All you gotta be is Sottish

https://www.youtube.com/watch?v=oOOghKacg40 x cc The Editor, Wireless World

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http://www.ivorcatt.co.uk/howie2.pdf

Dear Archie,

Thank you for your letter dated 15 10 83.

I agree with you that since you are certain that there is no problem; that is, that the Catt Anomaly (Wireless World Aug 1981, Aug 1982) is specious, that therefore it would be totally unreasonable for me to expect you to involve luminaries in the field. As you indicate, they have betterthings to spend their time on.

I think the proper way to close up this dialogue is for you to advise me as to your view on the Severn Bore.

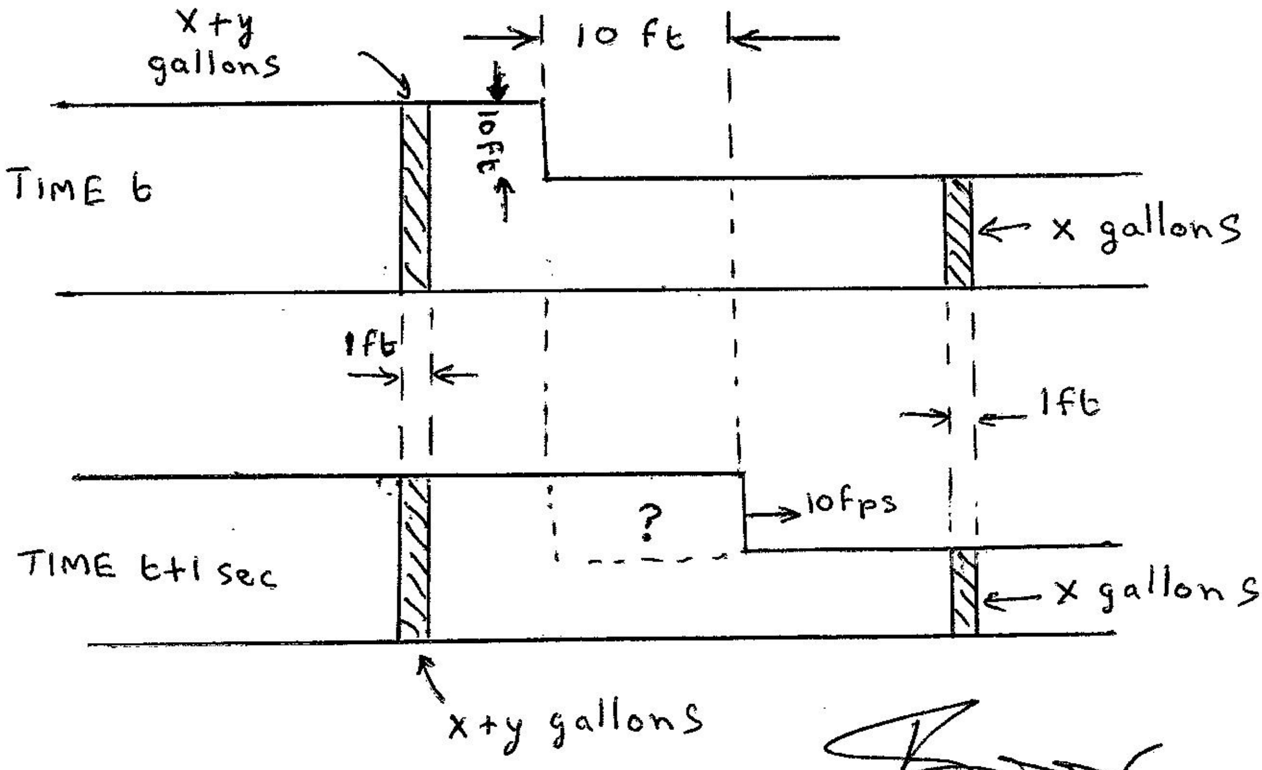
The following is postulated:

> The level of the river Severn is flat and placid. There is no flow. Suddenly a step of water advances upthe river at 10 f.p.s. Behind the step, which is to a height of 10 ft, all is placid again. The surface is againflat. (There is now some flow of water upstream.)

