The Forbidden Equation: $i = qc$

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Mr. Bishop's label "the forbidden equation" is actually quite appropriate. But, it is not just because he has found no one else who mentions or uses it; rather, it is because it should be forbidden from physics, not admired as a new discovery about physics. - Prof. William A. Gardner, Electrical Engineering, UC Davis

There is any number of equations used to describe electric current. But there is one simple equation that is seldom to be found in any Academic textbook or Peer-reviewed journal article. Yet what I've named "The Forbidden Equation", $i = qc$, is nothing more or less than the defining equation of electric current, with i the electric current, q the net line charge per unit length, and c the speed of light. It is apparent why this equation is buried so deeply as to be unheard of- it destroys the idea of electric current, and all that descends from that idea, by its very definition. There have been a few recent sightings of The Forbidden Equation, all curiously enough in papers addressing The Catt Question.

$i = qc$ is a mainstream equation, inseparably contained within their other electromagnetic equations and easily derived from them using elementary algebra. It is Gardner's Equation, Maxwell's Equation, and Einstein's Equation as well. Behold the abyss.

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1. $i = qc$: Introduction

There is any number, depending on whom you talk to, of equations used to describe electric current, but there is one simple equation gone missing. A years-long search has not turned it up in any of hundreds of relevant textbooks and papers. (late update- found it in one book, see Addendum) Yet $i = qc$ is nothing more or less than the defining equation of electric current, the continuity equation for electric charge in an electric circuit or a transmission line... or would be.

I stumbled across this little equation myself in 2008 while manipulating some of the other lesser-known equations of electric current, the ones they don't quite teach you in Physics, or Aerospace, or Electrical Engineering. At the time it seemed interesting but I did not work through its many ramifications until sometime later. [1] It is apparent why this equation is not to be mentioned- it destroys the idea of electric current by its very definition, as your messenger will show you. [2]

$i = qc$ is an old, though implicit, mainstream equation. It is not at all "Mr. Bishop's... new discovery about physics" as William A. Gardner thought. It is inseparably contained within the other conventional equations. It is Maxwell's Equation. It is Gardner's Equation, who is quite correct in that it should not be admired as a new discovery. [3] Yet even with coaching he was unable to provide a derivation, and apparently did not think such a derivation was possible. The promoters of Maxwell's Equations and the rest have clearly not thought through the math in their own theory(s).

In August of 2012, after my publication the preceding May [1], came the first Academic sighting of "The Forbidden Equation", from The Clarendon at Oxford, no less. [4] It came in an email, over the e-transom from a secondary source. We (Catt, myself, and other interested parties) were told that the author was a physics teacher or a physicist at The Clarendon who wished to remain anonymous. His friend at Oxford, Dr. John Roche*, said that "Anonymous of Clarendon", as we came to call him, had taken ill or something. To distinguish this work, we began to call his six-page, handwritten treatise "The Clarendon Letter", even though Anonymous had titled it "The Catt Question". [5] Anonymous surfaced later on and turned out to be Dr. C.W.P. Palmer, and the story we were told proved to be true.

*It turns out that Roche had earlier played a pivotal, historic role in the unfolding story of **The Forbidden Arrow**, the arrow that must not be noticed, drawn, or discussed, a tale for another day.

Poor Prof. C.W.P. Palmer of The Clarendon did not realize, at least not consciously, that he had committed a grave heresy. He did take the precaution of anonymously publishing The Forbidden Equation, and did lay low for some time, but I know for a fact, a provable fact, that he had not thought through the ramifications of this blasphemy. How could he? You see, The Forbidden Equation is so toxic, so devastating to Modern Physics that most of them have probably never even heard of it let alone thought about it.

My next sighting of The Forbidden Equation was in 2013, and again in a published response to The Catt Question. [6] This time the equation was a bit more disguised, broken into pieces. The Italian electrical engineering professors, like Palmer, attempted to join it up with their version of an equation for electron drift current. They left this derivation out of their IEEE article, opting instead to include it in a "physics education" magazine. This attempt at "joining two speeds together" fails for several reasons, not the least of which is that the particles in a current can only move at one speed at a time. Attempts by several people [7] to correct the sundry libels and errors of the Italians by publishing letters in these same journals were rebuked, though this may change.

In re: The Clarendon Letter; On 12/18/2012 1:36 PM, Ivor Catt wrote: [2]

Dear Forrest,

IC: *You point to the equation having been written by someone in the Establishment. Note that I have never written it...*

IC: *It is extraordinary that I have trouble progressing to the "obvious" conclusion...*

IC: *...Do you, Forrest, think that the mere statement* i = qc *refutes classical theory, showing us that since charge gained mass in around 1900, classical theory was no longer fit for purpose?*

FB: *Yes,* i = qc *means that q has to be massless because c is the only speed at which this equation can hold... The Clarendon man makes a valiant attempt to save classical theory... but his argument fails for several reasons.*

IC: *It is interesting to think of the possibility that when reasoning is taking one to see a fallacy in the classical paradigm, common sense ceases to operate, even in me...*

FB:*...we are all imprinted (or infected, choose your poison) with certain patterns of thought at a very early age that become such second nature that we don't even realize they are there. I don't think there was a vast conspiracy to squelch* i = qc*... rather it mostly* happens as a natural progression in the transmission of culture.*

FB: **I'm thinking here of higher-ups that do occasionally see the problems but don't talk when there is a duty to speak...*

Behold the abyss:

2. $i = qc$: Deriving The Forbidden Equation

There are a myriad of ways to derive $i = qc$ depending on which variables one begins with. With caveats, you may begin from Maxwell's Equations for example. You may also construct $i = qc$ by reconstituting the expression $i = Q/t$ (with Q the charge passing through a plane), a truncated equation that can be found in many places. You may start from the equations found in Halliday and Resnick's *Physics (Vol II)*, in David Griffith's *Introduction to Electrodynamics* [8], in *The Feynman Lectures* [9], in JD Jackson's *Classical Electrodynamics* [10], or, most easily, from equations in Catt's *Electromagnetism I*. [11] All of the cases below are for perfect conductors in vacuum, the same conditions that the basic Maxwell's Equations are derived under, with the speed of light $c \equiv c_o$ and wire resistance per unit length $R_L = 0$. This is called the "lossless" condition in electrical engineering, a topic discussed in the remarkable ***i = qc*: The Gardner Equation** section below.

