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THE BRITISH SOCIETY OF RHEOLOGY

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New Memberships accepted at Committee Meeting held on 14th February.

Mr. Harold John Richards, P.A.T.R.A., Randalls Road, Leatherhead, Surrey.
Interests : Printing Inks.

Dr. K. J. Hill, John & E. Sturge Ltd., Lifford Chemical Works, Lifford Lane, Kings Norton, Birmingham 30. Interests : Pastes and dispersions of solids by rotational and efflux viscometry.

Mr. D. Abson, Research Department, John Mackintosh & Sons Ltd., Albion Mills, Halifax, Yorkshire. Interests : Viscosity and plasticity of foodstuffs.

Mr. A. Rimmer, Research Department, Pilkington Bros. Ltd., St. Helens, Lancs.
Interest : Glass.

Dr. F. L. Hudson, Textile Chemistry Department, College of Science & Technology, Sackville Street, Manchester 1. Interests : Paper and plastics.

Dr. J. S. Sodhi, A.B. Casco, Stockholm, Sweden. Interests : Rotational viscometry, thixotropy.

Mr. A. D. Bramhall, 64 Park Road West, Birkenhead, Cheshire. Interest : Petroleum products.

Mr. M. C. Day, Bexford Ltd., Brantham, Manningtree, Essex. Interests : Rheology of Non-Newtonian solutions, and visco elastic materials.

Mr. J. C. Holden, 18 Defoe Avenue, Kew, Richmond, Surrey. Interests : Emulsions and colloid suspensions, viscosity and thixotropy measurements.

Mr. R. G. Kinsman, 111 Watford Road, Croxley Green, Rickmansworth, Herts. Interests : Printing inks, high shear studies and relaxation methods.

Mr. J. Dow, Smith & Nephew Research Ltd., Hunsdon Laboratories, Ware, Herts. Interests : Plasticized rubber compounds, adhesion.

News of Members.

Dr. Vernon G. W. Harrison, our editor for many years and a founder-member of the Society, has been appointed the Director of Research of P.A.T.R.A.

News of other Societies.

Cahier du Groupe Français d'études de Rhéologie. The "groupe Français d'études de Rhéologie" are publishing from the Centre National de la Recherche Scientifique a "Cahier" containing news, bibliography, articles with diagrams, abstracts, etc. Among the articles in the first issue were :—

Pourquoi un "Cahier de Rhéologie"?

Les Groupes d'Etudes de Rhéologie : une famille internationale, par G. W. Scott-Blair.

La vie du Groupe Français d'Etudes de Rhéologie, par P. Thirion (Institut Français du Caoutchouc).

Quelques remarques sur les courbes de fluage des métaux, par A. Constant et C. Crussard (Institut de Recherches de la Sidérurgie).

Essais à charge constante et température croissante sur polyméthylméthacrylate, par G. Fabre (Centre d'Etudes des Matières Plastiques).

Le choix d'un viscosimètre, par G. Vallet (Centre de Recherches de la Compagnie Saint-Gobain).

Microrhéomètre à grande gamme de mesure, par A. Képès (Centre de Recherches de la Compagnie Saint-Gobain).

Project de Terminologie française de Rhéologie.

A useful list is given, page 37, from which the following are taken :—

Anomalous viscosity	Viscosité anormale	anomale Viskosität
Apparent flow	Ecoulement apparent (ou fluage)	scheinbares Fliesen
Apparent micro-flow	Micro-écoulement apparent	scheinbares Mikrofließen
Apparent viscosity	Viscosité apparente	scheinbare Viskosität
Brittle solid	Solide fragile (à l'essai de résilience)	spröder Festkörper
Creep	Fluage (ou déformation retardée)	Kriechen
Creep recovery	Reprise (ou recouvrance) retardée	Kriech-Erholung
Decelerating fluid	Fluide décélérant	verzögerte Flüssigkeit
Deformation	Déformation	Verformung
Delayed elasticity	Elasticité retardée	nachwirkende Elastizität
Elastic shear	Cisaillement élastique	elastischer Schub (siehe Schub)
Fatigue	Fatigue	Ermüdung
Flow-elasticity	Visco-élasticité — Fluo- élasticité	Fließelastizität
Fluid elastic deformation	Déformation fluído- élastique	fließelastische Verformung
Hysteresis loop	Boucle d'hystérésis	Hysteresisschleife
Initial yield-value	Seuil d'écoulement initial	Anfangs-Fließfestigkeit
Limited deformations	Déformations limitées	begrenzte Verformung
Low elasticity	Elasticité de faible amplitude	Tiefelastizität
Non-recoverable deformation	Déformation permanente	bleibende Verformung (irreversible)
Permanent shear	Cisaillement permanent	bleibende Schubverformung
Rate of flow	Vitesse d'écoulement	Fließgeschwindigkeit (Stromstärke?)
Recovery	Reprise (ou recouvrance)	Erholung
Shear hardening	Durcissement de cisaillement	Schubhärtung
Thixotropy	Thixotropie	Thixotropie
Work hardening	Consolidation (écrouissage)	Wirk-Härtung

A summary of the second number is as follows :—

La vie du Groupe Français de Rhéologie, par P. Thirion (Institut Français du Caoutchouc).

Quelques expériences de biréfringence mécanique, par B. Persoz et J. Bonnet (O.N.E.R.A.).

Critères d'une expérimentation reproductible sur les matières plastiques, par A. J. Kovacs (Centre de Recherches sur les Macromolécules).

Extraits de l'ouvrage de H. Green : Industrial Rheology and Rheological Structures.

Traduction française du tableau de classification du "Rapport sur les Principes de Nomenclature Rhéologique" établi par J. M. Burgers et G. W. Scott-Blair.

Note sur le microconsistomètre, par M. Képès (Compagnie Saint-Gobain).
Le coin du constructeur.

Comptes-rendus de la Commission Nationale de Rhéologie.

Les relations internationales.

The third number includes the following papers read before the group :—

Quelques généralités sur la Rhéologie des suspensions, par R. Durand et H. Lafuma.

Propriétés Rhéologiques des boues de forage, par A. Thomas.

Le Rhéologie dans l'industrie du ciment, par M. Papadakis.

La Rhéologie des coulis d'injection, par R. Barbedette.

Le Rhéologie et la Thixotropie des liants hydrocarbonés et de leurs compounds,
par M. Duriez.

Society of Rheology (U.S.A.) 1956 Annual Meeting. This was held at the Mellon Institute, Pittsburgh on November 7th, 8th and 9th. The technical programme of five half-day sessions covered a broad range of fields of interest to Rheologists. Once again the bringing together of scientists from such diverse fields of interests as adhesives, metallurgy, polymers and viscous liquid through the common bond of rheology produced stimulating discussions and resulted in cross fertilization of the various fields represented.

The Social Hour Smoker was held at the Pittsburgh Athletic Association on the evening of November 8th. Dr. J. H. Dillon acting as proxy for Sir Hugh Taylor made the presentation of the 1956 Bingham Medal to Arthur V. Tobolsky. This presentation speech will be printed in the forthcoming first issue of the Transactions of the Society of Rheology. Departing somewhat from the usual custom of discussing a technical subject Dr. Tobolsky presented his views on the economic and sociological problems of the scientist in our time. His very pertinent remarks were well received and it is planned to have this paper published in an early issue of Physics Today. Following the presentation and acceptance of the Medal, the formal meeting was adjourned and the remainder of the evening was devoted to informal discussion. Once again this part of the programme of the Annual Meeting was found to be most stimulating and productive of interchange of ideas.

