Reply

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1. Introduction

It is encouraging to note the questions generated by my article (Boatman, 1974) discussing the variation of pilot balloon ascent rates with changing atmospheric temperature. It has long been assumed that pilot balloons rise at an essentially constant rate. The data I presented earlier, though inconclusive, questioned this assumption. There were two purposes in presenting those data. First, to point out that pilot balloon ascent rates are not always constant. Second, to show that further empirical and theoretical research was and is necessary to support or refute the long-held assumption of constant pilot balloon ascent rates.

2. Discussion

Nelson's comments are appreciated. However, several points deserve expansion.

As mentioned earlier, my primary concern was not to develop a comprehensive theory explaining the observed variability in pilot balloon ascent rate but to present data which demonstrated the variability. Nelson's criticism concerning the theory developed is partially correct. His comment that the lapse-rate dependence should have been carried through explicitly in arriving at my Eq. (9) is valid. However, when taking the limit of Nelson's Eq. (4) as $\Gamma \rightarrow 0$ one arrives at the following:

$$V^2 \xrightarrow[\Gamma \rightarrow \pm 0]{} (FgR_d/P_0d^2\kappa)300 \exp(gz/R_d). \qquad (1)$$

This is equivalent to Nelson's Eq. (6):

$$V^2 \xrightarrow[\Gamma \rightarrow \pm 0]{} (FgR_d/P_0d^2\kappa)300 \exp(gz/300\, R_d). \qquad (2)$$

Nelson states that a general balance between increasing balloon diameter (which decreases the balloon rise rate) and increasing altitude (which increases the balloon rise rate) provides an approximately constant rate of rise.

One can define a coordinate system positive in the upward (z) direction. In this system pressure and gravitational attraction are vectors in the downward

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($-z$) direction. Balloon free lift is a vector in the upward (z) direction. Thus, Eq. (1) becomes

$$V^2 \xrightarrow[\Gamma\to\pm 0]{} (-gFR_d/-P_0d^2\kappa)300\exp(-gz/R_d), \qquad (3)$$

where g and P are now positive quantities. This simplifies to

$$V^2 \xrightarrow[\Gamma\to\pm 0]{} (FgR_d/P_0d^2\kappa)300\exp(-gz/R_d). \qquad (4)$$

It is seen in Eq. (4) that in a constant temperature lapse rate environment pilot balloon ascent rate cannot remain constant. In fact, both increasing height and increasing balloon diameter decrease pilot balloon ascent rate. Only the slowly decreasing aerodynamic resistance aids in maintaining pilot balloon ascent rate in an isothermal ($\Gamma=0$) environment. Overall, a decrease in ascent rate must occur. The results found in Boatman (1974) are predicted by Eq. (4).

Care was taken during all pilot balloon launches to follow the standard procedures outlined in Circular 0 (U. S. Weather Bureau, 1942). Although not discussed previously, data gathered with the double-theodolite system were taken at half-minute intervals throughout each launch. Continuous two-way radio communication allowed readings to be made within $\pm\frac{1}{2}$ s. Errors in pilot balloon ascent rate resulting from this source were not considered significant.

In light of Eq. (4) it would be wise to develop exponentially dependent expressions for pilot balloon height as a function of time while within isothermal layers rather than the simplified quadratic relations previously used. However, a more conclusive data base is desirable before such expressions are developed or used.

To obtain the needed data, studies are now being done as a portion of HIPLEX. Data from eight radiosonde balloons launched daily within 150 km of Miles City, Mont., are being analyzed for balloon rise rate at 1 min intervals. These data will be compared with the tropospheric temperature structure recorded by each radiosonde. Results are forthcoming.

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REFERENCES

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