RHEOLOGY BULLETIN

Publication of the Society of Rheology

Volume 31, No. 1 Spring, 1962

THIRTY-THIRD ANNUAL MEETING

The Annual Meeting of the Society this fall will be held at The Johns Hopkins University, Baltimore, Maryland, Monday through Wednesday, October 29-31, 1962. Local arrangements are under the surveyance of Professor J. L. Ericksen, Chairman of the Local Arrangements Committee, and Professor Stanley Corrsin. Technical sessions will be held in Shriver Hall and there will be a Smoker on Tuesday evening, October 30.

Technical sessions are expected to comprise about 30 papers. The feasibility of a symposium on Molecular and Particulate Rheology is being assessed by Dr. J. Gavis, The Johns Hopkins University. An attempt to organize a symposium on Polymer Chain Entanglement is being made by Drs. N. Nakajima and W. L. Peticolas. The possibility of a second session on Blood Rheology is being considered by Dr. E. A. Collins.

Those wishing to participate at the Annual Meeting should notify Dr. Edward A. Collins, B. F. Goodrich Chemical Co., P. O. Box 122, Avon Lake, Ohio, Chairman of the Program Committee, or a Committee Member as soon as possible, and a title should be submitted. Two copies of abstracts should be in the hands of the Program Committee by August 15 to permit the Committee to establish the final program and to allow publication in the Fall issue of the Bulletin. The size of these abstracts should not exceed two hundred words. No drawings can be included, and all symbols used should be defined. Each abstract will be reviewed by the Program Committee for general content, originality, relevance to Society purposes and technical character as a basis for acceptance. Any members who are aware of persons likely to present suitable papers are urged to call the Fall meeting to their attention, or to refer their names to the Program Committee. Presentation of papers is not restricted to members of the Society.

The Society encourages submission of papers presented at the Annual Meeting for publication in the Transactions. It would be helpful if authors would inform the Editor of such intent as soon as possible after the program has been selected, and certainly not later than at the Annual Meeting. Two copies of manuscripts, including a brief synopsis, must be submitted to the Editor by November 15th. Earlier submission would be appreciated, since it would expedite the processing of papers and so contribute to earlier publication of the Transactions. The deadline for submission of papers is set two weeks after the Annual Meeting, not in the expectation that authors will write up their contributions after presentation, but to permit minor revision of a manuscript in the light of discussion at the meeting. What delay has occurred in the current volume is mainly due to some apparently hurriedly prepared manuscripts which placed inordinate demands on referees and caused delay because of the need for extensive revision. Papers will be refereed by authorities in the field, and this will form the basis for the Editor's decision concerning suitability for publication in the Transactions. It is expected that the Transactions will be issued early in the following summer.

NEW SOCIETY OFFICERS

New Society officers for 1962-63 elected last Fall are as follows:

J. D. Ferry, *President*
J. T. Bergen, *Vice-President*
E. H. Lee, *Editor*
J. C. Miller, *Secretary-Treasurer*
H. Markovitz, *Member at Large*
R. S. Marvin, *Member at Large*

COMMITTEE APPOINTMENTS

The President has appointed the following committee chairmen and committees:

Bingham Award
T. G. Fox, Chairman
E. B. Bagley
S. Prager
T. L. Smith
J. P. Tordella

Program
E. A. Collins, Chairman
E. B. Bagley
W. H. Bauer
J. Gavis
N. Nakajima
W. L. Peticolas
D. J. Plazek

Meeting Arrangements
J. L. Ericksen, Chairman
S. Corrsin

Publicity
R. B. Pond, Chairman

Membership
A. F. Lewis, Chairman
T. L. Smith

RHEOLOGY BULLETIN
E. H. Lee, Editor
Division of Applied Mathematics
Brown University
Providence 12, R. I.

Transactions of the Society of Rheology — Volume V

A radical change in the circulation mechanics at the American Institute of Physics in 1961 resulted in some undesirable side effects. One of these effects was to overlook a number of 1961 members when Volume V was mailed. If any 1961 members did not receive their copy of Volume V, please notify the Secretary-Treasurer, Dr. John C. Miller, Union Carbide Plastics Company, Bound Brook, New Jersey.

