others for tea." . . . Ecstasy and tea—could the two ideas be combined anywhere but in England? And the fact that they can be so combined is a high-light on that English character which so completely puzzles our friends and baffles our enemies.

NAVIGATION.

By J. C. Kingsland and D. W. Seager. Oxford University Press. 1943. 2/6. (Series: Oxford Air Training Manuals.)

Here is yet another manual for the A.T.C. cadet, closely following the pre-war 2nd Class Navigator's syllabus: Form of the Earth, Maps and Charts; Magnetism and Compasses; " Meteorology " (in this case used as a synonym for a paragraph or two on atmospheric pressure and its effects on instrument readings), and Dead Reckoning Navigation. In less than 100 pages, the authors contrive to impart a good deal of useful information. The chapter on Magnetism is particularly clear, and so is the explanation of the effect of pressure changes on Altimeter readings—a subject which is of vital importance to the prospective pilot, and is only too frequently presented in such a way as to leave him altogether bemused. The diagram illustrating the effect of temperature differences on altimeter reading (Fig. 38) is admirable. There are a number of exercises, to which answers are given at the end of the book.

RADIO.

By I. R. Vesselo and R. D. Morrison. Allen and Unwin. 1942. 2/-.

This new publication in the " Air Cadets' Handbooks " series may with advantage be read as a " second step " by those who have worked through the handbook on " Elementary Electricity " reviewed in our February issue. The first 50 pages give an outline of Electricity and Magnetism, followed by an explanation of radio valves and some typical transmitters and receivers. In the last two chapters we have a brief description of the principles of aircraft radio: fixed and trailing aerials, direction-finding, and a few notes on the plotting of radio bearings and the errors to which they are subject. We suggest that, in the section on Magnetism, it is preferable to use the terms " Blue " and " Red " poles, as the geographical connotation of " North " and " South " Pole is apt to confuse a beginner. The book would also be improved by more diagrams in the section on " Radio as an Aid to Navigation." This section is introduced by the sentence: " Bearings obtained by radio are subject to certain errors which must be clearly understood," but in our opinion the description of Quadrantal Error, Coastal Refraction and Night Effect is simplified to the point where it would only be " clearly understood " by those readers who already knew what the authors were talking about.

CORRESPONDENCE.

To the Editor of the JOURNAL OF THE ROYAL AERONAUTICAL SOCIETY.

February 5th, 1943.

Dear Sir,—Many will thank you, Sir, for publishing, and Mr. Manley for writing, the articles on vibrating systems which appeared in your January number. We who teach, and others, echo Mr. Manley's strictures upon the muddle which has arisen owing to the injudicious use of the term " mechanical impedance." It does, however, seem a pity that in these articles (and in his book) Mr. Manley did not criticise constructively by adding his voice to those who do use this term to denote a quantity precisely analogous to the electrical impedance.

Mr. Manley defines

$$\text{dynamic stiffness} = \text{force} \div \text{displacement},$$
$$\text{effective inertia} = \text{force} \div \text{acceleration}.$$

Neither of these has, for the general electric circuit, an analogue which the electrical engineers are in the habit of using. But mid-way between them is another quantity—

$$\text{force} \div \text{speed},$$

which is analogous to

$$\text{voltage} = \text{current} \div \text{impedance},$$

and so can rightly and usefully be termed " mechanical impedance."

The present writer sincerely hopes that the above use of the trinity " dynamic stiffness," " mechanical impedance," and " effective inertia," with the above definitions, can rapidly become standard.

Yours faithfully,

W. G. BICKLEY.

To the Editor of the JOURNAL OF THE ROYAL AERONAUTICAL SOCIETY.

" Kvik Michael," Hillfield Road,
Farnborough, Hants,
3rd February, 1943.

" ELECTRO-MECHANICAL ANALOGY, ETC."

Dear Sir,—It is puzzling that Mr. R. G. Manley should have been unable to find a full description of the electro-mechanical analogy or, to be more precise, analogies. There is an extensive literature, especially in the English language, and most text books give it as much detail as it requires or deserves. In view of the paper shortage, I will not give a bibliography, but will suggest study of the yearly indexes of Science Abstracts (A and B).

The main difficulty about these analogies is to discover what purpose they serve, as usually employed. If they are used, as in fact they sometimes are, for the construction of computing apparatus their value is obvious, but such applications are rarely mentioned.

If the purpose is to enable electric circuit notation to be used for mechanical systems, then the analogy proposed by Mr. Manley largely defeats itself. By identifying mass and inductance, one is forced to represent mechanical elements in series by electrical elements in parallel, a rich source of blunders.

