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DR. FAIR—1950 BINGHAM MEDALIST

The third Bingham Memorial Award Committee has announced that Dr. W. F. Fair, Jr. will be the 1950 recipient of the Bingham Medal to be presented at the November 3 evening session of the Society's annual meeting. Dr. Fair was chosen from a list of eleven nominees prominent in the fields of education and industry.

The medalist is well known to rheologists throughout the country for his work on bituminous materials at Mellon Institute and with the Koppers Co. and is chairman of an American Society for Testing Materials committee on Rheological Properties.

Dr. Fair is a past member of the Governing Board of the American Institute of Physics and served four years as a vice-president and four years as president of the Society of Rheology. With Professor Bingham he did much toward arranging our publication agreement with the Academic Press, and was responsible for maintaining the Society's excellent technical programs and activities during World War II.

With Mrs. Eugene C. Bingham's original contribution and his diligence in obtaining donations from fifteen industries, Dr. Fair was instrumental in establishing the Medal as a self-perpetuating, annual memorial to "the father of modern rheology" and founder of the Society.

GAIN IN MEMBERSHIP

Through the combined efforts of Membership Committee and individual members about 60 new members have been added to the Society. Present member strength stands at about 386 as of August 1950, compared with 346 at the same time last year. The difference represents losses due to deaths and registrations and is somewhat higher than last year's.

The results of this year's campaign can be attributed to three important factors—1) Solicitation of prospects by individual members, 2) solicitation of prospects by the Membership Committee and 3) unsolicited applications for membership. Unfortunately, it is not possible to credit much of the individual effort. However, the work of Mr. D. W. Brookfield, which has resulted in a number of new members, is acknowledged with considerable pleasure.

During the 1950 campaign the Membership Committee solicited about 350 prospects. These were obtained from three main sources: (1) Prospects suggested by general

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PROGRAM — NOVEMBER 3 & 4

Hotel New Yorker

THE VISCOSITY OF A CONCENTRATED SUSPENSION OF SPHERICAL PARTICLES: M. Mooney, United States Rubber Co.

Einstein's viscosity equation for an infinitely dilute suspension of spheres is extended to apply to a suspension of finite concentration. The argument makes use of a functional equation which must be satisfied if the final viscosity is to be independent of the sequence of step-wise additions of partial volume fractions of the spheres to the suspension. There is good agreement of the theory with experimental data.

THE MIXING OF VERY VISCOUS LIQUIDS: R. S. Spencer, R. M. Wiley; Dow Chemical Company.

The problem of mixing two or more materials, so as to produce a relatively homogeneous mass, is a very common one in chemical technology. When the only nondisperse components are low viscosity liquids, solution of the problem is fairly straightforward. Turbulence and diffusion provide randomizing phenomena which may be utilized to advantage in designing mixing equipment. Although a theoretical treatment might prove difficult, the general principles are understood and practical know-how has produced many useful types of equipment.

When the materials to be mixed are very viscous liquids the situation is quite different. Neither diffusion

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WEST COAST SECTION MEETING

The first annual meeting of the West Coast Section was held on November 4, 1949 as announced in the Rheology Newsletter of October 1949. Nine excellent papers were presented by rheologists from the San Francisco Bay Region as well as from southern California and Utah. More than 90% of those attending were members of industrial and governmental research laboratories, indicating that in those regions, too, rheology is practiced more than it is taught.

The second annual meeting is planned for December 1, 1950 in Berkeley, California. It is anticipated that the program will include papers on the creep of solid high polymers and of metallic engineering materials, the stress-strain relation of textile fibers and elastomers, the properties of various liquid and semi-solid colloids, and the viscosity of liquids at high pressures.

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MEMBERSHIP

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membership; (2) Non-member registrants to meetings. (3) Prospects from the 1949 campaign.

During the first part of January return post cards were sent out to the general membership requesting two or three prospect suggestions. When returns were complete these names were processed, divided into groups and sent out to the members of the Membership Committee for out to the members of the Membership Committee for solicitation. Copies of a descriptive brochure, application blank and return envelope were also sent to be included in the soliciting letters. Information regarding the Society and its activities was also sent to all non-member registrants to both the New York and Berkeley (West Coast Section) meetings of the Society. The remaining prospects, which were solicited were obtained from the 1949 membership campaign files. About 20% of the prospects so available were selected for re-solicitation.