WEST COAST REGIONAL MEETING

The West Coast Regional Meeting was held on February 1-2, 1962 at the California Institute of Technology, Pasadena, Calif. Abstracts of papers presented are printed below:

INVITED LECTURE. *"Phenomenological Theory of Linear Viscoelastic Behavior of Polymers, with Applications"*, HERBERT LEADERMAN, National Bureau of Standards, Washington, D. C.

The nature of first order linear viscoelasticity theory will be discussed in the light of recent developments in the mechanics of continuous media. The relationships between the response functions corresponding to step, ramp, and sinusoidal excitation will be considered. The application of quasi-empirical time-temperature relationships will be discussed. The representation of linear viscoelastic properties by spectra and the calculation of these functions will be outlined. The relationships between linear viscoelasticity theory, linear circuit theory, and phenomenological dielectric theory will be presented. In conclusion, some applications of the linear theory and recent developments in non-linear phenomenological theory will be given.

"Dilatometric Relations in the Neighborhood of a Glass Transition", T. F. SCHATZKI, Shell Development Co., Emeryville, California.

A theoretical relation has been derived for the specific volume as a function of temperature during constant rate heating or cooling in the neighborhood of a glass transition. It is assumed that the lattice volume relaxes instantaneously while the free volume relaxes with a single relaxation time whose temperature variation is given by the Williams-Landel-Ferry expression. With these assumptions a closed expression can be obtained for the specific volume. The cooling curves contain two parameters, T_g, and the product $k\tau_g$, where k is the cooling (heating) rate and τ_g the relaxation time at T_g. The heating curves depend in addition on the frozen-in free volume in the initial state. A discussion is given of the use of dilatometry in determining the glass transition temperature and the monomeric friction coefficient. The curves obtained in this fashion agree qualitatively with published dilatometric work, although exact agreement requires some relaxation of the assumptions. In the light of this the validity of the assumptions made, specifically that of a single relaxation time, is discussed in some detail.

"Time Dependent Rheological Properties of Whole Polymers", WARNER L. PETICOLAS, International Business Machines Corporation, San Jose, California.

Equations which predict the time-dependent rheological properties of blends of whole polymers from the corresponding properties of the blend components have been derived through an extension of earlier calculations on time-independent rheological properties.

Methods for the treatment of rheological data to obtain an estimate of the degree of polydispersity have been worked out and applied to selected data.

"Description of a Dynamic Shear Modulus Tester", W. G. GOTTENBERG, Space Technology Laboratories, Inc., Los Angeles, California.

In order to perform an analysis of the stress or strain response of a structure to dynamically applied loads one must have on hand a method of mathematically representing the material in the structure. For materials whose mechanical properties are time dependent, the only available material representation which is manageable in a dynamic analysis is that provided by linear viscoelasticity. It, therefore, is quite important that techniques be established for measuring the mechanical behavior of real materials to determine the limits of validity of the theory of linear viscoelasticity as applied to these materials and also to establish the actual properties required for use in dynamic analyses. In order to completely characterize the material, its response to both dilatational and distortional loading must be obtained (if possible, independently).

No such techniques, in fact, exist which are adequate primarily with respect to permitting an understanding of the dynamic response of the test specimen. It is for this reason that a newly developed apparatus to measure the dynamic shear modulus will be described which is a forced vibration, torsional shear device. Considerable discussion will be given to the boundary value problem involved and a few preliminary experimental results will be described.

INVITED LECTURE. *"Mechanical Damping, Molecular Motions and Birefringence Effects in Solid Polymers"*, R. D. ANDREWS, Plastics Research Laboratory, Massachusetts Institute of Technology, Cambridge, Massachusetts.

Multiple damping peaks are observed in many amorphous polymers below their glass transition temperatures, and in crystalline polymers below their melting points. The molecular mechanisms responsible for these damping peaks in amorphous polymers, such as styrene and acrylic types, have been worked out fairly well, and

these will be discussed. The behavior of the crystalline polymers is less well understood. Some of the hypotheses advanced to explain the observed behavior will be described.