The Society now has a membership of about 400 personal and 40 company members.

The National Bureau of Standards is setting up a Rheology Section under Dr. Robert S. Marvin.

5th Japanese Symposium—The 5th Japanese Rheology Symposium was held in Kyoto, 9th–11th November, 1956, under the joint auspices of the Japanese Chemical Society, Physical Society, High Polymer Society and Material Test Association. There were 20 contributions including an invited lecture given by Dr. H. Leaderman of the National Bureau of Standards, who came to Japan as a visiting professor under the Fulbright act for 1956–57.

Proposals on the Japanese translations of rheological terms on the basis of "Cahier du Groupe Français d'Études de Rhéologie" were introduced by Prof. Tamamushi at this meeting, which will be worked out by the Nomenclature Committee in the near future.

The abstracts, in English, of papers presented to the Symposium are now under preparation.

Swedish Group—A Swedish group, organised as a special section for Rheology, has been formed by the Swedish National Committee for Mechanics.

The President of the Group is Docent E. Forslind, the Royal Institute of Technology, Stockholm 70, the Vice-President is Professor H. Faxen and the Secretary is Dr. J. Kubat, c/o Svenska Traforskningsinstitutet, Swedish Forest Products Research Laboratory, Paper Technology Department, Drottning Kristinas Vag 61, Stockholm, O, Sweden. The Section of Rheology was started on October 10th, 1956 in connection with a conference with Professor Marcus Reiner, Haifa, as guest lecturer. In seven lectures a review was given on rheological problems in Sweden.

Summaries of papers to be read at the "Rheology of Elastomers" Conference on May 30th and 31st, 1957 at the Rubber Producers Research Association at Welwyn Garden City.

The Present Status of the Theory of Large Elastic Deformations by

L. R. G. TRELOAR (British Rayon Research Association).

The statistical theory of rubber elasticity has provided the essential molecular basis for the interpretation of the principal elastic phenomena encountered in rubberlike materials, and leads to formulae for the stress-strain relations which agree to a first approximation with the behaviour of a typical vulcanized rubber. There are, however, important discrepancies in detail, which may be represented in terms of a more general phenomenological theory. The general basis of the phenomenological theory is discussed, and the particular form of the theory devised by Mooney is considered in some detail.

The Tearing of Rubber by

H. W. GREENSMITH (British Rubber Producers' Research Association).

A brief review is given of some of the work carried out at the B.R.P.R.A. on the tearing of rubber. The methods originally evolved for measuring the tear resistance of rubber have enabled the growth of tears to be studied under controlled conditions, providing an effective means of studying the rupture properties of a rubber.

The measurement of a characteristic tearing energy is described, and the interpretation of this energy is briefly discussed. A short account is then given of the information which can be derived from tearing energy measurements on tears propagated at various rates and temperatures.

Temperature Frequency Relationships of Dielectric and Mechanical Properties of Polymers by

A. R. PAYNE (Research Association of British Rubber Manufacturers).

The experimental results from mechanical and dielectric measurements can be treated by the method of reduced variables developed by Ferry. If the material behaves according to certain theoretical conditions, the treatment yields an overall curve relating the chosen physical parameter to an extended frequency scale. The theory of reduced variables is discussed and applied to the mechanical measurements of an unvulcanized, a lightly vulcanized, a hard vulcanized (Ebonite) rubber and also a carbon black filled natural rubber vulcanizate, and the derived relationships for the real and imaginary parts of the complex shear modulus are presented by overall master curves, which allow the experimental results obtained over a frequency and a wide temperature range to be presented very concisely. The dielectric properties of unvulcanised and vulvanised natural rubbers are compared with the mechanical data. A linear relationship between the reference temperature T_s (related to the second order glass transition temperature) and combined sulphur content is shown. The complete range of the transition from the rubbery to the glass-like state has been investigated and the four regions of viscoelastic behaviour are demonstrated (low temperature glassy region, transition region, the pseudo static rubbery elastic plateau and the flow region).

The second part of the paper discusses the variation of the temperature with the frequency at which the maximum of $\tan \delta$ occurs. As the customary exponential expression between the relaxation time and absolute temperature with a constant activation energy is not valid, the following algebraic one has been found, by Ferry *et al*, to describe the temperature dependence:—

$$\log a_T = -c_1 (T - T_s) / (c_2 + T - T_s)$$

where a_T represents the ratio of any relaxation time at temperature T to its value at a reference temperature T_s which is suitably chosen for each system. c_1 and c_2 are constants. Nearly all the data on polymeric materials appearing in the literature, relating temperature variation with the change of frequency at which the maximum of the $\tan \delta$

peak occurs, have been analysed for their fit to the above empirical equation. The nature of the polymer has a marked influence on the manner in which the experimental results fit this equation, and it is found that materials can be separated into three distinct groups. The grouping can also be based on the chemical structure of the material, for materials with a marked hindrance to movement on one hand are clearly distinguished from those where the hindrance to movement is almost absent. The secondary maxima in the glassy amorphous region of a few materials were also studied for the fit of data with the empirical equation, as were also the secondary peaks in the softening ranges of some co-polymers. The distribution of maxima data for the dielectric materials have been compared with similar data obtained from mechanical measurements.

The derived T_s values obtained from fitting the $\tan \delta$ maxima data to the empirical equation are compared with T_s values obtained from other types of physical measurement, i.e. dynamic mechanical, stress relaxation, percentage creep or recovery and viscosity measurements.

From the wide variety of materials studied the empirical equation is an adequate description of the temperature dependence of the relaxation times within a range of temperature $T_s \pm 50^\circ\text{C}$.| Cross-linking and inclusion of filler materials does not invalidate the temperature reduction principle, and the empirical equation appears to be a universal function for the mechanical and dielectric relaxations of amorphous polymers and glass forming liquids.

An Experimental Study of Stress Relaxation and Viscous Flow in Natural Rubber

G. GEE, G. ALLEN and B. E. READ (University of Manchester).

The relaxation of stress in a natural rubber vulcanizate maintained at constant strain has been studied under conditions where only physical mechanisms contribute to the relaxation.

A continuous measurement of the change in stress in a rubber strip is made during the stretching process (0.05 secs) and for the first 10 seconds of the relaxation period when the strip is maintained at constant elongation. The stress is recorded on an oscilloscope during this period, and a meter is incorporated in the apparatus so that the relaxation curve can be determined over long periods of time (usually 15 mins). The rubber strip is enclosed in an air thermostat which is maintained to $\pm 0.5^\circ\text{C}$ during an experiment.

Variation of the extension ratio within the limits 1.12 to 1.55 has little effect on the relaxation curves obtained at a given temperature. The effect of temperature is more pronounced and has been investigated in the region 20°C to -45°C . At the higher temperatures the decay of stress is a linear function of $\log$ (time) except for a small initial peak. Below -30°C however the initial peak increases in size and the decay of stress is no longer linear with $\log$ (time). In the region -30 to -45°C Maxwellian behaviour is observed during the initial part of the relaxation, the stress being a linear function of the rate of change of stress. After approximately 0.1 secs a more complicated relaxation behaviour appears and ultimately the stress tends to be a linear function of $\log$ (time).