Question. Is it possible for the Severn Bore to advance upstream at 10 f.p.s. even though not one single molecule of water ever reaches a velocity of 10 f.p.s.?

Second question. Is the problem of the Severn Bore in the same category as the problem of the Catt Anomaly, WW Aug 81, Aug 82? If not, then where does the similarity break down?

For the record, it is extremely important for me to get your answers tothe above two questions. There is a failure of understanding, or grasp, at a very elementary level,and it is important to isolate it Note that behind the severn bore, the number of gallons of water residing ineach foot distance (up the stream)of theriver is greater than the number of gallons of water per foot in front of the step.



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Dear Ivor,

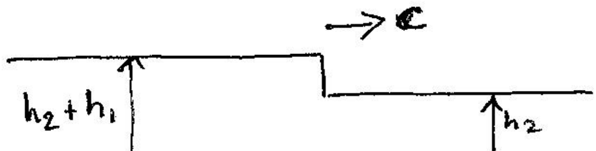
24th October 1983

I think that your analogy between the flow of electrons in a wire to generate a step function of current and charge density and the passage of the Severn bore is potentially quite a useful one if you bear in mind some differences.

1. The water flow is essentially incompressible whereas the electrical current flow is not — electrons can pack closer together in the wire behind the step and indeed do.

2. The water level can rise behind the bore — i.e. extra space is available when required for excess water, whereas the electrons are confined to the wire.

Clearly these two points substantially but not completely compensate one another.



3. The flow behind the bore could be generated by giving all the molecules there a velocity $u = c h_1/(h_1+h_2)$

Of course just behind the step itself (within a distance of order h_1 behind the step) this flow pattern will have to be modified to allow the step with its sharp profile and rise of height h_1 to propagate — and molecular velocities as great as c and maybe even greater will be required. This is because the molecules just behind the step are occupying a previously unoccupied region of space. However I don't know the precise hydrodynamic flow pattern. ~~The situation for the is~~

4. The situation for the current flow in the wire is rather different. The geometrical relation $u = c h_1/(h_1 + h_2)$ still applies where (referring to my previous letter) $h_1/(h_1+h_2) \Rightarrow q/Ne$ and is a fantastically small number in practice. Moreover because of points 1 and 2 above there is no need for a special flow pattern behind the step with electron velocities anything like c since the ~~electron~~ ~~the~~ electrons do not have to

move into previously unoccupied regions of space and can simply pack together more closely. In my earlier letter I gave a simple analysis of the electron displacements behind the step which supports ~~this~~ the view that such a step can be propagated at c with quite small electron velocities — although one might have to worry about accelerations if you insist on an infinitely sharp step.

I hope that this makes clear my view of the similarities and differences between the two problems.

Best wishes.

Archie

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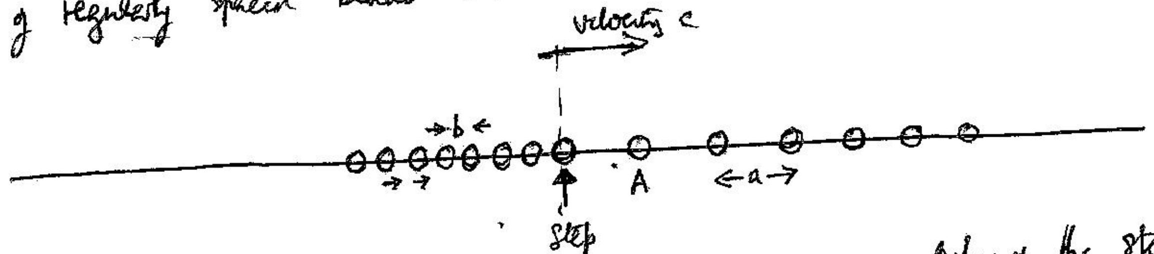
3 November 1983

