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In my view most of the debate and most of the profusion of erroneous statements on this subject arise from a failure to ask the proper questions. Except for a few competitors of greatly similar character the theory of general relativity is presently accepted as the proper description of space–time and its interaction with matter (for problems in which quantum effects may be ignored). Thus the theoretical prediction for the result of round-trip clock experiments should be done with general relativity as Sachs asserts. The questions that should be asked are then: What is the correct result, and is it the same as predicted by a naive application of special relativity? In contrast, much of the debate seems to concern itself with the question of whether special relativity is or is not a logically complete theory for dealing with such problems.

As several of the letters in reply to Sachs assert, experimental evidence seems to provide the answer to the first question; that is, for experiments carried out in small regions, naive special relativity gives the answer. The second question is where erroneous answers abound. The fundamental idea of relativity theory is that physical laws have the same mathematical expression for all observers regardless of their position or state of motion. Special relativity consists of those results obtainable from restricting that principle to observers moving uniformly with respect to each other. (That is, they have to be "far away" from large masses or only compare measurements over small intervals of space and time!) Thus, in this view the answer to the second question is an emphatic no. Statements that the felt acceleration of the "travelling" twin creates an asymmetry that resolves the "paradox" (Korenman) or that acceleration is an absolute (Terrell) appear as *ad hoc additions* to the special theory, which can only derive their justification from a larger theory describing effects due to acceleration in terms of motion with respect to matter. General relativity is believed to be that theory.

In his article Sachs presents a formulation of space–time theory that is supposed to remove an ambiguity in general-relativistic computations of proper time intervals, namely the sign of the square root of a quadratic form. The requirements for such a formulation are that the interval computed be always equal to that computed according to the original method and that it always successfully remove the ambiguity. Sachs's formulation, as several of the letters pointed out (Richard Price and Vern Sandberg, John Fletcher), falls on the first count and is thus a theory different from general relativity. Meeting the second criterion is not really so helpful, since the supposed ambiguity is easily resolved. In principle one may refer, say, to measurements of the Hubble parameter at the beginning and end of an interval to determine whether the appropriate sign of ds be positive or negative for the interval.

In the present view then the question may be stated as follows: The comparison of ages between a "stationary" and a "travelling" twin is made by comparing

$$\int ds = \int (g_{ij}dx^i dy^j)^{1/2}$$

computed for each in a coordinate system obtained by solving the general-relativity equations. Provided the "travelling" twin doesn't travel very far (as in laboratory experiments), or on long trips he remains "away from large masses" (black holes for example) and is accelerated by mechanical rather than gravitational forces, the answer will be essentially the same as given by special relativity. To demonstrate the nonexistence of a paradox, an adequate general-relativistic description of an accelerated coordinate system is required; to my knowledge this does not exist yet.

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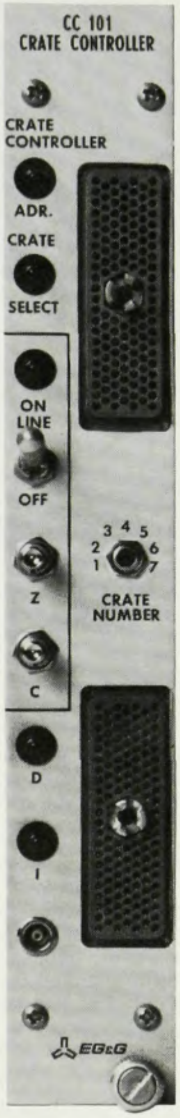
Metric time?

