Westerner Howie, Head of the Cavendish. Also, Josephson.
http://www.ivorcatt.co.uk/howie2.pdf
cf Southerners Pepper, Lago, Morgenthaler.

CAVENDISH LABORATORY
MADINGLEY ROAD
CAMBRIDGE CB3 0HE

From: Professor M. Pepper, FRS

June 21, 1993

Ivor Catt, Esq
121 Westfields
St Albans
AL3 43R

Dear Mr Catt,

As a Trinity physicist the Master suggested that I might provide some comments on the questions you raised in your recent letter to him on aspects of electromagnetic theory.

If I understand the position correctly, your question concerns the source of the charge at a metal surface which by responding to the presence of the EM wave ensures that the reflectivity of the metal is virtually unity, hence providing waveguide action and related applications.

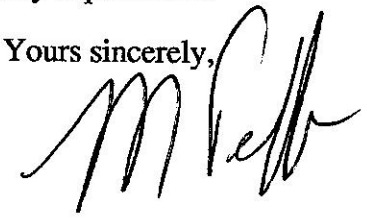
If I may restate the basis of your question, what is the maximum frequency of radiation which is reflected? It is this parameter rather than light velocity which is important. The solution lies in the maximum frequency of response of the electron gas, which is the plasmon frequency ω_p and is calculated in a straightforward way. If light frequency is greater than ω_p then the electron gas in the metal can no longer respond and the reflectivity tends to zero. The problem you are posing is that if the wave is guided by the metal then this implies that the charge resides on the metal surface. As the wave travels at light velocity, then charge supplied from outside the system would have to travel at light velocity as well, which is clearly impossible.

The answer is found by considering the nature of conduction in metals. Here we have a lattice of positively charged atoms surrounded by a sea of free electrons which can move in response to an electric field. This response can be very rapid and results in a polarisation of charge at the surface and through the metal. At frequencies greater than ω_p the electron gas cannot respond which is the reason for the transparency of metals to ultra-violet radiation. However for frequencies used in communications the electron gas can easily respond to the radiation and reflectivity is unity.

If a poor conductor is used instead of a metal, i.e. there are no freely conducting electrons, then there is no polarisation, and as you point out charge cannot enter the system, and there can be no surface field. Consequently reflection of the radiation will not occur at these low frequencies and there is no waveguide action.

I hope that these comments provide a satisfactory explanation.

Yours sincerely,



cc: Sir Michael Atiyah - Trinity College
Mr A Weir - Trinity College

Telephone: 0223 337330 Secretary: 0223 337482 Switchboard: 0223 337733 Fax: 0223 337271 Telex: 81292

UNIVERSITY OF CAMBRIDGE

DEPARTMENT OF PHYSICS

CAVENDISH LABORATORY
MADINGLEY ROAD
CAMBRIDGE CB3 0HE

From: Professor M. Pepper, FRS

August 23, 1993

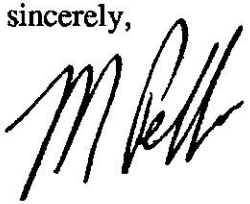
Raeto C West
58 Littleton Road
Ashford
Middlesex
TW15 1UQ

Dear Raeto West,

I write with reference to your letter of August 19. Your description of the process is correct; as a TEM wave advances so charge within the conductor is polarised and the disturbance propagates at right angles to the direction of propagation of the wave.

When the frequency of the wave is sufficiently high that the charge cannot respond then the solid behaves as an insulator and is essentially transparent to the wave. There is no anomaly concerning this behaviour, which is covered in the standard texts on solid state physics.

Yours sincerely,



UNIVERSITY OF CAMBRIDGE
DEPARTMENT OF PHYSICS

Telephone : 0223-66477
Telex 81292

CAVENDISH LABORATORY
MADINGLEY ROAD
CAMBRIDGE CB3 0HE

15th October 1983

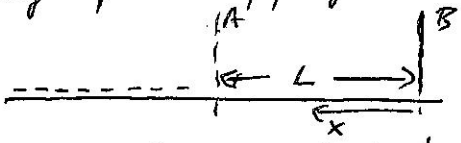
Dear Ivor,

Many thanks for your communication which I had been awaiting following Melvin's report on your phone conversation. Actually I had already seen some of it since Wireless World with its heretical letters section is taken by the Cavendish library!

