

BRITISH RHEOLOGISTS' CLUB



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CLUB NOTES.

Future Meetings.

Rheology of Emulsions. It is proposed to hold a meeting on this subject at the Institute of Physics, London, on November 11th, 1949, at 3.30 p.m.

Rheological Instruments and Apparatus will be exhibited and discussed at a meeting at the Polytechnic, Upper Regent Street, London, on Friday, Jan. 6th, 1950. The Hon. Secretary would be glad to hear from members who wish to exhibit.

Manchester Meeting. It is hoped to hold a meeting in Manchester on Lubrication in March 1950.

A Cambridge Meeting will be held in about April 1950 on Biological Aspects of Rheology.

Further particulars of all these meetings will be sent to members in due course. The Committee hopes that members will help them by sending in suggestions for subjects and speakers for future meetings. Only with such help can we be sure that the range of interest of our members is being fully covered.

News of Members.

The Earl of Halsbury, has been appointed adviser to the Board of Trade on matters connected with the National Research Development Corporation, of which he will become managing director when it is formally established.

American Rheology. We are glad to receive further good news of our sister Society of Rheology which has now caught up and passed us in numbers. Membership is now about 350. May the good work continue!

News has just been received that the Bingham Memorial Award Committee has decided to present the 1949 medal to Prof. H. Eyring of Salt Lake City. The Club will

wish to offer its heartiest congratulations to a rheologist whom some of us have had the privilege of knowing personally and whose work we have all admired.

Proceedings of the 1st International Congress of Rheology are now available (publ. North Holland Publ. Co., Amsterdam), 3 guineas from British Booksellers. We had hoped to include abstracts of all the papers to this number of the Bulletin but this has not been possible and a few papers will have to be held over until the December Issue.

International Rheology. The Joint Committee on Rheology (I.C.S.U.) met at Amsterdam, Sept. 6th-8th. It was decided to found an International Union of Rheology, which it is hoped will unite the activities of national rheological organisations, and later to make application for recognition by the I.C.S.U. It is hoped that the Union will be inaugurated by about the end of the year.

The first activity of the new Union will be to organise an International Rheology Bulletin under the General Editorship of Dr. V. G. W. Harrison, and it is planned that this new Journal will take over the abstracting work of our present Bulletin, probably in about a year's time. The Union will seek special funds for this work. If these are forthcoming, there should be a considerable financial saving to the Club.

On the other hand it is hoped that the Club will adhere to the Union, for which purpose a subscription would naturally be required.

Adherence to the Union would entitle the Club to nominate members to the Assembly of the new organisation.

The Officers of the Union have been provisionally appointed for the first year of its existence (1950) as follows:—

<i>President:</i>	PROF. J. M. BURGERS	Deft
<i>Vice-Presidents:</i>	PROF. T. VON KRÁMÁN	Pasedena
	MME. DOBRY-DUCLAUX	Paris
<i>Hon. Sec.:</i>	DR. G. W. SCOTT BLAIR	Reading
<i>Hon. Treas.:</i>	PROF. R. SIGNER	Berne

A number of individual rheologists, including all members of the present Committee (which will be dissolved once the Union is fully established) were elected to the Assembly. British members are SIR GEOFFREY TAYLOR, F.R.S., DR. P. EGGLETON and DR. V. G. W. HARRISON.

Postscripts

(1) At the Annual General Meeting held at Bristol on September 27th, 1949, the following were elected for the ensuing year:—

<i>President</i>	DR. G. W. SCOTT BLAIR
<i>Hon. Sec.:</i>	DR. E. W. J. MARDLES
<i>Hon. Treas.:</i>	DR. J. G. OLDROYD
<i>Hon. Editor:</i>	DR. V. G. W. HARRISON
<i>Hon. Auditor:</i>	MR. A. DE WAELE

Members of Committee: MRS. B. S. NEUMANN, DR. A. H. NISSAN MR. M. W. THRING, MR. A. G. WARD.

Northern Representative: MR. W. A. RICHARDSON.

(2) Heartiest congratulations to our Past President, Prof. E. N. da C. Andrade, F.R.S., on his appointment to the Royal Institution.

RHEOLOGY ABSTRACTS

NOTE.—The initials following the Abstracts are those of the abstracting member except for the following abbreviations for abstracts re-produced from other Journals by permission :—

B.C.R.A.	British Ceramics Research Association.
I.D.I.B.	Industrial Diamond Information Bureau.
NICKEL BULL.	Nickel Bulletin.
P.A.T.R.A.	Printing and Allied Trades Research Association.
SCI. ABSTR.	Science Abstracts.
B.S.A.	Building Science Abstracts.

1368. **X-Ray and Electron Microscope Studies of the Interaction of Myosin and Actin.**

W. T. ASTBURY. *Proc. 1st Intern Congr. Rheol. Scheveningen 1948 p. II 197 (Publ. North Holland Publ. Co. 1949).*

Szent-Györgyi found that when a solution of actomyosin is injected into a weak solution of KCl to form a precipitated gelatinous thread the addition of a small quantity of adenosine triphosphate (ATP) causes an intense and rapid shrinkage. This observation has been made the basis of a theory of muscle contraction. However the X-ray and electron microscope studies reported in the present paper indicate that this observed contraction is obtained by a different mechanism from that responsible for contraction of muscles *in vivo*. Hence it is concluded that the theories based on Szent-Györgyi's observation are untenable.

A.H.N.

1369. **Shape Factor in Particle Size Measurements.**

A. E. W. AUSTEN AND K. R. GILBERT. *Nature* **163** 527, 1949.

The degree of uniformity of alumina powders was derived from the coeff. of variation K , obtained by dividing the standard deviation by the diameter. It consists of K_1 , due to scatter in size and K_2 , due to deviation from spherical shape which makes the measured diameter depend on the orientation. K_2 varies from zero for particles of circular profile to 0.484 for needle-like particles and is obtained by measuring the diameter of a number of particles in four orientations spaced at intervals of 45° . The four diameters of each particle are divided by their mean; K is then the standard deviation from unity of all the quantities obtained in this way.

Use of K_2 enables the variation in size to be determined from the relation $K^2 = K_1^2 + K_2^2$.

E.W.J.M.

1370. **A Plastic Theory of Design for Ordinary Reinforced and Prestressed Concrete including Moment Re-distribution in Continuous Members.**

A. L. L. BAKER, *Mag. Concr. Res. No. 2, 57, 1949.*

A general expression is derived for the ultimate strength in bending of ordinary reinforced concrete and two types of prestressed concrete beams, taking into account plasticity. A method of calculating elasto-plastic deformation is developed and applied to the problem of re-distributing bending moments in continuous members and frames.

P.H.

1371. **Theory of Viscosity.**

F. BALÁZS. *Nature*, **164**, 191, 1949.

Flow is treated as a rate process represented as a unimolecular reaction. E.W.J.M.

1372. Yield Value of Bentonite Suspensions.

E. R. BALLANTYNE. *Nature*, **163**, 995, 1949.

The yield values of thixotropic aqueous suspensions of bentonite measured by the thin plate viscometer were found to be dependent on the material of the plate, the order of the apparent yield values for the three materials used being aluminium > mica > platinum. Surface finish or variation in contact angle were insufficient to account for the differences. Platinized platinum which was completely wetted and certainly not smooth gave the lowest yield value.

E.W.J.M.

1373. The Influence of Liquids on the Breaking Strength of Glass.

C. BENEDICKS AND G. RUBEN. *Jernkontorets Annaler*, **129**, 37, 1945.

Results previously obtained by Benedicks and Sederholm, that bending resistance of glass is considerably affected by the presence of a wetting liquid on the surface subjected to tensile stress, have been confirmed. On the other hand, it has been found that water lowers the bending resistance by 20 to 30% according to the test applied. By a special method, using water, the "breaking time" was reduced to a very low fraction of that in the dry test. On the other hand it has been shown that certain liquids increase the bending resistance to an approximately equally marked degree both according to the methods applied for the determination of the bending resistance and to that of the "breaking time."

I.D.I.B. (See Abstr. 740).

1374. The London Clay. III. Strength Variations in London Clay.

A. W. BISHOP. *Verre Silicates Industr.*, **13**, No. 9, *COBEA Suppl.*, 109, 1948.

Site investigation of the London Clay at Walton shows a softening of the upper layers of the stratum which is very significant from the engineering point of view and stands out from the other more random strength variations. The observed variations are consistent with the geological history of the site, and may therefore be expected elsewhere in the Thames Valley. There is at present less detailed information about other sites, but at Datchet and Wraysbury strengths of 25-30 lb/sq. in. were found in the upper zone compared with 70-80 lb/sq. in. at greater depths, and at Chingford upper zone strengths are of the same order. In many boreholes sampling is commenced only at depths below the soft upper zone and will therefore give rise to very misleading results in stability calculations both for dams and building foundations. It is hoped that this paper may draw attention to the need for sampling where the most critical overstressing is likely to occur.

B.C.R.A.

1375. Effect of Internal Stresses on Hardness.

P. BLAIN. *Sheet Met. Ind.* **26**, 135, 1949.

Stresses due to various causes have of course considerable effect on hardness, which may be disguised to some extent in penetration hardness tests (Brinell, etc), owing to fact that existing stresses may be modified or even cancelled out by further stresses induced by hardness test. More accurate method for hardness in such cases is compression method, based on that used by Hertz. Test specimen is carefully polished and then submitted to pressure of highly polished steel ball. Pressure is gradually increased and observation made after each test to see whether there is indentation or not. This can be ascertained visually by noting reflection of light on polished surface of test piece. Hertz's formula is applied to determine maximum pressure in contact circle. It is concluded that surface of steel in same condition of heat treatment can vary in ratio 1: 5, according as metal is subjected to stress or compression of order of 165 kg./sq.cm. in region tested. This difference cannot be accurately measured by penetration hardness tests. Stresses of this magnitude often exists in hard steel hardened and tempered at low temperature.

I.D.I.B.

1376. Gear Wear as Related to the Viscosity of the Gear Oil.

H. BLOK. *De Ingenieur* 61, 39, 1949.

In gears, subject to impact loading, viscosity was found to rank foremost among the oil properties that affect wear. The effect of anti-welding additives was at the utmost of secondary importance only. In appraising the anti-welding action of gear oils *in simulating test machines*, the hydrodynamic effect of viscosity should preferably not be allowed to interfere. This can be achieved by the new test method described. Its tentative application to the S.A.E. machine is considered to be quite promising and is expected to lead to results more significant in terms of anti-welding action. Author's abstr. (abridged).

1377. The Yield Point of a Metal.

W. L. BRAGG. *Rep. Conf. "Strength of Solids"* (1947) (*Phys. Soc., Lond.*) 26, 1948.

A discussion of the metal slip problem in terms of a previously established criterion that γ_{lim} (the shear strain at the elastic limit) = ks/t where s is the interatomic distance and t the length of "perfect" blocks in the crystal. The constant $k \sim 1$. A formula of Dean and Mann expressing change of energy when slip occurs is applied to the case of Cu and an upper limit of the yield point is derived. The picture upon which such methods are based is generally discussed, leading to suggestion that the criterion holds for a number of metals, confirmation being limited by knowledge of t . SCI. ABSTR.

