

BRITISH RHEOLOGISTS' CLUB



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ROYAL AIRCRAFT ESTABLISHMENT,
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THE UNIVERSITY, READING.

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Bulletin No. 22.

March, 1949.

Price to non-members, 5s.

CLUB NOTES.

The American Society of Rheology.

We are delighted to hear very encouraging news of our Sister Society in U.S.A. "The membership stands at the highest point in the twenty years since the Society was founded. The finances are in good order and a satisfactory reserve is in the bank. . . . Plans have been made to resume publication of 'The Rheology Bulletin' as a medium for news and reports of Society activities."

News of Members.

We hear with deep regret of the death of MR. W. J. LUND of the British United Shoe Machinery Co., Leicester. Mr. Lund had been a member of the Club since 1943.

DR. L. R. G. TRELOAR will shortly be taking up an appointment with the British Rayon Research Association and will be working at the Royal Institution, London.

MR. A. G. WARD has been appointed Director of the newly-established Glues and Gelatine Research Association.

New Members.

The Club's Membership List is being revised and a corrected list will soon be available. The following new members have been elected since June 1948:

MR. ARNOLD AXON .. c/o Messrs. Burroughs Wellcome & Co., Acacia Hall, Dartford.

Interests: Pharmaceutical Preparations, Ointments and Creams, Viscometers and Thixotrometers.

M. PIERRE DELCROIX .. Sec. Gén. de l'ATIP, 154 Boulevard Haussmann, Paris (8^e), France.

Interests: Papiers et autres matériaux cellulosiques.

MR. S. M. FREEMAN .. Messrs. May Ltd., Dundee Road, Slough, Bucks.

MR. E. C. W. A. GEUZE .. Director, Soil Mechanics Laboratory, Oostplantsoen 25, Delft, Netherlands.

Interests: Soils.

M. R. L'HERMITE .. Directeur des Laboratoires du Bâtiment et des Travaux Publics, 12 rue Brancion, Paris XV^e, France.

Interests: Tars and Bitumen, Fresh Pastes of Cement, Mortar, Plaster, Concrete, etc., Clays.

- DR. C. G. LAWSON .. 5 Sandhurst Flats, R.G.P.F., Waltham Abbey, Essex.
Interests : Thermoplastics, Rubbers, Wetting and Mixing Processes, Adhesion, Tensile Machines.
- MR. PETER MASON .. 17 Tanners Green, Abbots Langley, Herts.
Interests : Lime—Suspensions, Rotation—Viscometry, Effects of Vibration.
- MR. ALFRED NIGHTINGALE Physics Department, Guy's Hospital Medical School, London Bridge, S.E.1.
Interests : Human circulation—Flow of Blood through Narrow Vessels.
- MR. HUBERT LL. D. PUGH Mechanical Engineering Research Organisation, D.S.I.R. 21 Princes Gate, Kensington, London, S.W.7.
Interests : Metals, Plastic Flow, Deformation Processes.
- DR. HERBERT F. RANCE . Grays Cottage, Candlemas Lane, Beaconsfield, Bucks.
Interests : Paper and Cellulosic Materials.
- M. MICHEL ROEGIERS .. Rue haute 11, Ghent, Belgium.
Interests : Oils.
- DR. K. H. SWAINGER .. Civil Engineering Department, Imperial College, London, S.W.7.
Interests : Metals.
- MR. FRED TAYLOR .. c/o The Pharmaceutical Development Laboratories of Burroughs Wellcome & Co., Acacia Hall, Dartford, Kent.
Interests : Pharmaceutical and Cosmetic Emulsions Creams, Suspensions, etc. Viscosity, Thixotropy, Tackiness, Consistency, etc.
- DR. ERNEST R. WINTER . Chemistry Department, Imperial College, Prince Consort Road, South Kensington, London, S.W.7.
Interests : Suspensions, Sols, Rotation—Viscometry.
- MR. N. WOOKEY 82 Dallas Road, London, N.W.4.
Interests : Foods especially those based on Cereals.

Future Events.

EXETER MEETING.

A Discussion on the subject of Suspensions and Sedimentation has been arranged jointly with the local sections of the Chemical Society and the Royal Institute of Chemistry at the Washington Singer Laboratories of the University College of the South-West, Exeter, on Friday, 6th May, and Saturday, 7th May.

Members will be notified shortly about hotel accommodation. Speakers will include :

Dr. H. de Bruijn (Limburg, Holland) : The Flow of Concentrated Model Suspensions.

Mr. R. L. Whitmore and Professor S. G. Ward (Birmingham) : The Viscosity of Granular Suspensions.

Dr. E. R. Winter (London) and Mr. A. J. Hughes (Birmingham) : The Properties of Suspensions of Fine Powders.

Mr. P. G. W. Hawksley (London) : Sedimentation of Non-flocculating Suspensions.

Dr. P. Eggleton (Edinburgh) : Rheology of Blood.

Visits are being arranged to local mines on the afternoon of Friday, 6th May.

BIRMINGHAM MEETING.

A Conference on the Rheology of Thickened Liquids will take place at Birmingham University on Friday-Saturday, 15th-16th July, under the Chairmanship of Professor F. H. Garner.

Speakers will include the following: Professor S. G. Ward, Dr. Mysells, Dr. E. W. J. Mardles, Dr. A. B. Toms and Dr. A. C. Merrington.

Annual General Meeting and Conference.

Bristol University, September 26th to 29th, 1949.

Further particulars of the Annual Conference are now available. The main subjects for discussion, arranged for the three principal sessions are:

1. *The Solid State* (introduced by the President, Professor N. F. Mott, F.R.S.)
2. *Thermo-plastics* (Mr. H. A. Nancarrow on Extrusion of Thermo-plastics).
3. *Fibre Assemblages* (Dr. H. Rance on Paper and Dr. W. Barkas on Wood).

Other subjects include methods of measurement and nomenclature, internal friction of solid materials, high elasticity and rheology of paints and printing inks, etc.

Accommodation will be provided at Wills Hall, Bristol University.

Members are invited to make suggestions as to further subjects for discussion and places of rheological interest for visits.

CORRESPONDENCE

DEAR DR. SCOTT BLAIR,

B.R.C. members interested in the analysis of finite strains may appreciate this advance information from a paper awaiting publication. It appears that the usual "finite strains" expressions, non-linear in displacement gradients, do not represent physical strains. The expressions due to Saint-Venant, 1847, occur when the inverse strain quadric is defined with respect to a given co-ordinate system while those due to Filon, 1931, appear from the strain quadric equation and should not be given physical significance beyond this. Pure normal straining in the co-ordinate directions illustrates my argument briefly here.

A point of a deformable body is initially at vector position R° . During deformation it displaces finitely by D to position R so,

$$D = R - R^\circ \quad (1)$$

With the vector gradient operator and its conjugate and also the idemfactor $\bar{\phi}$ rearrange (1) and forming the scalar product for this homogeneous straining gives,

$$R \cdot \bar{\phi} \cdot R = (R^\circ)^2 \quad (2)$$

where

$$\bar{\phi} = (\bar{I} - \text{grad } D) \cdot (\bar{I} - D \text{ grad}) \quad (3)$$

If R° is unity and $\bar{\phi}$ self-conjugate then (2) represents the strain quadric in the deformed body generated from a unit sphere in the undeformed body. With scalar components D_i of D , R_i of R and r_i the direction cosines of R equation (2) becomes,

$$\left(\frac{R^\circ}{R}\right)^2 = 1 + \sum_i \sum_j \left(-2 \frac{\partial D_j}{\partial R_i} + \sum_k \frac{\partial D_r}{\partial R_i} \cdot \frac{\partial D_k}{\partial R_j} \right)$$

This expression with co-ordinates relating to the point in the deformed body was found by Cauchy in 1827 but he simplified the case by considering only infinitesimal strains and displacements so that the squares and products of displacement gradients were neglected. Filon, presumably by mathematical analogy with the infinitesimal strains case, accepted half the complete coefficient of $(r_i r_j)$ as a finite strain component but remarks in Photoelasticity p. 189 that strains had to be small for the expressions to represent physical stretch or slide components.