2.1. $i = qc$: Derivation from Observing a Voltage Step

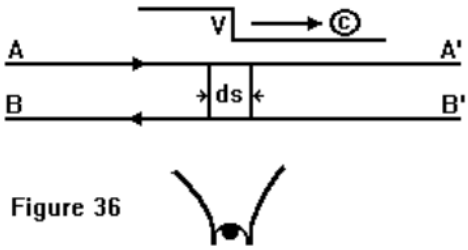

Figure 1. Watching a step TEM wave pass by

Ivor Catt almost derives The Forbidden Equation in his unique fashion using differentials (Figure 1.). Excerpted from his *Electromagnetics I* [11], with q the net electric charge per unit length that forms the electric current:

"*In order to discover how we characterise a transmission line we shall consider an observer watching a step passing him along a two-wire line (Fig.36).*

"*The observer knows... that electric charge is conserved... "In a time* δt *the step will advance a distance* δs *such that*

$$\frac{\delta s}{\delta t} = C \tag{1}$$

[i.e. the step advances at the speed of light, c, his C -FB]

"*Now we consider the conservation of charge. In a capacitor in general,* $q = cv$*. In our case, the charge* $i\delta t$ *entering the line in time* δt *equals the charge trapped in charging up the next segment* δs *of the line,* $c\delta sv$*, where c is the capacitance per unit length between the pair of wires, and* $c\delta s$ *is the capacitance of our section.*

$$i\delta t = vc\delta s \tag{2}$$

"*which means that*

$$i = vcC \tag{3}$$

End of excerpt. I recently spoke at great length with Ivor Catt about this derivation and about The Forbidden Equation. It was originally in his historic 1967 paper, *Crosstalk* [12] along with more analysis. He was one step removed from deriving $i = qC$ (using his notation), which can be found by substituting $q = cv$ back into Equ (3) to receive

The Forbidden Equation

$$i = vcC = qC \tag{4}$$

Catt was using Equ (3) as an intermediate step in his mathematical proof of the existence of two modes of wave propagation in a four-conductor line, and so did not pursue this equation further. At eighty years old, he said that he had never seen The Forbidden Equation before (aside from my pointing it out). William A. Gardner and Harry H. Ricker III also stated that they have never seen it anywhere before. Ricker took the trouble to search his library and was only able to come up with one similar equation, $i = qv$, in an old book on transmission line theory.

2.2. $i = qc$: Derivation from $C_L = 1/cZ$: Another Forbidden Equation

Below I use a Forbidden Equation of Line Capacitance, $C_L = 1/cZ$, in one of my several derivations of $i = qc$. This derivation relies on another unfamiliar equation, but it is most compact and direct. I also 'discovered', or stumbled across, $C_L = 1/cZ$ in 2008, but I think I remember seeing it later in one old book on transmission lines.There are apparently different levels of Forbidden. It comes directly from generalizing the expression of permittivity in terms of c_o and Z_o, Equ (1), and by multiplying it by the dimensionless, geometric form-factor f for the two conductors of an electric circuit in the plane of their impedance, described in some few textbooks. [11]

In all of the below, Z_o is the vacuum wave impedance, Z is the characteristic, aka surge, aka line impedance, so that $Z = fZ_o$ and $c = c_o$. This is also vacuum-valued for all of the instant cases; material dielectric adds some irrelevant complexity to the argument. The L subscript is used to set off quantities per unit length, C_L is the capacitance per unit length (farad/m), L_L is the inductance per unit length (henry/m), and $q_L \equiv q$ from above. Begin from the two published equations that are not to be found together on the same page [units in square brackets],

$$Z_o = \sqrt{\frac{\mu_o}{\varepsilon_o}} \quad \textbf{and} \quad c_o = 1/\sqrt{\mu_o \varepsilon_o} \tag{5}$$

With the above two equations in front of you on the same page you may easily deduce the electric permittivity/constant and magnetic permeability/constant equations, in wave impedance, Z_o, and $c \equiv c_o$:

A Couple More Forbidden Equations

$$\varepsilon_o = \frac{1}{Z_o c_o} \quad [\text{ farad/m }] \tag{6}$$

and

$$\mu_o = \frac{Z_o}{c_o} \quad [\text{ henry/m }] \tag{7}$$

The line capacitance is the capacitance per unit length of the electric circuit, C_L (Catt's c above). It is found by multiplying the permittivity by the dimensionless geometric factor, f, where f is calculated from the cross section of the two wires in the plane of impedance. [11]

$$C_L = \frac{\varepsilon_o}{f} \quad [\text{ farad/m }] \tag{8}$$

Substitute Equ (6) into Equ (8) to receive

Another Forbidden Equation

$$C_L = \frac{\varepsilon_o}{f} = \frac{1}{fcZ_o} = \frac{1}{cZ} \quad [\text{ farad/m }] \tag{9}$$

where $c \equiv c_o$ is the speed of light in vacuum, and $Z = fZ_o$ is the characteristic impedance of the electric transmission circuit line in vacuum.

With V the voltage between the two wires of an electric circuit as measured in the plane of impedance,

$$C_L = \frac{q_L}{V} = \frac{1}{cZ} \quad [\text{ farad/m = (coul/m)(volt) }] \tag{10}$$

which can be rearranged to express the line charge (charge per unit length) as

$$q_L = \frac{V}{cZ} \quad [\text{ coul/m = (volt)/(m/s)/(ohm) }] \tag{11}$$

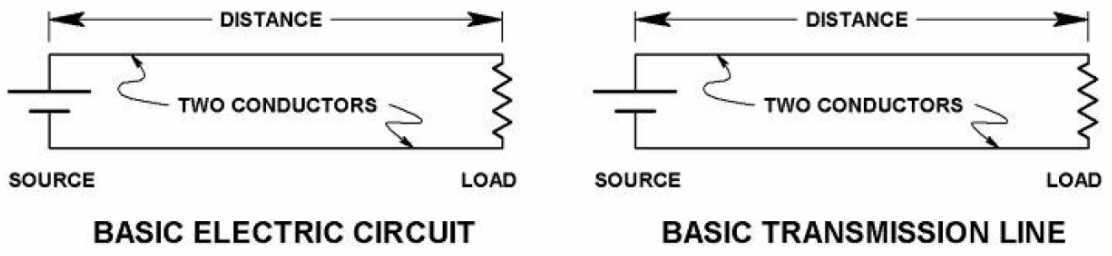

Figure 2. One phenomenon, two concepts. "Electric circuit line", "Electric transmission circuit line", "Electric transmission circuit", "Electric circuit", "Electric line", "transmission circuit line", "transmission circuit", "transmission line", etc. are used interchangeably. They are all different names for the same thing.