1378. Random Fracture of Solids and Natural Frequency Distribution.

R. L. BROWN. *Metallurgia*. 39, 277, 1949 (Paper given at Meeting of B.R.C.).

Physical mechanism and mathematical expression of fracture have recently received attention. Frequency distributions, characteristic of natural phenomena, other than the Gaussian distribution, are emerging from investigations. Weakest link hypothesis, first formulated by F. T. Peirce, placed in statistical context by B. Epstein, applicable to fracture of solids under slowly applied loads. R. L. Brown has proposed hypothesis that when large loads are applied suddenly (as often happens in industry) strength is determined by flaws in material. Also derives strength/volume relationship and reports confirmatory evidence for coal. There are two models for which strength/volume relationships and size-distribution laws can be derived, the need now being for experimental data with which to test theoretical analyses and refine the models. Two models, although they appear algebraically related, are fundamentally different, the logarithmico-normal law (a variant of the Gaussian law) being fundamentally a conservation law, while the Rosin-Rammler law is fundamentally one of destruction, where after one breakage step, the parameter is unity and in successive steps decreases steadily. I.D.I.B. (See Abstr. 954).

1379. The Viscosity of Concentrated Solutions of Polymers.

H. DE BRUIJN. *Proc. 1st Intern. Congr. Rheol. Scheveningen 1948*, p. II 95 (*Publ. North Holland Publ. Co.* 1949).

The general picture of a polymer solution is that of a suspension of spherical coiled chains, and the theory of the intrinsic viscosity of such solutions has been worked out by Kuhn, Debye and Brinkman. For more concentrated solutions, interaction effects between the particles must be taken into account. Two forms of mechanical interaction are distinguished: a long-distance "hydrodynamic interaction," and a "mechanical interaction by contact." The exact theoretical treatment is difficult, but an empirical relation covers both forms when small spherical particles are concerned. In more concentrated polymer solutions the radius of the spherical coils will change and the "rheologically effective radius" will become smaller in more concentrated solutions. From a provisional theory to cover the influence of this compression the equation

$$\sqrt{\eta_r} = \frac{1 + \beta c}{1 - 5/4 \cdot c}$$

is derived, where β is a dimensionless constant. Calculation of this constant from data published by several workers for a large number of polymers shows that it is, in fact,

approximately independent of the concentration. A relation connecting the intrinsic and actual viscosities of polymer solutions at different concentrations is derived. V.G.W.H.

1380. Viscometry of Settling Suspensions with a Rotational Viscometer.

H. DE BRUIJN AND P. G. MEERMAN. *Proc. 1st Intern. Rheol. Scheveningen*, 1948 p. II 160 (Publ. North Holland Publ. Co. 1949).

A stormer viscometer was used to measure the viscosity of settling suspensions by calibration with Newtonian liquids of different viscosities and densities. (Density effects had to be studied because the system had to be maintained turbulent). It was found that for coarse suspension viscosity increased with speed of rotation. An explanation is offered: the work necessary for maintaining the settling particles in suspension is the cause of this apparent increase in viscosity and a certain amount of evidence in support of this hypothesis is produced.

In the discussion which followed the presentation of the paper, H. Blok suggested that dimensional analysis might be applied to the problem which might throw strong light on it and the authors agreed to do so. A.H.N.

1381. Plastic Deformation of Crystals According to Taylor's Conceptions.

N. A. BRUNT. *Metalen* 3, 169, 1949.

A general view of the theory of dislocations, as developed by Taylor, is given. The generation and movement of dislocations under the influence of the stress field and the possibility of explaining the work hardening in metals, by this theory, are discussed. Finally, the more general treatment of the problem, as published by J. M. Burgers, is mentioned. (Author's Abstr.)

1382. Introductory Remarks on the Problem of Nomenclature in Rheology.

J. M. BURGERS. *Proc. 1st Intern. Congr. Rheol. Scheveningen* 1948 p. I 3. (Publ. North Holland Publ. Co. 1949).

The properties of any sample of non-living matter can, in theory, be described at any given instant in terms of its fundamental structure. Hence it may be argued that the parameters involved in the analysis of the structure should furnish the elements for a physical system of nomenclature to be adopted in rheology.

In practice the structure is not often known in detail, particularly if it is varying, as is the case when a liquid or gas is disturbed and the equilibrium distribution and speeds of the molecules are affected; also in the case of metals changes in structure on the molecular scale accompany deformation.

Such non-equilibrium conditions on the molecular scale often manifest themselves as relaxation phenomena. A body in the process of relaxation is in a different physical state than in the relaxed condition, and stress-deformation relationships differ for the same material if in different physical states. In describing the rheological behaviour of any materials capable of slow relaxation it is therefore imperative to state the history of the treatment to which the body was subjected.

The most frequently adopted mode of interpretation of rheological processes is phenomenological, fitted into the Newtonian system of mechanics. A great number of phenomena can be adequately described in terms of the independent variables of localized stress, deformation, and their derivatives of all orders with respect to time, i.e. time is taken as another co-ordinate. To facilitate the mathematical analysis in terms of the symbolism of this mechanical picture the recoverable and the permanent part of the total deformation should each be known at any instant during the deformation process, and the physical state—if necessary in terms of the history of the sample—should be recorded. In some practical testing methods this is not easy to achieve, and may be unimportant in certain fields of investigation. Whenever possible, it is desirable to base nomenclature upon the mechanical system, in preference to a terminology based on "tack", "rheopexy" etc.

Just as in multi-dimensional geometry patterns can be projected onto various systems of co-ordinates, there must be various ways of projecting the infinite variety of possible rheological phenomena onto suitable frames of reference. The first aim in striving to attain the possibility of transformation from one method of description to another conformal with it, is to attempt to analyze rheological phenomena in such a way that the various data are independent of one-another.

This aim is realized by employing the mechanical method of description, which may be referred to in the "Report on Principles of Rheological Nomenclature" prepared for discussion at the International Rheological Congress (Scheveningen 1948) by G. W. Scott Blair and the author. (See Asbtr. 1383) P.F.

1383. Report on the Principles of Rheological Nomenclature.

J. M. BURGERS AND G. W. SCOTT BLAIR. *Proc. 1st Intern. Congr. Rheol. Scheveningen 1948 Section V (Publ. N. Holland Publ. Co. 1949).*

In the Report, which exceeds seventy pages, the whole field of rheological nomenclature is critically surveyed. Much that is standard usage is accepted but some new suggestions are made, particularly in the fields of creep and viscosity where at present wide divergencies exist in defining and using terms descriptive of phenomena.

The terms "recoverable", "partly recoverable" and "non-recoverable" as applied to deformations, and other concepts are defined in the first chapter. The first of these types of deformation is said "not to affect the physical state", the last as affecting it.

Optimum conditions for exact measurements are obtained when experiments are performed either adiabatically or isothermally. If this proves impossible, information about the actual heat-exchanges should be given. Results confirmed by repeated experiments on the same specimen are said to be "reproducible": if a fresh specimen is used in each confirmatory test, the results are said to be "replicable."

In the second chapter the elements of the analysis of stress and deformation are defined; nomenclature relating to the resolutes of the symmetric stress tensor is given, and the characteristics of pure-, simple-, tangential-, and axial shear (the last two in concentric cylinders), and other types of deformation and stress are made clear, while in the following chapter the terminology relating to fluid- and plastic-behaviour respectively is discussed. A plastic substance is characterized by having a yield stress, while a fluid deforms under the smallest shear stress. Substances capable of flowing are further classified according to the nature of the flow, i.e. "limited", "decelerating", etc. Viscosity is either "Newtonian" or "non-Newtonian", according to whether the (stress)/(flow velocity) curve is a straight line passing through the origin or not.

The fourth chapter deals with nomenclature relating to recovery effects and friction of the dynamic and static type, the latter remaining active even if the deformation rate approaches zero. The terms describing different types of recovery, like "spontaneous-" and "stimulated restoration" are defined, and the various types of hardening and softening encountered in rheology are considered. With reference to work-hardening in plastic solids, the distinction between "initial-", "increased-" and "limiting yield-values" is clearly set out. It is proposed to extend the meaning of "thixotropy" to cover all cases of softening followed by a time-dependent return to a harder state, irrespective of whether there is a sol-gel transformation or not.

The subjects included in the sixth chapter relate to nomenclature involved in various types of experiments in which the material is subjected to shear, i.e. when the deformation is kept constant or when it is varied periodically as in fatigue tests. The relaxation of stresses is discussed, and the "relaxation time" is defined, it being pointed out that a whole spectrum of relaxation-times can be involved in the deformation of certain substances.

In the last chapter several particular applications of the terminology developed in the report are given and compared with the nomenclature used by some writers on rheological subjects. P.F.

1384. **Nature of the Effect of Air-Entraining Substances in the Technical Properties of Cement Mortars and Concrete.**

YU. M. BUTT AND T. M. BERKOVICH. *Doklady Akad. Nauk, U.S.S.R.*, **60**, 1551, 1948.

Kennedy and Gonnerman (*J. Am. Conc. Inst.*, **15**, 6, 1944) explain effects entirely in terms of air entrainment—elastic bubbles giving improved plasticity and reducing the water needed for standard consistence. B. and B. believe that the effect is due to the pronouncedly surface active nature of these substances.

P.H.

1385. **Influence of Solvent Movement on Sedimentation.**

R. CECIL, J. P. JOHNSTON AND A. G. OGSTON. *Nature*, **163**, 919, 1949.

A criticism of Enoxxson's view that the major factor which causes the sedimentation constant of a protein to change with concentration is the counterflow of solvent.

E.W.J.M.

1386. **Rheological Problems in Biology.**

A. L. COPLEY. *Proc. 1st Intern. Congr. Rheol., Scheveningen, 1948, p. 1, 47. (Publ. North-Holland Publ. Co., 1949).*

Author enumerates methods of measuring viscosity, viscous anomalies and thixotropy of protoplasm and of blood, and discusses complex rheological properties of cellular coats and intercellular substances. The importance of blood agglutination is also stressed.

G.W.S.B.

1387. **Rôle of Intergranular Boundaries in the Deformation of Metals and its Application to Flow and Fatigue.**

C. CRUSSARD. *Rev. Mét.*, **43**, 307, 1946.

The micrography, X-ray analysis and heat of activation of metals under the action of various loads and at various temps. are studied. A hypothesis is put forward which explains some of the phenomena associated with flow and fatigue; an accelerated estimation of fatigue strength, which is in accord with experimental results and modern theory, is facilitated. In an annealed metal there is considered to be no amorphous grain-boundary layer. The action of increasing load is considered; under small loads, a certain type of deformation, micro-flow, which is either crystalline or intergranular in origin, appears, and gives rise to some internal friction. Above the limit of micro-flow, ordinary flow and work-hardening appear. Work-hardening has two origins, one intergranular and one intracrystalline: with metals possessing strong grain-boundaries (e.g. hexagonal metals) the intergranular work-hardening appears first; the corresponding deformations are reversible and do not give rise to fatigue if repeated. When internal forces at the grain boundaries are near their max., intracrystalline work-hardening becomes noticeable and repetition of cycles causes fatigue. For cubic metals, both types of work hardening proceed simultaneously from the beginning of deformation and the phenomena are more complex. Flow at the grain boundaries gives a thin distorted zone (0.01μ or less) which may be the site of viscous movement of individual atoms; it requires compatibility of deformation in neighbouring grains, which is easy with cubic metals but difficult with hexagonal metals (in which the grains are always distorted unless they recrystallize). Intragranular flow causes distorted zones and the probable deformation of layers adjoining the grain boundaries. The effect of temp. on flow is discussed, and the temp. of equicohesion is defined as that where intergranular flow becomes preponderant; values for this temp. are determined experimentally and also calculated from Boltzmann's formula.