Eyring's equations for viscoelastic behaviour have been applied to the regions in which the decay of stress is linear with $\log$ (time), and "activation flow volumes" of the order of 10^{-19} ccs. are obtained. Tobolsky's superposition principle has also been applied to the relaxation curves, yielding an activation energy of 45 k.cals in the region -35 to -45°C . The activation energy for the relaxation process decreases as the temperature rises.

Elastic Effects in the Extrusion of Polythene.

P. L. CLEGG (Imperial Chemical Industries, Plastics Division).

It has long been recognized that polythene melts are elastic and various experiments have been specifically designed to measure this property. In the majority of practical cases polythene is fabricated by extrusion and it is with some of the phenomena associated with the extrusion of a visco-elastic melt that this paper will be concerned. Polythene

flows in a markedly non-Newtonian manner, and the conventional characterization of the melt by one point on its flow curve (e.g. its "Melt Flow Index") is not really adequate. In our work an inverted ram type of machine has thus been used to extrude a uniformly hot (190°C), homogeneous, polythene melt over a range of shear stresses through a series of cylindrical dies with differing (length/diameter) ratios.

A study of the extrudates and associated flow curves has shown that the extrusion of a uniform filament of gradually increasing diameter corresponds to the flow curve up to moderate shear stresses. At a critical shear stress (or shear rate) the flow curve undergoes a relatively sudden change of slope, and it is at this stress that the extrudate begins to show signs of irregularity. An intermittently wavy or knobbly extrudate is produced under these conditions and the disturbance becomes more violent as the shear stress is increased further, until it eventually distorts the entire filament. It is interesting to note that, especially in the case of high density polythenes, a remarkably uniform helical extrudate can be obtained at shear stresses in this critical region. Another form of irregularity which may occur at shear stresses either substantially below or, sometimes, above the critical stress, is surface roughness. In its early stage, this is a local, small scale, surface defect which again becomes more pronounced as the output rate is increased.

The former of these two irregularities has been investigated in detail: firstly by extruding filaments containing a coloured core and studying the appearance of this core as the output rate was increased, and secondly by taking cine films of polythene being extruded through various glass dies with different lead-in angles. The results of the first experiments indicated that the seat of the irregularity was in the body of the melt near the die entry and the films, which will be shown to the meeting, confirm this view. At low shear stresses a laminar flow region exists converging towards the die entry, this is surrounded by a streamlined flow system circulating radially outwards near the entry. As the shear stress is increased, this pattern begins to oscillate or precess, at first gently and then more violently, in the region just above the entry itself. As the shear stress is further increased the flow pattern breaks down completely and the main central flow stream becomes spasmodically choked off. The critical shear rate can be increased markedly, for dies of a constant diameter, by decreasing the lead-in angle sufficiently.

Some measurements of melt elastic properties have been made in a concentric cylinder and the results suggest that polymers for which irregular flow begins at lower shear stresses (or rates) have longer relaxation times. These polymers also have a lower value of the maximum shear stress as measured from a stress-strain curve obtained at a constant rate of shear strain.

No direct evidence could be found to corroborate the idea that melt fracture occurs during irregular flow.

The Recovery Behaviour of Polythene at Large Strains by

J. J. BENBOW (Imperial Chemical Industries Ltd., Akers Research Laboratories).

Descriptions of viscoelastic behaviour are usually based on Boltzmann's superposition principle and on theories derived from it. Although the limitation of this principle to small strains is well known, viscoelastic behaviour at very high strains has received much less attention. A marked deviation in behaviour from that expected from Boltzmann's theories was noticed in these laboratories during some experiments involving the indentation of polythene. To study the observed effects more quantitatively a series of torsion experiments have been made. In these, polythene cylinders were held twisted through various angles for fixed times and, when released, their recovery was measured. The imposed initial angle of twist was varied over a large range. At the smallest strains, of the order of 0.001, as expected the recovery conforms to Boltzmann's theory but over most of the range explored the results show pronounced deviations from it. The largest strains used were approximately 1.0; with these, the recovery is almost independent of the loading time. In other words, the ability of polythene to "remember" the duration of an imposed strain cycle decreases as the strain is increased.

High Temperature Tensometry and its application to Amorphous Polyethylene Terephthalate by

E. L. FOSTER and H. HEAP (Imperial Chemical Industries Ltd., Fibres Division).

Amorphous polyethylene terephthalate is a material which, at elevated temperatures, is able to crystallize either under the action of a stretching process or by the influence of the temperature alone. From the practical point of view, the former case is of greater importance since it results in oriented crystalline material with greatly enhanced strength.

In order to contribute towards a good understanding of the processes which occur in the spinning and drawing of this material into fibres, the stress-strain characteristics of initially amorphous material have been investigated at elevated temperatures. In order that the effect of the stretching process on crystallization might be studied, it was necessary to design an apparatus such that filaments could be tested at elevated temperatures but would spend a minimum amount of time at these temperatures, thereby minimizing the amount of crystallization which occurs solely as a result of the temperature.

This was accomplished by means of a modification to an Instron tensile testing machine which permitted the filament under test to be immersed in silicone oil at the required temperature. Under these conditions, the rate of heating of the filament was so rapid that the stretching test could be commenced immediately on immersion.

Stress-strain curves were recorded in the temperature range 90°C to 120°C over a wide range of rates of straining. These curves show that the shape of the stress-strain curve is markedly dependent on both the temperature and the rate of straining. At the lowest rates of straining, the behaviour of the material tends towards that of a simple viscoelastic material and a filament will extend to very great extensions at low stress. At the highest rates of straining, on the other hand, the stress strain curve is that of a material which undergoes some process of reinforcement and once this reinforcement has occurred, the filament breaks at high stress with very little further extension. At intermediate rates of straining, there is a gradual transition from one form of stress-strain curve to the other, but the rates of straining over which this transition occurs increase very rapidly with temperature.

A crude method of comparison is applied to these various sets of stress-strain curves in order to deduce the effect of temperature on the stretching process. A 'characteristic' stress-strain curve of arbitrary shape is the basis of this comparison and both the 'characteristic' rate of straining required to produce the curve of this shape and the 'characteristic' stress at the point of inflexion on this curve are examined as functions of the temperature.

A rapid rise of the 'characteristic' rate of straining with temperature and the approximate constancy of the 'characteristic' stress are consistent with the idea that the stretching of amorphous polyethylene terephthalate at elevated temperatures is basically a viscous flow process accompanied by a certain amount of molecular alignment which is controlled primarily by the stress resulting from the viscous flow. A reinforcement process takes place when a sufficiently high degree of molecular alignment is achieved and the rate of straining necessary to produce this reinforcement is thus dependent on the viscosity of the material.

Network Theories of Stress-Relaxation and Set in Rubber by

J. SCANLAN (British Rubber Producers Research Association).

The earliest attempt to treat the stress-relaxation and set occurring in stretched rubber strips during oxidative ageing in terms of changes in the vulcanized network was made by Andrews, Tobolsky and Hanson (*J. Applied Physics*, 1946, **17**, 352). These authors suggested what may be called the two-network hypothesis, i.e. that the rubber network becomes, because of rupture and cross-linking reactions, effectively two interpenetrating but independent networks. An immediate consequence is that cross-links introduced when the rubber strip has a certain length do not affect the tension at that

length. This paper is concerned with the closer examination of this treatment on the basis of the theories of rubber-like elasticity.