Dear Ivor,

Thank you for your latest communication of 26 October. It does not change my view that the analogy between the Severn bore and the flow of electrons behind a voltage step in a wire, though picturesque, has some serious limitations. The incompressibility of the fluid flow in the river is partially compensated by its ability to change its level occupying previously empty regions of space. As I said in my earlier letter this means that the details of the flow pattern (which are no doubt worked out in some detail in Fluid Dynamics texts) must certainly involve fluid motions in the vertical and probably also horizontal directions just behind the step which are similar or maybe even greater than the velocity c of propagation of the step. However the same is not true of the flow in the wire which is compressible flow and where the fractional change in the electron density before and behind the voltage step is extremely small.

As a more relevant analogy I would suggest that you consider the case of regularly spaced beads on a wire when a compression step passes along



Let the spacing of the beads before the step be a and behind the step be b. Suppose now that all the beads behind the step ~~move forw~~ (including the arrowed bead) move forward together at velocity v & preserving their spacing b. The bead A ahead of the arrowed bead (and all others ahead of it) remain at rest until the spacing between the arrowed bead and A has been reduced from the original value a to the new value b whereupon bead A moves forward at velocity v keeping the distance to the arrowed bead constant at b. A thus begins to move ~~a time~~ after the arrowed bead has travelled a distance $a - b$ i.e. after a time $\Delta t =$ ~~...~~ $(a-b)/v$. ~~Durin~~ After a time $2\Delta t$ the next bead to the right of A begins to move and so on. During each of these time intervals ~~A~~ Δt the step of compression clearly advances a distance a so that its velocity $c = a/\Delta t = av/(a-b)$

Thus velocity of beads $v = \left(\frac{a-b}{a}\right) \times$ velocity of step $= \left(\frac{a-b}{a}\right)c$

$$= \frac{n_a - n_b}{n_b} \; c$$

where $n_a = 1/a$, and $n_b = 1/b$ are the densities of beads i.e. the numbers of beads per unit length of the wire before and behind the step respectively. This expression which I believe is essentially the same as qc/Ne (the formula quoted in my letter of October 15) shows that v ~~can~~ will be less than c and indeed much less than c when the ratio $(n_a - n_b)/n_b$ or qc/Ne is small.

How does the bead A "know" when the arrowed bead has reached the distance b when it should start to move? For the bead problem this could be arranged either by letting $b =$ the bead diameter when contact occurs or by placing suitable thickness collars on the wire between the beads to produce contact when the bead separation is b. In the wire the electrons do not have a contact interaction with one another but of course ~~interact with electric or~~ magnetic fields. The message that the electrons at the step have now advanced to the distance b behind those in front when ~~they~~ the latter should start moving is thus transmitted at the speed of electromagnetic waves and this is the only factor which limits the velocity of the voltage step along the wire.

Best wishes

Archie

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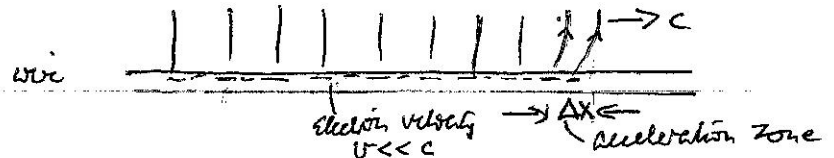
10th November 1983

Dear Ivor,

Your latest letter seems to me to be changing ground somewhat. My previous letters were mainly aimed at clearing up your erroneous idea that the electromagnetic wave could not propagate along the wire unless some of the electrons in the wire had velocities equal to that of the ~~velo~~ wave i.e. the velocity of light. Via examples of beads on strings, plus rather detailed descriptions of the electron behaviour in the wire (with additional excursions into the rather irrelevant Severn bore), I have I believe made it as clear as possible that <u>such high electron velocities are quite unnecessary</u>. You have <u>not</u> however responded by indicating either that you accept that point or describing in detail ~~the~~ whatever is the error you still believe to be present in the electron <u>velocity</u> argument I advanced. It seems to me that your obvious preference for moving on to fresh points before we can reach an agreement on this rather simpler one is a rather ominous sign and causes me to doubt whether there is much point in continuing with this discussion.

