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LETTERS TO THE EDITORS

COMMENT ON THE PAPER "AN EVALUATION OF BULEEV'S MODEL OF TURBULENT EXCHANGE"

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QUARMBY's paper [1] requires a comment relative to a number of statements directed to our results which we obtained with an improved version of Buleev's model and have been published previously. We will restrict ourselves to those statements which are related to our result for the ratio of the eddy diffusivity in the tangential direction $\varepsilon_{h,w}$ to that in the radial direction $\varepsilon_{h,r}$ in a circular tube [2].

Quarmby states that he could not achieve our result revealing for the ratio $\varepsilon_{h,w}/\varepsilon_{h,r}$ values greater than unity by direct application of Buleev's method. Further, after examining the mathematical properties of Buleev's solution, he finally arrives at the following conclusion: "It is clear that the result claimed by Ramm and Johannsen [2], that the ratio $\varepsilon_{h,w}$ to $\varepsilon_{h,r}$ is greater than unity and in agreement with experiment, Fig. 5, is impossible." This statement clearly implies that we published incorrect results either by purpose or by obvious incompetence in applying Buleev's model adequately. In view of the fact that we never published any results obtained by direct application of Buleev's original model but always stated that we removed "certain deficiencies (as also evaluated in Quarmby's paper) which become apparent on physical grounds and with respect to empirical evidence in predicting turbulent transport properties" [2] Quarmby's statement is completely unjustified and must be considered unfair if not malicious.

The "impossible" result that $\varepsilon_{h,w}$ to $\varepsilon_{h,r}$ is greater than unity is the immediate consequence of introducing length scales which are dependent on direction. This essential extension of Buleev's model (as well as others) is most elaborately described in [3] but was also clearly discussed in references 4, 5 and 7 cited by Quarmby in his paper.

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REJOINDER*

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QUITE often, progress in science and engineering has been made by recognising that an established idea is wrong, that some concept is false or some claim overstated; though the production of "negative" results is not highly regarded. Only the French remember who corrected Newton's mistaken idea that sound travels *isothermally*.

Ramm and Johannsen make the particular point that they modified the method of calculating the length scale and also made it a function of direction, thereby, supposedly, re-establishing the credibility of Buleev's model and the results obtained from it.

Examining equations (12), (13) and (16) of [1] it is clear that altering the definition of length scale and the method of calculating it from one configuration to the next is equivalent to changing the coefficients from one configuration to the next. Ramm and Johannsen [7] of [1] say that the choice of the method appropriate to each case is the result of "intuition". It is not surprising that they concluded that there was no need to alter the coefficients also.

Further, in Buleev's model the length scale is a function of position and in principle an eddy diffusivity could be calculated for any direction from a particular point of interest. The choice of the usual co-ordinate directions r, ω is for convenience. Making the length scale a function of the direction of the line along which the integration is being performed, means that the length scale can have an infinity of different values at the same one point. Consequently, the "mole" at that point has an infinity of different diameters, means, free paths and velocity fluctuations, all at the same time. This is not a convincing physical picture.

However, maybe Ramm and Johannsen's modifications could have been justified heuristically. Their proposals for the length scale in the tangential direction, L_ω, are that: (i) in [4] of [1], it decreases linearly to zero as the wall is approached; whereas: (ii) in [7] of [1] they used two options which become identical for the case of a plain tube or parallel plate channel and which in the notation of [1] can be written:

$$L_\omega = L_r(y_0^+)\left(\frac{y^+}{y_0^+}\right)^m \quad (1)$$