Scott and Stein (*J. Chem. Physics*, 1953, **21**, 1281) have attempted a more fundamental treatment based on the Kuhn-Wall-Flory theory of elasticity in the case where cross-link rupture and cross-link formation reactions proceed at equal rates. They reached the conclusion that the force would decrease more slowly than expected on the basis of the two-network theory, a result which they put down as due to new cross-links which, although not affecting the tension at the time of their introduction, later become effective. It is shown in the present paper however that their mathematical treatment, when applied to the case of cross-link formation in a stretched strip without breakdown, leads to the result that the force should increase, which is not consistent with this interpretation. It is also shown that this result is due to an erroneous assumption made by Scott and Stein in their treatment and that for this simple case the postulates, in fact, give the same result as the two-network theory.

The two-network hypothesis is also shown to be supported, in the simple case of cross-link formation only, by application of the James and Guth vulcanisation theory which makes unnecessary some of the restrictive assumptions of Scott and Stein.

Consideration is given to the applicability of the two-network hypothesis in the more complex case of simultaneous cross-link formation and breakdown. A complete solution of the problem has not been achieved but arguments are presented for believing that it can represent only an approximation, though probably a fairly good one in this case.

RHEOLOGY ABSTRACTS

3469. Deposition of Particles on to a Streamlined Body from a Stream.

A. G. AMELIN and M. I. BELYAKOV, *Koll. Zh.*, 1956, **18**, (4) 385.

Equations are developed for calculating numbers of oil droplets on back and front of cylinders of different sizes. G.W.S.B.

3470. The Rheological Behaviour of Aqueous Bentonite Dispersions.

J. BARNA and B. MARSCHALCO, *Acta Technica Hung.*, 1956, **15**, 77.

A rotary viscometer facilitating measurements in the range of 10^{-1} to 800 r.p.m. was used to test local montmorillonite and bentonite dispersions. The shear rate versus angular momentum curve shows three distinct parts. At shear velocities in the range 10^{-4} – 10^{-1} r.p.m. the dispersions behave as solids, in the range 0.1–50 r.p.m. transition to liquid behaviour takes place, while at still higher rates the behaviour can be characterized by a Bingham Body. A detailed analysis of the results and a theoretical discussion are given. P.F.

3471. Investigation of the Dynamic Properties of Synthetic Rubbers by the Method of Spontaneous Contraction.

G. M. BARTENEV, M. M. REZNIKOVSKII and M. K. KHROMOV, *Koll. Zh.*, 1956, **18**, (4) 395.

Authors' earlier treatments require extension if they are to apply to filled rubbers. "Internal friction modulus" is related to brittling temperature of vulcanized unfilled butadiene and natural rubber. G.W.S.B.

3472. Tests on the Improvement of the Plasticity of Kaolins.

A. A. BAUDRAN, *Bull. Soc., franc. Ceram.*, 1955, No. 26, 22.

Measurements of viscosity, pH, bending-strength, shrinkage, and setting-time in plaster moulds show that of the additions having a purely chemical effect the pyrophosphate seems to give the best results. On the other hand the bakelite, which confers some of its own physical characteristics on the treated kaolin, gives much more interesting results which cannot, however, be directly compared with those from the other products. A.

3473. A Viscometric Micro-Method for the determination of alpha-amylase in cereals and milling products.

B. BELDEROK, *Chem. Weekblad*, 1956, **52**, 649.

A modified Zeitfuchs cross-arm capillary viscometer, with a bulb-content of 0.35 ml, is used. The influences of beta-amylase and of other concomitant substances in the extract are taken into consideration. The method may be used for the analysis of single kernels. P.G.M.

3474. Determination of Dynamic Plastic Strain through the Use of Diffraction Gratings.

J. F. BELL, *J. appl. Phys.*, 1956, **27**, 1109.

A new method is given for measuring dynamic plastic strain in metals under impact loading. Strain-time curves for initial and reflected wave fronts have been determined using a gauge length of $\frac{1}{32}$ in. The measurements are made by observing the behaviour during strain of the diffracted and central images of an 8300 line reflection grating ruled on the specimen surface. A.

3475. The Determination of Dynamic Moduli and Internal Friction of High Polymers from Creep Measurements.

J. J. BENBOW, *Proc. Phys. Soc. B*, 1956, **69**, Pt. 9, 885

An account is given of the use of Fourier analysis to transform creep measurements to dynamic quantities with specific reference to some measurements made on polythene. The method is based on a technique described by Roesler, but additional theory is given which eliminates the necessity of determining the retardation spectrum explicitly. Using the derived dynamic quantities as a standard it is shown that more approximate methods provide sufficiently accurate transformations for many practical purposes if the retardation spectrum of the material is very flat. A.

3476. The Effects of Entrapped Air and Optically Oriented Clay on Aggregate Breakdown and Soil Consistence.

R. BREWER and A. V. BLACKMORE, *Aust. J. Appl. Sci.*, 1956, **7**, (1) 59.

Four fine-textured soil materials, which cover a wide range of consistences as described by Butler (1955), have been subjected to various physical tests and to thin-section studies. The results have shown that the behaviour of these materials under various conditions can be explained largely on the basis of the fabric of the original, undisturbed soil aggregates. E.R.B.

3477. Shock Waves in Elastic and Elastic-Plastic Media.

K. B. BROBERG., *K. Tekn. Högsk. Avhandl.*, 1956, No. 111, 141 pp.

This paper is a review of a present position and covers the literature plus experimental work done by the author. It is mainly concerned with the propagation of shock waves through metals, but some paragraphs deal with rock. The types of wave resulting from the detonation of a cylindrical charge against a plane surface and the impact of a sphere on such a surface are described and considered theoretically. The next section deals with the properties of the target materials and particular reference is made to the conditions under which they cease to behave elastically. The propagation of elastic waves is then considered, the waves discussed being plane, cylindrical and spherical. Sections deal with waves in a semi-infinite medium, in an elastic half-space having its surface subjected to an impulsive line or point load, in an elastic half-space subjected to impact by a sphere and an explosive charge, in a steel plate struck by a sphere and a plate subjected to an explosive charge. The propagation of shock waves in an elasto-plastic medium is then discussed with special reference to detonation of a charge in contact. Reflections of shock waves are also considered and illustrated by such phenomena as spalling and scabbing. A.

3478. On the Hydrodynamics of Visco-Elastic Fluids.

L. J. F. BROER, *Appl. sci. Res.*, 1956, A 6, 226.

The hydrodynamical equations of motion for a visco-elastic fluid are established. The exact solution for periodic laminar flow in a cylindrical tube and an approximate solution for flow in a film of variable thickness are given. The importance of the elasticity number $N = \tau V/R^2$, determining the ratio of elastic to inertia forces, is pointed out. AUTHOR.

3479. Flexure of Thin Elastic Plates under specified edge tractions.

V. CADAMBE, R. K. KAUL and S. G. TEWARI, *Indian J. Phys.*, 1955, **29**, 403.

This problem is solved by two second-order simultaneous differential equations in U and V defining the bending and twisting moments in the plate. The Southwell differential equations and the boundary conditions are derived by variational principles and to illustrate the definite advantage of the process, two typical examples are also worked. A.

