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RHEOLOGISTS ABROAD

FRANCE

The recently founded Groupe français d'études de rhéologie is now a flourishing concern. The writer was fortunate enough to be able to attend the second meeting of the group, in Paris. Five short papers were read, followed by brisk discussion. Later, M. Vallet introduced a Discussion on Nomenclature based on the Burgers-Scott Blair Report. The meeting was very well attended and showed strongly that atmosphere of friendly informality which has always characterized rheology meetings in this country. The French Group (Hon. Sec. M. H. Weiss) is anxious to maintain the closest possible contacts with the B.S.R.

Prof. Reiner's "Twelve Lectures" will appear in French translation in the near future.

GERMANY (W.)

There are, at present, two Societies in W. Germany. The Deutsche Rheologische Gesellschaft (President: Prof. Dr. L. Ubbelohde—Hon. Sec.: Dr. H. Umstätter), issues a Bulletin, the first number of which describes the Herbert Freundlich Memorial Symposium held in Berlin last May.

The Deutsche Rheologische Vereinigung (President: Dr. W. Meskat—Hon. Sec.: Dr. H. Kroepelin) is a branch of the Processing Section of the Society of German Engineers. This Society held a Conference in Stuttgart on October 15th.

HOLLAND

The Netherlands Rheological Society, which now forms part of the Society for Testing Materials in Holland and has about seventy members, held a meeting in December, 1953, at which Mme Dobry-Duclaux was the speaker, and in April 1954 Dr. H. Oberst, of Brunswick, addressed a meeting. Dr. P. G. Meerman has prepared a preliminary Report on Nomenclature. The Society does not issue a Bulletin.

ISRAEL

The writer recently visited the Rheological Laboratory in the new buildings of the Israeli Institute of Technology, high up on Mt. Carmel. He had hoped to represent the B.S.R. at the formal opening of Prof. Reiner's magnificent new quarters, but it was decided not to hold any ceremony until the whole block of laboratories is completed.

Much valuable rheological work is also being done at the Weizmann Institute, Rehovot. (The writer gave lectures on rheology at this Institute, and in Haifa, Tel Aviv and Jerusalem.)

Prof. Reiner and other Israeli rheologists are at work on a six-language rheological dictionary.

JAPAN

The Tokyo Rheologists' Group (President: Prof. B. Tamamushi) appears to be very active. Japanese rheologists are much concerned with problems of translation. For example, in the phonetic script (Kanamoji), "Rheology" would be read "Reoroji"; whereas in the Kanji script, "Ryudogaku" means, literally, "Flow science." Which

word shall be used? This type of problem faces translators in many languages : e.g., German and Hebrew.

Dr. Scott Blair's "Survey" is being translated, but the work is proceeding rather slowly, partly on account of these difficulties.

U.S.A.

The Bingham Medal for 1954 has been awarded to Dr. T. Alfrey for his work on viscosity, thixotropy and visco-elastic behaviour and for his outstanding achievements as a teacher.

The (American) Society of Rheology will hold its A.G.M. and Annual Conference in early November, at the Bureau of Standards in Washington. This will commemorate the 25th anniversary of the first meeting also held at the Bureau. (The writer had the privilege of presiding at one of the Sessions of this meeting).

Most of the Proceedings of the Conference will be published in the Rheology Issue of J. Appl. Phys. The Editor of the Society's Bulletin is Dr. F. R. Eirich.

U.S.S.R.

The writer, together with Prof. Reiner, recently had the good fortune to meet two members of the staff of the Moscow Baking Research Institute (both called Nikolaev, but unrelated). These Russian workers were most anxious to keep in touch with rheologists in Western countries, and many items of personal news were exchanged. Prof. Volarovich's inability to come to the Oxford Congress was explained by the fact that he had to attend an important meeting in Poland just at that time.

It is a pity that, during their visit, these rheologists did not have an opportunity to meet more of our Members, but we had no notice of their coming.

(The writer is indebted to many friends in the countries concerned for the information contained in this short Report).

G. W. SCOTT BLAIR.

Standard Method for Determining Viscosity

The B.S. 188 method for the determination of the viscosity of liquids in c.g.s. units is being revised by the technical committee c/17, of the British Standards Institution in co-operation with the Institute of Petroleum and the American Society for Testing Materials.

Comments on the final draft which will be available in the new year will be welcomed by the B.S.R. representative (E. W. J. Mardles, Royal Aircraft Establishment, Farnborough).

It is hoped that the revised method and viscometers will be particularly of use to research workers and any suggestions as to how the method may be extended in any special fields of work will be helpful.

E.W.J.M.

Forthcoming Meetings

It is planned to hold the next Annual General Meeting of the Society at the Washington Singer Laboratories of the University College, Exeter, in September, 1955. It is hoped to arrange a meeting and visit jointly with the local branch of the Chemical Society, on subjects relating to the physics and chemistry of surfaces. Suggestions as to suitable papers are invited and should be sent to the Secretary as early as possible.

We understand from Professor J. M. Burgers of Delft that the Netherlands Rheological Society plan to hold a meeting in May to discuss problems of nomenclature; and further that the Society will co-sponsor an International Symposium on problems of Macromolecules, for which a Committee has been appointed with J. J. Harmans as Secretary.

News from Members

Members are invited to supply the Editor with details of personal data suitable for inclusion in the Bulletin.

Accounts for the Year Ending 30th June, 1954

	RECEIPTS						£	s.	d.
Balance on 1st July, 1953	..	..	..	..	..	..	426	2	6
Members' Subscriptions	..	..	..	..	..	..	237	0	10
From Sale of Bulletin to non-members	..	..	..	..	..	..	23	16	7
Received in connection with meetings	..	..	..	..	..	..	11	6	0
Accrued Interest	..	..	..	..	..	..	5	0	0
							<u>£703 5 11</u>		

	EXPENDITURE						£	s.	d.
Postage and receipt stamps	..	..	..	..	..	..	21	14	8
Stationery and printing	..	..	..	..	..	..	151	11	8
Secretarial help and Committee expenses	..	..	..	..	..	..	20	0	10
Expenditure in connection with meetings	..	..	..	..	..	..	55	9	9
Refunds of subscriptions	..	..	..	..	..	..	1	8	0
Balance on 30th June, 1954	..	..	..	..	..	..	453	1	0
							<u>£703 5 11</u>		

N. WOOKEY,
Hon. Treasurer,
 15th July, 1954.

A. DE WAELE,
Hon. Auditor,
 30th July, 1954.

Obituary

The Editor regrets having to announce the death of the following members:—

DR. W. W. BARKAS.

DR. P. EGGLETON.

DR. J KNAGGS.

RHEOLOGY ABSTRACTS

3008. **1. Bibliography on viscosity of and workability aids for cement pastes.**
2. Bibliography on grinding and grinding mills.

REV. MATER. CONSTR., 1953, (459), 347, 348-52.

1. About 15 references to the literature. 2. Over 50 international references to the literature of crushing, grinding etc., with special reference to the manufacture of cement.
B.S.A.

3009. **An apparatus for measuring the dynamic shear elasticity and viscosity of solids at high audio frequencies.**

J. sci. Instrum., **30**, 412-13 (Nov., 1953).

3010. **Fundamental relations in photoplasticity.**

S. E. A. BAYOUMI AND E. K. FRANKL. *Brit. J. appl. Phys.*, 1953, **4**, 306.

Photoelastic methods of stress analysis have so far been limited to the study of problems of elasticity. The usefulness of such methods has been extended to cover inelastic behaviour by showing that the relative retardation due to loading is determined by the stress and strain components independently of the history of loading. A relation expressing relative retardation as a linear function of stress and strain differences has been derived. This fundamental relation has been verified experimentally for a wide variety of model materials. A fundamental procedure for photoplastic investigations is proposed. This consists of taking two fringe photographs of the same model, one under load, the second immediately after removal of the load. The difference between the fringe counts at corresponding points gives the stress difference which in elastic problems is derived from a single photograph.
B.C.R.A.