Birefringence measurements provide an interesting way to study molecular motions in solid polymers — both motions produced by internal stresses (photoelastic effect) and internal thermal motions. The latter can be investigated by measurements of the temperature dependence of orientation birefringence. Birefringence data can clearly provide useful information on the types of molecular motions involved in such rheological behavior as mechanical damping. Birefringence data will be presented to illustrate this, including measurements of the stress-optical coefficient of copolymers of ethylene and vinyl acetate, whose dynamic mechanical behavior has been studied by Nielsen.

The desirability of studies of stress-optical coefficient as a function of both time (frequency) and temperature will be pointed out. This type of information should be of great value in developing a molecular theory of impact strength.

"Dynamic Properties of Homo and Copolymers of 4-Methyl-1-Pentene", W. A. HEWETT and F. E. WEIR, Shell Development Co., Emeryville, California.

Dynamic mechanical properties of homopolymers of 4-methyl-1-pentene and copolymers of the same monomer with 1-pentene and 1-hexene prepared by stereospecific polymerization were determined by means of a torsion pendulum. Glass transition temperatures of the copolymers were calculable with good accuracy from those of the appropriate homopolymers by means of an equation suggested by Fox.

"The Effect of Finite Time of Loading on Creep and Relaxation Response of a Linear Viscoelastic Material", R. P. FELGAR, Space Technology Laboratories, Inc., Los Angeles, California.

Theoretical descriptions of the creep and relaxation behavior of a linear viscoelastic material assume step function loading. Since this cannot be achieved experimentally, it is necessary to evaluate the effect of finite loading time. With this end in view, an analysis is presented of the effect on relaxation stress and creep strain for the following loading conditions: 1) ramp-step; and 2) quarter-sine wave-step. The technique can also be applied to other shapes of the loading-time curve.

"Experimental Observations on the Stress Relaxation Behavior of Filled Polymeric Propellants", J. R. BOHN, Space Technology Laboratories, Inc., Los Angeles, California.

The effect of finite loading time on the transient behavior of viscoelastic materials during relaxation is a major concern in analysis and experiment. A definitive relaxation test implies transient loading rates which are at least an order of magnitude higher than the highest rate of relaxation. Loading times on the order of milliseconds are involved in obtaining relaxation moduli comparable to those obtained from steady state dynamic tests at low frequencies.

A device for measuring the relaxation characteristics of viscoelastic materials in uniaxial tension is described. The apparatus employs a pneumatic ram to provide pulsed tensile loads based on pre-set increments of strain. Provisions were made for rapidly changing the initial strain conditions during testing. A special low compliance load cell is used to measure transient and long time degradation of load.

The relaxation spectrum for several filled polymer propellants is presented with particular emphasis on the transient characteristics.

"Thermoelastic Behavior of Continuous Media", PAUL J. BLATZ, Guggenheim Aeronautical Laboratory, California Institute of Technology, Pasadena, California.

In the usual formulation of thermoelastic behavior of continuous media, the thermal expansion of the volume which arises in a non-isothermal process is neglected. An analysis is presented in which this effect is rigorously introduced. The notation of finite elastic theory is used. The fundamental thermostatic equation is presented in the cartesian tensor form. The problems of simple tension and torsion are solved.

INVITED LECTURE. *"Streaming Birefringence as a Rheological Tool"*, J. HAROLD WAYLAND, California Institute of Technology, Pasadena, California.

Streaming birefringence appears to be best correlated with strain rate for systems of rigid macromolecules and with stress in certain polymer solutions. The present state of both experiment and theory will be reviewed in order to help establish guide lines for the use of streaming birefringence in studying stress distribution, in measuring normal stress effects, and in throwing light on the nature of the constitutive equation for polymer systems.

"Some Applications of a New Stress Relaxation Function", EMORY MENEFEE, Western Regional Research Laboratory, U. S. Department of Agriculture, Albany, California.

Stress relaxation in fluids may be measured following either steady-state straining or sudden straining. The former method is often preferable, since it weights longer relaxation times and also avoids some uncertainties due to a finite loading time. For high molecular weight materials in the terminal relaxation zone an empirical function can be used to fit relaxation data. It has the form.

$$\frac{\sigma(t)}{\gamma_0} = \eta_0 \exp\left(\frac{\delta}{\tau}\right)^m \exp - \left(\frac{t+\delta}{\tau}\right)^m,$$

where $\sigma(t)$ is the stress at time t after relaxation begins, γ_0 is the initial shear rate, η_0 is the viscosity at that shear rate, and δ, τ and m are parameters found from the data.