SCI. ABSTR.

1388. **Some Flow Properties of Solutions of Polymers.**

C. N. DAVIES. *Proc. 1st Intern. Congr. Rheol. Scheveningen, 1948 p. II, 152. (Publ. North Holland Publ. Co., 1949).*

Newtonian liquids of low viscosity form a main drop with a string of satellite droplets when ejected from a fine nozzle, whilst those of high viscosity form a drop on a long

thread which then breaks up into a larger number of satellite droplets of smaller size than those obtained with low viscosity liquids. Non-Newtonian liquids do not form satellite drops except under certain circumstances which can be used as evidence of molecular degradation. Flow in capillaries under a wide range of shear rates is reported and the influence of molecular entanglements is discussed. Finally shatter of jets under high transient stresses and the influence of volatility of solvent are demonstrated. A.H.N.

1389. The Change in Strain Energy Caused by a Dislocation.

W. R. DEAN AND E. H. MANN. *Proc. Camb. Phil. Soc.*, **45**, 131, 1949.

Two systems of 2-dimensional strain in a homogeneous elastic medium, bounded internally by 2 long circular cylinders, are considered. The first is in a state of simple shear and the stress-function and displacements are calculated. In the second the strain arises from a dislocation in which a relative displacement in the direction joining the cylinders is imposed on a certain pair of planes. The stress-function and displacement are obtained and compared with those of the first system. SCI. ABSTR. (See Abstr. 591)

1390. Use of Torsional Stresses for Observing High-Temperature Characteristics of Ceramic Materials.

A. R. DECKER AND H. F. ROYAL. (*J. Amer. Ceram. Soc.*, **31**, 332, 1948.)

A method is described for testing ceramic specimens under torsional stresses at temperatures to 1,370° C. With simple apparatus and minimum time, consistent values are obtained for modulus of rigidity, Poisson's ratio (when the modulus of elasticity is known), tensile (torsion) strength, torque-twist graph, approximate softening temperature, plastic deformation, and short-time creep rate. The results are in satisfactory agreement with tensile test, bending test, and long-time creep-rate results and thus provide a quick means of making a preliminary selection of promising compositions for more extensive testing. Among the advantages of torsion testing are freedom from error caused by thermal expansion, absence of need for close dimensional tolerances, simplicity of specimen installation in grips, and the ability to make deformation measurements outside the furnace on the cool end of the specimen. Data for a sillimanite body and a beryllia body illustrate the types of information given by the method. The beryllia body has more suitable high-temperature characteristics. B.C.R.A.

1391. Stress-Strain Relations for Finite Elastoplastic Deformations.

J. E. DORN AND A. J. LATTER. *J. Appl. Mech.* **15**, 234, 1948.

Stress-strain relations are proposed for plastically deforming isotropic materials, in which the elastic strains are not necessarily small. J.G.O. (See Abstr. 1210).

1392. Report on Fundamental Experimental Methods in Rheology.

F. R. EIRICH. *Proc. 1st Intern. Congr. Rheol. Scheveningen*, 1948, p. IV, 3. (*Publ. North Holland Publ. Co.*, 1949).

Author enumerates rules and precautions in selecting experimental methods, discusses macroscopic and microscopic pictures of deformation and explains uses of mechanical models. The merits of a large number of individual methods of rheological testing are also considered. G.W.S.B.

1393. Electroviscosity. III. Sedimentation Phenomena in Ionic Liquids.

G. A. H. ELTON. *Proc. Roy. Soc. A*, **197**, 568, 1949.

It is demonstrated that the rate of sedimentation of a system of particles in an ionic liquid may vary markedly with the ionic concentration, due to variation in the electroviscous forces which resist shear in the double layer of ions associated with each particle.

Equations governing the rate of sedimentation are derived, and used to calculate values for the electrokinetic potentials of carborundum in KCl solutions, from data on sedimentation velocity. These values are compared with those previously obtained from data on electro-endosmosis. SCI. ABSTR. (See Abstr. 1074, 1075).

1394. The Adhesion of Inorganic Bonds and the Plasticity and Thixotropy of Clay.

K. ENDELL AND U. HOFMANN. (*Angew. Chem., A*, **60**, 237, 1948).

Adhesion is developed when the contact between two surfaces is so intimate that it approximates to the conditions in the interior of the material, and to attain this it is usually necessary to employ a colloidal cementing substance. In the case of the green strength developed by clay-bonded foundry sands, and by ceramic mixes, a certain amount of water is necessary to spread the clay over the quartz grains, but an excess weakens the electrostatic attraction which is essential to the mechanism of adhesion, the clays with the highest base exchange capacity possessing the greatest bonding strength. The higher dry strength is produced when the evaporation of the water draws the particles closer together, and leaves them with a stronger cationic bond. The gelling of thixotropic clay suspensions is governed by the high surface energy of some acicular or lamellar particles, which enables them to form a loose but rigid structure when touching only at the corners. The main difference between organic and inorganic bonds lies in the comparative absence, in the latter, of the three layers normally recognized in the former, and of the effect of structural viscosity. B.C.R.A.

1395. Dislocations as a Cause of Mechanical Damping in Metals.

J. D. ESHELBY. *Proc. Roy. Soc. A*, **197**, 396, 1949.

Zener has shown how thermoelastic effects give rise to damping of the mechanical vibrations of a solid. In a vibrating single crystal of a metal an additional energy loss is observed which is usually attributed to the motion of dislocations. In the present paper the following mechanism is proposed. Dislocations are trapped in "potential troughs" at the minima of the internal stress in the crystal. When the crystal vibrates the dislocations oscillate in their potential troughs and the moving stress-system associated with them produces a fluctuating temp. distribution in the material; this leads to damping as in Zener's case. The rate of loss of energy produced by a dislocation oscillating with given amplitude is calculated and the effect of a collection of them is discussed. An actual estimate of the damping in a vibrating crystal requires (i) a knowledge of the relation between the amplitude of oscillation of a dislocation and the vibrational stress causing it to move, and (ii) a knowledge of the density of dislocations in the material. A tentative discussion of (i) is given. The quantity (ii) is unknown; however, it is shown that the damping depends only on the ratio of the number of dislocations per unit area to the number of potential troughs per unit area. If this ratio is calculated from the theoretical result and the observed damping in Cu single crystals, it is found to be ~ 1 . The present theory predicts that the damping should increase with frequency. This is in disagreement with the limited experimental data available. Two subsidiary effects are also investigated, the thermoelastic damping arising from the interaction between the vibrational stresses and the stresses surrounding stationary dislocations, and the damping due to the emission of elastic waves from an oscillating dislocation. Both these effects are shown to be small compared with the thermoelastic damping caused by moving dislocations. SCI. ABSTR.

1396. Uniformly Moving Dislocations.

J. D. ESHELBY. *Proc. Phys. Soc., Lond. A*, **62**, 307, 1949.

An expression is derived for the displacements in an isotropic elastic medium which contains an edge dislocation moving with uniform velocity c . When $c = 0$ the solution reduces to that given by Burgers for a stationary edge dislocation. The energy density in the medium becomes infinite as c approaches c_s , the velocity of shear waves in the med-

ium; this velocity therefore sets a limit beyond which the dislocation cannot be accelerated by applied stresses. The atomic structure of the medium is next partly taken into account, following the method already used by Peierls and Nabarro for the stationary dislocation. The solution found in this way differs from the one in which the atomic structure is neglected only within a region of width ζ which extends not more than a few atomic distances from the centre. ζ varies with c and vanishes when $c = c_r$, the velocity of Rayleigh waves. It becomes negative when $c_r < c < c_2$. Thus c_r rather than c_2 appears to be the limiting velocity when the atomic nature of the medium is taken into account. Since $c_r \simeq 0.9 c_2$ the difference is not of much importance. The same method applied to a screw dislocation gives, in the purely elastic case, the expression already derived by Frank. The corresponding Peierls-Nabarro calculation shows that the width ζ is proportional to $(1 - c^2/c_2^2)^{1/2}$. This "relativistic" behaviour is analogous to Frenkel and Kontorowa's results for their one-dimensional dislocation model. SCI. ABSTR.

1397. **Supercooled Sulphur and its Viscosity.**

R. FANELLI. *J. Amer. Chem. Soc.*, **67**, 1832, 1948.

Liquid S can be cooled in bulk to approximately 50° and in droplets to room temp. without it undergoing any essential change in nature from that in which it exists in the range 115-160°. Values of the viscosity from 50° to 155° are given and discussed; values below 80° have been extrapolated. SCI. ABSTR.

1398. **Anisotropic Plastic Flow.**

J. C. FISHER. *Trans. Amer. Soc. Mech. Engrs.*, **71**, 349, 1949.

The mathematical theory of plasticity has been generalized to apply to plastically anisotropic materials. The anisotropic flow theory has been shown to reduce to the resolved shear-stress/shear-strain relationship for single crystals, and to the distortion energy theory for isotropic polycrystals. Experimental data concerning the plastic flow of anisotropic polycrystalline Al indicate that the predictions of the anisotropic flow theory are in good agreement with experiment, and are significantly better than the predictions of the distortion energy theory. As plastic anisotropy is the rule rather than the exception, caution is indicated in interpreting the results of combined stress tests by means of the distortion energy theory. SCI. ABSTR. (See Abstr. 1009).

1399. **Slow-Motion Pictures of Impact Tests by Means of Photoelasticity.**

L. FOEPL. *J. Appl. Mech.* **16**, 173, 1949.

1400. **Computation of Traffic Stresses in a Simple Road Structure.**

L. FOX. *Road Research Technical Paper No. 9, R.R.L., D.S.I.R.*, 1948.

In this paper two methods are applied to the computation of stresses in two-layer systems. Both methods depend on the solution of the general equations of elasticity for axial symmetric systems, and do not apply to edge or corner loadings. The first method, due in principle to Professor Burmister, obtains explicit solutions in the form of integrals for the stress components at points on the vertical axis, which are evaluated by numerical quadrature. The second, the relaxation method of Professor Southwell, solves the differential equations, and hence obtains the stress components everywhere, by approximate numerical methods. The cases of perfectly rough and perfectly smooth interfaces are considered separately, and numerical results by the first method are given in both cases. Four examples of the relaxation method for a perfectly rough interface are included, and the paper ends with a discussion of possible application of the method to three layer systems. D.C.B.

1401. **Intrinsic Viscosity-Molecular Weight Relationships for Polyisobutylene.**
T. G. FOX AND P. J. FLORY. *J. Phys. Coll. Chem.*, **53**, 197, 1949.

