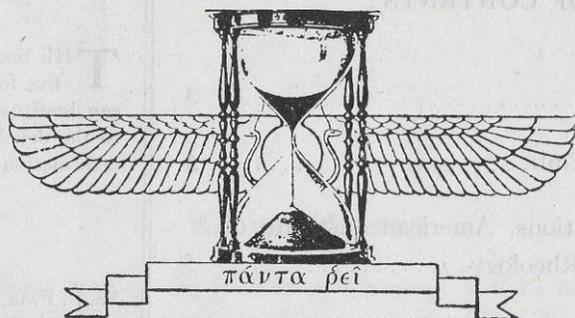


RHEOLOGY

BULLETIN



ANNUAL MEETING
NOVEMBER 1 AND 2

PUBLICATION OF THE

SOCIETY OF RHEOLOGY

VOLUME 17, NO. 2

AUGUST, 1946

RHEOLOGY BULLETIN

Vol. 17, No. 2

August, 1946

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Published for the

Society of Rheology

by

The American Institute of Physics

57 East 55 Street

New York 22, New York

THE Society of Rheology is one of the five founder societies of the American Institute of Physics and is dedicated to the development of the science of the deformation and flow of matter.

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57 East 55 Street
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Rheology Bulletin

Publication of the Society of Rheology

Vol. 17, No. 2

August, 1946

Annual Meeting

THE 1946 meeting of the Society of Rheology will be held at the Hotel Pennsylvania, New York, on Friday and Saturday, November first and second. The meeting will be known as the Bingham Memorial Symposium and will consist of a series of papers on Friday and Saturday mornings covering the theories and practices of rheology in their many applications, with contributed original research papers Friday afternoon. In addition, an important business meeting dealing with Society policies concerning publications, finances, American Institute of Physics activity, and constitutional amendments is scheduled for Friday afternoon. On Friday evening we will have our first "mixer." Its program is one of refreshment, entertainment, and general good will. It is also hoped that we may have there an informal discussion of improved international cooperation on rheological matters. A member of the British Rheologists' Club may be present to assist us in this endeavor. Members of the American Society for Testing Materials will also be with us. The proceedings of the meeting will be published in a single volume—either a special issue of the *Journal of Colloid Science* or in a separate booklet.

The meeting has been placed in the capable hands of Dr. H. K. Nason and Dr. Turner Alfrey. Don't miss it! A complete program will be sent to you soon.

The British Rheologists' Club

(1945-6)

President

PROFESSOR E. N. DA C. ANDRADE, F.R.S.

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Communications to the Club should be sent to:
The Hon. Secretary, Royal Aircraft Establishment,
Farnborough, Hants.

DEFINITION

RHEOLOGY is the science of the deformation and flow of matter.

OBJECTS

The objects for which the Club is established are the advancement and diffusion of a knowledge of rheology pure and applied and for this purpose especially:

- (i) To co-ordinate the activities of Rheologists in the British Isles.
- (ii) To further the appreciation of the importance of rheology in industry.
- (iii) To facilitate the pooling of information with respect to problems and new methods of research.

MEMBERSHIP

Anyone who is either a British subject or residing in the British Commonwealth is eligible for membership. He should be proposed by a member of the Club. Acceptance of the proposal is at the discretion of the Committee.

SUBSCRIPTION

Each member is required to pay a subscription of £1 per annum. Payments become due on 1st October in each year. Cheques, payable to the Club, should be sent to the Hon. Treasurer at "Inglemere," Dagden Road, Shalford, Guildford.

ACTIVITIES

Co-operation with rheologists overseas has been maintained since the Club started in 1940. Meetings, with lectures and discussions, and visits to laboratories where rheological methods and equipment are in use are arranged regularly at various centres in this country.

A week-end conference was held in Oxford, 1944, and arrangements are in progress for another, possibly in London, September, 1946.

Printed bulletins are issued to members. These bulletins feature such items as short accounts of progress in specific industrial and academic rheological problems; requests for information contributing to the solution of problems; abstracts of papers on rheological subjects, more especially those published in technical or trade journals not usually seen by members, including periodicals; news and views concerning rheology generally. Reprints of papers read at joint meetings of the Club with learned Societies are circulated when available.

MUTUAL ASSISTANCE

The Club Officers will be happy to act as a medium for the arrangement of informal contacts between individual members for discussion of urgent technical problems of mutual interest. From time to time copies of a list of members are circulated showing the class of materials with which each is most familiar, and other relevant data. The list is a confidential document for the use of members only.

SUGGESTIONS

The Committee invites suggestions and criticisms on any matters affecting the activities of the Club.

Amendments to Constitutions,
American Institute of Physics and
Society of Rheology

AT the March 1, 1946 meeting of the Governing Board of the American Institute of Physics, the Policy Committee of that board presented several proposed amendments to the A.I.P. constitution which were voted favorably by a three-quarter majority of the Governing Board. *These amendments will become effective if approved by a majority of the members of each of four of the five Founder Societies, which are:*

Acoustical Society of America
American Association of Physics Teachers
American Physical Society
Optical Society of America
Society of Rheology

All of the proposals will affect the functions of all of the Founder Societies of course; however, **two of them are of direct and immediate importance to the Society of Rheology.** If passed, they will require modification of our own constitution.

The changes in both constitutions will be discussed and voted on at our annual meeting, November 1 and 2. However, it is believed you should be given an opportunity to consider and express yourselves before that meeting on the two subjects of greatest importance to your Society.

These amendments involve both cash and representation, so please read the following:

1. The new proposed Constitution of the A.I.P. provides for the Societies to continue as members in much the same way as they are now. It also provides, however, that the members of the Societies may be members of the Institute as a whole and receive a general journal which would be a kind of news edition for physics. This privilege, however, is only open to those who are paying dues of \$4.00 or more. In other words, if the Society of Rheology's members are to qualify for membership in the Institute, as will be the case of all of the other societies, it will be necessary to change the annual dues in the society to \$4.00 or more.

