of value *even* if it is imperfect, flawed" (my emphasis). I think that the only reasonable use of the term "hard science" is to describe those subjects where the theories and facts have precision quantitative measures as a dominant feature. Not all our experience can be encompassed by quantitative measures; if we go to a play by Shakespeare we may be interested in the statistics of word frequencies, but our experience of the play and sense of the truth which we see in it is not measured numerically or topologically.

Vituperative comments about careerist scientists adds nothing but 'soft subjectivity' to the argument. I know the world of science is just as full of self interest and politics as any other, but let us not mix up our frailties with the significance of the science. I hope that in any case we would complain of a situation where somebody loses a job because his theory is wrong – most (if not all) theories are wrong in some way. Of course some people lay themselves open to attack by presenting their ideas dogmatically to start with, but in all areas of human study we don't judge an individual by the wrong theories but by the contribution to the evolution of the subject. Remember Newton's comment about seeing further by standing on someone's shoulders.

Finally, the list. "Uncertainty": a very unfortunate nomenclature for the Heisenberg principle which is not uncertain at all. "Dualism": although the wave-particle model may seem inelegant in its explanations of systems in terms of the language we have been using in science for the past few hundred years, surely the prediction of the magnetic moment of the electron to 1 part in 1,000,000,000, as well as the theory's effectiveness in atomic physics in general, classifies it as "hard". "Observer and observed": this is one of many genuine attempts to come to an understanding of what quantum theory is about. It may not be the right direction but it has been analysed in quantitative detail. "Relativity": I know that *EWW* has much debate on this and there are many competing mod-

els, but the E=mc^2 which first came from Special Relativity is precisely shown in the atomic bomb, and the bending of light is predicted correctly in General Relativity; these are hard measurements, which may still of course be consistent with alternative models. "Statistics and probability": thermodynamics has worked for us precisely for hundreds of years, yet it can be derived from statistical mechanics which brings with it the possibility of calculating some thermodynamic parameters from more fundamental constants.

The only way science evolves is by the open contribution of a large community of people. I believe that although the flesh is weak, the spirit is willing, so let us keep to specific criticism of fact and not deal in subjective innuendo. I might add that I am a "hard" scientist with considerable misgivings about current interpretations of quantum theory and I argue consistently for theoretical pluralism as the best way to test our theories.
Robert D. Dyson,
Kidlington,
Oxfordshire.

Relativity

I would like to question the version of Einstein's thought experiments summarized by M.H. Butterfield in the penultimate paragraph of his February letter.

Einstein's symbols A and B are two positions in the same system, not as Butterfield assumes abbreviations symbolizing an observer in one system A, exchanging data with an observer in another system B.

We can apply the rules governing the use of mathematical models to Einstein's original paper 'On the Electrodynamics of Moving Bodies' (1905). Firstly, find the problem, secondly, find the model of the Moving Bodies used to solve the problem, and finally, judge whether the model is realistic.

Einstein's problem. Clue: "...the unsuccessful attempts to discover any motion of the earth relatively to the 'light

medium,'..." (Einstein's introduction).

Einstein's model. Clue: Einstein's first though experiment – "Let a ray of light start at the 'A time' t_A from A towards B, let it at the 'B time' t_B be reflected at B in the direction of A, and arrive again at A at the 'A time' t_A".

This is a modified Michelson-Morley experiment (MME), or rather the arm of the experiment headed directly into the ether wind, Einstein's problem and moving bodies. A is the position of the angled mirror, a clock, an observer, and the source of the ray of light. B is the position of the reflecting mirror, a clock and an observer. Einstein's "rod to be measured" is the distance between the mirrors and his "measuring rod" is a tape-measure. He defines his "stationary system" as "a system of co-ordinates in which the equations of Newtonian mechanics hold good." This is a fictitious stationary Newtonian MME in Newtonian time and space. (See N. Rudakov's Fiction Stranger than Truth.pp. 88-89.)

The first thought experiment (TE) is performed in a stationary Newtonian MME to synchronize clocks fixed to the angled mirror A and the reflecting mirror B. All clocks are first synchronized in pairs in a stationary Newtonian MME. Symbols A and B identify the positions of the mirrors, clocks and observers in the first and fifth TE's. Symbols r_0 and r_2 are substituted for position A and r_1 for position B in the last TE. The moving clock and observer are significantly absent from reflecting mirror r_1. Time at r_1 is not $r_2 - r_0$ divided by two.