3011. **Effects of viscosity on Taylor instability.**

R. BELLMAN AND R. H. PENNINGTON. *Quart. Appl. Maths.*, 1954, **12**, 151.

3012. **Composition of apparent shearing forces during shear degradation of polymers.**

A. B. BESTUL. *J. Appl. Phys.*, 1954, **25**, 1069.

An investigation has been made of the degradation of Vistanex polyisobutenes having viscosity-average molecular weights from about 500,000 to 2,500,000 by shearing in solution in cetane at polymer concentrations from 5 to 20 weight per cent, at nominal rates of shear from 9,000 to 66,000 sec^{-1} , and at temperatures from 20° to 80° C. The initial apparent shearing loads, observed at the beginning of the degradation process, vary in unexpected ways with variations in nominal rate of shear, temperature, concentration, and initial molecular weight of the polymer. In some cases the observed variations are opposite to those which would be expected on the basis of viscoelastic resistance to shearing. These results can be explained on the basis of the hypothesis that the observed apparent shearing forces include some contribution associated with the energy used up in breaking chemical bonds in the polymer molecules during the degradation process. If this hypothesis is correct, valid viscosity values cannot be obtained directly from observed apparent shearing forces in viscometry measurements under conditions where shear degradation occurs. A.

3013. **An electromagnetic viscometer for molten silicates at temperatures up to 1,800° C.**

J. O'M. BOCKRIS AND D. C. LOWE. *J. sci. Instrum.*, 1953, **30**, 403.

3014. On the mechanism of the process of drawing of synthetic textiles.

G. BOZZA. *Nuovo Cimento*, **10**, Suppl. No. 1, 55-82 (1953) *In Italian*.

The factors affecting the drawing of fibre threads from a more or less viscous mass are analysed. The main processes involved are coagulation, tension and a mechanical force owing to the contraction of the fibre. The first two involve surface tension, viscosity, diffusion, velocity and acceleration in the drawing. These factors are discussed theoretically. SCI. ABS.

3015. Influence of rate of shear on the apparent viscosity of (a) dilute polymer solutions, and (b) bulk polymers.

F. BUECHE. *J. Chem. Phys.*, 1954, **22**, 1570.

The measured viscosity of bulk polymers and their solutions varies with the magnitude of the applied shearing stress. In this paper we show that this is a natural consequence of the fact that the molecules are caused to rotate by the shearing action. This rotation gives rise to sinusoidal forces which alternately stretch and compress the molecules. The viscous behaviour of such a system is shown to be analogous to that of a spring immersed in a viscous medium and being acted upon by sinusoidal viscous forces. We have treated the problem quantitatively using the method of a previous paper. Good agreement is obtained between theory and experiment without the aid of adjustable parameters. It is found that, if the molecule is considered shielded, the theory accurately represents the experimental data for dilute solutions. The behaviour of the bulk polymer is well represented by means of the free draining approach. It is pointed out that the variation of the viscosity of dilute polymer solutions with the rate of shear may provide a convenient method for determining molecular weights of coiling type polymers. A.

3016. On the viscosity of volume. I.

A. CARRELLI AND F. CENNAMO. *Nuovo Cimento*, **11**, 429-35 (May, 1954) *In Italian*.

According to a theory developed by Eckart, a consequence of the existence of a second viscosity coefficient is the generation of a fluid current in a medium traversed by ultrasonic waves; Liebermann has succeeded in observing the motion and measuring this second coefficient for some liquids. In the present paper measurements are reported for water in experimental conditions nearly similar to those of Liebermann, results being obtained according to theory; but there are some peculiarities which require further experimental investigation; for instance the considerable variation of the second coefficient for water at frequencies of 1.8, 3.0 and 4.2 Mc/s. SCI. ABS.

3017. Flow of melts in "crosshead"—slit dies; criteria for die design.

J. F. CARLEY. *J. Appl. Phys.*, 1954, **25**, 1118.

"Crosshead"—slit dies are widely used for the extrusion of polymer sheeting, flat film, and blown film. In this paper we analyze the laminar flow of liquids in such dies, deriving an equation relating pressure to position along the slit for materials that obey the "power law." The equation yields an index of uniformity (UI), which is the ratio of the rate of extrusion at the far end to that at the feed end, given by

$$UI = \left[1 - \frac{[(1+0.05n) n \alpha L]^{(n+1)/n}}{(1+0.05n) (n+1)} \right]^n$$

where n = the exponent of the power law, L = the length of the die from feed end to far end, and α = a parameter depending on the other die dimensions and the exponent n , having the unit (in.)⁻¹. An illustrated procedure is given for designing dies that will make film whose caliper is satisfactorily uniform over its whole width. We show that the UI for centre-fed dies is always greater than for end-fed dies of the same length. A.

3018. Elastoviscous properties of amorphous polymers in the transition region.

II. Stress-relaxation of butadiene-styrene copolymers.

E. CATSIF AND A. V. TOBOLSKY. *J. Appl. Phys.*, 1954, **25**, 1092.

Experimental data have been obtained on the stress-relaxation modulus $E_r(t)$ of several copolymers in their transition regions. The new data are expressed as master

curves which can be fitted to the Gauss error integral form of reduced equation, as previously proposed. It appears possible to characterize the time and temperature-dependence of E_r of amorphous polymers in general by means of the parameters of this equation: E_1 (glassy-state modulus), E_2 (rubbery-state modulus), T_d (distinctive temperature, related to second-order transition temperature), K_d (characteristic relaxation time at T_d), and h (parameter related to steepness of master curve). In the butadiene-styrene series, the effect of composition on these parameters has been determined. A.

3019. The processing of market cream.

E. L. CROSSLEY AND J. ROTHWELL. *Dairy Sci. Abstr.*, 1954, **16**, 688, 780.

An admirable review article, including full refs. to work on measurements of consistency and on industrial processes for its improvement, especially by appropriate heating and cooling. Also discusses ageing, homogenization, agitation, whipping properties, flavour, keeping quality, tests for adequate pasteurization, etc. G.W.S.B.

3020. Relaxation time spectrum of dough and the influence of temperature, rest and water content.

J. R. CUNNINGHAM AND I. HLYNKA. *J. Appl. Phys.*, 1954, **25**, 1075.

3021. The Two Viscosities of Fluids.

R. O. DAVIES AND L. ROSENHEAD. *Nature*, 1954, **173**, 1209.

Report of discussion at the rooms of the Royal Society, April 1954. Generally assumed relations between stresses and rates of deformation in a homogeneous fluid lead to equations containing μ a shear co-efficient of viscosity and μ^1 a dilatational co-efficient of viscosity. The combination $\mu^1 + \frac{2}{3}\mu$ is referred to as the bulk viscosity. E.W.J.M.

3022. Investigation of the interrelations between frictional and adhesive forces by the method of crossed fibres.

B. V. DERYAGIN, S. B. RATNER AND M. F. FUTRAN. *Dokl. Akad. Nauk SSSR*, **92**, No. 6, 1137-40 (1953) *In Russian*. English translation, *U.S. National Sci. Found. NSF-tr-228*.

