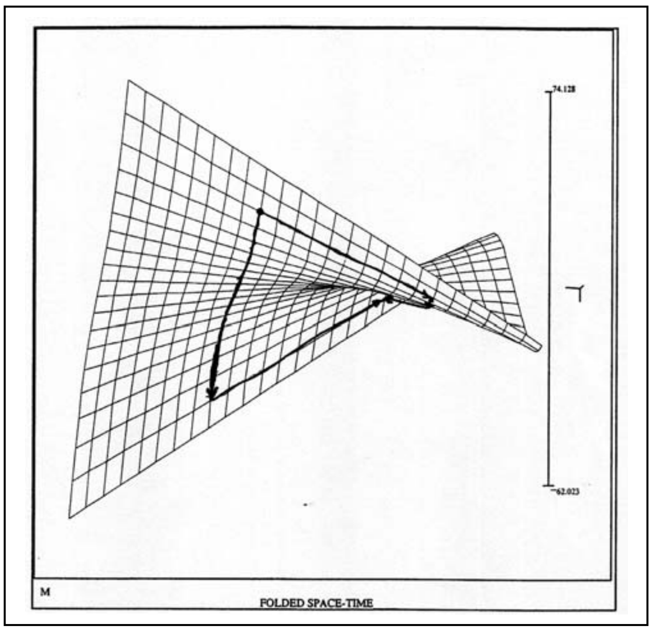

Figure IV.1
Space-Time Manifold crinkled by Torsion

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* Unified Field Theory of Gravitation and Electricity.

Einstein then returned to Kaluza's five-dimensional strategy, but within the year he had rejected this approach also. Although publically rejecting the 1925 theory, clearly Einstein was not giving up on a Unified Field Theory.

(4) In papers published in 1928 **(51)** and 1929 **(52)** Einstein admits that the Riemannian geometry of general relativity, although it leads to a physical description of gravitational fields, furnishes no concepts to which electromagnetic fields might belong. Instead of starting from a variational principle, he now sidesteps into differential geometry and introduces the mathematical concept of distant parallelism (fernparallelismus), also called teleparallelism or absolute parallelism. Distant parallelism is a mathematical prescription for the parallel displacement of a vector, between two points in a manifold, that is independent of any particular choice of path between the two points. (A Euclidean manifold is an example of a space with distant parallelism.) In the curved Riemannian geometry of classical general relativity, however, the results of parallel transport are path-dependent. Accordingly, in spite of the fact that the newly found metric tensor and affine connection can even be nonsymmetric, the Riemann-Christoffel curvature tensor now vanishes identically (there is no Schwarzschild solution), and as Wolfgang Pauli noted, the classical tests of general relativity that depend upon curvature go out the window! But, at least in the first approximation, the new approach did give Maxwell's equations in free space.

The idea behind distant parallelism is to erect a field of orthonormal tetrad frames over the entire space-time manifold

$$\vec{e}_a(P) = {}_{(a)}e^{\mu}\frac{\partial}{\partial x^{\mu}} = h_a^{\mu}\frac{\partial}{\partial x^{\mu}} \quad \textbf{(4)}$$

where the latin subscript a numbers the base vector and the greek index p specifies the component on the local tangent basis vector a/olx" at the given point. The corresponding arms of the tetrads at different points are mutually parallel since the **iE,,** satisfy **Vbe**,, = **0**. Vectors at different points are accounted parallel if they have the same components on the tetrad field at the different points.

An unsymmetric affine connection can be determined from the null covariant derivative of the tetrads as

$$\Gamma^c_{ab} = -{}_{(a)}e^{\mu}\frac{\partial^{(c)}e_{\mu}}{\partial x^b} = -h_a^{\mu}\frac{\partial h^c_{\mu}}{\partial x^b} = -h_a^{\mu}h_b^{\nu}\frac{\partial^c_{\nu}}{\partial x^{\mu}} \quad \textbf{(5)}$$

which further leads to the conclusion that the Riemann-Christoffel curvature tensor vanishes and the torsion is nonzero:

$$S^c_{ab} = \tfrac{1}{2}\left[\Gamma^c_{ab} - \Gamma^c_{ba}\right] \quad \textbf{(6)}$$

The geometrical significance of this is shown in the attached Figure IV.1 and was explained in Figures 11 and 12 of our paper. [(53)] A metric tensor may introduced through the inner product

$$\vec{e}_{\mu}\bullet\vec{e}_{\nu} = g_{\mu\nu} = {}^{(a)}e_{\mu}{}^{(b)}e_{\nu}\eta_{ab} \quad \textbf{(7)}$$

where η_{ab} is the Lorentzian metric with signature **(1, 1, 1; - l).** The result is a metrical geometry with torsion.

