boundary. It is quadratically convergent to any eigenvalue given that a sufficiently close first approximation has been inserted. I should perhaps have stressed more strongly the equivalence of the inverse method and GRQ techniques in my paper, rather than to put it out to references. Instances in which the modified inverse method would fail to converge to an eigenvalue of the system (which might not be an aeroelastic system) were, however, covered in the paper. Such instances are not indicative of failure of the GRQ technique, but rather of the particular manner of its implementation in the inverse method — and this may often be easily altered to cope with special problems. I have yet to encounter an aeroelastic problem in which convergence does not occur, including the non-standard flutter problems encountered in industrial aerodynamics.

I agree with Jack that the question of 'physical insight' gained from the inverse method is not addressed in R&M 1716. However, in the Introduction, I did give a brief account of the progress of the inverse method through the ARC, following the original suggestion by Collar in the early 1930s. Unfortunately, I do not have access to the minutes of the appropriate ARC Committee Meetings, but have been assured, at first hand, that a major attraction of the inverse method as presented at those early meetings was its physical meaningfulness. This, of course, is otherwise obvious: the force required to sustain SHM at a given frequency and (at the point of application) at unit amplitude is the impedance of the system viewed from the force application point. Again, perhaps this should have been made clear in my paper. Certainly, in the present context, I can think of few quantities which have greater physical appeal (particularly to engineers) than direct impedance. Indeed, in the early days it had been envisaged that the results of an inverse method flutter study could be related to the results of shake tests in flight.

In the method described in my paper, the use of diagonal pivoting ensures that the force excitation point at any \( V, \omega \) is such that the direct impedance is lowest there, i.e. response per unit load is greatest. It must therefore be admitted that until the process settles down during convergence to a flutter boundary or subcritical eigenvalue, the point of force application may change several times. Direct physical interpretation of the convergence process is thus not easy, but this would hardly be required.

In a future publication, I hope to address the problem of flutter boundary assessment in the inverse method: i.e. to provide a means of ranking flutter boundaries. However, I cannot share Jack's pessimism on the current state of affairs vis-à-vis the choice of a first approximation and convergence to the lowest critical flutter condition. The logical progression through binaries, ternaries, etc. leaves little scope for omission or commission. An incidental point is that the inverse method is not unique in its requirement of a first approximation. Determinantal search procedures such as Muller's method require one, as indeed does inverse iteration.

On Jack's last point, there would appear to be the implication that the inverse method (as presented in my paper) might not cope adequately with the task of interpreting the initial flutter condition with regard to its accuracy, its sensitivity to improving modifications and the optimisation of improvements. My worry is that standard methods may well fall short on such tasks, especially where the frequency effect is strong. The inverse method, with its requirement of a first approximation, surely an ideal vehicle for the implementation of 'exact' sensitivity analysis? On accuracy of eigenvalue prediction, GRQ is a favoured method. On optimisation, special programs are in any event required, and the task might well fall outside the capacity of the small computers referred to in the title of my paper.

I thank Jack for giving me the opportunity to make the above points.

ALAN SIMPSON
Bristol, 18th June 1984

**CORRECTION**

'The performance of man-powered aircraft' by Professor G. M. Lilley, *Aeronautical Journal*, March 1984, page 69. The entries in Table (C) are incorrect. The corrected table is printed below:

| Kw     | slugs/ft² |
|--------|-----------|
|        | kg/m²     |
| 0.00159| 0.25      |
| 0.00318| 0.50      |
| 0.00477| 0.75      |
| 0.00637| 1.00      |
| 0.00955| 1.50      |
| 0.01273| 2.00      |
| 0.01591| 4.00      |
| 0.03979| 10.00     |

Wing density conversion
The following corrections to the paper ‘Hypersonic large deflection similitude for quasi-wedges and quasi-cones’ by Dr. Kunal Ghosh, published in March 1984 Aeronautical Journal, pages 70-76, were unfortunately received too late to be incorporated into the paper.

Page 71:

The equation of a wedge or cone is \( Y_1 = 0 \), or \( y - U \sin \alpha = 0 \). A quasi-wedge or quasi-cone which differs slightly in shape from the wedge or cone is given by:

\[
F(x, y, t) = y - U \sin \alpha - \phi(x + Ut \cos \alpha) = 0 \tag{6a}
\]

where \( \phi \) is the angle between the attached shock and \( x \)-axis at the apex; for axisymmetric flow \( \phi \) is defined in the meridianal plane (see Fig. 1). It will be referred to as the shock stand-off angle or stand-off angle. \( \phi \ll 1 \) in hypersonic flow.

The equation of the shock is:

\[
G(x, y, t) = y - Ut \sin (\alpha + \phi) - \psi(x + Ut \cos \alpha) = 0 \tag{6b}
\]

Page 74:

Let any point \( P \) at \( y \) subtend an angle \( \theta \) at the nose of the cone (Fig. 2a). Therefore,

\[
y = \frac{U \sin \theta \, t}{\cos (\theta - \alpha)} \tag{29a}
\]

The potential at \( P \), setting \( \cos \phi = 1 \),

\[
\varphi = t \cdot U^2 \sin^2 \alpha \left[ \frac{\sin \sigma}{\sin \alpha} \left( \frac{\sin \sigma - \sin \theta}{\sin \alpha} \right) \right] + \frac{1}{2} \left( \frac{\sin \theta}{\sin \sigma} \right).
\]

\( \partial \phi / \partial t \) is to be evaluated at \( \theta = \alpha \) i.e., at the piston boundary, where the term in square bracket has a value

\[
\left( 1 + \frac{\phi}{\tan \alpha} \right) \frac{\phi}{\tan \alpha} + \ln \left( 1 - \frac{\phi}{\tan \alpha} \right) = \frac{1}{2} \phi^2 / \tan^2 \alpha.
\]

From equation (26), for \( j = 1 \), it can be shown that \( \epsilon = 2 \phi / \tan \alpha \). Therefore \( \partial \phi / \partial t = (1/8) \epsilon^2 \) times \( U^2 \sin^2 \alpha \). Since \( \nu_{2b} = U - \sin \alpha \), equation (35) can be written as

\[
\frac{1}{8} U^2 \sin^2 \alpha \cdot (1 + \frac{\phi}{\tan \alpha}) + \left( U - \sin \alpha \right)^2
\]

Dividing throughout by \( \epsilon \) \( U^2 \) and since

\[
\frac{p - p_s}{\rho U^2 \epsilon} = \left( \frac{1}{2} c_{pb} - \frac{1}{2} \frac{c_{pb}}{U^2} \right),
\]

we get after neglecting \( \epsilon^2 \) and higher terms

\[
\frac{1}{2} c_{pb} = \sin^2 \alpha \cdot \left( 1 + \frac{1}{4} \right)
\]

Hayes and Probstein (1966) gives the result for a cone as

\[
\frac{1}{2} c_{pb} = \frac{\sin^2 \alpha}{\left( 1 - \frac{\epsilon}{4} \right) \cos^2 \phi}
\]