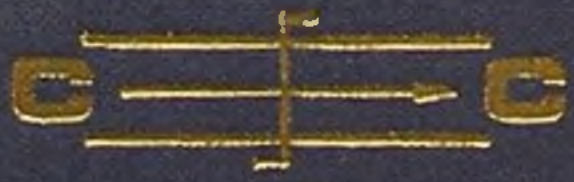
ELECTROMAGNETIC THEORY
VOLUME 2

IVOR CATT



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ELECTROMAGNETIC THEORY

Volume 2

By

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PREFACE

This volume contains the first disclosure of the most important advance in electromagnetic theory for a hundred years.

PREFACE TO THE SECOND EDITION

Theory C took off like a lead balloon. However, by now, 1986, it is clear that parts of the Body Scientific are lumbering towards Theory H. (We call it the Body Scientific not the Mind Scientific!) In a few more decades, it might finally reach Theory C.

CONTENTS

C.A.M.

HISTORY OF THE DEVELOPMENT OF THEORY H AND BEYOND

I entered the computer industry when I joined Ferranti (now I.C.L.) in West Gorton, Manchester, in 1959. I worked on the SIRIUS computer. When the memory was increased from 1,000 words to a maximum of 10,000 words in increments of 3,000 by the addition of up to three free-standing cabinets, there was trouble when the logic signals from central processor to free-standing memory cabinet were all crowded together in a cableform 3 yards long. The logic signal current pulses - each down a single wire with common return via a shield (through one or two pins on each plug and socket) were NEURON logic signals, 1 μsec wide current pulses driven by 9 volts.

The crosstalk was regarded by everyone as caused by mutual capacitance. However, Gordon Scarrott suggested mutual inductance as the cause. This was the first time I had heard the suggestion of mutual inductance as a mechanism of interference. Sirius was

the first transistorised machine, and mutual inductance would not have been significant in previous thermionic valve machines with high voltages (300v) and low currents (1ma).

In 1964 I went to Motorola to research into the problem of interconnecting very fast (1 nsec) logic gates. I solved all the problems, and we delivered a working partially populated prototype high speed memory of 64 words, 8 bits/word, 20 nsec access time, 20 nsec cycle time. (See article in Fall Joint Computer Conference 1966). We won the follow-on contract against competition from Texas Instruments, and later delivered a fully populated memory.

I developed theories to use in this work, which are outlined in my IEEE Dec. 1967 article (EC-16, no. 6).

One of the problems to be solved was the question of what was the nature of the voltage decoupling given by two parallel voltage planes. I told Bill Herndon about the problem, and he gave me the answer: "It's a transmission line." (See DED211). I said, "Is that your idea?" He said, "No, I wish it was. It's Stopper's idea."

Stopper, a German, had previously worked with Bill at G.E. Phoenix. Later he returned to Germany. I never met Stopper.

The fact that two voltage planes when used as voltage decoupling at a point look like a transmission line was for me an important breakthrough. (N.B. There is an unimportant arithmetic error in my treatment of the subject in my Dec. 1967 paper.)

So we see Stopper and W. Herndon as being part of the history of the development of Theory H and beyond. Stopper came up with the idea, and Herndon had the ability to transmit it. Herndon later went to Fairchild in Silicon Valley.

The idea that parallel voltage planes, when entered at a point, behave like a transmission line and not a capacitor, was the beginning of the end of Maxwell's "Displacement Current".

I never (as far as I can remember) translated this concept into the insides of a component sold (and described as) a capacitor - at least not for many years.

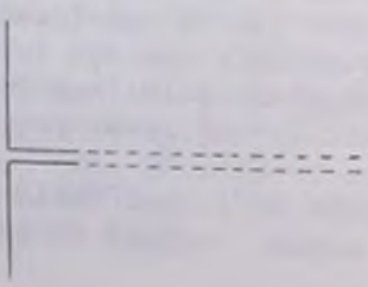
In late 1975, Dr. David Walton became acqua with me and the idea

of a co-operative business activity arose. However, electromagnetic theory seemed to be the main, overriding common interest.

Among other things, Walton read my article asserting that, contrary to the popular view, the high frequency performance as voltage decoupling capacitors of 10 μF electrolytics and other high capacity capacitors was no worse than that of 20,000 pF mica and other types. Walton showed that my experiment to prove the point had a flaw because the circuit was heavily damped, far more than critically.

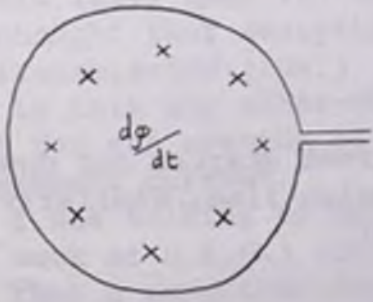
Walton kept hammering away at trying to understand the performance of capacitors - both Walton and I asserted that there was no mechanism to make capacitors inductive.

I said that a high capacitance capacitor was merely a low capacitance capacitor with more added.

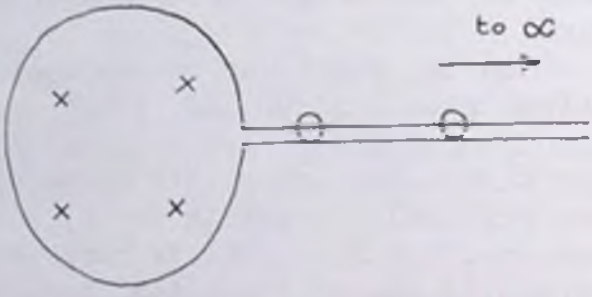


Walton then suggested a capacitor was a transmission line. I grabbed this idea - which was of course a reappearance of the Stopper idea in another form.

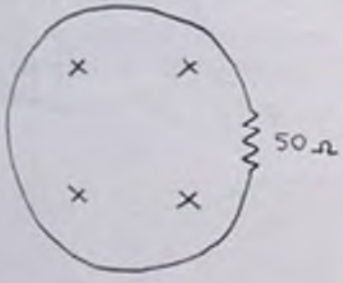
Then one night, as he was wont to, Walton phoned me up and talked about a number of things - how he knew he should get sine waves out of his thinking but how difficult it was to do so; how he wondered how the particle came in to Faraday's Law of Induction; that perhaps the law was only an approximation and did not hold exactly at the atomic level. I for my part wanted no particles introduced into the argument. Then Walton raised the point about a "Faraday's Law" loop with a capacitor as part of the loop.



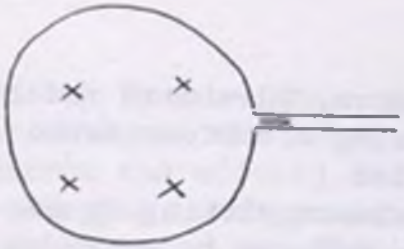
I said that if instead of a C you had the end of a very long transmission line,



it would look just like a resistor:



a wave front started out down the transmission line. Similarly the capacitor.



Walton said: "So that gets rid of displacement current."

That statement was enormously important. Maxwell's displacement current was gone, after more than 100 years.

Walton and I promptly agreed that a capacitor was a transmission line. Because of the high ϵ, the wave travelled outwards very slowly ($c = 1/\sqrt{\mu\epsilon}$)

Walton said, "If the capacitor is a transmission line, what about the inductor?"

(Walton said later that for some time he had thought that everything should be a transmission line.)

I refused to talk any more, saying it was enough for one evening to get rid of displacement current.

Next day, I was talking to Malcolm Davidson (at work at G.E.C.) about it, and told him that a capacitor was a transmission line and displacement

current was no more. (Davidson and I had been discussing electromagnetic theory quite a lot.)

Then with Davidson sitting by me, I told him I had refused to consider the inductor the night before over the long distance telephone with Walton. I then tried it out, and the answer was there within five minutes. (Meanwhile Walton was working to the same conclusion with the inductor and the transformer.)

The resulting transmission line models for reactive components are discussed in the next chapter.

Then, while talking to Malcolm Davidson, the realization hit Catt, and he said, "The electric current goes!" This was shattering. No electric current! What was the point of electric current? What did it do? Who had ever seen one? Then Ivor showed Malcolm that if ϵ in a conductor was $\rightarrow \infty$, the velocity of an energy current in a conductor would approach 0. A perfect conductor was a brick wall to an energy current!

Whereas in Theory N, electricity was the cause and E-M field the effect; for

(Theory H) Heaviside, E-M field (energy current) was the cause and electric current the effect; for Theory C, now developing, Energy Current (E-M field) was the cause and there was no effect. When water flowed down inside a pipe, the pipe experienced no effect. Nothing flowed inside the metal piping! Energy Current flowed where it was allowed to flow, and that was all.

Earlier in the same conversation, Malcolm Davidson had said that an RC waveform should be able to be built up from little steps, illustrating the validity of the transmission line model for a C. Catt had been thinking that loss, or distortion, was necessary for a capacitor to behave well, that otherwise reflections from the edges would upset performance. Davidson had thought that a perfect transmission line would be fine, and Catt changed to the same view. (The model was later published in Wireless World in December 1978.)

It is worth emphasising that this occurred in two distinct steps during May 1976. First "Displacement Current" went. Then "Electric Current" went. Displacement current - that shadowy, strange "fudge factor" in the equations, had always been the Achilles Heel of Electric Current, and in the end it was instrumental in the downfall of Electric Current. The demise of Electric Current, which suddenly came to Catt while he was talking to Davidson, was completely unexpected, and a great shock. It was unexpected because, whichever side of the Theory N - Theory H one stood on (there being no Theory C yet), the Electric Current - Energy Current dual looked symmetrical. The only point at issue was which caused which.

PHILOSOPHY

It is believed that (Theory N) voltage causes current causes field.

Heaviside says (Theory H) that voltage causes | energy current field | causes current.

Theory C says that to keep within the principle of conservation of energy, the ruling principle, the cause-effect sequence need only go as far as energy goes. So (Theory C)

| energy current field Heaviside signal | causes nothing.

THE THREE THEORIES

There have been two major advances in electromagnetic theory. The first, the transition from Theory N to Theory H, was made by Oliver Heaviside a century ago. The second, from Theory H to Theory C, is here disclosed. It is to be hoped that the response to Theory C will be more perceptive than the general response to Theory H a century ago, as typified by Sprague and quoted in these volumes (see index).

Until it was revived recently by the author, Theory H had been ignored and then suppressed for a century. It was revived because of its great value in digital electronic design.

Theory C, here disclosed, has major implications across a whole spectrum of subjects. Unless it is ignored, like Theory H, it will trigger an exciting renaissance in many fields of endeavour.

Two conductors guide the energy current from battery to resistor. It enters the resistor sideways. 'Electric current' is merely the edge of a wave

of energy current. If the energy current has a sharp edge, the 'electric current' has infinite density in the outside surface of the 'electric conductor', which Heaviside called an obstructor.

