Response

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Professor Bird's mathematical approach to non-Newtonian phenomena appears to represent a fruitful method of attack. Indeed, its only apparent limitation is one which he points out near the end of the paper: viz., his assumption of an empirical relationship between shear stress and shear rate. By contrast, the method of approach used by Metzner and Reed requires *no assumption whatever* as to the specific relationships between these quantities. This statement of fact may be readily verified by reference to the original papers by Rabinowitsch and Mooney, upon which our development was based. (These references have been cited in our paper.) Indeed, the utility and beauty of the clever mathematical work in these two references lies in the fact that the need for any assumption as to the type of fluid behavior is unnecessary, and the results are perfectly applicable to *all* common types of non-Newtonian behavior. This question has been discussed in somewhat greater detail elsewhere (*2*), as well as in the original paper, and need not be repeated here.

It is true that we have implicitly assumed that the grouping of variables in our generalized Reynolds number (α and β in Professor Bird's nomenclature or n' and K' in the Metzner-Reed paper) will be the same outside the laminar region as well as within it. More recent theoretical work at the University of Delaware indicates that the friction factor in turbulent flow may depend on both n' and the generalized Reynolds number when this is done. However, the utility of the generalized Reynolds number in predicting the end of the laminar-flow region suggests retention of this form of the dimensionless group for all flow regimes.

This recent work has progressed to the point of predicting the form of the $f - N_{Re} - n'$ relationships for non-Newtonian fluids in turbulent flow. The assumptions required were substantially identical to those commonly employed by workers dealing with the same problem for Newtonian fluids. However, as the validity of some of these usual assumptions cannot be accepted without question, no publication of these results is planned until experimental confirmation of the theory is obtained. It is relevant to note, on the other hand, that the recommended design procedures given by Metzner and Reed in their summary is supported by this further theoretical work as being conservative in regions where it is not rigorously correct.

It has been pointed out (*1*, *2*) that most non-Newtonian fluids approach Newtonian behavior at the extremes of very low and very high shear rates. The latter situation arises in most work on turbulent flow of non-Newtonians. Accordingly, accurate experimental verification of any theory for the case of fully developed turbulence may prove to be very difficult unless non-Newtonian fluids of exceptional character are employed. Suggestions which readers may have along these lines may well turn out to be a major key to progress in this entire area and are earnestly solicited.

Correspondence with Professor Bird on these problems has been most stimulating and useful to the writer.

LITERATURE CITED

1. Alves, G. E., D. F. Boucher, and R. L. Pigford, *Chem. Eng. Progr.*, **48**, 385 (1952).
2. Metzner, A. B., 'Non-Newtonian Technology-Fluid Mechanics, Mixing and Heat Transfer,' in "Advances in Chemical Engineering," Vol. I, Academic Press, Inc., New York (1956).

BOOKS

The Atomic Nucleus. Robley Evans. McGraw-Hill Book Company, Inc., New York (1955). 972 pp., $14.50.

It is rare that one finds a book that is well suited as a text at an early graduate level and can also be recommended as a reference book for the worker in the field. Evans's is such a book.

As one who has been teaching such a course for several years this reviewer finds that at last he can recommend a text which parallels the material taught and maintains an equivalent level. Further, with its wide and clear coverage and its many references it should provide stimulation and basic understanding and, in addition, sources for a more detailed study.

Emphasis is placed on specific sample experimental procedures and interpretations which then lead into a more general and unifying presentation of a given field. For example, the subject of nuclear reactions is introduced by presenting various experimental studies of the B^{10} (α, p) C^{13} reaction. A study of the fine structure of the protons serves to introduce nuclear-energy levels, whose decay is then discussed. Subsequently, evidence for the neutron, radioactivity, the compound state, and resonances is introduced with historical background, all within the framework of the initial reaction or its competing reactions.

Sufficient theory is presented to provide a basic and qualitative understanding of the various topics. The notation in general corresponds to that in Blatt and Weisskopf's "Theoretical Nuclear Physics." In many ways it can be considered "an experimentalist's guide to Blatt and Weisskopf." The treatment is simpler and more qualitative, places major emphasis on the experimental approach, and assumes less background knowledge on the part of the reader.

Among the subjects covered which are not yet standard are nuclear models, includ-