In pure normal straining

$$\frac{\delta D_i}{\delta R_j} = 0 \quad (j \neq i) \quad (5)$$

Also by taking "true" strain e_r as linewise relative displacement per unit length in the deformed body gives

$$R^o = R (1 - e_r) \quad (6)$$

Then from (4) with R in direction R_i gives

$$1 - 2e_{ii} + (e_{ii})^2 = 1 - 2 \frac{\delta D_i}{\delta R_i} + \left(\frac{\delta D_i}{\delta R_i} \right)^2 \quad (7)$$

It appears from this,

$$e_{ii} = \frac{\delta D_i}{\delta R_i} \quad (8)$$

which is the "true finite normal strain definition for direction R_i .

All other writers but myself on finite strains would take

$$\frac{\delta D_i}{\delta R_i} - \frac{1}{2} \left(\frac{\delta D_i}{\delta R_i} \right)^2 \quad (9)$$

as the finite strain component in direction R_i . Noting that (7) *was derived from the strain quadric* (2) there seems no obvious physical reason why (9) should be called "strain" to be related to the stresses operating. Restriction (5) ensures $\bar{\phi}$ is self-conjugate and (2) is a central quadric for this case. However, my complete treatment shows this to be true in general when rotation of the *whole* body is prevented or cancelled by selecting the co-ordinate axes appropriately as in *Phil. Mag.*, June, 1947.

Examination of the inverse strain quadric with the Cauchy nominal strain definition gives analogous results questioning the validity of the Saint-Venant expressions which take the co-ordinates of a point in the undeformed body.

The foregoing suggests that it is unnecessary to use strain definitions non-linear in displacement gradients as a linear form certainly suffices for this pure normal straining.

Yours sincerely,

K. H. SWAINGER.

RHEOLOGY ABSTRACTS

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

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

II92. Viscosity—Volume Relation for Liquids.

E. N. DA C. ANDRADE AND C. DODD. *Nature*, **163**, 101, 1949.

Jobling's hypothesis (Abstract 1164) that the dependence of the viscosity of a liquid on temperature for ether above 0°C and probably for many other liquids, is due entirely to the change of volume, is shown to be incorrect from data for ether, mercury, isoamyl alcohol and carbon dioxide.

E.W.J.M.

II93. Measurement of the Elastic Constants and Internal Friction of Wood.

I. BARDUCCI AND G. PASQUALINI. *Nuovo Cim.*, **5**, 416, 1948.

Elastic parameters and internal friction have been determined on strips of wood by a dynamical method, involving the measurement of the resonance frequency and the Q of a vibrating reed. The experimental results lead to the following conclusions : (a) the sound velocity c and the Q are strongly dependent on the direction of the sample, yet, as a first approximation, their ratio c/Q is not a directional parameter. Moreover, c/Q is independent of frequency ; (b) as a first approximation, the angle between direction of elastic waves and direction of fibres is sufficient to determine the direction of the sample ; (c) the conifers show interesting regularities in their elastic and dissipative properties ; (d) the elastic parameters and the Q of very old woods seem to be highly modified by an ageing process. The mean values of some elastic and dissipative parameters for eighty-five different woods are tabulated.

SCI. ABSTR.

II94. The Viscosity and Heat Conductivity of Gases with Central Intermolecular Forces.

J. DE BOER AND J. VAN KRANENDONK. *Physica, 's Grav.*, **14**, 442, 1948.

The coefficients of viscosity and heat conductivity have been calculated for gases, consisting of molecules which interact according to an intermolecular potential field of the form : $\phi(r) = 4\epsilon[(\sigma/r)^{12} - (\sigma/r)^6]$. The results are given in reduced form so as to allow a comparison to be made with all substances for which the constants ϵ and σ of the intermolecular field are known. The results are in agreement with the available experimental data for Xe, A, Ne, H₂, D₂ and He. The deviations which appear for the light gases at low temperatures pointing to the necessity of applying quantum theory to the transport phenomena are discussed from a theoretical point of view and are compared with previous theoretical calculations of the transport phenomena based on quantum mechanics.

SCI. ABSTR.

1195. **Thixotropic Qualities of Soap—Hydrocarbon Systems.**

C. J. BORER. *J. Phys. Coll. Chem.*, **52**, 1383, 1948.

Using the A.S.T.M. standard apparatus and procedure, the penetration of lubricating greases made from a wide variety of metal soaps was measured at intervals after cessation of shearing. It was found that soap-mineral oil systems containing soaps of monovalent metals were less thixotropic over a period of seventy minutes than were such systems based on soaps of di- and tri-valent metals the latter showing the greatest degree of thixotropy for short periods. Systems containing soaps of the metal of lowest atomic weight in a series were more thixotropic over an extended period than were systems containing heavier metals of the same series. W.P.F.

1196. **The Thixotropy of Certain Sedimentary Rocks.**

P. G. H. BOSWELL. *Sci. Progr.*, **36**, 412, 1948.

Reference is made to Freundlich's early work on the thixotropy of Solnhofen lithographic stone, moulding sands and quick sands; he showed that thixotropy is often increased by the addition of an electrolyte and that many substances (e.g. powdered quartz) are more thixotropic in salt water than in pure water. Freundlich also showed that the addition of a small quantity of fireclay or other colloid which was strongly hydrophilic served to make a dilatant sand thixotropic. The degree of thixotropy can be represented by the ratio of the volume of liquid to volume of solid at the point when, after a run of one minute, the mixture just does not flow in a vertical inverted tube, but flows freely if *tapped*; some volumes for this ratio are: glacial brick-earths and boulder clay, 1.1–1.9; Lias, Oxford Clay, Kimmeridge clay, Gault or London clay, about 2.5; ball clays, about 3.0; china clay, about 3.7; Wyoming bentonite, 27. (The last figure may be not strictly comparable since much of the liquid is probably absorbed within the loosely-bound layer-lattice of montmorillonite, and this does not assist the thixotropy.) The shape of the solid particles as well as their degree of fineness influences thixotropy, a flaky or acicular habit promoting it. Of the clay minerals, the montmorillonite group is the most thixotropic. B.C.R.A.

1197. **General Survey of Certain Results in the Field of High Pressure Physics.**

P. W. BRIDGMAN. *J. Wash. Acad. Sci.*, **38**, 145, 1948.

Nobel Laureate Lecture. Improvements in experimental technique are described. Compressibilities and polymorphic transitions of some thirty elements and simple compounds have been studied with pressures up to 100,000 kg/cm². Polymorphic changes are quite common. Melting curves up to 40,000 kg/cm² have shown no signs of any critical pressure. Yellow phosphorus and carbon disulphide are permanently changed by high pressure at 200°C. Electrical resistance of metals may either increase or decrease with pressure and semi-conductors may become good conductors. A few thermal conductivity measurements have shown no change in the Wiedemann-Franz ratio with high pressure. The effects of pressure on the thermo-electric effects are sometimes complicated. Viscosity rises with increasing pressure, the extent of the rise depending on the complexity of the molecule. SCI. ABSTR.