The fresh point you now want to discuss concerning how the electrons get the message to start moving takes us into the question of electron <u>acceleration</u> (mentioned you will find in my first letter) rather than <u>velocity</u>. The detailed treatment required will depend on the assumptions made about the conductor e.g. you could take a conductor with real $\sigma(\omega)$ conductivity (σ) vs. frequency (ω) behaviour, you could take a "perfect" conductor i.e. zero D.C. resistance but containing electrons of <u>finite</u> mass m_0 or you could take a perfect DC conductor with electrons of zero mass which can therefore accelerate to the required velocity instantaneously. Probably only the first of these can be safely assumed to be free of internal ~~contradictions~~ contradictions.

In any case however it is clear that an electron will only accelerate from rest if there is a component of electric field <u>along</u> the wire at the requisite point as sketched below. There is no requirement that E.M. waves in a conductor have to be purely transverse — at high frequencies in metals there are for instance electron density waves called plasmons with longitudinal electric fields.



PTO.

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As I mentioned before, the full details of the field in the acceleration zone are probably quite complicated to work out* – there may be published accounts somewhere but I am not aware of any nor do I feel any obligation at present (as you seem to believe I ought) to spend a lot of my time now in working out the details of an elaborate but basically pedestrian EM problem. I must admit that my lack of enthusiasm for such an undertaking arises from the experience of the velocity problem above. Even if I produced a satisfactory solution you might very well just ignore it in the same way and move on to yet another point!

It seems that you take a somewhat legalistic view of these discussions and that anything I write can be taken down and used in evidence against me whereas I and I believe any other scientist interested in these matters would put more value in a more free and easy discussion of the various points. I know you believe that I am just "peddling the party line" or worse "cheating" because I have some sort of vested interest in the status quo. On thinking about that I have however come to the conclusion that this is not correct – I may adhere to the status quo (i.e. Maxwell) because I lack the imagination to see something better however there is little or no vested interest for me in this view – rather the reverse in that if I had some definable objection to EM theory it would be entirely in my interest to broadcast it. You on the other hand, having put yourself on the pedestal with Galileo, Einstein et al have certainly got an enormous psychological vested interest in your position as a demolisher of established theory and I suspect there is nothing that can be done to convince you of your error in this instance.

I certainly refute the suggestion that I am "denying you access" to luminaries – I am just not willing to make suggestions about suitable people or to use my good offices with any of them to entangle them in the net!

Archie

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* A simple estimate of the width ΔX of the acceleration zone (where the field lines bend round to give a longitudinal component) is $\Delta X = c\Delta t$; $\Delta t = V_{\text{electron vel.}} / \text{acceln.} = V m_0 / e\mathcal{E}$ (↑ electric field).
From previous letter $V = q\,c/Ne$, also for a wire of radius a
$$2\pi a \mathcal{E} \approx \frac{q}{\varepsilon_0} \quad (\text{Gauss Theorem}); \quad \text{Electron density/unit vol } n = \frac{N}{\pi a^2}$$
$$\text{so} \quad \Delta X \approx \frac{2c^2}{a\,\omega_p^2} \qquad \omega_p = \left(\frac{ne^2}{\varepsilon_0 m}\right)^{1/2} \text{ is the plasmon frequency} \simeq 10^{16}\,s^{-1}$$
working in cm $\Delta X \simeq \dfrac{10^{-11}}{a}$ so even if we assume a should be the skin depth ~~rather~~ $\delta \simeq 10^{-4}$ cm rather than the actual wire radius ΔX is extremely small.