It is interesting to see that the point of failure in electrodynamics which you identify now is rather more elementary than the ones we discussed previously when I recollect a kind of tar baby – bramble patch arrangement of interlocked problems! I feel a bit more confident with the electron theory of metals although I am far from sure that I can convince you that it can cope with your problem perfectly well.

To come swiftly and bluntly to the point, I believe that your apparent demolition job on Dawe, Robinson and Brown (culminating in the picturesque but spurious analogy of egg deliveries to Oxford) is quite invalid. I would be interested to know whether they actually conceded defeat i.e. error or later merely given up realising that there is no hope of convincing you.

Consider the flow of charge on to and along a length $L = cT$ of the wire which the step function TEM wave has just swept past in a time T. The enormous number of electrons already present in the wire N / unit length can build up the front charge density required simply by crowding a little closer together (shuffling to the right). If the charge per unit length required behind the step is q, then a charge qL must clearly flow past A in the time T but there is no need for any electron to travel from A to B in this time. In the time T electrons at distance x behind B move a distance $\Delta x = qx/Ne$ to the right. If you use some of the numbers quoted by Brown and Robinson in their somewhat different approach to the problem you will see that the velocities are quite small – the biggest value at $X = L$ being $qL/NeT = qc/Ne \ll c$. To pursue your dangerous egg sales analogy the egg salesman has previously dumped a large dump of eggs all along the road to Oxford from London and all over the Oxford area. A small movement of all the eggs towards Oxford suffices. We are not entitled to ask for labels on our electrons but in the way we could demand eggs which had been laid in London a few hours before.



The only possible problems that I can see with this simple picture are

(1) In very thin wires with large voltage (i.e. large electric field and hence large q) steps the ratio q/Ne might imply a velocity approaching v_{Fermi} – although this is still much less than c, it might modify the conductivity of the wire.

(2) The electrons cannot pick up their velocity instantaneously even though it is small.

Because of their finite mass there will be a finite acceleration time so that the sharpness of the step will be slightly blunted. This is a problem of acceleration however not of velocity and quite different to the one you raised.

I cannot see the point of my inducing prominent people in the field to take part in this. In the first place I really believe that you are making an error and that it is really a problem of communication to get the correct picture over to you — these people are not particularly good at that being in general not willing to spend the time on it. Secondly I am not sure how I can induce them to take part.

I was glad to hear that there have been recent developments with your computer ideas and hope they prosper. It is just as well that the pulses continue to propagate along or near the veins despite the apparently confused state of the theory!

Best wishes

Archie F.R.S

THE INSTITUTION
OF ELECTRICAL
ENGINEERS
Michael Faraday House, Six Hills Way,
Stevenage, Herts. SG1 2AY United Kingdom

4/3/96

Tel: Stevenage (01438) 313311
Telex: 825578 IEESTV G
Fax: Stevenage (01438) 313465

Full text of review of Ivor Catt's book by Dr. Lago.

With the compliments of

Paul Stramford

ELECTROMAGNETISM 1 by Ivor Catt

From the introduction the following quotes provide some indication of the style and content of what is to follow:

(i) *'The TEM wave has virtually disappeared from today's electromagnetic theory.'*

(ii) *'Text book writers of the last fifty years seem to have fed on each other.'*

(iii) *'Generally a growing welter of dubious and irrelevant mathematics has submerged the subject.'*

(iv) *'Their (the writers) divorce from practical experience of driven waves (as opposed to the standing waves of wireless and radar) makes the present challenge, to bring the art back to the Heaviside mainstream, difficult but rewarding for the author and for the reader.'*

(v) *'Bizarre extremes adopted as quick-fixes in 'modern physics' further confuse the subject, which should be reasonably straightforward.'*

Item (i) is a false statement. Every book which deals with the loss-free transmission line is dealing with TEM waves, although the term may not be used in all cases. Item (ii) is fair comment. Item (iii) suggests that much of the mathematics is quite unnecessary and that the author is about to present a new and simple way of solving electromagnetic problems. This, alas, never happens. Item (iv) introduces the *'driven wave'* which is not defined or even mentioned again anywhere in the book. It is contrasted with the *'standing waves of wireless and radar'*, suggesting that the author's experience (if any) of such systems must have been with very inferior apparatus. Item (v) is the first of several indications within the book that the author dislikes modern physics. Indeed he prefers the philosophers of science to its practitioners (a red rag to this reviewer).