3480. Intrinsic Viscosity (of a Polymer Solution) as a function of Velocity Gradient. II.

M. ČOPIČ, *Ž. Chim. phys.*, 1956, 53, 440.

Is derived for a flexible coil using the dumb-bell approximation, and taking account of the tensor character of the hydrodynamic interactions of the segments. The gradient dependence is due to the anisotropy of the interactions and it is unnecessary to postulate an "inner viscosity" as in Kuhn's theory. The intrinsic viscosity decreases with increasing gradient and the deviations from the zero gradient value are proportional to the second power of the gradient, to a first approximation. A graph shows qualitative agreement between the theory and experimental data for polystyrene in benzene and in MEK. A limiting value of 25% of the zero gradient is predicted for the intrinsic viscosity and the gradient dependence is independent of the molecular weight of the polymer. The coefficients of diffusion are shown to be tensor quantities. A.

3481. On the Equation of Motion for a Particle in Turbulent Fluid.

S. CORRSIN and J. LUMLEY, *Appl. sci. Res.*, 1956, A 6, 114.

A comment on the dissertation of C. M. TCHEN.

(Mean value and correlation problems connected with the motion of small particles suspended in a turbulent fluid. Dissertation Delft 1947, Martinus Nijhoff, the Hague.) P.G.M.

3482. Mechanization of Curd Fusion in (Cheddar) Cheese Manufacture.

J. CZULAK and L. A. HAMMOND, *Austral. J. Dairy Technol.*, 1956, 2, 58.

The "cheddaring" of curd by classical methods involves a gradual syneresis of whey and takes much time. New processes involving higher temperatures and applied pressures can produce the required curd fusion but studies of the nature of the deformation of curd particles are needed. The method involves compression of a curd mass so restrained as to flow in pure shear, the amount of which is measured. The more the flow under these conditions, the better the fusion. A machine for promoting fusion under pressure is described. G.W.S.B.

3483. The Elasto-Plastic Behaviour of a Hard Porcelain from the Moist Mix to the Fired Product.

E. DEEG, *Ber. dtsh. keram. Ges.*, 1956, 33, 1.

The damping factor (ϵ) and elasticity modulus ($\bar{E}$) are combined into a complex elasticity, modulus $E = E(1 + i\eta)$. $\bar{E}$ is determined from the resonance curve of a test-rod in flexural vibration. Since there is only a slight strain on the specimen and since measurements could be carried out at frequencies of about 1 kc/s., it was possible to measure the damping factor, which is a criterion of non-elastic deformation, and also the elasticity modulus. For 27% water content, E was 6×10^{10} dynes/cm.² The method described is suitable for the investigation of the firing behaviour of ceramic bodies. Reactions during firing are accompanied by changes in E or in η or in both simultaneously as a result of the release of adsorbed water, decomposition of the octahedral layer of kaolinite, quartz conversion, collapse of the SiO_4 layer of metakaolin, mullite formation or the melting of feldspar. With the decomposition of kaolinite as an example it is shown that the measurement of η is also suitable for investigating the rate of reaction in the solid state. A.

3484. The Mechanism of Rupture of Solid Bodies.

B. V. DERYAGIN, N. A. KROTOVA and V. V. KARASEV, *Dokl. Akad. Nauk SSSR*, 1956, 109, 728.

The variation of the work of splitting 'A' with velocity 'v' depends on the external pressure. For a given v, as the pressure is decreased, A increases, passes through a maximum and then decreases. A is lower in argon than in air due to variation in the magnitude of the discharge potential at separation of an electric double layer. A.

3485. On the Role of Polymer Chain Diffusion in the Mechanism of Adhesion and Auto-adhesion of Rubbers.

B. V. DERYAGIN, S. K. ZHEREBKOV and A. M. MEDVEDEVA, *Koll. Zh.*, 1956, **18**, (4) 413.

Whereas in many cases adhesion of pairs of rubbers depends on cold-welding of surfaces, butyl rubber adheres through quite other types of mechanism. G.W.S.B.

3486. On Uniqueness in the Theory of Plasticity.

D. C. DRUCKER, *Quart.-appl. Math.*, 1956, **14**, (1), 35.

The fundamental definitions of work hardening and perfect plasticity have far-reaching implications with respect to uniqueness of solution for elastic-plastic bodies. Satisfaction of the basic postulate that, in a cycle, work cannot be extracted from the material and the system of forces acting upon it, guarantees an existing solution to be stable but not necessarily unique. Uniqueness follows for the usual linear relations between the increments or rates of stress and strain and also for combinations of such linear forms. Conversely, lack of uniqueness results for an elastic-perfectly plastic body when, for example, the maximum shearing stress criterion of yield is employed with the Mises flow rule. D.P.D.

3487. The Extrusion of Metals. (A Simple Theory of the Criteria Press Design and Process Efficiency in the Industrial Extrusion of Metals).

P. FELTHAM, *Metal Treatment* 1956, **23**, 440.

(Summary in Bulletin No. 48, Sept., 1956, p. 7).

3488. Formation of Submicroscopic Inhomogeneities in Plastic Deformation of Rocksalt.

R. I. GARBER, I. V. OBREIMOV and L. M. POLYAKOV, *Dokl. Akad. Nauk SSSR*, 1956, **108**, 425.

Rocksalt crystals are mounted in a beam of light and subjected to longitudinal stress. When gliding sets in an appreciable intensity of Tyndall scattering is observed; intensity increases with increasing distortion. Experiments are interpreted by assuming that the gliding planes are occupied by submicroscopic scattering centres. A.

3489. Movement of a Newtonian Liquid between Rotating Coaxial Cylinders in presence of Internal Thermal Processes affecting Viscosity.

T. YA. GORAZDOVSKII and S. A. REGIRER, *Zh. tekhn. Fiz.*, 1956, **26**, No. 7, 1532.

Familiar viscometric formulae are corrected for the effect of frictional heating on the coefficient of viscosity. By the way of an example it is shown that this correction amounts to 5% of the viscosity of castor oil if the radii of the cylinders are 2.5 and 2 cm and the angular velocity of the inner cylinder increases from 1.2 to 11.35 sec⁻¹ and the outer cylinder stays at rest. A.

3490. An Investigation of the Forces Required for Tube Drawing.

R. HANTOS, J. HEERINGER and J. SCHEY, *Acta Technica Hung.*, 1956, **15**, 127.

No differences were found in the plug drawing of mild steel tubes with phosphated or lime coated surfaces, the frictional drag being about the same in either case. The forces acting on the mandrel were about 10–20% of the drawing force. Formulae for the calculation of the pull, as proposed by several authors, were tested, those of Geleji giving closest correspondence with experiment. The tests were on a works scale. P.F.

3491. Temperature Dependence of the Viscosity of Liquids.

E. J. HELLUND, *J. chem. Phys.*, 1956, **24**, No. 6, 1173.

The consequences of the introduction of long-range disorder into the theory of the liquid state are examined. Application is made to the analysis of viscosity. A.

3492. Deformations of an Elastic-Plastic Cylindrical Shell with Linear Strain Hardening.

P. G. HODGE, JR., and F. ROMANO, *J. Mech. and Physics of Solids*, 1956, **6**, (3), 145.

A thin-walled circular cylindrical shell of finite length is subjected to a slowly increasing uniform radial pressure. Using simplifying assumptions the complete solution is obtained directly from the governing equations. D.P.D.