On the theory of Deryagin [*Dokl. Akad. Nauk SSSR*, **3**, 93 (1934)], frictional force has two components, one depending on the load (N) and the other on the adhesive force between surfaces (N_0). Experiments with crossed quartz fibres designed to obtain direct measurements of second component. Authors find for $N > 0$ the unexpected result that friction force depends on load in accordance with Deryagin's theory. For $N < 0$, a friction force independent of load and contact is maintained between fibres for values of N down to $-N_0$. Tangential adhesion and friction are equal at zero load. These effects cannot yet be explained. SCI. ABS.

3023. A contribution to the study of plasticity.

H. DETAILLE. *Bull. Soc. franç. Céram.*, 1953, No. 21, 2.

The deformation of elasto-plastic material under a given stress is studied as a function of the water content. Research undertaken at the Institut National des Silicates and based on torsional deformation proved that deformation does not follow Bingham's law for all water contents. The colloidal and rheological properties of clay, the interpretation of torsional deformation curves obtained with normal, thixotropic and rheopectic bodies, and the determination of the water content giving maximum working plasticity, are discussed. Particular emphasis is laid on the existence of a critical water content. B.C.R.A.

3024. Rotational plastometry applied to molten polyethylene.

F. D. DEXTER. *J. Appl. Phys.*, 1954, **25**, 1124.

A concentric cylinder rotational plastometer which automatically plots the shear strain v. time curve for each of a number of shear stresses is described. The flow behaviour of molten polyethylene resins, measured with this instrument from 130°C to 210°C, is discussed. It is shown that, at each shear stress, the shear strain v. time curve for these resins is describable in terms of a viscosity, an elastic shear strain and a retardation time.

As the shear stress is raised both the viscosity and retardation time decrease, while the elastic shear strain increases. The shear stress dependency of the viscosity and elastic shear strain are shown to be related and in a manner which suggests that the viscosity change is the result of an entropy effect. A.

3025. The effects of various oxides on the viscosity of glasses of the soda-lime-silica type.

A. G. F. DINGWALL AND H. MOORE, *J. Soc. Glass Tech. (Trans.)*, 1953, **37**, 316.

3026. Viscosities of benzene-d₆ and cyclohexane-d₁₂.

J. A. DIXON AND R. W. SCHLISSLER, *J. Phys. Chem.*, 1954, **58**, (5), 430-432.

The viscosities of deuterated benzene and cyclohexane are measured over the range 293-18 to 333-18°K and compared with the ordinary hydrogen compounds. G.E.B.

3027. The sinkage of tracked vehicles on soft ground.

I. EVANS, *Brit. J. appl. Phys.*, **4**, 330-4 (Nov., 1953).

The depth of the rut made by a tracked vehicle when crossing soft ground (the "sinkage") is an index of the difficulty experienced by the vehicle. Sinkage is due to plastic flow of the soil under the imposed stresses and can be related to the shear strength of the soil and the characteristics of the vehicle. Two distinct theories are given, one by Mickelthwait and Sherratt based on deductive reasoning, and a simpler inductive method by the author. SCI. ABS.

3028. The rolling resistance of a wheel with a solid rubber tyre.

I. EVANS, *Brit. J. appl. Phys.*, **5**, 187-8 (May, 1954).

The rolling resistance of a wheel with a solid rubber tyre, running on a rigid plane surface, is calculated on the assumption that it is due to hysteresis losses in cyclic deformation of the rubber. The results and certain other deductions from the theory are in reasonably good agreement with experimental observations. SCI. ABS.

3029. Effect of rheological behaviour on thermal stresses.

A. M. FREUDENTHAL, *J. Appl. Phys.*, 1954, **25**, 1110.

Since the conventional elastic analysis of thermal stress problems coupled with limiting creep rates and time-dependent fracture stresses as (inelastic) design criteria, results in design procedures for thermal stresses (in heat exchanges, nuclear reactors, flight structures at supersonic speeds, etc.) of considerable unreality, the effect of various types of rheological behaviour (viscoelastic, plastic, work hardening) on the level of thermal stresses is analyzed under simplified assumptions, such as uniaxial stress and polar or cylindrical symmetry. The effect on the thermal stress intensity of the rheological behaviour of the material is shown to be very significant, particularly with respect to stress relaxation and the development of residual stresses. A.

3030. Dynamic double refraction and the geometrical dimensions of macromolecules in solution.

E. V. FRISMAN AND V. N. TSVETKOV, *Zh. eksper. teor. Fiz.*, **23**, No. 6 (12) 690-702 (1952) In Russian.

The method of double refraction in a flow was used to study the structure of macromolecules in solution. A new universal type of dynamo-optimeter was developed, the construction of which is such that it is possible to obtain laminar flow using an internal and an external rotor. It was established experimentally that the apparatus can be used for liquids of low viscosity within a wide range of velocity gradients under conditions of laminar flow. The dynamic double refraction of solutions of polystyrene in toluene and in butanone (methyl ethyl ketone) was investigated. The co-efficients of the rotational diffusion of macromolecules were determined. The radii, the degree of transparency and the degree of coagulation of macromolecules in solution were determined by a comparison of the data obtained with the values of progressive diffusion for the same solutions. The possibility was shown of determining the molecular weight of a polymer from the measurements of the orientation angle of the dynamic double refraction of its solutions. SCI. ABS.

3031. Intrinsic viscosities of polyelectrolytes. Poly- (acrylic acid).

P. J. FLORY AND J. E. OSTERHELD. *J. Phys. Chem.*, 1954, **58**, (8) 653-661.

Intrinsic viscosities of poly-(acrylic acid) neutralised to various degrees were determined in the presence of NaCl, Na₂SO₄, CaSO₄ and CaCl₂, at several rates of shear, such that extrapolation to zero shear rate was permissible. The theoretical treatment of the influence of long-range intramolecular interactions of polymer molecules upon viscosity in the presence of electrolytes is considered in relation to these data. G.E.B.

3032. Laboratory methods for determining the plasticity and stiffness of clay.

E. C. W. A. GEUZE. *Klei*, Rijswijk, 1953, **3**, 105.

A so-called "triaxial apparatus" is described. In the compression test commonly used in industry the force needed to compress a clay cylinder between two parallel plates until its length is reduced by say, 10 per cent, is measured. The "triaxial" test is similar except for the manner of loading and general procedure. The clay cylinder is enclosed in a rubber envelope and is then placed in a cylindrical vessel which is filled with water. Hydrostatic pressure is applied and a stress-deformation diagram is obtained. B.C.R.A.

3033. Non-Newtonian behaviour of solutions of macromolecules.

P. GOLDBERG AND R. M. FUOSS. *J. Phys. Chem.*, 1954, **58**, (8), 648-653.

Experimental viscosity data on polyvinyl pyridine solutions, using capillary viscometers, are used for calculation of the initial co-efficients of power series in rates of shear, assuming that the viscosity of a non-Newtonian liquid may be expressed in this way. It is shown that results with different viscometers agree for similar values of Radius times Pressure divided by Length of capillary. It is found that limiting values of apparent viscosity at low values of Q are linear in Q rather than quadratic, where Q is the maximum gradient which would exist at the capillary walls if the liquid were Newtonian. G.E.B.

3034. A simple electromagnetic microviscometer for semi-transparent liquids.

J. HART. *J. sci. Instrum.*, **31**, 182-4 (May, 1954).

Observation of the motion of a small steel sphere through 0.04 ml of semi-transparent biological secretion contained in a glass tube gives a measure of the apparent viscosity and an indication of the elastic properties of the specimen. The sphere is propelled by the non-uniform magnetic field of a solenoid energized by a known variable direct current.

SCI. ABS.