Intrinsic viscosities of polyisobutylene fractions covering a wide mol. wt. range have been measured in cyclohexane, carbon tetrachloride, di-isobutylene, toluene, and benzene from -10° to 90°C .; they decrease regularly from the best to the poorest solvent for the polymer in the above order. The intrinsic viscosity in the poorest solvents, benzene and toluene, increases rapidly with temp.; in the other solvents only a low temp. coeff. is observed. Log-log plots of the intrinsic viscosity-mol. wt. in a given solvent at a particular temp. are approx. linear over a wide range. Results compared with recent theory indicate agreement with the postulate that the intrinsic viscosity reflects directly the effective volume of the molecule in dilute solution, the hydrodynamic factor expressing the interaction of the equivalent sphere with the solvent remaining very nearly constant except at low mol. wts.

SCI. ABSTR. (See Abstr. 1080).

1402. **On Slip Bands as a Consequence of the Dynamic Behaviour of Dislocations.**

F. C. FRANK. *Rep. Conf. "Strength of Solids"* (1947) (*Phys. Soc., Lond.*) **46**, 1948.

Considers the interaction of screw and edge dislocations with free boundaries and with each other at velocities approximating to that of sound. A possible mechanism which would account for the "seizing up" of slip on glide planes, as well as the fine structure of slip bands, is put forward and correlated with observed values.

SCI. ABSTR. (See Abstr. 1218).

1403. **Rheology and the Constitution of Matter.**

S. M. FREEMAN AND K. WEISSENBERG. *Proc. 1st Intern. Congr. Rheol. Scheveningen 1948 p. II*, 12. (*Publ. North Holland Publ. Co.*, 1949).

The materials studied in Rheology range from *coarse-grained*, in which a discontinuous structure is apparent, to the *fine-grained*, which appear continuous. The coarse-grained may be made to give combinations of mechanical properties not easily available in the fine grained, and because of the visible nature of their structure, their behaviour may help to elucidate the hidden structure of the apparently continuous materials. In comparing the behaviour of the various materials, particular attention has been paid to the powers of strain recovery in both shear and volume. Sponges and aggregates of fibres have been compared with certain sols and gels; both types show a large power of strain recovery and a close resemblance in those phenomena which depend upon shear properties. In other respects their properties diverge on account of differences in compressibility. These similarities and differences are illustrated by photographs of various materials under torsion.

V.G.W.H. (See Abstr. 1081, 1082).

1404. **A Law of Work-Hardening.**

A. M. FREUDENTHAL AND M. REINER. *J. Appl. Mech.* **15**, 265, 1948.

Based on the "blocking" theory of the strength of a polycrystalline metal, a law of work-hardening is derived and checked experimentally on mild steel deformed by wire-drawing up to a deformation of 4.6 in the logarithmic measure. The law correlates the recoverable strain work with the total work of deformation in a series of exponential functions, the number of which corresponds to the number of sizes of crystal grains present in the annealed state.

AUTHORS' ABSTRACT.

1405. **The Viscosities of Rotation Within a Liquid.**

P. GIRARD AND P. ABADIE. *Proc. 1st Intern. Congr. Rheol. Scheveningen 1948, p. II*, 83. (*Publ. North Holland Publ. Co.* 1949).

The experimental study of the dielectric relaxation of liquid media leads to the conclusion that the viscosity concerned in the rotation of molecules is the same as the familiar viscosity which we can measure (macroscopic viscosity) only in the case of very large and almost spherical molecules (large colloidal molecules.) With molecules of smaller volume

the viscosity involved in their rotation is entirely different (microscopic viscosity), notably in the law of variation with concentration. The physical mechanisms of the two viscosities are likewise different. In the case of molecules having the shape of an ellipsoid of revolution, two microscopic viscosities of rotation are distinguished, the one corresponding to oscillations of the ellipsoid about its axis, the other to oscillations of this axis itself. Thus with molecular rotations viscosity loses the meaning of an intrinsic property characteristic of a liquid, except in the case of very large and nearly spherical molecules. V.G.W.H.

1406. **The Mechanism of Thixotropic and Plastic Flow.**

C. F. GOODEVE. *Proc. 1st Intern. Congr. Rheol. Scheveningen, 1948, p. II 5.* (Publ. North Holland Publ. Co., 1949).

The theoretical treatment of non-Newtonian or thixotropic flow may start from one of two approaches. In the *solido* approach the stress applied to one plane generates a strain followed by a repetitive "relaxation" of the links which transmit the force from one plane to the other; thus there is a series of jumps resulting in creep. In the *fluido* approach, the flow generates a viscous resisting force, usually explained on the basis of transfer of momentum from one plane to the other. Both give a reasonable explanation of Newtonian flow. In the simpler examples of thixotropy (here defined as an isothermal reversible decrease of consistency with flow) there is also a component of the force independent of shear rate, thus

$$F = \eta_0 \sigma + \theta$$

where F is shearing force per unit area, σ is rate of shear and η_0 and θ are constants. This equation applies only to the steady state. In all known systems showing appreciable thixotropy the material is not molecularly homogeneous, and the thixotropic contribution rises rapidly with the concentration of suspended or dissolved phase. These facts are explained on the impulse theory which assumes links, capable of withstanding forces up to a critical value, which transmit impulses from the moving to the reference plane before breaking. This theory is developed and illustrated by mechanical models. The "coefficient of thixotropy," θ , though dimensionally the same as a yield point, is nevertheless distinct and corresponds to different rheological conditions. The theory can be extended to cover hysteresis phenomena. What little evidence on temperature coefficients of viscosity and thixotropy exists is in agreement with the theory. V.G.W.H.

1407. **The Flow Optical Properties of Visco-Elastic Media.**

V. R. GRAY. *Proc. 1st Intern. Congr. Rheol. Scheveningen, 1948, p. II, 23.* (Publ. North Holland Publ. Co. 1949).

The characteristics of flow birefringence in aluminium soap solutions (visco-elastic) are: (1) Initial birefringence, (2) Extinction angle not zero and increasing at low shears, (3) Increase of double refraction with shear, (4) Non-Newtonian viscosity. A liquid under steady laminar flow is considered as subject to a system of permanent stresses in much the same way as in a photoelastic solid. For a homogeneous liquid of spherical or anisometric molecules the optic axis is the principal axis of strain and also the principal axis of stress. For liquids with more than one component, the optic axis, principal axis of strain and principal axis of stress have in general different orientations relative to the streamlines. Certain limiting cases are often approached and are discussed. In most visco-elastic systems the stress and strain axes coincide with the optic axis, and the birefringence is made up of two parts: (1) due to orientation of particles, (2) due to deformation of the system of particles, molecules of liquid and network structure in the liquid. The double refraction in a fibrillar liquid subjected to uniform shear is analyzed mathematically, and a theoretical relation connecting extinction angle with shear is deduced. This relation is confirmed experimentally. The stress optical coefficient of some aluminium soap solutions is calculated. V.G.W.H.

1408. **The Kinetic Theory of Elasticity and Viscosity of Liquids.**

H. S. GREEN. *Proc. 1st Intern. Congr. Rheol. Scheveningen, p. I 12 1948. (Publ. North Holland Publ. Co. 1949).*

In the author's theory, elastic and viscous properties of fluids are related to the statistical configuration and motion of the constituent molecules. The stresses in a liquid are expressed in terms of the mutual potential energy of a pair of molecules, a radial distribution function defining molecular distances, and the temperature explicitly. Expressions for the rigidity modulus and viscosity coefficient are deduced, by considering the distortion of the molecular configuration due to the macroscopic deformation or motion of the fluid. An integral equation which it is necessary to solve in order to find the viscosity is derived.

J.G.O. (See Abstr. 741, 742, 1088, etc.).

1409. **Abrasion Tests on Diamonds.**

P. GRODZINSKI AND W. STERN. *Nature, 164, 193, 1949.*

Using a new micro-abrasion tester consisting of a 1 in. diameter (110° included angle) cast iron wheel of double conical shape provided with fine diamond powder, 0.2 micron size, and rotated at about 10,000 r.p.m., which is pressed against the diamond surface, well pronounced abrasion marks were obtained in a number of directions. Results of investigations on two different diamonds, one an alluvial and another a so called "glassy" octahedron with almost plane faces suggest that there are only 3 good grinding directions and a fourth very poor one.

The alluvial stone accepted an abrasion mark in two directions whereas the glassy stone could be abraided only in a single preferred direction.

E.W.J.M.

1410. **Some Aspects of Swelling.**

J. J. HERMANS. *Proc. 1st Intern. Congr. Rheol. Scheveningen 1948, p. II 179. (Publ. North Holland Publ. Co. 1949).*

In a long paper it is shown that thermodynamic relationships for swelling are much simplified if they are worked out in terms of forces and displacements instead of stresses and strains. Furthermore, certain mistakes that may be made, and conclusions drawn, by use of stresses and strains are discussed. It is also shown that for gels that may be anisotropic in their swelling tendencies, but which are isotropic in their response to small stresses, orientation of structural elements is a function of the coordinates of the elements and that under certain conditions this orientation is unaffected by swelling and de-swelling processes. In an addendum it is shown that these conclusions apply also to gels that are anisotropic in their response to stresses as well as swelling.

A.H.N.

(See Abstr. 872-874).

1411. **Rheology in Industry.**

R. HOUWINK. *Proc. 1st Intern. Congr. Rheol., Scheveningen, 1948, p. I, 111. (Publ. North Holland Publ. Co., 1949).*

In spite of complexity of rheological behaviour of many industrial systems, an attempt is made to relate phenomena encountered to simple concepts of viscosity and yield-value. Clay has the advantage over plastics and glass that its viscosity-temp. coefficient is low. Its 'body' is controlled by differences in moisture. A comparison is made between behaviour of chain-molecule substances and thermo-plastics with globular molecules. Rheology of thermo-setting plastics and of rubbers is discussed. Thixotropy of paints is considered in relation to quality.

G.W.S.B.

1412. **An Improved Viscometer.**

H. R. JACOBS. *Rev. Sci. Instrum., 19, 816, 1948.*

The instrument is of the tube type and consists of two reservoirs connected by a horizontal capillary tube and associated devices, which drive the liquid through the capillary from one reservoir into the other.

B.C.R.A.

1413. Recrystallization of Relaxed Animal Fibres.

L. JAGGER AND J. B. SPEAKMAN. *Nature*, **164**, 190, 1949.

Craftsmen of a more leisurely age used to insist on allowing wool textile materials periods of rest between processes at all stages of manufacture. The authors explain the beneficial effects of the ageing process on the basis of relaxation due to the slow unfolding of the grids of α keratin in the crystalline regions, accompanied by refolding of the grids in the amorphous regions which are the first to be stretched during rapid extension.

Rearrangement of the disorganized structure is accompanied by re-strengthening; this occurs extremely slowly in water at low temperatures but it can be accelerated by raising the temperature (maximum recovery temperature 70°C.). E.W.J.M.

1414. Quelques Propriétés de l'Énergie d'Activation d'Écoulement Visqueux des Couches Monomoléculaires et leur Interprétation Structurale.

MAURICE JOLY. *Proc. 1st Intern. Congr. Rheol. Scheveningen*, 1948, p. II, 35. (*Publ. North Holland Publ. Co.*, 1949).

