

RHEOLOGY BULLETIN

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THE BINGHAM MEDAL, 1954

It speaks well for the present state of rheology in this country that our Bingham Committee time and again is able to arrive as such excellent choices as that of this year's Candidate, Dr. T. Alfrey, of the Dow Chemical Company.

Known to everyone interested in mechanical behavior, by the great pioneering effort laid down in his book, Dr. Alfrey has to his credit important original papers on solution viscosity, thixotropy, and viscoelastic behavior. In addition he has a record as an enthusiastic teacher and lecturer who propagated understanding and recognition of rheology to untold students and colleagues, as well as in many industrial research laboratories. The value of his achievements is further increased by his great knowledge of, and many contributions to, other branches of physical chemistry.

Dr. Alfrey is a member of the unique group of younger physicists and chemists which Professor Mark built up at the Polytechnic Institute of Brooklyn from where they became disseminated throughout the country. It has been a most happy thought to request Professor Mark to be the master of ceremonies when the Award will be made at our Annual Fall Meeting.

THE ANNUAL FALL MEETING, 1954

The popularity of New York meetings notwithstanding, our Society could not resist the attraction of an invitation to hold the '54 Annual Meeting at the National Bureau of Standards, Washington, D. C. There were many arguments in favor, with respect to organization, attendance, and last but not least, to the opportunity for many members to re-acquaint themselves with the enthusiastic staff and the excellent facilities of the Bureau

The genius loci may also have had something to do with the record turnout of papers which will be presented. In any case, the program committee has contributed its fullest snare to making this meeting worthwhile even for distant travellers. Since the schedule will be such a busy one, it will unfortunately not be possible to allow more than 30 minutes per paper for presentation and discussion. A great deal of cooperation and forbearance will be required of session chairmen, scheduled speakers and contributors to the discussion, in order to keep within this short time.

The Meeting headquarters will be at the Sheraton Park Hotel. Application cards for room reservations are enclosed for the convenience of members. Registrations will be taken at the Hotel and in front of the lecture room in the "East Building" at the National Bureau of Standards, where all lectures will be given.

The Society's Annual Business Meeting will be held on Tuesday, November 4, 1954, at 4:45 in the same lecture room. Members are sincerely requested to attend. At 6:30 there will be a Buffet Dinner at the Sheraton Park Hotel. It will be followed by the Presentation of the Bingham Medal. After this, Dr. A. T. Waterman, Director of the National Science Foundation, has kindly agreed to address the gathering; a Social Mixer will conclude the evening.

The papers have been arranged in five sessions, from Wednesday afternoon through Friday afternoon. The titles and authors of the papers will be given below in the order of presentation. As usual, the speakers will be invited to publish their contributions in the Rheology Issue of the J. A. P. under the auspices of the Society of Rheology. Interested authors are requested to get in touch with this Editor for discussing details. It is hoped that the response will be as satisfactory as in the past, since the value of collective volumes has been generally recognized. Every effort will be made to permit the Rheology Issue to appear at an early date.

ABSTRACTS OF PAPERS TO BE PRESENTED AT THE FALL MEETING

While it is hoped that as many papers as possible will appear collectively, in the Rheology Issue, experience has shown that some papers are always published elsewhere. For the sake of record, we will give below an abstract of each paper, in the order in which they will be presented at the Meeting.

Wednesday, November 3, 1954:
1:30 P.M.

"DETERMINATION OF BAKING VALUES OF BREAD DOUGHS BY RHEOLOGICAL MEASUREMENTS"

C. W. BRABENDER AND STEPHEN J. LOSKA, JR.,
PILLSBURY MILLS, INC., MINNEAPOLIS, MINN.

Progressing bakery mechanization in the last few decades has limited the craftsman baker's ability to freely adjust a complex physical, chemical, and biological system. Consequently greater emphasis has been placed on the uniformity of ingredients, particularly flour, since it is the major ingredient in baked products. A system of rheological measurements is described by the authors which permits a measurement of functional properties of flour, alone and in combination with other ingredients. The system provides the miller with a means of producing a uniform product from a changing raw material; it gives the baker a way of interpreting performance permitting intelligent use of flours, and the researchers a means of measuring dough properties.