TEs Nos 2, 3 and 4 are all performed in the same MME. The MME is stationary during No 2, and moving at 30 km/s during No 3, "operation (a)", and No 4, "operation (b)". The distance between the mirrors is measured with the same tape-measure during TE's Nos 2 and 3. The same solitary observer performs TEs Nos 3 and 4. TE No 4 carries a Mental Health Warning, THIS GIBBERISH MAY DAMAGE YOUR SANITY. Positions of artefacts are not identified by symbols in these three TEs. Observers in a stationary Newtonian

MME do not exchange data with observers in a moving MME.

Is the model realistic? Clue: Art. 4 of his paper headed Physical Meaning of the Equations... After explaining by implication that the transverse arm of the MME is Newtonian and the other arm is not, Einstein confirms his conception of a realistic model. "...we shall, however, find in what follows, that the velocity of light in our theory plays the part, *physically*, of an infinitely great velocity." In other words, light acts instantaneously at a distance. The finite velocity of light is an essential measureable quantity in the Lorentz transformation.

Lorentz's model does not question L. Essen's measurement of light's velocity. Einstein's does, with a vengeance.
M.G. Wellard,
Kenley,
Surrey.

Time and space

I enjoyed reading Scott Murray's article "If you want to know the time ..." (December issue of *Wireless World*, p.28) but searched in vain for the rider "ask a relativistic policeman". Can it really be that clocks at the pole and at the equator can cooperate to prove Einstein wrong?

Such a proposition is outrageous and I have it on good authority. The editor of *Physical Review Letters* has drawn my attention to an experiment reported by NASA. It appears that in 1976 the NASA-SAO rocket-borne redshift experiment proved that the theory of relativity was correct and that over a 10,000km range from the Earth light speed was the same in opposite directions to within 3 parts in a billion. If this is true, then, as an antirelativist, I am defeated and Scott Murray should hoist the white flage as well. No longer can *Wireless World* entertain us by encouraging debate in this exciting arena or 'relativity'.

It would indeed be sad if *Wireless World* followed the example of *Applied Optics*. The editor of this journal, published

by the American Institute of Physics, had occasion to write at p. 544 of the March 1977 issue: *'It was probably unwise for Applied Optics ever to have ventured into the controversial area of relativity theory (and the various optical tests for it). In that area even the experts carry long swords and enjoy duelling to the death. Unarmed editors of applied journals would be well advised to avoid that battelfield'.*

It appears that NASA did send a stable maser oscillator into space to test relativity. As a clock, it behaved as expected in slowing down as it returned to the stronger gravitational potential in its descent. This is just as Scott-Murray would predict. But what about the time dilation effect due to motion? Well, since relativity references motion on the observer, the speed of the rocket was referenced on the Earth frame and the time dilation terms were small enough to be ignored. The experiment performed by NASA had such small residual error that it could be said with confidence that the radio signals sent to the rocket travelled at the same speed as those sent back from the rocket. No evidence of motion through the preferred frame was found, and the range was 10,000km.

Now, what is fascinating about this experiment is that it was a major NASA project involving numerous scientists and aimed at testing relativity. It was seen as an experiment to detect motion through the aether, besides testing the effects of gravity. Yet, in the analysis the time dilation was calculated as reference on the Earth frame, whilst the resulting equation was used to estimate motion relative to the preferred frame. Could one really credit such an error? When the time dilation formula is referenced on the preferred frame the resulting equation contains no terms which would allow the anisotropy to be tested. The effects cancel out completely, making the test completely inconsequential so far as detecting our motion through space is concerned.

Such is the arena of debate on this question of relativity. The

Establishment scientist wants to believe in relativity and no one seems to question results which support relativity. All the venom is directed at those who seek the truth and need convincing.

In conclusion, it is relevant to mention that the so-called time dilation formula has only been tested for atoms and particles moving at very high speeds, speeds far in excess of any expected motion relative to the preferred frame. The privileged role of the relativistic observer has not been tested in this context.

