posed by John Eddy.[1] As a matter of fact, I am a bit allergic to such alignments. Too many authors have seen alignments in sets of objects as different as quasars, megalithic stones in Cornwall, or Roman roads—alignments that have been assigned some profound (and often unspecified) meaning, but whose significance does not withstand a proper statistical analysis. The alignments with bright stars observed in the Medicine Wheel are in the same category, as will be shown in the following simple calculation.

The problem under investigation is as follows. Given a set of objects and a second set of randomly distributed objects, what is the *a priori* probability of finding a member of the second set aligned—within some acceptance angle—on two of the first set? Actually, the two sets may coincide with one another, as is the case for the megalithic stones. Broadbent has applied[2] some simple techniques to judge the significance of proposed alignments among those stones (he found that they are due to random coincidence); these techniques could also be applied to the proposed alignment with astronomical objects. In the present case, the second set consists of the rising positions of bright stars. How many such alignments are expected? This is very easy to calculate. The alignments about any 2 out of N stones point to $N!/2!(N-2)!$ positions on the eastern horizon. A bright star is considered to be aligned if its rising point falls within an angle ϵ from such position. Let us take ϵ equal to one degree, which, judging from figure 6 in Aveni's article, is a very conservative estimate. For instance, the direction towards Rigel passes more than 2 degrees from the center of the eastern structure. If N is small, the total area on the horizon, as defined by the stone positions and the acceptance angle, is $2\epsilon \cdot N!/2!(N-2)!$ and, therefore, the probability for any random point of the horizon to be aligned with 2 of the stones is

$$P = \binom{N}{2} \times 2\epsilon/180.$$

For $N=6$ positions on the circle, one finds $P=\epsilon/6$; for $N=7$, $P=0.23\epsilon$. The $N=7$ case is probably an overestimate, because the boulder in the center causes some intervals on the horizon to overlap. In general, such overlapping becomes important for P larger than about 0.5, but here we can neglect this complication for the $N=6$ case. Thus $P \sim 1/6$ to $1/3$. There are 10 stars brighter than 1^{m} (Aldebran: $m_{\mathrm{v}}=0.85$) visible from Wyoming. Hence we expect that purely by chance $P \times 10 = 2$ or 3 such bright stars will be aligned, which is as observed by Eddy. Note that for a uniform sky distribution, the density of rising points is not uniform but peaks in the east. Therefore the probability for alignments in the east is somewhat increased, but, in order to compute the expected number, we can use the average density. Of course the above does not mean that these bright stars were not considered when the Medicine Wheel was built, only that the number of alignments is indistinguishable from the expected one if the builders would not have bothered about stars at all. Therefore arguments in favor of the opposite have to come purely from other considerations. The reasoning quoted from Eddy (that the stars mark the time of good weather) is hardly "a tight argument." It is an amusing exercise for a cloudy night to take any random subset of 3 bright stars and then try to find *a posteriori* a common property of, or a trend defined by them. In this, one will almost always succeed. The statement that Aldebaran, Rigel and Sirius are rising in three consecutive months has therefore the same content of proof as the statement that those stars have marked different colors (red, blue and white, respectively). To be more specific: Rigel can be replaced by Capella (yellow) to form a triad with similar "properties." Yet no alignment with Capella is observed.

Apart from all this, it is not clear to me why the proposed alignments on stars are needed at all. A culture capable of knowing in detail the motions of the Sun and Moon in the sky would also be capable of knowing when the good and bad weather periods are due, without having to rely on the observations of particular stars.

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7/84

Quality of science teaching

As a physicist and recent chairman of the Board of Education of Howard County, Maryland, I was particularly interested in the article entitled "Leaving teaching: A difficult choice" by James E. Mowbray (PHYSICS TODAY, September 1983, page 36). Mowbray had been a very successful teacher in the Howard County school system and enjoyed the respect of his peers and his students. Many of the specific recommendations he made deserve careful consideration. Unfortunately, he misrepresented some elements of the problem in a way which may make an

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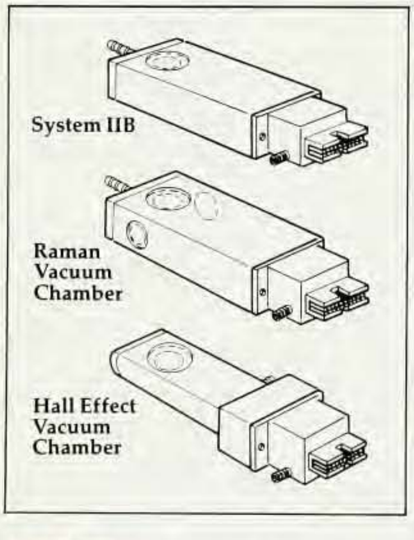

informed discussion of this issue difficult.