The viscosity of monomolecular layers may be measured by adapting existing methods to two-dimensional systems. The method of capillary flow gives very precise results, even with very fluid layers. There is no slipping between the layer and its support, but the viscosity of the support in the immediate neighbourhood of the interface has been up to the present in doubt. The author has derived equations governing the laminar flow of a monomolecular layer in a canal; this cannot be integrated exactly, but an approximate solution is well supported experimentally. Eyring and Moore have derived an expression from which the activation energy of viscous flow may be calculated from measured values of the superficial viscosity and molecular area. The measured superficial viscosity corresponds to the combined viscosity of the organic monomolecular layer and the topmost layer of water molecules, therefore the activation energy of viscous flow of the surface film is the sum of the activation energies of the layer proper and of the water immediately adjacent. From this the true viscosity of the layer can be calculated. These true viscosities are much lower than is usually thought and are, moreover, often smaller than those for the same substances in the three dimensional state. The experimental values of activation energy of flow plotted as a function of molecular area can be well represented by broken lines, such breaks showing the beginning or end of a molecular transition. At these critical points the layer consists of a single type of molecule; between them, the layer consists of a mixture of two molecular shapes. Although a molecule has no permanent shape, it has nevertheless a sort of "mean shape" representing the statistical mean of the possible configurations for a given set of conditions. These "mean shapes" may be calculated from the experimental data and are illustrated in the text for a number of aliphatic compounds. V.G.W.H. (See Abstr. 782).

1415. Measurement of the Internal Friction of Solids.

R. KAMEL. *Phys. Rev.*, **75**, 1606, 1949.

For steel, zinc, lead, glass, brass, and tin the existence of a frequency corresponding to a maximum value for the internal friction is regarded as confirmation of Zener's theory which attributes the internal friction in polycrystalline solids primarily to thermal currents.

R.S.

1416. The Possibility of Bonding and Orientation of Molecules of a Liquid on solid. Epitaxy between Kaolinite and Water.

C. KIEFER. *C.R. Acad. Sci., Paris*, **226**, 1602, 1948.

Polarity of the liquid medium is necessary, but not in itself sufficient to ensure that a suspension of clay will remain stable. The presence of the hydroxyl group increases the stability. No liquid has equal power to that of water in keeping the clay slip deflocculated.

The fitting of the hexagonal structure of water on the monoclinic structure of kaolinite is discussed. Something akin to a surface condensation of the water on kaolinite is postulated. This concept is considered to offer an explanation of thixotropy and plasticity. B.C.R.A.

1417. Hydrodynamic Properties of Randomly Coiled Long Chain Molecules as Determined by Experiments on Large Scale Models.

HANS KUHN. *Proc. 1st Intern. Congr. Rheol. Scheveningen 1948, p. II, 44 (Publ. North Holland Publ. Co. 1949).*

Long chain molecules can be assumed to have the shape of a "statistical coil." The amount of drainage of solvent through such a coil may vary between the limits of completely hampered flow and free draining; and theoretical treatment of the degree of immobilization to be expected in any case is very difficult. An approximation may be obtained by experiments on macroscopic models. The method of calculating the exterior dimensions of a randomly coiled molecule is outlined. On the basis of these dimensions large scale models have been constructed out of wire. Experiments on the frictional force produced by the translational motion of such models through a viscous liquid have led to a relation connecting the translational resistance with the viscosity of liquid, the velocity and the parameters that characterize the shape of the coil. From this equation expressions for the sedimentation constant and diffusion constant may be derived, and by the introduction of experimental values into these the length and diameter of a statistical element in the chain may be computed. Figures obtained for cellulose acetate in acetone show satisfactory agreement between the "hydrodynamic" and "true" thickness of an element as derived from molecular structure data. The translational resistance of a random coil is compared with that of an equally large sphere and the results are expressed graphically for various numbers and dimensions of the statistical elements. The frictional resistance of a random coil in the process of rotation round its centre of gravity has also been studied by experiments on large scale models and this resistance, compared with that of an equally large compact sphere, is also expressed graphically for various numbers and dimensions of the statistical elements. It is concluded that the solvent inside the coil is more immobilized in a translational than in a rotational motion. Two approximations of the intrinsic viscosity (η_{sp}/c) are derived and plotted against the degree of polymerisation, the curves so obtained agreeing with measurements of intrinsic viscosity by Staudinger and Daumiller. The author appends a note on the bearing of recent work by Debye and Bueche, and by Kirkwood and Riseman, on these results. V.G.W.H.

1418. Rigidity of Thread Molecules and its Determination from the Viscosity and Streaming Double Refraction of Dilute Solutions.

W. KUHN AND H. KUHN. *Chimia*, **2**, 173, 1948.

The configuration of thread molecules in solutions, at rest and moving, is considered. The dependence of the optical anisotropy of thread molecules on the statistical distance between the head and the tail of the thread is pointed out, and the variation of streaming double refraction and viscosity with the streaming gradient is calculated for thread molecules with different internal viscosities. SCI. ABSTR.

1419. On the Influence of Plastic Deformation on the Elastic Modulus.

P. LAURENT AND M. EUDIER. *C.R. Acad. Sci., Paris*, **220**, 225, 1949.

Quotes the observed change of elastic modulus of an Al-Cu alloy with time of plastic deformation, the value of the modulus falling initially and then increasing after $\sim 0.20\%$ extension. Suggested that the decrease is connected with the plastic flow mechanism, and the increase with a modification of the metal texture. SCI. ABSTR.

1420. On the Comparison of Flow and Relaxation.

L. LAURENT AND M. EUDIER. *C.R. Acad. Sci., Paris*, **227**, 259, 1948.

Considers experimental results with an Al-Cu alloy in relation to results derived theoretically from a development of the flow-relaxation method of Boltzmann. The resulting equation is applied by 3 separate procedures, yielding 3 theoretical curves of rate of flow against rate of relaxation. These are discussed, as is the implication in the theory that an "equation of state" can be formulated. SCI. ABSTR.

1421. The Behaviour of Powders under the Influence of Pressure.

R. LECUIR. *Industr. Ceram.*, Nos. 389-390, 177, 1948.

In dry-pressing, to obtain uniform products it is not sufficient to standardize only the compressive force and the weight of powder; it is also essential to fill the mould uniformly and to bring the plunger down at the same speed every time. The results of some experiments indicate that a laminated structure may be produced in powders the grains of which can be broken down progressively under increasing pressures. This is considered to be attributable to a bridging effect. After the bridges have been broken, a further increase in pressure will cause the particles to slide over each other. Gas becomes trapped between the laminae and, when the pressure is later released, this trapped gas expands and forces the laminae apart. B.C.R.A.

1422. On the Determination of Corrections in Measurements of Viscosity.

E. L. LEDERER. *Schweiz. Arch. angew. Wiss. Tech.*, **14**, 372, 1948.

An expression is derived which gives the correction to viscosity measurements when the temp. of the liquid differs by a known amount from any of four standard temp. (0, 20, 50, 100°C). Tables are supplemented by a nomogram rendering any reference to the standard temp. unnecessary. SCI. ABSTR.

1423. Effect of Size and Shape of Specimen on the Tensile Strength of Fiberboards.

W. C. LEWIS. *U.S. Dep. Agric., For. Service, For. Prod. Lab.* R1716, 1948.

Tension-parallel-to-surface tests were made on six different building boards using four specimens of different shapes for each board to obtain a comparison of results of test for the different specimens with the intent of arriving at a recommended standard specimen for this strength property. One type of specimen had a uniform cross-section, as required by Federal Specification, and the other three types were "necked down" specimens. One conformed to the Amer. Soc. Test. Mat. Tentative Stand. C209-46T, and the other two types were variations of the A.S.T.M. Standard. These tests showed that, in general, the strength values obtained from the specimens of uniform section were lower than the values obtained from the other types of specimens because concentrations of stress or crushing at the grippers caused most of the failures to occur in the area adjacent to the grippers. The strength values obtained from the other types of test specimen were essentially the same, indicating that the most satisfactory specimen would be the one with the largest area in tension consistent with good testing techniques and limited by commercially available testing equipment. Therefore the specimen recommended, a variation of the present A.S.T.M. standard, is 10in. long 2in. wide at the grippers, and has a reduced centre section 1½in. wide and 2in. long. Since it is only 2in. wide, it has the advantage of being adaptable to test with standard self-aligning grippers commonly available in this width. Self-aligning grippers 3in. wide, as required in the A.S.T.M. Tentative Stand. C209-46T, are considered special and can be obtained only at high cost. The 2in. wide specimen is recommended for adoption as a standard for evaluating the tensile strength of building boards. P.A.T.R.A.

1425. Flow Properties of Asphalt Emulsions

D. V. LYTTLETON AND R. N. TRAXLER. *Ind. & Eng. Chem.*, **40**, 2115, 1948.

Evidence is given that the rate of shear versus absolute consistency of asphalt emulsions is a straight-line relationship when plotted on log-log coordinates. For over thirty different emulsions studied, each fell into one of three categories—namely—“Plastic flow,” “inverted plastic flow” and “Newtonian flow”—given in order of decreasing frequency of appearance of each type. Data obtained confirm previous indications that asphalt emulsions have low susceptibility to consistency change with change of temperature. Effects of centrifuging on consistency of emulsions of various types are discussed. D.C.B.

1426. An Investigation into the Working Principles of the B.S. Vibration Machine for Consolidating Cement Cubes

G. B. MITRA. *J. Sci. Inst. Res.* **7**, 102, 1948.

(Refers to B.S.S. 12-1940). Shows that the C.G. of the mould describes a circle whose centre is subject to an elliptic motion, and is not fixed as assumed by the Standard. Also that the amplitude is dependent on the tension of the belting and stiffness of the springs, these factors not being specified by B.S.S. 12. P.H.

1427. A Theory of Viscous Deformation in Polymers, the Volume and Surface Cohesional Energy of the Basic Moving Aggregate.

D. R. MOREY. *J. Phys. Coll. Chem.*, **53**, 569, 1949.

An analysis of viscous flow based on the dynamics of particle bonding and movement leads to the following expression for the viscosity :

$$\eta = \frac{B}{V^{0.2/3} T^{2.3} e} V^{2/3} (4.8 \times 10^{24} Z - 1.9 \times 10^8 S) / RT$$

The choice of exponents depends on the range of internal force fields. T is temp.; V is the average volume in cm^3 of the material which flows as a unit in deformation; Z is a surface-energy factor measuring the intensity of secondary bond development per cm^2 of surface of the flow unit; and S is the applied tensile stress in dynes/ cm^2 . In addition to this basic form, it is necessary, in order to characterize viscosity completely, to recognize the existence of the functions; $V = f(T, S)$, $Z = G(T, S)$. The non-Newtonian character of viscosity is accounted for, and is intimately connected with the size of the flow unit. For polyvinyl acetate film, it is shown that V decreases with increasing temp. but that Z may, under certain non-plasticized conditions, actually be increased by a temp. rise. This accounts for the interesting behaviour observed on dry polyvinyl acetate where the activation energy of flow increases rather than decreases with increasing temp. A device is illustrated which automatically keeps the stress constant over deformations up to 50%. From the curves of viscosity v . stress, values are calculated for the volume of the flow unit for dry polyvinyl acetate, using the formula :

$$V^{2/3} = \frac{2.3RT \log \eta_1 / \eta_2}{1.9 \times 10^8 (S_2 - S_1)}$$

where S is the tensile stress in dynes.

SCI. ABSTR. (See Abstr. 1132).

