'The Schuler Pendulum and Inertial Navigation'

Frank Coffman Bell

MR. J. A. LEE by his commentary (*Journal*, 22, 267) rightly suggests that instead of saying in my par. 1 (*Journal*, 21, 504), as I did after quoting Mr. Carr and Sq.-Leader Scott, R.A.F. (*Journal*, 20, 406, sec. 2, par. 1) my words '—and from this deducing velocity and position of the vehicle,' I could better have simply continued their words, 'From this acceleration we can then, by successive mathematical integrations, deduce first velocity and secondly the displacement of the vehicle.' Furthermore, it was superfluous and careless of me to add my quite worthless opinion as to soundness and virtue of expression on their part, but I comfort myself, and I hope also Mr. Lee, with the knowledge that there is no evidence that my opinions have ever previously had any effect whether for good or ill. To the extent, if any, that I can understand Mr. Lee's learned commentary, I believe I quite agree with him and am especially grateful for the clear definition given in his final sentence. If, however, an answer has been given to the question I raised as to the connection of Schuler's 1923 paper with inertial navigation, I am not presently aware of this.

I will take this opportunity to mention a statement in terms of elementary servo theory and bearing on my question. The Mathieu differential equation, which for infinitesimal θ and in one and the same plane can be written

$$\frac{d^2\theta}{dt^2} + (\alpha + \beta \cos t)\ \theta = 0,$$

is the general system equation for both Schulerian and inertial navigations. In Schulerian systems, both α and β vanish identically. In inertial navigation systems β vanishes identically and $\alpha \equiv g/R$. This statement is mine, but the ideas on which it rests (if it does) are, as far as I am concerned, entirely due to Professor Hsue Shen Tsien, Ph.D., who has set them forth in his 1954 book *Engineering Cybernetics*, McGraw-Hill Book Company, Inc., New York, Toronto, London, esp. Chapter 11, 'Nonlinear Systems', pp. 160–167.

Position Finding with Spirit Level

F. W. G. Smith

THE use of the Sun's shadow is a very old method for position finding. It is easy to adapt a small spirit level to produce a shadow on a millimetre scale which will give results of sufficient accuracy to add to the interest in learning to work out position lines for the Sun; less accurately for the Moon. Schools might find this useful for theoretical and practical classes.