Energy current penetrates an imperfect conductor in the same way as it enters a resistor. In this case, the region containing 'electric current' widens and penetrates into the conductor; skin depth is no longer zero.

Nothing exists behind a mirror; nothing happens there. The velocity of the 'things' behind a mirror does not depend on the medium, or material, behind the mirror. All the same, complex 'theories' and predictions can be constructed about the comings and goings of the mirages behind a mirror.

As Maxwell's Equations show, 'electric current' is always derivable as a gradient on the side of a wave of energy current. Unlike energy current, electric current contains no energy, it has no function, and it explains nothing. Electric current does not exist.

In the following analogies, the sheep represent energy, the dogs electricity. THEORY N. The sheep are forced out of

the pen by the sheep-dogs. The dogs then run alongside the sheep. There can only be a forward flow if sheepdogs first advance on both sides of the flow of sheep, which the dogs direct and cause.

THEORY H. The sheep rush out of the pen into the great open spaces. They will go forward regardless, but their direction direction is guided by the sheep-dogs running alongside, the front of the line of dogs always keeping level with the foremost sheep.

THEORY C. There are no sheep-dogs. The sheep leave the pen and flow out into the great open spaces. Some of the space is rougher. (This rough space was previously thought to be the terrain preferred by the dogs.) Here less sheep go, and their rate of advance is slower. Some ground is very obstructive; nearly impassable for sheep. Although it might appear that the sheep are guided by the rough terrain towards the smooth terrain, this is not so. Neither does a grease mark on blotting paper guide the ink towards the ungreasy areas. There is no guidance mechanism; greasy paper is merely bad blotting paper with poor capillary action.

The excision of sheep-dogs from the theory is a giant simplification.

Nothing flows in the conductor; nothing happens therein. Heaviside was right to call it an obstructor.

Although a house cannot exist if it does not have sides, the sides of a house do not exist. They have no width, volume or materiality. However, the sides of a house can be drawn; their shapes can be manipulated graphically and mathematically. The same is true of so-called 'electric current'.

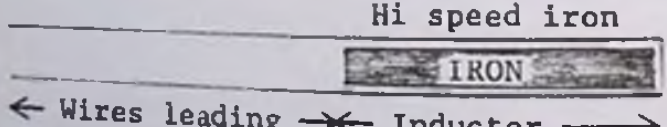
TRANSMISSION LINE MODELS
FOR REACTIVE COMPONENTS

CAPACITOR All capacitors behave as transmission lines in the manner described in earlier books DIGITAL HARDWARE DESIGN, pub. Macmillan, page 39 and DIGITAL ELECTRONIC DESIGN VOL 1, page 109.

Because ϵ is very high, the outwards velocity of propagation is very slow.

E.S.R. is the initial characteristic impedance of the transmission line.

INDUCTOR Single turn inductor, iron cored.



$Z_o \approx 100\,\Omega$

μ very high

$Z_{oI} \approx \sqrt{\frac{\mu}{\epsilon}}$

$\textcircled{c} = \textcircled{c}_o$

$\therefore Z_o$ very high

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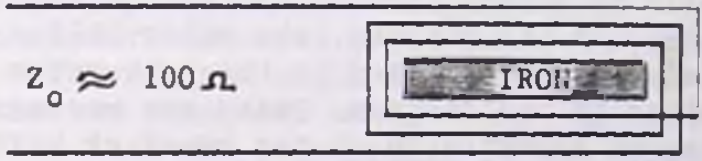
$$\textcircled{c} = \frac{1}{\sqrt{\mu\epsilon}} = \text{very slow}$$

since μ is so hi·

MULTI-TURN INDUCTOR



← Wires leading to inductor → ← Inductor →

μ very high

"Z_{oI}" is even larger than in single turn inductor as a result of crosstalk to other turns.

© still very slow

At this point, use the approach in my paper "Crosstalk (Noise) in Digital Systems", IEEE Trans. Electron. Computers, EC-16 (1967), pp. 743-63.

DISCUSSION OF MULTI-TURN INDUCTOR.

When an incident wave travelling down the 100Ω transmission line from the left reaches the front end of the inductor, it partially reflects and partially continues forward. The forward travelling portion divides and half is guided forward by the top two wires in the diagram, the other half being guided forward by the bottom two wires in the diagram. These two waves travel essentially at the speed of light in vacuo, because they do not significantly travel in iron. When they reach the right hand end of the inductor, they see a hybrid termination and so reflect back towards the left in a different mode, in the same sense as the description headed "Reflections" on page 755 of my IEEE paper*, but in a more complex manner. When the reflected waves get back to the front face of the choke (in the middle of the diagram), they are partially transmitted onwards to the left but they partially reflect again, into new modes. The wave front oscillates to and fro a number of times, gradually 'climbing down" through various modes towards the iron, where the waves travel much slower. They then

* Details on p208 ,p50.

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gradually climb back up out of the "deep" modes and the energy returns back to the left, out of the choke. This oscillating through many modes takes a long time, and it is the entrapment of energy for a long period of time that gives the inductor its capacity for delayed response, and therefore reactive performance.

The student might like to consider the two turn, air cored choke. He will find that the calculation of the various transformations from mode to mode will be quite difficult enough.

The mechanism is similar to but more difficult than the mechanism of energy entrapment described for the L - C oscillator circuit on page 249 of DIGITAL ELECTRONIC DESIGN VOL 2.

TRANSFORMER

At P (and also at Q) reflections and crosstalk occur between primary and secondary, and also between windings of the primary. Again, follow the method for crosstalk in my IEEE Dec. 1967 paper. If the transformer core is air not iron, the resistive paper analogy will work. For resistive paper, take a cross section perpendicular to the paper and perpendicular to the direction of the transmission lines.

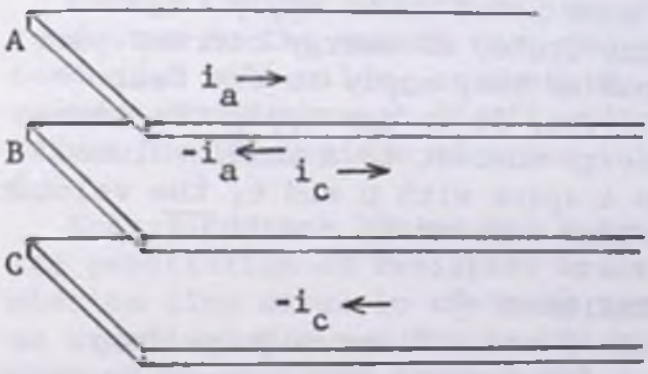
Real iron is not high speed iron, so the full μ does not arise as the step, or wave front, passes the aterial. So with real iron the story is ore complex, with new wave fronts being projected behind the original wave front as the effective μ changes (as the magnetic domains accelerate, gain velocity etc.).

Probably the best model to start with is an air cored transformer or choke. Get familiar with it, and proceed from there to the more complex practical case of a slow (1 μsec) μ, that is, a μ with finite frequency bandwidth.

DISCUSSION OF TRANSFORMER ON THE LAST PAGE. An initial wave front ⌐ reaches P where it sees a change of

impedance from Z_o, so that there is a reflection but some of the energy current continues towards Q. If μ is larger than μ_o, the velocity between P and Q is slower. At Q, reflections occur and also some of the wave front proceeds further to the right on the secondary (O/P) of the transformer.

TRANSMISSION LINES CAN BE CASCADED



Assume no fringing (i.e. imagine a coax within a coax ◎).

Keep μ, ϵ the same for line AB and line BC.

Project a step (wave front) down AB and at the same time project one down BC. It can be arranged that the first front has currents $i_a = -i_b$ equal to those for the second wave front $i_b = -i_c$. Total current down B is then zero. Plate B can be removed and the wave fronts are unaffected. This is if the stress level (ExH) in each

energy current is the same.

Therefore wave fronts can be cascaded laterally. Therefore the transmission line wave front rules apply to one segmant (tube) of energy current just as much as they apply to the full wave front. So we can apply the ideas of energy current to a small volume.

In a space with μ and ϵ, the velocity of energy current is $c = 1/\sqrt{\mu\epsilon}$

DISCUSSION OF ϵ

High ϵ means "less voltage drop across for a given displacement current" in the language of Theory N. A conductor allows "displacement current" or even "electric current" through itself with no voltage drop. That is what is meant by "a conductor". Therefore a conductor is a material with $\epsilon = \infty$. Therefore the velocity of an energy current in a conductor is

$$© = 1/\sqrt{\mu\epsilon} = 1/\sqrt{\mu\infty} = 0$$

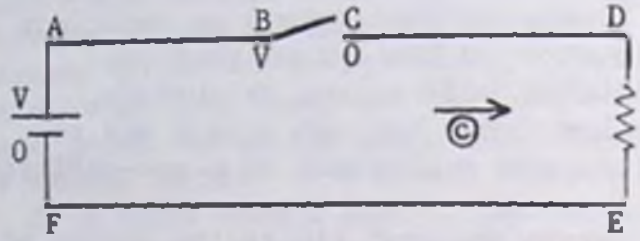
This means that energy current cannot enter a perfect conductor, because it would enter at zero velocity. So in a two wire transmission line, the energy current is steered by the wires, because the energy current cannot enter

them, in the same way as water is steered down inside a pipe because it cannot enter the metal of the pipe.

Energy current enters an imperfect conductor to the extent that the conductor will allow, or sustain, voltage drops through itself and so effect the equivalent of a non-infinite ϵ.

Energy current limits the extent of its penetration of resistive transmission line wires in the same way as an overflowing river limits the speed with which it flows through the impeding bushes etc. far from its normal river bed.

THE RESISTOR



The energy stress, or pressure, pushes throughout the rectangular space above and then expends itself through the open switch. The maximum stress (i.e. Theory N voltage drop) is across the switch contacts, and the energy stress then spreads out above the switch, the stress falling away with distance. When the switch is closed, the pressure no longer exercises itself at that point, and rushes to the right as the potential (theory N) at C suddenly moves from 0v to V and the wave front rushes towards R at a velocity ©. If R were zero ohms, the energy current would hit a solid wall of $\xi = \infty$ and bounce back. However, an R of reasonable value allows the

penetration of the energy current and its dissipation in a lateral mode.

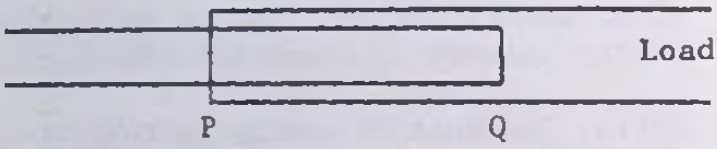
In short, a perfect conductor will not allow the ingress of an energy current. $\epsilon = \infty$ so the current enters with zero velocity. An R, however, does accept the incursion into its side of an energy current. Inside the R the energy current is converted into heat.