1198. **Large Plastic Flow and the Collapse of Hollow Cylinders.**

P. W. BRIDGMAN. *J. Appl. Phys.*, **19**, 302, 1948.

The collapse of heavy steel cylinders under external pressures up to 412,000 lb/in² was studied. The distortions are so large that the conventional small strain analysis is not adequate. The presence of large strains is recognized by writing the stress equations of equilibrium in terms of the final displaced positions of the particles

instead of the initial positions. Negligible volume change is assumed. In the experiments the cylinders showed no change of length. The generality of the conditions under which this may be expected is examined. A linear relation was found experimentally between collapsing pressure and $\log (r_{\text{ext}}/r_{\text{int}})$. Furthermore, $P/\log (r_{\text{ext}}/r_{\text{int}})$ is not constant but rises continually with increasing collapsing pressure. These results indicate that the strain hardening increases continually with increasing distortion, but at a rate two- or three-fold less than would be given by experiments in simple tension. The collapse was extended experimentally to such extremes that the geometrical symmetry was lost because of the grain structure, thus limiting the region of applicability of any simple theory.

SCI. ABSTR.

II99. **Non-Linear Relations Between Viscous Stresses and Instantaneous Rate of Deformation as a Consequence of Slow Relaxation.**

J. M. BURGERS. *Proc. Kon. Ned. Akad. v. Wetenschappen, Amsterdam*, **51**, 787, 1948.

In visco-elastic materials, where laminar flow is accompanied by elastic deformations, flow is possible in consequence of a relaxation phenomenon; and owing to the finite rate at which the re-arrangement of molecular structure takes place, every element of volume of a flowing medium will bear in its molecular pattern reminiscences of its past. In consequence of this circumstance the actual pattern during flow deviates from the equilibrium pattern. There is thus a state of physical deformation, which must be clearly distinguished from the progressively increasing deformation of the boundary surface of an element of volume as it occurs in flow. In the ordinary theory of viscosity it is supposed that the state of physical deformation is proportional to the instantaneous rate of deformation, as will be the case when the re-arrangement of the molecules takes place sufficiently quickly. On the other hand in liquids or fluids where this is not the case, "memory" will extend further into the past and the physical deformation will be determined by less simple relations. In hydrodynamical theory, when deformations are changed or repeated periodically in intervals of time short compared with the time necessary for re-arrangement, the medium in general will show elastic behaviour when $\eta = G\lambda$ where G is the shear modulus and λ the relaxation time, which is very short, compared with the time in which an appreciable geometrical deformation of the boundary surface of an element of volume takes place. When the relaxation time becomes large, it must be expected that the deviation of the molecular arrangement will bear reminiscences of a more remote past. The physical deformation will then no longer be simply proportional to the instantaneous rate of deformation, but will be determined by some integrated quantity.

E.W.J.M.

1200. **Damped Oscillations of a Spherical Mass of an Elastic Fluid.**

J. M. BURGERS. *Proc. Kon. Ned. Akad. v. Wetenschappen, Amsterdam*, **51**, 1211, 1948.

A theoretical treatment of the results of de Jong on the oscillatory movements presented by some soap solutions, is given using hydrodynamic theory as developed by Lamb. Burgers considers (a) motion in concentric spherical layers or shells and (b) axially symmetric motions in meridian planes.

E.W.J.M.

1201. **Universal Plastics Testing Machine.**

G. S. BURR, W. J. GAILUS, J. O. SILVEY, S. YURENKA AND G. H. DIETZ. *A.S.T.M. Proc.*, **47**, 1030, 1947.

The large range of elastic and plastic properties of plastics, and their sensitivity to time rates as well as to ambient atmospheric conditions necessitate the construction of testing equipment having unusual speeds, travel and controls. The machine finally developed, and here described and illustrated, had a loading capacity up to 30,000

lb. and 18 in. crosshead motion, minimum inertia in the weighing and recording mechanism with controls for constant rate of crosshead motion, of load application and of strain. The rates of crosshead motion vary from 0.005 to 30 in. per minute, in continuously variable increments, whilst there is positive control over crosshead motion in either direction with fastest possible reversal in direction. The design also embodies reversal of load on the specimen without backlash when passing through zero, as well as grips capable of applying compressive and tensile loads continuously on the same specimen. The movable crosshead is controlled by a servo system.

B.S.A.

1202. The Swelling and Contraction of Moulding Plasters.

L. CHASSEVENT. *C.R. Acad. Sci., Paris*, **225**, 302, 1947.

The results of tests show that the swelling that takes place when plaster is moistened is roughly proportional to the quantity of plaster hydrated per unit volume, if the mass remains saturated with water during setting. The degree of swelling also depends on the presence of impurities such as clays or salts, or of uncalcined plaster.

B.C.R.A.

1203. Large Deformations of an Elastic Solid.

E. G. CHILTON. *J. Appl. Mech.*, **15**, 362, 1948.

Hencky's stress-strain relation for large deformations of a rubber-like material is reviewed. It is then applied to the specific cases of pure tension, compression, bending, shear and torsion. Each of these cases is verified experimentally on samples made from natural rubber. Particular emphasis is placed on the shear and torsion analysis because of its importance to practical applications.

AUTHOR'S ABSTRACT.

1204. Dislocation Theory of Yielding and Strain Ageing of Iron.

A. H. COTTRELL AND B. A. BILBY. *Proc. Phys. Soc. A*, **62**, 49, 1949.

A theory of yielding and strain ageing of iron, based on the segregation of carbon atoms to form atmospheres round dislocations is developed. The form of an atmosphere is discussed and the force needed to release a dislocation from its atmosphere is roughly estimated and found to be reasonable. An explanation is given of the temperature dependence of the yield point and close agreement is found between theory and experiment.

Strain ageing is interpreted as the migration of carbon atoms to free dislocations and its rate depends upon the carbon concentration in solution. Experimental agreement with the calculated initial rate of ageing is found.

W.P.F.

1205. A Kinetic Approach to the Theory of the Strength of Glass.

S. M. COX. *Nature*, **162**, 947, 1949.

Kinetic treatment involving the determination of conditions under which a local disorder will become accumulative, has been neglected on the grounds that the activation energy necessary for the spontaneous formation of flaws is too high; but there is evidence supporting the contention that atomic configuration changes, characterized by comparatively small activation energies, can take place in glass. Data given in three figures are discussed from the kinetic standpoint. If the strength of glass depends on the spontaneous development of flaws under an applied stress, then breakage can only occur if the stress exceeds a certain minimum. Above the minimum stress the probability of breakage increases with sample size and with time for the same reason, that such increases provide increased opportunity for that rare event which is automatically recorded by the fracture of the specimen.

E.W.J.M. (See Abstr. 968).

1206. The Concentrated Solution Viscosity of GR-S : its Variation (in Benzene) with Temperature and Concentration.

L. H. CRAGG, L. M. FAICHNEY AND H. F. OLDS. *Canad. J. Res.*, **26B**, 551, 1948.

Viscosity-concentration relation determined in a falling ball viscometer is found to follow a modification of Abernethy's equation :

$$\eta = A \exp. \left\{ \left(B + \frac{C}{T} \right) C_w^{\frac{1}{2}} \right\}$$

where A, B and C are constants and C_w is weight % concn. Extrapolation to 100% polymer (for what it is worth) leads to an energy of activation of flow for GR-S of 13.0 k. cal per mole which approximates to the expected value. G.W.S.B.

1207. Behaviour of Steel under Biaxial Stress as Determined by Tests on Tubes.

H. E. DAVIES AND E. R. PARKER. *J. Appl. Mech.*, **15**, 201, 1948.

Experimental results are presented, showing that a metal can be reasonably ductile in a state of plane stress, and much less so in a state of triaxial stress. J.G.O.

1208. How Forging Acts to Enhance Metal Properties.

E. O. DIXON AND E. J. FOLEY. *Trans. A.S.M.E.* p. 147. February 1949.

It is shown that when steel is forged in a closed die the transverse ductility as measured by the reduction of area in the tensile test, and toughness in the notched bar test, are improved even though the amount of plastic flow permitted by the die is negligible. This indicates that it is the closing of pores by the high pressure rather than the actual work hardening by plastic deformation which causes the improvement in transverse ductility. M.W.T.