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RHEOLOGY BULLETIN

F. R. EIRICH, EDITOR

The Polytechnic Institute

Brooklyn 1, N. Y.

"RHEOLOGY OF BITUMINOUS PAVEMENTS"

C. MACK, RESEARCH DEPARTMENT, IMPERIAL OIL LIMITED, SARNIA, ONTARIO.

Bituminous pavements consist of a compacted mixture of mineral aggregate, asphalt and voids filled with air. Under compressive loads, a bituminous pavement is deformed elastically in a stress region which has the yield value as upper limit. At greater stresses the deformation consists of an instantaneous and a retarded elastic deformation followed by a plastic deformation. The latter is most important for the mechanical behavior of bituminous pavements, since it is accompanied by hardening as a function of stress and time according to the following relationship:

$$\sigma = B \left[\dot{\epsilon} (t+1) \right]^{\frac{b}{\beta}} = B \dot{\epsilon}^{\frac{b}{\beta}} \quad (1)$$

where σ = compressive stress, $\dot{\epsilon} = d\epsilon/dt$ = strain rate, B and b are constants. At constant stress, the product of strain rate and time is constant and equal to the parameter β which has the dimension of strain. The presence of the time factor in the above equation indicates that the mechanical behavior of a bituminous pavement depends upon its history and varies also with the type of loading.

The mechanical properties can be described by a coefficient of plastic traction

$$\mu = d\sigma/d\dot{\epsilon} \quad (2)$$

This coefficient increases in the hardening range with increasing stress and time to a maximum at a stress σ_m . In this range the density and Young's modulus increase also to a maximum. At the stress σ_m , where the coefficient of plastic traction is a maximum, all deviatoric stresses vanish. The system behaves like a material under simple compression and the maximum coefficient of plastic traction represents the volume viscosity.

At stresses in excess of σ_m , the strain rates increase and become constant at constant stress. The coefficient μ decreases rapidly until the pavement fails. The stress σ_m represents therefore the bearing strength and is the load per unit area which the pavement can carry without undergoing initial failure.

This deformation mechanism is exemplified by laboratory and field data.

"TIME AND TEMPERATURE EFFECTS ON THE DEFORMATION OF BITUMENS AND BITUMEN-MINERAL MIXTURES"

C. VAN DER POEL, EXPLORATION AND PRODUCTION RESEARCH DIVISION, SHELL DEVELOPMENT COMPANY, HOUSTON, TEXAS.

The development of a nomograph, which allows easy determination of stiffness of bitumens as a function of time and temperature is briefly described. This system requires the knowledge of two routine test data of the bitumen, one to indicate its hardness (ring and ball softening temperature), the other to indicate its rheological type (penetration index).

A further study revealed that the deformation (stiffness) of bitumen-aggregate mixtures is a function of the stiffness of the bitumen it contains (this stiffness being taken at the appropriate time and temperature) and the volume concentration of the aggregate only. As a consequence, a simple system can be built up by means of which the deformation of all bitumens and bitumen-mineral mixtures can be quickly derived with an accuracy sufficient for engineering purposes. The system gives information over a large interval of time and temperature covering the range of practical interest.

A short description of measuring methods used is given.

"STRESS-STRAIN RELATIONSHIPS IN YARNS WHEN STRAINED AT IMPACT VELOCITIES RANGING FROM 10 TO 100 METERS PER SECOND"

HERBERT F. SCHIEFER, TEXTILES SECTION, NATIONAL BUREAU OF STANDARDS, WASHINGTON, D. C.

Equipment will be described for longitudinal impact tests of yarns, including a procedure for obtaining load-extension curves for loading and for unloading of the specimen in a time interval of only a few milliseconds. Mathematical analyses will be discussed for Hookean and for visco-elastic behavior of the material during impact and for obtaining critical velocity and energy to any strain, including maximum and rupture strains. The importance of stress and strain propagation will be indicated. Results of tests on different materials will be presented and compared with those computed from theory. The results of impact tests on yarns are of practical importance in a number of applications, such as high speed sewing, safety ropes and belts, parachute webbing and shroud lines, tire cords, and high speed processing of yarns.