An example of the use of the original steady-shear stress relaxation data is afforded by the calculation of non-Newtonian viscosity. A short analysis is given which shows that a plot of $\frac{\sigma(t)}{\gamma_0}$ versus $1/t$ is approximately equivalent to a plot of $\eta(\gamma)$ versus γ. Through the use of the empirical relaxation function the analysis is continued, and the existence of a limiting stress postulated as equal to $\epsilon_m G_o$, where ϵ_m is an ultimate strain and G_o the instantaneous modulus. A plot is given of

G_0 versus the melt-fracture stress of several polymers which shows that ϵ_m is about 5. A few other examples further illustrate possible uses for the continuous relaxation function.

"Degradation of Polymer Molecules by Shear in Dilute Solution", R. E. HARRINGTON and B. H. ZIMM, University of California, La Jolla, Calif.

Studies are being made on the breakage of high polymer molecules in solution at extreme shear rates. Polystyrene of molecular weights above 5,000,000 can be broken down in toluene solution by forcing the solutions through fine capillaries (20 to 50 micron radius) at shear rates up to 3,000,000 sec^{-1}. Laminar flow still appears to be maintained under these conditions. From a theoretical point of view, one would expect that the rate of breakdown would be correlated with the average force per molecule, the quantity

$$f = \tau \frac{\eta_{sp}}{\eta_{rel}} \frac{1}{CL_z}$$

where τ is the shearing stress, η_{sp} and η_{rel} the specific and relative viscosities respectively, C is the molecular concentration, and L_z is the component of the average end-to-end length perpendicular to the x streamlines. We find experimentally that a value of f near 10^{-6} dynes is the critical force per molecule at which rapid breakdown of molecular weight sets in with polystyrene.

Polystyrene solutions can also be broken down very effectively by forcing them through sintered glass discs; breakdown is perceptible at molecular weights as low as 300,000, but quantitative investigation is difficult because of adsorption of the polymer in the discs.

"Bubble Growth In Viscous Media", W. E. LANGLOIS and E. J. BARLOW, International Business Machines Corp., San Jose, California.

The growth of a bubble within an isothermal volume of a Newtonian liquid containing uniformly distributed dissolved gas is considered. The problem of characterizing this growth is reduced to an integro-differential equation for the bubble radius as a function of time, and a computer solution is obtained. The initial and final stages of growth are treated analytically.

"The Rheology of Suspension. Part II. The Effect of Particle Size Distribution on Viscosity", K. H. SWEENY, Aerojet-General Corp., Azusa, California.

The flow properties of very concentrated slurries is an area of great interest. The rheological properties of concentration suspensions of sized glass spheres were to be investigated using a rotational viscometer for these studies. These studies show that the viscosity at a given volume loading can be markedly decreased by using a bimodal distribution of particles. The decrease in viscosity bears close relationship to the increase in the bulk density of the bi-modal distribution of particles.

The generalized relation of Mooney (J. Colloid Sci., *6*, 162-170 [1949]) previously shown by the author to satisfactorily represent the data for mododispersed systems (J. Appl. Phys., *25*, 1135-1144 [1954]), applied equally well to bidispersed systems. The results are interpreted in the light of packing small spheres into the interstices of the larger spheres by bi-modal distribution.

"An Approximate Stored Energy Function for Amorphous Elastomers", ROBERT F. LANDEL, Jet Propulsion Laboratory, Pasadena, California.

An approximate, empirical stored energy function is derived, based on the Martin-Roth-Stiehler expression for uniaxial stress-strain behavior. It is assumed that the elastomer is incompressible and that dw/dI_1 is constant. The results are used to show that the simple extension data of Rivlin and Saunders can be converted to their pure shear data, for samples not too highly cross-linked. The condition of incompressibility is then relaxed in a discussion of various experimentally attainable paths across the I_1 -I_2 surface and the influence of volume changes on these paths.

