potential between two walls of different temperature whereby the cold wall should be at a positive potential with respect to the hot wall. This, in fact, has always been observed.

In order to find the wall potential, the electron energy distribution at the wall must be known. Assuming this to be a near Maxwellian and that the ion temperature is approximately equal to the local gas (wall) temperature T_W, the wall potential[5] is given by:

$$-V_W = (kT_e/2e) \ln (T_e m_i/T_W m_e)$$

where kT_e is the mean electron energy at the wall and m_i/m_e the ratio of ion to electron mass. V_W is here usually of the order -10 V.

Assume one wall to be at 300° and the other at 600° K., $m_i/m_e = 2{,}000$ and electrons of $kT_e = 2$ eV. at a point where combustion becomes negligible. Through losses the electrons are cooled down to $kT_e = 0{\cdot}6$ and 1 eV. at the respective walls and the potential difference between the walls Δ V. is about 2 V. The observations in flames agree with this.

Larger wall potentials can be obtained by using other ionized media, for example high-frequency discharges in mercury, and in fact potential differences of more than 10 V. have been observed between electrodes kept at different temperatures.

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[1] Klein, S., *Proc. Conf. Ioniz. Phen., Munich*, 1961 (Amsterdam, 1962).
[2] Klein, S., *C.R. Acad. Sci., Paris*, **251**, 65 (1960).
[3] Klein, S., *C.R. Acad. Sci., Paris*, **251**, 2492 (1960).
[4] Gaydon, A. G., and Wolfhard, H. G., *Flames* (London, 1960).
[5] von Engel, A., *Ionized Gases* (Oxford, 1955).

METEOROLOGY

Relationship between Density of Newly Fallen Snow and Form of Snow Crystals

It has been suggested[1] that there should be a relationship between the density of a snowfall and the shape and size of the predominant snow crystal form which makes up the snowfall.

During the winter of 1960–61 concurrent measurements of density of newly fallen snow and snow crystal forms prevailing during the snowfall were taken at Montreal to test the assumption that the snowfall density is a function of crystal type.

Depth of snow was measured on a standard snow board 4 ft. × 4 ft. The weight of the snow corresponding to the measured depth was recorded in a standard Bendix–Freiz recording snow gauge. Snow crystals falling during the storm were caught in a portable cold box 12 in. × 12 in. × 5 in. and the sample was observed and photographed under a low-power stereomicroscope.

There appears to be a general variation of density with different types of crystals. Needles show a low density although one might expect that they would pack together to give a relatively high density snow. However, needles occur at relatively high ambient temperatures. They thus tend to form into snowflakes rather than fall as single crystals, and this gives a more open structure to the snowfall.

Riming shifts the density for needles one class range higher (approximately 2·5 per cent), while the effect on plates is a density increase of 5 per cent or more. This points to a greater collection efficiency for cloud droplets in the case of plates (and probably irregular assemblages) than for needles; this is what would be expected from the respective cross-sectional areas. Thus the removal of liquid water from a cloud system by the accretion process is a function of the crystal type; the latter would, therefore, appear to be an important parameter for consideration in precipitation models which include the ice phase.

Table 1

Snow density	0–0·05	0·051–0·075	0·076–0·10	0·101–0·125	Greater than 0·125
Predominant crystal types	Dendrites	Needles	Irregular assemblages of plates and columns, spatial dendrites; rimed needles (few rimed dendrites)	Nil	Rimed plates (few rimed dendrites)
Inches of snow	7·63	6·50	21·75	—	16·50
Percentage of total seasonal sample (52·38 in.)	14·6	12·4	41·5		31·5
No. of storms	5	4	6	0	4

The main results are indicated in Table 1.

No snowfalls were recorded of density 10–12·5 per cent. This gap appears to be a general characteristic of the area since the data for Burlington, Vermont[2], only 70 miles to the south-east, also show a marked drop in frequency of snowfalls of density greater than 9·5 per cent. In spite of the gap, the average snow density during the tests does not vary greatly from 10 per cent—the accepted average density figure for Canada.

The dependence of forms of snow crystal on ambient temperature (and humidity) prevailing during crystal growth has been established for crystals grown in the laboratory[3]. In the free atmosphere, confirmation of this relationship has also been made[4]. Thus, it now appears possible to relate also the density of snowfall to the conditions prevailing in the atmosphere aloft during the storm, at least on those occasions when one crystal type predominates.

The apparent dependence of snowfall density on crystal type may give an insight into the physical basis for part of the areal variation in the water equivalent of snow during storms. This variation is of importance in evaluation of cloud-seeding tests during winter months[5]. Observations on snow crystal types and the necessary conditions for riming (presence of supercooled water cloud below the snow generating level, etc.) might thus assist in reducing the variance in the precipitation series during experimental seeding tests; also anomalies of density or crystal types[6] may appear between seeded and unseeded areas.

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[1] Diamond, M., and Lowry, W. P., *J. Meteor.*, **11**, 512 (1954).
[2] Wilson, W. T., *Weekly Weather and Crop. Bull.*, **42**, 7 (1955).
[3] Nakaya, U., *Compendium of Meteorology*, 207 (Amer. Meteor. Soc., Boston, 1951). Mason, B. J., *Quart. J. Roy. Met. Soc.*, **79**, 104 (1953).
[4] Gold, L. W., and Power, B. A., *J. Meteor.*, **9**, 447 (1952); **11**, 35 (1954). Weickman, H. K., *Ber. deutsch. Wetterd.*, U.S. Zone, No. 6, 54 *SS* (1949).
[5] Summers, P. W., and Power, B. A., *Bull. Amer. Meteor. Soc.*, **41**, 89 (1960).
[6] Isono, K., *Intern. Conf. Cloud Physics, Canberra*, Abst. Paper 9.6 (September 1961).