UNITS. The unit of energy current is the Watt.

Energy current flows through a surface, so it has a current density. The unit of energy current density is the Watt per square metre. This we shall call the "Heaviside". Mercer has said that we should have used the great man's name for one of our fundamental units.

This name for Watts per square metre will need to be ratified by international convention.

MORE THOUGHTS ON THE TRANSFORMER



We have a complex multiple reflection situation at P and at Q and at Load. Clearly, a low (say a short) at Load will send back reflections finally calling for more input, only after alteration at Q and at P. The story is the same if primary and/or secondary have more than one turn.

(More strictly, the reflections do not call for more input; rather, reflections are the dumping of incident energy current back into the source. Lack of reflections means that a net flow of energy current can take place from left to right.)

For years I have said that the change in impedance Z_o of a transmission line is primarily a power transformer.

(See Digital Electronic Design page 86 or Digital Hardware Design, Macmillan, page 13.) It follows that on entering the transformer at P most of the power continues. At Q, again most of the power continues. Only, the v and i will obviously change.

When we reach the load, the normal reflection - absorption rules apply, and if the load is "reasonable", most power will be absorbed. However, a short or an open circuit will reflect 100% and rush back with its devastating news (power), hardly changing as it passes P, to tell the source the doleful tale.

That is, in practice, points P and Q do nothing to the passing power (energy current) but transform its v and i.

THE NATURE OF SPACE AND ETHER

This whole subject is confused, but I think my long experience of fast digital signal transmission will clarify it.

An important cornerstone of my position is as I stated to A.W. Holt and C. Seitz some four or five years ago:

> Space is the ability
> to accomodate energy

Consider a signal (energy) transmitted from A to B. It is best to consider a narrow digital pulse.

A • B •

Assume that A and B are separated by distance. The following sequence occurs:

1) The signal is launched from A.
2) The signal resides in space between A and B.
3) The signal arrives at B.

If (3) occurs at the same time as (1), the signal has "travelled at

infinite velocity." That is, it has not resided in the intervening space. That is, there is no space between A and B, and A is at the same point in space as B.

(We can get over relativity quibbles by sending the signal on a round trip A - B - A. The argument still applies.)

For space to exist between A and B, it is necessary that a signal travelling from A to B be "lost" for a period of time between A and B.

Now we know that velocity © = $1/\sqrt{\mu\epsilon}$. For space to exist between A and B, © must be finite. If © = 0, then signals will not travel from A to B, and there is no space between them; no link. Instead, there is a "brick wall". If c = ∞ on the other hand, the signal arrives at B at the same moment as it leaves A. If follows that:

> Space which supports infinite propagation velocity is non-space. That is, it does not exist.

There would be no means of detecting such "infinite velocity supporting" space, so that it does not exist as a

scientific concept, being non-measurable and performing no function. i.e. if space cannot accomodate energy, it has no function and so does not exist.

Conclusion. We are left with the only real space, that which supports a finite velocity, and thus where $1/\sqrt{\mu\epsilon}$ is non-zero and non-infinite.

In this context, "ether" is a synonym for "space". Space has the characteristics $\mu_o \epsilon_o$; ether has the characteristics $\mu_o \epsilon_o$.

The above dealt with the definition of space and the propagation velocity it will support. A similar argument applies to its impedance.

A medium can only accomodate energy if it resists it to a "reasonable" degree. Neither an infinitely strong spring nor an infinitely weak spring can absorb (accomodate) energy by being compressed. Neither an infinitely large mass nor an infinitely light mass can absorb (accomodate) energy by being given velocity. The same is true of space. Energy could not enter space of zero impedance (i.e. $Z_o = \sqrt{\mu/\epsilon} = 0$) any more than a force can bear on a mass of zero magnitude. Similarly, energy could not enter space of infinite impedance any more than a force could introduce energy into a brick

wall.

It follows from the above that the necessary characteristics of space are;

1) finite propagation velocity and

2) finite impedance.

Lacking these, space does not exist.

Also,

Action at a distance implies no distance.

DISCUSSION OF © , Z_o, μ, ϵ

Space must have finite impedance and sustain finite velocity.

$$© = \frac{1}{\sqrt{\mu\epsilon}} \qquad Z_o = \sqrt{\frac{\mu}{\epsilon}}$$

μ, ϵ are of course the characteristics of unit volume. But we have not yet arrived at volume, which implies distance (space) at this point in the argument. All we have so far is © and Z. Therefore μ, ϵ must be defined in terms of them. It turns out (by algebra) that

$$\epsilon = \frac{1}{©Z} \qquad \mu = \frac{Z}{©}$$

Although we have said that the fundamental characteristics of space are © and Z, perhaps we should say instead that they are Z and t, t being the time delay through a segment of space AB and replacing ©, the velocity through that segment.

We should try to get away from the idea of constant velocity through space

©, which leads to the idea that a segment of space which is traversed in 1 nsec is 1 foot long. We should instead start with the concept of a segment of space t. For instance, a segment of space may be 1nsec wide. Energy entering it reappears 1nsec later. Subsidiary concepts of length and velocity can then be deduced. We may say the space is (a) 1 ft wide and the velocity is 1 ft/nsec. However, the last sentence is unnecessarily precise. The space could equally well be (b) 2 ft wide and the velocity 2 ft/nsec. Fundamental to the proposed world view is that no experiment could help us in deciding between (a) and (b).

So; the essence of space is time, not distance.

It is important in this framework that we hold onto the idea that

> Only one velocity of propagation $1/\sqrt{\mu\epsilon}$ is possible through a segment of space.

Thus, time through a segment is tightly related to "length" of the segment. Propagation which is not "at the speed

of light" cannot exist according to this world-view.

GENERAL DESCRIPTION OF ENERGY TRANSFER

Consider energy current flying "straight and level" down a uniform transmission line. The energy does not know the width of the channel down which it is passing.

If the energy reaches a point where the dielectric (but not the geometry) changes, some of it will continue and some of it will reflect.

If the energy reaches a change in the width of the transmission line, some of it will continue and some of it will reflect.

The energy current will not know whether

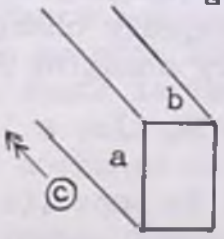
a) the dielectric is changing or

b) the geometry is changing.

Energy current does not have directional inertia, so that (a) is the same as (b).

Energy current has an aspect ratio; if the aspect ratio is required to change, some of the energy will reflect so that its "total" aspect ratio does not change. Crudely, aspect ratio is

the same thing as the ratio of E to H, or the same thing as the ratio of ϵ to μ. $\sqrt{\mu/\epsilon}$, like the aspect ratio of a region of space, can change. $1/\sqrt{\mu\epsilon}$ cannot really change; it is merely our way of conceiving time delay when energy resides in a region of space.



a/b = aspect ratio

or

$\frac{a}{b} \cdot \sqrt{\frac{\mu}{\epsilon}}$ = aspect ratio

Uniform loss-free space has only two parameters,

1) aspect ratio
2) time delay.

Aspect ratio defines the shape of the energy which may enter, but not its amplitude.

"Velocity", "length", define the time during which the properly shaped energy can be accomodated by a region of space.

Aspect ratio is really a definition of the relative compatibility of adjacent regions of space; does flowing energy current largely continue past

the interface, or does it largely reflect. Space has "quiet" zones, through which energy glides virtually uninterrupted (unreflected), and "noisy" zones, where itinerant energy current bounces about and gets split up.

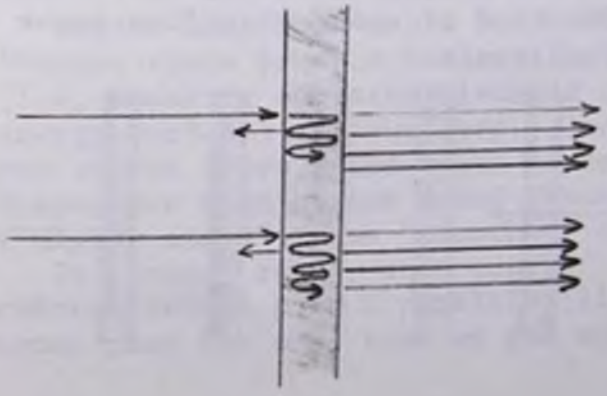
We think of "noisy" zones in space as having either (a) rapidly changing geometry or (b) rapidly changing $\sqrt{\mu/\epsilon}$.

ZEBRA SPACE AND LEOPARD SPACE

Energy current flows calmly and freely through free space (of uniform impedance and cross sectionalgeometry, or to be more accurate, aspect ratio). Such space is "smooth" space.

If a wall of energy current runs into a change of impedance (or aspect ratio), some of it reflects and some continues. Space with many such changes is "noisy" space.

If energy current passes through a thin segment of very different $\sqrt{\mu/\epsilon}$ followed by the old type of medium, the most significant effect is a delay in

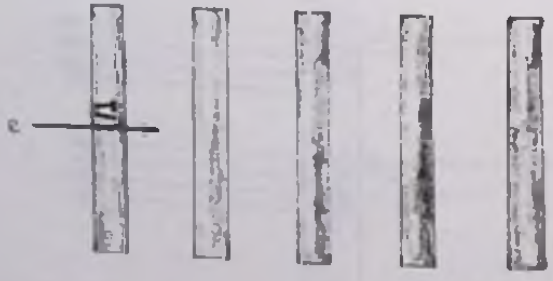


the main body of the wave front.

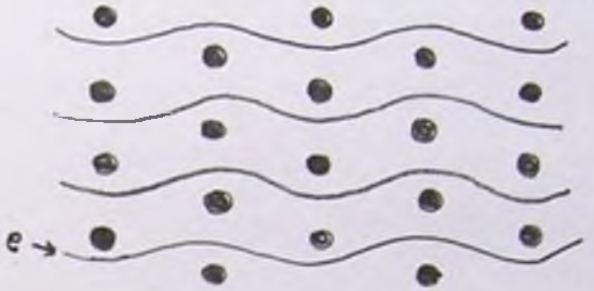
Space with rapidly alternating high impedance and low impedance would be very slow space. Energy current would take a long time to pass through it. (This is analogous to the long delay as energy is transferred to and fro between a C and an L in an LC tank circuit. See D.E.D. page 249.)

Noisy space, or alternate walls of high impedance and low impedance, will of course cause dispersion. A zero rise time signal will only get through to a tiny degree. Most of it will arrive later. The signal rise time will fall off to a value related to the width of the alternate walls and the ratio of the two impedances (and of course velocities. Width means time width not physical width.)

The kind of space described above is "zebra" space



Another kind of space which would slow down energy current is "leopard" space.



The energy current will of course undulate through this space.

We can of course postulate that each spot in leopard space is a standing wave of energy current with maximum value at the centre of the spot. That is, a particle.