The main body of the book is devoted to transmission lines, for the author's passion is digital electronic design. The implication seems to be that, since transmission line theory is all that he requires for his purposes, it should also suffice for all other purposes. Hence the reader will find no reference to other important topics and no reference to radiation processes (except for a very peculiar discussion of 'The car headlight '). One suspects that, for the author, a TEM wave must be either a step or a pulse. Sine waves are rarely mentioned and in a footnote reference to one writer's description of the TEM wave as a 'degenerate form' the author bristles:

'This passage then deteriorates from degenerate into typically irrelevant mathematical clutter whose flagship is ω.'

The frequency domain seems to be an anathema to Ivor Catt, and he certainly cannot be accused of generating mathematical clutter. The precision of mathematical statement is not for him.

The author's hero is Heaviside who suggested that energy flow is in the electromagnetic field, not in conductors which act to contain and guide the energy flow. There can be no objection to this point of view. Maxwell's equations are open to physical interpretation and Heaviside's interpretation is, in many ways, more attractive (and more productive) than others. But Catt is wrong to think that *he* has rescued Heaviside from oblivion. Many workers have taken this point of view for many years. Those working on radiation from antennae and on wave guidance in metal tubes and dielectric fibres are virtually forced to think along these lines. Maxwell himself provided an alternative point of view in his 'vector potential' which allows delayed action at a distance to be used to compute the fields when all charge and

current distributions are known, and this has practical computational advantages when good approximations to these charge and current distributions can be guessed. But it must be said that, once the fields are known, the charge and current distributions are of little further interest. Problems of interpretation of Maxwell's equations arise mainly because our education system concentrates on circuit theory to the virtual exclusion of the electromagnetic principles from which it stems. This has clearly been a problem for the author. His reading seems to have given him flashes of insight which have then been badly developed, and that is the problem with this book.

There are numerous examples of sloppy argument in the text. For example, the usual representation of a transmission line as a sequence of cascaded L-C networks is dismissed on the grounds that such networks have a high frequency cut-off and that capacitors are themselves transmission lines so that the transmission line is modelled in terms of itself. The flaws in these arguments are easy to see. Since, in the conventional approach, the cascaded networks are made infinitely short and infinite in number, the cut-off frequency is infinite so that no high frequency cut-off is implied . An infinitely short capacitor has an infinitely small propagation delay and need not be regarded as a transmission line. One suspects that limiting processes such as those used in the conventional treatment are not properly understood by the author and his collaborators. The conventional approach models the line in terms of *inductance* and *capacitance*, **not** in terms of *inductors* and *capacitors*, but the distinction may be too subtle for the author.

The author sees an anomaly in the conventional view of the transmission line. This he calls the 'Catt anomaly' and it is the starting point of his proposals for an improved theory.

THE 'CATT ANOMALY'

> *When a TEM wave travels along a transmission line, there must, according to conventional theory, be charge distributions on the surfaces of the conductors behind the wavefront. For a vacuum dielectric the speed of the wavefront is the speed of light so that, according to Catt, the charges on the conductors must travel at the speed of light which is impossible. This is the 'Catt anomaly'. Since the wavefront* does *travel at the speed of light, so do the charges which then have infinite mass. It follows that there cannot be charges on the conductor surfaces and conventional theory must be wrong.*

The flaw here is the assumption that the charges move with the wave, whereas in reality they simply come to the surface as the wave passes, and when it has gone they recede into the conductor. No individual charge moves with the the velocity of the wave. The charges come to the surface to help the wave go by and then pass the task to other charges further along the line which are already there and waiting. This is the mechanism of guidance and containment. There is no anomaly.

