CORRESPONDENCE

A proposed mechanism of squall lines: the pressure jump line

By ABDUL J. ABDULLAH

Dept. of Meteorology and Oceanography, New York University, New York 53, N. Y.

28 October 1952

In the February 1950 issue of the JOURNAL, Dr. Tepper[1] published, under the above title, an interesting paper in which he clarified the role of pressure discontinuities in the phenomenon of squall lines. The mechanism which he suggests is entirely in agreement with the viewpoint that I advocated in 1949, in the paper[2] to which he referred. However, he made two minor remarks which must not pass without some discussion.

> 1. On page 22, Dr. Tepper said: ". . . the pressure gradient at 2206 EST near Station 23 is of the order of magnitude of . . . 1.15 mb km^{-1}. For such a pressure gradient, the equilibrium geostrophic wind would have to be of the order of 2500 *miles per hour*. Obviously, since winds of even a small fraction of this order of magnitude are never experienced, geostrophic balance is not reached, and we may conclude that the individual air particles remain under the influence of the pressure gradient only a very short interval of time."

The point of argument in regard to this statement is that Dr. Tepper seems to admit that there is a finite pressure gradient across the jump, which therefore must have resulted from a continuous pressure distribution. If this is the case, all the theoretical analysis of which he makes use in his paper does not apply. However, it is clear that a real jump of the kind he described must be associated with a real discontinuity in the pressure field, and the pressure gradient across the jump must have an infinite value.

The attempt to apply the geostrophic wind relation to the jump is in itself misleading. For as we know, the geostrophic relation is derived from the hydrodynamic equations under certain simplifying assumptions. But even the unsimplified hydrodynamic equations themselves cannot be applied across a jump, for the very obvious reason that these equations are derived on the assumption that the fields of pressure, velocity and density are continuous throughout the region. The derivations of those equations make use of Taylor's series which, evidently, cannot be used across a discontinuous field like that of the jump. The appropriate equations for this case are, neglecting the Coriolis force, compressibility, friction and external forces,

$$[\rho\, dV/dt] = -[\nabla p]$$

and

$$[\mathrm{div}\,(\rho V)] = 0,$$

where brackets denote the finite difference between similar terms across the jump.

Therefore, it can hardly be overemphasized that the strong winds which Dr. Tepper computes do not exist not because the individual particles remain under the influence of the pressure gradient only a very short interval of time, but because the strength of the winds cannot be computed from the preliminary hydrodynamic equations.

> 2. On page 26, Dr. Tepper said: "That the Coriolis force acting on any particle may be disregarded follows from our earlier conclusions that any individual particle remains under the influence of the intense pressure gradient only a very short time and that during that time the winds blow normal to the gradient in response to the pressure gradient alone."

In connection with this statement, I wish to make the following two remarks.

First, it has been shown by me, in the paper to which Dr. Tepper made reference, that if the initial conditions were those of perfect rest, *i.e.*, if the piston starts pushing against a fluid which was initially at rest, the horizontal velocity of the individual particles that are right at the jump when it is just formed is zero. This means that the jump cannot give rise to winds right at the jump line. It is then an easy thing to extend the application to the case of a pre-existing current of fluid. The jump cannot produce any change right at the jump line. In the actual case which is observed in the atmosphere, I presume that after the fluid at the jump breaks, winds will be observed because of the vertical velocities initiated by the intense turbulence of instability caused by the breaking process.

Second, it has also been shown in my paper that the horizontal velocity of the individual particles is a function of the distance from the moving piston, being a maximum right at the piston (where it is equal to the instantaneous velocity of the piston), and a minimum at the jump. Since the movement of the piston must persist for an appreciable time to produce an appreciable jump, it follows that the individual particles which lie behind the jump must continue to move for a considerable time. This being the case, the Coriolis force must act on them and deviate them to the right. It appears, therefore, that even though the Coriolis force does not act right at the jump, it must act behind it. Whether this would or would not make any difference in the mechanism of a squall line is

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[1] M. Tepper, "A proposed mechanism of squall lines: the pressure jump line," *J. Meteor.*, 7, 21–29, 1950.

[2] A. J. Abdullah, "Cyclogenesis by a purely mechanical process," *J. Meteor.*, 6, 86–97, 1949.

debatable. It certainly must show its influence in the region bounded by the advancing cold front and the pressure jump line. I believe this question can only be settled by further theoretical and observational work.