1428. Dislocation Theory and Transient Creep.

N. F. MOTT AND F. R. N. NABARRO. *Rep. Conf. "Strength of Solids"* (1947) (*Phys. Soc., Lond.*) **1**, 1948.

Surveys the modern concept of dislocations and discusses the interpretation of creep in terms of their motion in a stress field. A consideration of the flexibility of dislocations from the standpoint of their elastic energy leads to an expression for the tension existing in them, and to the conclusion that they will approximate to smooth rather than to “square” curves. Their radius of curvature, ρ , is deduced to be equal to $\mu a / \sigma_i$, where μ is the shear modulus, a the interatomic distance, and σ_i the internal shear stress. The cases where, Δ the spacing of particles of precipitate, is $\geq$ or $< \rho$ are each discussed, the

equality suggesting the "critical dispersion" of former theories. The case where $\Lambda \gg \mu a/\sigma_i$ yields an order of magnitude of potential barrier of $\sigma_i a \Lambda^2/\pi$, which $\simeq 1,000$ eV using possible values. The activation energy when σ_i is nearly equal to the applied stress is derived. A theory of transient creep is developed where the Becker-Orowan formula is replaced by an expression for the chance per unit time of a loop of dislocation jumping forward, $a = v \exp [-U(\sigma)/kT]$ where v is the frequency of vibration of the dislocation in its potential trough, U the activation energy. From consideration of increase of strain due to a loop movement, creep rates for certain models are calculated. If all loops have same σ_i , the yield strength at room temp. is deduced to differ by a few % only from that at the absolute zero. The large observed temp. dependence is discussed. Another model based on the assumption that a range of σ_i values exists (a distribution function giving the number of loops per unit volume moving under the stress range σ_i to $\sigma_i + d\sigma_i$) leads to an expression:—extension equals const. $T^{2/3}(\ln vt)^{1/3}$, where t is time. The characteristics of this formula are examined in terms of the distribution function. The other case, when $\Lambda \ll \mu a/\sigma_i$ (i.e., in solid solutions), gives an expression for the yield strength, agreeing well with experiment, of approximately $\mu \epsilon^2 f$, where ϵ = misfit of foreign atom in the lattice, and f is the atomic concentration of the solid solute, ϵ being estimated from $(1/a)(da/df)$.

SCI. ABSTR.

1429. The Delayed Elastic Effect in Glass Fibres and the Constitution of Glass in Fibre Form.

J. B. MURGATROYD. *J. Soc. Glass Technol. (Trans.)*, **32**, 291, 1948.

The evidence produced by several investigators has shown that massive glass most probably has a constitution similar to that of a liquid. Such a system contains numerous weak bonds due to the distortion of the atomic structure, and some regions of weak bonds in glass are capable of viscous yield at room temperature. This explains the "delayed elastic effect" observed in glasses. Since glass fibres are drawn from glass at high temperature and are cooled very rapidly it is to be expected that they contain a greater proportion of bonds due to the greater fluidity of glass at high temperature. The system is frozen before it can reach its room-temperature equilibrium. Hence fibres should exhibit a greater delayed elastic effect than the massive glass from which they are drawn, and experiments are reported which prove this to be true. The delayed elastic effect increases as the fibre diameter is reduced, being five to six times that in the massive glass when the fibres have a diameter approximately 0.002 cm. The present work confirms earlier experiments, which showed that the elastic properties of glass fibres are smaller in value than those of massive glass. The increased strength of the fibres is due to the orientation of the weak bonds normal to their axis, it being shown that the method of drawing glass fibres must produce such an orientation. The conclusion is reached that the low strength of massive glass is due to the numerous weak bonds it contains, and there is therefore no necessity to suppose that glass contains "Griffith cracks." B.C.R.A. (See Abstr. 797, 798).

1430. The Viscosity Anomaly Causing the Spinning of Liquids. Stress—Flow Curves of Liquid Threads.

H. NITSCHMANN. *Proc. 1st. Intern. Congr. Rheol. Scheveningen*, 1948, p. II, 32. (Publ. North Holland Publ. Co. 1949).

The spinning properties of certain fluids are stated to be caused by a viscosity anomaly consisting of an increase in flow resistance with increasing rate of stress. This anomaly does not occur in the usual viscometers in which the particles are forced to rotate continuously. A "spin balance" is described in which a liquid thread is pulled from a capillary outlet at variable speed and the stress applied to the thread is measured simultaneously. The viscosity under these conditions is calculated from Trouton's equation. Results for a 25% solution of nitrocellulose in a high boiling solvent and for chlorinated diphenyl show the expected anomaly, and the results of measurement in the "spin balance" and in an ordinary viscometer are distinctly different.

V.G.W.H.

1431. **A Suggested Method of Detecting Wall-Effects in Turbulent Flow Through Tubes.**

J. G. OLDROYD. *Proc. 1st Intern. Congr. Rheol. Scheveningen, 1948, p. II, 130. (Publ. North Holland Publ. Co. 1949).*

Certain results by Toms on the high rates of flow of polymer solutions (see Abstr. 1456) are explained on the hypothesis that a turbulent regime exists with a wall effect akin to the σ -phenomenon. The Reynolds number is calculated on the basis of taking the viscosity at the highest rate of shear—i.e., at the wall—to characterise the viscosity of the fluid. It is suggested that one effect of the slip at the wall is to produce, sometimes, conditions where the addition of a solute results in an *increased* rate of flow for standard pressure gradients. This phenomenon has been observed by Toms. A.H.N.

1432. **Flow Through a Pipe with a Porous Wall.**

F. C. W. OLSON. *J. Appl. Mech.* **16**, 53, 1949.

Flow through a pipe with a porous wall is more tractable mathematically than the more practical case of flow through a pipe with uniformly spaced orifices. The differential equations for the pressure and rate of flow are solved. J.G.O.

1433. **Accurate Measurement of Viscosity in Small Amounts of Liquid.**

J. T. G. OVERBEEK AND C. L. J. VINK. *Chem. Weekbl.* **45**, 494, 1949.

An Ostwald type of viscometer is used for viscosity measurements in 5 ml of liquid or less. Duplicability is better than 0.1%. There are, however, systematic discrepancies with other determinations. These discrepancies may be caused by surface tension and draining. P.G.M.

1434. **Theory of Viscosity of Colloids: Influence of Solvent on Intrinsic Viscosity.**

W. PHILIPPOFF. *Z. Naturforsch.* **3b**, 151, 1948.

The effect of solvent and of temperature on the value of $[\eta]$ is examined for two models: (1) rigid ellipsoids, (2) coiling chains. The first model is unsuccessful, but the observations can be interpreted in terms of the second model, in which the extent of coiling of the long-chain molecules is represented by the number of monomer units per link. SCI. ABSTR.

1435. **Viscosity Blending Relationship of Heavy Petroleum Oils.**

M. H. RAHMES AND W. L. NELSON. *Anal. Chem.* **20**, 912, 1948.

A total of 30 petroleum oil systems, using 17 different oils, were investigated. Each system was investigated at three or more compositions. The results were compared with viscosities predicted by a number of methods that have been proposed in the literature. The Wright method, a new way of using the A.S.T.M. chart for predicting blend viscosities, was found to give the best results in most cases. Many of the systems investigated were rather extreme, in that the component oils varied considerably in chemical nature. Two of these systems were found to exhibit definite viscosity minima. It was concluded that the use of viscosity-temperature characteristics of the component oils, as in the Wright method, is a definite improvement in viscosity prediction methods. However, sometimes differences in oils are not indicated by these relationships, but do affect blend viscosities to a considerable extent. D.C.B.

1436. **Relation between Stress and Strain in Complicated Systems.**

M. REINER. *Proc. 1st Intern. Congr. Rheol. Scheveningen, p. IV, 44, 1948. (Publ. North Holland Publ. Co. 1949).*

Materials may deviate from the classical laws of elasticity, plasticity or viscosity because the coefficients in the idealized stress, strain relations are not strictly constants. More generally, the properties of materials will be combinations of elasticity, plasticity

and viscosity which might be represented symbolically by a model of elastic springs and viscous dashpots coupled in series and parallel. A concise notation for complicated models is introduced, and several possible combinations are enumerated. The possibility of volume flow (plastic or viscous) as well as shear flow is emphasized. Dilatancy, finite strain and cross-elasticity are further complications of which rheological theory must take account. J.G.O.

1437. Effect of Air Entraining and Dispersion Promoting Agents on the Mechanical Properties and the Mixing of Cement and Concrete.

A. RIO. *Il Cemento*, **45**, 50, 1948.

Discusses the use of commercial agents (mostly U.S.): the action is claimed to be through electrostatic charge effects, and the result is a reduction in the water needed to produce a workable consistency. Strength therefore increases, and workability is also improved. Air entrainment must not exceed 6% to obtain benefit in mechanical properties. P.H.

1438. Large Elastic Deformations of Isotropic Materials. V. The Problem of Flexure.

R. S. RIVLIN. *Proc. Roy. Soc. A*, **195**, 463, 1948.

A cuboid of highly elastic incompressible material, whose stored-energy function is W , is bent so that: (i) every plane, initially normal to the x -axis, becomes part of the curved surface of a cylinder whose axis is the z -axis; (ii) every plane, initially normal to the y -axis, becomes a plane containing the z -axis; (iii) there is no displacement parallel to the z -axis. Such a state of flexure may be maintained by surface tractions only. These are calculated. It is then assumed that W is of the form suggested by Mooney for rubber. For this case the flexure can be maintained without the application of surface tractions to the curved surface, provided a certain condition is satisfied. SCI. ABSTR.

1439. The Hydrodynamics of Non-Newtonian Fluids. II.

R. S. RIVLIN. *Proc. Camb. Phil. Soc.*, **45**, 88, 1949.

The theory of a previous paper (Abstr. 1117) is applied to the problem of the flow through a tube of circular cross-section. Abs. values of the normal stress components are not uniform over a cross-section of the tube, but the pressure difference between points at equal radii on 2 such cross-sections is independent of the positions of the points. SCI. ABSTR.

1440. A Theory of Elasticity Applicable to Disproportionate Structural Changes.

P. M. RIZ. *Dokl. Akad. Nauk, U.S.S.R.*, **59** 223, 1948.

Discusses the proportionate equiponderant conditions within a field conditionally denominated as plastic. Elastic processes, however, involving drastic modifications of elastic characteristics are taken into consideration. It is emphasized that the theory is static only and does not cover the dynamics of plastic conditions. SCI. ABSTR.

1441. Propriétés Rhéologiques de Quelques Ensembles Naturels.

V. ROMANOVSKY. *Proc. 1st Intern. Congr. Rheol. Scheveningen*, 1948, p. II, 173. (Publ. North Holland Publ. Co., 1949).

A "rigidity meter" consisting of a cylinder suspended on a steel wire is described. The strain produced in a system by subjecting the wire to a twist is studied against time and stress as the independent variable. Artificially produced systems—e.g., agar agar, bentonite, quartz and limestone powders—are studied first and used as standards of comparison for the behaviour of natural marine mud consisting of 15% sand suspension in water. The presence of air is found to have a definite influence on the elastic behaviour of the mud which exhibits a distinct yield value. A.H.N. (See Abstr. 725, 909).