At first it may appear to be exorbitant to double our dues. However, your Executive Committee proposes that the cost of the special annual rheology issue of *Journal of Colloid Science* be included in your dues. Also included will be your annual subscription to *Physics*, the "news edition," of A.I.P. which will have publication space allotted to our Society for each issue. Consequently, if you have already agreed to pay \$2.00 dues plus \$1.50 for the *Journal of Colloid Science*, it does not seem unreasonable to ask fifty cents more a year in order that members of the Society of Rheology will join in having good standing and full participation in the Institute including a subscription to the new journal.

2. A proposed amendment to Article VIII of the A.I.P. Constitution will entitle the Founder Societies to directorships on the Governing Board based on Society memberships as follows:

Up to 500 members	—	1 director
501 to 1000 members	—	2 directors
1001 to 2000 members	—	3 directors
2001 to 4000 members	—	4 directors
Over 4000 members	—	5 directors

In addition, three directors shall be elected at large from the total A.I.P. membership by vote of the total membership.

Under the present A.I.P. Constitution there are 15 directors, three from each Founder Society. Under the proposed amendment S.R. will be reduced to one director and Am. Phys. Soc. will be increased to five. The others will remain at three.

Although this division of the Board does appear to be rather severe from our point of view, it must be remembered that we *are* a small society. Obviously, the thing to do is to drive for more members. A year ago Dr. Bingham urged that we increase the size and activity of our membership committee—will you help?

At the back of this issue you will find a ballot on which the Executive Committee hopes you will express yourself.

