In this a marked upper depression which had developed unexpectedly over western Bass Strait was traced backward for 24 hr. to a region of the Great Australian Bight, where the available observations could not have shown its existence. The calculation also indicated the presence of a depression over the southern Tasman Sea, where the analysis previously had shown only an indefinite trough.

These results suggest that the retracing of large-scale flow developments may also have practical utility. Even with the best of present-day networks, forecasts remain affected by the uncertainties of regions lacking observations. The backward integration procedure can be used to make the analysis in such regions dynamically consistent with that for the network area. This approach will be explored in detail when we test the performance of the barotropic and other models in the Australian region.

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Small-Scale Turbulent Diffusion in the Atmosphere

Clarenburg and Tang[1] recently published a communication under this title in which they compared observations of smoke cloud spreading made by Frenkiel and Katz[2] with the relationships t, and $(t + 3)^{(2-n)/2}$, where t is time after generation of the burst, and n describes the shape of the one-point Lagrangian velocity autocorrelation; n was assigned the value 0·26, following Sutton[3]. Before the conclusion by these authors about the results of this comparison can be accepted, two points must be made:

(1) The authors base their computation of the spreading of smoke puffs on Sutton's well-known diffusion theory. It was pointed out in 1946, by M. I. Yudine[4], who referred to Richardson's[5] work and to the paper by Obukhov[6], that Sutton's treatment describes average dispersion, computed with reference to a fixed space-point or axis; but it does not describe relative diffusion of particles about a centre of gravity which is itself at liberty to move with the turbulence, as is the case with a smoke puff. The point has been emphasized and clarified in papers by Brier[7], and Batchelor[8–10], and many others. Relative diffusion depends on factors additional to the single-point, Lagrangian velocity correlation and hence cannot be described correctly by means of the parameter n. The additional factors governing relative diffusion are: (a) the initial size of the smoke puff; (b) multi-point Lagrangian correlations. Arguing from Obukhov's dimensional theory of turbulence, Batchelor deduced that the dispersion of a smoke puff should be proportional to a power of t less than unity at first, and afterwards to $t^{3/2}$.

(2) Clarenburg and Tang compared their diffusion theory with Frenkiel and Katz's excellent series of observations of the diameters of nineteen smoke puffs. The experiments were made on two successive days, and consisted of 7–20 photographic puff observations per experiment, made at one-second intervals. When a smoke puff spreads, at first its visible diameter increases; but later a maximum is reached, followed by a rapid decrease to zero. This maximum diameter seems actually to have been recorded[2] for at least eight of Frenkiel and Katz's smoke puff observations; runs number 6, 7, 13, 16, 18, 20, 9 and 11. The observed puff diameter is clearly not the same quantity as the (root mean square) dispersion of diffusion theory. The dispersion increases with time indefinitely. It is for this reason that other workers, starting with Roberts[11] (and including Frenkiel and Katz) have interpreted the visible smoke puff outline as a line-of-sight integrated smoke concentration value. According to this interpretation, it was shown by Gifford[12] that Frenkiel and Katz's smoke puff data (among others) support the predictions of the theory of relative diffusion. The observed puff dispersion proceeds at first according to a power of time less than unity, as long as the influence of the initial puff size is still dominant. But after about 10 sec. (for these puffs), the dispersion, but not the puff diameter, is found to obey a $t^{3/2}$ law for the remainder of the puff's visible lifetime.

The high correlations of smoke puff diameter observations with the assumed dispersion law $(t + 3)^{0\cdot 87}$, obtained by Clarenburg and Tang, stem from two separate, unrelated effects, neither of which has been considered by them: (a) At first, smoke puff diameters do increase in proportion to a power of time less than unity; this initially slow spreading does not, contrary to Clarenburg and Tang's assumption, reflect the degree of turbulence present, or the shape of the one-point Lagrangian autocorrelation function. Instead, it reflects primarily the influence of the initial puff size, according to the prediction of the theory of relative diffusion. (b) Later, when the influence of the initial puff size decreases to zero, relative diffusion proceeds at an accelerating rate, that is, according to a power of time greater than unity. The puff diameters, on the other hand, reach a maximum and then actually decrease with time. This is, of course, a purely optical effect, and does not reflect any corresponding decrease in the real turbulent diffusion-rate. In fact, the higher the real turbulent diffusion, the more marked this latter effect should be.

For the above reasons, it is difficult to agree with the conclusion by these authors that their theoretical results are in good agreement with these experimental data.

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