3035. Constant stress elongation of soft polymers : plasticizer studies.

M. R. HATFIELD AND G. B. RATHMANN. *J. Appl. Phys.*, 1954, **25**, 1082.

Constant stress measurements have been made on lightly cross linked GR-S and polyisobutylene of 7 million molecular weight. The modulus values as a function of temperature, time and concentration of mineral oil plasticizer have been treated according to the "reduced variables" principles. Since both plasticized and unplasticized samples shows the expected equivalence of temperature and time, the modulus values could be shifted to produce master curves for each composition. In the case of GR-S the concentration of plasticizer could be similarly reduced to yield a single curve for all the data.

The polyisobutylene results, however, showed quite clearly that the plasticizer had a unique effect not paralleled by temperature or time. This effect has been attributed to the pseudoequilibrium modulus which apparently results from chain entanglements. Since the pseudoequilibrium modulus should be proportional to the number of chain entanglements per gram of polymer, it should vary as the square of the volume fraction of polymer. It is shown that a correction of this type improves the shift of the curves for polyisobutylene.

Changes in activation energy with the addition of plasticizer are apparently within experimental error (± 2 kcal) in all cases. A.

3036. The viscoelasticity of linear polymeric substance.

S. HAYASHI. *J. Phys. Soc. Japan*, **9**, 56-8 (Jan.-Feb., 1954).

The viscoelasticity of highpolymeric substance is discussed from the standpoint of a molecular theory. From Sci. Abs. 5037 (1954).

3037. The density, surface tension and viscosity of deuterium oxide at elevated temperatures.

J. R. HEIKS, M. K. BARNETT, L. V. JONES AND E. ORBAN. *J. Phys. Chem.* 1954, **58**, (6), 488-491.

Density and viscosity measured at 30° to 250°C, and surface tension measured at 100° to 216°C are reported. A Lawaczeck falling body viscometer with a radioactive plummet was used for the viscosity measurements. G.E.B.

3038. Modern developments in fluid dynamics.

Edited by L. HOWARTH, H. B. SQUIRE AND C. N. H. LOCK. *Oxford: Clarendon Press; London: Oxford University Press* (1953) Volume I: xvi+476 pp. Volume II: viii+400 pp. [*The Oxford Engineering Science Series*].

Review in *Nature [London]* **173**, 604-5 (April 3, 1954).

3039. A note on the elastic wedge problem.

J. H. HUTH. *J. Appl. Phys.*, 1954, **25**, 929.

The problem of determining the stress field within a wedge subjected to normal and shearing stresses on two faces is discussed. S.T.

3040. High speed elongation of long test-piece of rubber.

S.-I. HYODO. *J. Phys. Soc. Japan*, **8**, 563-5 (July-Aug., 1953).

A method is described for stretching a test-piece 32 cm long and 7 mm² in cross-section to rupture at rates of elongation of the order of 100 sec⁻¹. A gunpowder explosion is used to fire a harpoon which pulls out the specimen. The stress-elongation curves are concave towards the stress axis. SCI. ABS.

3041. Navier-Stokes' equations for non-Newtonian liquids.

A. A. K. IBRAHIM. *J. Chem. Phys.*, 1954, **22**, 1274.

In deriving the general equations of flow of non-Newtonian liquids account is taken of the elastic forces. S.T.

3042. Errata: the intrinsic viscosities and diffusion constants of flexible macromolecules in solution.

J. G. KIRKWOOD AND J. RISEMAN. *J. Chem. Phys.*, 1954, **22**, 1626.

The solution of a differential equation given in a previous paper (*J. Chem. Phys.*, 1948, **16**, 565) was incomplete. The consequences of this error are discussed. S.T.

3043. Elastic constants of gels.

M. KRISHNAMURTHI AND G. S. SASTRY. *J. Chem. Phys.*, 1954, **22**, 1133.

The elastic constants of silica and alumina silica gels have been obtained under dynamic conditions using an ultrasonic method. S.T.

3044. The rheological properties of dielectric polymers at frequencies from 1 kc/s-200 kc/s.

W. LETHERSICH. *Rep. Brit. Elect. Res. Assoc., Ref. L/T272*, 7 pp. (1952).

Creep was found to occur which is wholly elastic and can be represented by a system of Kelvin elements in series each having a relaxation time τ . It was shown that the distribution function of relaxation times is expressible in the form k/τ for values of τ ranging from 10^{-3} to 10^4 sec. The tests described in this report extend the lower range to around 10^{-5} sec and the hyperbolic relation still holds although for ebonite the lowest relaxation time appears to be about 10^{-4} sec. Poisson's ratio is found to be much greater when measured under alternating stress than under constant stress. This can be attributed to a volume viscosity, but this explanation is not wholly satisfactory as the co-efficient of internal friction should be raised. No such increase is observed. SCI. ABS.

3045. Theory of formation and breakdown of welding bridges between the friction surfaces.

M. P. LEVITSKII. *Dokl. Akad. Nauk SSSR*, **92**, No. 4, 797-8 (1953) *In Russian*.

Analyses the process of bringing together the atomic lattices of the solid surfaces A and B which are in the state of mutual friction as a reaction given by the equation $(A+B)_2 \rightleftharpoons AB^{++} \rightleftharpoons (A+B)_1$, where $(A+B)_1$ are atoms of surface A and B , which produce the lattice of the pseudo-stable phase before the free-energy barrier ΔF^{++} has been reached and form the easily deformable portion of the welding bridge; $(A+B)_2$ are atoms of the same surfaces, which have come sufficiently near to each other to form a common lattice of the strong crystalline portion of the bridge, while AB^{++} are atoms forming an active complex. SCI. ABS.

3046. Re-evaluation of glass viscosities at annealing and strain points.

H. R. LILLIE. *J. Amer. ceram. Soc.*, 1954, **37**, 111.

A review of the early work that has led to the present definitions of the annealing- and strain-points. New tests on the same primary standards, with modern apparatus and corrections applied for expansion, indicate that the definitions should be modified. A recommendation is put forward regarding such redefinitions, by which the viscosities at the annealing- and strain-points would be 10^{13} and $10^{14.50}$ poises, respectively, during cooling at 4°C./min . B.C.R.A.

3047. Viscosity data on commercial glass. Correlation with working characteristics.

A. K. LYLE. *Industr. Engng. Chem.*, 1954, **46**, 166.

Viscosity/temperature curves of glasses are indicative of the working characteristics of glasses, but they require numerous measurements with elaborate apparatus and time-consuming procedures, and their complex character makes quantitative interpolation difficult. Procedures for overcoming both difficulties have been developed and are presented here. B.C.R.A.

3048. Viscosity studies of system $\text{CaO-MgO-Al}_2\text{O}_3\text{-SiO}_2$. IV. 60 and 65% SiO_2 .

J. S. MACHIN AND T. B. YEE. *J. Amer. ceram. Soc.*, 1954, **37**, 177.

In this final paper of a series on viscosity in the system $\text{CaO-MgO-Al}_2\text{O}_3\text{-SiO}_2$ data are presented for melts containing 60 and 65 per cent SiO_2 . There are also diagrammatic presentations of the systems of isokoms at intervals on planes parallel to the zero Al_2O_3 , zero CaO , and zero MgO faces of the tetrahedron, the apices of which represent 100 per cent of each of the four oxides that make up the system. B.C.R.A.

3049. The viscosity of suspensions of spheres—a note on the particle interaction co-efficient.

R. ST. J. MANLEY AND S. G. MASON. *Can. J. of Chem.*, 1954, **32**, 763.

Measurements of the reduced viscosity of suspensions of glass spheres $5\ \mu$ diameter have been made up to 18 per cent v. The results are defined by the empirical equation $\eta_{sp}/c = 2.5 + 12.7c + \dots$

The co-efficient of c due to interactions is in fair agreement with a value of 10.05 based upon a modification of Vand's theory. E.W.J.M.