Building upon the, above, Einstein then identifies the contracted torsion tensor S^b_{ab} with the electromagnetic four-vector potential:

$$\Phi_a = S^b_{ab} \quad \textbf{(8)}$$

In his review of this approach to a Unified Field Theory, Eddington declares, "The general idea is that the nature of the field can be completely described by specifying the values of the 16 quantities h_a^{μ} at every point. Such a description is more comprehensive than if the 10 quantities $g^{\mu\nu}$ required to define the gravitational field are specified, so that it is able to embrace the electromagnetic field in addition." (54)

As stated earlier, the theory leads in first approximation to Maxwell's equations, but, since $R^a_{bcd} = 0$ (which makes the distant parallelism possible), the classical general relativistic effects evaporate.

(5) By 1930, Einstein realized that his first 1929 paper "needed improvement" and his second 1929 paper (55) (which attempted to obtain the new Unified Field Theory from Hamilton's principle) "contained a fatal error". (56)

(6) In 1931, he states that the previous "distant parallelism" approach is the wrong direction. In October of 1931 he wrote,

"Until now, the general theory of relativity primarily has been a rational theory of gravitation and the metrical properties of space. However, concerning the treatment of electromagnetic phenomena, it had to content itself with a bare superficial incorporation of Maxwell's theory into the relativistic scheme. In addition to the quadratic metrical form of the gravitational field, one had to introduce a logically independent linear form whose coefficients are interpreted as the potential of the electromagnetic field; the covariantly written Maxwell tensor of the electromagnetic field stood beside the curvature tensor in the tensor equations of the gravitational field -- superficial, and logically joined only arbitrarily by a plus sign. This must be perceived all the more painfully since Maxwell's theory is supported as a field theory only to first approximation, albeit through very rich empirical experimental data; the suspicion could not be escaped that the linearity of Maxwell's equations does not correspond with actual reality, but on the contrary, the true equations of electromagnetism deviate from those of Maxwell's for strong fields.

For that reason theoreticians are interested, since the formulation of the general theory of relativity strives to formulate a logical unified theory of the overall field. One cannot maintain, however, that the great efforts previously devoted to the problem have led to a satisfactory result." (58)

From 1931 to 1938 Einstein returned to five-dimensional Kaluza-Klein theories, and then discarded these forever.

(7) Finally, between 1945-1955 Einstein publicly returns to the unsymmetric Unified Field Theory of 1925 with renewed vigor and considerably more rigor. He now recognizes that it is the infinitesimal displacement $\Gamma^{\alpha}_{\mu\nu}$, and *not* the metric tensor $g_{\mu\nu}$, that makes it possible to avoid inertial systems. He asserts,

". . . there is no compelling reason to restrict Γ by the condition of symmetry with regard to the lower indices... If one does not subject Γ to a restrictive symmetry condition, one arrives at that generalization of the law of gravitation that appears to me as the natural one." (59)

He employs the variational principle from 1925 and arrives at a final set of field equations, which still fail to yield an exact set of Maxwell's equations but does give conservation of charge.

Einstein's Search for UFT Experiments in the 1920's

It appears that attempted experimental investigations of the Unified Field Theories actually predate the Philadelphia Experiment. Starting with the 1923 version, it has been stated by Gerlach (of Stern and Gerlach fame) that Einstein was actively searching for experimentally observable effects of a Unified Field theory. [60] In a letter to Max Born, Einstein stated that he was searching for an experimental examination of the 1923 Affine Field Theory which involved the earth's magnetic field. [61] The efforts recall to mind the 1915-1917 Einstein-de Haas Effect experiments.

Vizgin asserts that, "Einstein did not abandon searches for experimental confirmation of his affine filed theory." [62] In another incident, Vizgin states, "Einstein (together with Ehrenfest) considered making a delicate electrostatic experiment that would make it possible to confirm consequences of the affine theory that went beyond Maxwell's electrodynamics." [63] In a letter to Ioffee, Ehrenfest wrote, "Einstein and I immerse ourselves for many hours everyday in an experimental study to establish whether there exists a completely crazy electrostatic effect assumed by him." [64] The experiment was subsequently abandoned.

