ice cannot be said to have predominantly horizontal *c*-axes. When the distribution of the *c*-axis orientation is considered, the mode of random distribution of the *c*-axis should always be kept in mind. Statistical treatment is also necessary for detailed analysis of the data of *c*-axis distribution. In this sense, the data obtained by observing Tyndall figures at Peters Lake support the conclusion that the ice has a predominantly horizontal *c*-axis orientation.

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SIR,

Discussion on Kamb and LaChapelle's paper "Direct observation of the mechanism of glacier sliding over bedrock"

In their paper, Kamb and LaChapelle (1964) conclude that the observed velocity of cubes 1 cm. on a side pulled through ice disagrees with the prediction of figure 2 in my original sliding paper (Weertman, 1957). Figure 2 indicated that a 1 cm.^{3} cube pushed with a force of 16 kg. will move through ice at the same velocity regardless of whether the mechanism of motion is provided entirely by pressure melting or by creep-rate enhancement. The results of Kamb and LaChapelle show that at a force (17·6 kg.) which is close to 16 kg., the velocity is faster if pressure melting is the operative mechanism. Moreover, Kamb and LaChapelle point out that in their experiment, the effective stress to be used in the creep enhancement mechanism must be increased over the stress I used by factor of 2. This modification increases the predicted velocity of the creep-rate enhancement mechanism by a factor of 2^n, where n is of the order of 3 to 4. This increase makes the disagreement between theory and experiment even greater.

In figure 2 of my original paper Glen's value of $n = 4 \cdot 2$ was used in the calculation. It is more fashionable now to use a value near 3. If Glen's other value of $n = 3 \cdot 2$ is used in the calculations, the velocity predicted by figure 2 for the creep enhancement mechanism is decreased by a factor of 8. This factor of 8 has to be multiplied by $2^n = 2^{3 \cdot 2} = 9 \cdot 2$ in order to make a comparison with the experiments of Kamb and LaChapelle. Thus the velocity due to the creep-rate enhancement mechanism is a factor of $9 \cdot 2/8 = 1 \cdot 15$ larger than that given by figure 2. It would appear that theory and experiment still disagree.

Although Kamb and LaChapelle modified the calculation of the creep-rate enhancement velocity by the factor 2^n, they neglected to make a similar modification in the pressure-melting velocity calculation. They pointed out that the hydrostatic pressure difference on either side on an obstacle should be increased by a factor of 3 over the value I used, but they did not correct figure 2 for the resultant factor of 3 increase in velocity. They also neglected to take into account the fact that the thermal diffusion coefficient used in my calculations for figure 2 was a factor of 2·4 smaller than the thermal diffusion coefficient of dunite and plexiglass used in their experiments. Therefore, the calculated pressure melting sliding velocity of figure 2 should have been increased a factor of $2 \cdot 4 \times 3 = 7 \cdot 2$. The sliding velocity due to the pressure-melting mechanism thus should be a factor $7 \cdot 2/1 \cdot 15 = 6 \cdot 2$ larger than that of the creep-rate enhancement mechanism. These modifications of the calculations result in a predicted pressure-melting velocity of 3 cm./day, as compared to that observed, at the melting point, of 3·4 cm./day for a dunite cube and 1·6 cm./day for a plexiglass cube. The theoretical value for the velocity

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caused by the creep-enhancement mechanism, if $n = 3 \cdot 2$, is 0·4 cm./day. This is approximately the velocity of the cubes just before they reach the pressure-melting point. I conclude that theory and experiment agree reasonably well. Any discrepancy between the theoretical and experimental values can be attributed to the uncertainty in the experimental creep data which must be used in the theory.

I have discussed elsewhere ([Union Géodésique et Géophysique Internationale], in press) other points of Kamb and LaChapelle's remarkable paper which bear on sliding theory, and thus there is no need to repeat that discussion here.

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