"ELASTIC MODULI AS A MEASURE OF ANISOTROPY IN NYLON AND DACRON FIBERS"

J. H. WAKELIN, E. T. L. VOONG, AND J. H. DUSENBURY, TEXTILE RESEARCH INSTITUTE, PRINCETON, NEW JERSEY.

Using a quasi-static method, the elastic moduli of extension, E , have been determined for a series of nylon 66, nylon 6, and Dacron filaments, ranging in draw ratio from one to six. Dynamic measurements have been used for these same fibers to obtain the corresponding elastic moduli of bending, Q , and of torsion, G . According to theory, the ratios $E/3G$ and $Q/3G$ should be unity for a homogeneous, isotropic substance. Values of these ratios greater than unity indicate a condition of anisotropy where fiber molecules are oriented preferentially along the fiber axis.

For the three man-made fibers studied, these ratios have been observed to increase smoothly with increasing draw ratio, from a value near unity at draw ratio one. The torsional moduli, G , are largely unaffected by drawing, so that increases in these ratios of moduli are chiefly reflections of increases in the extensional and bending moduli. As an attempted check on the experimental procedure, measurements have also been made on tungsten wires.

"DIFFUSION CONTROLLED STRESS-RELAXATION"

R. H. McMICKLE AND E. T. KUBU, B. F. GOODRICH RESEARCH CENTER, BRECKSVILLE, OHIO.

The action of H_2O solutions of dimethyl formamide on Dinitrile A fibers was studied using the stress-relaxation technique. After prior conditioning and stress-relaxation in

water, the addition of dimethyl formamide-water solutions produced an exponential stress-relaxation. It was found that the rate and extent of stress-relaxation in dimethyl formamide-water solutions is dependent on the dimethyl formamide concentration. The rate of stress-relaxation in dimethyl formamide-water solutions is also dependent on the cross-sectional area and the state of orientation of the fiber. These data can best be explained by postulating that the rate of diffusion of the dimethyl formamide-water solution controls the rate of stress-relaxation. The diffusion coefficient is found to be concentration dependent, and the diffusion process has an activation energy of 14 k cal.

Thursday, November 4:
9:00 A.M.

"THE STATISTICAL MECHANICS OF VISCOSITY"

MELVILLE S. GREEN, NATIONAL BUREAU OF STANDARDS, WASHINGTON, D. C.

The derivation and significance of a new statistical mechanical formula for viscosity will be discussed and its relation to the Generalized Nyquist Theorems of Callen, Jackson, and Takehasi shown. While the formula is general, and applies to all fluid states of aggregation, at present it can be evaluated in terms of molecular force laws only for dilute gases where of course other methods are available. The possibilities for evaluating the formula for dense gases and liquids will be explored.

"CONTRIBUTION TO THE STUDY OF TRANSPORT PHENOMENA IN GASES AT HIGH DENSITIES"

A. MICHELS, UNIVERSITY OF MARYLAND, COLLEGE PARK, MARYLAND, AND
A. S. FRIEDMAN, NATIONAL BUREAU OF STANDARDS, WASHINGTON, D. C.

The results of recent measurements of the viscosity and thermal conductivity of Argon have shown the importance of studying these transport phenomena over a large density range in different regions of the reduced temperature. It appears that the Chapman-Enskog theory can not give an adequate description of the new experiments.

Up to now it is not possible to give a full account of the observations. However, a less rigorous theoretical discussion will readily demonstrate the relevant physical features of the problem. For the moment it serves to indicate a new experimental program.

This research may contribute to a clearer understanding of the transport properties in different states of a material, including the difficult intermediate region between the gas and liquid state.