"A Microscopic Study of the Dewetting of Solid Particles in Filled Polymer Systems", K. W. BILLS, W. D. HART, R. A. SMITH, Aerojet-General Corporation, Sacramento, California.

Dewetting is defined as a failure of the filler-elastomer adhesive bond. One of the effects of dewetting, which is readily observed microscopically, is the formation of small cavities around the filler particles. The production and growth of these cavities has been studied as a means of characterizing the dewetting phenomenon. Interactions between the filler particles and between the elastomer and the filler particles are described.

Studies were made under uniaxial, biaxial and shearing conditions with a variety of fillers and polyurethane rubbers. In addition, some of the gross mechanical effects of dewetting are described.

"The Effect of Specimen Size Upon the Mechanical Behavior of Solid Propellant", K. W. BILLS, W. D. HART, W. E. HOLLAND, Aerojet-General Corporation, Sacramento, California.

The tensile behavior of highly filled elastomers is observed to be quite unlike that for homogeneous materials like rubber or steel. Some preliminary attempts were made to describe the behaviors of these systems. Studies were performed on end-bonded tensile specimens varying over a wide range of cross-sectional area A, and gage length, G. The (A/G^2 values were from 0.0036 to 154) to produce conditions extending from uniaxial tension to triaxial tensile stress conditions. The effects upon the apparent modulus and other key parameters of the stress-strain curve are discussed.

"Failure Criteria for Some Polyurethane Propellants", WARREN T. MILLOWAY and JAMES H. WIEGAND, Aerojet-General Corp., Sacramento, California.

Experimental and theoretical studies were made on failure criteria applicable to simple case-bonded, hollow cylindrical grains. The minimum strain at break at −75°F for uniaxial tensile test was found to be at least twice the hoop strain at −75°F of a thermally cycled, case-bonded, hollow cylinder of propellant when no failures were observed, whereas, when the minimum strain at break was equal to or less than the hoop strain of the cycled cylinder, the grain always cracked. For uniaxial tension, where the rate of elongation and temperature are controlled variables, the failure elongation varies from specimen-to-specimen and from batch-to-batch. A study of batch variability of the uniaxial test

showed that a test at any test temperature from –40 to 180°F could be used to characterize batch quality. The correlation of breaking strain at different rates and temperatures using the WLF technique on one batch was found to be improved if an additional vertical shift factor was added to account for the lowering of the maximum failure elongation for temperatures below 0°F. However, by using a diagonal shift with rate, a graph of failure elongation versus temperature shows lower variability than for the WLF analysis.

Meetings of other organizations of interest to Rheologists

PRINCETON UNIVERSITY CONFERENCE. On Thursday and Friday, May 10 and 11, a conference titled, "Current Problems in Rheology," will be held on the Princeton University campus under the auspices of the Princeton University Conference. The Princeton University Conference is an organization within the University which exists to provide a forum for exchange of ideas in a wide variety of areas. The speakers are:

Professor J. L. Ericksen, Johns Hopkins University
Professor A. Fredrickson, University of Minnesota
Professor B. Maxwell, Princeton University
Dr. W. Philippoff, Esso Research & Engineering Co.
Professor W. Schmid, Princeton University
Professor W. R. Schowalter, Princeton University
Professor A. Tobolsky, Princeton University

For further information contact Professor W. R. Schowalter or Professor D. C. Leigh, Co-directors of the Conference.

THE FOURTH U. S. NATIONAL CONGRESS OF APPLIED MECHANICS will be held on the Berkeley campus of the University of California during June 18-21, 1962.

The members of the organizing committee on the Berkeley campus are:

Professor W. Goldsmith, Secretary
Professor E. V. Laitone, Treasurer
Professor R. M. Rosenberg, Chairman of the Editorial Committee
Professor W. W. Soroka, General Chairman

Inquiries regarding the Congress should be addressed to Professor W. Goldsmith, Secretary, Division of Mechanics and Design, University of California, Berkeley 4, California.