3050. A capillary viscometer with continuously varying pressure head.

S. H. MARON, I. M. KRIEGER AND A. W. SISCO. *J. Appl. Phys.*, 1954, **25**, 971.

A new capillary viscometer has been designed to study the flow behaviour of non-Newtonian fluids. The instrument is convenient, absolute, and accurate, and covers continuously a wide shearing stress range in a single determination. A falling mercury column forces the sample through the capillary. Measurement of the column height as a function of time gives both pressure drop and flow rate. Provision is also made for the use of driving fluids less dense than mercury for measurements at lower shearing stresses.

The density of the sample need not be determined. Methods and illustrations are given of the application of the new instrument to the determination of the absolute viscosities of Newtonian liquids, and the flow curves of non-Newtonian fluids. A.

3051. On the nonlinear elastic constants of crystals.

M. MATSCHINSKI. *C. R. Acad. Sci. [Paris]* **238**, 365-7 (Jan. 18, 1954) *In French*.

To the classical linear tensor relation between stress and strain is added a quadratic strain term to allow for nonlinear but reversible deformations. The numbers of additional nonlinear elastic constants are computed for each of the crystal systems. SCI. ABS.

3052. On the after-effect theory of elastic relaxation.

J. MEIXNER. *Z. angew. Phys.*, **6**, No. 5, 215-17 (1954) *In German*.

An after-effect function $Q_{ik}(t)$ is introduced so that the stress at time t is given by $\sigma_i(t) = c_{ik}\epsilon_k(t) + \int_0^\infty Q_{ik}(tl)\epsilon_k(t-u)du$. It is shown that for an isotropic body only two functions Q , for hydrostatic and shear stress, are necessary. It is shown how further functions may be introduced to deal with temperature variations and the specific entropy of a solid, and the treatment is extended to cubic crystals. The Onsager reciprocal relations naturally arise from this treatment. SCI. ABS.

3053. Variation of viscosity of liquids with temperature.

S. S. MITRA. Letter in *Curr. Sci.*, **22**, 329-30 (Nov., 1953).

Sutherland's theoretical viscosity temperature relation for gases is modified for liquids and the resulting formula is shown to behave very well for a number of liquids. SCI. ABS.

3054. An improvement in plastic pressure experiments by enforced sliding friction.

E. MÖNCH. *Z. angew. Phys.*, **5**, No. 10, 363-9 (1953) *In German*.

The basic ideas underlying a new procedure for experiments on plastics, in which pressure and lateral frictional forces are applied, is described. The method, which can also be used for metals, is not suitable for routine measurements. SCI. ABS.

3055. The rheological unit in raw elastomers.

M. MOONEY AND W. E. WOLSTENHOLME. *J. Appl. Phys.*, 1954, **25**, 1098.

Reasons are adduced for suspecting that in a raw elastomer subjected to continuous shear there exist groups of molecules which are held together by entanglement or by thixotropic attachments and move and rotate essentially as elastic solid bodies. Such coherent molecular groups are called rheological units.

If an elastomer in continuous shear consists essentially of closely-packed rheological units, such units, rolling on each other, will transfer a rubber soluble dye across the shear planes as the ink rollers transfer ink in a printing press. This predicted phenomena has been observed with a Mooney viscometer fitted with a smooth rotor, the face of which is covered with a thin film of dried cement containing a dye in high concentration. From the velocity of the colour front a rough value can be computed for the mean diameter of the rheological units. The diameters for a series of different elastomers lie in the range from 1 to 35 microns. A.

3056. Deviations from Hooke's Law within the elastic range.

D. MORRISON. *Engineering*, 1954, **177** (4592) 141-4.

3057. The character of the rheological curves of paraffinic crude oil containing different quantities of resins.

V. F. NEZHEVENKO. *Kolloidnyi Zh.*, 1954, **16**, (3) 196.

3058. Internal friction and dynamic modulus of cold-worked metals.

A. S. NOWICK. *J. Appl. Phys.*, 1954, **25**, 1129.

The complexities of the internal friction and dynamic modulus of metals in the cold worked condition may be understood reasonably well by separation of the phenomena into the following three distinct effects: (1) the "non-linear" effect, characterized by strong amplitude dependence, frequency independence, and its disappearance after severe deformation; (2) the Köster effect, which shows rapid recovery after deformation, at temperatures well below the recrystallization temperature; (3) the "viscosity" effect, characterized by strong frequency and temperature dependence. The origin of each of these effects is briefly discussed from the point of view of dislocation theory. A.

3059. Determination of the viscosity of industrial glasses by nomograms.

M. V. OKHOTIN. *Glass & Ceramics*, Moscow, 1954, **11**, No. 1, 7.

The author claims that the following formula can be used for the construction of nomograms for the determination of the viscosity of silicate glasses within the range of 10^3 – 10^{13} poises: $t = ax + by + cz + d$, where t = temp.; x = % Na_2O ; y = % $(\text{CaO} + \text{MgO})$; z = % Al_2O_3 ; and a, b, c, d are constants, the values for which are obtained by experiment. An example of the use of the nomogram is given. B.C.R.A.

3060. Some rheological properties of concentrated polyisobutylene solutions.

F. J. PADDEN AND T. W. DEWITT. *J. Appl. Phys.*, 1954, **25**, 1086.

Three types of measurements have been made on concentrated polyisobutylene solutions. Dynamic measurements have been extended to low frequencies and the dynamic viscosities and rigidities determined in the region close to that in which pure viscous flow predominates. A modified Stormer viscometer has been used to determine the apparent (non-Newtonian) viscosities of the same solutions. Pressures developed (normal stress) at the inner cylinder have also been measured in a concentric cylinder apparatus with the inner cylinder rotating. It is noted that superposition procedures currently used for dynamic data are apparently applicable to the viscosity and pressure data with the rate of shear taking the place of frequency. Relations between these phenomena are discussed in the light of a theory proposed by one of the authors. A.

3061. On a generalisation of Synge's criterion for sufficient stability of plane parallel flows.

S. I. PAI. *Quart. Appl. Maths.*, 1954, **12**, 203.

3062. On the viscosity and the self-diffusion in liquids.

S. PETER. *Z. Naturforsch.*, **9a**, 98–104 (Feb., 1954) In German.

A liquid model theory is proposed and a formula developed for the calculation of melting point viscosities. Good agreement is obtained for a considerable number of organic liquids and also for four liquid metals. SCI. ABS.

3063. The viscosity of molten enamels. II. The effect of some milled batches on the fusion viscosity of enamels.

A. PETZOLD. *Silikat Tech.*, 1953, **4**, 443.

The influence of various mill additions on the viscosity of a vitreous enamel was investigated. It was found that the addition of clay in the mill considerably increases the melting viscosity. W. Machu's statement that clay can lower the melting point of enamels is considered erroneous. Bentonite, which is often added in the U.S.A. in addition to clay, also increases the viscosity during melting although to a less extent than clay; SnO_2 also increases the melting viscosity, but NaSbO_3 decreases it. B.C.R.A.

3064. The viscosity of molten enamels. III. The influence of iron oxides on the viscosity of ground enamels.

A. PETZOLD. *Silikat Tech.*, 1953, **4**, 485.

The influence of Fe oxides on the viscosity of vitreous enamels is dealt with; FeO , Fe_3O_4 , and Fe_2O_3 lower the viscosity of ground-coat enamels between 750° and $1,000^\circ\text{C}$. With increase of FeO up to 20 per cent the viscosity steadily decreases. B.C.R.A.