1209. A Kinetic Theory of Turbulence.

G. F. DJANG. *Chin. J. Phys.*, **7**, 176, 1948.

A theory of turbulent flow is developed on the basis of analogy between the motion of fluid particles in turbulent flow and that of individual molecules in a gas. Such an analogy exists between Prandtl's "mixing length" and the mean free path of kinetic theory. The analogy is here extended to include parameters of turbulent motion equivalent to temperature, pressure and entropy. The "turbulence temperature" T is defined by the equation $T = \bar{u}^2 \lambda^2 / \nu^2$, where $\bar{u}^2$ is the mean square of the velocity fluctuations at a point, λ is a characteristic dimension specifying the size of a "turbulence particle" and ν is the kinematic viscosity. The theory is applied to flow through a circular pipe ; it is found that the turbulence temperature is uniform over the cross-section and that the theoretical velocity distribution agrees with experiment. Similar agreement also exists for flow between parallel planes and for turbulence decay in the wake of an obstacle. SCI. ABSTR.

1210. Stress-Strain Rate Relations for Anisotropic Plastic Flow.

J. E. DORN. *J. Appl. Phys.*, **20**, 15, 1949.

Preferred grain orientation and banding of microconstituents frequently cause wrought metals to have anisotropic plastic properties. A simple theory for stress-strain rate analyses during plastic flow of anisotropic sheet metals is proposed for the work hardening range. The theory appears to be approximately correct for mild steel plates which exhibit planar isotropy. W.P.F.

I2I1. Factors Affecting the Strength of Paper.

S. R. H. EDGE. *Chemistry and Industry*, No. 51, 803, 1948.

Factors discussed are length of fibre, bonding of fibres, fibre orientation in machine-made paper (it has been shown that the marked difference in properties in machine and cross directions cannot be attributed to fibre orientation, but rather to stretching on the paper machine) and the layer of water-swollen cellulose on the surface of the fibre. The effect of time on the strength determination is indicated. The effect of the following materials which increase strength when added to paper pulp was investigated: rice starch, water-soluble cellulose ethers and aluminium or iron salts with hard water.

P.A.T.R.A.

I2I2. A Simple and Convenient Instrument for Measuring the Shearing Resistance of Clay Soils.

I. EVANS AND G. G. SHERRATT. *J. Sci. Instr.*, 25, 411, 1948.

The simple theory of a vane rotating in a soil is given and an instrument based on this principle is described.

J.E.C.

I2I3. The Mechanism of Flow for Solid Metals.

H. EYRING, J. W. FREDRICKSON AND D. McLACHLAN. *Proc. Nat. Acad. Sci., Wash.*, 34, 295, 1948.

The solid state is treated as a continuum of varied density in which exist both regions of exact atomic order as well as actual holes. Imperfections are discussed under "equilibrium" and "non-equilibrium" headings, those created by fluctuations in density being handled by the use of the equation $(\Delta\rho/\rho)^2 = kT\beta/V$, together with an equation relating strain-rate to certain thermodynamic and structural (e.g. V_h the volume of a "hole") parameters. The experimental temperature-independence of $\Delta F^*/T$ is discussed. Using experimental data obtained with brass and steel, the value of V_h calculated is found to be unreasonably small, and an explanation is discussed on the basis of the compressibility of the positive kernels of atoms—i.e., without conductance electrons. It is deduced that the value of V_h is the most influential of the flow factors. (ΔF^* = free energy of activation).

SCI. ABSTR.

I2I4. Viscoelastic Properties of Polymer Solutions.

J. D. FERRY. *J. Res. Nat. Bur. Stand., Wash.*, 41, 53, 1948.

In a concentrated polymer solution, the entanglement of long-chain molecules results in a transient network structure, to which may be attributed certain aspects of the viscoelastic behaviour of such a system. A suitable mechanical model for representing this network as a first approximation is a retarded Maxwell element with one spring and two dashpots. Experimental measurements of mechanical properties of polymer solutions may be made either by periodic deformation under conditions where inertia forces can be neglected or by propagation of transverse waves. The data are expressed in terms of frequency-dependent parameters from which can be derived the constants of the corresponding mechanic 1 model. A solution of polystyrene in xylene is cited as an example. In this case, analysis in terms of a recent theory of Kuhn suggests that elastic energy may be stored in the network strands by twist against the potential hindering free rotation about bonds in the chain.

SCI. ABSTR.

I2I5. Rheological Properties of Incendiary Gels.

L. FINKELSTEIN. *J. Phys. Coll. Chem.*, **52**, 1460, 1948.

Incendiary gels are essentially non-Newtonian liquids whose viscosity varies with the stress. Various subjective tests are described for the estimation of friability, rate of healing of a cut surface, strength, resilience, adhesion and extensibility. Numerous methods are discussed for measurement of specific rheological properties, and it is found that a single test is inadequate for the reliable evaluation of these materials. Only in a limited number of cases have satisfactory correlations with test firing data been obtained.

W.P.F.

I2I6. An Investigation of the Streaming Birefringence of Amylose Solutions.

J. F. FOSTER AND I. H. LEPOW. *J. Amer. Chem. Soc.*, **70**, 4169, 1948.

The authors show that the amylose component of starch, dispersed in ethylenediamine / glycerol mixtures is readily orientable in a rotary viscometer (100 to 3,000 r.p.m., 1 mm. gap between cylinders of mean radius 3.22 cm.) The orientation is predominantly due to elongation of coiled molecules.

E.W.J.M.

I2I7. Experimental Studies of Biaxially Stressed Mild Steel in the Plastic Range.

S. J. FRAENKEL. *J. Appl. Mech.*, **15**, 193, 1948.

This paper describes static tests of tubular specimens of medium steel under biaxial stresses and at room temperature. The so-called "third rule of plastic flow", that Mohr's stress and strain circles are similar for all stress ratios, is found not to apply.

J.G.O.

I2I8. On the Equations of Motion of Crystal Dislocations.

F. C. FRANK. *Proc. Phys. Soc. A.*, **62**, 131, 1949.

It is shown that when a Burgers screw dislocation moves with velocity v it suffers a longitudinal contraction by a factor $(1 - v^2/c^2)^{1/2}$, where c is the velocity of transverse sound. The total energy of the moving dislocation is given by the formula $E = E_0/(1 - v^2/c^2)^{1/2}$, where E_0 is the potential energy of the dislocation at rest. Taylor dislocations behave in a qualitatively similar manner, complicated by the fact that both longitudinal and transverse displacements and sound velocities are involved.

AUTHOR'S ABSTR.

I2I9. Recrystallization of Metals under Stress.

J. N. GREENWOOD. *Nature*, **163**, 248, 1949.

Rate of strain has a fundamental effect on the mechanism of creep. The author considers that the transition from constant creep rate to accelerating creep rate in uniform load tests is not necessarily due either to the increased stress or to recrystallization at this stage except in the case of single crystals. Various detailed conclusions relating to the behaviour of lead and its dilute alloys under stress are given.

E.W.J.M. (See Abstr. 980).

I220. Delayed Fracture of Materials under Tension, Torsion and Compression.

C. GURNEY AND Z. BORYSOWSKI. *Proc. Phys. Soc., Lond.*, **61**, 446, 1948.

Delayed fracture experiments were made in tension, torsion and compression, the times to fracture under a series of constant loads being determined. The materials

tested were brass in NH_3 vapour, polymerized methyl methacrylate (p.m.m.) in liquid CCl_4 and glass in air. In all cases delayed fracture is attributed to the gradual spread of cracks caused by the preferential attack by the surrounding medium of the highly stressed material at the ends of the cracks. In tension, fractures were transverse and in torsion they were helical. In the case of brass and glass, subjected to tension and torsion, fracture of the respective materials occurred in not greatly differing times when the materials were subjected to the same maximum nominal principal tensile stresses. P.m.m. withstood higher nominal principal stress in torsion than in tension for equal times to fracture. The p.m.m. results were complicated by the absorption of CCl_4 , which was greatly accelerated by tension or torsion stresses. During the time occupied by the tests, absorption was inappreciable when the p.m.m. was stress-free or stressed in compression. In no case did delayed fracture occur in compression.