THE ASTM ANNUAL MEETING will be held June 24-29, 1962, at the Statler Hotel in New York. A special symposium, co-sponsored by the Society of Rheology on "Stress-Strain-Time-Temperature Relationships in Materials" will be presented by the Division of Materials Sciences on Wednesday, June 27. The morning program consists of talks by:

Professor B. J. Lazan, University of Minnesota
Professor G. V. Smith
Professor W. D. Kingery, Mass. Institute of Tech.
Dr. Thor L. Smith, Stanford Research Institute

In the afternoon these will be discussed by a panel including the morning speakers and:

Professor Jack Lubahn, Colorado School of Mines
Mr. F. Garofalo, U. S. Steel Corporation
Dr. W. H. Duckworth, Battelle Memorial Institute
Dr. I. L. Hopkins, Bell Telephone Laboratories, Inc.

THE PRINCETON UNIVERSITY SUMMER CONFERENCE on "Non-Ideal Mechanical Behavior of Solids and Liquids" starts August 13 and will continue for three weeks through August 31, 1962. The morning lectures will consist of three 15 hour lecture courses given by three faculty members of Princeton University. Their names and the titles of their course are as follows:

B. Maxwell, Associate Professor of Mechanical Engineering *"Viscoelasticity"*
W. R. Schowalter, Assistant Professor of Chemical Engineering, *"Non-Newtonian Liquids"*
D. C. Leigh, Assistant Professor of Mechanical Engineering, *"Continuum Theory of Deformation and Stress"*

Guest lectures will be given by experts on topics which have been discussed in the morning lectures. This program is sponsored by the National Science Foundation.

For further information please write to:

MR. A. J. MARUCA,
Administrative Director
Summer Activities
128 Pyne Administration Building
Princeton, New Jersey

POLYMER GROUP OF SOUTHERN CALIFORNIA. The Polymer Group is the name of a new organization, recently born in Southern California. It is made up of people from all branches of the plastics and polymer field. The Polymer Group has been organized under the auspices of the Southern California Section of the American Chemical Society, but its membership is open to all who are interested. There are no educational restrictions.

The new group was organized after a series of meetings of academic and industrial polymer specialists. They were interested in encouraging the progress of polymer science in the Southland. Although several technical societies in the Los Angeles area are active in the polymer field, these men felt that the interests of the older groups lie in special areas, not those visualized for the new organization. The need for an organization centered on general polymer science seemed obvious.

The Polymer Group will cooperate with the several National American Chemical Society divisions active in polymer science in addition to operating as a subject division of the local A.C.S. Officers of the Polymer Group include William C. Teach, Chairman (U. S. Borax Research Corp.) and Anton J. Havlik, Secretary-Treasurer (Jet Propulsion Lab., Cal. Tech.).

THE NATIONAL LUBRICATING GREASE INSTITUTE will hold their annual meeting on October 21-24, 1962 at the Edgewater Beach Hotel, Chicago. For information contact:

MR. T. W. H. MILLER, General Manager
National Lubricating Grease Institute
4638 J. C. Nichols Parkway
Kansas City 12, Missouri

MINUTES OF 1961 BUSINESS MEETING

WISCONSIN CENTER,
UNIVERSITY OF WISCONSIN
OCTOBER 31, 1961

1. The meeting convened at 4:10 pm and adjourned at 4:40 pm. About 60 members were present. President Elliott presided.
2. The Minutes of the meeting held November 1, 1960 at Mellon Institute, as published in the Spring 1961 issue of the Bulletin, were approved.
3. The interim report of the Secretary-Treasurer (published elsewhere in this Bulletin) was approved.
4. It was noted that because the letter ballots were not available at this time they would be sent express to the Tellers Committee, Dr. Peter Francis (Chairman) and Dr. John Tordella and a final report made as soon as possible. It was noted that this action had been approved in the Executive Committee meeting held October 29 as was also the action for the principal nominated officers (Ferry, President; Bergen, Vice-President; Miller, Secretary-Treasurer; Lee, Editor) to serve pro-tem until the ballots had been counted and the formal report made.
5. Dr. Thor Smith noted that the West Coast Meeting would be held at Cal Tech, February 1-2, 1962 and that plans for local arrangements and program were well underway.
6. Dr. Lee announced that plans for the International Congress on Rheology to be held the last week of August 1963 at Brown University were well underway.
7. The next annual meeting will be held at Johns Hopkins University, October 29-31, 1962.
8. A letter expressing good wishes for the success of our meeting from Dr. Bun-ichi Tamushi, Chairman of the Committee on Rheology of the Chemical Society of Japan, was read by Dr. Elliott.
9. It was announced that Dr. Arthur B. Metzner, Department of Chemical Engineering, University of Delaware, Newark, Delaware was very interested in making arrangements for a distinguished foreign rheologist to visit the country under the visiting scientists program but to date had been unable to select a candidate suitable to all those consulted. Anyone having any ideas along these lines was urged to get in touch with Dr. Metzner.
10. The retiring president, Dr. Elliott, expressed his sincere thanks to the many committee chairmen and members who had served so well. He commented that he had had no refusals in his appointments which spoke very well for membership cooperation.
11. Dr. Elliott turned the meeting over to Dr. Ferry. There being no new business, the meeting was adjourned.