3493. Elastico-viscous Properties of Solutions of Polyisobutylene.

L. V. IVANOVA-CHUMAKOVA and P. A. REBINDER, *Koll. Zh.*, 1956, **18**, (4), 429.

Viscous and elastic properties of solutions of polyisobutylene in xylene and toluene at all concns have been measured between parallel plates and coaxial cylinders at 20°C. The limiting maximum viscosity (L.M.V.) for true flow varies from $6 \cdot 10^{-3}$ to $5 \cdot 10^{10}$ poises. Equilibrium elastic modulus (E.E.M.) is linear with conc. The L.M.V. and E.E.M. are shown to be independent of shear stress over a wide range. G.W.S.B.

3494. On the Regularity of the Development of Shear Strains and Stress Relaxation in Elastomers and their Solutions.

L. V. IVANOVA-CHUMAKOVA and P. A. REBINDER, *Koll. Zh.*, 1956, **18**, (5), 540.

Authors describe apparatus for measuring elastic deformation and subsequent stress relaxation of polyisobutylene. Relaxation follows a somewhat complicated modification of the Maxwell equation. G.W.S.B.

3495. Slurry Tests.

R. E. JACOBY, *Rock Prod.*, 1956, **59**, (2), 122, 126.

A slurry test laboratory for the analysis of cement slurries is described and its use in checking and studying the flow characteristics of slurries (non-Newtonian) is explained. D.P.D.

3496. Plastic Deformation at a Low Temperature of Single Crystals of Refined Aluminium.

B. JAOU, *C.R. Acad. Sci. (Paris)*, 1956, **242**, No. 26, 3039.

The deformation curves of single crystals at -195°C are found to be but little influenced by the orientation of the specimens, in contrast to the behaviour at room temperature. Furthermore the geometry of the deformation is of the same form for all the experiments in tension at -195°C . The deformation is more confused than at room temperature, the slip lines being fine and numerous, but also short and sinuous and more than one system is seen to be operating. Study of the variation in the rate of hardening shows that the mechanism proposed by Friedel starts to develop actually at the elastic limit. A.

3497. Variations in the Slope of the Curves of Plastic Deformation of Metals.

B. JAOU, *C.R. Acad. Sci. (Paris)*, 1956, **243**, No. 1, 16.

After a "pseudo-elastic" (reversible slip) and an "elastic-plastic" (only some slip reversible) region, the slope of the deformation curves reaches a value equal to $E/100$ where E is the modulus of elasticity. After this point deformation is completely plastic and the rate remains constant if the temperature is sufficiently low; otherwise the hardening increases less rapidly and the curve departs from theory. This rate of hardening already observed in single crystals can perhaps be considered as a modulus of plasticity. Deformation curves for polycrystalline Al-Mg alloys, Al, Zn, Fe, Cu, Fe-Ni and stainless steel are given. A.

3498. Viscoelastic Properties of Ice.

H. H. G. JELLINEK and R. BRILL, *J. appl. Phys.*, 1956, **27**, 1198.

An apparatus has been constructed for the study of deformation under tension of single and polycrystalline ice. Deformations down to 10^{-5} cm could be measured. Deformation of single and polycrystals was investigated as a function of time, stress and

temperature. Whereas the strain rate for polycrystalline ice decreases with time, that for single glacier ice increases linearly with time. The deformation for fine-grained polycrystalline ice consists of an instantaneous elastic deformation, a transient creep and a steady state creep. Deformation curves can be represented by empirical equations. The recovery curves on removal of the loads have also been investigated and the plastic flow has been deduced from the residual deformation after complete recovery. This plastic flow was found to be Newtonian within the range of stresses investigated and the viscosity coefficients can be represented by an exponential relationship. A.

3499. Report on 8th Conference on General Questions concerning Chemistry and Physics of High-Polymer Compounds.

V. A. KROPACHEV, *Koll. Zh.*, 1956, **18**, (4), 506.

3500. Application of the Equation of Stochastic Processes to Mechanics of Loose Bodies.

J. LITWINISZYN, *Arch. Mech. Stos.*, 1956, **8**, No. 4, 393.

Instead of the usual rheological equations of state, the theory of stochastic processes is applied to the description of physical phenomena such as turbulent flow, filtration, displacements in sand and of the earth's crust. An abstract model of heuristic importance is described. E.W.J.M.

3501. On Volume Visco-Elastic Theory of Fluids and its Application to Sound Dispersion Phenomena.

H.-F. LU, *Scientia Sinica*, 1956, **5**, No. 1, 33.

It is shown that the volume of viscoelastic theory of fluids is not merely applicable to the case of structural relaxation, but equally applicable to all three kinds of relaxations—thermal, structural and chemical. From an equation of irreversibility of volume change is inferred the equation of thermal irreversibility as originally assumed by Herzfeld and Rice for the case of thermal relaxation. Also, in the case of chemical relaxation, the equation of irreversibility of volume change is shown to imply the equation of chemical irreversibility as obtained from kinetic considerations by Liebermann. Regarding the application of this theory to sound absorption and dispersion phenomena, Bourgin-Kneser equations for the case of thermal relaxation and the Liebermann equation for the case of chemical relaxation are shown to follow directly from the results of the theory of compressibilities when appropriate thermodynamic considerations have been made. Finally, the appropriateness of the definition of volume viscosity is discussed. A.

3502. On Creep and Creep Testing Machines.

J. MADEJSKI, *Rozprawy Inzynierskie*, 1956, **4**, 43.

An analysis is made of the effects of the characteristics of soft and hard vertical tensile creep machines and of the influence of machine vibrations on the creep curves of materials having idealised rheological properties. The non-linear part of creep curves are shown to be unsuitable for use in the computation of the rheological behaviour of materials. P.F.

3503. The Plastic Buckling of a Bar.

J. MADEJSKI, *Rozprawy Inzynierskie*, 1956, **4**, 353.

The time factor is considered. The effective buckling stress coincides with the true yield point above which the temperature of the test piece starts increasing. If the stress exceeds the true yield point the test piece will be broken after a finite period. A relation is given for the breaking strength and bar dimensions. E.W.J.M.

3504. On Viscoelastic Bodies Behaving Linearly.

J. MANDEL, *C.R. Acad. Sci. (Paris)*, 1956, **242**, No. 24, 2803.

An application of a new method is made to the theory of propagation of stress discontinuities and sinusoidal elastic waves. A.

3505. The Valency Theory of Viscosity and the Fluidity in the Critical Temperature Region of difficulty-meltable Glass-forming Substances.

R. L. MYULLER, *Zh. prikl. Khim.*, Leningr., 1955, 28, 1077.

An equation is developed relating the activation energy and temperature in a random-network system. The theoretical constant in this equation agrees satisfactorily with the measured viscosities. The viscosity of glass-formers is governed by the presence in glass of non-ionizable oxides and depends directly on the nature of the valency bonding. Experimental results of the viscosities of silicates were used to determine values of free energy, entropy, and heat of activation and their variation with temperature. At temperatures considerably above the softening temperature the flow activating process occurs without an entropy increase. The critical region is characterized by a lower and upper limit, at which there is restrained and unrestrained atomic oscillation respectively. A.