SCI. ABSTR.

1221. Consistometer.

B. S. HARRINGTON. *U.S. Pat.* 2, 437, 194, 2nd March, 1948.

A device for determining the consistency of oils, fats, etc., which, when in liquid form thicken upon chilling, comprises a tank for the chilling medium and a tube for the liquid which can be suspended in the medium. A sleeve which can slide in the tube, and a means for reciprocating the sleeve are incorporated. When the liquid thickens, the tube moves with the sleeve a predetermined distance.

B.C.R.A.

1222. On the Statistical Theory of Turbulence.

W. HEISENBERG. *Z. Phys.*, 124, 628, 1948.

Following on the work of Taylor the results of v. Weizsäcker are developed by means of Fourier expansions. By suitable approximations and graphical methods the diameters of the smallest turbulence elements are estimated and the spectral energy distribution for the smallest wavelengths is obtained. Expressions for the energy losses and the correlation function are deduced.

SCI. ABSTR.

1223. A Variational Principle of Maximum Plastic Work in Classical Plasticity.

R. HILL. *Quart. J. Mech. Appl. Math.*, 1, 18, 1948.

Classical equations for an ideal plastic material are reviewed and a variational principle of max. plastic work is derived. This principle is applied to the problem of a uniform bar of arbitrary section deformed in combined tension, torsion and bending.

SCI. ABSTR. (See Abstr. 1092).

1224. The Deformation and Recrystallization of an Alloy Containing Two Phases.

R. W. K. HONEYCOMBE AND W. BOAS. *Aust. J. Sci. Res. A*, 1, 70, 1948.

The deformation and recrystallization of a duplex brass containing 60% Cu and 40% Zn has been studied using microscopic and X-ray methods. In compression and tensile tests the α phase commences to deform plastically at a lower stress than the β phase, and even after heavy deformations, it is deformed more severely. Which of the two phases starts to recrystallize first on annealing depends on the rate of cooling of the alloy prior to deformation. In the quenched wires the α phase commences to recrystallize $\sim 100^\circ\text{C}$. below the β phase, whereas in the slowly cooled wires the β phase commences to recrystallize before the α phase. In the former case, the β recrystallizes at a lower temperature, the smaller the amount of β present, i.e. the lower the temperature of quenching. It has been shown that the order-disorder

transformation is responsible for the difference of behaviour of the slowly cooled wires from that of the quenched wires. Microscopic examination shows that the α phase starts to recrystallize at random, whereas the β phase tends to nucleate at the boundaries between the two phases. The experiments indicate that it is not possible to conclude that a phase has suffered more severe deformation because it commences to recrystallize at a lower temperature. SCI. ABSTR. (See Abstr. 528).

1225. Stiffness Testing of Paper.

P. M. H. JACOBSEN. *Das Papier*, **2**, 170, 1948.

A method of determining stiffness in absolute units is described. Results are given for a number of papers and boards, including board for playing cards, bitumen kraft and crepe papers. The apparatus used is described and illustrated and its theoretical basis elaborated. P.A.T.R.A. (See Abstr. 779).

1226. Effect of the Sulphate Ion on the Plasticity of Brick Clays.

A. L. JOHNSON AND G. B. HUGHES. *J. Amer. Ceram. Soc.*, **31**, 194, 1948.

The sulphate content of brick clays was satisfactorily determined by the Schroeder volumetric method (tetrahydroxyquinone as internal indicator), which is considered suitable for plant control tests. The amount of barium carbonate required to react with the SO_4 ion can then be calculated so that a reduction in plasticity of the clay may be obtained. The significant differences in plasticity noted during plasticity measurements on (1) samples treated with the amount of barium carbonate indicated by the sulphate content (2) untreated samples, and (3) samples treated with normal plant additions could be explained by variations in the zeta potential of the clay-water system due to corresponding variations in the sulphate content.

B.S.A. (See Abstr. 283, 284, etc.).

1227. Considerations on Mohr's Theory of Failure.

H. KASTNER. *Öst. Ingen. Arch.*, **2**, 298, 1948.

A discussion is given of the forces brought into play by the deformation of a solid body. Mathematical expressions for the criterion of failure, particularly the Mohr stress circles, are discussed in detail, for the various types of force involved, i.e. tension, compression and shear. SCI. ABSTR.

1228. A Method of Fitting the Andrade Creep Equation to Experimental Results.

A. J. KENNEDY. *Proc. Phys. Soc.*, **61**, 510, 1949.

A method is described whereby the constants in the Andrade's formula, $l = l_0(1 + \beta t^3)e^{kt}$, for the flow of metals under constant stress, can be rapidly deduced from experimental results by direct reading from a system employing sliding templates of calculated shape. The general equation to which the method is applicable is deduced. AUTHOR'S ABSTR.

1229. The Volume Viscosity of an Ideal Gas as a Kinetic Theory Transport Phenomenon.

M. KOHLER. *Z. Phys.*, **124**, 757, 1948.

The macroscopic theory of fluid motion gives a stress tensor $p_{ij} = (p + \mu \operatorname{div} u)\delta_{ij} + \eta w_{ij}$ (η is the viscosity and w the shear tensor). The last term is α to the rate of volume expansion. The volume viscosity μ vanishes for a monatomic gas but not for molecules unless the mean energy for each internal degree of freedom is

$\frac{1}{2}kT$. A calculation of μ is made using the Chapman-Enskog method to first approximation, assuming that the molecules are perfectly elastic and rough spheres, with a parameter K , the ratio of the moment of inertia to that of a spherical shell, which indicates the distribution of mass. The result is $(\mu/\eta) = (9 + 13K)/60K$, showing that μ is of the same order of magnitude as η . The consequences in the propagation of sound and energy dissipation are discussed. SCI. ABSTR.

1230. New Kind of Paper Testing Apparatus.

F. KÜHN. *Polygraph*, **1**, 214, 1948.

In the "Hydroskop" the paper strips to be tested are fastened to two clamps in a glass cylinder. The lower clamp is provided with a variable load. The tearing test can be carried out in moist air, under water and other liquids. The time which elapses before tearing takes place is measured. The extension can be read off from a scale. P.A.T.R.A.

1231. Convection of a Fluid in a Porous Medium.

E. R. LAPWOOD. *Proc. Camb. Phil. Soc.*, **44**, 508, 1948.

Under certain conditions convective flow may occur in fluid which permeates a porous stratum and is subject to a vertical temperature gradient, assuming that the flow obeys Darcy's law. The criterion for marginal stability is obtained for three sets of boundary conditions, and the motion described. If such convection occurs in a stratum through which a bore-hole passes, the usual method of calculation of the heat flow must be modified, but in general the correction will not be large. SCI. ABSTR.

1232. Ball-Point Pens and Inks.

C. H. LINDSLEY, R. B. SCHMIDT AND R. S. CASEY. *Chem. Industries*, **63**, 50, 1948 ; *Bull. Inst. Paper Chem.*, **18**, 836, 1948.

Following a brief history and a description of ball-point pens, the authors discuss ball-pen inks. They are viscous liquids consisting of a vehicle of oil or other organic liquid, in which is dispersed the colouring material; other additives may be present to control specific characteristics, such as rheological and wetting properties. The vehicle must not contain drying or semi-drying oils, nor should it be volatile. The colours used should be sufficiently dense to yield a sharply legible line with the minute quantities laid down by the ball. The dyes used must have a preferential attraction for cellulose fibres, or the vehicle may diffuse through the paper carrying colour with it. Practically all inks are unaffected by water, but there is a great variation in their light permanence. The amount of ball-pen ink produced is relatively small, about 7,000 lb. a year. P.A.T.R.A.