The NASA reference mentioned above is to a paper by Vessot and Levine, *Gen. Rel. and Grav., 10,* 181 (1979).

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Class B crossover distortion

There appear to be many errors in this article by E. Margan (June 1987). While accepting that the circuit is experimental and not fully developed, I must point out that it cannot function in the non-switching Class-B mode, since the bias voltage is a fixed source. Sage Audio have found, during the development of their own amplifiers, that the bias voltage must have compliance – it must not be a voltage source such as two diodes or a V_{be} multiplier. This is so that the upper transistor's base may be left biased just above V_{out}, whilst the lower transistor's base swings increasingly negative when supplying the negative output current cycle. The bias must be variable under signal control, varying in exact opposition to the increased volts drop across the lower emitter resistor.

Examination of all the recent Japanese n.s.b. circuits reveals this to be so, with the exception of Technics, who use a simplified Peter Blomley design. This is not a true n.s.b. system, but simply transfers the crossover region switching to an earlier
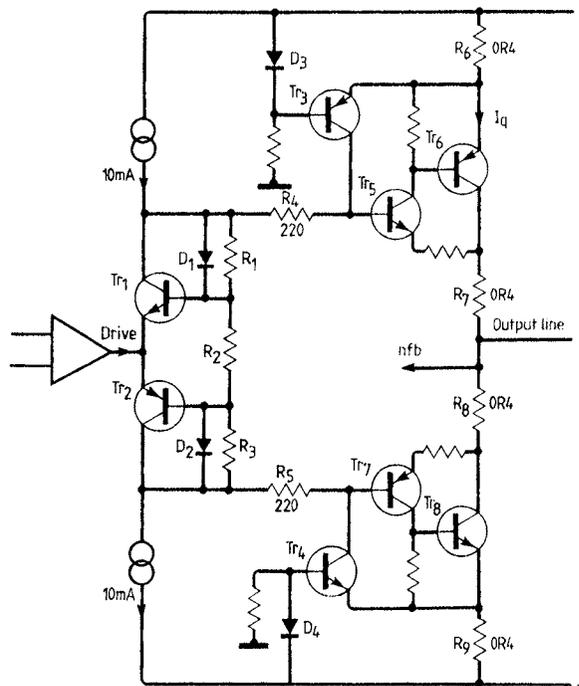
section of the amplifier: the output transistors are then biased continuously on with a small standing current via a resistor from the opposite supply, the driver transistors then being allowed to switch. Technics use the same idea, but replace the switching drivers with switching diodes. A skeleton diagram of the Blomley amplifier is in Fig.1, showing a fixed voltage, which means that something (in this case the drivers) must switch. Mr Margan's circuit is a failed attempt to develop the Blomley system further. I fear he has misinterpreted the Blomley compound output transistor configuration. For simplicity the skeleton diagrams for each system have been drawn with the same output configuration. It is clear that the Blomley amplifier drivers in Fig.1 are alternately switched on and off in driving the output transistors. However, with a fixed trickle current via R_3, the output transistors will remain conducting. This is only part way towards non-switching – driver-transistor switching pulses are still detectable, but

Fig.1. Simplified Blomley amplifier in which $Tr_{1,2}$ alternately switch on and off but in which $Tr_{3,4}$ remain conducting due to R_3. Both circuits feature a fixed voltge-source bias; hence, some part of the circuit must switch if I_{out} is to exceed I_q. A true n.s.b. system must include a dynamic variable bias working in opposite direction to the drive, giving bias voltage compliance.
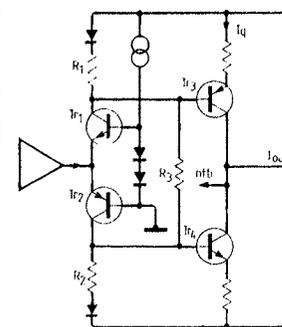
Fig.2. Skeleton circuit of the Margan amplifier. This is very similar to the Blomley design, although the Blomley system does leave each output transistor permanently conducting, while allowing the drivers to switch off.

much smaller due to lower storage charge in the smaller driver transistors.

In Mr Margan's circuit, the bias compliance offered is entirely due to $R_{4,5}$. This is better than standard Class AB, but is not a totally non-switching circuit.

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