Respectfully submitted,

WILLIAM R. WILLETS
Past Secretary-Treasurer

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INTERIM REPORT OF SECRETARY-TREASURER ANNUAL MEETING — 1961

1. FINANCIAL STATEMENT

The tentative financial statement for the year is appended. It will be noted that the "Balance in Account" at the beginning of 1961 included dues for 1961 collected in 1960. It will also be noted that the "Estimated Working Balance" at the end of 1961 does not include 1961 dues collected since June 30 (which would be relatively small) nor dues for 1962 collected in 1961, which might be a fairly large item. This is offered in explanation of why this interim financial statement does not gibe very well with the final statement of our finances for the year as submitted by the American Institute of Physics. This tentative financial statement is only an approximation, as when this report was written the cost of mailing Volume V of the Transactions was not known, nor the cost of printing and mailing the Fall issue of the Bulletin. A new item, Membership on the U. S. National Committee for Theoretical and Applied Mechanics (costing about $100), was approved by the Executive Committee at its meeting February 2, but to date we have not been billed for it. The estimated budget for 1962 is based on the final financial statement of 1960 (published in the Bulletin, Vol. 30, No. 1 Spring 1961) and on the tentative statement for 1961. Income in 1962 should be higher but so will expenditures, especially those for the Transactions and the Bulletins. Our financial position appears relatively unchanged but again with the small unassigned balance extraordinary expenses are definitely not warranted and expenditures beyond those necessary for the usual Society operations should be carefully scrutinized.

2. MEMBERSHIP

Under the continued excellent guidance of Dr. John C. Miller, Membership Committee Chairman, membership continues to increase and now exceeds 600.

3. PUBLICATIONS

Two issues of the Bulletin and Volume V of the Transactions have been published. These publications have been distributed to all members in good standing for 1961. (Hard bound copies of the Transactions can be purchased by anyone from Interscience Publishers, Inc. 440 Park Ave. South, New York, N. Y. The Society does not sell any copies.)

4. ANNUAL MEETING FOR 1961

Dr. John D. Ferry of the University of Wisconsin is in charge of the meeting with Dr. Edward A. Collins of B. F. Goodrich Chemical Company serving as Program Chairman. A list of titles and authors was distributed in September and the Bulletin with abstracts early in October.

5. EXECUTIVE COMMITTEE

The Executive Committee held meetings on October 30, 1960 and February 2 and October 29, 1961. Publication policies, membership on the U. S. National Committee for Theoretical and Applied Mechanics (which would increase this country's representation in the International Union), west coast meetings and the possibility

of a west coast section, plans for future meetings, the 1963 International Congress on Rheology, and the future development of the Society were some of the topics under consideration.

6. ELECTION

The nominations for officers for 1962-1963 were published in the Spring issue of the Bulletin. No additional nominations were made by petition (as provided for by the Constitution and By-Laws). Ballots were mailed to all members early in the summer and approximately 240 returned by the deadline (October 1 postmark). These are being delivered to the Tellers Committee.

7. RELATIONS WITH THE AMERICAN INSTITUTE OF PHYSICS

Messrs. Elliott and Willets attended the meetings of the Governing Board March 25, 1961 and September 27, 1961. The latter preceded the meetings of Member Society Officers and of the Corporate Associates of A.I.P. held at Arden House, Harriman, N. Y., September 27-29, 1961 which were also attended. We were represented by proxy (Dr. Elmer Hutchisson and Miss Mary M. Johnson) at the Annual Meeting of A.I.P. on February 24, 1961 (this meeting of the Corporation is a formality held in compliance with New York State law since the regular business of the Institute is handled by the Governing Board).