Notice that both zebra space and leopard space produce dispersion (i.e. smearing out over distance of energy current) without loss. Also, we can expect lower speed space to be more dispersive than higher speed space. ("Higher speed" means "smoother" space.)

In leopard space, when energy current swings past a particle (like a comet past the sun) some of the energy

current reflects because the zone near the particle has different impedance $\sqrt{\mu/\epsilon}$ from the zone far away between particles.

FIELDS AND CURRENTS

Electromagnetic theory is dualistic in that it postulates conductors and insulators, with activity going on in both. The insulator is also called a dielectric. Imperfect media - resistive conductors and leaky insulators - we shall ignore, because they can be regarded as degradations of, or corruptions of, the pure, platonic situation of perfect conductors and perfect insulators.

Electric current, which is the flow of electric charge, occurs in conductors. Electric field - E and H - occurs in insulators. Neither phenomenon exists in the other medium.

Strictly speaking, electric charge and electric current exist only in the surface of a conductor. However, the fact remains that their home is conductors and not insulators. By contrast, electric and magnetic fields exist throughout the volume of an insulator.

It is important to fully grasp this dualism, that the home of fields is insulators and the home of electric currents is conductors - before proceeding to the important case.

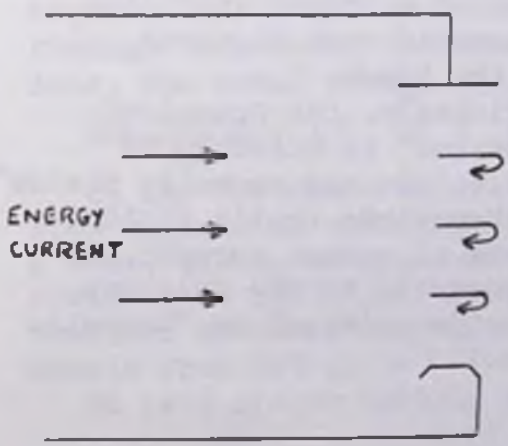
The reader will by now be familiar with the dualism of Theory N and Theory H. According to Theory N, electric current flows in conductors, as a result of which field exists in the insulator. By contrast, according to Theory H, field (energy current, or the Heaviside signal) flows down the insulator and as a result, electric current flows in the conductors.

Theory H drastically upsets the conventional view, because the subject is turned through 90^{c}. A battery no longer pushes electric current into and out of its connecting wires; it pushes field out sideways, between the conductors, into the space between the wires.

Energy current enters a diode from the space in between the two conductors, immediately entering the crucial interface between the P region and the N region. In the case of a transistor, energy current guided between the emitter lead and the base lead enters

sideways into the emitter-base junction. This is a drastically different picture from Theory N, where electrons are poured down the base lead, and then roam around the base region doing marvellous things. According to Theory H, energy current is fed directly to the critical interface between emitter and base regions.

In a cathode ray tube, energy current travels <u>sideways</u> across the c.r.t. in the space between cathode and anode. On reaching the far side of the electrodes, the energy current sees an open circuit and reflects.



An electron is conductor-bound, and has no place in the insulating space between cathode and anode. Also, the supposed electron travelling between cathode and anode would be travelling at right angles to the direction of signal (energy) flow. Probably, the "electron" is a dislocation in a reciprocating wave front of energy current. This dislocation gradually (slower than the speed of light) flows across the wave front, from cathode to anode.

One can visualise such sideways travelling dislocations in a standing wave of water in a river, or the sideways movement of a frothy surf line across the serried rows of waves approaching the beach.

Not surprisingly, the travel of such an "electron" is affected by impressed "electric and magnetic fields", (which are themselves really further standing waves of energy current.) These are generated by the "electrostatic deflection plates" or "magnetic deflection coils".

ELECTROMAGNETIC ENERGY

This chapter supplements "The Heaviside Signal", on page 17 of volume 1.

The rate of flow of energy through a surface is E.H per unit area. This energy flows at the speed of light for the medium, $1/\sqrt{\mu\epsilon}$. E,H are at right angles to each other, and both are normal to the direction of energy flow.

Energy density is $\frac{E \cdot H}{©}$.

If two Heaviside signals of equal magnitude E/2, H/2 are travelling through each other in opposite directions, the total energy density is

$$\frac{(E/2)\times(H/2)}{©} \times 2 = \tfrac{1}{2}\,\frac{E.H}{©}$$

If the direction of the two Heaviside signals is such that H cancels and E adds, giving an apparently steady field E, we still get the same energy density. However, the value of E will double from E/2 to E.

It is a simple matter, using the

formulae $E/H = \sqrt{\mu/\epsilon}$ and $C = 1/\sqrt{\mu\epsilon}$ (2) for a TEM wave, to get rid of H and © and so convert (1) into the well known formula for energy density in a so-called electrostatic field,

$$e = \tfrac{1}{2}\epsilon E^2 \quad \text{or} \quad \tfrac{1}{2} DE$$

Similarly, if two Heaviside signals flow through each other and give the appearance of a steady magnetic field as a result of their E fields cancelling, it can easily be shown, using (2) to get rid of E and ©, that

$$e = \tfrac{1}{2}\mu H^2 \quad \text{or} \quad \tfrac{1}{2} BH.$$

"Modern Physics" is based on the apparently faulty assumption that electromagnetics contains two kinds of energy, the electric and the magnetic. (See for instance M. Born, "Natural Philosophy of Cause and Chance", Clarendon, 1949, page 140; W. Pauli, "Theory of Relativity", Pergamon, 1958, page 85.) This assumption leads to a baroque view of physical reality, since the energy seems to be associated with the square of the field intensity rather the much more reasonable view of the new theory, that it is linearly proportional.

It is worth remembering that neither the "modern physicists" nor Einstein were or are familiar with Heaviside's concept of energy current, let alone the now postulated Heaviside signal. (see page 17.) It would be surprising if their theories survived such a major paradigm change. (Of course, "modern physicists" will probably survive happily by the simple stratagem of ignoring energy current, the Heaviside signal, Catt and any other progress in electromagnetic 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 $i = q$ ©. 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,

$$\frac{F_1}{F_2} = \frac{i\,B}{q\,E} = \frac{\mathrm{©}\,B}{E} = \frac{1.(\mu H)}{\sqrt{\mu\epsilon}.E} = \sqrt{\frac{\mu}{\epsilon}}\ \frac{H}{E}$$

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

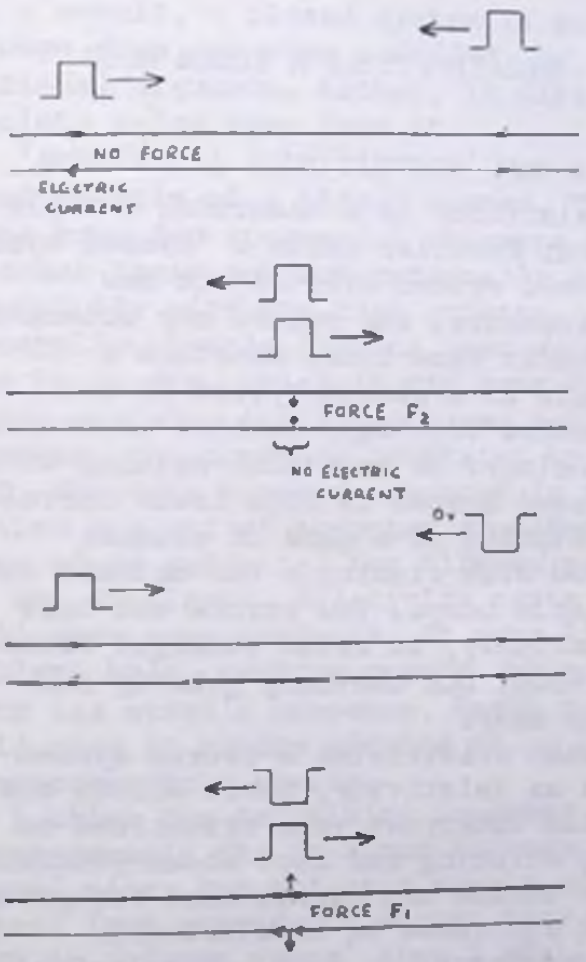
We conclude that when a TEM wave (which we call a Heaviside signal) glides along between two conductors at the speed of light, there is no force on the conductors guiding the signal. This very interesting feature of a Heaviside signal was first pointed out by David Walton, and is here proved.

(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.)

Please note that the last two chapters have been written assuming Theory N. (See page D121, M66.)



Also see letters in Wireless World, June, July and October 1985.

RELATIVITY AS A BLACK HOLE

Relativity is a beautiful example of what Koestler calls a 'closed system'. A closed system will reject new developments, and oppose any attempts to profit from them. Koestler's example of a closed system is the Communist ideology. Another is Freudian psychology. He says that arguing with a closed system is like Lewis Carrol's description of a game of croquet played with flamingos for mallets and moveable hoops. You strike the ball beautifully; it rolls straight towards the hoop, but the hoop gets up and walks away.

When criticising a closed system such as Relativity, those within the system interpret your criticisms as demonstrating far more about yourself - your social and educational background, your ignorance or intellectual incompetence, or your psychological hang-ups - than about the closed system you (not they) think you are discussing.

As a result, a closed system is not broken down, or even modified, by rational argument. Rather, it dies when society walks away from it.

'Artificial intelligence' was a good example of a closed system. There were very few successful attempts to discuss their subject rationally and fruitfully with its high priests. Generally, people like me just waited for it to die, which it did some four years ago when its funding was cut off. However, the nonsense generated by A.I. devotees blocked advances in the allied subject of computer architecture (one of my subjects) for fifteen years or so. Similarly, Relativity casts its pall over many subjects. It acts like a black hole, sucking nearby subjects into its sterile nonsense. Essen has said that it blocks advance in electromagnetic theory.

I think the Relativity nonsense will spontaneously die in about fifteen years' time, but not as a result of attack from outside. I regret very much that in fifteen years' time I shall be sixty, and have little time to contribute in the new, cleaner

scientific environment.

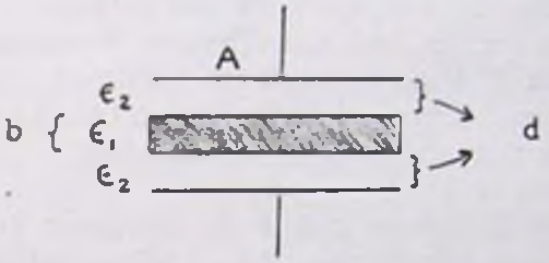
Einstein never saw a high speed logic pulse, and would not have brewed up his theory if he had. Contemporary relativity magicians have not seen a high speed logic pulse either. Those who adhere to what they call 'modern physics' - the Einstein - Bohr - Heisenberg et al. package - place a lot of faith in the misty lines photographed in a cloud chamber, but pay no attention to a C.R.T. picture of a high speed logic pulse (See for example Digital Hardware Design, pub. Macmillan, page 57) which they have never seen.

