CORRESPONDENCE.

The Hamiltonian Revival.

To the Editor of the *Mathematical Gazette*.

Sir,—In his fascinating article "The Hamiltonian Revival", in your issue of July last, Professor E. T. Whittaker turned aside to deal an uncalled-for stroke against two great men and part of their work in the following passage:

> "Then those who were in the outer circles of Hamilton's influence—*e.g.* Willard Gibbs in America and Heaviside in England—wasted their energies in devising bastard derivatives of the quaternion calculus—dyadics and vector-analysis—which reproduced its most regrettable feature, namely the limitations imposed by its close association with the geometry of ordinary space, and which represented no advance, but rather a retrogression, from the point of view of general theory."

Doubtless many others besides myself read these words with surprise and regret, because no one can be unaware of the growing appreciation and use of vectors (and to a less extent of dyadics), both as a means of expression and as a tool in mathematical technique.

The word *bastard* may be used in either a technical sense or merely as a term of abuse, but its user may reasonably be asked to justify its application, and also the charge of *wasted* energies. Professor Whittaker indeed indicates what he regards as the "most regrettable feature" of vector analysis and dyadics, and I hope to comment on that criticism; but before doing so it would be well to know whether this is the sole justification of his condemnatory words, or if not, what are the other counts in his indictment.

E. A. Milne.

To the Editor of the *Mathematical Gazette*.

Sir,—May I take the occasion presented by Professor Milne's letter to explain more fully what was in my mind when I wrote the sentence he objects to.

First, let me recall a definition: Any set of objects of thought may be called *generalised numbers*, provided we can define what is meant by the "equality" of any two of them, and can also define the operations of "addition" and "multiplication" with respect to them, and provided also that the set of objects form a "group" with respect to these operations, *i.e.* the effect of combining two of the objects by means of one of the operations is to produce an object which also belongs to the set. The operations should satisfy certain conditions which need not be given here.

Thus, matrices of any order n may be regarded as generalised numbers; for we can define the equality, addition, and multiplication of matrices; and the result of adding or multiplying two matrices is to produce another matrix.