3065. Further dynamic investigations on polymers.

W. PHILIPPOFF. *J. Appl. Phys.*, 1954, 25, 1102.

Using the vibration tester of the Franklin Institute, a check of the proportionality between stress and strain in dynamic testing disclosed that a proportionality exists when heating is eliminated. A comparison of values of the dynamic test and steady-state experiment in the same range of rates of shear and shearing stress showed that the behaviour is basically different; whereas in the dynamic test the viscosity is independent of both amplitude and shearing stress, in the steady-state test experiment a very high dependence exists. The curve of viscosity v. rate of shear (D) is very similar to the one of dynamic viscosity v. frequency (f). A frequency shift of the order of two is involved in comparing D and f . The application of Ferry's method of reduced variables to a polyisobutylene solution, liquid polyesters, and solid plastics showed its validity. A precision test on the polyester showed that the temperature shift, T_p/T_{p0} , is necessary to make experimental values at different temperatures fit. The reduced curve of G^1 v. frequency for different plastics has an S shape with different slopes in a very wide range of frequency around 10^{24} . A.

3066. Viscosity fluctuation within the system casein-calcium hydroxide-sodium hydroxide-water.

K. F. PLOMLEY AND H. G. HIGGINS. *Aust. J. Appl. Sci.*, 1954, 5, 233.

Within the system casein-calcium hydroxide-sodium hydroxide-water the viscosity-time curve, under suitable conditions, shows two points of inflection and the viscosity may even pass through a maximum, followed by a minimum, before increasing towards the sol-gel transition. The mechanism of this behaviour has been investigated by using casein fractions of different solubility and composition, and by varying the concentrations of calcium hydroxide and sodium hydroxide and the interval between addition of the two alkalis to the system. It is postulated that three principal mechanisms contribute to the observed rheological behaviour, namely, intermolecular bridging of protein acid groups by calcium ions, partial replacement of bound calcium by sodium ions, and alkali-sponsored gelation (the pH effect). E.R.B.

3067. Compression of dehydrated mutton slices.

A. R. PRATER. *Aust. J. Appl. Sci.*, 1953, 4, 603.

The loose packing density of dehydrated mutton slices (0.2 g/ml) has been increased more than threefold by compression. The effects of various compression techniques on texture of blocks have been studied, and a procedure described for the production of firm, compact blocks with good slice size after reconstitution. A.

3068. An instrument for estimating the spreadability of butter.

J. H. PRENTICE. *Lab. Practice*, 1954, 3, 186.

Butter is driven through a standard orifice at a constant speed of just over 1 cm/sec. and the thrust is recorded. Results are compared with subjective assessments of "spreadability" on a seven-point scale. A correlation co-efficient of 0.896 was obtained. Linearizing by taking log. thrust raises this to 0.935. Replicate accuracy of the instrument is about twice as great as that of subjective assessments. G.W.S.B.

3069. Experiments with a laboratory extrusion apparatus under conditions of plane strain.

N. W. PURCHASE AND S. J. TUPPER. *J. Mech. Phys. Solids*, 1953, 1, 277.

Experiments on the small-scale extrusion of lead are described. The results are compared with the theory of extrusion due to Hill (*J. Iron St. Inst.*, 158, 177, 1948). Excellent agreement is found between the measured pressures of extrusion and those predicted by the theory; the flow patterns also are in general agreement. In minor details, such as the extent and shape of the "dead" metal region, and the behaviour of material along the longitudinal plane of symmetry, there are some divergences. B.C.R.A.

3070. The correction of elasticity measurements on slightly anisotropic materials.

H. PURSEY AND H. L. COX. *Phil. Mag.*, **45**, 295-302 (March, 1954).

3071. The viscosity-temperature behaviour of glass melts.

J. E. QUINCKE. *Z. Elektrochem.*, 1953, **57**, 715.

Viscosity measurements on the glass used in the glass-fibre industry are reported. With melts that easily crystallize the viscosity/temperature curves show discontinuities characteristic of crystallization, and the degree of crystallization can thus be ascertained.

3072. A relation between the activation energy for viscous flow and the Lennard Jones (12, 6) potential parameter, ϵ/k .

C. J. G. RAW. *J. Chem. Phys.*, 1954, **22**, 1627.

The relation is derived and a table giving the comparison of calculated and experimental values of the activation energy for viscous flow is shown. S.T.

3073. A study of the deformation of filled rubbers.

M. M. REZNIKOVSKII, L. S. PRISS AND B. A. DOGADKIN. *Kolloidnyi Zh.* 1954, **16**, (3) 211.

A study of interrelationships between the various moduli. G.W.S.B.

3074. Mechanism of the disruption of liquid jets.

E. G. RICHARDSON. *Appl. Sci. Res.*, 1954, **4A**, 374.

By means of a technique of micro-flash illumination, photographs are obtained of a water jet issuing from a straight nozzle. Three régimes of flow can be distinguished, each of which results in a special type of break-up into drops. The sinuous type and the type called "atomization" are discussed in the light of theory. A.

3075. Acoustic and ultrasonic relaxation processes.

E. G. RICHARDSON. *Appl. Mech. Rev.*, 1954, 377-378.

3076. Measurements on the damping of flexural vibrations in rods immersed in liquids.

E. G. RICHARDSON AND R. I. TAIT. *Österreichisches Ingenieur-Archiv.*, 1954, **8** (2/3), 200.

The decrement of vibrating rods of circular section and of flat reeds due to damping by a liquid ambient medium is measured, using both the Q method and a measurement of the rate of decay. The effects of the form of clamping and the shape of the vibrator are studied. It appears that the decrement in the frequency range up to 600 c/s. in a liquid is proportional to its shear viscosity and is not related to the ultrasonic absorption in the same liquid. A.

3077. Friction research.

G. ROBINSON. *J. Franklin Inst.*, 1954, **257**, 243.

This brief note refers to a high speed friction testing machine used for work at speeds of relative motion of 100,000 ft/min. with bearing pressures as high as 30,000 lbs/square inch. Mention is also made of a machine designed to test water-lubricated thrust bearings and of a project aimed at determining the optimum bearing material for solid freight car journal bearings. R.S.

3078. The viscosity of market cream.

J. ROTHWELL. *Dairy Inds.*, 1954, **19**, 477.

The factors influencing consistency and some methods of measurement are discussed. G.W.S.B.

3079. Higher approximation methods for the relaxation spectrum from static and dynamic measurements of visco-elastic materials.

F. SCHWARZL AND A. J. STAVERMAN. *Appl. sci. Res. A*, **4**, No. 2, 127-41 (1953).

It appears that better approximations are obtained when higher time-derivates of the moduli are measured. A chart showing quantitative relations between the accuracy of an approximation and the accuracy of various static and dynamic experiments is given.

SCI. ABS.

3080. Measurement of the viscosity of alkali-cooked pulps with cupriethylene-diamine.

G. SCHWERIN. *Aust. J. Appl. Sci.*, 1954, **5**, 242.

The cupriethylenediamine viscosity of various bleached alkali-cooked pulps has been measured. The solvent proved reasonably stable and measurements were reproducible and sensitive to small structural differences of the pulps. Corrections for variable velocity gradients were used to make all results comparable. Sodium hydroxide pulps were found to have a lower intrinsic viscosity than sodium sulphide pulps of comparable Klason Lignin content. There was an indication that the cupriethylenediamine solutions of sulphate pulps of *Pinus taeda* L. were more sensitive to atmospheric oxidation than the solutions of the euclypt sulphate pulps.

E.R.B.