1233. An Improved Accessory More Particularly for Use in Viscometry.

A. L. LOVECY. *Brit. Pat.* 598,613, 23rd February, 1948.

A device for the determination of viscosity comprises a body of uniform cross-section carried by a support on which are spaced a number of elements lengthwise. These extend laterally from the support, and are provided with similar V-shaped openings. The body is held in contact with both divergent surfaces of the several elements. B.C.R.A.

1234. Statistical Theory of the Elementary Process of Plastic Deformation.

W. J. LYONS. *Phys. Rev.*, **73**, 413, 1948.

A statistical framework is proposed into which a more detailed theory may be built. Two general assumptions are made concerning the probability of rate of dislocation in terms of the force acting over the area concerned with such a jump. B.C.R.A.

1235. Viscosity Studies of System $\text{CaO-MgO-Al}_2\text{O}_3\text{-SiO}_2$. II. $\text{CaO-Al}_2\text{O}_3\text{-SiO}_2$.

J. S. MACHIN AND T. B. YEE. *J. Amer. Ceram. Soc.*, **31**, 200, 1948.

Viscosity data are presented covering those compositions in the $\text{CaO-Al}_2\text{O}_3\text{-SiO}_2$ system which are liquid at $1,500^\circ\text{C}$. The pattern of isokoms on the $\text{CaO-Al}_2\text{O}_3\text{-SiO}_2$ face of the compositional tetrahedron which represents the $\text{CaO-MgO-Al}_2\text{O}_3\text{-SiO}_2$ system is a system of lines roughly parallel to the lines along which the lime content is constant. There are, however, considerable deviations from this parallelism in regions of very low and very high alumina content. B.C.R.A. (See Abstr. 382).

1236. Plastic Flow, Creep, and Stress Relaxation. Part IV. Anomalous Flow as an Order-Disorder Transition.

C. MACK. *J. Appl. Phys.*, **19**, 1082, 1949.

Plastic systems show effects of steric hindrance at rest which results in a molecule preventing its neighbours from occupying certain positions and introduces a certain degree of orientation. Under stress many more positions, resulting from rotation are forbidden to a molecule in motion. In order to make more positions available, the system must increase its volume under stress and changes from a state of greater order to a state of greater disorder. Based on this concept equations are given which present the strain rate at constant temperatures as functions of stress, change in volume and degree of order and disorder. The changes in entropy and energy of interaction, accompanying the strained state, are expressed by a generalized partition function. This concept of anomalous flow is extended to visco-elastic effects for systems with rubber-like elasticity and has been exemplified by data on polychloroprene under tension.

AUTHOR S ABSTR. (See Abstr. 553-555).

1237. The Thermodynamics of Gas Flow.

E. MADELUNG. *Ann. Phys., Lpz. (Folge 5)*, **43**, 417, 1943.

The question "how does the motion of a small quantum of gas change its temperature?" is solved by combining thermodynamics, hydrodynamics and heat conduction theory.

SCI. ABSTR. (abridged).

1238. On the Cause of the Frictional Difference of the Wool Fibre.

K. R. MAKINSON. *Trans. Faraday Soc.*, **44**, 279, 1948.

An analysis has been made of the ratchet theory of the frictional difference of the wool fibre, and the theory developed into a semi-quantitative form. The theory has been shown to be in agreement with a number of experimental observations, some of which are not explicable in terms of an asymmetrical molecular field at the surface of the fibre, and some of which were previously regarded as disproving the ratchet theory. It therefore appears probable that the frictional difference is due to a ratchet effect.

SCI. ABSTR.

1239. A Mathematical Theory of Photo-Viscoelasticity.

R. D. MINDLIN. *J. Appl. Phys.*, **20**, 206, 1949.

A phenomenological law of optical birefringence, induced by small strain in visco elastic materials, is formulated and applied to an idealized medium. The resulting optical-stress-strain-time-temperature relations are used in finding conditions under which models made of viscoelastic materials may be employed in the photo-elastic method of solving boundary value problems in the linear theory of elasticity.

AUTHOR'S ABSTR.

1240. Viscometer for Heterogeneous Mixtures.

B. N. MITRA AND B. M. MANEL. *Current Sci., Bangalore*, **16**, 180, 1947.

The apparatus described is suitable for heterogeneous mixtures in which a solid phase is uniformly distributed in a liquid phase. The working principle is the measurement of time taken by a paddle to complete a definite number of revolutions under the force of a falling weight, or the weight required to turn the paddle at a given speed. Standardization is effected by using (homogeneous) compounded greases of viscosities determined independently in the Redwood viscometer. B.C.R.A.

1241. Viscosity Measurements of Highly Concentrated Cream.

W. MOHR AND J. WELLM. *Milchwissenschaft*, **3**, 181, 1948.

Measurements of "viscosity" of cream in relation to fat content made with a H $\ddot{o}$ ppler Consistometer. Cream has a very high temperature coefficient of viscosity. Fat globules lose their roundness on very tight packing, which is an important factor in the new Fritz butter-making process. G.W.S.B.

1242 and 1243. Consistency of Butter.

W. MOHR AND J. WELLM. *Milchwissenschaft*, **3**, 234, 1948.

W. MOHR AND F. SCHULZ. *Ibid.*, **3**, 362, 1948.

The consistency of butter is studied by three methods—sectility (cutting by a wire), cone penetrometer and bending under gravity. G.W.S.B. (See Abstr. 62).

1244. An Instrument for Measuring Stress Relaxation of High Polymer Materials.

W. S. MACDONALD AND A. USHAKOFF. *J. Colloid Sci.*, **3**, 135, 1948.

The apparatus applies a pre-determined initial stress to the sample; the strain built up in the sample is then maintained essentially constant and the stress is allowed to relax. The stress is then recorded automatically as a function of the time. B.C.R.A.

1245. General Solution of the Problem of Plane Plasticity for any Isotropic or Anisotropic Law of Flow.

H. NEUBER. *Z. angew. Math. Mech.*, **28**, 253, 1948.

The solutions of classical theory are only valid for isotropic materials where Mohr's limiting curve is a straight line. By means of a "surface of plasticity" (i.e. 3-dimensional representation of the plane plastic flow in a co-ordinate system formed by the 3 stress components) the general solution of any law of plastic flow may be given by a simple graphical method. The characteristic curves of the equations of equilibrium are the curves of 45° gradient on the surface of plasticity. SCI ABSTR.

1246. Mechanical Stability of Bitumen—Aggregate Mixtures.

L. W. NIJBOER. *J. Soc. Chem. Ind.*, **67**, 244, 1948.

1247. X-Ray Line Broadening in Cold-Worked Metals.

M. S. PATERSON AND E. OROWAN. *Nature*, **162**, 991, 1949.

X-ray line broadening in cold worked metals, probably due mainly to internal stresses, appears to tend towards a limiting value as the amount of deformation increases; and this may be due to self-annealing with consequent strain release or recrystallization as soon as the internal strains reach a critical magnitude. Results obtained at low temperatures using back-reflection X-ray photographs from wire specimens plastically deformed in torsion are given. E.W.J.M. (See Abstr. 687).

**1248. The Stress-Strain Laws of the Mathematical Theory of Plasticity—
a Survey of Recent Progress.**

W. PRAGER. *J. Appl. Mech.*, **15**, 226, 1948.

Typical stress-strain laws of flow and deformation types are discussed with particular reference to the conditions of continuity and uniqueness which these laws must fulfil if they are to make sense physically. Alternative forms of some of these laws are presented, and conditions are discussed under which different laws yield identical results. It is shown how these laws may be generalized so as to fit test data more readily. Methods of integration are indicated and the use of variational principles is stressed.