Bibliography: Works of E. C. Bingham

- E. C. Bingham, "The conductivity and viscosity of solutions of certain salts in mixtures of acetone with methyl alcohol, ethyl alcohol and water," Diss., Johns Hopkins University (1905).
- H. C. Jones and E. C. Bingham, "The conductivity and viscosity of solutions of several salts in mixtures of acetone with methyl alcohol, ethyl alcohol and water," *Am. Chem. J.* **34**, 481-554 (1905); *Chem. Zentr.* **I**, 522 (1906).
- E. C. Bingham, "Viscosity and fluidity," *Am. Chem. J.* **35**, 195-217 (1906); *Chem. Zentr.* **I**, 1521-2 (1906).
- E. C. Bingham, "Vapor pressure and chemical constitution," *J. Am. Chem. Soc.* **28**, 717-23 (1906).
- H. C. Jones, E. C. Bingham, and L. McMaster, "Concerning conductivity and inner friction of solutions of certain salts in the solvent-mixtures: water, methyl alcohol, ethyl alcohol and acetone," *Zeits. f. physik. Chemie* **57**, 193-250, 257-320 (1906); *Chem. Zentr.* **I**, 321 (1907).
- E. C. Bingham, "Solubility," *Am. Chem. J.* **37**, 549-57 (1907).
- E. C. Bingham, "Solubility," *Am. Chem. J.* **38**, 91-118 (1907).
- E. C. Bingham, "Viscosity and fluidity," *Am. Chem. J.* **40**, 227-80 (1908).
- E. C. Bingham, "Viscosity and fluidity: algebraic analysis of viscosity data," *Zeits. f. physik. Chemie* **66**, 238-54 (1909).
- E. C. Bingham, "Viscosity and fluidity," *Zeits. f. physik. Chemie* **66**, 1-32 (1909).
- E. C. Bingham, "Viscosity and fluidity. IX," *Am. Chem. J.* **43**, 287-309 (1910).
- E. C. Bingham, "Viscosity and fluidity of matter in the three states of aggregation and the molecular weight of solids," *Am. Chem. J.* **45**, 263-81 (1911).
- E. C. Bingham and G. F. White, "The viscosity and fluidity of emulsions, crystalline liquids and colloidal solutions," *J. Am. Chem. Soc.* **33**, 1257-75 (1911).
- E. C. Bingham and T. C. Durham, "Viscosity and fluidity of suspensions of finely divided solids in liquids," *Am. Chem. J.* **46**, 278-97 (1911).
- E. C. Bingham, "Fluidity and vapor pressure. XIII," *Am. Chem. J.* **47**, 185-96 (1912).
- E. C. Bingham and G. F. White, "Fluidity and hydrate theories. I. Viscosity of water," *Zeits. f. physik. Chemie* **80**, 670-86 (1912).
- E. C. Bingham, "Viscosity and fluidity. A summary of results," *Phys. Rev.* **35**, 407-33; **I**, 96-123 (1913).
- E. C. Bingham, "Criticism of some recent viscosity investigations," *J. Chem. Soc.* **103**, 959-65; *Proc. Chem. Soc.* **29**, 113 (1913).
- E. C. Bingham, "A new viscosimeter for general scientific and technical purposes," *J. Ind. Eng. Chem.* **6**, 233-71 (1914).
- E. C. Bingham, "Viscosity of binary mixtures," *J. Phys. Chem.* **18**, 157-65 (1914).
- E. C. Bingham, "Fluidity as a function of volume, temperature and pressure. The equation of state, and the two kinds of viscous resistance so-called 'slipping' of gases. (Preliminary)," *J. Am. Chem. Soc.* **36**, 1393-408 (1914).
- E. C. Bingham, H. I. Schlesinger, and A. B. Coleman, "Some sources of error in viscosity measurement," *J. Am. Chem. Soc.* **38**, 27-41 (1916).
- E. C. Bingham, "Plastic flow," *J. Wash. Acad. Sci.* **6**, 177-9 (1916).
- E. C. Bingham and R. F. Jackson, "Standard substances for the calibration of viscometers," *Bur. Stand. Sci. Paper No. 298*; *J. Wash. Acad. Sci.* **7**, 53-5 (1917).
- E. C. Bingham, "Variable-pressure method for the measurement of viscosity," *Proc. A.S.T.M.* **18**, **II**, 373-86 (1918).
- E. C. Bingham, H. S. VanKlooster, and W. G. Kleinspehn, "The fluidities and volumes of some nitrogenous organic compounds," *J. Phys. Chem.* **24**, 1-20 (1920).
- E. C. Bingham and H. Green, "Paint, a plastic material and not a viscous liquid; the measurement of its mobility and yield value," *Proc. A.S.T.M.* **19**, 640-75 (1919).
- E. C. Bingham and L. A. Sarver, "Fluidities and specific volumes of mixtures of benzyl benzoate and benzene. XXIX," *J. Am. Chem. Soc.* **42**, 2011-22 (1920).
- E. C. Bingham, "Progress in metric standardization," *J. Ind. Eng. Chem.* **14**, 332-4 (1922).
- J. E. Booge, E. C. Bingham, and H. D. Bruce, "Relation of yield value and mobility of paints to their so-called consistency," *Proc. A.S.T.M.* (1922).
- E. C. Bingham and H. L. Young, "The drainage error in measurements of viscosity by the capillary tube method," *J. Ind. Eng. Chem.* **14**, 1130 (1922).
- E. C. Bingham, H. D. Bruce, and M. O. Wolbach, Jr., "The plastometer as an instrument for process control," *J. Ind. Eng. Chem.* **14**, 1014-5 (1922).
- E. C. Bingham and W. L. Hyden, "Study of Nitrocellulose," *J. Franklin Inst.* **194**, 731-40 (1922).
- E. C. Bingham, H. D. Bruce, and M. O. Wolbach, Jr., "Study of the plasticity of paint," *J. Franklin Inst.* **195**, 303-17 (1923).
- E. C. Bingham, "Edward Hart," *Ind. Eng. Chem.* **15**, 974-5 (1923).
- E. C. Bingham and A. G. Jacques, "Some factors which affect the plasticity of a paint," *Ind. Eng. Chem.* **15**, 1033-6 (1923).
- E. C. Bingham, "Plasticity and elasticity," *J. Franklin Inst.* **197**, 99-116 (1924).
- E. C. Bingham and H. A. Murray, "A new combined viscometer and plastometer," *Proc. A.S.T.M.* **23**, **[II]**, 655-68 (1923).
- E. C. Bingham and S. B. Stone, "A study of the fluidity relationships in the system, nitric acid, sulfuric acid, and water," *J. Phys. Chem.* **27**, 701-38 (1923).
- E. C. Bingham, *et al.*, "Consistency discussion," *Proc. A.S.T.M.* **23**, **[II]**, 460-74 (1923).
- E. C. Bingham, W. L. Hyden, and G. R. Hood, "Fluidity anomalies in refined mineral oils," *Ind. Eng. Chem.* **16**, 25-6; 535 (1924).
- E. C. Bingham, "Determination of softening temperatures by the fluidity method," *J. Phys. Chem.* **28**, 263-6 (1924).
- E. C. Bingham, "Plasticity as a means for control of properties," *J. Am. Cer. Soc.* **7**, 430-6 (1924).
- E. C. Bingham, "The rhe as the absolute unit of fluidity," *Ind. Eng. Chem.* **17**, 47 (1925).
- E. C. Bingham, "The shimer filter tube," *Ind. Eng. Chem.* **17**, 293-4 (1925).
- E. C. Bingham, "Plasticity in colloid control," *Ind. Colloid Symposium Monograph*, 106-13 (1925).
- E. C. Bingham, G. F. Rolland, and G. E. Hilbert, "Sulfite liquor as a protective colloid," *Ind. Eng. Chem.* **17**, 952-3 (1925).
- E. C. Bingham, "Plasticity," *J. Phys. Chem.* **29**, 1201-4 (1925).
- E. C. Bingham, "Colloid Types," *Fifth Colloid Symposium Monograph*, 219-28 (1928).
- E. C. Bingham and T. R. Thompson, "The fluidity of mercury," *J. Am. Chem. Soc.* **50**, 2878-83 (1928).
- E. C. Bingham and J. W. Robertson, "A method of simultaneous determination of plasticity and elasticity," *Kolloid-Zeits.* **47**, 1-5 (1929).
- E. C. Bingham, "Rheology. I. The nature of fluid flow," *J. Chem. Ed.* **6**, 1113-9 (1929).
- E. C. Bingham, "Rheology. II. The nature of plastic flow and its relation to fluid flow," *J. Chem. Ed.* **6**, 1206-14 (1929).