3081. A note on the flow of gases through very fine tubes.

G. W. SEARS. *J. Chem. Phys.*, 1954, **22**, 1252.

It is shown that Knudsen's laws of flow for rarefied gases must be modified for very fine tubes. Gas flow occurs by diffusion of molecules in the adsorbed layer on the tube walls as well as in the gas phase. When the tube dimension is comparable to the mean free path in the gas film, the two flow mechanisms become comparable in effectiveness. A.

3082. Relation between the velocity profile and the sensitivity of electromagnetic flowmeters.

J. A. SHERCLIFF. *J. Appl. Phys.*, 1954, **25**, 817.

A formula for the potential difference set up in a fluid flowing along a duct of circular section and subject to a transverse magnetic field is derived. The effect of velocity profile is briefly discussed.

S.T.

3083. Objective measurements with instrumental tests.

D. SHEPPARD. *Instrument Practice*, 1954, **8**, 600.

A study of subjective errors in reading instruments, including some examples from rheology.

G.W.S.B.

3084. Polyvinylacetate. A light scattering and viscosity study.

A. R. SHULTZ. *J. Amer. Chem. Soc.*, 1954, **76**, 3422.

The prediction is confirmed that the extent to which a linear polymer molecule is expanded beyond its random-flight dimensions is a function of its molecular weight. The Flory-Fox limiting viscosity number theory is found to be valid for high molecular weight polyvinylacetate fractions in methyl ethyl ketone.

E.W.J.M.

3085. An observation of the falling of water-drops on to an oil surface.

B. N. SINGH. *Z. Phys.*, **136**, No. 1, 105-7 (1953) *In German*.

In an earlier paper (1944) Singh and Sinha describe a technique for observing water-drops falling on to liquid surfaces. The drops sink into the liquid, as a whole, up to a certain critical height and if the height from which the drops fall exceeds this critical value the drops break up into two or more droplets. In the present paper curves are given which show the relation between this critical height and (a) mass of drop, (b) composition of the oil into which they drop, (c) surface pressure of the oil, (d) temperature, (e) viscosity of the oil.

SCI. ABS.

3086. Dielectric relaxation, viscosity and molecular shape.

C. P. SMYTH. *J. Phys. Chem.*, 1954, **58**, (8), 580-582.

A theoretical consideration of the relations between dielectric relaxation time, measured (macro-) viscosity, and internal friction co-efficient (microviscosity). It is shown that the microviscosity is much smaller than the macroviscosity and that the former should be used in calculating relaxation times. G.E.B.

3087. Thermodynamics of viscoelastic behaviour (model theory).

A. J. STAVERMAN AND F. SCHWARZL. *Proc. K. Ned. Akad. Wetensch. B*, **55**, No. 5, 474-85 (1952).

The problem of calculating thermodynamic functions of visco-elastically behaving materials is treated by means of considerations on mechanical models. In simple relaxation or creep experiments the thermo-dynamic functions at time t depend on the relaxation or creep function at time $2t$. Formulae for the thermodynamic functions in general cases of prescribed strain and of prescribed stress are given. It turns out that models consisting of springs and dashpots connected by rigid side bars are thermo-dynamically equivalent whenever they are mechanically equivalent. This means that when two models are mechanically equivalent, not only the dependence of the forces and deformations on the time is identical, but also the amount of energy stored in the springs and dissipated in the dashpots. However, in order to reach this conclusion the mechanical equivalence of the models did not suffice, but certain physical properties of the links between the units had to be taken into account. Therefore the question whether or not the conclusions drawn from model-considerations are also valid for real viscoelastic materials, cannot yet be answered unambiguously. SCI. ABS.

3088. Non-equilibrium thermodynamics of visco-elastic behaviour.

A. J. STAVERMAN AND F. SCHWARZL. *Proc. K. Ned. Akad. Wetensch. B*, **55**, No. 5, 486-92 (1952).

Linear visco-elastic behaviour is described as resulting from an arbitrary number of molecular processes proceeding in a sample which is subjected to visco-elastic deformations. Describing the course of the molecular processes by a set of quantities, ξ_i , indicating the degree of progress of the processes, and applying non-equilibrium thermodynamics, one can construct a set of molecular processes which behave independently in a relaxation experiment. From this description the physical meaning of the relaxation spectrum becomes clear at once: the intensity of the spectrum at a certain frequency is a measure for the contribution of the independent molecular process of that frequency to the elasticity moduli at very short times. Boltzmann's superposition principle can be derived from these thermodynamical considerations without further assumption. The course of free energy in visco-elastic deformations is shown to be in accordance with the results obtained with models. SCI. ABS.

3089. Contribution to the theory of plasticity.

F. STÜSSI. *International Association for Bridge and Structural Engineering Publications*, 1953, **13**, 327-38.

For static stressing $\sigma_1, \sigma_2, \sigma_3$ of isotropic material, the specific deformations may be represented as linear combinations of the stress-strain diagrams for single axis stressing, if the stresses are "equivalent", i.e. if the stress condition $\sigma_1 \sigma_2 \sigma_3$ causes the same resulting shearing stress in the octahedral plane or the same comparison stress σ_g where $\sigma_g^2 = \sigma_1^2 + \sigma_2^2 + \sigma_3^2 - \sigma_1 \sigma_2 - \sigma_2 \sigma_3 - \sigma_3 \sigma_1$ as the compared single-axis stress causes. The proposed allowance satisfies the hypothesis of the constancy of the work of structural deformation for structural materials and passes over into Hooke's Law for stress conditions lying below the limits of proportionality. On the other hand these connections do not hold good if the material has previously been stressed beyond the proportionality limit since after such a loading the material no longer behaves isotropically. A.

3090. Stress and strain.

W. F. G. SWANN. *J. Appl. Phys.*, 1954, **25**, 1108.

An expression, which can be used for sinusoidal or steady state conditions, is constructed for visco-elastic materials relating the stress to the time derivatives of strain. S.T.

3091. The rheology of suspensions.

K. H. SWEENEY AND R. D. GECKLER. *J. Appl. Phys.*, 1954, **25**, 1135.

The rheological properties of concentrated suspensions of sized glass spheres in an equal-density medium has been investigated with the rotational viscosimeter. It has been found that the variation of fluidity with rate of shear can be expressed satisfactorily by a form of an expression suggested by Reiner relating the fluidity to the shearing stress, the fluidity at rest, and the fluidity at infinite shearing stress. It is also shown that values of the apparent fluidity are influenced by the time of shearing, the ageing of the suspensions, and temperature effect attributed to the work of shearing.

The viscosity of suspensions of sized spheres at concentrations as great as 55 volume per cent solids may be satisfactorily represented by either the relation of Mooney or of Maron, Madow, and Krieger; the identity of their relations is also shown. The constants for the equation relating viscosity and concentration are shown to be in satisfactory agreement with those predicted by Mooney. Constants for the viscosity-concentration equation are also given for several examples of experimental work selected from the literature; the form of equation proposed by Mooney relating viscosity and concentration is generally useful though the constants may not agree with the predicted values.

It has been found that the apparent fluidity of the glass bead suspensions decreases with an increase in particle diameter when the suspending fluid is zinc bromide in aqueous glycerol though the viscosity is independent of particle diameter when the suspending fluid is the nonaqueous mixture of ethylene tetra-bromide and diethylene glycol.

The viscosity of a bimodal system of glass beads was shown to decrease very significantly as the bulk density was increased by packing progressively smaller spheres into the interstices of the larger spheres of the bimodal system, in qualitative agreement with a relation proposed by Mooney. A.