AUTHOR'S ABSTR. (See Abstr. 1174).

1249. A Note on the Mathematical Theory of Vibrations of Walls of Blood Vessels.

N. RASHEVSKY. *Bull. Math. Biophys.*, **9**, 123, 1947.

The vibrations are studied by assuming the blood to be an ideal fluid. The solution obtained is more exact than the approx. solution found earlier in which a viscous fluid was taken. Only axially symmetric deformations of the blood vessel are considered.

SCI. ABSTR.

1250. The Theory of Stresses in Two Component Glass to Metal Tube Seals.

H. RAWSON. *J. Sci. Instr.*, **26**, 25, 1949.

Lamé's theory of stresses in thick cylinders is used to calculate the stress distribution in a two component tube seal.

J.E.C.

1251. A Uniqueness Theorem in the Theory of Highly-Elastic Materials.

R. S. RIVLIN. *Proc. Camb. Phil. Soc.*, **44**, 595, 1948.

It is assumed that an incompressible, highly elastic material has a stored-energy function W given by $W = C_1(\lambda_1^2 + \lambda_2^2 + \lambda_3^2 - 3) + C_2(\lambda_1^{-2} + \lambda_2^{-2} + \lambda_3^{-2} - 3)$, where C_1 and C_2 are two positive constants and λ_1 , λ_2 and λ_3 are the principal extension ratios. It is proved that if a cube of such material is deformed in a pure, homogeneous manner into a cuboid, under the action of surface forces, its equilibrium state of deformation is uniquely determined and is stable if the stresses are specified.

SCI. ABSTR. (See Abstr. 1176, etc.).

1252. Test Apparatus and Procedure for Determining Resistance of Structural Insulating Board to Impact and Concentrated Loads.

F. B. ROWLEY AND M. H. LAJOY. *Paper Trade J.*, **127**, 152, 1948.

Impact strength may be defined as the resistance of insulating board to shock or impact loads on those areas where there is no rigid backing under the area of impact. The method recommended consists of firmly supporting the sample around its edges in a horizontal position, dropping a given weight having a definite shape of contact point through a specified distance, and noting the number of drops necessary to produce failure in the material. Among the variables considered in developing the method and test apparatus were: (1) the shape and area of the indenter; (2) the weight of hammer and distance through which it should be dropped; (3) the apparatus; and (4) the various methods of rating the size of sample and method of supporting it in the test results. The design of the machine, the method of supporting the specimen, and the test procedure are given in the paper in detail. Concentrated load strength may be defined as the resistance to pressure on a small surface area under which there

is no rigid backing. The difference between the impact load and the concentrated load tests is primarily in the method by which the load is applied, even though the properties of the materials under these two tests are different. The variables considered were : (1) the size of the test specimen and the method of supporting it, together with the relation of the test point to the position of support ; (2) the size and shape of indenter ; and (3) the rate at which the load is applied. Investigation showed that the method of supporting the test specimen and the size of the specimen were not as important for the concentrated load tests as for the impact strength test. The same method of support was used as that developed for the former test. Likewise, the same hemi-spherical indenter was used. The details of a suggested apparatus, together with test procedure for concentrated load, are given in the paper, and also the relative ratings of several different structural insulating and sheathing boards are shown.

P.A.T.R.A. (Abridged).

1253. **Determination of the Elastic Constants of Solids by Ultrasonic Methods.**

W. C. SCHNEIDER AND C. J. BURTON. *J. Appl. Phys.*, **20**, 48, 1949.

The application of ultrasonic methods to the determination of the elastic constants of solids is considered in some detail. An experimental method is described for the derivation of Poisson's ratio and mechanical moduli from the relation between transmission and angle of incidence of ultrasonic waves in a plate of the material in question. Figures for metals are in good agreement with other published data and figures are also given for various thermoplastic and thermosetting resins. W.P.F.

1254. **Creep and Shrinkage in Reinforced-Concrete Structures.**

H. B. SEED. *Engineering*, **164**, 309, 1947.

The relative merits of the many methods developed for the calculation of the magnitude of creep and shrinkage effects in reinforced concrete members are compared, with the object of incorporating any reliable data in routine design procedure. The nature of the inelastic deformations causing creep and shrinkage movements in concrete is first discussed. These movements are determined mainly by the applied stress, quantity of moisture in the gel, the rate of seepage and moisture conditions surrounding the gel, as well as by the water/cement ratio, type of cement, type and grading of aggregate, mix proportions, size of specimen, curing conditions, age at loading (in the case of creep), and age of the concrete at time of the first observation (in the case of shrinkage). Seven methods of evaluating creep are critically considered. It is concluded that for design purposes any allowance made for creep under sustained loads must be calculated either by the effective modulus method or from the rate-of-creep equation $dC/dt = f\phi^1(t)$, for which two methods the errors are of the order of 10%, but in opposite directions. B.S.A. (Abridged).

1255. **A Field Instrument for Measuring Volume and Instantaneous Flow Rate of Inspired Air.**

L. SILVERMAN, T. PLOTKIN AND G. LEE. *Rev. Sci. Instrum.*, **19**, 513, 1948.

A portable self-contained instrument which records the rates of inspiratory air flow through protective canisters under actual field conditions. Observations made in the laboratory can be checked under actual field conditions. Measurements of air flow on subjects in tanks or parachute troops or men moving in industrial operations cannot be obtained without a portable instrument. The essential requirements of this instrument are that it obtains records of air flow, air volume, and respiration rate while worn by or held closely to the individual under observation. The apparatus should be rugged and independent of positional effects or a reasonable amount of rough handling. Its operation should be automatic and not require attention by the subject.

SCI. ABSTR.

1256. Measurements of the Mechanical Properties of Polymer Solutions by Electromagnetic Transducers.

T. L. SMITH, J. D. FERRY AND F. W. SCHREMP. *J. Appl. Phys.*, **20**, 144, 1949.

A rod vibrated axially by a current carrying coil in a magnetic field shears a concentrated polymer solution. Equations are given for the derivation of dynamic viscosity and rigidity from electrical measurements on the coil. Results are given and the advantages and limitations of the method are discussed. W.P.F.

1257. The Determination of Stresses in Plastic Regions in Problems of Plane Flow.

P. S. SYMONDS. *J. Appl. Phys.*, **20**, 107, 1949.

A simple numerical graphical method for the calculation of stresses in plastic zones adjacent to boundaries of arbitrary shape as outlined, applicable to problems of plane plastic flow in ideally plastic materials. The method is applied to determine the stresses in plastic zones near elliptic free boundaries. The yield load of a tensile bar containing elliptic notches is obtained for a series of notches of varying sharpness. Some related problems are discussed briefly. AUTHOR'S ABSTR.

1258. Plastic Deformation of Optical Glass.

E. W. TAYLOR. *Nature*, **163**, 323, 1949.

A lightly-loaded pyramid diamond was found to leave a well-defined and permanent impression on the polished surface of optical glass. With borosilicate crown and extra dense flint glasses, impressions were formed with loadings up to about 50 grams. With loadings of 100 grams, fractures appeared emanating generally from the corners of the square impression. A light interference test showed a raised rim of glass around the depression. E.W.J.M. (See Abstr. 1183).

1259. Green's Theory of Liquid Helium.

L. TISZA. *Nature*, **163**, 102, 1949.

According to Green, the transition of helium I to helium II is due to a rapid drop in the "potential viscosity" (due to molecules in liquids having to pass potential barriers). The author states that the change cannot be described by assuming a value for the viscosity of helium II but that the change is more radical and the macroscopic hydrodynamic equations must be changed by going from ordinary one-fluid hydrodynamics to a two-fluid hydrodynamics and he suggests that Green's theory might be adjusted so as to conform to experimental facts and to the phenomenological theory systematizing the facts. In a footnote, H. S. Green points out that "potential viscosity" is for the most practical purposes the difference between the viscosity of the liquid and that of the vapour at the same temperature. In helium I this has a value $\sim 15 \mu$ poise, almost constant along the saturated vapour curve. A detailed exposition of the quantum theory of liquids to helium II has now appeared and is in agreement with all experimental evidence much of which also agrees with the two-fluid theory. E.W.J.M.