The general equation for the line impedance is

$$Z = \frac{V}{i} \quad [\text{ ohm = volt/amp }] \tag{12}$$

Solve Equ (12) for V and substitute into Equ (11):

$$q_L = \frac{V}{cZ} = \frac{iZ}{cZ} \tag{13}$$

Cancel Z and rearrange to discover

The Forbidden Equation

$$i = q_L c \quad [\text{ amp = (coul/m)(m/s) }] \tag{14}$$

2.3. $i = qc$: Derivation from the Fusion of Two Common Line Equations

This derivation begins from the very well known equations for line capacitance and line inductance. I use an algebraic operation (which might have another name) which I call the "Fusion of Equations". The generic idea is to set *any* two equations each equal to a dimensionless 1, then to equate them with each other. This technique is explored in more depth in another pending paper of mine called **Maxwell's Algebra**.

Two different Forbidden Equations will emerge from the instant derivation, one is the title of this paper and the other is its "companion" equation for voltage in terms of the speed of light.

Rearrange the well-known equation for capacitance per unit length,

$$C_L = \frac{q_L}{V} \quad [\text{ farad/m = coul/volt }] \tag{15}$$

as

$$\frac{C_L V}{q_L} = 1 \quad [\text{ dimensionless }] \tag{16}$$

With ϕ_L the magnetic flux per unit length, rearrange the well-known equation for inductance per unit length,

$$L_L = \frac{\phi_L}{i} \quad [\text{ farad/m = (V-s)(amp-m) }] \tag{17}$$

as

$$\frac{L_L i}{\phi_L} = 1 \quad [\text{ dimensionless }] \tag{18}$$

Notice that both of the equations, when set equal to 1, are dimensionless. Any equation set to a dimensionless 1 can be equated with its inverse, which, as can be seen on rearrangement, is algebraically equivalent to squaring it. This is a special case of the general rule that any equation set to 1 can be equated with any other equation set to 1, *or its inverse*, as long as the 1 in both is dimensionless. I will use this mathematical fact to find both The Forbidden Equation in i and then its companion in V from the same starting equations:

Equate the dimensionless line capacitance, Equ (16), with the inverse of the dimensionless line inductance, Equ (18):

$$\frac{C_L V}{q_L} = \frac{\phi_L}{L_L i} \quad [\text{ dimensionless }] \tag{19}$$

Set this equation to 1:

$$L_L C_L \frac{i}{q_L}\frac{V}{\phi_L} = 1 \quad [\text{ dimensionless }] \tag{20}$$

Since it is well known that

$$L_L C_L = \frac{1}{c^2} \quad [\text{ henry-farad}/m^2 = s^2/m^2 \text{ }] \tag{21}$$

we can see immediately that

$$\frac{i}{q_L}\frac{V}{\phi_L} = c^2 \tag{22}$$

Again equate the dimensionless line capacitance, Equ (16), with the dimensionless line inductance, Equ (18), this time without inverting the latter:

$$\frac{C_L V}{q_L} = \frac{L_L i}{\phi_L} \quad [\text{ dimensionless }] \tag{23}$$

Set this equation to 1:

$$\frac{V}{i}\frac{\phi_L}{q_L}\frac{C_L}{L_L} = 1 \quad [\text{ dimensionless }] \tag{24}$$

Since it is well known that the electric transmission circuit line impedance can be expressed as

$$Z = \frac{V}{i} = \sqrt{\frac{L_L}{C_L}} \quad [\text{ohm}] \tag{25}$$

or, after squaring and inverting as

$$\frac{1}{Z^2} = \frac{C_L}{L_L} \tag{26}$$

we can see from substituting these two expressions for impedance into Equ (24) that

$$Z = \frac{\phi_L}{q_L} \tag{27}$$

which may be another Forbidden Equation. Equate Equ (27) with Equ (25) as

$$Z = \frac{V}{i} = \frac{\phi_L}{q_L} \tag{28}$$

and solve for V:

$$V = \frac{i\phi_L}{q_L} \tag{29}$$

Substitute Equ (29) for V into Equ (22):

$$\frac{i}{q_L}\frac{V}{\phi_L} = \frac{i}{q_L}\frac{1}{\phi_L}\frac{i\phi_L}{q_L} = c^2 \tag{30}$$

Collect or cancel like terms:

$$\frac{i^2}{q_L^2} = c^2 \tag{31}$$

Take the square root of Equ (31) and rearrange to yield

The Forbidden Equation

$$i = cq_L \equiv cq \tag{32}$$

To find the companion to The Forbidden Equation, solve Equ (28) for i:

$$i = V\frac{q_L}{\phi_L} \tag{33}$$

As before with Equ (30), substitute Equ (33) for i into Equ (22):

$$c^2 = \frac{i}{q_L}\frac{V}{\phi_L} = V\frac{q_L}{\phi_L}\frac{1}{q_L}\frac{V}{\phi_L} = \frac{V^2}{\phi_L^2} = c^2 \tag{34}$$

Take the square root of Equ (34) and rearrange to discover

The Companion Forbidden Equation

$$V = \phi_L c \tag{35}$$

This equation can be interpreted as saying that whatever it is that is associated with the 'voltage' concept moves at the speed of light just as $i = q_L c$ does for electric current. The quantity ϕ_L, the magnetic flux per unit length, is not usually used. Dimensionally it lies halfway between the magnetic flux and the magnetic-flux-areal-density. The objection could be raised that this is not a physical quantity, which I would agree with and extend to include i and most of the rest. The speed of light, c, and the geometric form factor, f, come the closest to describing reality, the rest are at least one more step removed. Electric current itself, i, cannot exist as a circulating fluid. It fails to satisfy continuity among several other problems.

3. $i = qc$: A Continuity Equation

The continuity equation is a staple of physics and engineering. It mathematically expresses the idea that all of the material in a given flow- a "current"- has to be accounted for at all times and places along that flow. Material cannot simply appear and disappear without any accounting.

This equation applies to the water in a river, to the fluid flow in a pipe, to the stream-tubes in aeronautics, and of course to electric current in a wire. Kirchhoff's 1st law as used by electricians, "what goes in must come out", is a special case of the continuity equation applied to junctions for an incompressible flow and without sources or sinks.

A continuity equation can have only one velocity at any given point in the flow. This follows from the idea that a particle can only be moving in one direction at a time, and can only move at one speed at a time. In the general continuity equation,

$$\textbf{current} = \rho u A$$

where ρ is the fluid density, u is the speed of the fluid through the area, and A is the area of the transverse cross-section that the fluid is flowing through. For electric current, A would presumably be the cross-sectional area of the wire that is said to carry it and contain it within, like a pipe. For the usual case of the wires in a two-wire electric circuit the cross-sectional area, A, of the wires is constant.

There are three major types of density, often confused or not made clear in the literature: the linear-density, the areal-density, and the volume-density (line, area, volume). All three are used in various expositions on continuity. The equations above only use the linear-density of charge. q_L. "Current density", J, is actually an areal density: so many charges passing through an area per unit time. ρ as used in the generic continuity equation is a volume density.