But Catt goes on; having removed charges from the surfaces of his conductors, Gauss' law can no longer be applied and the displacement current in the wave has to go somewhere. Catt's solution is typically ingenious; the current must continue as displacement current in the conductors, which are actually dielectrics with a very high permittivity; there is no conduction current in conductors - ever !. Catt's Ockham's Razor has been wielded to remove conduction current as well as electric charge from electromagnetic theory. There is of course the small problem of a value for the permittivity of copper. Catt is equal to the challenge; since, for a capacitor with a copper dielectric, the reciprocal of the capacitance must be almost zero, the

permittivity of copper must be extremely large. The conductors of his transmission line are regarded as other transmission lines in series with the main line, but having, due to the very high permittivity of the copper dielectric, very small values of characteristic impedance and propagation velocity.

For a loss-free line the permittivity is infinite and the characteristic impedance and propagation velocity of the conductors are both zero. Zero energy is extracted from the main line at zero speed. But when the line is not loss-free some energy *is* extracted, so what is its final destination ?. We are not told, although the author insists that there is still no conduction current , so that I^2R losses are not involved. We conclude that copper must be a rather lossy dielectric.

Throughout the book use is made of well-known concepts and formulae from conventional theory. Indeed several conventional texts are referred to and such texts are all based on the existence of charge and current which the author now rejects. If he is determined to continue to promote Theory C, he must now show that all of those results of conventional theory which he does accept are also derivable from his theory *without the use of the concepts of electric current and charge*. He will also have to show that the new theory explains certain observed effects which are unexplained by conventional theory. This he claims to have done with the pulse amplitude and duration when discharging a capacitor into a transmission line but he can be assured that conventional theory does give the same result without using the concept of superposed oppositely travelling waves in a statically charged capacitor. Thus far he has failed to propose any new concept which is testable. It is significant that, having introduced his new theory and abolished charge and current (Page 14), he then proceeds to use these concepts quite unashamedly in the rest of the book.

Einstein proposed that the speed of light is the same for all observers. This is the basis of his special theory of relativity. Thus travelling at the speed of light parallel to a beam of light one will **not** see a spacially oscillatory field at rest. But Ivor Catt insists that he has actually *'observed and photographed such a stationary wave'* using *'a high speed sampling oscilloscope'*. The reviewer was not aware of the availability of sampling oscilloscopes which could travel at that speed, but the photographic proof was, according to Catt, published in IEEE Trans. Elect. Comp. Dec 1967.

Here are a few more items which give cause for concern:

- When stating Amperes law, $\oint \boldsymbol{H}.d\boldsymbol{l} = i$, a footnote informs us that this is Faraday's discovery of electromagnetic induction.

- *Page 9: 'It is regrettable that the intrusion of the particle, or photon, into an otherwise straightforward system with rich development potential should obstruct forward progress. The political compromise nearly a century ago which caused 'modern physics' to exploit the pedigrees of both wave theory and particle theory has inevitably led to a sterile century with no development, and it blocks development today.'*

- *Page 9: 'Keeping within the wave theoretical system, it is possible to explain why so-called 'particles' should appear to have equal size, although a totally wave theory appears to be scalable and therefore incompatible with the apparently recurrent electron and hydrogen particles with consistent size. One method would be to discuss the collision of two such particles, and the resulting energy/matter exchange. There are three possibilities. Either the larger steals from the smaller, or there is no*

transfer, or the smaller steals from the larger. The fact that there is more than one 'particle' in today's galaxy indicates that if a galaxy is very old the first possibility must be wrong. The second possibility is unlikely. The third possibility would fully explain the gradual equalising out of particles over time. (This approach only explains why all hydrogen particles are equal, and needs extension to explain the existence of more than one type of particle.)'

- *Page 12 ' . . . tubes of flux do not exist on their own. there only exists the TEM wafer composed of a two dimensional surface travelling forward at the speed of light for the medium. One lateral direction is called electric field and the other is called magnetic field. The surface is closed. It is a Gaussian surface. It is like a balloon surface where every point of the surface travels outwards at the local speed of light. At the rear the surface speeds backwards towards the battery, the source of the energy. Many of these surfaces coexist in space, and periodically divide as changes in impedance are reached. At such points some of the surface retreats and the rest continues forward.*

It seems unnecessary to continue. The author will not be pleased with this review and from his combative style a vigorous response from him is anticipated if this is published. Catt's belief in his own work is clearly sincere, but this reviewer, after lengthy and careful consideration, can find virtually nothing of value in this book.

The book has 36 pages and is priced at £20.