For a good discussion of today's dogmatic science and the way it operates, see "Against Method" by P. Feyerabend, pub. NLB, London, 1975, page 42.

CONDUCTORS AND OBSTRUCTORS

We shall first do some "Theory N" analysis.

Consider a parallel plate condenser.



$$C = \frac{1}{\frac{1}{\frac{\epsilon_1 A}{b}} + \frac{1}{\frac{\epsilon_2 A}{d}}}$$

As $\epsilon_2 \longrightarrow \infty$, $C \longrightarrow \frac{\epsilon_1 A}{b}$

We also know that if the centre section is a slab of perfect conductor,

$$C = \frac{\epsilon_1 A}{d}$$

This gives us the idea that in a conductor, $\epsilon = \infty$

Other arguments will bring us to the same conclusion. Since $C = q/v$ and an infinite amount of charge can traverse a conductor without generating a voltage difference, it follows that the "capacitance" of a perfect conductor is infinite and so ϵ is infinite.

Now let us use the Theory H approach.

If a TEM wave tries to advance into a region of very low Z_o, nearly all the incident signal is inverted and reflected.

If a TEM wave tries to advance into a perfect conductor, all the incident signal is inverted and reflected. So we can postulate that the Z_o for a perfect conductor is zero.

As ϵ increases for a region of space, the velocity (c) with which a TEM wave enters it diminishes.

A TEM wave enters a conductor at zero velocity; that is, (c) for a conductor is zero. Again we get the indication that ϵ is infinite.

In summary, if we regard perfect conductors as dielectrics with zero Z_o and zero (c), all the theories about

wave transmission in a region with more than one dielectric can be applied to a region with conductors as well as dielectrics, the conductors being treated either as dielectrics with infinite ϵ or as dielectrics with zero Z_o and zero ©.

Electric current is generally thought to reside within conductors in the same way as electromagnetic field resides in dielectrics. In fact, electric current resides only in the surface of perfect conductors, and never penetrates. In the dualistic "Theory H" theory of electromagnetics, energy current (the Heaviside signal) is distributed throughout the region of non-conductors (dielectrics). Electric current, by contrast, is the poor relation, and is all smeared across the outside surface of the conductors. Energy current penetrates imperfect conductors, and carries electric current with it into the interior of the imperfect conductor, which has now taken on some of the characteristics of a dielectric. However, the reader should think carefully back to the perfect case, where energy current has a proper $\frac{E \cdot H}{©}$

energy density but electric current does not. Electric current density is always infinite, in the surface of zero volume between the conductor and the dielectric.

Electric current exists only on the edge of some energy current. The reverse is not true. Energy current can exist on its own, a good example being the "steadily" charged capacitor, where energy current exists but (net) electric current does not.

What is the nature of this mysterious electric current, this layer of substance (or movement) of infinite density? It is certainly not so-called electrons leaking through the interstices of a crystal, because in that case it would have penetrated into the volume of the crystal, not merely staying on its surface. We cannot believe in electrons sliding along the outside surface of a metal crystal. Energy current is obviously more substantial, since it is distributed in space and its density relates directly to the total energy, which the "electric current" does not.

ATTITUDES TO DISPLACEMENT CURRENT

The previous volume contained letters resulting from the publication by WIRELESS WORLD of articles on Displacement Current. (Reprinted in DED pp 212 and 253.) This chapter consists of a letter by H.L. Austin, Bath, my reply, and the same for Haine;

"Dear Sir,

I have been following the series of articles by Messrs Catt Davidson and Walton with great interest.

"If my understanding of conventional em theory is correct, it rests on a few basic relationships:

static charges ⟶ static E fields (1)

steady currents ⟶ steady B fields (2)

time-varying E fields ⟶ time-varying B fields (3)

(Maxwell's hypothesis: $Hdl = dD/dt$ or curl $B = \mu\epsilon\, dE/dt$)

time-varying B fields ⟶ time varying E fields (4)

(Faraday's Law : $\int Edx = -d\phi/dt$ or curl $E = -dB/dt$)

"Number 3 has been tenaciously denied, and 4 flatly contradicted, but I do not find the arguments completely convincing, and am suspicious of the aggression with which the authors meet readers' letters.

"If Messrs C D and W's insights theories hypotheses and assertions are as profound as they believe, I feel that they (and WW editors) owe it to us all to carefully unfold them in text-book fashion, starting from basic principles we can all agree on, and citing relevant experimental observations and techniques.

"Let us have an end to the present guerilla-campaign on conventional theory, and the disreputably evasive and aggressive attacks on readers' letters. If Catt Davidson and Walton can render the edifice of conventional em theory obsolete, let them start building, but the mere vandalism we have seen to date will not do."

Here is my reply;

Please forgive the authors if they tend to identify the hostile letter writers as perhaps the same men who, as journal referees, prevented disclosure

of even a tiny part of their results for so many years.

No British technical journal has published any mention of the patented computer inventions of Ivor Catt, even though British Government support of his ideas, which started seven years ago, is now nearing the £100,000 mark in four separate concurrent projects. This shows that other subjects as well as E-M Theory are being kept out of the scientific literature.

I am afraid that Mr. Austin will have to accept that today, scientists cannot communicate their new ideas to each other. We see no way round the barrier.

The editor of WIRELESS WORLD was bitterly attacked for publishing "Displacement Current" (WW Dec. 1978). It had previously been rejected by every relevant journal in Britain and the U.S.A. including the following:-

Proc. IEE. They had previously rejected other papers submitted by I. Catt over a period of seven years.

Electronics Letters.

New Scientist.

Nature.
IEETE.
Physics Review.
Physics Review Letters.
Inst. Physics.
Proc. IEEE.
International Journal of Electronics.
Proc. IERE.

"The Heaviside Signal" was rejected by numerous journals including the following:-
The British Journal for the Philosophy of Science. (Title given to paper, "The Two T.E.M. Signals.")

In most cases, there was an appeal followed by a further rejection.

The paper "History of Displacement Current" (WW Mar. 1979) was rejected by "Physics Bulletin". It was then accepted by a second journal of the Institute of Physics, "Physics Education." However, six months later they broke their contract with the authors and revoked their commitment to publish.

Advances in electromagnetic theory are not publishable in American and British journals today. There is not even a procedure for recording them for posterity. The same rigid block applies to discussions of advances in

Relativity.

Wireless World cannot be expected to fill the role which is being evaded by the twenty relevant journals in Britain and the U.S.A. For many years now CDW have been making advances at a much faster rate than it is possible for them to publish, and the already large log-jam is currently increasing, The problem is analysed in detail in "The Rise and Fall of Bodies of Knowledge" by I. Catt, The Information Scientist, 12 (4), Dec. 1978, pp 137-144, which article was itself rejected by many journals over a period of many years. Theo Theocharis, 7A Diogenes St., Limassol TT08, Cyprus, has a great deal of information on suppression in contemporary science, including the suppression of some advances which twenty years later won a Nobel Prize. See also the writings of Michael Gordon at the University of Leicester.

Mr. Austin must either adjust to the realisation that contemporary science is about the re-appraisal and mathematical manipulation of old ideas, but not the presentation of new ideas, or else he must do something about the mechanism

of suppression. We would advise him that those who bring gifts (the people like us with new, undisclosed ideas) are not the right people to attack.

Another letter: * page 279

"Messrs Catt, Davidson and Walton are perhaps right to draw attention yet again to the importance the distributed nature of real capacitors can have in real circuits (December 1978 issue). Its significance in r.f. circuits is well-known and obviously it has some slightly unexpected subleties in high-speed pulse circuits. But I cannot see how they can claim to have excised displacement current from Electromagnetic Theory - or in their case circuit theory- in any useful way.

"To begin with, Kirchoff's "Laws" apply to ideal circuits of zero physical extent described by simple mathematical relationships between their terminal voltages and currents. No assumptions are made about their physical nature, nor is the concept of "displacement current" necessary for the development of all the richness of modern circuit theory from these basic assumptions. Nor is there any doubt about the practical

usefulness of the resulting theory, for example, in successfully designing high-performance filters.

"If one must, for the sake of peace of mind, equate the terminal current of a capacitor with " ... a mathematical manipulation of the electric field E between the capacitor plates" all well and good, and no harm will come provided the limits of the approximations necessary are always borne in mind; for example, that the dimensions of the capacitor must be small compared with the wavelength of the electrical disturbance being considered. But where is the conceptual improvement in equating the terminal current to what must in the end be a mathematical manipulation of the electric and magnetic fields associated with a transmission line? Especially when the manipulations involved are a lot more difficult.

If, as they claim, the concept of displacement current permits the retention of Kirchoff's laws, does their "excision" of it throw out those too? And if so, what analytical tools are left to us for circuit analysis? If their transmission-line concept replaces displacement current, then how so? For

there is still no closed path in which current can flow.

In short, are we to regard this article as a warning to beware of transmission-line effects in capacitors at frequencies (or pulse widths or risetimes) where they may be important, and can we therefore take the philosophical claims with a pinch of salt? Or are we asked to change the fundamental basis of circuit and electromagnetic theory as we know it? If the latter, I find the claims made to be very unconvincing." - John L. Haine, Chelmsford, Essex.

The authors reply: We find the second paragraph of Dr. Haine's letter ambiguous, and so cannot reply to it except to say that "modern circuit theory" is rich, in the same way as other tall stories are rich. High-performance filters are not designed using "modern circuit theory", because inductors and capacitors are not designed using theory; they are cobbled in a haphazard, experimental way. Try talking to the "experts" in a company designing chokes or capacitors.

As with para. 2, we find para. 3 is

back to front, or at least ambiguous.

Para. 4. The answer is, yes. Traditional analytical tools have been useful in the setting and passing of examinations, but not in practical engineering problems; emphatically not in the interconnection of high speed (1 ns) logic, where they have created havoc, leading to the abandonment of virtually all such projects.

Para. 5. You are asked to change the fundamental basis of circuit and electromagnetic theory as we know it. The need to successfully assemble high speed logic systems forces us to abandon the slovenly mess which has masqueraded as electromagnetic theory for fifty years, and build a sound theory from the ground up. The first casualty is displacement current, the bastard issue of a marriage between ignorance and nonsense. We must clear away the rubble before we begin to build.

"Our electrical theory has grown like a ramshackle farmhouse which has been added to, and improved, by the additions of successive tenants to satisfy their momentary needs, and with

little regard for the future. We regard it with affection. We have grown used to the leaks in the roof.... But our haphazard house cannot survive for ever, and it must ultimately be replaced by a successor whose beauty is of structure rather than of sentiment."
- Intermediate Electrical Theory, by H.W. Heckstall-Smith, Dent, 1932, p283.

