Menzel, Donald H. A symbolic solution of the equation of radiative transfer.

The basic equation of radiative transfer,

$$\mu \frac{\partial I}{\partial \tau} = I - B, \quad (1)$$

has the symbolic solution

$$\left. \begin{aligned} I^+ &= \frac{1}{1 - \mu D} B \\ I^- &= \frac{1}{1 - \mu D} B - e^{\tau/\mu} \left[\frac{1}{1 - \mu D} B \right]_{\tau=0} \end{aligned} \right\}, \quad (2)$$

where I^+ and I^- represent the specific intensities of the outgoing and incoming beams. D is the symbolic differential operator, μ is the cosine of the angle between the beam and the outward vertical, τ is the optical depth and B is the "source function." The equation of radiative equilibrium,

$$\int_0^1 I^+ d\mu + \int_{-1}^0 I^- d\mu = \int_{-1}^1 B d\mu = 2B, \quad (3)$$

when combined with (2), gives the equation for B :

$$\begin{aligned} \int_0^1 \frac{\mu^2 D^2}{1 - \mu^2 D^2} B d\mu \\ = \frac{1}{2} \int_0^1 e^{\tau/\mu} \left[\frac{1}{1 - \mu D} B \right]_{\tau=0} d\mu. \end{aligned} \quad (4)$$

Setting

$$B = a + b\tau + \int_0^1 e^{-\tau/y} \varphi(y) dy, \quad (5)$$

and taking

$$\varphi(y) = \sum_0^\infty A_j y^j, \quad (6)$$

we obtain a set of simultaneous linear equations for determining the coefficients a and A_j in terms of b . The general solution is

$$B = a + b\tau + \sum_0^\infty A_j E_{j+2}(\tau), \quad (7)$$

where

$$E_n(\tau) = \int_1^\infty \frac{e^{-\tau x}}{x^n} dx. \quad (8)$$

Three terms of the summation give ample accuracy for most purposes. Equations (7) and (2) determine the angular distribution of the radiation intensity. Placzek has tabulated the functions E_n .

*Harvard College Observatory,
Cambridge, Mass.*

Millman, Peter M. and D. W. R. McKinley. Three-station radar and visual triangulation of meteors.

This paper presents one phase of the combined Dominion Observatory-National Research Council program for the observation of meteors. Since the summer of 1947 the following observational data have been collected:

- 100 meteor photographs,
- 5,000 visual meteor plots,
- 50,000 photographic recordings of Doppler meteor whistles,
- 1,500,000 photographic records of meteor radar echoes.

The Doppler and radar work has been carried out in the 30 megacycle band. In previously reported results we have indicated the dependence of the form of the echo on the distance of the meteor from the radiant, i.e. on the angle between the meteor path and the line of sight. We have also shown, in agreement with others, that the great majority of meteor echoes are produced in a fairly restricted region of the upper atmosphere centered somewhere between 90 and 100 km above sea level. Since the radar employed was essentially non-directional, all height data depended on a correlation of visual and radar observations.

To investigate the possibility of height determination by radar alone, three stations located at Ottawa, Arnprior and Carleton Place respectively, were put into operation in August, 1948. The base lines between stations were 36, 41 and 57 km in length. Photographic, visual and radar observations were carried out at all three stations. It was found that a large percentage of the meteors producing enduring echoes were detected by all radar sets. Where visual observations were also available from two or more points this made possible the computation of heights in three ways:

- (a) by the use of the three radar ranges,
- (b) by the combination of one radar range with a visual plot,
- (c) by the use of two or more visual plots.

To study the relation between heights determined by the three methods detailed computations have been carried out for the night of Aug. 10/11, 1948. Since the computation of meteor heights by radar range alone becomes insensitive for objects at long ranges the most reliable