- E. C. Bingham and D. Figlioli, "Capillary Siphons," *J. Rheology* 1, 167-73 (1930).
- E. C. Bingham and L. B. Darrall, "A study of the fluidities and densities of the octyl alcohols. The association of liquids," *J. Rheology* 1, 174-205 (1930).
- E. C. Bingham and H. J. Fornwalt, "Association and constitution," *Science* 71, 564-5 (1930).
- E. C. Bingham and B. Lowe, "The nature of flow," *Colloid Symposium Annual* 7, 205-12 (1930).
- E. C. Bingham and H. J. Fornwalt, "Chemical constitution and association," *J. Rheology* 1, 372-417 (1930).
- E. C. Bingham, "Determination of the fluidity of water as a reference standard," *J. Rheology* 1, 433-8 (1930).
- E. C. Bingham and T. R. Thompson, "The correction in viscometry when using capillary tubes which have trumpet-shaped openings," *J. Rheology* 1, 418-23 (1930).
- E. C. Bingham, "Rheology index," *J. Rheology* 2, 10-107 (1931).
- E. C. Bingham, "Some fundamental definition of rheology," *J. Rheology* 1, 507-17 (1930).
- E. C. Bingham and L. W. Spooner, "Polymerization vs. association and condensation," *Ind. Eng. Chem.* 23, 785-6 (1931).
- E. C. Bingham, "Rheology subject index," *J. Rheology* 2, 10; 424-45 (1931).
- E. C. Bingham, *et al.*, "Notes on the fluidity of water in the vicinity of 20°," *J. Rheology* 2, 403-23 (1931).
- E. C. Bingham and D. F. Brown, "The fluidity mixture law," *J. Rheology* 3, 95-112 (1932).
- E. C. Bingham, "Fluidities of nonaqueous mixtures," *J. Rheology* 3, 113-20 (1932).
- E. C. Bingham and L. W. Spooner, "Fluidity method for the determination of association," *J. Rheology* 3, 221-44 (1932).
- E. C. Bingham and H. DeTurck, "A further study of association by the fluidity method," *J. Rheology* 3, 479-93 (1932).
- E. C. Bingham and R. A. Stephens, "Fluidity and association of alcohols and esters of high molecular weight," *Physics* 4, 206-7 (1933).
- E. C. Bingham and J. A. Geddes, "New corrections in viscometry by the capillary-tube method," *Physics* 4, 203-5 (1933).
- E. C. Bingham and W. H. Stevens, Jr., "Heavy water inert, due to low association," *J. Chem. Phys.* 2, 107-8 (1934).
- E. C. Bingham and J. A. Geddes, "The relation between constitution and association, especially in reference to aromatic compounds," *Physics* 5, 42-52 (1934).
- E. C. Bingham, "Viscosity and its expression," *Proc. World Petroleum Congr.*, London 2, 512-14 (1933).
- E. C. Bingham and L. W. Spooner, "The fluidity method for the determination of association. II," *Physics* 4, 387-400 (1933).
- E. C. Bingham and R. A. Stephens, "The alternating stress method for the measurement of the consistency of very stiff materials," *Physics* 5, 217-20 (1934).
- J. A. Geddes and E. C. Bingham, "The fluidity of anisole," *J. Am. Chem. Soc.* 56, 2625-6 (1934).
- E. C. Bingham and J. E. Hatfield, "The association by the fluidity method of substances that are solid at ordinary temperatures," *Physics* 6, 64-8 (1935).
- E. C. Bingham, "Chemical engineering at Lafayette College," *J. Chem. Ed.* 13, 284-6 (1936).
- E. C. Bingham and C. E. Coombs, "Fluidity and molecular complexity," *Phys. Rev.* 45, 645 (1934).
- E. C. Bingham, "Improved chemical hood," *J. Chem. Ed.* 14, 310-12 (1937).
- E. C. Bingham, "Recent progress in consistency measurement," *A.S.T.M.*, Symposium on Consistency 1937, 3-8 (1938).
- E. C. Bingham and S. D. Stookey, "Relation between fluidity, temperature and chemical constitution of pure liquids," *J. Am. Chem. Soc.* 61, 1625-30 (1939).
- E. C. Bingham and Paul W. Kinney, "The relation of fluidity to volume in organic liquids," *J. App. Phys.* 11, 192-202 (1940).
- E. C. Bingham, H. E. Adams, and G. R. McCauslin, "Interrelations of fluidity, volume, pressure and temperature in liquids," *J. Am. Chem. Soc.* 63, 466-74 (1941).
- E. C. Bingham, "Fluidity of electrolytes," *J. Phys. Chem.* 45, 885-903 (1941).
- E. C. Bingham and D. Figlioli, "A new reflectometer and a study of its performance," *Paper Trade J.* 113, No. 23, 32-7 (1941).
- E. C. Bingham and R. R. Roepke, "The rheology of the blood. II. The effect of fibrinogen on the fluidity of blood plasma," *J. Am. Chem. Soc.* 64, 1204-6 (1942).
- E. C. Bingham, "Proposal for the extension of our system of mensuration," *J. App. Phys.* 14, 196-8 (1943).
- E. C. Bingham, "The grading of rheological materials," *Rheology Bull.* 14, No. 1, 3-5 (1943).
- E. C. Bingham and R. T. Foley, "The fluidity of electrolytes," *Rheology Bulletin* 14, No. 1, 5-8 (1943).
- E. C. Bingham and R. T. Foley, "Fluidity of electrolytes. II.," *J. Phys. Chem.* 47, 511-27 (1943).
- E. C. Bingham and R. R. Roepke, "Rheology of the blood. III.," *J. Gen. Physiol.* 28, 79-93 (1944).
- E. C. Bingham and R. R. Roepke, "Rheology of the blood. IV. The fluidity of whole blood at 37°," *J. Gen. Physiol.* 28, 131-49 (1944).
- E. C. Bingham and G. F. White, *A Laboratory Manual of Inorganic Chemistry* (John Wiley and Sons, New York, 1911).
- E. C. Bingham, *Fluidity and Plasticity* (McGraw-Hill Book Company, Inc., New York, 1933).

H. K. NASON

Ballot on Publication Policy—May Issue

ALTHOUGH the returns from the ballot published in the May issue of the *Rheology Bulletin* did not represent a majority of the Society's membership, it is believed to be representative of your wishes since it confirmed the Executive Committee's interpretation of last year's ballot on publication policy and was overwhelmingly one-sided.

In the light of the returns from this last ballot the following policies will be adopted until you recommend otherwise:

The Executive Committee will decide on matters pertaining to Bulletin publication.

The Constitution will not be amended to permit cessation of Bulletin publication before the appearance of the A.I.P.'s new *Physics*.

The *Journal of Colloid Science* will be communicated with in regard to the publication of our annual meeting papers in a special Society of Rheology issue of the *J. Coll. Sci.* to appear in the spring following our meetings.

