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aware. We have consulted the pages cited by Mr Chadney, and consider the material there in no way weakens the tentative claim to the originality of the r.f. link described in the article.

Page and Adams consider two cases of a pair of inductively-coupled serious-resonant circuits in forced continuous oscillation. In the first, the tuning of the circuits is constant, the coupling coefficient is a parameter and the frequency is the independent variable. The authors show the usual single- or double-humped curves for primary and secondary current, depending on whether the coupling is below or above critical.

In the second case, the frequency is fixed, couping coefficient is the independent variable, and it is supposed that, as the coupling coefficient varies, somebody keeps the tuning adjusted so that both circuits remain resonant. It is then found that the secondary current rises with coupling coefficient until the latter reaches a critical value, after which the current remains constant. This behaviour is similar to that exhibited by the MRC link, but the two systems are quite different. The arrangement described in the June 1987 article represents a third case, in which coupling coefficient is the independent variable, the tuning is fixed, and the frequency adjusts itself automatically – over the stabilising range – to achieve constant secondary current.

This third case is not considered explicitly by Page and Adams, nor is its useful behaviour obviously implicit in the cases they do consider; if it were, they would surely have mentioned it.

If it should turn out that the MRC distance-insensitive link has not in fact been reported before, we offer two possible reasons for this:

1. Much of the theoretical work on such systems was done by radio men at a time when economy in the use of the spectrum was becoming essential. A system in which the carrier frequency wandered about would be anathema.
2. Much of the theoretical work on such systems was done when the valve reigned supreme, and valves went naturally with shunt-resonant circuits. Writers were inclined to use series-resonant configurations only as a stepping-stone to shunt circuits, because the analysis was simpler. You couldn't make an efficient series-resonant oscillator using valves, so there wasn't much point in dwelling upon what such an oscillator would do.

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Relativity

Having been assured by Dr C.F. Coleman (Letters, March 1987) that I am now bereft of my sense of weight discrimination I invite him to yet further my education and also that of your readers by telling us how to calculate the angular momentum of the top as it moves round the tower?

Alex Jones
Swanage
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The letter by J.C.G. Field (*EWW*, March 1988, p.243) will hearten those who find the Einstein debate is becoming rather tedious, besides being unwarranted. His message is that we should not need 'proof' of the kind demanded by philosophers; it is sufficient to know that Einstein's theory works and is used by engineers.

I submit that if an engineer (and I am one myself) thinks that Einstein's theory is used in designing apparatus in which an electron's mass tends to become infinite as the speed of light is approached, then he has missed the point of Dr Essen's criticism (*EWW*, February 1988, p. 126). Classical electromagnetic theory explains why energy has a mass property and why the mass of a particle increases progressively as its kinetic energy escalates with both speed and mass. J.J. Thomson did not need to know anything about Einstein's 20th century theory when, in the 19th century, he designed cathode ray tubes and studied why the electron mass becomes infinite at the speed of light.

However, the reference to NAVSTAR is much more relevant. If engineers really have found it necessary to adjust for time dilation to allow for a loss of 350 nanoseconds per hour and avoid a build-up of positional error of 100 metres per hour, then that makes nonsense of the philosophical discussions. It is time that the 'engineering' details involved were published to clear up the misunderstandings. The weaker gravitational effect on atomic clock rates certainly can be dismissed as irrelevant to Einstein's hypothesis. It is worth reading Leon Brillouin's book 'Relativity Reexamined' (Academic Press, 1970) to see why. Einstein would have us believe that a photon or EM wave changes frequency as it passes through a gravitational field, whereas a quantum physicist should prefer the gravitational effect to have something to do with the potential of the energy quantum in the atom that determines the photon frequency. An engineer might be satisfied with Einstein's formula, because it works, but that does not mean that the underlying abstract hypothesis used by Einstein is valid.

So, we are left with Dr Essen's topic, the issue of how atomic clock frequencies can depend on motion relative to the different observers. It may well be that engineers concerned with NAVSTAR do make allowances for relativistic time dilation, but I would also expect them to make overriding empirical adjustments which make the whole system function by extrapolation techniques. Otherwise, they must know what is happening to those wild 'ticks' and should come forth and answer the specific question posed by Dr Essen.

Finally, I draw attention to a comment by Professor Santilli in his book on 'Ethical Probe on Einstein's Followers in the U.S.A. – An Insider's View' (Alpha Publishing, 1984). He tells the story of how NASA found they could not predict where SKYLAB would fall on its return to Earth and how a high governmental officer urged more consultation with relativity experts. The NASA scientist replied "If a professor comes in here with his relativities, he will be chased out of NASA's premises".

H. Aspden,
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In his article in the January 1988 issue, Dr Essen misrepresents the treatment of the 'twins paradox' in the Special Theory of Relativity. The situation envisaged has two experimenters, initially moving together without acceleration; one remains unaccelerated; the other travels in a space ship which accelerates away for time in a straight line and then undergoes three further accelerations, in the same line, to return to its original relation to the stay-at-home. The supposedly paradoxical behaviour predicted by SR is that the stay-at-home should believe the journey to have taken a greater time than that measured by the traveller. For convenience there should be such a long period of unaccelerated movement on both legs of the journey that the time spent accelerating may be neglected. That we can imagine this makes it plain that the acceleration is not in itself the source of the unexpected behaviour. The experiment has not been done in this form but a simpler version without return to the starting point provided one of the first experimental verifications of SR, although its numerical accuracy was poor. A later version involving curved paths is rather harder to analyse but yields very precise confirmation of Einstein's predictions. The first successful experiments

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involved high velocities but the curved path form of the experiment has been performed at low speed. In spite of the problems of measuring the very small effects predicted this also confirms the theory.