3506. On the Steady Laminar Flow of certain Non-Newtonian Liquids through an Elastic Tube.

M. N. L. NARASIMHAN, *Proc. Indian Acad. Sci. A*, 1956, 43, No. 4, 237.

A study of the effect of cross-viscosity on the radius of an elastic tube when certain highly viscous non-Newtonian liquids flow through it under pressure gradient. The effect is found to be of opposite nature to that of inertial and viscous forces and causes the radius of the tube to increase with the distance along the axis. A.

3507. The Influence of Vibration on the Structural-mechanical Properties of Asphalt-concrete as a Thixotropic Colloidal System.

S. K. NOSKOV and N. V. MIKHAĬLOV, *Koll. Zh.*, 1956, 18, (4), 461.

Author describes a "vibroplastometer" in which asphalt-concrete mixes are subjected to vibrations of controlled frequency and amplitude. Very big changes are produced in rheological constants, especially at large frequencies and amplitudes. G.W.S.B.

2508. Assemblage Stresses in Plates.

W. NOWACKI, *Archiwum Mechaniki Stosowanej*, 1956, 8, (2), 215.

P.F.

3509. On the Foundations of the Theory of Non-homogeneous Elasto-Plastic Bodies. II.

W. OLSZAK, *Bull. Acad. Polon. Sci. Cl. 4*, 1955, 3, 111.

Equations are formulated which describe the plastic flow when the yield value and the parameters in the stress-strain relations are general functions of position. Elastic terms in the equations are taken into account. Special attention is given to the case when the yield criterion at any point is related to the local stress-strain relations by its identification with the attainment of a certain value of the shear strain energy. A.

3510. Basic Theoretical Problems relating to Prestressed Structures.

W. OLSZAK, *Archiwum Mechaniki Stosowanej*, 1956, 8, (2), 53.

(Shortened version in *Appl. Mech. Rev.*, 1955, pp. 1-7).

P.F.

3511. Non-homogeneous Elasto-Plastic Semi-Infinite Plate Loaded by a Concentrated Force.

W. OLSZAK, J. MURZEWSKI and J. KOLECKI, *Archiwum Mechaniki Stosowanej*, 1956, 8, (2), 197.

P.F.

3512. The Orethotropy and Non-homogeneity in the Theory of Plasticity.

W. OLSZAK and W. URBANOVSKI, *Archiwum Mechaniki Stosowanej*, 1956, 8, (1), 85.

Yield criteria of materials showing orthotropic anisotropy are developed in several co-ordinate systems. As an example an application of the theory to a body showing polar orthotropy and axially symmetric non-homogeneity is investigated. P.F.

3513. On a Minimum Principle in Elastic-Plastic States.

M. V. DE PANDO, *Rev. Cienc. apl.*, 1956, 10, 97.

A basic explanation of the minimum principle relating to the equilibrium states of elastic-plastic systems is given; then the hypotheses on which the theory is based are critically examined, in particular their connection with the published theories on plasticity. A.

3514. Gradient Dependence of the Intrinsic Viscosity of Linear Macromolecules.

A. PETERLIN and M. ČOPIČ, *J. appl. Phys.*, 1956, 27, No. 5, 434.

3515. An Application of the Diffusion Equation to Viscous Motion with a Free Surface.

J. R. PHILIP, *Aust. J. Phys.*, 1956, 9, (4), 570.

The advance of a viscous translatory wave over a dry or initially submerged surface may be analysed by treating the problem as one in diffusion. Application to the study of the hydraulics of overland flow is mentioned. E.R.B.

3516. Flow Birefringence and Stress.

W. PHILIPPOFF, *J. appl. Phys.*, 1956, 27, No. 9, 984.

Simultaneous measurements of flow birefringence, shear and normal stresses on a 15% solution of polyisobutylene in decalin were performed. They proved that the extinction angle measured in birefringence is identical to the orientation of the principal tensile stress calculated from the normal stress measurements and that the birefringence was proportional to the difference in principal stresses in flow. A detailed discussion of the significance of this result is given with a possibility of a far-reaching generalization of the mechanical behaviour of high polymer solutions. A.

3517. Influence of NaCl and C_2H_5OH on the Mechanical Properties of Al_2O_3 sols.

P. V. RUFIMSKIĬ, *Koll. Zh.*, 1956, 18, (5), 589.

Studies movement of short column along a narrow tube. Measures rates of thixotropic setting in terms of wall-stress required to initiate movement along tube. G.W.S.B.

3518. The Adhesion of High Polymers: 2. Developing a Method for Determining the Adhesion of High Polymers to One another.

A. I. SHAPOVALOVA, S. S. VOYUTSKIĬ and A. P. PISARENKO, *Koll. Zh.*, 1956, 18, (4), 485.

Adhesion of butadiene acrylonitrile to cellophane was measured under varying conditions of rate of separation, width of interface, thickness of adhesive layer, time of contact, etc. Adhesion is ascribed to processes of molecular diffusion. G.W.S.B.

3519. Studies on the Clay-water System. Stress-strain hysteresis of Clay-water Mass.

Y. SHIRAKI, *J. ceram. Ass. Japan*, 1955, 63, 319.

Experiments with alternating torsional stresses on clay bars are described. The stress-strain hysteresis loops so obtained show that repeated cycles produce not only a softening but also a hardening apparently analogous to the thixotropy, dilatancy, and rheopexy which occur in clay slips. The "backlash" phenomenon is also discussed in detail, and some notes on jiggery are given. A.

3520. The Laminar Flow of Streams of Suspended Particles.

T. V. STARKEY, *Brit. J. appl. Phys.*, 1956, 7, 52.

Experiments are described in which streams of coloured particles of mixed sizes suspended in water were admitted at a given point on the horizontal diameter of a tube placed horizontally, through which a steady flow of water was maintained. These coloured streams diverged on entry to the water and formed filaments in a horizontal plane. A study of the lateral movement of these filaments relative to one another, as the point of their admission to the tube and the rate of flow of water in the tube are varied, leads

to the conclusion that lateral forces act on the suspended particles. Such forces, the magnitudes of which increase with particle size and with mean shear gradient, result from the motion of the particles in non-uniform velocity gradients. The motions observed lead directly to a simple flow mechanism, independent of particle configuration and orientation, which is shown to be qualitatively consistent with a number of well-known phenomena. A.

3521. A New Look at the Reynolds Stresses in Turbulent Shear Flows.

R. W. STEWART, *Canad. J. Phys.*, 1956, **34**, No. 7, 722.

The Reynolds stresses, in turbulent shear fluid flow, initiated by the work of Townsend, (The structure of turbulent shear flow, Cambridge University Press, 1955), are discussed in tensor form by application of the Navier-Stokes equation. These stresses are shown to express only the effect of anisotropy of the turbulence on the flow, mean velocity gradients imply mean rates of strain; the scale of turbulence is of no consequence so far as its effects on mean flow are concerned, and the Reynolds stresses are important only in that they express the amount and orientation of the anisotropy of the turbulence. A.

3522. The Rheology of Kaolinite Suspensions.

N. STREET, *Aust. J. Chem.*, 1956, **9**, (4), 467.

The rheological properties of constant volume concentration kaolinite suspensions were measured and compared with potential measurements. The correlation is good and the results are interpreted on the basis of the existence of both positive and negative areas on the clay surfaces linking the particles together in "bipolar" flocculation; these floccules uncoil with increasing neutralization of the H-clay, then at the equivalence point the positive areas are neutralized, the clay suspension deflocculated and the viscosity considerably reduced. AUTHOR'S SUMMARY.