3092. Precise measurements with Bingham viscometers and Cannon master viscometers.

J. F. SWINDELLS, R. C. HARDY AND R. L. COTTINGTON. *J. Res. Nat. Bur. Stand.*, **52**, 105-20 (March, 1954).

A critical study of the techniques used at the National Bureau of Standards with Bingham viscosimeters and Cannon kinematic viscosimeters. From SCI. ABS. 6321 (1954)

3093. On the co-efficient of restitution.

E. TAKEDA. Note in *J. Phys. Soc. Japan*, **8**, 790 (Nov.-Dec., 1953).

Pendulum experiments with 3 cm spheres of glass, ivory, copper and lead show how the co-efficient of restitution between two spheres of the same material decreases as the relative velocity before impact increases, the variation being especially marked as the velocity tends to zero. SCI. ABS.

3094. The dynamic mechanical and electrical behaviour of polymethyl methacrylate.

D. TELFAIR. *J. Appl. Phys.*, 1954, **25**, 1062.

The effect of temperature on the shear modulus and on the mechanical damping have been investigated with a torsion pendulum apparatus. S.T.

3095. On the effect of normal load on the frictional force in mixed boundary-hydrodynamic lubrication.

D. M. TOLSTOI. *Dokl. Akad. Nauk SSSR*, **90**, No. 5, 819-22 (1953) In Russian.

Deryagin's theory for the normal reaction between sliding surfaces under boundary lubricating conditions has been modified for surfaces where the roughness and speed of

sliding lead to mixed boundary and hydrodynamic conditions. Two extra terms are introduced to account for the parts of the load supported by hydrostatic compression of liquid trapped between surface asperities and by the wedging pressure of liquid flowing in small channels between asperities. The effect of these additional terms is considered for a number of surface geometries and lubricants. SCI. ABS.

3096. **Corrections and additions to "The mechanical foundations of elasticity and fluid dynamics".**

C. TRUESDELL. *J. Rational Mechanics & Analysis*, 1953, 2, 593.

Includes numerous additions to the bibliography of the original paper (Abstract 2492). R.R.

3097. **Viscous properties of plastic lubricants and rotational resistance of anti-friction bearings.**

G. V. VINOGRADOV AND M. D. BEZBOROD'KO. *Dokl. Akad. Nauk SSSR*, 90, No. 6, 1019-22 (1953) *In Russian*, English translation, *U.S. National Sci. Found. NSF-tr-165*.

Shows, experimentally, that with viscous (grease) lubricants, the part of a bearing resistance which depends upon the lubricant and also varies with temperature and speed may be determined uniquely in terms of the viscosity-temperature and viscosity-speed characteristics of the lubricant. SCI. ABS.

3098. **Investigations on the rheological properties of dispersed systems.**

M. P. VOLAROVICH. *Kolloidnyi Zh.*, 1954, 16, (3), 227.

A historical survey is given starting with pictures of capillary viscometers designed by Lomonosov (1751) and Petrov (1885) and the famous rotation instrument of Shvedov (1889). (Lomonosov's "viscometer" looks more like a Redwood than a strictly capillary viscometer; but is, in any case, remarkable for the date quoted.) General principles are discussed and a useful bibliography for over 100 papers is appended. The experimental section describes studies on compression of peat in which deformations are followed by X-rays. G.W.S.B.

3099. **On the elastic and optical properties of cellulose fibres.**

H. DE VRIES. *Delft: Technische Hogeschool* (1953), 111 pp.

A detailed investigation of the deformation properties of regenerated, continuous cellulose fibres, in which an attempt is made to provide a basis for the classification of such fibres. From Sci. Abs. 3899 (1954).

3100. **Non-Newtonian viscosity of dilute high polymer solution. I. Preliminary observation and effect of solvent.**

E. WADA. *J. Sci. Res. Inst. [Tokyo]* 47, 149-58 (Dec., 1953).

Non-Newtonian viscosity of fractionated polymethyl metacrylate solutions in various solvents was measured over a wide range of shear rate with a Hess-type horizontal viscometer. Effects of solvent, temperature, concentration, degree of polymerization and plasticizer were investigated. Viscosity decreases with increasing rate of shear and (a) the better the solvent, (b) the higher the degree of polymerization and the concentration, and (c) the lower the temperature, the more markedly non-Newtonian behaviour was observed. In all cases the observed values were represented by a power law $Q/R^2 = K(PR/2L)^N$ within about $5 \sim 1000$ dynes/cm² of shearing stress. SCI. ABS.

3101. **Non-Newtonian viscosity of dilute high polymer solution. II. Effects of concentration, temperature and degree of polymerisation; method of measuring true intrinsic viscosity.**

E. WADA. *J. Sci. Res. Inst. [Tokyo]* 47, 159-67 (Dec., 1953).

Non-Newtonian viscosity was measured at low rates of shear with an improved horizontal viscometer and a modified Ostwald viscometer. Viscosity-gradient curves clearly show antisigmoidal shape having a horizontal tangent at the origin. As the con-

centration and the degree of polymerization decrease and the temperature increases, initial linear parts of the curves extend towards high rate of shear. The shear dependence of the viscosity at zero concentration was in accord with Kuhn's theory within the experimental error in the measured range of shear rate. From these experimental results a new method of measuring the true intrinsic viscosity was proposed. SCI. ABS.

3102. Non-Newtonian viscosity of dilute high polymer solution. III. Tobacco mosaic virus solution.

E. WADA. *J. Sci. Res. Inst. [Tokyo]* **47**, 168-71 (Dec., 1953).

This was measured and the results compared with Kuhn's and Saito's theory concerning prolate spheroid solution. Axial ratios $P=a_1/a_2$ (where a_1 is the major and a_2 the minor axis) obtained were: (1) 20 for $c=1.14$ g/l (assuming $a_2=15$ m μ in the theory), (2) 19 for $c=1.14$ g/l and 17 for $c=0$ (Simha's or Kuhn's theory), and (3) 18.8 for $c=0$ (light scattering measurements). SCI. ABS.

3103. On small disturbances of plane Couette flow.

W. WASOW. *J. Res. Nat. Bur. Stand.*, **51**, 195-202 (Oct., 1953).

The Orr-Sommerfeld equation for the function $\phi(y)$, which appears in the component $\phi(y) \exp \{i\alpha(x-ct)\}$ of the stream function, is analyzed in detail for the case of plane Couette flow. A set of solutions is found whose asymptotic behaviour as $\alpha R \rightarrow \infty$ can be calculated in the whole complex y -plane (R is the Reynolds number). A disturbance with given α is proved stable, for any α , if αR is sufficiently large. In addition, an investigation is made of the asymptotic properties of an allied equation for which, in contradistinction to the singular Couette case, an inner friction layer does exist. SCI. ABS.

3104. The viscosity of glass as a function of the temperature.

A. WINTER-KLEIN. *Verres et Réfr.*, 1953, **7**, 217.

A revised definition of the co-efficient of viscosity is suggested and the resultant theoretical studies are noted. The vitrification process in glass appears to be closely associated with definite viscosity, e.g. 10^{13} poises. To study viscosity variation in the transformation field, a complete curve of the viscosity from room temperature to high temperatures must be known. A complete curve has therefore been traced from data obtained from the work of Lillie, Jones, Gérardand, Troussard, Blaimont, De Bast, Migeotte, Vandecapelle, and Pearson, for glasses of similar compositions. The curve comprises 2 slightly sloping sections joined by a steeper part. The change in viscosity, like that of other physical constants, shows the existence of the transformation region. The limits of the transformation region deduced from the viscosity variation (10^8 - 10^{15} poises) seems in accord with those deduced from the refractive index. The existence of the transformation region is also shown by the variation with temp. of the activation energy (H) and the constant (A) according to the formula $\eta = AT_e^{H/RT}$. (5 figs., 2 tables.) B.C.R.A.