One common definition of electric current, in words, is "electric charges moving past a point along a wire". This is a reduced form of the continuity equation, as density ρ and area A are missing. It's written in differential form, with i the electric current, Q an arbitrary amount of electric charge, and t is time, as

$$i = \frac{\delta Q}{\delta t} \qquad [\text{ ampere }] \tag{36}$$

which Miles Mathis [13] has shown does not add any more information than is already present in the algebraic form as

$$i = \frac{Q}{t} \tag{37}$$

This equation, $i = Q/t$, is behind the definition of the ampere, or, in MKSA dimensions, solving it for Q forms the definition of electric charge in coulombs. Notice there is no sign of a velocity or an area in this equation. It's as if an aircraft designer had to design a wing knowing only how many air molecules pass by it each second.

There are two more "hidden" dimensions in $i = Q/t$ for the speed ratio- [length/time] or [m/s]. Written out in full, the dimensions are [(coul/m)*(m/s) = (coul-m)/(m-s)]. The two lengths look like they cancel, but they don't, not really. One refers to the length of the charged object and the other is tied up as part of the speed the object is moving at. For the "moving i", with the linear-charge-density q_L or Q/L,

$$i = \frac{Q}{t} = \frac{Q}{L}\frac{L}{t} = q_L * \frac{L}{t} = q_L u \tag{38}$$

With this in mind we can unpack q_L and write out an explicit continuity equation for electric current, $i = \rho_Q u A$, with ρ_Q the volume-density of electric charge, u the speed of the charged particles, and A the cross section area of the wire.

The volume, Vol, is area * length, or $Vol = AL$. The volume density, ρ_Q, is

$$\rho_Q = \frac{Q}{Vol} = \frac{Q}{AL} \tag{39}$$

Rearrange this as

$$q_L = \frac{Q}{L} = \rho_Q A \tag{40}$$

Then to the full continuity equation:

$$i = \frac{Q}{t} = \frac{Q}{L}\frac{L}{t} = q_L(\frac{L}{t}) = q_L u = \rho_Q u A \tag{41}$$

The Forbidden Equation is a continuity equation with c for the speed of the current. **A current can only have one speed.** Either

$$i = q_L c \quad \text{or} \quad i = Q_{Drift} u \tag{42}$$

with $Q_{Drift} > q_L$ and $u < c$, but not both at the same time, anymore than the water in a pipe can run at two different speeds with two different densities all at the same time and place.

The definition of the coulomb in terms of the ampere also has this hidden-variable problem. From Equ (38), with t = 1 second [s], Q = one coulomb [coul], and i = one ampere [A],

$$Q = it = A - s = \frac{A(D)}{c} \quad \text{with} \quad D = ct \tag{43}$$

The linear-density q_L, Q/L, or charge per length, is a slippery variable. There is no way to tell if it means a positive charge or a negative charge just by looking at it by itself, or even when it is in an equation. As the electron-current goes around the circuit, Q has to change signs. Actually, this has to happen within the LOAD in Figure 2. But it can't change sign without running into the problems highlighted by the Palmer Equations.

4. $i = qc$: The Palmer Equations

To distinguish this paper from others of a similar title, and not knowing the author's name nor realizing that CWPP are his initials, we began to call his six-page, handwritten treatise "The Clarendon Letter" [4], even though the author had titled it "The Catt Question". It begins in a grand fashion:

"*Dear Mr Catt*

"*I'm concerned- indeed appalled- that your question has waited for so long for an answer, and apparently caused so much controversy. It seems to me a very straightforward question which can be answered with reference to equations whose validity is unquestioned, and thus in a way which should command universal assent*".

The first three pages are devoted to debunking the "Southerner" theory of where the electrons come from in The Catt Question setup, that they rise up from within the wire. This had been promoted by Sir Michael Pepper of The Cavendish (Cambridge) and is of no further technical interest here.

There are two instances of The Forbidden Equation in The Clarendon Letter, one for each of the two wires. Palmer constructs these equations as part of a model, rather than derive them from basic mainstream equations as I did above. With q and q' the net line charges on the upper (signal) and lower (return) wires respectively, e the electron charge, and a the atomic spacing between the stationary charges (assuming one free electron per atom in a regular, 1D lattice, like a row of dots), Palmer states:

"*where v and v′ are the drift velocities on the two lines. Similarly the net current on the two lines (from this particular line of charges) is*

$$i = 0 + \frac{(-e)(-v)}{a(1+\frac{v}{c})} = \frac{ev}{a(1+\frac{v}{c})} = cq \tag{44}$$

"*for the signal line and*

$$i = 0 + \frac{(-e)(v')}{a(1-\frac{v'}{c})} = \frac{-ev'}{a(1-\frac{v'}{c})} = cq' \tag{45}$$

"*on the return line. The drift velocity must be such that at each point on the surface of each conductor the surface current has the correct value determined by the equations above...*"

Palmer does not explain where the cq terms come from; he did not respond to my asking. Since $i = i$ and $c = c$, we can see at once that $q = q'$. Changing the sign of q' in the second equation won't solve the problem, either. As shown by considerations of continuity and voltage across the two wires, q has to simultaneously be of both signs, which is physically impossible. q' has to equal $-q$ in order to satisfy the requirement of net-negative charge on the lower wire and net-positive charge on the upper wire, while at the same time q' has to equal $+q$ to satisfy continuity. The moving charges are thinned out on the upper wire, $q < \frac{e}{a}$, and they are bunched up on the lower wire, $q' > \frac{e}{a}$. Mathematically,

$$\frac{e}{a} > -q' = q = q' > \frac{e}{a} \tag{46}$$

This equation has no solution. That suffices to falsify the model.

There is some confusion on the point of which directions the v's are having the current going. The confusion stems from the ambiguity of the negative sign for v. If this v, and also the v', are speeds, they both have to be non-negative numbers. Actually, both have to equal zero to satisfy the Palmer Equations. Either an object is moving or it is sitting still; it can't 'move negatively' for the same reason there is no such thing as negative degrees Kelvin. This negative-speed error is commonly made in areas outside of kinetic theory. The Drude/Fermi electron-gas model comes from kinetic theory, and the model that Palmer and the other Westerners are using is a simplified version of it.

Many times the confusion between speed and velocity works out in the end- the errors cancel- but here is an example of what can go wrong. There is already another quantity, electric charge, that is using negative numbers- but a negative charge cannot cancel a negative speed anymore than a negative orange can cancel a negative apple to produce a positive orange-apple.