3523. Recent Advances in Knowledge concerning the process of Creep in Metals.

A. H. SULLY, *Progress in metal physics*, 1956, **6**, 135.

A review. Discusses experimental work on the structural changes accompanying the first and second stages of creep, considering particularly the work of Wood, Crussard, McLean and Grant. The dislocation mechanism of primary and secondary creep is discussed qualitatively, and tertiary creep, leading to fracture, is considered. The variously proposed creep laws are discussed, and the practical consequences of creep described. 93 references. A.

3524. Thermal Stresses and Strains in Plates Resting on Elastic Foundations.

Z. THRUN, *Rozprawy Inzynierskie*, 1956, **4**, (1), 71.

3525. On some Ideas concerning the Mechanical Properties of Structured Colloidal Systems and Some Methods for their Investigation.

A. A. TRAPEZNIKOV, *Koll. Zh.*, 1956, **18**, (4), 496.

Reply to article by N. N. Mikhailov. abstr. No. 3214.

3526. Stress Theory of Plastic Flow.

D. TRIFAN, *J. Math. Phys.*, 1956, **35**, (1), 44.

3527. Stress-Strain Relation for Tensile Tested Metals.

W. TRUSZKOWSKI, *Arch. Mech. Stos.*, 1956, **8**, No. 4, 581.

A survey of published equations. It includes the relation between the theoretical cold work and the true stress. The discrepancy between the formulae and the experimental curves just before neck formations constitutes a measure of the non-homogeneity of the metal. The coefficients of the stress-strain formula have a physical meaning and determine the plastic properties, the hardenability and, in some measure the yield point of the metal. E.W.J.M.

3528. The Flow of a Liquid of Anomalous Viscosity between Two Flat Plates and between Two Co-axial Cylinders.

N. V. TYABIN, *Zh. tekhn. Fiz.*, 1956, **26**, No. 9, 1994.

The rheological behaviour of a non-Newtonian liquid is assumed to be determined by an equation between the tensors of stress and of the rate of strain. It is further assumed that this relation can be represented graphically in such a way that linear segments are joined continuously but with a kink. From these assumptions the velocity distribution and other quantities of interest are derived by standard procedures. A.

3529. Sakurada Equation for the Intrinsic Viscosities of Polymer Solutions.

V. V. VARADIAH and M. RAMAKRISHNA RAO, *Curr. Sci.*, 1955, **24**, No. 9, 296.

Viscosity data obtained from light scattering behaviour on some solutions of polymethyl methacrylate, polystyrene and polyvinyl acetate support Sakurada's equation. See *Chemistry of High Polymers* (Japan) **2**, 253, 1945. A.

3530. Elasticity and Plasticity.

F. A. VENING MEINESZ, *Appl. sci. Res.*, 1956, **A 6**, 205.

The writer, in dealing with stress-strain relations, separates the states of stress and strain into two parts, the compression by hydrostatic pressure and the change of shape by the deviatoric part of the stress; each part has its own behaviour and modulus. He develops a graphical representation of the state of stress, which gives a simple way of comparing the different states of stress corresponding to the yield-limit. P.G.M.

3531. The Viscosity of Clays.

U. VENTRIGLIA, *Clay Minerals Bulletin*, 1954, **2**, 176.

Plasticity is characteristic of systems with "bound water" films in contact. It can only be properly compared for clays of different mineralogical composition if suitable mixtures (different in each case) are used, such that $f/\eta\gamma f$ is a maximum, where f = elastic limit, η = viscosity, and γ = maximum elastical deformation. R.H.S.R.

3532. Fundamental Relations of Design for Strength.

Z. WASIUTYNSKI, *Archiwum Inzyniernii Ladowej*, 1956, **2**, (1P2), 3.

P.F.

3533. Elastic Compliance of Polymethyl Methacrylate.

J. M. WATKINS, *J. appl. Phys.*, 1956, **27**, 419.

A theoretical equation giving the steady-state elastic compliance of a concentrated polymer solution in terms of the molecular weight distribution is tested experimentally by observing elastic recovery from steady flow in a rotational viscometer on removal of the stress. A.

3534. Stress Relaxation in Concentrated Solutions of Polymethyl Methacrylate Molecular Weight Dependence.

J. M. WATKINS, R. D. SPANGLER and E. C. MCKANNAN, *J. appl. Phys.*, 1956, **27**, 685.

3535. Creep of Aluminium Single Crystals.

J. WEERTMAN, *J. appl. Phys.*, 1956, **27**, 832.

3536. Creep of Tin Single Crystals.

J. WEERTMAN and J. E. BREEN, *J. appl. Phys.*, 1956, **27**, No. 10, 1189.

The activation energy of creep was determined for a series of tin single crystals oriented with the specimen axis close to a (110) direction. Two activation energies were found. A value of approximately 22,000 cal/mole was obtained for temperatures above 130°C; a value of about 11,000 cal/mole for temperature below 130°C. A.

3537. Creep of Poly-crystalline Nickel.

J. WEERTMAN and P. SHAHINIAN, *J. of Metals*, 1956, 8, 1223.

The creep rate between 400° to 1100°C appears to be proportional to (stress)^{4.6} at stresses below 7×10^8 dyne. cm⁻². A.

3538. Large Deflections of a Circular Plate.

WEI-ZANG-CHIEN, *Archivum Mechaniki Stosowanej*, 1956, 8, (1), 3.

P.F.

3539. On a Viscosimetric Method for the formation of the products of Two Measured Values with Progressive Time Summation.

A. WESP, *Z. angew. Phys.*, 1956, 8, No. 4, 158.

Using paddle viscosimeters and venturi flowmeters, methods are described for integration of viscosities, temperatures and flows of gases and liquids. A.

3540. The Role of Viscosity in the formation of the Vitreous State.

A. WINTER-KLEIN, *Silicates Industr.*, 1956, 21, 157.

Viscosity is a periodic property of elements related to atomic number and can be related to certain electron forces. The importance of the study of the change in viscosity with temperature is stressed and the viscosity of various bodies which vitrify at very different temperatures is given. The measurements were carried out in such a way as to include the transformation range. Whatever the temperature at which a body changes to the vitreous state, its viscosity always varies between the same limits (poises): $10^{16} > \eta > 10^6$. An attempt is made to determine the reasons for this. A.

3541. Temperature Dependence of Viscosity of Liquefied Nitrogen at Constant Density.

N. F. ZHDANOVA, *Zh. éksper. teor. Fiz.*, 1956, 31, No. 1 (7), 14.

Results of measurement of the temperature dependence of the viscosity of liquified nitrogen are presented; the measurements were carried out in the density range from $\rho = 0.38$ g/cm³ to $\rho = 0.86$ g/cm³ and for temperatures varying from the condensation temperature up to 300°K. A gas-like temperature dependence of the viscosity of liquid nitrogen at low densities has been detected for the first time. A.

3542. Computation of Critical Forces for Elastic Bars by a Method of Partial Interpolation.

M. ZYCZKOWSKI, *Rozprawy Inzynierskie*, 1956, 4, 369.

The values of the critical forces can be obtained by solving transcendental equations involving Bessel's functions. E.W.J.M.

3543. The Limit Load of a Thick-walled Tube in a General Circularly Symmetrical Case.

M. ZYCZKOWSKI, *Archivum Mechaniki Stosowanej*, 1956, 8, (2), 155.

P.F.

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