Quite a few unsolicited letters were received by the Membership Committee chairman requesting information regarding the Society. Some of these, by direct reference, were the result of the active reinstatement of the Rheology Bulletin and certainly serve to demonstrate its value to the Society in this respect. Other letters were undoubtedly prompted by the efforts by individual members and the importance of this work to the Society cannot be over-emphasized.

While the number of new members obtained during the campaign (about Jan. 1 to June 1, 1950) was quite satisfactory the loss of 20 members during the past year is disturbing. A normal loss would have put the member strength very close to the hoped for goal of 400. There is little doubt that more effort should be directed to the retention of present members. The efforts of all members can be of tremendous importance in this respect.

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nor turbulence can assist very much in mixing. Rather, mixing must be effected by some complex, continuous deformation which serves to disperse the components to the desired degree. This might be termed **streamline mixing**, to distinguish it from **turbulent mixing**. Examples of this type of mixing might include making up rubber formulations on compounding rolls, using an extruder as a mixer, kneading bread dough, and pulling taffy.

The lack of a randomizing factor in streamline mixing introduces both difficulties and advantages. One cannot

DUE YOU?

There are still a number of members who have not paid their 1950 dues. Prompt payment is requested so that the 1950 Rheology Issue of the Journal of Colloid Science may be mailed to these members. The dues are \$4.00 per year plus a voluntary \$2.00 contribution toward Physics Today. Remittance should be sent to American Institute of Physics, 57 East 55th Street, New York, N. Y.

depend upon the randomizing process to give satisfactory dispersion, if only sufficient time is allowed. The process of deformation must be carefully designed to do just the job required. This has the advantage, however, of permitting the engineer to design very efficient mixing processes.

Because streamline mixing is so different, in many respects, from turbulent mixing, the discussion will begin by defining certain fundamental concepts. These will then be discussed in some detail and a few general conclusion drawn. Finally, the different basic types of mixers will be discussed briefly, and a few simple examples considered.

ACTIVATION ENERGY FOR VISCOUS FLOW OF POLYMERS: G. J. Dienes, North American Aviation, Inc.

In recent years the melt viscosities of a few polymers have been determined over a wide temperature range. The results indicate quite conclusively that the viscosity temperature behavior of many of them, for example polystyrene and polyisobutylene, is characterized by a large energy of activation. Furthermore, the energy of activation is not constant but depends on the temperature. A notable exception is polyethylene. It has been difficult to assign a clear physical meaning to these large and variable energies of activation. The purpose of this note is to present a simple picture which seems to explain the available experimental facts and suggests several profitable directions for future experimentation.

The viscosities under discussion have been evaluated from the purely viscous component of the deformation and viscoelastic effects are absent. They can be considered to be Newtonian since they were either determined at low rates of shear or extrapolated to zero shear stress. The experimental facts concerning viscosity-temperature characteristics are as follows. The activation energy, E , is high at low temperatures, varies quite rapidly over a certain temperature range and approaches a considerably lower value at high temperatures. It is to be noted that this type of behavior is not explainable by a simple superposition of two mechanisms, as in that case the process of low E would predominate at low temperature.

MECHANICAL PROPERTIES OF GRAPHITE AT HIGH TEMPERATURES: C. R. Malmstrom, R. D. Keen, L. Green, Jr., North American Aviation, Inc.

The short-time tensile breaking strength of various grades of graphite was measured as a function of temper-

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EX. COMMITTEE MEETING NOV. 2

The Executive Committee will meet at 4:00 P. M. on the afternoon of November 2 in Dr. Traxler's room at the Hotel New Yorker. All SR members interested in discussing any matters of business or policy with the Executive Committee are urged to be present. Prominent on the agenda will be finances, publication and a discussion of the joint anniversary meeting of all the founding societies (now Member Societies) of the American Institute of Physics at Chicago in October 1951.

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ature from room temperature to the sublimation point. A characteristic common to all the strength vs. temperature curves is that the strength approximately doubles in going from room temperature to about 2500°C. and then decreases rapidly to zero near the sublimation point. The dependence of strength on room temperature bulk density and the density distribution within an original block is given for grade EBP graphite. The creep characteristics of grade ECA graphite under tensile stress at elevated temperatures were investigated. The activation energy and change in entropy defined by rate theory have been calculated.