A lot more sludge has collected since 1935. We must dredge deep, through a century of sycophancy.

Note on the H.L. Austin letter, which ends on page 274.

"Death of Electric Current", pub. Wireless World, December 1980, was previously rejected by:-
American Journal of Applied Physics.
Scientific American.
Physics Bulletin.

I now believe that I can isolate quanta of information which will not be tolerated in any learned journal for ten years, but which will be standard teaching in twenty years from now. To cynically quote from my writing in Wireless World, August 1981, page 40, "There is a time and place for theories". However, I did not mean it in quite that way. One such quantum of information is that the so-called steady charged capacitor contains two reciprocating energy currents. This has been rejected by the four leading learned journals in Britain and the U.S.A.

C.A.M.

AFTER MAXWELL'S EQUATIONS REVISITED

In March 1980 the chapter on page 97 was published in WIRELESS WORLD. There were many replies. The rest of this chapter is my reply to the replies.

All twenty-two replies ignored the physics and concentrated on the mathematics. It seemed that whether Maxwell's equations mapped meaningfully and usefully onto reality mattered not. All that mattered was that the maths should be internally correct, or at least respected. An engineer like myself, who has successfully interconnected high speed (1 nsec) logic, working as if through a blizzard of irrelevant, convoluted maths, takes the opposite view.

Some of the replies thought the minus sign should be there; some said it should not be. None noticed or contradicted my point, that the minus sign had no physical significance. (In fact it is an outgrowth of partial

For another discussion of Maxwell's Equations see Wireless World Nov84.

differentiation. Full differentiation has no minus sign, being a completely different operation from partial differentiation, in which the sign appears regardless of the nature of that which is being differentiated. Always at a point on a surface in a three dimensional graph, the three slopes are related by

$$\frac{\partial z}{\partial x} \cdot \frac{\partial y}{\partial z} \cdot \frac{\partial x}{\partial y} = -1$$

The minus sign has nothing to do with electromagnetic theory.

This contrasts with

$$\frac{dx}{dy} \cdot \frac{dy}{dz} \cdot \frac{dz}{dx} = +1$$

which is always true of the gradients of lines in two dimensional graphs.)

The following letter was sent to a number of leading lights in the field;

Dear Professor Mott, Dirac, Salaam,
Brown, Lindsay, Bleaney,
Gosling, and
Dear Mr. G.G. Scarrott,

The article "Maxwell's Equations Revisited", Wireless World, March 1980, has caused many readers to write replies,

virtually all of them hostile. Many of them express concern that damage will be done by such a misleading article if it is not followed by a rebuttal.

Since it is impossible for Wireless World to devote space to all the replies, the editor has suggested that the author summarize the replies and then answer his own summary.

The author is concerned that he would then be acting as judge and jury in his own trial. It seems much better if a renowned senior scientist construct the summary.

Your name has been put forward as appropriate for this role, and the author will be very grateful if you agree to help in this matter. An early reply would be very much appreciated, and a s.a.e. is enclosed.

Yours sincerely,

Ivor Catt.

Professor Brown, IEE and Imperial College, replied as follows;

Dear Mr. Catt,

Thank you for your letter and copy of your paper in Wireless World. I am afraid I cannot help as you

suggest. There are two reasons for this. I shall be out of the country for the next month and am fully committed when I return. The second reason is that I disagree completely with your paper and would not approach the discussion in an unbiassed way.

The reason for my disagreement is very very simple. You imply that equation (1) is a general statement which will be always true. This is not the case. Consider your example of the train - a complete statement of the situation is covered by the expression

$$h = h(x-ut)$$

where the train is travelling with uniform velocity, u, in the positive x-direction.

Let $w = x - ut$

Then $\frac{\partial h}{\partial x} = \frac{dh}{dw}\frac{\partial w}{\partial x} = \frac{dh}{dw}$

and $\frac{\partial h}{\partial t} = \frac{dh}{dw}\frac{\partial w}{\partial t} = -u\frac{dh}{dw} = -u\frac{\partial h}{\partial x}$

For this case - the one you discuss - equation (1) becomes

$$\frac{\partial h}{\partial t} = -\frac{dx}{dt}\frac{\partial h}{\partial x}$$ since $\frac{dx}{dt}$ has the

constant value u.
I therefore cannot agree that there is any anomaly of the kind you suggest.

Yours sincerely,

John Brown.

His letter is typical, in that after saying he disagreed with me, he methodically proved the starting point of my article, viz:

$$\frac{\partial h}{\partial t} = -\frac{dx}{dt}\frac{\partial h}{\partial x}$$

which surely means that he agreed with me up to my equation (2). What his feelings were beyond that point, about the article proper, we do not know.

All the other luminaries refused to contribute, except G G Scarrott, IEE and ICL, who wrote, "... I will be delighted to try." However, on being sent the first eleven letters (by date) he backed off, saying,

Dear Mr. Catt,
Thank you for your letter of 28 April and the reminder dated 19 May.
Now that I have seen the letters to the Editor, it seems unnecessary for me to summarise them since the letter writers have already made the essential points

quite clearly. I therefore suggest that the Editor publish one of the letters to which you reply with a brief note that similar letters have been received from others. My choice for the most representative letter is R.C. Hayes from the Department of Electrical Engineering and Electronics, Liverpool University.

Yours sincerely,
for INTERNATIONAL COMPUTERS LIMITED

G.G. Scarrott
Manager-
Research and Advanced Development Centre

I wrote to the rest of the first eleven letter writers and asked them if they agreed with Scarrott. Some said yes, and others did not reply.

Here is the Hayes letter.

Dear Sir,

Regarding Mr. Catt's latest article "Maxwell's equations revisited" ..., I feel that he should be relieved of some of his pseudo-mathematical delusions.

For example, what exactly does he mean by the equation

$$\frac{\partial h}{\partial x}\,\frac{dx}{dt} = \frac{\partial h}{\partial t} \qquad (1)$$

"One criticism is that dx/dt can only be used to represent the velocity of the train if x represents the x - coordinate of a fixed point on it. Mr. Catt originally introduced x and t as independent variables to define a point in space-time, so dx/dt is a meaningless quantity.

Also, if Mr. Catt had really performed a "careful analysis" he would have had great difficulty in deriving equation (1) in the first place, as anyone with even an elementary knowledge of partial differential calculus could tell him.

Equation (2)

$$\frac{\partial H}{\partial x}\,\frac{dx}{dt} = -\frac{\partial H}{\partial t} \qquad (2)$$

falls into the same category of fallacies. Small wonder that it never appears in the textbooks!

Mr. Catt then goes on to say that "almost anything" is a solution to the equations

$$\frac{\partial E}{\partial x} = -\frac{\partial B}{\partial t} \qquad (3)$$

and

$$\frac{\partial H}{\partial x} = -\frac{\partial D}{\partial t} \qquad (4)$$

"This, to put it mildly, is a slight exaggeration of the facts. It is a fact that a sinewave, or a number of sinewaves, is the solution of the equations given the correct boundary conditions. Mr. Catt's train is also a solution of the equations but since it obeys a different set of boundary conditions it does not appear as a sinewave. More rigourously, the train profile can be considered as a Fourier series comprising an infinite number of sinewaves with different frequencies and amplitudes, and possibly also some exponential terms. terms.

"Having demonstrated the nonexistence of any justification for the "theoretical" part of the article, I would like to ask the author if he has any justification for the abuse he proceeds to hurl at mathematicians in general. Mathematics is a tool for the scientist or engineer to enable him to concisely describe physical phenomena. Insight, or a "feel" for the phenomena, is built into the equations and a competent engineer should be able to "look inside" the equations and visualise what they represent. Visualisation of abstract concepts is more difficult but simply

because mathematics is used as an aid in describing them does not make the theory "ludicrous and false".

"Waveguides, antennae and the like are designed using Maxwell's equations, not by hit-and-miss methods, and behave as predicted by the mathematics. Electromagnetic theory is mathematical by its very nature and if Mr. Catt abandons the mathematics he will be left with very little of any practical use.

Yours faithfully,
R.C. Hayes,
3rd year undergraduate student."

Here is my reply to the Hayes letter.

Equation (1) relates three things,

(a) The slope of a surface,
(b) Its forward velocity,
(c) The rate of rise of the surface.

If the slope is 1 in 4, the forward velocity 10 metres/sec, then the rate of rise of the surface is 2½ metres per sec.

This kind of relationship is the stuff of which science and engineering is composed. I think Hayes knows full well what (1) means, since he has studied A level mechanics.

Equation (2) says that if an unchanging TEM wave moves forward at the speed of light, the gradient of H with forward distance is related to the gradient of H with time. If it is a fallacy, then what is the correct formula? Or are we not allowed to relate $\partial H/\partial x$ to $\partial H/\partial t$ for a TEM wave?

Let Hayes tell mechanical engineers to convert their trains into a Fourier array of sinewaves, and see how they react! Thank God mechanical engineers are too practical to be sucked into the kind of nonsensical quagmire that permeates electromagnetic theory! I do not want to travel in a train with some exponential terms designed into or out of it! Would Hayes recommend that the passengers be positioned so as to minimize their harmonic content?

Waveguides, antennae and the like are emphatically <u>not</u> designed using Maxwell's equations, any more than a tribal dance wins the battle that

follows.

My successful pioneering attempts to interconnect high speed (1 nsec.) logic in Motorola in 1964 forced me to abandon all the nonsensical maths that had grown like weeds to choke electromagnetic theory. A logic step is emphatically not a Fourier array of sine waves, and you will run into all sorts of nonsense if you kid yourself that it is. Also, you can only successfully decouple the 5 volt supply to sub-nanosecond logic because it is untrue that capacitors have stray series inductance. The regular abandonment, at vast cost, of high speed logic systems during development will only cease if Hayes and the rest let us infiltrate some common sense into electromagnetic theory, and it stops serving merely as a favourite stamping ground for physically ignorant, fancy maths obscurantists. We must take the blarney out of electromagnetic theory.

(I then said I enjoyed the Irish letter best, and my letter ended with a copy of a curious letter, all in capitals, from Ireland.)

