

BRITISH RHEOLOGISTS' CLUB



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EDITOR'S LETTER.

Your Committee is at present considering the advisability of changing the name of our Club to *The British Society of Rheology* or its equivalent. Several prominent members have recently expressed the opinion that we labour under a real disadvantage at present with our misleading name which gives scant indication of the true nature of our activities. Whether we like it or not, they say, we are in effect a minor scientific society with aims and methods of achieving them differing in no important respect from those of other learned societies, and so long as we retain the name "Club" we continue to put needless obstacles in the way of our foreign and junior members. There is much weight in this argument.

When the *British Rheologists' Club* was founded in the autumn of 1940, there was no intention of starting yet another scientific society and the name "Club" was chosen deliberately to emphasize the informal nature of our activities. We did not then know what the membership was likely to be, but we estimated (incorrectly as subsequent events proved) a total of about forty. We supposed that this little group would meet for an occasional meal to discuss rheological problems and to offer "mutual aid" of the type familiar to readers of the motorcycling press—save that in our case we should barter penetrometers and Newtonian liquids of high viscosity instead of magdynos and big-end assemblies. In fact, however, the membership has increased to well beyond the limits of what we had at one time considered possible; an Annual Conference with printed (if belated) Proceedings is now usual; we have an increasing number of distinguished overseas members; and many large firms have elected representatives solely in order to obtain this *Bulletin* for their libraries. All this is highly gratifying; but the inevitable corollary is that we can no longer run on a purely informal basis.

Some older members of the Club will deplore any change of name and the establishment of a constitution and rules, however simple. They tell us that the outstanding features of B.R.C. meetings have been their informality, friendliness and vitality, which should be retained at all costs. A *Society* tends to become "stuffy" and a *Royal Society* "stuffer" still. The word "stuffy" in this context is not precisely defined, but one can guess roughly what is meant. They also fear that the subscription will be raised.

This point of view is acknowledged. Against it one must weigh the fact that the name "Club" puts difficulties in the way of overseas members who wish to remit subscriptions. To Customs and Treasury officials, *British Rheologists' Club* conjures up

mental pictures of a large lounge in the West End furnished with hide armchairs in which are seated silent rheologists, asleep or reading *The Times*. It will make the payment of foreign subscriptions easier if we get ourselves recognized officially as a learned society—and in any case official recognition of our status has now become advisable for several reasons.

We are told further that employers who would not hesitate to let their junior rheologists attend a meeting of the *So-and-So Society*, may refuse them leave to attend a *Club* meeting; for to them *British Rheologists' Club* suggests not unnaturally a purely social organization, probably on a par with the *Hogsnorton Darts Club*.

Finally, the *British Rheologists' Club* will be representing British Rheology in the International Union, and for this purpose the name "Club" seems inappropriate.

Whether we like it or not, we are being forced to adopt certain simple rules. We have, for example, to deal with those rheologists whose researches are of so world-shaking a character that they have time neither to pay subscriptions nor to answer repeated letters from the Hon. Treasurer. Other rheologists have queer notions about what constitutes suitable "copy" for the press and some rules here are essential if those responsible for editing the yearly Conference Proceedings are to keep their sanity.

On balance, therefore, the Committee, though desiring to avoid "stuffiness", feels that the time for a change of name and the establishment of a simple constitution and code of rules is now overdue. Nothing can be done without the approval of a majority expressed at a General Meeting, and the whole matter will be discussed at the Reading Conference in the autumn. The purpose of this letter is to acquaint you with what is going on and to give you time to think over the proposed changes. If you have strong views, for or against, you are free to express them in this *Bulletin*. In any case, your Committee will be glad to hear from you.

To Non-Abstractors Only

The appeal in the December *Bulletin* for more abstractors has met with the exact response a cynic would expect—namely, no response whatever. Moreover, there have been two important resignations this last quarter and an examination of our panel of abstractors shows that a few of them never "perform" no matter how many papers of rheological interest may appear in the journals they are reputed to abstract.

The few remaining regular abstractors are not the least busy members of the Club. They carry a heavy load and cannot be asked to do more. To abstract *one* journal which you receive regularly (and, as a good rheologist, doubtless already abstract for your own use) and to send these abstracts to me quarterly on request, is not a very heavy task; and if only five per cent of our non-abstractors were to undertake this, we should have a much better *Bulletin*. You will find on another page a short list of important journals which are now abstracted irregularly or not at all. If you agree with me that this is deplorable, the remedy, as our Dutch friends say, *lies before the hand*. Only it's *your* hand and not the other fellow's. He is always much too busy!