"ACOUSTICS AND THE LIQUID STATE"

R. B. LINDSAY, BROWN UNIVERSITY, PROVIDENCE, RHODE ISLAND.

It is the purpose of this paper to present a brief review of the role of acoustics and particularly ultrasonics in the study of the structure of liquids. In recent years the inadequacy of classical viscosity to account for the observed absorption of sound in liquids has led to the development of relaxation theories similar to those which have been successful in gases. Such a theory postulates, for example, the transfer of translational energy of the molecules (the energy represented in the sound transmission) into internal states of molecular energy with a time lag or relaxational effect in the pressure-density relation. A relaxation process of this kind is usually termed *thermal* and has been successful in the

case of non-associated liquids. For associated liquids like water, a type of structural relaxation, involving a change in the short range order of the molecules, seems more appropriate. In both cases the liquid acts as if it possessed a compressional viscosity in addition to its ordinary shear viscosity. The possible application of the "hole" theory of liquids to acoustic velocity and absorption will also be discussed.

"DYNAMIC MECHANICAL PROPERTIES OF NON-POLYMERIC LIQUIDS"

THEODORE LITOVITZ, CATHOLIC UNIVERSITY OF AMERICA, WASHINGTON, D. C.

Ultrasonic measurement techniques have allowed investigations into the visco-elastic properties of non-polymeric liquids. This paper will review certain aspects of the information available on the dynamic compressional and shear properties of these liquids. A comparison of the characteristics of shear and compressional viscosity will be made. Evidence indicates that these two viscosities might be intimately related in certain liquids. Ultrasonic relaxation measurements will be discussed, especially data on the elasticity exhibited by liquids at frequencies well above the relaxation frequencies associated with flow time in the liquid. Studies of this "high frequency" elasticity offer an interesting insight into the relationship of liquid structure and the elastic properties of liquids.

"THEORY OF NON-NEWTONIAN FLOW. I. SOLID PLASTIC SYSTEM"

TAIKYUE REE AND HENRY EYRING, UNIVERSITY OF UTAH, SALT LAKE CITY, UTAH.

The relaxation process of viscous flow may be visualized as the sudden shifting of some small patch on one side of a shear surface with respect to the neighboring material on the other side of the shear surface. Any shear surface will divide a mosaic of such patches lying on the two sides of the surface. Except for the simplest systems, this mosaic of patches will be heterogeneous and can be described by groups each characterized by its mean relaxation time β_n , by x_n the fractional area of the shear surface which the group occupies and by a_n , a characteristic shear volume divided by kT . The resulting generalized expression for viscosity is:

$$\eta = \sum_{n=1}^{\infty} \frac{x_n \beta_n \sinh^{-1} \beta_n s}{a_n \beta_n s}$$

where s is the rate of shear. This equation is applied to masticated natural rubber, polystyrene, X-672 GR-S, X-518 GR-S rubber, and Vistanex LM-S polyisobutylene. All applications give good agreement with experiment. The known criticisms of Eyring's simple relaxation theory for viscous flow are reviewed, and are apparently taken care of in this general treatment.

"THEORY OF NON-NEWTONIAN FLOW. II. SOLUTION SYSTEM OF HIGH POLYMERS"

TAIKYUE REE AND HENRY EYRING, UNIVERSITY OF UTAH, SALT LAKE CITY, UTAH

The authors theory developed in the preceding paper I is applied to solutions of polystyrene, polyisobutylene, X-518 GR-S rubber, and lime base grease with good agreement with experiment. The parameters, x_n/a_n and β_n (c.f. the abstract of the paper I), were calculated, and are tabulated; these parameters are proportional to the surface concentration and the relaxation time of the n th group of flow units, respectively. The effects of the molecular weights of polymers, concentration, solvent, and temperature on these parameters were studied. Our results establish the following facts:

- (1) The heterogeneity of flow units increases with increasing molecular weight.
- (2) In the range of low concentration, β_a (relaxation time) is independent of concentration, while the areal concentration of non-Newtonian units increases more rapidly than proportional to the bulk concentration of a polymer.
- (3) A "good" solvent increases the concentration of non-Newtonian units, while the contrary is true for a "poor" solvent.
- (4) In poor solvent solutions, the concentration of non-Newtonian units increases with increasing temperature, while the concentration is independent of temperature in good solvents.