At present most of the countries of the world are either metric or going metric, including traditionally minded countries like Great Britain. The advantages of the metric system are obvious, and so there is no reason why one should not extend this system to include the measurement of time. We cannot change the number of days in a year since Nature does not permit this, but it should be possible to divide one full day into twenty hours so that night and day will consist of ten hours each. This would be more convenient than dividing a full day into ten hours, because this would make an hour much longer as compared with the present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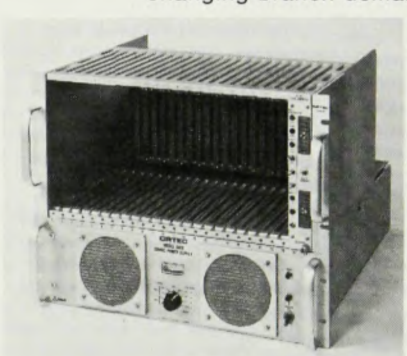

system. An hour can further be divided into one hundred minutes. The new minute will be 0.72 times shorter than the present unit. This ratio is reasonable, as it is comparable to that between a kilometer and a mile.

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Grammatical error

It has shocked me to find in the February issue (page 33) the following sentence: "He who neglects the connection between paper recycling and private investments in the Southern pine forests is spiritual brother to he who neglects the plasma potential in his ion source."

The message is good, but the grammatical error is inexcusable.

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Permanent part-time

I propose that university and college physics departments help to solve the problem of the overabundance of physicists with advanced degrees by providing for part-time, permanent faculty positions. These part-time positions would be completely equivalent to the present full-time positions in responsibilities and privileges. Course loads, research responsibilities, committee assignments, and so on, would be scaled down in accordance with salary. The professional regard and prestige associated with such positions should be the same as for full-time positions.

I have two reasons for suggesting such a scheme. First, it would result in more jobs for physicists. If two faculty members in a department switched to two-thirds-time positions, they would be creating a new two-thirds-time position. If, in each large physics department (15 or more full-time faculty members) in the nation, two faculty members out of every 15 or 20 switched to two-thirds-time positions, more than 225 new positions would be created. Additional positions could be created in some smaller departments in this manner.

My second reason concerns the lack of flexibility in our system. A physics faculty member usually has the choice of a full-time position or no position. He should have more alternatives; there are many reasons why a faculty member might want to hold a part-time position, and our system should be flexible enough to allow for individual choice in this matter.

What kinds of physics faculty members might be interested in switching to a part-time permanent position? A consultant—he needs the faculty position, but he might not need or want it full time. Someone who is nearing retirement and wants to ease into it gradually. The person whose health is endangered by the pressures of his job—a lightened work load could prevent a heart attack or ulcers. The parent of small children, who would like to take a more active part in rearing them. The person who is devoted to research and doesn't need the money from teaching but still would like to teach a little. The physicist who, for a reason either personal or professional, wishes to devote a great amount of time over a period of years to study in a discipline outside his field of specialization or outside of physics entirely. Surely there are other categories also.

What about economic considerations? Certainly many physics faculty have to earn a full-time salary to live comfortably. But others could support their families comfortably on, say a two-thirds-time or three-fourths-time salary. Still others have wives who contribute to the family income. Many more have wives who could work and would work if appropriate jobs were available, and if they and/or their husbands were persuaded that it is socially acceptable and morally right for husband and wife to share in the breadwinning responsibility. (In this regard, permanent part-time jobs should be promoted throughout the educational system and in as many other walks of life as possible.) Finally, perhaps many of us should lower our standard of living purposely, to reduce our contribution to the pollution of our environment.

What would be the benefits to the physics profession? New blood would be brought into departments to enliven them and prevent their stagnation. The quality of teaching would improve, as a result of the additional time available for reflection and personal and professional development. Speculative, creative research, often neglected because of the pressure to engage in research for which grants can be obtained and publications produced, could flourish under these more relaxed conditions. For a researcher could satisfy the lessened demands of his profession for grants and publications, and have spare time to speculate to his heart's content.

Innovations are needed quickly if we are to ease the current crisis in which highly trained people in many academic fields find themselves unable to secure rewarding jobs. I suggest that our own discipline set an example to others. I urge that every college and university physics department give immediate and serious consideration to methods for alleviating the academic unemployment crisis, and I suggest that one of the

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