Weather Bureau,
Melbourne.

13th April, 1953.

Editor,
"Australian Meteorological Magazine",
Commonwealth Weather Bureau.

Dear Sir,

It is regrettably necessary to correspond further on the subject of Mr. Mizon's article on frost forecasting, criticised by me on p.24 of issue Number 2, dated December 1952.

I. Unfortunately mistakes occurred in the reproduction of my original note, in which the final equation should have read:

$$\bar{u} = \frac{\Delta T}{s} R\, t \ln \frac{p_o}{p}$$

where $\bar{u}$ is the mean velocity of circulation round a closed circuit whose length is s , whose lower pressure is p_o, and upper pressure p and whose vertical limbs consist of isotherms T and T + ΔT.

R is the gas constant, and t is time.

Now it is true that s in general does not remain steady with time, since variable wind velocities occur perpendicular to the plane of the circuit, and the original chain of particles in the circuit will become distorted with passage of time. Since, however, we are studying <u>only</u> the katabatic effect under stable conditions, we can assume that the only movement present is that due to the katabatic. We can also assume that the coriolis acceleration will not, in the period under consideration, seriously affect the circulation, and that the initial conditions of pressure and temperature remain unchanged despite the circulation. This is a rather unrealistic assumption, but is necessary to avoid great mathematical complications. With these assumptions, s does not change with time; the particles maintain their positions relative to each other. It is completely wrong to write $ds/dt = \bar{u}$, for **u** is the velocity of a particle, $\bar{u}$ the mean velocity of the particles, round the circuit. If $ds/dt \neq 0$, we must,

/39

if we are to use this theory, evaluate it; this would be difficult, but unnecessary, if we are only concerned with the katabatic. Thus in no wise can the statement $\bar{u}\, ds/dt = \bar{u}^2$ be justified. It is clearly the result of not understanding the meaning of s.

2. An unfortunate transcription error on my part was responsible for the figure "10 hours" instead of "one hour" appearing in the example I worked.

3. If Mr. Mizon wishes to account for the gradual increase of the katabatic to a maximum value which is then maintained for some time, he should obviously include a friction term in his equation.

We may then write

$$\frac{d}{dt}\oint u\,ds = R\Delta T \ln \frac{p_o}{p} - \oint F\,ds$$

where F is the friction force per unit mass acting on a particle.

If we use the (admittedly rather inaccurate) Guldberg-Mohn relation

$F = ku$ where K is the so called friction constant

we obtain

$$\frac{d\bar{u}}{dt} + k\,\bar{u} = \frac{R}{S}\Delta T \ln \frac{p_o}{p}$$

whence, by solution of the differential equation,

$$\bar{u} = \frac{R}{S} \cdot \frac{\Delta T}{K} \ln \frac{p_o}{p} \left(1 - e^{-kt} \right)$$

This clearly approaches a limiting value $\frac{R}{S} \frac{\Delta T}{K} \ln \frac{p_o}{p}$

as t approaches infinity.

If we evaluate the expression when p_o, p, T, s, are as previously quoted, and k has the value 5×10^{-4},

we find $\bar{u}$ has limiting value 1.1 ΔT m/sec;
after 12 minutes $\bar{u}$ has 37% of this value
after 1 hour ....90% ....
..... 2 hours..........99% ....

Thus we should expect that a temperature difference between hill and valley of about 1.3/1.1 or about 1.2°C is sufficient to produce a katabatic of 3 m.p.h. (1.3 m/sec), and that its full value would be reached after an hour or so from the establishment of the necessary temperature gradient.

R. H. Clarke