Thursday, November 4:
2:00 P.M.

"VISCO-ELASTIC DENSITY CHANGES IN GLASS"

O. L. ANDERSON, BELL TELEPHONE LABORATORIES, INC., MURRAY HILL, NEW JERSEY.

Quasi-permanent density changes have been observed in glass under the action of very high pressure (200,000 atmos.) by Bridgman and under the action of high temperatures (1075°C) and modest pressures (1700psi) by Douglas. Similar density changes are reported here which occur at lower pressures (50,000 psi) and lower temperatures (200°C).

It is shown that the parameters associated with volume flow are quite different from those associated with shear flow. The experimental results are interpreted by regarding glass as a supercooled liquid with the *random-network* structure ordinarily assumed in theories of the glassy state.

"DYNAMIC INVESTIGATIONS ON POLYMERIC SOLUTIONS USING DIFFERENT METHODS"

WLADIMIR PHILIPPOFF AND KARL SITTEL, THE FRANKLIN INSTITUTE, PHILADELPHIA, PA., AND JOHN D. FERRY AND D. J. PLAZEK, UNIVERSITY OF WISCONSIN, MADISON WISCONSIN.

Up to now, dynamic measurements on polymers or polymeric solutions have been performed in separate laboratories on single materials. Only the Bureau of Standards has the cooperation of a number of laboratories on solid polyisobutylene. We have attempted to measure dynamic properties of 20% polyisobutylene in decalin with three completely different methods:

- a. Ferry's method of wave propagation (optically).
- b. The method of the Franklin Institute (mechanically).
- c. Torsion crystal method (electrically).

Measurements made over a large range of amplitudes, frequencies, and temperatures could all be correlated to one single reduced curve of isothermal measurements over about eight decades of frequency with which the measurements of other temperatures agree satisfactorily. This shows that the dynamic properties are real properties of the solution independent of the method used to measure them.

"PRELIMINARY RESULTS IN MEASURING DYNAMIC COMPRESSIBILITIES"

WLADIMIR PHILIPPOFF, THE FRANKLIN INSTITUTE, PHILADELPHIA, PENNSYLVANIA.

The relation between shear modulus, bulk modulus, Young's modulus, and compressibility is given by the fun-

damental relations of deformational mechanics. Up to now, Young's modulus and the shear modulus have been investigated in dynamic tests as a function of frequency and have been found to be complex. It is probable that the other quantities involved, bulk modulus and compressibility, are equally complex. A measuring device used as an attachment to the dynamic tester of the Franklin Institute is described for measuring the dynamic compressibility of plastics in a large range of frequencies. Some preliminary results are discussed.

"CONCENTRATION DEPENDENCE OF THE RHEOLOGICAL BEHAVIOR OF THE POLYISOBUTYLENE-DECALIN SYSTEM"

T. W. DE WITT, H. MARKOVITZ, F. J. PADDEN, JR. AND L. J. ZAPAS, MELLON INSTITUTE, PITTSBURGH, PENNSYLVANIA.

The dynamic moduli and dynamic viscosities, as well as the apparent steady-state viscosities, in the polyisobutylene-decalin system have been studied in considerable detail. It is found, above about 8% concentration, that it is necessary to assume that moduli are proportional to the square of the concentration, rather than to the first power, in defining reduced variables. With this assumption, data for solid polymer satisfactorily superpose on master curves with those of concentrated solutions. The same procedure achieves superposition for the apparent steady-state viscosities. The latter, when plotted as a function of reduced rates of shear, yield curves closely similar to, but not quantitatively identical with, those of the dynamic viscosities as a function of the frequency. It is suggested that in concentration ranges where c^2 is required in the reduced variables, and in the solid polymer, a temporary gel structure exists as a result of bimolecular association between monomer units in the polymer chains. The primary data are compared with the results of two recent molecular theories of visco-elastic behavior.

"EFFECT OF FILLERS ON THE DYNAMIC MECHANICAL PROPERTIES OF POLYSTYRENE"

LAWRENCE E. NIELSEN, ROBERT WALL AND PAUL RICHMOND, MONSANTO CHEMICAL COMPANY, SPRINGFIELD, MASSACHUSETTS.