If v is a velocity it would have to be in something like vector notation so as not to conflate its direction in space with the sign of the charges it is assigned to, which occurs as a result of treating it as a scalar. In his diagram

we can clearly see that the electrons on the upper wire are moving to the left (Westward) in a standard coordinate system, and the one on the lower wire move to the right (Eastward), but that directionality doesn't carry over to a scalar speed, v. Pieraccini & Selleri [6] below make the same speed-is-not-velocity mistake as Palmer.

Since $i = i$ we can equate the terms of these two equations in v and v':

$$\frac{v}{(1+\frac{v}{c})} = \frac{-v'}{(1-\frac{v'}{c})} \tag{47}$$

with v' some speed less than the speed of light. Let $v' = Sc$, where $0 \leq S \leq 1$. Then

$$\frac{v}{(1+\frac{v}{c})} = \frac{-Sc}{(1-S)} \tag{48}$$

which can be rearranged as

$$v - Sv = -Sc - Sv \tag{49}$$

cancelling, we find that

$$v = -Sc = -v' \tag{50}$$

This shows that the two different Palmer Equations are in fact the same equation written twice, with $v = -v'$ and $q = q'$. When applied all around the circuit, this equation has only one consistent solution: $v = 0$, $q = 0$, and $i = cq = 0$.

There is an implication in these equations for the drift speeds v and v', and indeed in all of the mainstream theory of electric current, that a line of negative charges moving Westward is physically the same as a line of positive charges moving Eastward. It's even worse, because the positive charges aren't moving at all; they are the protons of the fixed atoms. At least the old two-fluids idea (one invisible positive humor, one negative humor, each moving opposite directions) might have saved that part of the theory of electric current.

4.1. Electric Disconnection

In all of the many published responses to The Catt Question [14], not one of them has addressed the problems that arise when the charge carriers move from the lower wire, run through the load, and begin the trip back to the source on the upper wire. They have to thin out somehow, either by speeding up as they pass though the load, switching their signs, or something. The electrons would have to accelerate as they pass through, and presumably deliver power to, the load.

The compressed electrons on the ground wire would have to keep moving Eastwards even after a switch on it was opened back up; compressed air would not do that. After a switch is opened on the signal wire, the speedier, yet rarefied electrons that were moving Westward would have to stop and pile up, starting at the open switch and propagating as a density wave Eastward. The number of problems that people have been noticing with the electric-current picture has been increasing exponentially over the past few years, too many to keep track of.

No one has shown any mechanism by which the Eastward-moving TEM wave can generated a Westward force on the returning charge carriers either.

No one has shown how the electric field lines of the TEM wave, moving at the speed of light, are supposed to disconnect from one stationary or slowly-drifting charge carrier and reconnect to another one further down the line. This would violate Gauss' Law ($\nabla \cdot E = \rho$) in the process as the disconnected electric field lines momentarily dangle around somehow in space. The fallacy is quite like the problem of Magnetic Reconnection, in which it is claimed that magnetic field lines can disconnect and reconnect. That would create temporary magnetic monopoles, violating $\nabla \cdot B = 0$.

How are the speed-of-light field-lines handed off from one slowly-drifting electron to the next? How can the other side of the speed-of-light electric field hop from one stationary positive proton to the next?

5. $i = qc$: The Pieraccini-Selleri Equations

The next Academic sighting of The Forbidden Equation was in 2013, and again in a published response to The Catt Question. [6] This time the equation was a bit more disguised, broken into pieces. The Italian electrical engineers, like Palmer, attempted to join $i = qc$ up with their version of an equation for electron drift current, committing several grave errors in the process.

Many times when someone attempts to answer The Catt Question they end up (re)inventing a new model, or even a new theory. This is such a case as is both Palmer and Gardner. They have to make things up as they go because *there is no literature*, anymore than there is for The Forbidden Equation.

Pieraccini and his co-author Selleri had previously published yet another version of a response to The Catt Question in an IEEE magazine but did not publish The Forbidden Equation in it. That article was a MEMO, invited by an IEEE Associate Editor:

I read a novel, L'anomalia [16]*... authored by a colleague of mine, Massimiliano Pieraccini (University of Florence). The book... deals with a [scientist's] murder... Shortly before, he had declared that he was dealing with the Catt's electromagnetic "anomaly."...*"

Since the "anomaly" deals with fundamental electromagnetics, and since Catt is that kind of unconventional researcher, moving outside of academia and structured research, which was indeed quite common in the past- especially in the 18th and 19th centuries ..." [15]

In the IEEE article [17], the Italian's unconventional version of electromagnetic "Theory N+H" would have-

"*Moving charges do generate a field that interacts with charges down the transmission line at a speed c, even if the charges them selves move much slower. It is not a matter of moving charges generating a TEM wave, or a TEM wave moving the charges. Instead, it is a continuous back and forth, from moving charges to TEM wave to new moving charges, and again to TEM wave, and so on.* [17]

This is reminiscent of Feynman's "Dancing, Swishing Wave" [1], [9]-

"*a varying E field gives rise to a varying B field, which in turn gives rise to a varying E field, and so on. In this way the electric and magnetic fields of the wave sustain one another through empty space... by a perpetual interplay- by the swishing back and forth from one field to the other- they must go on forever... They maintain themselves in a kind of dance- one making the other, the second making the first- propagating onward through space...*"

Feynman does admit later, "*I'll tell you what I see. I see some kind of vague, shadowy, wiggling lines- When I talk about the fields swishing through space,* **I have a terrible confusion** *between the symbols I use to describe the objects and the objects themselves...*"

Combining Feynman's "*...and so on. In this way the electric and magnetic fields of the wave sustain one another... by... swishing back and forth from one field to the other... in a kind of dance*" with Pieraccini & Selleri's "*continuous back and forth, from moving charges to TEM wave to new moving charges, and again to TEM wave, and so on...* does not reduce the terrible confusion or address electric disconnection. Which swishes first, and so on?

In both the IEEE and the IOP articles they say that "*A possible analogy is the start of a marathon: the referee shoots the starting gun, the sound of the bang propagates in air, and each athlete begins to run when they hear it.*", which contradicts the "continuous back and forth" idea. If each of the runners heard the starting gun, began to accelerate up to running speed, and shouted out to the next runner down the line *as they were accelerating*, the analogy would be more accurate. This of course would introduce a time delay from one electron/runner to the next, dropping the TEM wave speed far below c. But the starting gun was already an independent, propagating TEM wave, so why would it even need to be heard by the runners in the first instance? What are the runners adding to the picture besides just getting in the way?

In the *IOP Physics Education* article [6], the authors introduce a figure with "*...two thin wires of radius a are sketched and the* [TEM] *wave is shown as it travels through a sampling cylindrical volume of [length]* Δx.

