the inability of the ear to separate individual voices in a crowd is the result of intermodulation distortion due to non-linearity in the transducer, and if damage to the peripheral hair cells causes this problem or makes it worse, then it is likely that these flanking hair cells, connected to the brain (but only to receive signals, not to transmit them) are in fact part of a negative-feedback system employed by the ear to improve the linearity of the acoustic transducer mechanism.

If this is the case, then the sharpness of tuning of the hair cell acoustic transducer — inexplicable on purely mechanical grounds, but necessary if an adequate degree of frequency analysis is to be performed — is most probably accomplished by some form of frequency filter, within the brain, in the feedback path to the flanking hair cells.

Interestingly, it has been found that the cochlea also emits sounds, identical to those received, but with a small delay of a few milliseconds, presumably due to the response time lag of the feedback loop, and that in some cases of 'tinnitus' (ringing in the ear), the sounds due to this can be detected, emerging from the cochlea, by a sensitive microphone.

If there is indeed a negative feedback system in the inner ear, with the comparator element being the acoustically coupled central and flanking hair cells, then it seems plausible to the engineer that the problem of 'tinnitus', which usually causes ringing in the ear at one or more specific frequencies, could well be due, in some cases, to feedback loop instability, leading to continuous oscillation. Since an inadvertent increase in loop gain, at certain frequencies, appears unlikely, it seems possible that this could be due to damage to some of the hair cells, so that the projecting cilia were able to touch one another, giving a greater degree of mechanical coupling in the feedback path.

Also, the few milliseconds delay in the response of the feedback system, noted above, makes the cochlea seem unsuitable as a receptor for rapid acoustic transients. This lends support to the hypothesis — which arose from the observation that listeners are often able to distinguish differences in timbre between sounds reproduced from sine and square wave audio waveforms, when the harmonics were outside their ears frequency range — that

there may be two separate hearing mechanisms operating simultaneously.

Of these, one is associated with the cochlea and is largely responsible for the detection and analysis of more or less steady state tones, and one is associated with the musculature and bone linkage between ear drum and the window of the cochlea and detects rate-of-change, or transient type pressure signals. This latter function is plausible since this bone linkage is already thought to be responsible for the protection of the inner ear from overload on sudden loud noises through the relaxation of the muscles associated with it.

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RELATIVITY

I fear that Mr Berriman (Feedback January 1986) may be in for a shock if he hopes that the process of tidying up will involve a straight choice between classical and relativity theory, with victory to the former.

That space and time are both absolute is axiomatic to classical theory. During the past fifteen or so years work at the US Naval Observatory, Washington, has unequivocally shown the existence of the phenomenon called time dilation. This finally destroys the logical basis of classical theory, leaving only relativity on the field, whether or not the dilation measured accords precisely with the predictions of that theory. We have got to find another champion if relativity is to be unseated.

With respect to the "basis of relativists' beliefs", in his 1905 paper "On the Electrodynamics of Moving Bodies" Einstein makes it quite clear. After pointing out that there was both theoretical and experimental evidence to suggest that the laws of physics might follow the same principles as do the laws of mechanics, he says: "We will raise this conjecture (the purport of which will hereafter be called the 'Principle of Relativity') to the status of a postulate," and then adds his second postulate. This latter is often condemned as being arbitrary and unjustified, but I have rehearsed elsewhere (Feedback June 1985) the very simple arguments which show that it is in fact implicit in Newton's principles. Relativists beliefs are

therefore based fair and square on Newton's principles as laid down in his Principia Mathematica, and the idea that they apply to all of physics. Such things as the Principle of Covariance are merely the logical extension of these ideas.

This may give us a clue as to where to look to find the theory that is able to challenge relativity, because if that is wrong it would appear to be due either to Newton's principles being wrong, or it not being permissible to apply them quite so indiscriminately. I understand that in measurements of the 2.7°K background radiation in the universe some anisotropy has been detected. One interpretation or this is that it gives us a measure of our motion through that radiation. I am totally unqualified to judge whether this interpretation is sound, but if it is it may perhaps give us a pointer as to where to look in our attempts to tidy up.

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RAKE'S PROGRESS

I feel bound to speak for the Establishment against Mr Catt's recently expressed views on electromagnetism which are at best eccentric and at worst nonsense.

Mr Catt claims:
(1) that Maxwell's equations contain no more information about nature than the two constants c, the speed of light and Z_0, the impedance of free space.
(2) that the electric field E and the magnetic field H in an electro-magnetic wave are not coupled as Maxwell's equations imply.
(3) Maxwell's equations are normally expressed in terms of unnecessarily abstruse mathematics like divs, curls and grads in order to keep 'knowledge brokers' in employment.

Taking point (1) first, the equations quoted represent a very particular case of Maxwell's equations i.e. the one-dimensional case with no sources (charges or currents). All the interesting physics of electromagnetism (radiation from aerials or even pulsars, refraction of light etc.) comes from including the usual source terms in Maxwell's equations. If Mr Catt leaves them out what does he expect?

Moreover, with regard to point (3), such problems are usually three-dimensional and therefore require the use of Maxwell's equations in their full three-dimensional form with all the divs, curls and grads that Mr Catt finds so abhorrent — or possibly doesn't understand. Each div, curl or grad of a field corresponds closely with a physical concept e.g. curl E is closely related to Faraday's induced e.m.f.; div B = 0 succinctly states that there are no magnetic monopoles. Thus these mathematical constructs actually give physical insight into problems rather than being something to satisfy the egos of mathematicians as Mr Catt seems to think.

Regarding point (2), Mr Catt gives a nice, but inexact, analogy between a moving tapered plank of wood and a travelling plane-polarized electromagnetic pulse with a wedge profile. He claims that this analogy proves that E and H do not interact or are not coupled. The essential point here is that they are coupled as required by Maxwell's equations and this coupling determines that their ratio could be anything. Mr Catt gets his analogy by artificially imposing the requirement that the width to height ratio is an arbitrary constant. The fact that E/H is a constant of nature follows naturally as a consequence of Maxwell's equations and does not have to be imposed.

The mechanism of the coupling between E and H is well known. At any point, as H changes it generates a perpendicular E field (by Faraday's law which is an integral statement of Maxwell's equation curl $E = -\partial(\mu H)/\partial t$). As that E field changes, it in turn generates a perpendicular H field according to a second Maxwell equation $c^2 \text{curl} (\mu H) = \partial E/\partial t$). Thus the electric and magnetic fields are mutually sustaining which is a million miles from being uncoupled!

I can only conclude that Mr Catt's view of Maxwell's equations stems from a poor understanding of mathematics and physics. He also displays an amazing arrogance in stating so boldly that he is right and most of the great 19th and 20th century physicists who believe in the conventional interpretation of Maxwell's equations, are wrong. Such arrogance would be forgivable if backed up by sound arguments but alas there are none. Stick to digital design Mr Catt, and you should be OK.

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