ATOMISTIC INTERPRETATION OF DUCTILITY AND BRITTLENESS: W. A. Weyl, The Pennsylvania State College.

In a previous paper it has been shown that the mechanical properties of glasses, metals and even of rubber become more alike, if the materials are tested under conditions which paralyze the effect of dangerous flaws and which equalize the effect of the atmosphere on the severing of chemical bonds. An attempt is made in this paper to provide an explanation for the different effects which flaws have in metals and in glasses. Why are pure metals ductile and glasses brittle? The response of solids to shear stresses and their fracture are affected not only by the strength of the cohesive forces, but also by the symmetry of their atomic arrangement and the polarizability of their constituent ions. Plastic deformations involve transitions through atomic arrangements which are characterized by strongly asymmetrical force fields. These positions represent the energy barriers between equilibrium positions. The symmetry of the substance and the direction of the shear stress determines the absolute distance between equilibrium positions. The activation energy of the flow process, however, is determined primarily by the polarizability of the flow units and, thus, decreases with increasing polarizability of the ions.

This concept is used for explaining the different degrees of brittleness and ductility of alkali, silver and thallos halides. If the mechanical properties were primarily the result of cohesive forces, i.e., the Coulomb forces acting between the constituents, there should be no major difference between NaCl and AgCl; however, the former is brittle and the latter can be plastically de-

formed at room temperature. Some factors are discussed which influence the ductility of a substance such as symmetry, temperature, pressure, environment and the electron configuration of the ions.

FLOW PHENOMENA IN THE INJECTION MOLDING OF POLYSTYRENE: R. S. Spencer, G. D. Gilmore; Dow Chemical Company.

The steps in an injection molding cycle comprise dead time, filling, packing, discharge, sealing, sealed cooling, and mold open time. Those steps involving polymer flow are discussed in this paper.

The filling time is directly proportional to the polymer melt viscosity, and inversely to a power of the ram pressure. Raising the mold wall temperature lowers the filling time. Reducing friction between solid polymer and metal lowers the filling time, but only if the cylinder ahead of the heating chamber is cool.

Studies with a glass-window mold show that hot polymer flows only in a central region, there being stationary layers next to the mold walls. When flowing polymer reaches the advancing front it contacts the mold wall, cools, and ceases flowing. In a typical case the thickness of the central region was 40% of the total thickness.

An approximate equation is presented for calculating maximum pressure in the mold during packing. Agreement with experimental values is good. Approximate treatment of sealing by "freezing" in the gate leads to a linear relationship between temperature and pressure in the mold at the sealing point.

THE ABSOLUTE VISCOSITY OF WATER AT 20 DEG. C.: J. F. Swindells, J. R. Coe, Jr.; National Bureau of Standards.

An accurate knowledge of the viscosity of liquids in absolute units is of fundamental importance in many scientific fields. The measurement of these viscosities is almost universally based upon the absolute viscosity of water at 20°C. as a primary standard. During the past 50 years there has been an increasing need for a more accurate determination of this standard. Consequently, with the cooperation of the Society of Rheology and some financial assistance from the Chemical Foundation, this project was undertaken by the National Bureau of Standards and has now been completed.

The determination was made using the method of capillary flow. By means of a calibrated injector, various known rates of flow were induced in capillaries of measured dimensions, and observations were made of the corresponding pressure drops across the capillaries.

The value found for the viscosity of water is 0.010019 poise as compared with 0.01005 poise which is used at the present time. The estimated accuracy of the new determination is ± 0.000003 poise. The adoption of the new value by the National Bureau of Standards for the calibration of viscometers and standard sample oils will make possible the evaluation of the viscosities of other liquids with an accuracy of 0.1 per cent or better.

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RESIDUAL STRAINS IN INJECTION MOLDED POLYSTYRENE: R. S. Spencer, G. D. Gilmore; Dow Chemical Company.