A large majority of those voting expressed a desire to purchase only the single rheology issue of *J. Coll. Sci.* without yearly subscription.

Arrangements will be attempted to have a Society "smoker" on Friday evening, November 1.

Two Rheology Symposia

DURING the war years two rheology symposia have been held abroad, one in Moscow on May 12-16, 1941 by the Institute of Machinery (Division of Technical Sciences of the Academy of Sciences of the U.S.S.R.), the proceedings of which cover ca. 600 pages(!) and appeared in two volumes in Moscow in 1941 and 1944 respectively, and the other one was held by the British Rheologists' Club in conjunction with the Institute of Petroleum on April 18, 1945 in London. Its proceedings and discussions appeared in the *Journal of the Institute of Petroleum* **31**, pp. 239 to 338 (1945).

The Russian Symposium covered a rather wide range of topics (from theory of viscosity and the non-viscous flow of helium II to the behavior of lubricants at low temperatures and even the flow of coal-fuel-oil suspensions). Many of the 57 papers have been abstracted in the *J. Inst. Petr.*, some in C.A. and some are appearing as translation in *Petroleum* (London), as did the complete index in *Petroleum* (London), **8**, 164, 185 (1945). If the editor of the *Rheology Bulletin* should so desire, we shall prepare a complete abstract collection of this work.

The British Symposium covered the following topics:

I. The Precision and Accuracy of Viscometry using B.S.I. Tubes, by the Viscosity Panel of the Standardization Sub-Committee No. 6 Lubricants, pp. 239-247.

Conclusions reached were:

(1) It is not satisfactory to rely solely on the present dimensional specifications for B.S. 1 tubes if viscosities are to be determined with ± 0.1 percent maximum error

from the mean value for results obtained in different laboratories using the same basis for the practical unit.

(2), (3) Practical methods to remedy the situation are proposed.

(4) Further investigation regarding reproducibility of temperature and time measurements were found necessary.

(5), (6) British mean values of viscosities on the same oils are consistently 0.35 percent below the mean values obtained in the U.S.A., suggesting that the fundamental unit of centistoke has a different practical value in the two countries (!).

II. The Testing of Greases for Ball-Bearings. S. R. PETHRICK, pp. 248-54.

A new test apparatus is proposed to measure several rheological properties of greases as well as their mechanical and chemical (oxidation) stability.

III. A Rational Basis for the Viscosity Index System. E. W. HARDIMAN AND A. H. NISSAN, pp. 255-70.

The Viscosity Index System has been revised to represent better a wide viscosity and viscosity temperature range without the anomalies of the present system, by basing it on a new (empirical) exponential form of the base-oil curve families.

IV. The Problem of Engine Deposits. A. LAHIRI, Z. KARPIRSKI, AND E. W. J. MARDLES.

The rheological properties of engine deposits are recognized as most important in the problem of ringsticking, etc. The change in viscosity characteristics of oils is accordingly observed in a very ingenious apparatus during oxidation at high temperatures. Viscosities of suspensions of typical aero-engine deposits and of carbon black in oil are also determined.

V. Lubricating Greases. A. S. C. LAWRENCE.

Qualitative aspects of the change of grease viscosity with temperature, esp. the humps due to phase transitions of the soap crystals were discussed. The concurrent changes in the state of dispersion of the soap in oil is given as the basic cause of the viscosity anomalies in lubricating greases.

A. BONDI

Do You Have Rheology Leaflet No. 1?

OUR secretary, Dr. Dow, has been collecting two copies of all the back numbers of the publications of the Society so that they may be suitably bound to give us two sets of reference archives for the future use of the Society. His collection is almost complete; the only missing issue is "The Rheology Leaflet," No. 1, March, 1937. Will two kind members please donate or sell their copies to the Society? Send them to Dr. R. B. Dow, Bureau of Ordnance, Re9d, Navy Department, Washington 25, D. C.

Reviews and Abstracts

Restricted Free Rotation, Viscosity and Birefringence of Solutions of Chain Molecules. W. KUHN AND H. KUHN, *Helv. Chim. Acta* **28**, 1533 (1945), **29**, 71 (1946).—The effect of finite velocity gradients on dilute solutions of molecules of varying degrees of internal flexibility is examined. This latter property is characterized by a parameter B which has the dimensions of force per unit velocity, that is of a viscosity times length. B therefore is a friction constant which measures the internal resistance to deformations of the chain. Such deformations are characterized by relative motions of the two chain ends. The following results are then obtained for the two extremes of rigid (high B) and very flexible (low B) particles: The intrinsic viscosity in the first instance is reduced by a factor which for small gradients may be expressed in terms of a power series:

$$1 - A_1 S^2 + A_2 S^4 + \dots$$

where $S = (\kappa\eta_0/RT)M[\eta]_0$, η_0 is the viscosity of the solvent, $[\eta]_0$ the intrinsic viscosity at zero velocity gradient expressed in ccg^{-1} and M the molecular weight of the (homogeneous) polymer. A more rigorous calculation performed by the reviewer leads to the same type of result, as is to be expected. The coefficients A are different in magnitude and are furthermore slightly dependent on shape. If the chains are very flexible then the velocity gradient has no effect on the viscosity, as one might expect. The majority of actual cases will be found in between these extremes.

A set of experimental data on cellulose nitrate in butyl acetate attributed to Staudinger and Sorokin¹ is examined on this basis. Unfortunately only the molecular weights calculated by the original authors from viscosities were available. Hence an interpolation of ultracentrifuge values on different samples analyzed by Mosimann² is used. In view of the inhomogeneity of these and the sensitivity of the parameter S to this factor the numerical agreement obtained may possibly not be as close as it appears to be in the article in question. However these results indicate that the friction constant B decreases with increasing degree of polymerization. This appears plausible since in longer chains there are more ways of realizing a change in configuration by means of internal diffusion. In the last paper reviewed below this is confirmed.