The basis of your correspondent's criticism of SR is a symmetry it is supposed to postulate between the two experimenters' experience which would make an asymmetry in recorded time impossible. First we can see that there is no particular symmetry between the physical experience of the two: if they are equipped with accelerometers these will record entirely different sequences of readings. SR is a physical theory of measurement so it must, if it is to be acceptable, take account of this. How does it do so?

With Einstein we begin by noting something that seems more obvious now than it did 83 years ago: that experimenters travelling without acceleration can record the time and position of their experiments using a rectangular coordinate system and synchronised clocks fixed at convenient places. The assumptions we make are (i) Einstein's principle of SR; that all such experimenters will discover the same laws of nature (Lenz's Law etc.) and (ii) that they will measure the same velocity of travel for light, in free space. From these assumptions it can be deduced that the coordinates and times which different experimenters measure for the same event should be related by linear equations. If suitable axes are used these take the form known as the Fitzerald-Lorentz transformation. While it is possible to believe that the assumptions do not square with physical reality, though one would have to discount an awful lot of experimenting to do so, they have to be accepted in a discussion of the theory's internal consistency, as do the mathematical conclusions. (Unless an algebraic error can be discovered.)

In describing our experiment it is natural to use coordinate and time systems in which the experimenters are at rest. Three are required: one for the stay-at-home and two for the traveller, one on the outward path and another for the return. To relate measurements in any pair of these it is, in SR, necessary to use a Fitzgerald-Lorentz transformation, even though the same physical measuring systems may be used at all times by the traveller. The analysis is quite easy using the fixed experimenter's coordinates; more complex from the traveller's point of view, because more coordinate systems must be used, but both versions yield the same result: the traveller's clock will record a shorter travel time than the stationary one.

Michael Weatherill
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Scotland

I appreciate the prominence given to my short article and hope that it will make the relativitists think and help the doubters. Unfortunately several phrases have been omitted, disturbing the logical sequence of some points of the argument, and I should be grateful if a correction could be published in your next issue. The sentence beginning on line 32, p127 (omitting the lines in heavy type) should read "One of the predictions of the theory was that a moving clock goes more slowly than an identical stationary clock when viewed from the position of the stationary clock."

On line 15, from the bottom of the middle column of p127 after "stages of the journey" it should read "As before, he concluded that the time recorded by the moving clock was less than that recorded by the stationary clock." Finally in line 13 of the third column of p.127, insert after "nanoseconds" "and yet the result was claimed to be accurate to 10 nanoseconds."

L. Essen
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Flow chart

The flowchart technique proposed by David Sweeney in the August 1987 issue does very little to solve the real problems associated with this old but far from reliable system of logic design.

The problems with a graphical flowchart technique are twofold:

- the lack of any method of imposing structure, which usually leads to obscure and tangled code – difficult to debug, understand and modify;
- the difficulty in updating, maintaining and printing graphical documentation.

In an ideal software world, and following established ground rules for structured design, these problems would be solved by a universally powerful, flexible and friendly language.

In the real world, where many designers are still working with assembler or C, a high – level design technique (such as flowcharting) is essential. The solution I have adopted to the problems above is to use a text-based system which solves the maintainability and printing problem, incorporating a pseudo-high-level language to aid in imposing structure. This idea is of course far from new.

The advantage of this approach is that you can choose all the best features of your favourite language(s) and add new constructs or functions unique to your application. The language I use is heavily based on Algol (which was/is extremely readable), leavened with bits of BASIC. (Complex data structures and I/O techniques are not relevant to my application.) For example here is the LINEGEN algorithm from Mr Sweeney's article

```
begin
    call INITIALISE LINEGEN
    repeat
        call PLOT (x,y)
        x = x + 1
        if b<0 then b = b + a
        else
        begin
                y = y + 1
                b = b + c
        end
    until x = XIST + 1
end
```

It should be noted that the action of the algorithm is not identical to the original in that b and possibly y are different on exit. This follows from the good established practice of structured design in which loops are only exited at the beginning (while loops) or at the end (repeat.. until loops). A flowchart is the graphical equivalent of a GOTO!

A danger of a graphical approach to a high-level design is that, once complete, the difficulties of updating and issuing the design may preclude it ever being done. The original design then gets lost in a cloud of later additions and bug fixes. The above technique is supportable on any word processing system with a standard printer.

C.I.Perkins

Getting to grips with electromagnetism

I have always thought that electromagnetism should not be a book subject, and I have waited for the technology to arrive which would make visual communication possible. Finally it came, and I have spent most of the last year developing moving computer graphics which would give the viewer a proper grasp of the subject. I now have more than half an hour of moving graphics which run on an Acorn Master. It also can be seen as a VHS videotape, but quality is much degraded. All the content is conventional.

I have held back on selling these products because of fear of piracy, and I shall be very grateful if any readers can advise me on how to deal with piracy of an Acorn Master disc and also of a VHS videotape.

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