The dynamic shear modulus and mechanical damping were measured on polystyrene containing various fillers such as powdered calcium carbonate, mica, asbestos, and wood flour. In general fillers increase the shear modulus and decrease the damping over that of pure polystyrene. The heat generated by a unit deformation of the material, however, usually is increased by a filler. The results can be partially explained in terms of the individual mechanical properties of the polystyrene and filler and by an "adhesion factor".

Friday, November 5:
9:00 A.M.

"THE ANALYSIS OF DYNAMIC TESTS OF VISCO-ELASTIC MATERIALS"

E. H. LEE AND D. R. BLAND
BROWN UNIVERSITY, PROVIDENCE, R. I.

In this paper methods of analysis of dynamic tests of visco-elastic materials are examined. It is shown that it is important to develop the analysis on the basis of a general stress-strain relation, since the particular form of the relation for the material under test is not known in advance, and any arbitrary assumption about it may lead to contradictions. Such a general method of analysis is discussed for

a simple longitudinal stress test, and for the vibrating reed test. References to the published literature indicate that such contradictions appear in currently accepted analyses, and their influence is detailed.

In seeking a visco-elastic model of springs and dashpots to represent the behavior of the material, the method presented separates the analysis of the test results from the determination of the appropriate model.

"SOME REMARKS ON THE THEORY OF NON-LINEAR VISCO-ELASTICITY"

R. S. RIVLIN, BROWN UNIVERSITY,
PROVIDENCE, RHODE ISLAND.

Suppose we make some general physical assumption regarding the variables which determine the stress in an isotropic material. The manner in which the stress components can depend on these variables is limited to some extent by the isotropy of the material and by the fact that the form of dependence must be independent of the reference system chosen. These limitations will be discussed.

"NON-LINEAR VISCO-ELASTIC BEHAVIOR IN SHEAR OF RUBBER"

HERBERT LEADERMAN, NATIONAL BUREAU OF
STANDARDS, WASHINGTON, D. C.

A study has been made of the retarded elastic deformation under constant load and retarded elastic recovery following removal of load of a nonlinear model. This model consists of a Voigt element with nonlinear spring, the behavior of which is Hookean for infinitesimal deformation. Data are given of the creep behavior in simple shear and of the creep recovery of raw and vulcanized rubber. The nonlinear retarded elastic behavior is qualitatively similar to that of the model. Other nonlinear models are also considered.

"APPLICATION OF THE SUPERPOSITION PRINCIPLE AND THEORIES OF MECHANICAL EQUATION OF STATE, STRAIN- AND TIME-HARDENING TO CREEP OF PLASTICS UNDER CHANGING LOADS"

W. N. FINDLEY AND GAUTAM KHOSLA,
BROWN UNIVERSITY, PROVIDENCE, R. I.

The superposition principle and the theories of mechanical equation of state, strain and time hardening were applied to the results of creep tests under changing loads of four unfilled thermoplastics — polyethylene, monochlorotrifluoroethylene in a crystalline state, polyvinylchloride annealed, and polystyrene.

A comparison of the theoretical results predicted by these theories with the experimental results indicated that: the mechanical equation of state was applicable when the load was increased; the superposition principle and strain hardening theories were reasonably satisfactory; but the time hardening theory was not.

"DYNAMIC CREEP OF PLASTICS"

JOSEPH MARIN, THE PENNSYLVANIA STATE
COLLEGE, STATE COLLEGE, PENNSYLVANIA.

This paper presents a theory for predicting creep strain under fluctuating stresses. The prediction is based on an assumed static tension creep strain-stress-time relation. In a comparison the theoretical dynamic creep strain values obtained are compared with actual test results of a plastic designated commercially as Plexiglas 1-A. In view of the preliminary nature of this field of study the agreement between tests and theory is considered to be good.