The "vindictiveness" attributed to the local school board in Mowbray's article consisted of an attempt to discourage any teachers from leaving classes mid-year without strong reason. The teacher contract is, in our opinion, mutually binding for teachers and the school system and exists in part to ensure that students have a full year of competent instruction. By county policy, any teacher who leaves mid-year without reasonable cause violates the contract and is subject to those penalties allowed under Maryland law. In Mowbray's case, those penalties were applied.

If it is difficult to obtain qualified physics teachers given adequate time and the availability of new graduates from colleges and universities, the problem is even more difficult on short notice in the middle of the school year. As a result, the education of students suffers when their teacher leaves under such circumstances. Any discussion of school-board–teacher relationships needs to recognize the reciprocal responsibility both parties have to students.

As a further point in the same article, Mowbray describes his frustrations at the unwillingness of the school board to approve higher pay for science and mathematics teachers. In fact, the major opponents of such differential pay are not local boards of education, but Mowbray's fellow teachers. Our local experience has been that teachers in non-science and math specialties, and their local education associations (the designated collective bargaining agents under Maryland State Law) have resolutely opposed any discussion of differential pay.

In collective bargaining, issues flatly opposed by one negotiating party are not easily won. In addition, it is arguable whether this is the best way to improve the supply of qualified teachers in the sciences.

The issue of physics education, specifically, and of science and math education, generally, is an important one in which The American Physical Society, through its various professional organizations, can play a role in focusing public attention on this urgent problem and on recommending solutions. However, it is essential that the Society provide accurate information to its members if the discussion is to be fruitful. I suggest that, in the future, PHYSICS TODAY provide an opportunity for "peer review" of allegations such as those made in Mowbray's article. Finding "villains" for social problems is sometimes a convenient way to mobilize public opinion, but it is fundamentally demagogic and has no place in a discussion at the professional level expected by members of the Society.

This discussion in no way responds to the real issues of quality science teaching, the recruitment and compensation of competent teachers, and the adequacy of curriculum and graduation standards. Howard County, among others, has taken a number of significant steps to attempt to meet these challenges. I would be happy at another time to summarize some of these steps and to give a local board of education perspective on the political, personnel and fiscal aspects of these problems and possible solutions that might be considered.

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10/83

Physics on microcomputers

At the risk of excessively belaboring a point, I would like to offer a few additional observations on the relative performance of micro- and mainframe computers. These differ sufficiently from those reported by Albert DePristo and Stephen Elbert (July, page 15) to cast personal computers in a significantly more favorable light relative to mainframes. A Sanyo MBC 550, using the 8088 at 3.6 MHz plus the 8087 coprocessor, runs their demonstration program in 83 seconds, using Microsoft's FORTRAN 77 version 3.2 compiler (decent, though not ideal) and generating in-line code for the 8087. This is considerably less than the 194 seconds reported by DePristo and Elbert for the 4.77 MHz IBM PC. Incidentally, the same hardware, using Borland Turbo Pascal, which is a single-pass compiler (in contrast to the two-pass optimizing Microsoft compiler), executes the program in 300 seconds, illustrating the importance of good software. It also demonstrates the kind of savings one could obtain, as Per Bak evidently has, by working in assembly language rather than depending on less than optimal software. Finally, a DEC 11/23 with floating-point unit executes the program in about 400 seconds under RT11 FORTRAN. This was the first 16-bit microprocessor produced and it illustrates the kind of progress which has been made since.

It should also be noted that the test program does not include trigonometric functions, at which the 8087 shines. Consider, therefore, the following program:

```
real*8 difsqr, pihalf, step, a, b, c
pihalf = 1.5d0
read(*, *)niter
difsqr = 0.0d0
a = 0.0d0
```