The [TEM] *wave travels at the speed of light, c, from point x to point* $x+\Delta x$ *in the time interval* $\Delta t = \Delta x/c$. *During this time a current I flows in the sampling volume from its left side at x, equalling*

$$I = \pi a^2 veN \tag{51}$$

"*where v is the drift velocity of the charges (in practice electrons, and the speed is much lower than the speed of light),* [e is the elementary charge] *charge (*$1.602 * 10^{-19}C$*) and N is the concentration of free electrons in the metal (for copper it is* $8.4830 \times 10^{28} m^{-3}$"

This is their first equation, their Equ (1), a continuity equation. (I changed their elementary electron charge q to the more commonly used e. N, the "concentration", is the particle volume-density. $eN = \rho_q$ of continuity Equ (41) above.)

With this equation, the authors would have the entire mass of free electrons in a volume, $\pi a^2 \Delta x$, squeeze over into a new volume of the same size in Δt and beginning at $x+\Delta x$. The new mass of electrons is riding in right on top of the same mass and density of free electrons that is already present in the wire, ahead of the TEM wave. This results in a free-electron density of $2N$, an extraordinary claim. The new volume already has the same neutral,"at rest" density, so this process would double its free electron density in a compression process that would probably produce energy densities comparable to a nuclear bomb core. The existing electrons in the new volume can't get out of the way by moving forward, either.

They would like to have v be the drift "velocity" (speed, actually, as Crothers [18] also points out) by their simple declaration, but this mass of electrons cannot satisfy that desire without moving at the speed of light for at least some portion of the journey- in jumping over to collide with the next electron, for example. That would also require either an infinite acceleration and deceleration of an ensemble of massive objects, or at least a speed in excess of superluminal for at least part of that journey. In either case, the mass of each electron would go to infinity in this microscopic version of The Catt Question.

By their equation below together with my equations above, this "unbalanced" (their word) mass and charge of electrons, $\pi a^2 \Delta x eN$, is emanating an electric field that is many orders of magnitude too strong to account for the voltage between the two wires. On the upper wire,

the charged-particle density would have to be an equal and opposite N, which can only be accomplished by *removing all of the free electrons from the copper wire*. Continuing with this,

"*This incoming current lasts for a time interval Δt and produces in the wire length Δx an imbalance of charge ΔQ given by*

$$\Delta Q = I\Delta t = I\frac{\Delta x}{c} \tag{52}$$

This "imbalance of charge" is presumably the same net linear line charge per unit length , my q or q_L, described above. Dividing their second equation through by Δx yields

$$\frac{\Delta Q}{\Delta x} = I\frac{\Delta t}{\Delta x} = I\frac{1}{c} \tag{53}$$

Rearrange, with $q \equiv q_L \equiv \Delta Q/\Delta x$, and behold

The Forbidden Equation

$$I = \frac{\Delta Q}{\Delta x}c = q_L c \tag{54}$$

Their eN is the volume density of charge, ρ_Q in Equ (40) above, $eN = \rho_Q$. Their πa^2 is the area A of the wire cross section introduced in Equ (39) above. With those substitutions, and using my Equ (41) and their Equ (2), their Equ (1) reads

$$I = \pi a^2 veN = Av\rho_Q = q_L v = q_L c \tag{55}$$

or $v = c$. The drift velocity is the speed of light.

They then go on to construct a third equation and to discuss the electric field associated with q_l, conflating a longitudinal field with the transverse electric field, by using an un-sub-scripted, un-bolded letter "E" to ambiguously refer to both in two different equations, as Crothers also points out. [18] By this sleight-of-variables the speed $v = c$ from their first two equations is transformed into a much slowed drift speed, orders of magnitude lower. The same v becomes two wildly-different speeds.

Crothers also notes a basic algebra error in their skin-effect derivation- the addition of a superfluous "2" as well as a confusion between velocity and speed, similar to Palmer's. In this same *IOP Physics Education* article, both their Figure 1. and Figure 2., showing the setup for The Catt Question, have the Gaussian analytic volume on the upper wire while in their text they claim to educate the reader as to conditions on the lower wire.

This construction fails for several reasons, not the least of which is that each of the particles in a current can only move at one speed at a time. Attempts by Catt, Ricker, Crothers, myself, and others to correct the sundry libels and errors made by the Italians by publishing letters in these same journals were rebuked, though this may change. [7]

6. $i = qc$: The Gardner Equation

Gardner states [3] that The Forbidden Equation is "Mr. Bishop's... new discovery about physics". He is quite mistaken- this is a mainstream equation, not "Mr. Bishop's", nor is it a new discovery. It is Maxwell's Equation. It is inseparably contained within the other mainstream equations. It is William A. Gardner's Equation.

An astonishing and historic set of email exchanges between Gardner and myself took place in late 2015, in what became a scientific case study. Not only are some of the alleged authorities unfamiliar with a fundamental equation ($i = qc$) in their own field, they can't even derive it after being given many clues. That last point is absolutely new to me, and can be used in future applications. Along with his sundry libels against me, Gardner was responding to my initial questions, in particular:

- Have you ever seen the equation $i = qc$?
- Can you derive $i = qc$?

A few of the many findings. William A. Gardner (WG):

- Stated that he had never seen i = qc before;
- Consistently failed to state that this is a mainstream equation;
- Failed to note that the lossless condition is a prerequisite for deriving Maxwell's Equations;
- Was not able to derive $i = qc$ even after coaching;
- Once he was shown a derivation of $i = qc$, he still could not understand its significance;
- Did not reprint or critique the actual derivation of $i = qc$, but only mentions it as "a few lines of algebra";
- Thought I was the author of The Clarendon Letter and critiqued that, though missed the analysis shown above;
- Created a novel, though easily falsified, theory of electromagnetism in the process of responding to The Catt Question (this is common);

- Brought up "frequency" several times in regards to The Catt Question and The Forbidden Equation (this is a common diversion from the DC setup, Pieraccini also does it in [6]);
- Padded out both the exchange and the essay with repetitive and irrelevant material, i.e noise (this is common);
- implied that vacuum and zero-resistance conductors are "non-physical", "lossless" situations (both are well-known experimental facts);
- Stated that lumped elements can be used but $i = qc$ can not ("lumps" are unreal, non-physical entities of no dimension)

The last two items listed are a remarkable inversion of the physical and the non-physical. Gardner uses the word "lossless" 13 times in his 7000 word essay, apparently without ever realizing that the lossless condition is used to develop all of Maxwell's Equations, along with the Lorentz force law. This can be seen by simple inspection: there are no resistivity terms, no *R* or *G* for resistance, or anything of the sort in any of those equations, nor in any of the standard equations used here to derive $i = qc$. This of course is standard practice in deriving or constructing any physical equation, to treat the ideal case first.