THE EDITOR
WIRELESS WORLD.
DEAR SIR,
DOES ANYONE PROOF-READ YOUR ARTICLES? I REFER
I REFER TO MR CATT'S ESSAY IN WW MARCH
1980. HIS EQUATION (2), WHICH IS ABSURD
(ASSUMING CONVENTIONAL MEANINGS FOR THE
SYMBOLS) IS DERIVED FROM A TRIVIAL
ERROR. HE NEGLECTS THE FACT THAT HIS
OBSERVER, SITTING ON A FENCE WATCHING
THE TRENDY (125) TRAIN, IS TRAVELLING,
RELATIVE TO THIS (125) TRAIN, IN THE
DIRECTION OF DECREASING 'x'. THIS
SUPPLIES THE MISSING NEGATIVE SIGN.
I PLEAD WITH YOU TO DEVOTE YOUR VALUABLE
- AND MUCH RESPECTED - SPACE TO A BETTER
QUALITY OF MATERIAL THAN THAT PRODUCED
BY SUCH 'CONSULTANTS' AS MR CATT. MANY
PEOPLE BELIEVE WHAT THEY SEE IN YOUR
MAGAZINE, AND THIS CAN GENERATE GREAT
HARM - IT FOSTERS A TENDENCY TO SCOFF
AT ESTABLISHED PRINCIPLES WITHOUT
SERIOUSLY ATTEMPTING TO ANALYSE THEM.
I HOPE YOU WILL PUBLISH A CORRECTION
OF MR. CATT'S BLUNDER.
JOHN LYSAGHT
14 PINE LAWN
OLD BAWN
TALLAGHT
CO. DUBLIN

P.S. WHAT EXACTLY
IS A (125) TRAIN???

C.A.M.

RELATIVITY

After some years of first hand experience of the contemporary body scientific's hostility and fear in response to attempts to present new information, I started to look back to earlier times in an endeavour to find statements more consonant with my own more scientific position.

The loud, pervasive braying that the turn-of-the-century men were philosophers as well as scientists (c.f. "Albert Einstein - Philosopher-Scientist" ed. Schilpp, 1949) led me to hope that I would find solid virtues propounded by them; foundations upon which a healthy body scientific might be rebuilt.

My hopes were ill founded. For all their excruciating, continual mutual congratulation of each other's philosophical profundity, I found them to be shallow.

It is of course important to begin by trying to discover who are the

"great men" and who are their possibly ignorant, misguided sycophants. However, since I find the work of all of them muddled, I cannot do this by direct inspection. This has forced me to take seriously all those invited to contribute to "great men commemoration" volumes, and to point with concern to major howlers in their writings.

One finds ample evidence of the seeds of decadence in the writings of the leading scientists of the 1900's which would inexorably lead to the farcical mess which passes for profound science and philosophy of science today.

THE CORRESPONDENCE PRINCIPLE

In 1979 when a contemporary "scientist", one Mr. Burrows of U.K.A.E.A. Culham, sat in my house and insisted that "any new theory must contain the old theory as a subset", my colleague M. Davidson and I were horrified. Later, I was even more horrified to find that the essence of that idea - surely the death-knell to scientific advance - was attributed to Niels Bohr.

On page 244 of the book "Niels Bohr" edited by S. Rozental, pub. North Holland, 1968, in a chapter written by C. Møller and M. Pihl, we read;

"In brief, this principle states the condition that, in the limit when the new theory is applied to that part of our experience for which classical physics is able to account satisfactorily, the two theories must agree."

This statement, admittedly <u>about</u> Bohr and not <u>by</u> Bohr, contains an elementary error, in spite of the fact

that on page 95 of the same book, Heisenberg writes with approval, "Bohr was primarily a philosopher, not a physicist...."

It is easy to show the error in the "Correspondence Principle" as defined above.

Suppose Theory A meets (predicts) experimental results P. A, being a theory and not merely a set of experimental results, is more than P.

Let us say that A = P + L

If we come up with a new theory, Theory B, it will likewise be more than the experimental results P

Let B = P + M

It is clearly possible that M = L + X, where X is an addition to the first theory A. But this is obviously not necessary, except in the sense that academia does not want to modify its courses and text books.

On page 244, Møller and Pihl go on to say,

"What Bohr could get out of consistently and obstinately applying this principle, which in 1918 he stated very generally and quantitatively, was almost unbelievable. One could turn things

upside down and say that he taught physicists to think in such a way that the unavoidability of every old and well-tried theory being contained in a newer and more comprehensive theory, came to be used as an extremely fertile systematic principle in efforts to extend the limits of knowledge."

The use of the word "knowledge" here is probably the nearest one can get to scientific blasphemy. Self-serving systems for protecting established scientists and their theories should not be described as "efforts to extend the limits of knowledge".

See also "Against Method" by P Feyerabend, pub. NLB 1975, page 36.

THE RIGID ROD

Einstein considered a universe which contained no instantaneous action at a distance. He peopled this universe with rigid rods travelling at constant velocity and observers also travelling at constant velocity, some of these observers finding it convenient to attach themselves to a suitable rigid rod.

Observers were equipped with clocks and with flashlights for signalling to each other.

The nature of the rigid rods was never discussed. This caused no concern to those scientists with no practical experience of "rigid" rods, which excludes me.

Many years ago I worked on the design of a high speed line printer. A rod, or hammer, collided with a suitable letter etched onto a rotating drum. Paper and ink ribbon caught between hammer and drum would cause the printing of a letter. The letter would

be smeared for a time which related to the dwell time of the hammer on the drum.

This led me and others to consider the minimum dwell time, or contact time, for a hammer bouncing off a drum. We concluded that when the front face of the hammer hit the drum, a message would travel down the rod at the speed of sound, telling the back end of the hammer that there was a problem. On receipt of the message, or sound wave, the back end would start to accelerate away, at the same time sending a message, or sound wave, back to the front end of the hammer. On arrival, this return sound pulse would cause, or allow, the front end of the hammer to recoil from the drum.

Minimum dwell, or smudge, time was thus equal to twice the time for sound to travel the length of the rod.

It was not clear why, after impact and recoil, the sound waves should ever cease to run up and down the rod, causing periodic changes in the length of the rod. Similarly, a rod composed of particles composed of standing electromagnetic waves in the manner of Schrödinger could be expected to have periodic changes in length merely as a

result of the past history of the rod.

A necessary part of a credible description of the Principle of Special Relativity by Einstein would be a discussion of the nature of the "rigid" rods or reference systems used in the theory. Until I find a discussion of the rigid rod which alters my view of it, I shall continue to see the "rigid rod" of Special Relativity as a device which by definition breaks the rule of no instantaneous action at a distance, and so can have no place in the theory.

Reference. "A Sophisticate's Primer of Relativity" by P.W. Bridgman, R.K.P. 1963, p95.

COMPLEMENTARITY

Niels Bohr postulated his Principle of Complementarity around the turn of the century. The Principle states that light is both wave and particle, and behaves as one or the other or both. This idea has captured the stage of science, and is not disputed by established scientists today - that is, scientists who are paid for their "scientific" activity.

Let us describe the two concepts which together form the Principle of Complementarity. The particle, or photon, is something like a billiard ball, solid, unchanging. The wave, or photon, is a sinusoidal excitation spread through a small region of space. In his book, "Albert Einstein: Philosopher-Scientist", ed. Paul Arthur Schilpp, pub. Library of Living Philosophers, 1949, Walter Heitler says of the wave, page 191;

"Now a wave track with a given wave length has necessarily a long extension in space and therefore leads to a great uncertainty of the position of the

electron. On the other hand, if the position is sharp, the wave function is such that it is different from zero only in a very small region of space. There is no trace of what we usually call a wave. As is well known, from Fourier analysis, such a "wave packet," as it is called, can be built up by a superposition of many monochromatic waves with many very different a e lengths. It follows then that we cannot assign a given wave length or, by the relation $\lambda = h/mv$, a given velocity, to such an electron. In other words, the velocity is not sharp." Previously, on page 188, Heitler says, ".... not much would be changed if we substitute a beam of light for a beam of electrons and a light quantum for an electron."

Now presumably the particle, or photon, continues in its state of uniform motion in a straight line by the mechanism of Newton's Laws of Motion. The wave needs quite another theory to explain its motion forward at the speed of light. This explanation involves a continuing metamorphosis between electrical energy and magnetic energy, and tends to be regarded as only possible

for a sine wave

Particle Wave

The mechanism for wave propagation is outlined in Kip (see page 32), Carter (see page 107) and many other books.

The dualistic explanation of light was needed because neither particle nor (sine) wave was on its own versatile enough to explain all aspects of the behaviour of light. Had some hybrid concept, some way between that of the particle and that of the wave, been available, it would have won the day and saved science from the awkward dualism of Neils Bohr.

Such a hybrid did appear a century ago, but was then and remains today unknown to physicists, who therefore have to struggle along with their awkward wave-particle dual.

The Heaviside signal was described at length in Wireless World, July 1979,

and reprinted on page 17. It has many of the attributes of a sine wave but also many of the attributes of a particle. It will surely prove to be the missing link which resolves the wave-particle dualistic paradox and puts physics back on a sound footing after nearly a century of confusion.

EINSTEIN ROCKS THE BOAT

Einstein's theoretical position should not be identified with what its adherents (and we shall) call "modern physics". He rejected the legacy of the early twentieth century with which his name tends to be associated. I am impressed by his firmness in refusing to yield to the blandishments of most of his closest associates, who tried to get him to "come quietly" on the questions of quantum theory and the uncertainty principle.

In "The Born-Einstein Letters" by Max Born, pub. Macmillan 1971, we read on pages 158, 164 and 168 statements made in the late 1940's by Einstein:

"... I am quite convinced that someone will eventually come up with a theory whose objects, connected by laws, are not probabilities but considered facts, as used to be taken for granted until quite recently."

"... We all of us have some idea of what the basic axioms in physics will

turn out to be. The quantum or the particle will surely not be amongst them; the field, in Faraday's and Maxwell's sense, could possibly be, but it is not certain."

"Quantum Mechanics and Reality. In what follows I shall explain briefly and in an elementary way why I consider the methods of quantum mechanics fundamentally unsatisfactory."

On page 170, Einstein says,

"If one asks what, irrespective of quantum mechanics, is characteristic of the world of ideas of physics, one is first of all struck by the following: the concepts of physics relate to a real outside world, that is, ideas are established relating to things such as bodies, fields, etc., which claim a 'real existence' that is independent of the perceiving subject- ideas which, on the other hand, have been brought into as secure a relationship as possible with the sense-data. It is further characteristic of these physical objects that they are thought of as arranged in a space-time continuum."

Born criticises Einstein's position on page 227, where he says;

"... as an unconditional follower and apostle of the young Einstein, I swore by his teachings; I could not imagine that the old Einstein thought differently. He had based the theory of relativity on the principle that concepts which refer to things that cannot be observed have no place in physics: a fixed point in empty space is a concept of this kind, in the same way as the absolute simultaneity of two events happening in different parts of space. The quantum theory came into being when Heisenberg applied this principle to the electronic structure of atoms. This was a bold and fundamental step which made sense to me immediately and which caused me to concentrate all my efforts in the service of this idea. It was, then, clearly incomprehensible to me that Einstein should refuse to accept the validity of this principle, which he himself had used with the greatest success, for quantum mechanics, and that he insisted that the theory should supply information about questions of the type of 'how many angels can sit on the point of a needle'. For this is

what Einstein's requirement, that a physical state must have an objective real existence even when it proves impossible to postulate a principle for it, amounts to, as Pauli clearly explains. And he claims, moreover, that any theory which offends against this is incomplete. In an earlier letter he expressed this by saying that he was opposed to the philosophy of 'esse est percipi'."