The second article deals with the amount and direction of double refraction. The optical anisotropy increases more rapidly with the quantity S for flexible than for rigid chains, while the direction of the birefringence tends more rapidly towards zero for rigid particles.

ROBERT SIMHA

¹ Ber. **70**, 1993 (1937).

² Helv. Chim. Acta **26**, 369 (1943).

Interpretation of the Internal Viscosity of Chain Molecules, I. W. KUHN AND H. KUHN, *Helv. Chim. Acta* **29**, 609 (1946).—The previous considerations are extended and an expression is derived for the constant B . It turns out to be inversely proportional to the degree of polymerization. The proportionality constant is determined by

the geometry of the chain unit (segment length, position of rotation barrier minima etc.) and by the height of the internal rotation barrier. From experimental data on viscosity and birefringence the magnitudes of these constants are estimated and employed for a calculation of the times necessary for a 100 percent change of the distance between chain ends and of the effective rotation barriers. "Configuration times" of the order of magnitude of 10^{-3} to 10^{-5} sec. are obtained. It can be seen that they are approximately of the same order as or smaller than the times necessary for a complete rotation of a rigid particle. This indicates that the actual molecules are not completely rigid. The barriers calculated correspond to values around 10 kcal. mole⁻¹. It should be kept in mind that these numbers are based on experimental information such as molecular weights, which may be somewhat uncertain. The work briefly reviewed here represents an important contribution to the question of the internal flexibility of polymer molecules and their behavior in solution.

ROBERT SIMHA

Crucible Failure in the Induction Melting Process. ANDREW GEMANT AND JOSEPH STICHER, *J. App. Phys.* **16**, 661 (1945).—Experience shows that in the course of melting of metals in crucibles by means of induction heating, occasional local overheating of the crucible takes place which, in extreme cases, leads to perforation of the latter. This local disturbance may occur while the bulk of the charge and of the crucible is appreciably below the melting point of the latter. An explanation of this occurrence is presented on the basis that it is essentially a phenomenon of thermal instability. Zirconia, a material often used for crucibles, has a generally low electrical conductivity, but the conductivity *vs.* temperature characteristic is exponential, hence rather steep. At sufficiently high temperatures the conductivity locally may increase to such magnitudes that the heat generated in the charge and in the crucibles becomes greater than the heat dissipated. In such a case, the temperature locally rises indefinitely. Actually, it is not even necessary that the melting point of the zirconia be reached, if the latter only becomes sufficiently plastic so that the fluid charge can cause mechanical failure of the crucible. The theory shows that overheating becomes more probable with increasing steepness of the electrical conductivity *vs.* temperature characteristic, a condition favored by impurities present in the material. This circumstance explains why the process develops at a certain spot of the crucible. Numerical calculations, indicating the transition from stable to unstable operating conditions, are carried out for a small experimental and a large industrial furnace. The equations developed show how the various operating conditions, particularly the frequency of the current in the induction coil, have to be selected in order to insure operation in the stable region.

AUTHOR'S ABSTRACT

Structure and Elastic Properties of Synthetic Fibers. W. T. ATSBURY, *Chem. and Ind.* p. 110 (March 1946).—

The two extremes of state of synthetic fibers are the amorphous and the crystalline states. The properties of fibers depend on the conflicting tendencies toward each of these extremes. From the experience gained by the knowledge of natural fiber-forming, chain-molecules, production of synthetic fibers has been directed so that the desirable mechanical and elastic properties could be obtained. Perfectly oriented crystallinity is undesirable in fibers and means of increasing the mobility, other than by temperature effects, may be by intra-chain irregularities (internal plasticization) or by the incorporation of smaller molecules between the chains (external plasticization). An illustration of the extreme range of states occurring in a single plastic fiber is shown by unstretched and stretched polyisobutylene. Here, as with most rubbers, the orientable structure has a great tendency to disorganize at ordinary temperature. Long range elasticity is a manifestation of chain folding. Two types of transformation, depending on the restoring force active, are evident. The rubbers pass, on stretching, from an irregular to a regular state and the restoring force is largely entropy. On the other hand, elastic proteins pass from one regular state to a second regular state and the restoring force in this case is caused by internal energy as shown by the components of the free energy equation. Usually both restoring forces are present in synthetic fibers. However, the restoring force due to entropy is much weaker than that due to internal energy and the higher loads are borne by the latter. Nylon is a good example of this behavior. The author states that the ultimate exact interpretation of the physical properties of synthetic fibers depends on the detailed knowledge of the atomic arrangement gathered along many lines of approach.

W. W. PENDLETON

Influence of Method of Deesterification on the Viscosity and Acid Behavior of Pectinic Acid Solutions. T. H. SCHULTZ, H. LOTZKAR, H. S. OWENS, AND W. D. MACLAY, *J. Phys. Chem.* **49**, 554-563 (1945).—Pectins from citrus fruits and apples were subjected to deashing and deesterification treatments under various conditions. The pectinic acid was filtered and purified, and the pH adjusted to desired values by additions of sodium hydroxide or hydrochloric acid, to a range between about 1.5 and 7.5. A Beckman pH meter was used for the pH measurements. The viscosities were determined on Ostwald-Cannon-Fenske pipets with an electric timer, at $25 \pm 0.05^\circ\text{C}$. In order to make the aggregation influence nearly constant, concentrations were selected which showed viscosities relative to water of 3 to 6. The values for relative viscosity were plotted against the pH. The curves show a general maximum at a pH of 6 while the low methoxyl pectinic acids have minima at a pH of 4. The nature of the catalyst used (enzymes, alkali, or acid) influences the shape of the curves. (The same is true of temperature and concentration.) The typical transition from high to low methoxyl pectinic acids takes place at 8 and 6 percent methoxyl content enzyme and acid or alkali deesterification, respectively. The authors propose an explanation for the dif-

ferent ways of deesterification behavior obtained by enzymatic and acid/alkali catalyst.