The "lumped element", on the other hand, is a purely mathematical fabrication, used for rule-of-thumb engineering work. It has no basis in reality. How big is a lump? Bigger than a breadbox? What is the coefficient of lumposity? This "Lumped Element Gambit" is also common, J. D. Jackson uses it as well. [10]

"*It should be clear that the Catt question about the fundamentals of electromagnetism in connection with transmission lines...*" -WG

A transmission line is physically the same thing as an electric circuit. What applies to the one applies to the other, without exception. There is no mention of transmission lines in The Catt Question. [5]

"*[The Catt Question] should not be addressed using non-physical models such as a lossless transmission line or a vacuous propagation medium...*" -WG

Maxwell's Equations are written for perfect conductors in a "vacuous propagation medium", i.e. a vacuum. They are "lossless" equations. If no Forbidden Equation then no Maxwell's Equations.

"*the so-called "forbidden equation" $i = qc$ introduced by a follower of Catt, Mr. Forrest Bishop, should actually be forbidden from use in any scientific studies of the fundamentals of electromagnetism because it is valid only for models of transmission lines that are non-physical (lossless) or, more generally, lines in which the drift speed of free electrons in the conductors equals or exceeds the propagation speed of the EM wave in the dielectric...*" -WG

"*In contrast, $i = qc$ is unlikely to ever be a useful approximation because there is unlikely to be any physically viable conditions under which the drift speed S in a physical conductor is almost as fast as the propagation speed c in a physical dielectric surrounding that conductor...*" -WG

The alleged drift speed is irrelevant. $i = qc$ refers to properties of the external TEM wave and the dielectric it is travelling through. This is easily seen by looking at what all of the equations above are in reference to. The Forbidden Equation, and the other equations it is related to, make no reference at all to the material properties of the wires, how many free electrons are available, the resistivity, or the purported drift speed, only to the cross-section geometry. $i = qc$ directly links the purported electric current with the dielectric material, not the wire material.

Gardner inadvertently highlighted an interesting point about the wire resistance. Adding resistance in to The Catt Question makes the problem worse, not better. As the TEM step moves Eastward, the transverse voltage decreases due to resistive loss. The top of the step slopes down to the East, instead of being horizontal, so the very front of the wave has a lower height, a lower voltage, the further East it goes. The line charge, q_L, that comprises the electric drift current and terminates the transverse voltage, would have to diminish, from the original density launched from the source, to a lesser value, $q_L - q_{loss}$. **Where do these now-excessive q_{loss} electrons go?**

"*this brief investigation of the Catt question is the necessity of understanding how to bring physics and mathematical models of physics (and their analysis) together in a meaningful way that does not allow mathematics to dictate non-physical "physics". Mathematics is an essential tool in science, but one that can easily be and is commonly misused- presumably unconsciously.*" -WG

Presumably, and charitably, Gardner is unconsciously in error in his mis-characterization of how Maxwell's Equations and the equations used above were developed.

"*When he finally revealed his derivation (a few lines of algebra), it became clear that it is valid for only the non-physical uniform lossless transmission line with speed of propagation c. This mathematical result based on a non-physical model, is actually of no physical significance (and has no bearing on the Catt question)...*" -WG

Gardner did not address the "few lines of algebra" nor demonstrate any understanding of it. $i = qc$ is not about The Catt Question in the first place, nor did I ever state that it was. If Mr. Gardner's Forbidden Equation is of no physical significance then so are all of the other equations that rely on it. A lossy electric circuit does

not alter the fact that $i = cq$, with c understood as the propagation speed in the dielectric medium, vacuum or not. R and G attenuate the TEM wave, but they ideally do not alter its speed, and certainly not in the lossless Maxwell's Equations.

7. $i = qc$: A Gallery of Forbidden Equations

These are also Forbidden Equations of various degrees, with few, if any, sightings in the relevant mainstream literature. Some are very rarely seen but not quite as Forbidden, others are never found together on the same page. The geometric factor, f, is found in at least one old engineering book as well as in Catt; it may or may not be more common in newer books. The photon equations are my own discovery.

Most physics books use Z_o for the vacuum wave impedance and Z for characteristic and other impedances as used herein, the reverse of electrical engineering practice. λ, instead of q or q_L, is usually used for the line charge density in physics books, but only in the Electrostatics section. It disappears from the Maxwell's Equations section, then sometimes reappears in Relativity.

Wave impedance of the vacuum, AND the speed of light, never put together on the same page in a physics book, both in permittivity and permeability:

$$Z_o = \sqrt{\frac{\mu_o}{\varepsilon_o}} \quad \textbf{WITH} \quad c_o = 1/\sqrt{\mu_o \varepsilon_o} \tag{56}$$

With the above two equations in front of you on the same page you may deduce that:

Electric permittivity constant of the vacuum, in wave impedance, Z_o, and c [farad/meter]:

$$\varepsilon_o = \frac{1}{Z_o c_o} \tag{57}$$

Magnetic permeability constant of the vacuum, in wave impedance and c [henry/meter]

$$\mu_o = \frac{Z_o}{c_o} \tag{58}$$

Characteristic (surge) impedance of electric transmission line in magnetic flux/length and line charge [ohm]:

$$Z = f\sqrt{\frac{\mu_o}{\varepsilon_o}} = \frac{\phi_L}{q_L} \tag{59}$$

Geometric factor in the plane of impedance of an electric circuit line [dimensionless]

$$f = f(a,b,r,) \tag{60}$$

Vacuum capacitance per unit length of transmission circuit line, in Z_o, and c [farad/meter]:

$$C_L = \frac{\varepsilon_o}{f} = \frac{1}{Z c_o} \tag{61}$$

Vacuum inductance per unit length of electric transmission circuit, in Z_o, and c [henry/meter]:

$$L_L = f\mu_o = \frac{Z}{c_o} \tag{62}$$

Voltage in magnetic flux/length and c [volt]:

$$V = \phi_L c_o \tag{63}$$

Electric current in charge/length and c [ampere]:

$$i = q c_o \tag{64}$$

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8. $i = qc$: THE MEMO

The Catt Question has been around for about 35 years, still in circulation, still not widely known, still diagnosing. The 'newer' Forbidden Equation is not a question, but an irrefutable assertion about conventional theory. It cannot be denied or waffled around. A child can stump a Noble Laureate with it, who will not have heard of it or received the memo. Therefore, it can be used over and over again in many venues:

- Have you ever seen the equation $i = qc$?
- Can you derive $i = qc$?