I agree with Born that what I would call the 'bitter medicine' in Heisenberg's uncertainty principle, that that which cannot be measured does not exist; had already been administered by Einstein when he got rid of absolute space, on the same grounds. (We assume here that the commonly reported null result of Michaelson-Morley is a true report.) With his denial of the reality of absolute space on the grounds that it was unmeasurable, he sowed the wind. We and he have reaped a whirlwind in Heisenberg's uncertainty principle and all the other hobgoblinry which is called "modern physics". The page 170 quotation from Einstein serves well as an argument against the principles underlying

Relativity. If we have failed to measure absolute position or absolute velocity, it does not follow as a scientific fact that absolute space does not exist. That should have been obvious to Einstein and also to the "modern physics" mystics.

THE SIGN OF TIME

It was shown on page 101 that the equation $\frac{\partial h}{\partial x} \cdot \frac{dx}{dt} = \frac{\partial h}{\partial t}$ is clearly wrong if we use the usual conventions, because since velocity dx/dt is by convention positive, the left hand side of the equation is negative when the right hand side is positive. (There is further discussion of the subject on page 112.) The root cause of the problem is a misunderstanding of the relationship between space and time. This misunderstanding runs like a cancer thrcugh the writings on Relativity. Since we agree that the universe is essentially conservative rather than continually growing, it is absurd to think that as time goes by we gain both time and distance. Time goes. It does not come. Minkowski and the rest seem to believe that as a particle or observer traverses distance (space), time also is gained. This is implicit in his paper in the book "Principles of Relativity" by

A. Einstein etc., pub. Dover, 1952, page 76;

"Then we obtain, as an image, so to speak, of the everlasting career of the substantial point, a curve in the world, a world-line, the points of which can be referred unequivocally to the parameter t from $-\infty$ to $+\infty$."

More properly, as we saw on page 113, time passes from the distant past $t = +\infty$ to the distant future $t = -\infty$. The historical accident that clocks have the hours numbered 3 o'clock, 4 o'clock, 5 o'clock as the afternoon advances rather than 5, 4, 3 should not have eaten into our science as if it contained a fundamental truth, which it does not.

Minkowski and the rest play around with Pythagoras, (ibid page 80) $c^2dt^2 - dx^2 - dy^2 - dz^2$ and this obscures the flaw in his reasoning because the signs of dx/dt and of dt (which should both be negative) disappear when they are squared. The correct way to state his formula is

".... at any world-point the expression (cdt + ds) always has a negative value [where s represents distance] ...." He is wrong to say,

"..... $c^2dt^2 - dx^2 - dy^2 - dz^2$ always has a positive value, or, what comes to the same thing, that any velocity v always proves less than c."

The truth underlying his statement is merely that if you travel slower than the speed of light you fall behind; you are squandering an opportunity. There is nothing more significant in his statement, at least nothing useful or sensible.

As time goes by, we <u>lose</u> vt but we <u>gain</u> s.

$\Delta(vt) + \Delta(s) = 0$

or < 0 if we travel slower than c.

Now, $\Delta(vt) = -\Delta(s)$

and $(\Delta vt)^2 = (\Delta s)^2$ are true mathematical statements, but only serve to obfuscate. There is no justification for putting (velocity x time) and (distance) on the opposite sides of an equation. Also, childish algebraic manipulation should never have been used to obscure the negative relationship between time and space. Time and space do <u>not</u> increase together. It follows that time is totally different from space, and Minkowski's statement on

page 75, ".... only a kind of union of the two will preserve an independent reality." is nonsense.

It is scandalous that a confusion over the sign of velocity should have been covered up for seventy years by crude Pythagorian sum of squares foolery and that nobody has had the wit and the power to point out the flaw. Probably the answer is that power is inversely proportional to wit.

Minkowski continues with his ghastly, unintentional cover-up. See (ibid) page 88,

"We can determine the ratio of the units of length and time beforehand in such a way that the natural limit of velocity becomes $c = 1$. If we then introduce, further, $\sqrt{-1}\, t = s$ in place of t, the quadratic differential expression

$$d\tau^2 = -dx^2 - dy^2 - dz^2 - ds^2$$

thus becomes perfectly symmetrical in x, y, z, s; and this symmetry is communicated to any law which does not contradict the world-postulate. Thus the essence of this postulate may be clothed mathematically in a very pregnant manner in the mystic formula

$3 \cdot 10^5$ km = $\sqrt{-1}$ secs."

This is mathematical mania run riot.

To compound the mess, Sir James Jeans says in "The Mysterious Universe", Cambridge U.P., 1931, page 96,

"And we shall not measure time in ordinary seconds, but in terms of a mysterious unit equal to a second multiplied by $\sqrt{-1}$ (the square root of -1). Mathematicians speak of $\sqrt{-1}$ as an "imaginary" number, because it has no existence outside their imaginations, so that we are measuring time in a highly artificial manner. If we are asked why we adopt these weird methods of measurement, the answer is that they appear to be nature's own system of measurement; at any rate they enable us to express the results of the theory of relativity in the simplest possible form. If we are further asked why this is so, we can give no answer - if we could, we should see far deeper than we do now into the inner mysteries of nature."

This leads me to want to add "very bad" to his statement, page 115,

".... the universe appears to have been designed by a [very bad] pure mathematician."

All of this nonsense leads us to consider whether fundamental reforms are needed in the contemporary body scientific.

1) We must re-introduce the concept of "mistake" into science.
2) We must re-introduce the concepts "ambiguity" and "nonsense".

Since 1910, when science became too prestigeous, the Establishment has outlawed the idea of "mistake". In future any statement, however blatantly false, would merely be called "another point of view". There would in future be no way to separate the class of statements which includes "electric current is the flow of electrons" and "energy is conserved" from the class which includes " 2 + 7 = -9 ". In future the latter would be not a mistake, but a new theory (or point of view) just as much as the former are theories or points of view. It is noticeable that there are no recorded cases of "ambiguous nonsense" in mathematical physics, let alone "mistakes". Minkowski can make a simple mistake in his mathematics, as you or I have often done in a lower school test, and it becomes glorified into a "new theory"; even more so if

the author's name is foreign and he rates in the public eye alongside the Queen of England, Stanley Matthews and Agatha Christie as a Top Person. (It also helps to be a member of a displaced minority group, and to speak in broken English, of course.)

Minkowski's paper referenced above classifies him clearly as a second rate thinker and a poor mathematician with scant regard for detail.

THE SCIENTIFIC RECEPTION SYSTEM AS A SERVOMECHANISM

In order to survive, a body of knowledge must attract funding. "Funding" can mean, quite crudely, supplies of cash. It can also mean support by acolytes, or 'researchers' willing to 'work' for nothing and in this way subsidize the body of knowledge. Instead of money, such people accept as payment pieces of paper called 'degrees', institution membership, etc. etc. We shall call this activity "zero purchase". Also to attract funding, the body of knowledge must stabilize and create an easily recognizable destination for funding. This destination may be a university faculty or a scientific institution. Credibility is gained for such an institution if it owns leading knowledge brokers, or 'experts'. An individual achieves expert atatus by accumulating status symbols, from Nobel prizes down to A level passes, and by becoming the editor of an obscure journal or by publishing papers and obscure books. An important distinguish-

distinguishing feature of virtually all of these status symbols is that they are not directly profitable at point of purchase. Anticipated fringe benefits are all. For example, the book with low sales and low royalty counts as a status symbol for the author, but the profitable best seller does not.

By indulging in unremunerative activity helpful to a body of knowledge, a would-be knowledge broker gains 'credit points' for 'selflessness' and 'scientific honesty'. If he gains enough such credit points, he may become one of the leading members of the knowledge establishment and recoup his investment of unpaid toil during the previous decades. However, most people who run in the 'academic selflessness' sweepstakes never recoup in cash terms, but have to be satisfied with the periodical reception of further pieces of paper - M.Sc., Fellow of the Institute, CBE, etc. etc.

When a scientist has attained guru status within an organization and helps it to attract funding, it is important for him and for the organization that his guru status should be made secure.

He can ensure this either (1) by continuing to maintain mastery of the evolving body of knowledge, or more simply (2) through his refereeing and editorial power, by stabilizing that knowledge and preventing it from developing, or (3) by some combination of the previous two techniques. In practice, he opts for stability but garnished with gradual growth at a pace well within his (possibly by now failing) capabilities.

As well as by the ownership of gurus, an organization uses its official journals to establish itself as a proper destination for funding (and zero purchase). However, in the same way as a salesman tries not to disturb and confuse the customer when making a sale by throwing doubt on the merit of his product, journals can only serve their purpose if they contain no hint that the fount of knowledge may not reside within the organization. On the other hand, totally bland discourses in its journals (and totally bland lectures by its resident gurus) pose another threat to an organization's money supply; the charge that they have

gone to sleep, or are old, decadent and rusty. Discussion and dispute must be seen to occur, and this needs to be reasonably orchestrated so as to give both the indication of internal division (or life) in the organization, but not at such a level as to threaten fragmentation leading to the need for the money source (perhaps a government committee or charitable foundation) to take sides by deciding which fragment to finance in the future. Organizations which fail to 'fine tune' this orchestration have disappeared, so those that survive can do this job.

A money source (and even more so a "zero purchase" PhD student) also has to achieve status by pointing to the status of the organization or organizations it supports. In engineering terms, any 'life', or 'dispute', represents positive feedback, a destabilizing factor with dangerous possibilities, contrasting with the stabilizing effect of the reiteration of antique ideas.

Once, many years ago, I designed a triple Darlington amplifier, and was surprised to find that in addition to the heavy D.C. current, it could

oscillate at low amplitude and very high frequency, the frequency of the first, small, drive transistor, with the following two high power, low speed, transistors acting passively as forward biased conducting V_{be} diodes. This is a good model for the compromise invariably reached by the organizations milking a body of knowledge in order to secure their continued funding. The high frequency, superficial, harmless oscillation, or argument, shows the signs of life needed to reassure the funding sources, while paradoxically at the same time the large, steady, bland communication lower down also serves to reassure. This is why a body of knowledge will tolerate, and even encourage, argument and violent disagreement about trivial detail while at the same time blocking all questioning of fundamentals. To change the metaphor, a body of knowledge is like a large raft on which all kinds of violent games can and must be played, but no one must attack the raft on which they stand, because then everyone would drown in new ideas.

INDEX

This is a cumulative index covering the present volumes (E), the two volumes DIGITAL ELECTRONIC DESIGN (D), the Macmillan book DIGITAL HARDWARE DESIGN (M), and some WIRELESS WORLD articles (WW).