The Institute has been undergoing radical changes in the business systems involved in its operations and occasionally this has led to unavoidable delays and misunderstandings. In spite of this the staff has continued to cooperate fully with our Society in every way possible. A.I.P. as usual handled all our billings, bookkeeping and accounting as well as overall mailings.

8. CORRESPONDENCE

All correspondence, meeting notices and minutes, and membership applications have been handled as promptly as possible but again the secretary-treasurer wishes to state that his officership has been extra-curricular being subject to the performance of his regular business activities. He would have been unable to function as an officer were it not for the cooperation of his company management which in addition to giving his time provided incidental expenses, facilities and secretarial aid necessary to his officership.

9. ACKNOWLEDGMENTS

At the conclusion of eight years as your Secretary-Treasurer I wish to emphasize again my appreciation for the gracious cooperation which has always been given me by the Society officers, committee chairman and many individual members, and especially by the staff of the American Institute of Physics. Without this my job would have been intolerable instead of a source of satisfaction. I know that similar cooperation will be given my successor.

Respectfully submitted,

WILLIAM R. WILLETS
Secretary-Treasurer

CC

AMERICAN INSTITUTE OF PHYSICS, INCORPORATED for SOCIETY OF RHEOLOGY

STATEMENT OF ACCOUNT–DECEMBER 31, 1961

Balance in account, January 1, 1961			$6,070.93
Dues collected — January 1 — December 31, 1961:			
1960 dues		$ 12.00	
1961 dues		1,910.60	
1962 dues		139.00	2,061.60
Net income from meeting			549.00
Interest on U. S. Government Bond			38.74
			$8,720.27
Disbursements — January 1 — December 31, 1961:			
A.I.P. charge for collecting dues		$ 441.91	
Contribution to A.I.P.		285.60	
Membership Committee:			
Printing membership applications	$ 8.50		
Letterheads (500)	14.75		
Cards	21.00		
Miscellaneous	19.50		
Postage	11.06	74.81	
Spring Bulletin:			
Printing (800 copies)	$ 153.42		
Addressing, stuffing, and mailing	28.38		
Postage	9.21		
Postage on correction to Bulletin	25.80	216.81	
Fall Bulletin:			
Printing (1,100 copies)	$ 486.92		
Addressing, stuffing, and mailing	24.34		
Postage	53.50	564.76	
Transactions — Volume 5:			
Printing (660 copies)	$1,650.00		
Supplies, stuffing, and mailing	41.72		
Postage	87.01	1,778.73	
1961 Election:			
Ballot:			
Supplies, addressing, stuffing and mailing	$ 23.92		
Postage	24.45		
Report on Election	44.75	93.12	
Announcement of Fall Meeting:			
Preparing covering letter and supplies	$ 30.44		
Addressing, stuffing, and mailing	24.00		
Postage	54.58	109.02	
Bingham Medal		11.16	
Secretary's office — clerical assistance		50.00	
Total disbursements			$3,625.92
Balance in account, December 31, 1961			$5,094.35
Bingham Fund:			
U. S. Government Bond — 3⅞% due 5/15/68			$1,000.00

February 19, 1962

SOCIETY OF RHEOLOGY

ESTIMATED BUDGET–1962

Receipts	
Working balance 1/1/62 (not incl. 1962 dues collected in 1961)	$3934
Dues for 1962	3900
Total Receipts	$7834
Disbursements	
Bulletins	$ 800
Transactions Vol. VI	2000
Membership Committee (incl. Roster)	300
AIP Dues Collection	350
AIP Contributions	390
Membership U. S. Nat. Com. Theor. & App. Mechanics	100
Meeting Expenses	100
Stationery, etc.	100
Miscellaneous contingencies	100
Total Disbursements	$4240
Estimated Balance 12/31/62 (not including 1963 dues collected in 1962)	$3594

W. R. WILLETS
Secretary-Treasurer

October 31, 1961