B. R. ROBERTS

Correlation of Viscosities of Liquids with Temperatures. M. S. TELANG, *J. Phys. Chem.* **49**, 579-82 (1945).—Numerous equations correlating viscosity and temperature are known in the literature, but apply only to certain liquids and limited temperature ranges. Andrade's equation $\eta = Ae^{b/T}$ (A and b are constants, T is the temperature) seems to have a theoretical basis. Bingham and Stookey proposed $\eta/T = a + bT + \dots$ (a and b being constants), an equation, the applications and limitations of which have been discussed in the literature. Batschinski brought molecular volume and temperature in correlation in his equation $1/\eta = (V - W)/c$ (V being the specific volume at a given temperature, c and W are constants for each liquid). Sugden computed the relation between density and temperature of a liquid and by substituting his function in Batschinski's equation a new correlation of more general validity is obtained: $1/\eta = m/[(1 - Tr)^{3/10}] - K$ in which $m = \text{zero volume divided by } B\text{'s constant } c$, Tr is the quotient melting temperature divided by critical temperature. By plotting $1/\eta$ against $1/[(1 - Tr)^{3/10}]$, straight lines were obtained for non-associated liquids at all temperatures. Associated liquids as water and alcohol at lower temperatures, show deviations. Diagrams are shown for ethyl ether, *n*-hexane, acetone, chlorobenzene, benzene, chloroform, carbon tetrachloride; furthermore for ethyl-alcohol and water. The author points out that the last equation may be used for computing viscosity values for non-associated liquids at temperatures not recorded in the literature.

B. R. ROBERTS

Molecular-Size Distribution of Cross-Linked Polystyrene. I. VALYI, A. G. JANSSEN, AND H. MARK (Polytechnic Institute of Brooklyn). *J. Phys. Chem.* **49**, 461-71 (1945).—For a study of the cross-linking process of polystyrene with a stable compound, yielding soluble cross-linked products, two new divinyl derivatives, divinyl diphenyl and diisopropenyl diphenyl, were prepared. The latter compound proved very stable and was used for bulk polymerization with inhibited monostyrene. Blank polymerization experiments with monostyrene without cross-linking agents were made for comparisons. The catalyst was benzoyl peroxide, the concentration of diisopropenyl diphenyl was 10 to 1000 parts per million. Samples of polymers containing 10, 25, and 100 p.p.m. cross-linking agent were dissolved in ethyl methyl ketone (2 percent polymer) and fractionally precipitated with methanol. The fractions were dissolved in toluene (0.2 to 1.0 percent solutions) and their viscosities were measured in an Ostwald Viscometer. $\eta sp/c$ was plotted against the concentration c and the intrinsic viscosities were extrapolated. The molecular weights of the fractions were calculated from the equation

$$[\eta] = K \cdot M^a,$$

where $[\eta]$ is the intrinsic viscosity, $K = 1.0 \times 10^{-4}$, $a = 0.72$.

The molecular weights ranged from 40,000 to 750,000 for the uncross-linked material, and up to 1,600,000 for the highest fraction of the product containing 100 p.p.m. of diisopropenyl diphenyl. Light scattering measurements gave good agreements with the molecular weights computed from viscosity measurements. Molecular weight distribution curves showed that for increasing amounts of cross-linking agent the weight average DP shifts to larger values, the most frequent DP to smaller values and the distribution curve flattens out.

B. R. ROBERTS

Conductance and Viscosity of Concentrated Solutions of Calcium and Zinc Chlorides. DARWIN J. MEAD AND RAYMOND M. FUOSS (Research Laboratory of General Electric Company), *J. Phys. Chem.* **49**, 480-2 (1945).—On the system $\text{CaCl}_2\text{—ZnCl}_2\text{—H}_2\text{O}$ (concentration variations between 45.5 percent $\text{CaCl}_2\text{—}0.0$ percent ZnCl_2 and 0.0 percent $\text{CaCl}_2\text{—}22.6$ percent ZnCl_2) conductance measurements were made in 4-mm diameter U type conductance cells, and viscometric measurements on 10-cm capillaries (0.5- and 1.0-mm diameter), sealed to 30-cc pipets. The viscometer was calibrated by determining the flow time for water and from the equation

$$\eta = \eta_0 dt / d_0 t_0$$

(η being the viscosity in centipoises, d the density, t the time of flow, the subscript zero referring to water), the viscosities of the solutions were calculated. Replacement of Ca by Zn causes a very sharp initial decrease in viscosity but the conductance does not rise correspondingly. The known decrease of equivalent conductance with increasing concentration is here so outspoken that the *specific* conductance decreases. One figure and one table show the results of the experiments made over a rather wide range (viscosities made at 25°C, conductances at 25°, 0°, -20°, -40°C) measured at 1000 cycles, with preliminary experiments showing independence of frequencies between 500 and 5000 cycles.

B. R. ROBERTS

Relationship Between the Velocity of Sound and Other Physical Properties of Liquids. R. T. LAGEMANN AND W. S. DUNBAR. *J. Phys. Chem.* **49**, 428-36 (1945).—The known relationship between the density d of a liquid, its molecular weight M , and the velocity of sound v ,

$$v^{1/3}M/d = V,$$

where V is a constant, was found to have a wider application to certain properties of liquids. V , called by the authors the "molecular sound velocity" shows for homologous series a linear relationship with molecular refraction, parachor, Souders' viscosity constant* (I), van der Waals' b , molecular magnetic rotation and critical volume. For benzene hydrocarbons, esters of acetic acid, monohydric alcohols and paraffins, literature values of Souders' I and the authors' "molecular sound velocity" were plotted against each other and showed remarkably linear relation. For the thus established linear relation $V = A + BX$, the values A and B were evaluated by the method of least

squares. Relations may be set up between refractive index, viscosity, Verdet's constant, surface tension, and sound velocity.