PUBLISHED VERSION (BELOW) IS HALF ORIGINAL LENGTH

BOOK REVIEWS

REDUCED BY 50% WHEN PUBLISHED

Electromagnetism 1

Ivor Catt

Westfield Press
1994, 36pp., £6.80
Available from the author at 121 Westfields, St. Albans, Herts. AL3 4JR. Besides this A4 size version the book is available in A5 under the title 'Electromagnetics 1'.

The main body of the book is devoted to transmission lines, for the author's passion is digital electronic design. The implication seems to be that, since transmission line theory is all that he requires for his purposes, it should also suffice for all other purposes. Hence the reader will find no reference to other important topics and no reference to radiation processes (except for a very peculiar discussion of 'The car headlight'). One suspects that, for the author, a TEM wave must be either a step or a pulse.

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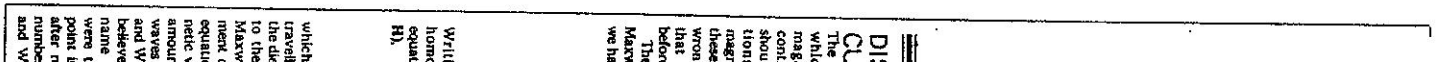
There are many other items in this book which give cause for concern, for example the false statement that 'The TEM wave has virtually disappeared from today's electromagnetic theory'.

Catt's belief in his own work is clearly sincere, but this reviewer, after lengthy and careful consideration, can find virtually nothing of value in this book.

B. LAGO



01784 452906

20 Penton Road,
Staines,
Middlesex TW18 2JY

16 October 1995

Professor Philip E Secker,
Deputy Secretary,
The Institution of Electrical Engineers,
Savoy Place,
London WC2R 0BL

Dear Professor Secker,

I gather that you have been in correspondence with Mr Ivor Catt and others in connexion with a putative anomaly in electromagnetic theory. Ivor Catt has given me copies of some of the letters and other documents.

As a former editor of the journal Wireless World in which much of the discussion on this subject took place, I write to make a suggestion to the IEE and also to request some information from you personally. (Incidentally, I was an IEE member for some years before retirement.)

The letter raising the original query was published in the August 1981 issue of Wireless World, but the name Catt Anomaly was not applied to this query until some time after I had left the journal. So, although I did not promote the idea of an anomaly, I feel partly responsible, having published Catt's original letter, for starting off the ensuing lengthy discussions involving several eminent academics.

The suggestion to the IEE arises from the fact that the discussions, regardless of the validity of the proposed anomaly, have revealed apparent disagreements between academics responsible for teaching our future electronics and telecommunications engineers. If "disagreements" is too strong a word then perhaps they are differences of conceptual approach to e-m theory. I enclose copies of two letters by senior academics as illustrations. (Please note that Dr McEwan says the proposed anomaly is "very instructive educationally" and also "fruitful".)

If such differences are prevalent in the understanding and teaching of basic theory it seems a poor intellectual heritage for engineering students now receiving their education in the country which once produced Faraday, Clerk Maxwell and J J Thomson, among other great scientists. This is sad, considering that electrical conduction and e-m theory are so central to all.electronics and telecommunications engineering. So:

Suggestion. The IEE, in words you quote, "has a responsibility to 'promote the general advancement of electrical science and engineering and their applications and to facilitate the exchange of information and ideas on these subjects to the members of the Institution.'". I would therefore suggest that the IEE should be able to clarify the intellectual situation, through discussions, consultations, public

meetings etc., and so arrive at a recommended line of teaching on both electrical conduction and e-m theory. This of course would not be a rigid 'party line' but an attempt to achieve a clear, internally consistent exposition of the fundamental physical processes. One result could be an authoritative IEE publication which could be of great value to teachers.

Request for information. In your letter of 19th September to Mr K Metzer you mention that the 'experts' have never accepted as a starting point "the physical model that Ivor Catt has postulated." From reading the published material, I myself do not understand what this model is. It does not seem to tie up with the free-electron theory of conduction in metals which I studied some decades ago. But as the 'experts' you mention obviously must have something definite in mind, in order to reject it, could you let me know what they consider Catt's postulated physical model to be? At least, perhaps you could put me in touch with one or other of the persons concerned who would be able to answer this enquiry.

Yours sincerely,

T. E. Ivall

Thomas Ivall