FUNDAMENTALS OF ENERGY TRANSFER

I agree with Chris Parton's attack on the definition of electric current, *Wireless World*, December, 1984, page 65.

Parton discusses "Forces on conductors guiding a TEM wave." I have a chapter with that title in vol. 2 of my book, Electromagnetic Theory. I feel that these strange forces may guide us to a unified field theory.

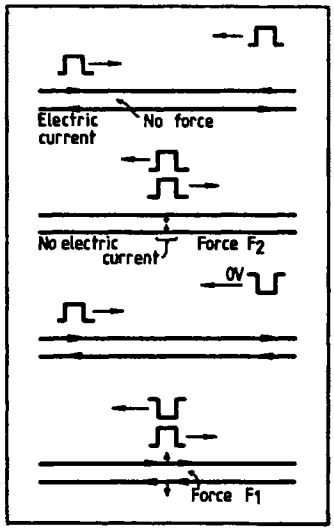
Force on conductors guiding a TEM wave

After a TEM wave step has passed by, guided by two parallel conductors, there remain two steady state "fields":

(1) Electric current flows down the wires, and a B field exists in the dielectric right next to the surface of the conductor.

(2) Electric charge remains on the surface of the conductors, and an E field exists in the dielectric right next to the conductor.

The magnetic field exerts a force into the conductor; that is, a force which tends to drive the conductors apart. The electric field exerts a force out of the conductor; that is, a force which tends to pull the two conductors together.



The forces are $F_1 = iB$, $F_2 = qE$. Now the electric current in the surface of the conductor i and the electric charge in the surface of the conductor q are related by the equation $i = q \mathbf{C}$. That is, the current is equal to the speed with which the charge density travels along the surface of the conductor. Dividing, we find that numerically:

$$\frac{F_1}{F_2} = \frac{iB}{qE} = \frac{\mathbf{C}B}{E} = \frac{1(\mu H)}{\sqrt{\mu . E}} = \sqrt{\frac{\mu}{E}}\frac{H}{E}$$

But we know that in a TEM wave, at every point $E/H = \sqrt{\mu/E}\,\mu$ Therefore $F_1 = F_2$ numerically.

We conclude that when a TEM wave (which we call a Heaviside signal) glides along between two conductors at the speed of light, there is no force on the conductors guiding the signal. This very interesting feature of a Heaviside signal was first pointed out by David Walton, and is here proved.

(For the equations giving F_1 and F_2, see for instance P. Hammond, "Electromagnetism for Engineers", Pergamon, 1978, pages 107 and 55.)

It is generally thought that if an electromagnetic wave travels down a coax cable from left to right and passes through another such wave travelling from right to left, then superposition applies. However, this is not true in the very important matter of the forces on the conductors. Where each wave on its own exerts no force, (the electric force and magnetic force cancelling,) when two waves are passing through each other one of the "fields" E or B — cancels, and we are left with a net force resulting from the non-cancelling "field". So superposition does not strictly apply, because when we superpose two TEM waves, something new suddenly appears, a physical force. If the two pulses passing in opposite directions are of the same polarity, another strange thing happens for the short time during which they overlap. That is, there is no electric current in the surface of the conductors. So if the conductors are imperfect, there is no resistive loss during that short period of time. (Similarly, if the pulses have opposite polarity, then if the dielectric is imperfect, there will be no losses due to leakage during the short period of pulse overlap.)

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I am not very surprised to notice that many readers of *Wireless World* (e.g. N.C. Hawkes, December, 1984) have been finding difficulty in appreciating the contradiction implicit in classical electromagnetic theory pointed out by Ivor Catt (September, 1984).

A slow drift of electrons along a wire may well account for a "steady state" movement of charge, and until recently it seems that this was all that was required.

However, with the growing importance of high-speed logical signals, new problems have been brought into the limelight which are inexplicable purely in terms of classical "electron drift".

I will attempt to explain the "Catt anomaly" from a slightly different angle in the hope that this may serve to shed more light on the contradiction.

(i) Experiment shows that a voltage "step" travels at the speed of light (of the dielectric between the wires).

(ii) Classical theory tells us that electrons cannot travel at the speed of light because they have a finite rest mass. (At normal temperatures the average speed of the free electrons is of the order of 1/1000 of the speed of light). In fact the "drift velocity" of the free electrons turns out be much smaller, (of the order of 1cm/second).

(iii) Electrons in a given section of wire will not start to "drift" until they have received the message to do so.

(iv) The signal which tells the electrons to move is the electric field caused by the charge on the electrons which have drifted in another section of the wire. Thus the signal resulting from the change in electric field (the voltage step) travels at the drift velocity of the electrons.

The contradiction and resulting inadequacy of the theory is clear to see.

This, the "Catt anomaly", seems to have fallen on many deaf ears. I am interested to see how the scientific community continues to react to this vitally important breakthrough, which could lead to a revolution in electromagnetic theory.

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With reference to the correspondence concerning the physical mechanism of energy transfer along transmission lines. I believe that Catt is correct in insisting that something much faster than electrons is involved. It seems reasonable to assume that as the electrons in the wires would be continuously entering and leaving the conduction band, there would be a corresponding traffic of the associated quanta, at the velocity of light, and that it is the existence of these quanta that constitutes the basis of the energy transfer mechanism. By considering all the quanta that at any given time travel in one direction along a wire as one energy current, and the contrary travelling quanta as an opposite current, Catt could justifiably speak of two superimposed slabs of energy and explain the experimental facts in connection with 1 metre long transmission line reported on page 80 of the December, 1980 issue.

I expect that the above suggestion, if correct, will lead to revised understanding of conduction phenomena generally, including such topics as superconductivity and the action of thermocouples.

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RELATIVITY

Modern physics assumes Einstein's Special Relativity true. S.R. is based on three postulates, two of which are well known and the third (the unmentionable) ignored. These three postulates are:

(1) Laws observed by an observer, A, who resides solely in an inertial frame, A_o, are the same as those observed by B who resides solely in an inertial frame, B_o, both of the observers using the same units.

(2) The speed of light produced in an inertial frame, A_o, is constant relative to A_o and is equal to c. Likewise, the speed of light produced in an inertial frame, B_o, is constant relative to B_o and is equal to c, the same units being used in both frames.

(3) Before landing on a moving object (in any inertial frame) light magically adjusts its own speed to make its reception speed relative to that object, equal to c.

Postulate (1) is called, "the principle of relativity". Postulate (2) is called, "the constancy of the speed of light". Postulate (3) is, of course, never mentioned, but it is often combined with postulate (2). The resulting, mixed-up postulate, (2/3), is called, "the invariance of the speed of light".

Most physicists today, accept postulates (1) and (2) because experiments confirm both postulates. It is the unmentionable (3) or the mixed-up, unmentionable (2/3) that produces intellectual indigestion.

Your contributor, Roy Hodges, (*Wireless World*,