1260. Brittle Fracture of Mild Steel Plates.

A. C. VIVIAN. *Engineering (Letter to Editor)* 7th January, 1949. p. 16.

It is emphasized that the plastic deformation curve of different steels is very definitely affected by changes in the rate of loading. Steels whose plastic deformation is small when the load is increased rapidly have a low Izod value. The important tests which should be made therefore are tests on the effective ductility of the steels

at various speeds of loading. The work of the Cambridge Conference on the above subject is criticized for not taking account of these facts. M.W.T. (See Abstr. 300).

1261. Relaxation Phenomena in Wheat-Flour Doughs.

M. P. VOLAROVICH AND R. A. BRANOPOL'SKAYA. *Kolloidnyi Zh.*, **10**, 406, 1948.

Relaxation times and shear moduli of flour doughs are measured in a Schwedoff Rotation apparatus. Dough, like other systems investigated by M.P.V., such as clays, peat and paints, does not follow a Maxwell relaxation law. The authors therefore designate their samples by an empirical relaxation time which, nevertheless, is claimed to be well correlated with flour quality. G.W.S.B.

1262. Thixotropic Behaviour of Petroleum Jelly.

A. DE WAELE. *Nature*, **163**, 248, 1949.

Using a perforated disk mounted centrally on a metal rod as a piston, moving in a 100 cc. cylinder filled with petroleum jelly it was found that resistance to movement decreased with working. On resting there was a slow increase in consistency but when the sheared jelly was re-sheared by pushing the plunger up and down as quickly as possible a rapid and progressive growth of consistency was observed.

The unsheared material showed thin needle-shaped crystals under polarized light while the slowly sheared jelly showed a great increase of crystallinity, the crystals apparently having the form of shorter, thicker double cones on a common base. The quickly sheared material again showed needles, but of shorter length. E.W.J.M.

1263. The Rheology of Stiff Pastes.

A. G. WARD AND P. R. FREEMAN. *J. Sci. Instr.*, **25**, 387, 1948.

Two viscometers suitable for stiff pastes are described. Both are coaxial cylinder viscometers, one has a narrow gap and the other a large one. In the latter a line can be drawn on the surface of the paste and from the displacement of the line from its initial position the rate of shear can be found. J.E.C.

1264. Instability in Pipe Flow.

R. B. WHITTINGTON AND E. W. S. ASHTON. *Nature*, **162**, 997, 1948.

The conditions necessary for the stability of laminar flow in a cylindrical pipe are considered from the standpoint of the dimensionless group G involving the quantities dv/dx the transverse velocity gradient, ν the kinematic viscosity of the liquid and ${}_x\text{Re}$ the localized Reynolds number, $\nu \cdot x/\nu$.

$$G = x \cdot \frac{d}{dx} ({}_x\text{Re}) - {}_x\text{Re}$$

The maximum value of G in fully developed laminar flow occurs when $x = d/3$ where d is the diameter of the pipe and $G_{\max} = \frac{8}{27} \text{Re}$. E.W.J.M.

1265. Investigations on the Structure-Mechanical Properties of Metallic Dispersed Systems by Means of a Cone Plastometer (Penetrometer).

B. YA. YAMPOL'SKIĬ AND P. A. REBINDER. *Kolloidnyi Zh.*, **10**, 466, 1948.

The rheology of concentrated amalgams of Na, Pb etc., is studied by means of a cone sinking into the test-piece under a constant load. G.W.S.B.

1266. **Influence of Surface-Active Substances on the Mechanical Properties of Concentrated Suspensions of Zinc Oxide.**

YU. S. ZUEV. *Kolloidnyi Zh.*, 10, 431, 1948.

The peptizing and flocculating effects of linseed oil, vaseline, etc. on ZnO suspensions is studied by means of a Veiler and Rebinder rotating disc viscometer. (The investigation relates to the properties of paints). G.W.S.B.

Erratum.

Bull. No. XXI, Abstr. 1087 for p. 29 read 129.

BOOK REVIEWS

SOLID AND LAMINATED WOOD BENDING. By W. C. STEVENS, M.A., A.M.I.Mech.E., and N. TURNER. H.M. Stationery Office, London. Price 5s. net; by post, 5s. 4d.

From the scarcity of published information on the subject, inexpert opinion might be excused for thinking that wood bending is a traditional art, about which everything worth knowing has been practised by its exponents for generations. That false impression will be pleasantly dispelled by perusal of this admirable book, the work of two members of the staff of the Forest Products Research Laboratory, who have studied both the scientific and practical aspects of wood bending, and have amplified the results of laboratory work by solving a wide range of industrial problems for which bent-wood offers increased strength with economy in material.

The book divides naturally into two main parts, concerned respectively with solid relatively thick pieces of wood which are softened by steaming or other heat treatment before being bent to shape; and the more recent techniques of gluing together several thin laminae of wood constrained to the desired curvature. Scientific investigation of alternative softening processes in relation to the type and quality of the wood, of machinery and aids to precision, and of post-bending treatments to control the "set" of the curvature, has brought about many improvements on the traditional technique, which are clearly evident from the authors' descriptions and illustrations. Laminated bending operations are illustrated by photographs and diagrams of modern plant used for continuous strip work and sundry types of pressure moulding. Methods and materials for gluing bent laminations are critically discussed, together with devices for making wood bends retain their shape; and an instructive concluding chapter treats theoretically the assessment of bending qualities from compression and tensile strength data.

While the authors are careful to state that successful wood bending depends as much upon skill and experience as on theoretical knowledge, their own familiarity with both aspects prompts them to embody in the text many suggestions conducive to good results, and indications of directions in which improvement may profitably be sought. Most of the processes described have been tested at the Laboratory, where a high standard of controlled experimental work has enabled the authors to survey the whole field of wood bending with authority and detachment. Their book is therefore to be recommended, not only to those directly concerned with the subject, but also to the many technicians who need to keep abreast of important developments in applied industrial research.

ENGINEERING, 10th December, 1948.

This book of 228 pages is divided into three sections dealing respectively with the structure, the mechanical properties and the thermodynamics of solids. Articles in each section are written by German experts in the field of physics in question. In the section on structure analysis reference is made to two new books by Laue: "X-ray Interference" (1941) and "Interference of Matter Waves" (1943). Crystals and crystal growth are dealt with by Kossell of Heidenheim; a critical review of modern crystal physics was prepared by Eucken and Schafer in 1944. In a chapter on the crystal chemistry of non-metallic compounds, Mehmel includes a useful table showing new German data on the space group, lattice type and lattice constants of quartz, chalcedony, calcium orthosilicate, zircon and other silicates. Advances in German knowledge of the structure of glass and plastics are summarized by Smekal, who was himself responsible for much of the research. Investigations of the structure of thin films have been advanced by the use of the electron microscope; of interest to the ceramic technologist is Mahl's work on the nature of the film of oxide that forms on metallic aluminium. Much of the work so far described lies in the field of physical chemistry rather than physics, but Part 2 of the report relates in its entirety to physics: the elasticity of solids, the plasticity of crystals, hardness, etc. Part 3 of the report considers German advances in thermodynamics: the equation of state, specific heat, thermal conductivity, diffusion and phase changes. It is perhaps worthy of note that the work referred to in Hettner's chapter on phase changes was all published in the earlier years of the war; there seems to have been a cessation of German activity in this important field since about 1942.

B.C.R.A.