Vizgin goes on to write, "During the 1930's and 1940's, the question of the magnetism of rotating masses was raised several times in connection with unified geometrized field theories. In 1923-1924 Einstein very insistently sought possibilities to relate his affine field theory to physical effects, above all to macroscopic electromagnetic phenomena. He attempted to interest the experimentalists Gerlach, Franck, Piccard, and others, and also his friend Ehernfest, in these ideas. None of these attempts gave results, but nevertheless they did not undermine Einstein's belief in the promise of the affine direction, which continues to develop during the whole of 1925." [65] We think that the torsion negation of the anholonomic Sagnac effect, which we described in some detail in our "Philadelphia Experiment" paper, now becomes even more significant as an experimental verification of these unsymmetric affine field theories. Clearly, the experiment needs to be funded and carried out!

Why are these Unified Field Theories of Interest Today?

At this point, every informed particle physicist reading this is probably wondering why in the world we are pursuing these arcane theories. Everyone today knows that a grand unified field theory , a ToE (Theory of Everything), embracing the strong and weak interactions of nuclear physics, is not to be found in Ricci calculus, and certainly not in the continuum unified field theories of the early twentieth century. However, what most modem physicists are not aware of is the central importance of these early unified field theories to electrical engineering and the experimentally successful application (the term is actually Bannesh Hoffmann's) [66] of these concepts to heavy electrical machinery. [67] Indeed, the form of Maxwell's equations written by early unified field theory workers [68] is the only correct version of Maxwell's equations in spaces with anholonomity [69] [70] [71] or torsion! *

SUMMARY

What does all this mean? It seems to suggest that, since charges, currents, and even ferromagnetic domain spin produce the four-potential Φ_μ (and its dual), and **Equation (8)** implies that this is related to the torsion of the manifold, various current distributions could be engineered to affect the affine connection of **Equation (5)** and, therefore, the metric tensor of **Equation (7**). Since gravitation is a metrical phenomenon, the implication is that, under appropriate conditions (whatever those might be), one could use current distributions to modify gravitation (propulsion?). A side effect might be the "crinkling of the manifold" (to use Eddington's

$$F_{ik} = \left(\frac{\partial A_k}{\partial x^i} - \frac{\partial A_i}{\partial x^k} \right) - 2\left(S_{ik}^{\,j} - \Omega_{ik}^{\,j} \right) A_j$$

words) [72] due to the excitation of torsion (a nonclosing of parallelograms due to the asymmetry of the affine connection), and this may lead to teleportation and time-travel. These incredibly bizarre notions appear to be resident in the classical non-Riemannian UFT equations.

CONCLUSION

In Vallee's paper, as with Pothier's papers, we look at the same evidence (meager though it may be) and conclude that the argument for the occurrence of the Philadelphia Experiment is *strengthened* all the more. Vallee complains, *"What can the individual scientist do when trying to introduce rational research into afield where stories like the Philadelphia Experiment clutter the literature* . . .?" **[(24)]** We counter by rephrasing the remark and echoing back, "What can rational scientists do when trying to introduce analytical thought into a field where shoddy scholarship, irrelevant obfuscations, and vanquished straw men clutter the literature?"

It seems to us that the paper was driven by cerebral predisposition, not scientific inquiry. (It's too bad that Vallee pursued his hoax hypothesis instead of listening more closely to the remarkable witness that he had available. In spite of the fact that his technical training was limited, Mr. Dudgeon could probably have supplied quite a few missing pieces of the puzzle if he were suitably questioned.) Surely, the two most obvious and important ingredients were omitted from Vallee's list of countermeasures for deception by a hoax. Let us suggest these two: (7) Do your own homework, and (8) Check the physics.

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* Reference 67 exhibits the first explicit generalized expression of Maxwell's equations in spaces with Torsion: Eq. 25. Kron added the anholonomic term, as required in engineering applications (Jour. Appl. Phys., Vol. 7, 1936, pp. 143-152: Eq. 46; Vol. 9, 1938, pp. 196-208: Eq. 5.4). This term was the key ingredient employed in the anholonomic Corum papers just referenced.

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1925

"Einheitliche Feldtheorie von Gravitation und Elektrizitat," by A. Einstein, Preussische Akademie der Wissenschaften, Physikalisch-Mathematischen Klasse, Sitzungsberichte, vom 9 Juli 1925, pp. 414-419.

1927

"Formale Beziehung des Riemannschen Krummungstensors zu den Feldgleichungen der Gravitation," by A. Einstein, Mathematische Annalen, Vol. 97, 1927, pp. 99-103.

“Zu Kaluzas Theorie des Zusammenhanges von Gravitation und Elektrizitat - Erste Mitteilung," by A. Einstein, Preussische Akademie der Wissenschaften, Physikalisch-Mathematischen Klasse, Sitzungsberichte, vom 17 Februar, 1927, pp. 23-25.

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1928

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1929

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1930

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