"THE EFFECT OF MOLECULAR WEIGHT ON THE CREEP BEHAVIOR OF CELLULOSE ACETATE FILMS"

D. L. SWANSON, AMERICAN CYANAMID COMPANY,
STAMFORD, CONNECTICUT AND J. W. WILLIAMS,
UNIVERSITY OF WISCONSIN,
MADISON, WISCONSIN.

The molecular weight distributions of fractions of cellulose acetate were determined by equilibrium ultracentrifugal analyses. Films of these samples were cast at room temperature and were annealed at elevated temperatures to relieve strains. In creep measurements carried out at 80°C., linear viscoelastic behavior was observed. Although the effect of molecular weight was not marked, it appeared that the presence of low-molecular-weight material in a sample decreased the amount of permanent set and increased the recoverable deformation. In all cases, more than half of the recoverable deformation occurred in less than 10 seconds.

The results suggest that there was present some sort of a network which may be crystalline although no direct X-ray evidence for crystallinity could be seen.

Friday, November 5:
2:00 P.M.

"VISCIOUS HEAT EFFECTS IN EXTRUSION OF MOLTEN PLASTICS"

R. BYRON BIRD, UNIVERSITY OF WISCONSIN,
MADISON, WISCONSIN.

When a fluid is forced through a capillary tube at very high shear stresses, heat is produced because of the internal friction of the fluid. Brinkman has developed a method for solving the differential equations of motion and energy balance to describe the heat effects for newtonian flow in capillaries of circular cross-section. In this paper it is shown how Brinkman's method can be extended to describe the heat effects for the flow of non-newtonian fluids which obey a power-law relation between the coefficient of viscosity and the shear stress. The temperature profiles are calculated for one particular power law corresponding to the flow of an Alathon plastic melt. Calculations are made for two cases: (I) the capillary walls are maintained at the temperature of the feed, and (II) the capillary walls are thermally insulated. It is shown how the temperature profiles change as the fluid flows down the tube, and the average and maximum temperatures are calculated. The effect of the viscous heat production of the rheometer flow curves is then calculated approximately. The theory predicts satisfactorily the value of the shear stress for which the viscous heat effects begin to be important and also gives a flow curve the shape of which is in good agreement with the experimental flow curve.

"TEMPERATURE, VELOCITY, AND VISCOSITY DISTRIBUTIONS FOR A TEMPERATURE SENSITIVE VISCOUS FLUID"

R. E. COLWELL, MONSANTO CHEMICAL COMPANY,
SPRINGFIELD, MASSACHUSETTS.

A procedure is presented for computing the temperature, velocity and viscosity distributions across a stream of a temperature sensitive viscous fluid in laminar flow. Solutions are given for several empirical temperature viscosity laws. The use of the procedure for correcting experimental viscosity measurements is described by examples using previously published data. Application of the procedure to the design and operation of plastic processing apparatus is discussed.

"FLOW IN THE HEATING CHAMBER OF AN INJECTION MOLDING MACHINE"

C. E. BEYER, R. B. DAHL, R. B. MCKEE, THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN.

Of critical importance in making good plastic moldings is the loss of pressure as the polymer passes through the heating chamber. There are two types of flow conditions that exist in the heating chamber. One is the movement of an almost solid block of compacted granules, and the other is viscous flow of the molten polymer. The frictional resistance in the granular region is proportional to the hydrostatic pressure and represents up to 80% of the total pressure loss, even with externally lubricated granules. The effects of some of the heating chamber conditions and material properties on the pressure losses in the granular and fluid regions are given.

"VISCOSITY AND ELASTICITY OF OIL SURFACES AND OIL-WATER INTERFACES"

DEAN W. CRIDDLE AND ARTHUR L. MEADER, CALIFORNIA RESEARCH CORPORATION, RICHMOND, CALIFORNIA.

A torsion-type surface and interfacial viscometer design is described that enables one to study the wide ranges of viscosities and elasticities of oil surfaces and oil-water interfaces. Some experimental techniques and errors are discussed in connection with surface and interfacial viscometers. Viscosity and elasticity data are reported for several types of conventional compounded oils. An example is given wherein the defoaming agent, dimethyl silicone, is shown to effectively minimize the surface viscosity of a compounded oil.

