ever been used to describe sea ice features, and undue brevity, when certain useful terms are not included. A parallel function is to choose between synonyms and near-synonyms in a given language, backing the chosen term and suppressing (by omission) any others. In these two areas the nomenclature must be judged successful; although in the first, my own opinion is that it errs slightly in the direction of too many rather than too few terms. This is no doubt the price of international agreement. One country may seek the inclusion of a term which the others do not see a need for, and the easy solution is to accept it because it does no harm, and after all no one is compelled to use it.

In general, this is a sensible list, and its availability in a usable form (that is, with pictures which really help) is welcome. There is some criticism to be made of minor points. On the definitions, one may wonder why the term "ice of land origin" (1.2) has in its definition "the concept includes ice that is stranded or grounded", when that phrase is included in the definition of the parent term "floating ice" (1), and not in that of the other main subdivisions "sea ice" (1.1), "lake ice" (1.3) and "river ice" (1.4), where it is also presumably true. There is not a term for a water area with no ice at all present. It may be argued that such a concept is not of proper concern to a sea ice nomenclature: but with "ice-free' and "open water" already included, and defined as areas in which some ice may occur, the user is at a loss for words not already pre-empted. There is a misprint on p. 6, under 8.2.2.6: "oiled" should read "piled". On the Russian translation, there is a discrepancy over the thickness of ice islands: the Russian text says 15–30 m, while the English text says 30–50 m. On the pictures, the excellence of many tends to emphasize the poor quality of some (31, 80, 81, 145, 160), and a few are unclear (36, 97, 143, 144). The twelve colour pictures are attractive but the colour is decisive for their purpose in only about half the cases. There is even one joke: bare ice (133) is apparently ice with bears on it. No doubt the intention is to improve the pictures by gradual replacement as better examples come to hand.

Will people use this nomenclature? One may suspect that while the various countries' officially-appointed delegates have reached agreement, their seamen, oceanographers and other interested parties go on using the terms they have always used. To some extent, this is bound to be so. But it may not matter too much. While the desirable thing would no doubt be for as many users as possible to accept exactly this set of terms, the essential thing is that they should be used by the relatively small group of meteorologists whose job is to collect, transmit and interpret the information; and this is probably already the case. Meanwhile, wider use will slowly grow.

TERENCE ARMSTRONG

N. RIEHL *and others, ed. Physics of ice: proceedings of the international symposium on physics of ice, Munich, Germany, September 9–14, 1968. Edited by N. Riehl, B. Bullemer, H. Engelhardt.* New York, Plenum Press, 1969. xix, 642 p. $25.

THIS book exhibits the usual merits and demerits of a symposium report; merits, because hardly by any other means would one get so many aspects of the science of ice treated between the covers of one book: and demerits, because of lack of rigour in refereeing and editing. With regard to the first of these charges, it in fact comes off very well: one can agree with Onsager's closing remark "there is very little I wanted to miss". On the other hand, the second usual defect is somewhat enhanced on this occasion by the fact that the language of the symposium, English, is not that of the editors, or of a majority of the contributors. Language apart, the number of occasions when the equation as printed is obviously not quite right is irritatingly many.

Printed in photo-reduced typescript (which, in the reviewer's experience, always makes for a lower standard of proof-reading) on rather thick paper, this is too cumbersome a volume to

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carry around for browsing. The diagrams are often so much reduced as to need a magnifier, but admittedly can always then be made out.

Of the 57 papers, the largest block, 12, deal with electrical properties: and since the next largest group, 9 dealing with diffusion and relaxation phenomena, include several on dielectric relaxation, electrical properties is, quite rightly, the dominant theme. Gränicher's introductory review to the whole symposium makes an excellent and much-needed guide through the conflicting evidence of this body of work, which still gives one the same impression as it did ten years ago that complete understanding is just around the corner. In the interim, estimates of the basic parameters have altered, some a little, some a lot, with the acquisition of purer specimens, discovery of relatively very large surface conductivities above -30° C, and recognition of the important difference between various kinds of electrodes. (Mounier and Sixou are perhaps the only workers who achieve an electrode with really well-defined simple properties—the completely blocking electrode realized by inserting sheets of mica between the electrodes and the ice.) In addition, new data on other phenomena such as self-diffusion and proton spin resonance have become available, and the complete scheme of defect behaviour which precisely fits all the facts still evades discovery.

Seven papers deal with mechanical properties, in which, in particular, the Japanese workers add significantly to our detailed knowledge of the creep laws, and dislocation motions and multiplication processes in ice. Higashi is less than enthusiastic for Glen's theory which connects dislocation motion with the migration of Bjerrum defects. Higashi attaches importance to the equality in activation energies of creep and self-diffusion, and deduces that dislocation motion is thermally controlled by the diffusion of molecular vacancies to dislocation jogs. Unfortunately for the strength of this argument, the activation energies of self-diffusion and dielectric relaxation are, within experimental error, the same, though, these processes *must* involve the motion of different defects—nature has played an unkind trick on us here. Whether his theory gives the whole story or not, Glen has clearly shown that dislocation motion and molecular reorientation are connected with each other: and an implication is that the man who is only concerned with the creep rate of ice cannot say that discrepancies in the proton spin-lattice relaxation time are no concern of his. All aspects of the science of ice are interrelated.