If, however, we identify inductance with spring and capacity with mass, this difficulty disappears, and the mechanical and electrical diagrams are identical, as are of course the equations. This being so, there seems little reason in calling in electricity at all, unless one is building a computor.

The main exponent of this last system is Dr. F. A. Firestone, who has described its application in many sources.*

Yours faithfully,

R. A. FAIRTHORNE.

To the Editor of the JOURNAL OF THE ROYAL AERONAUTICAL SOCIETY.

February 22nd, 1943.

Dear Sir,—The universal adoption of Dr. Bickley's suggested definition of " mechanical impedance," and of the resulting complete trinity of quantities, would be most advantageous to all who use or teach the theory of vibration. The connotation which we should like to abolish has been the result of usage, and it is unfortunately a fact that the most admirable changes in usage are the most difficult to accomplish; such difficulties should not, however, discourage the attempt to place the terminology of a science upon a rational basis, and I concur entirely in Dr. Bickley's expressed hopes for a rapid standardisation. There are other anomalies which should be eliminated; it is surprising, for example, how many writerss refer to the " centre of gravity " and " moment of inertia " of cross-sections which (being merely areas) are not influenced by gravity and have

* (inter alia) J. App. Phys. J., 6, pp. 373/87. " The Mobility Method of Computing the Vibration of Linear Mechanical and Acoustic Systems, etc." F. A. Firestone.

no inertia. The time has come for scientists and technicians to follow Mr. A. P. Herbert's advice and " worry about words."

Dr. Bickley's suggestion raises a question of some practical importance; would it not be advantageous to adopt the quantity which we agree to call " mechanical impedance " as a practical measure of vibration characteristics, in place of dynamic stiffness or effective inertia? The method of determining resonant frequencies by the intersection of characteristic curves has been developed mainly by aeronautical engineers; some such development was in fact necessitated by the inertia-plus-flexibility properties of the modern metal propeller. Now, it is immaterial, as far as results are concerned, which member of Dr. Bickley's trinity is selected for this purpose; and although mechanical engineers tend to think in terms of inertias and displacements rather than in terms of velocities, the adoption of a velocity basis of measurement would actually effect the elimination of a piece of apparatus; the electromagnetic torsiograph used in the practical determination of the dynamic stiffness of propellers gives an output voltage proportional to velocity, and this output is generally passed through an integrating device in order to obtain a measure of the displacement. This integration is, of course, unnecessary if the velocity measurements are required instead of displacement measurements.

It might be argued that the retention of the torsiograph as a displacement-measuring instrument is necessary for the calculation of T.V. stresses; it is now quite clear, however, that the presence of " rolling " components in the torsional vibration of crankshaft systems precludes the possibility of obtaining correct values for stresses by calculation from observed displacement-amplitudes at either end of the crankshaft, and that reliable results will only be obtained by the use of strain gauges.

I am grateful to Dr. Bickley for his suggestion, and trust that it will receive the consideration of other interested persons and so initiate the development of a standardised terminology and technique.

Replying to Mr. Fairthorne's points in order: No *complete* ab initio treatment of the analogy is given in the standard works on mechanical vibrations (Den Hartog, Timoshenko, Ker Wilson), although Den Hartog supplies a table of analogous quantities and one or two scattered examples. The " most text books " to which Mr. Fairthorne refers are concerned, I suppose, with electrical theory; if this is the case, writers on electrical theory are to be congratulated on retaining a less insular attitude towards other branches of science than is shown by their mechanically-minded colleagues.

It is surprising that the elementary characteristics of mechanical and electrical oscillations should ever have been studied separately; if the properties of the basic differential equations are ascertained, the properties of mechanical or electrical systems are obtained by substituting the appropriate physical quantities for the mathematical coefficients. I have personal knowledge, however, of electrical engineers engaged in mechanical vibration research who have wished to convert the mechanical systems to electric circuits, and have been unable to do so; the process I describe enables the conversion to be made without resort to the differential equations—a simplification which appeals to those who are not primarily mathematicians.

When reference is made to the basic differential equations, and retaining force and e.m.f. as analogous quantities, it is difficult to see the logical basis for identifying inductance and " spring," or capacity and mass. I am indebted to Mr. Fairthorne for bringing this " analogy " to my notice.

Yours,

R. G. MANLEY.

P.S.—In my paper may I make two small corrections? The caption to Fig. 1 on p. 7 should be deleted, and the reference to Fig. 9 on p. 20 should have been deleted from the mss. as I decided a diagram was not necessary.