"LOW SHEAR ROTATIONAL VISCOMETRY OF INJECTABLE DISPERSIONS. THE SQUIBB VISCOMETER"

RAYMOND R. MYERS AND A. C. ZETTLEMOYER, LEHIGH UNIVERSITY, BETHLEHEM, PA.

A precision rotational viscometer for the measurement of viscosities of highly fluid materials and for the detection of anomalous flow in dispersions has been constructed. The precision and accuracy of the viscometer are discussed, and an insight is given into its versatility as an instrument for the determination of fundamental flow properties of a wide variety of systems.

Features of the viscometer which have been instrumental in providing high sensitivity at low shear rates include a completely frictionless suspension, the application of shearing stress to both sides of the torsion member, the almost complete absence of end effect, exceptionally good heat transfer, and a null point method for determining stress.

A critical evaluation of the performance of the instrument has been made by means of studies on printing ink extenders, pharmaceuticals, and other dispersions. Examples are given of the use of the viscometer to determine the rate of an apparent buildup of structure of a suspension after injection, and of the detection of gradations of flow anomalies at low shear of dispersions whose behavior at high shear appeared to be identical.

"A CONE AND PLATE VISCOMETER"

H. MARKOVITZ, L. J. ELYASH, F. J. PADDEN, JR. AND T. W. DEWITT, MELLON INSTITUTE, PITTSBURGH, PENNSYLVANIA.

A weight-driven cone and plate viscometer is described. It has a simpler construction and can be used over a wider

range than some other instruments of this type. Liquids with viscosities from 1 to 50,000 poises have been investigated and rates of shear from 0.0002 to 9000 sec.⁻¹ have been achieved with this instrument. With one filling of the viscometer, a 1000 to 30,000 fold range of rates of shear can usually be covered. With concentrated polymer solutions, it is practically always possible to determine the zero shear viscosity.

CONSTITUTION AND BY-LAWS

A recent inventory of our Secretary revealed that copies of the Constitution and By-Laws of our Society had dwindled to a very few. A sufficient number has now been reproduced to provide every interested member with a copy. Requests for copies should be sent to the Secretary or Editor, or be made known at the registration desk during the forthcoming Fall Meeting.

RHEOLOGY IN MECHANICAL ENGINEERING

A conference under this heading was held by the British Rheological Society on June 10-12 in the Mechanical Engineering Research Laboratories, East Kilbride, Glasgow. The following papers were given:

The Relation of Certain Properties of Metals to Their Crystal Structures

J. F. W. Bishop.

Current Problems and Experiments on Time-Independent Plastic Deformation

H. Ll. D. Pugh.

On the Laws of Stress Relaxation and Creep in Solids

P. Feltham.

Some Aspects of the Behavior of Metals Under Complex Stresses at High Temperatures

A. E. Johnson.

An Experimental Approach to the Plastic Strain Speed Fatigue Tests

N. Wadsworth.

Lubrication from the Rheological Standpoint

F. T. Barwell.

Some Developments in the Theory of Viscosity

E. J. LeFevre.

Some Fluid Motion Problems

W. J. Robinson.

THE GERMAN RHEOLOGICAL SOCIETY

Since its founding in 1951, this Society has advanced by great strides. Since 1953 it issues quarterly "Berichte" which contains articles and news of rheological interest. Attached are abstracts of relevant literature in the form of cards enabling the members to start a reference card system of current publications. This parallels the abstract booklets issued by the British Society of Rheology. Distribution in both cases is limited to society members.

The Fourth Annual Meeting took place in Berlin on May 5-8, and was held as a Memorial Meeting for Herbert Freundlich. An impressive list of 25 German and International Rheologists participated, and we hope to report at least the lecture titles in the next issue.

Flow Properties of Disperse Systems

Volume IV of the Elsevier series on Deformation and Flow has recently appeared under the above title, edited by J. J. Hermans. Like the earlier three volumes, it will take an important place in the rheological literature by virtue of its comprehensive treatment of this focal area of Rheology.