Three types of residual strain in injection molded pieces are considered: (1) those accompanying quenching stresses, (2) frozen-in molecular orientation, (3) configurational volume strains. Quenching stresses sometimes relieve themselves by producing bubbles or sink marks in the article, and may be otherwise relieved by annealing. Configurational volume strains can be relieved only by annealing, which is frequently impractical, and are not important in many practical cases. Much of the frozen orientation present originates during "packing," that period of the plunger forward time subsequent to filling. Considerable reduction in the amount of frozen orientation may be effected by minimizing the packing time. This is rendered practical by the use of a mechanical device to seal the mold. Reduction in amount of frozen orientation reduces the tendency of the moldings to "craze," improves the dimensional stability on heating, and produces more consistent specimens for mechanical testing.

DIELECTRICS AND RHEOLOGY OF DISPERSED MAGNETIZED PARTICLES: Andries Voet, Louis R. Suriani; J. M. Huber Corporation.

In a previous paper it was shown that the dielectric constant of a dispersion is closely connected with the shape and the orientation of its particles. It was demonstrated that application of shear to more concentrated dispersions may result in a marked decrease of the dielectric constant, a change attributed to the breaking-up of particle aggregates. In addition, it was shown that orientation of nonspherical particles may cause changes in the dielectric constant. It appeared that the orientation of such particles perpendicular to the direction of the electric measuring field caused a decrease in the dielectric constant, in agreement with theoretical considerations of Bruggeman.

Rheological investigations showed that in the absence of particle agglomeration and/or orientation a Newtonian flow pattern exists. Non-Newtonian behavior becomes apparent where agglomeration and/or orientation occurs.

In more concentrated dispersions particle agglomeration usually occurs. Rheological investigations often fail to reveal this condition, since the shearing required for the measurements generally breaks up the existing structures. Dielectric measurements carried out in solutions in a quiescent condition are more suitable to reveal the formation of particle agglomeration.

SINTERING OF SYNTHETIC LATEX PARTICLES: R. E. Dillon, L. A. Matheson, E. B. Bradford; Dow Chemical Company.

Recent developments in the use of synthetic latices in the paint, paper and textile industries have focused attention upon the mechanism by which polymer particles,

at comparatively low temperatures, are welded together into a coherent film. These industries are using synthetic latices containing approximately 50% solids dispersed in water; the average particle size is about .2 micron in diameter. Some of the materials are film forming at room temperature, others must be formulated and dried at elevated temperatures. The film is formed by coating with the latex, usually containing some form of thickener; as the water evaporates the colloidal polymer particles are deposited upon the surface where they fuse into a film. It is this mechanism whereby the individual particles are united in the film that will be discussed.

The reasons for the extreme brittleness of glasses are derived. Furthermore, it is pointed out how the concept presented in this paper may be applied to viscosity and diffusion phenomena.

MEASUREMENT OF RESIDUAL STRESS IN THERMOSETTING MOLDINGS: T. Alfrey, Dow Chemical Co., R. De Waard, American Cyanamid Co.

A method is described for measuring the distribution of residual stress through the thickness of thermosetting moldings. Equations developed by D. G. Richards are employed in calculations based on the bending behavior caused by machining successive thin layers from one molded surface of rectangular specimens cut from flat molded discs. Moldings of commercial urea-, melamine-, and phenol-formaldehyde compounds with cellulose fillers have been examined by this technique, and are shown to possess sizable residual stresses.

WAVE PROPAGATION IN VISCOELASTIC MEDIA: T. Alfrey, T. Newman; Dow Chemical Company.

POISEUILLE'S MEMOIRS

A stock of copies of "Poiseuille's Memoirs" which formed the first and only issue of "Rheological Memoirs" was found in storage at Lafayette College after Dr. Bingham's death and was shipped to the Secretary by Dr. J. H. Wilson, head of the Lafayette Chemistry Department. This volume is a translation of the classic *Experimental Investigations Upon the Flow of Liquids in Tubes of Very Small Diameter*. The translation, by Winslow H. Herschel, has been annotated with critical notes by Professor Bingham. This book of 101 pages is a collector's item and is available to members of the Society at the following prices:

cloth bound (only 28 remain) \$2.00
paper bound (148 remaining) \$1.00

Those who wish to purchase copies are requested to send orders with remittance to the Secretary,

Dr. G. J. Dienes
North American Aviation, Inc.
P. O. Box 309
Downey, California.

Proceeds from the sale will be retained in a separate fund for publication of other classic papers; possibly Couette's article on the rotational viscometer would be an appropriate successor (*Ann. d. chimie*, 21 No. 6, pp. 433-510, 1890).