B. R. ROBERTS

* Souders found that for numerous liquids the viscosity η , density d , and a viscosity-density constant m , satisfy the equation $\log 10 (\log 10 \eta) = m \cdot d - 2.9$. The constant m , multiplied by the molecular weight is called I and describes a constitutive property of each compound. (Abstractor's note.)

Supercooled Sulfur and Its Viscosity. R. FANELLI. *J. Am. Chem. Soc.* **67**, 1832-4 (1945).—Liquid sulfur may be supercooled in bulk to about 50°C and in droplets to about room temperature. Viscosity values for supercooled sulfur were determined for the temperature range 80°-160°C. Viscosity values obtained by extrapolation of this data to 50°C are reported. The relationship between the fluidity, $1/\eta$, and the specific volume is represented graphically. Based on Batschinski's empirical relationship, which indicates a linear relationship between the fluidity and the specific volume for a number of non-associated liquids, the data tend to confirm the presence of simple non-associated molecules in the entire liquid range reported. The nature of the supercooled liquid is essentially the same as that between 115° and about 160°. A sketch of the viscometer employed is given.

R. G. FORDYCE

Temperatures of Zero Conductance and Infinite Viscosity of Some Negatively Charged Colloidal Systems. S. P. MUSHRAN AND S. PRAKASH. *J. Phys. Chem.* **50**, 251 (May 1946).—By means of an Ostwald viscometer the changes of viscosity with temperature were investigated on the following negatively charged sols, prepared by the authors. Ferric vanadate, ferric molybdate, ferric tungstate, ferric borate, ferric arsenate, and ferric phosphate. The temperatures at which the sols would have infinite viscosities were determined by extrapolation. The actual η -values were found from measurements made at temperatures between 20 and 40°C. By plotting $1/\eta$ against temperature, curves were obtained which could be extrapolated for the temperatures, at which $1/\eta$ was reduced to zero. (The paper gives the figures in tables but does not show the curves.) The temperatures of infinite viscosity were found to -17° to -28°C for the various sols. By a similar method the zero-conductance of these sols was determined. The values lie between -16° and -28.5°C. Therefore the temperatures of zero conductance are very close to those of infinite viscosity.

B. R. ROBERTS

Tracing Flow in Glass Tank Furnaces. F. L. BISHOP, JR. *J. Am. Cer. Soc.* **28**, 308-310 (1945).—The velocity, direction, and amount of surface flow of glass can be determined by adding a small amount of a rare earth to a definite portion of batch. The flow measurements are calculated from the resultant slight fluorescence of samples taken at intervals or by the change in transmission for certain wave-lengths of ultraviolet light. Sample results are shown and discussed.

J. A. PASK

Viscosity Studies of System CaO-MgO-Al₂O₃-SiO₂: I, 40 Percent SiO₂. J. S. MACHIN AND D. L. HANNA. *J. Am. Cer. Soc.* **28**, 310-16 (1945).—The measurement of glass viscosities at elevated temperatures with an oscillating cylinder-type viscometer is described. Viscosity data are presented covering these compositions in the CaO-MgO-Al₂O₃-SiO₂ system which contain 40 percent SiO₂ and which are liquid at 1500°C. The pattern of the system of isokoms presented indicates that viscosity is closely related to the ratio of basic to acidic components. Theoretical aspects of the variation of viscosity with composition in silicate-aluminate systems are discussed in terms of silica-alumina polymers.

J. A. PASK

Silicones: New Silica-Based Plastics of Interest to the Ceramic Industry. S. L. BASS, J. F. HYDE, AND R. R. MCGREGOR. *J. Am. Cer. Soc.* **29**, 66-70 (1946).—The author describes how silicones are formed and the properties and some of the uses of silicone products: liquid silicones, silicone greases, ignition sealing compounds, silicone resins, varnishes, and rubber. Silicones derive many of their most useful properties from the inorganic nature of silicon-to-oxygen links which they possess in common with glass and mineral silicates. They derive plasticity, solubility, and water repellency from the organic radicals attached to their basic structures. The chemical nature of silicon in combination with oxygen permits the develop-

ment of a variety of silicone compounds in various physical forms ranging from fluids through gels and resins to elastic materials. Because of their ease of application, their general heat stability, and chemical inertness, they are natural complements to ceramic bodies in many applications. They are already proving their usefulness with these materials in the production of new types of electrical insulation, in the surface treatment of glass and ceramic products, and as auxiliary dielectrics for use with ceramic insulating forms.

J. A. PASK

Study of Several Groups of Organic Binders under Low Pressure Extrusion. C. C. TREISCHEL AND E. W. EMRICH. *J. Am. Cer. Soc.* **29**, 129-132 (1946).—Thirty different organic binders, including (1) flours, starches (both short and long chain), (2) gums, (3) alcohols and cellulose derivatives, (4) weed extracts, and (5) alginates, were added to a talc-water system and the mixtures were extruded at low pressures through a deairing extruder. Data are presented on wet strength, water retention during extrusion, extrusion characteristics, drying shrinkage, water of plasticity, days required to air dry, warpage, dry modulus of rupture, hardness, and migration of binder. The data presented show no one outstanding material. Considered as groups the best possibilities are among the gums, alginates, and alcohols.

J. A. PASK

BALLOT ON AMENDMENTS

Please return ballot to

Dr. R. B. Dow
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BEFORE OCTOBER 1, 1946

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