There are groups of papers on structure (H_2O has more crystalline phases, 9, than any other substance we know: even more if an alleged ferroelectric transition at about 100 K is genuine) and on lattice dynamics and the infra-red spectrum. Whalley contributes important papers on both these topics.

Of many less connected points which emerge in this wide-ranging symposium, space permits mention of only a few. Mogenson finds no change in positron annihilation lifetime when ice melts, but a discontinuous change in water, between 2°C and 4°C. Kvajić, Brajović and Pounder find more impurity incorporation (from 5 ppm radioactive Cs_2CO_3 in distilled water) when the ice grows upwards than downwards—whereas a number of experimenters are careful to grow their crystals upwards, reasonably expecting that to produce a purer product. Dantl and others find ageing effects in ice: the density of freshly formed ice can be as much as 0.3% higher than after ageing.

Hobbs and Ketcham claim to produce the first direct experimental determinations of the surface free energies solid–liquid, solid–vapour, and grain-boundary for ice: however, their analysis is invalid—they cannot consistently make the approximation of isotropy and the assumption that a planar solid surface can be in equilibrium under a sessile drop.

Glen, in a general review of (field) glaciology grossly misuses the word "dilatant". It is too useful a word to throw away in the original, and etymologically sensible, meaning for which Osborne Reynolds coined it: but to use it in the reverse sense of a corrupted meaning is really too bad! This paper apart, there is nothing directly about field glaciology in the symposium. Papers bearing on meteorological phenomena continue to give the result that whereas there

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are observable processes producing charge separations which may account for thunderstorms, theoretical mechanisms which can explain the observed magnitudes of these charge separations are still lacking.

The report can be recommended as a massive source of both experimental and theoretical information, but a careful examination for conflicting results is needed.

F. C. FRANK

R. F. FLINT. *Glacial and Quaternary geology*. New York, etc., John Wiley and Sons, Inc., [1971]. xiii, 892 p., illus. $24, £10.95.

THE review of *Glacial and Pleistocene geology* ([1957]) in this journal in 1958 (Vol. 3, No. 24, p.325) included a lengthy comment on the tremendous increase in glacial and Quaternary research since publication of Professor Flint's earlier work, *Glacial geology and the Pleistocene epoch* ([1947]). Needless to say, the output of Quaternary research has continued to spiral, furthermore the glacial epoch of many areas has been pushed back well into the Tertiary. The resulting expansion of the science has in part been taken into account by enlargement (by greater than 30%) and extensive revision of the 1957 volume to this new one. It is suggested in the preface that the work contains "about 80 percent new material" and this is readily apparent as is the very noticeable increase in references and citations. Basically, however, it has a similar format to and only slightly greater scope than the previous volume, covering glacial geology as well as the stratigraphic, environmental and historical interests of the late Tertiary. It also has the same logical organization, direct analysis and well presented conclusions as the 1947 and 1957 books. The new chapter "Overall view of late-Cenozoic climate and glaciation" clearly defines the diverse problems and prepares the student for the multiple approaches considered in this volume.

The emphasis of this book, as of its predecessors, is toward the physical side but this volume is more strongly punctuated throughout by palynologic or ecologic observations and a new chapter, "North America outside the glacier-covered regions", relies almost entirely on faunal or vegetational interpretation. There are also the two very comprehensive chapters on Quaternary fossils which have been enlarged and extensively rewritten.

We cite as examples of new material on physical processes and interpretation the thorough review of snow line, the large addition of sedimentological studies in one of the two chapters on glacial drift, and the greatly expanded chapter on fluctuations of sea-level. The latter section, nearly twice its old length, has been revised completely to stress the importance of terrace sediments rather than terrace elevations in correlation and interpretation. In these and most other sections the author has been able to extract pertinent ideas from a large, and frequently complicated and controversial, literature.

"Glaciers of today" is a chapter that will be of considerable interest to the readers of this journal. It is, in general, an excellent review of existing knowledge and goes a long way toward bridging the gap between the physicist and non-specialist reader. However, it is unfortunate that the recommendations of this journal (Vol. 8, No. 52, 1969, p. 3) have not been used when dealing with such terms as "annual snowline", "net mass budget" and "regimen". The section on net mass budget would benefit from a more formal tabulation of the component parts of the mass balance equation together with their relative significance. The suggestion, at the bottom of p. 37, that latent heat can be neglected when considering ablation is decidedly misleading. The paragraphs dealing with "movement" include a very clear explanation of the way in which a glacier moves, but Flint's use of mixed units leads to some confusion. For instance, to be compatible with the units listed on p. 39, the equation for

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