1442. Viscosity of Dilute Macromolecular Solutions.

C. SADRON. *Proc. 1st Intern. Congr. Rheol. Scheveningen, 1948, p. I, 62.* (Publ. North Holland Publ. Co., 1949).

The macromolecular region lies between that of molecules and of gross suspended particles. The effect of size, size-distribution, shape and concentration of macroscopic particles on viscosity of solutions is discussed, especially following the work of Einstein, Burgers and Simha. Experimental verifications are sought from work on plant viruses. The intrinsic viscosity of solutions of molecular chains is considered, particularly in relation to degree of polymerisation.

G.W.S.B.

1443. New Method for the Determination of Tackiness.

E. SCHMIDT. *J. Rubber Res., 17, 195, 1948.*

The rubber mixture to be examined is calendered on a fine cotton fabric, a disc of this is placed on a flat elastic support, a strip of the same material is placed tightly around a cylindrical pendulum hammer, and the latter is set in motion. The recoil elasticity and the number of pendulum beats give a measure of the tackiness when compared with values obtained after coating with benzene or by the hammer without any rubberized fabric test strip. Tabular and graphical data show typical results under various conditions and with different elastomers.

P.A.T.R.A.

1444. Critical Reynolds' Numbers of Solutions of Large Molecules.

R. SCHNURMANN. *Proc. 1st Intern. Congr. Rheol. Scheveningen, 1948, p. II, 142.* (Publ. North Holland Publ. Co. 1949).

Experiments on high rates of shear obtaining in a jet viscometer show that the kinetic energy correction obtaining is less than that encountered with long tubes. The critical Reynolds' number for onset of turbulence appears to decrease with an increase in the molecular weight or length and the concentration of the solute in solutions of macromolecules. Evidence is further adduced that certain oils—e.g., castor oil—show temporary decrease in viscosity with very high rates of shear.

A.H.N.

1445. Psychophysical Aspects of Rheology.

G. W. SCOTT BLAIR. *Proc. 1st Intern. Congr. Rheol. Scheveningen, 1948, p. I, 95.* (Publ. North Holland Publ. Co. 1949).

A subjective judgment of rheological behaviour is difficult to analyse into specific properties. The combinations of properties which are observed subjectively may be more easily described in symbols if the operation of *fractional* differentiation with respect to time is introduced; for example, applied to strain when the strain and ordinary rate of strain do not suffice to describe what is observed in a simple way. Such a concept has already been found convenient in generalizing Nutting's equation for purely objective observations. In both fields (psychophysics and physics) it is found that physical behaviour must often be characterized by a group of several magnitudes (the members of which are insignificant except in combination) in order that materials which differ widely in behaviour may be compared.

J.G.O.

1446. Constant Stress Measurements of the Hardening of Soft Materials.

G. W. SCOTT BLAIR AND M. BARON. *Nature, 164, 148, 1949.*

The deceleration of rate of indentation of samples of cheese by a sphere at constant stress had been measured by using a machine in which a weight drawn at a steady rate along a beam, progressively increases the load on the indenting sphere with the arrangement that the rate of increase of load eventually just compensates for the increase in area of contact between sphere and material, so that the stress remains virtually constant for any batch of samples of comparable hardness.

E.W.J.M.

1447. The Description of Behaviour of Physical Properties.

G. W. SCOTT BLAIR. *J. Amer. Chem. Soc.*, **71**, 2950, 1949 (letter).

It is pointed out that the introduction of the "Reduced Parachor" by Telang (ibid. pp. 1883, 1898) corresponds to the use of Quasi-Properties in Rheology.

G.W.S.B.

1448. The Rheology of Cheese-Making.

G. W. SCOTT BLAIR AND M. BARON. *Proc. 12th Intern. Dairy Congr., Stockholm*, **2**, 49, 1949.

An account of work carried out at the (British) National Institute for Research in Dairying, 1938-1948.

G.W.S.B.

1449. Effect of Shape and Interaction on the Viscosity of Dilute Solutions of Large Molecules.

R. SIMHA. *Proc. 1st Intern. Congr. Rheol. Scheveningen*, 1948, p. II, 68. (*Publ. North Holland Publ. Co.* 1949).

The theory of intrinsic viscosity of rod-like molecules at vanishing shear rate as developed by Jeffery and others is outlined, and the results for not very asymmetric particles are tabulated numerically. For very asymmetric particles, an exponential equation is approximately valid. The theory is used to calculate molecular dimensions from viscosity measurements, which are compared with dimensions found by other means. The axial ratios of a number of globular proteins are given and Lauffer's data on the molecular shape of tobacco virus particles are quoted. The effect of increasing concentration on the viscosity of solutions and the complications arising from interaction affects in streaming solutions are discussed.

V.G.W.H.

1450. Effect of Concentration on the Viscosity of Dilute Solutions.

R. SIMHA. *J. Res. Nat. Bur. Stand., Wash.*, **42**, 409, 1949.

A theory of the higher coefficients of the viscosity-concentration curve of a suspension of non-spherical particles is presented. Starting with the simple model of a dumb-bell, the flow around a single particle and its modification due to interaction with other particles are considered. It is shown that the coefficients a_i in the equation $\eta = \eta_0 (1 + a_1c + a_2c^2 + a_3c^3 + \dots)$ are related to each other, namely, $a_2 = k_1a_1^2$, $a_3 = k_2a_1^3$, ..., where the k 's are independent of molecular size, in agreement with empirical equations. An explicit value for k_1 is obtained that applies also to models consisting of various arrays of spheres. The variation of k_1 with molecular shape is discussed, and various factors affecting the numerical values and the validity of the last-mentioned equation are pointed out.

SCI. ABSTR.

1451. Ink Flow on Rotating Rollers.

L. H. SJODAHL. *Mod. Lithography*, **17**, 85, 1949.

An analysis is made of the manner in which ink is transferred from roller to roller, from rollers to plate, to blanket, and to paper on a press. The most important flow takes place within the nip, or band of contact. Diagrams are presented to show the motion of the ink within and following the nip, the pressure distribution, and the velocity distribution. Filamentation, or the formation of filaments of ink, as the rollers separate, is an important factor. High-speed photographs are included, which show these filaments as they are formed on the Inkometer. Although viscosity and yield value are of primary importance, their determination by low-speed, constant-pressure instruments is believed to be inadequate. Finely dispersed air within the ink film and unrelaxed elastic forces are proposed as an explanation of the discrepancy between press results and viscosity measurements. The air expands greatly in the region of low pressure, and the shear does not take place in the direction of the applied force. In the light of this analysis, the advantages and disadvantages of the Inkometer are discussed. In spite of its limitations, it may be that the Inkometer is the only instrument which measures the complicated combination of forces affecting ink flow on a press.

P.A.T.R.A.

1452. A Study of the Geotechnical Properties of Some Post-glacial Clays.

A. W. SKEMPTON. *Géotechnique*, 1, No. 1, 7, 1948.

Considerations based on the properties and geological history of several post-glacial clays lead to the following tentative conclusions. (1) It appears that Casagrande's method of estimating pre-consolidation loads is at least approximately correct for these clays. (2) Assuming the validity of this method it is found that, in the clays considered in the present paper, shear strength (as measured in the unconfined compression test) increases with increasing consolidation pressure in the ground, although in some of the cases this does not imply that the strength increases with depth. (3) All the clays possess considerable internal friction. In the American clays, which appear to be colloiddally inactive, the great majority of the strength is composed of internal friction, whereas in the English clays about 50% of the strength is contributed by cohesion. The foregoing conclusions are not intended as general statements valid for a wide range of clays. However, the principles used in this study, and the results obtained, may prove helpful in further research on the properties of clay strata. (4) In addition, it is shown from general considerations that in all cases the $\phi=0$ analysis will give reasonably correct estimates of earth pressure, bearing capacity and slope stability in homogeneous saturated clays, provided the analysis is applied to conditions in which water content changes in the clay are negligible. The success of this analysis is entirely independent of whether strength is constant with depth or increases; and can lead to no conclusion other than the fact that the condition of no water content change held good in the case under consideration.

B.C.R.A.

(See Abstr. 979, 1024).

1453. Some Developments in Industrial Viscometry.

L. A. STEINER, *Chem. Age*, 60, 638, 1949.

Materials, such as mineral oils, bituminous materials, paints, etc. are now being controlled on an increasing scale by viscometric methods. With these materials past experience has shown that a certain grade is satisfactory for a certain application and viscosity was then measured with the view of forming the basis of control of production. On the other hand materials which have been developed recently, such as synthetic resins, waxes, fibres, polymers etc., are, of necessity, compared with the ones already on the market, and again the measurement of viscosity is a valuable guide for the assessment of possible applications.

In comparison with chemical methods, the viscometric method has the advantage of leaving the material in its original state and so available for other tests. In any case, for many industrial materials a very small variation in the chemical composition may cause a very large variation in viscosity, and experience has shown that where viscosity is significant, the most efficient method of analysis is the direct measurement of viscosity.

Viscosity has such a wide field of application that no single instrument can hope to be applicable to all purposes and the actual choice of the most efficient instrument will invariably depend on the conditions prevailing, but in this article four types which are commercially available are discussed in order to facilitate selection.

D.C.B.

1454. On a Molecular Theory of Viscosity of Solutions with Small Molecules.

H. A. STUART. *Z. Naturforsch.*, 3a, 196, 1948.

A molecular theory of the internal friction of solutions has been developed for the purpose of giving a better explanation of the specific viscosity η_{sp} of diluted solutions. η_{sp} is defined by means of the "mutual action viscosity" η_{12} which consists of 2 factors one of which contains the local density, while the other measures the intensity of the momentum exchange between the solute and solvent molecules. The negative viscosity values and their occasional increase with temp. are completely inexplicable in the light of thermodynamical theory, whereas the molecular theory gives an easy explanation. The paper furnishes a method for examining the molecular structure of liquids and solutions, since it becomes possible to study the different possibilities of association by measuring

the change in specific viscosity with temp. and concentration. The molecular model has also been adapted for solutions containing thread-like molecules.

SCI. ABSTR. (See Abstr. 1318).

1455. Application of Similarity to Anelasticity.

M. W. THRING. *Nature*, **163**, 772, 1949.

According to Kê the internal friction and the relaxation of rigidity of very pure aluminium are expressible as functions of a single parameter consisting of the product of the grain size (D), the absolute temperature (T), the frequency of vibration (f), and a dimensionless Boltzmann term, i.e.

$$D.f. \exp(H/RT).$$

The product D.f. is not dimensionless and Kê's parameter is unsuitable for determining identical functional relationships in the anelastic properties of different metals. A dimensionless parameter :—

$$\frac{D.f}{G.d/v_0} \exp(H/RT)$$

is suggested, in which d is the thickness of the intercrystalline grain-boundary layer, $v = v_0 \exp(-H/RT)$ is the effective grain-boundary viscosity, and G is the geometric mean of the relaxed and unrelaxed rigidity moduli. P.F. (See Abstr. 1184).

1456. Some Observations on the Flow of Linear Polymer Solutions Through Straight Tubes at Large Reynolds Numbers.

B. A. TOMS. *Proc. 1st Intern. Congr. Rheol. Scheveningen*, 1948, p. II, 135. (*Publ. North Holland Publ. Co.* 1949).

Experiments on solutions of polymethyl methacrylate in monochlorobenzene give results in line with Oldroyd's theory of the wall effects at high Reynolds' numbers.

