are used). Thus the emergence of a stake will be lower than the ablation in compressive flow ($\partial u/\partial x < 0$) and higher in extensive flow.

This effect is generally a small one, but it is not negligible—for instance if $l = 2$ m, $\partial u/\partial x = -0.1$ year^{-1}, and $\partial v/\partial y = 0$, it implies that $-b = -e + 0.2$ m). Its correction is absolutely necessary near ice falls, as $\partial u/\partial x$ rises to 0.3 to 1 year^{-1}. To calculate the correction it is necessary to remember that strain-rate is a continuous process and ablation is an intermittent one, and that while it is occurring strain-rate acts on a variable length l.

It is usually convenient to set systematically two stakes (about 10 m apart) along the same line of flow to evaluate $\partial u/\partial x$ (it is almost always possible to estimate $\partial v/\partial y$ on a small-scale map by observations of divergence or convergence of moraines or active glacier edges).

When articulated stakes (rods with an anchoring system at the foot of each, joined together with little chains) are used, it is necessary to know whether lower rods have or have not pulled or pushed the upper rod.

In regions of extending flow the whole stake is pushed up by the lower rod and knowledge of $\partial w/\partial z$ is sufficient, but when the flow is strongly compressive it becomes necessary:

(1) to provide a sufficient length of chain and a very good anchoring system (such as a stainless steel spring blade of sufficient length);

(2) at every survey, to note if the upper rod is well anchored, to push it down, and note its emergence before and after pushing.

In a cold glacier anchorage is very good and it is necessary to estimate carefully the minimum length of all the little chains (ablation often being small, the stakes will stay in the ice a very long time).

I would like to thank Professor Lliboutry for his good advice and criticism.

Laboratoire de Géophysique et Glaciologie,
2, rue Très-Cloîtres,
Grenoble, France
14 April 1967

MICHEL VALLON

SIR, *Errors in the determination of ablation using stakes: comments on Dr. Vallon's letter*

It may just be worth adding the following remark to M. Vallon's letter. When the strain of the ice over the interval considered is large it is perhaps not immediately obvious how to calculate the correction term, because the length of stake buried in the ice, the gauge length, is changing over the interval in an irregular way, as the ablation rate changes. But, if one assumes that the vertical strain-rate $\dot{\epsilon}$ is constant, it is easy to show that

$$b = e + \bar{l}\dot{\epsilon}\Delta t,$$

where b is the true ablation, e is the length of stake exposed (the apparent ablation), Δt is the time interval, and $\bar{l}$ is the time average of the length of stake between the anchored point (which may be the bottom of the stake) and the surface. This holds for any variation in ablation rate, however irregular. $\bar{l}$ will not normally be known accurately, and must be estimated from the varying ablation rate over the interval.

J. F. NYE

H. H. Wills Physics Laboratory,
University of Bristol,
Bristol, England
21 August 1967