There are many different theories of electricity & magnetism both within and without academia. These can be grouped, after Catt, into three broad categories:

Theory N(ormal): Electric current creates electric and magnetic fields.

Theory H(eaviside): "We reverse this": electromagnetic fields create electric current.

Theory C(att): When a battery lights a lamp, electric current is not involved.

The mainstream Theory N comes in many different flavors and has several different schisms within it, not the least of which is the division between ***electric circuit*** and ***transmission line***, a division that runs so deep it is reflected in the very layout of university campus architecture.

Theory N, Version 1, Dept. of Electrical Engineering: The lines are charged. (Westerners) This is needed to explain transmission line theory as well as the voltage between the wires of an electric circuit, a topic gone missing from Griffiths [8], Jackson [10], and others of that genre.

Theory N, Version 2, Dept of Physics: The lines are neutral. (Southerners) This is needed in order to derive Maxwell's Equations, Ampere's laws in particular. Griffiths [8] explains, p196, 202, 226.

Palmer, the Italians, and after awhile even Gardner, are what I call "Second Wave" responders to the Catt Question. They are using Theory H without acknowledging it, perhaps without even realizing it. The First Wave responders (Pepper, Josephson, etc.) were all attempting to answer it using two different versions of Theory N (conventional theory).

Over the past 35 years, The Catt Question itself has helped move the "Overton Window" of physics, i.e. the permissible range of discourse. Theory H had been suppressed over the past century. But the Question already builds in, or "frames", the problem in terms of either Theory H or Theory N, V1, by using the TEM wave and negative charge on the line in its setup. The First Wave responders, especially the Southerners, were attempting to dodge that; the Second Wave Responders have accepted it and even use the "TEM wave" terminology, which had also disappeared from the literature.

Conspiracy Theory. The Second Wave responders did not "receive the memo" instructing them to avoid admitting to the existence of Catt and his Question. THERE WAS NO WAY TO SEND THE MEMO. If a memo had been sent out overtly to all Depts., posted in the halls, etc. it would have drawn attention to Catt, not suppressed him. Instead, they are looking at the First Wave responses and re-framing in terms of Theory H. As there is no literature on this, the very first question about electricity, they have to individually make up a new theory each time. This is why Palmer has to open his treatise with:

"*I'm concerned- indeed appalled- that your question has waited for so long for an answer, and apparently caused so much controversy. It seems to me a very straightforward question...*"

Pieraccini had come up with a different way of getting THE MEMO out with his 2011 murder mystery, *L'Anomalia* [16], published two years before the paper cited above. He spent five years writing this book, but then ended up publishing The Forbidden Equation after all. A revealing excerpt-

'So what are you working on now?' Massimo asked Alexander [Kaposka]...

'On the Catt anomaly' replied Alexander seriously.

'Are you kidding?' 'Nobody with an ounce of common sense would risk their career and scientific reputation to study the Catt anomaly [an earlier name for The Catt Question.] *Massimo thought, 'and even if they were spending time on this, they wouldn't be telling people about it'.*

The characters were attending a scientific conference. Later on, in the hotel room right next to Massimo's (this character is an obvious projection of the author), Massimo Redi (Francesco Redi, Arezzo) and his sidekick Fabio Moebius (the same/other side of the author) discover the lifeless body of Alexander Kaposka. But Kaposka wasn't killed by Massimo Redi: Massimiliano of Arezzo did it. Mystery solved, with a projected Mobius twist:

"*The teacher can begin the lesson by capturing the attention of the students with the 'dramatic' story of the conflict between an unconventional man (Catt) and academia. Afterwards, the teacher presents an intriguing (apparent) paradox. Finally, the teacher gives the solution as a sort of twist. This 'narrative structure' could be a valuable way to maintain high attention and interest of students during class.*" -M. Pieraccini, [2013], *IOP Physics Education* [6]

"*Just the idea of twisting a scientific fact for narrative purposes makes me shudder. After all, my reputation would be at stake. And academia does not take these matters lightly. I am absolutely not going to end up like Catt... or like Kaposka!*"- Massimiliano Pieraccini blog, May 24, 2011 [19] (translated from Italian.)

9. $i = qc$: Requiem

The Forbidden Equation reveals another deep problem within The Narrative of academic physics, one which reaches back at least two centuries. It isn't just a falsification of the electric current hypothesis; there is also an insurmountable problem with the definition of electric charge and capacity. In all of the above I and the others used or implied the equation of capacitance, $C = Q/V$.

But the Q in $C = Q/V$ has to be two different things at the same time: now it is the charge on one of the plates, and now it is the opposite charge on the other plate. This is merely one of the many problems with the notion that "math is the language of science".

One single variable, Q, is used to refer to two different quantities, with two different meanings, two faces. That duplicity flows throughout all of the current theories of electricity, only to circle back around and mathematically wreck the theory of electric current itself. That is the purpose of this exposition. In order to build a new house with new pieces, the old one must be razed.

The academic men described above do not have very many of the replacement pieces, but the discernible shift toward Theory H over the past ten years has given them a few. The ones with an unshakable belief in the Medieval poltergeist called electric current will remain embalmed in the 18th and 19th centuries, in the ivory-towered mausoleums where Pelosi's "unconventional researcher[s] moving outside of academia" interred them. They are not to be disturbed.

Industry bypassed academia a long time ago. Catt-like ideas are already being used in proprietary technology, here and there, in fits and starts. A lot more people know of these things- and of Catt- than are letting on: they have a different kind of problem with the memos. No one yet has all the pieces- we can tell by looking at what they produce and also, tellingly, what they do not produce. A qualitatively different kind of electric technology is slowly emerging, driven by these new ideas, almost indistinguishable from magic.

10. $i = qc$: Addendum

An astonishing find was provided by Christopher Spargo in [20], pp 272-3. Morgenthaler has both a variant of The Forbidden Equation and the "Southerner" reply to The Catt Question together in the same section. He writes $J = \rho c$, and calls this the 'relativistic, convective current density'. Dividing through by the wire area, A, yields The Forbidden Equation.

Morgenthaler states that "*Mobile negative charge which is neutralized by the fixed positive charge of the lattice simply moves very slightly toward or away from the surface of the conductor as the electric field of the TEM pulse moves by. This creates the surface charges that are needed in order to originate and terminate the electric field.*"

In rebuttal, if the negative charges are already neutralizing the positive charges, then they are not available to terminate external TEM-pulse field lines. Shifting them around a bit doesn't change that. This is a very basic violation of Gauss' Law.

Secondly, the electrons have mass and so there would be a delay time as these particles accelerate and decelerate to shift into different positions. They can't have information available about the approaching transverse electric force of the TEM pulse because it is moving at the speed of light. It would already be upon them before they could move.

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