In the discussion following the presentation of the papers by Oldroyd and Toms, C. N. Davies maintains that merely suppressing the turbulence by addition of a solute explains the phenomena observed and that the wall-effect hypothesis is inadmissible. However, Oldroyd and Toms do not agree. A.H.N.

1457. Hardness and Brittleness of Quartz.

E. V. TSINZERLING. *Proc. Acad. Sci. U.S.S.R.*, **60**, 1033, 1948.

1458. Solid Solubility Effect of Metallic Surface Friction.

K. UMEDA AND Y. NAKANO. *Phys. Rev.*, **75**, 1621, 1949.

The suggestion is put forward that with a pair of metallic friction elements capable of forming an eutectic alloy the coefficient of friction tends towards zero at the melting point of the eutectic alloy and not at the melting point of the lower melting one of the two friction elements.

The experimental method is not described, but it is claimed that at the melting point of the eutectic alloy "a liquid state can be observed along the rubbed trace," and that the full course of the coefficient of friction-temperature curve is so similar to the solubility-temperature curve on the side of the lower melting point metal that an empirical linear relation can be deduced. R.S.

1459. Theory of Viscosity of Suspensions and Solutions. Effect of Small Particle Size.

V. VAND. *Čas. Pěst. Mat. Fys.*, **73**, 141, 1949.

Theory of viscosity of suspensions is extended to cover molecular particle size range by introducing a correction factor containing the ratio of the volumes of the solvent to the solute molecules. Viscosity formulae are given, in which interactions, collisions and hydration are taken into account, and which can be applied to solutions. SCI. ABSTR.

(See Abstr. 927, 1187).

1460. Tear Measurement with a Dynamometer.

J. VILARS. *Papeterie*, **70**, 397, 1948.

The Elmendorf tear tester and the dynamometer of Lhomme and Argy (*cf. Papier*, **33**, 1033, 1037, 1041, 1930) are compared; the latter was found to be more sensitive, and the only one permitting systematic testing of mechanical pulps and newsprint paper.

P.A.T.R.A.

1461. Viscosity and Dielectric Constant of Liquid Dispersions and Solutions.

A. VOET. *Proc. 1st Intern. Congr. Rheol. Scheveningen*, 1948, p. II, 15. (*Publ. North Holland Publ. Co.*, 1949).

The dielectric constant of dispersions is an excellent way of determining structural changes in liquid systems subjected to varying shearing stresses and is limited only by the accuracy of measurement possible in media of high conductivity. For the dielectric constant ϵ of a dispersion of particles in volume fraction V in a medium of dielectric constant ϵ_2 , the following approximate equation is used

$$\epsilon = \epsilon_2 (1 + 3fV)$$

where f is a form factor indicative of the deviation of the particle shape from spherical form. For the state of rest a marked increase in dielectric constant is noted, explicable only on the assumption of particle agglomeration. Dispersions for which the agglomeration factor is unity show Newtonian flow, those for which the factor is greater are non-Newtonian. The variation of the agglomeration factor with time once shearing stress is removed enables one to follow the process of rebuilding the particle structure, which may take many minutes. Evidence is adduced to show that in polymer solutions the polymer particles move independently at lower concentrations. Above a critical concentration the particles no longer move independently, though shearing stresses can break up most of the agglomerates. The higher the molecular weight of the polymer, the lower the critical concentration and the more pronounced the particle interaction. V.G.W.H.

(See Abstr. 1361, 1362).

1462. The Rheology of Suspensions.

A. DE WAELE AND E. W. J. MARDLES. *Proc. 1st Intern. Congr. Rheol. Scheveningen*, 1948, p. II, 166. (*Publ. North Holland Publ. Co.*, 1949).

The complexity of the factors that influence the rheological characteristics of suspensions are concisely, but very clearly, given. (The presentation is so concise that it cannot be usefully abstracted as it is in itself an abstract of a large amount of information and should be read *in extenso*). Experiments are then described which indicate the influence of interfacial forces and of friction on sedimentation volume and the rheological characteristics of suspensions. These influences become very great at high concentrations and they affect, even with dilute systems, flocculation and thixotropy. A.H.N.

1463. The Rheology of Building Mastics. I. Caulking Compounds for Gun Application.

A. G. WARD AND E. L. WESTBROOK. *J. Soc. Chem. Industr.*, **67**, 389, 1948.

Absolute measurements of the rheological properties of caulking compounds designed for use with hand- or air-pressure guns are described. The methods used are the tube plastometer, for extension measurements, and the divided cylinder plastometer, which can be used for measurements at stresses both above and below the yield value for continuous flow. Below this yield value irreversible deformation occurs, but the rate of shear decreases continuously as shear proceeds. Above the yield value the behaviour approximates to that of a Bingham plastic body complicated, in some instances, by thixotropy. The results obtained have been applied to the practical problems of filling and the use of hand-pressure guns. The temperature dependence of flow properties has also been studied.

B.C.R.A.

1464. **Abnormal Substances and Abnormal Phenomena of Flow.**

K. WEISSENBERG. *Proc. 1st Intern. Congr. Rheol. Scheveningen, p. I, 29, 1948. (Publ. North Holland Publ. Co., 1949).*

Many experiments are described, with the aid of a large number of photographs and diagrams, which demonstrate the difference in properties between *general* viscoelastic materials (for which part of a shear strain is recoverable when external forces are released) and *special* materials (for which this is not so). The principles upon which the author's theoretical explanation of these phenomena is based are outlined, with full references to earlier work. J.G.O.

1465. **On the Impact Behaviour of a Material with a Yield Point.**

M. P. WHITE. *J. Appl. Mech.*, 16, 39, 1949.

An analysis of longitudinal impact tests on an iron and a steel with definite yield points is described. The probable nature of the dynamic stress-strain relations for such materials is deduced. These appear to differ greatly from the static stress-strain relations, the upper yield stress for undeformed material being several times as great under impact as the static yield stress. The present analysis indicates that under impact, the material with a definite yield point is made harder at a given deformation, and ruptures at a higher (engineering) stress and smaller strain than when loaded statically. The critical impact velocity, defined as that at which nearly instantaneous failure occurs in tensions, is discussed, and the factors upon which it depends are given. SCI. ABSTR.

1466. **Physico-Chemical Studies on Solutions of Synthetic Rubber.**

II. Molecular Weight and Intrinsic Viscosity of Unworked (?Bessterzhnyi) Sodium Butadiene Rubber.

I. I. ZHUKOV, I. YA. PODDUBNYĖ AND A. V. LEBEDEV. *Kolloidnyi Zh.* 11, 151, 1949.

A comparison of Osmotic and Viscosity methods for molecular weight determination. M.W.'s. range from 41,000-729,000. The intrinsic viscosity follows the formula $[\eta] = 2.7 \cdot 10^{-4} M^{0.725}$. G.W.S.B.

BOOK REVIEWS

ELASTICITY AND ANELASTICITY OF METALS. By C. ZENER. University of Chicago Press, 1948.

This book, dealing with a subject of importance not only to the metallurgist but to the physicist and engineer, develops the theoretical interpretation of the property of metals termed "anelasticity," by virtue of which the stress-strain curve of metals, at low stresses, is not free from hysteresis effects as would have to be the case if Hooke's Law were strictly obeyed.

Of over 160 pages, about thirty constitute the first part of the book. Elasticity and the manner of evaluating the elastic constants corresponding to the various possible modes of deformation of crystals are dealt with. Theoretically and experimentally obtained values of these constants are compared. An interpretation of phase-transformations in terms of the change of free energy of crystallites with shear strain, as well as the associated phenomenon of "microelasticity" are discussed.

In the second part of the book, the formal theory of anelasticity is first developed, mainly by the aid of the "standard linear solid" (capable of stress- and strain-relaxations), and Boltzmann's theory of the elastic after-effect. It is shown that a whole spectrum of relaxation-times may contribute to the anelasticity, such as those due to thermal, atomic and magnetic diffusion; while inhomogeneous types of anelasticity arise from stress-

relaxations along previously formed slip-bands, across grain boundaries and across twin interfaces of crystals. In vibrating specimens these effects entail the loss of vibrational energy. The variation of the damping capacity of the specimen with frequency affords a means for determining the spectrum of relaxation times. Other methods, not necessitating the variation of frequency had been used.

A physical interpretation of the various sources of anelasticity is given, and comparisons with experimental results of many workers in this field shows, by the good agreement obtained, that the theory of anelasticity of metals rests upon sound foundations. A hundred and seventy references are given. P.F.

STREAMLINE FLOW. By H. F. P. PURDAY. Constable and Co., London. (Price 18s. net.)

The growing importance of fluid mechanics in engineering raises in the pre-occupied minds of teachers, students and research workers the difficult problem of how the essentials of hydrodynamic theory are most effectively to be acquired. The answer depends mainly on two factors: facility in mathematical methods of analysis, and the field of application or investigation; and where the latter is primarily mechanical engineering in character, it will be readily conceded that the analytical basis of streamline flow is at least a minimum requirement for more advanced studies of turbulent and supersonic fluid motion, while capable of many immediate applications in hydraulics, lubrication and heat transfer.

Mr. Purday, who is chief designer in the high-speed Diesel engine department of Messrs. Harland and Wolff, Limited, encounters a variety of such problems in the course of his work and rightly emphasises not only the similarities of theory underlying physical processes, such as lubrication and heat movement, that commonly occur simultaneously in practice, but also points out many useful analogies with the analysis of vibration, torsion and deflection. While illustrating the scope of utility of hydrodynamic theory, these relations are no more than incidental to the main object of the author's text, which is to show by the simplest means how to calculate velocities, pressures and boundary resistances arising in laminar fluid motion, and how to adapt the results to serve the theories of bearing lubrication and heat conduction. In an admirably logical sequence of chapters, Mr. Purday starts by reviewing viscosity and proceeds to establish the general equations of viscous flow, first in pipes and channels of various shapes, and then in fluid films of uniform and of varying thickness. The ground is thus prepared for studies of lubrication between sliding surfaces and in journal bearings, followed by analyses of the viscous resistance offered by rounded bodies, pipe walls and tangential boundaries, to which the author adds some useful notes on the influence of periodic velocity changes and the characteristics of laminar flow through beds of granular materials. He continues by deriving the equations representing flow of heat under various conditions of temperature distribution and enlarges the problem to deal with convectional heat transmission. The book is concluded by two short chapters which respectively illustrate the use of orthogonal functions and compare the general Navier-Stokes equations with the simpler forms they assume when compressibility, inertia or viscosity is neglected.

It will be clear from the foregoing survey that Mr. Purday's approach to streamline flow and its analogous problems is essentially mathematical, and that his own competence in analytical procedures is adequate to judge how far his occasional departures from strict mathematical rigour are justified by simplifying the solution of many of the technical applications exemplified in the text. He certainly shows most instructively how general principles can be put to practical use, though his assurance that the mathematics demands no more than elementary knowledge of the calculus possibly errs in the direction of understatement. Still, no engineer or physicist expects the analysis of fluid motion to be particularly easy, and the student with a liking as well as an aptitude for mathematical methods will appreciate Mr. Purday's consistently clear and orderly treatment and be grateful for his very valuable guidance, especially in lubrication theory.

Engineering. July 15th 1949