V. G. W. HARRISON.

CLUB NOTES

Our President

The many friends of Dr. G. W. Scott Blair will be sorry to hear of his illness, which prevents his taking any part in Club activities until further notice. At the time of writing we are glad to hear that he is making slow progress towards recovery. We send him our best wishes for a speedy and complete restoration to health.

News of Members

Dr. A. S. C. Lawrence, F.R.I.C., senior lecturer in physical chemistry in the University of Sheffield, has been appointed reader in colloid chemistry.

Prof. J. I. Graham is now at the University of Otago, Dunedin, New Zealand. He writes: "I left England last June with my family to take up the newly created Chair of Coal-Mining in this University, and had an interesting time coming across Canada and

in the States where I visited several Institutions connected with coal-mining. I hope it will be possible for the Rheologists' Club to visit New Zealand one day—or if any of your members come out this way, I shall be glad to see them.”

Journals

Abstractors are urgently needed for the following journals which are at present abstracted either inadequately or not at all :—

J. Franklin Institute
J. Phys. Chem.
J. Math. Phys.
Ind. Engng Chem. (both Editions)
Rec. Trav. Chim. Pays-Bas
Proc. Roy. Acad. Sci.
J. de Physique
Chemie et Industrie
Amer. J. Maths.
Mathematical Review

Offers of help with these will be gratefully received by the Hon. Editor.

Viscometry Standards

A member would be glad to know of any material of high viscosity, 10^4 to 10^6 poise range, which could be used to check the consistency of operation of instruments. Opaque materials would be suitable. The “standard” should be as near Newtonian as possible and able to be kept a reasonable length of time without deterioration.

Please send correspondence and samples to the Hon. Secretary.

Translations

A member undertakes to translate accurately into good English rheological papers in French, German, Dutch and Italian. Interested members are asked to write to the Hon. Editor.

Loan of Original Papers

As a result of recent enquiries, we take this opportunity of explaining that the Club does not maintain a library of periodicals, and articles referred to in the Abstracts are not available on loan. In most cases the originals can be consulted in the Patent Office Library or the Science Museum Library.

Authors' Abstracts

In the case of abstracts reprinted by permission from other journals, it is not always clear whether these abstracts are authors' own or prepared specially for the journals in question. It is impossible for us to verify every reference before publication. Authors who find their own abstracts apparently attributed elsewhere are therefore asked to accept this explanation with our apologies.

Date of Publication

Members are reminded that the date printed on these *Bulletins* is not the date of publication, but the closing date for the receipt of abstracts. Thus the present number contains abstracts received up to the end of March 1950 and is going to press in mid-April. It will be dispatched immediately on receipt from the printers. Issues are therefore not so late as would at first sight appear.

Suggestions

Suggestions for the improvement of this *Bulletin* or the running of the Club will be gratefully received, and acted upon if finance and available labour permit.

**EXHIBITION AND DISCUSSION HELD AT THE POLYTECHNIC,
REGENT STREET, LONDON. 6th JANUARY, 1950**

Exhibition of Rheological Apparatus

The number of exhibitors was small, but sufficient equipment was brought together to fill all the available time for those wishing to examine the apparatus. There was very good attendance, and a real need for further exhibitions, possibly on a more ambitious scale, was revealed.

Only very brief notes can be given here of the items exhibited; some of the apparatus, being of considerable complexity, would require lengthy description to make their construction and scope of application clear.

Two instruments were shown which were intended primarily for Newtonian liquids. These were the Steiner Kinematic Viscometer and the Techne Industrial Absolute Viscometer. The former instrument incorporates many refinements of technique, involving the use of a number of U-tube viscometers with capillary lengths up to 60 cm. and different diameters. Surface tension effects are minimised by constricting the bulb into which the liquid is flowing to match the shape at the lower end of the outflow bulb. Jet stirring, blade heaters, and electronic control are claimed to give $\pm 0.001^\circ\text{C}$ at 40°C and $\pm 0.01^\circ\text{C}$ at 100°C . The Techne Viscometer uses a dead weight gauge to apply the pressure, and the time for the liquid to flow between two marks in a tube is used as a measure of viscosity. High precision is not claimed, the advantages being speed in use, and ease of cleaning.

For non-Newtonian liquids, and also materials with a small yield value, there were a number of exhibits. G. W. Scott-Blair and F. A. Glover showed the Constant Speed Emptying and Filling Capillary Micro-rheometer, which has been designed to study the properties of human and bovine uterine cervical secretions. The method can be applied to very small quantities of material, and can give figures which indicate the degree of non-Newtonian behaviour. J. Pryce Jones exhibited the Twin Couette Viscometer in which, by using a Newtonian liquid in one viscometer, the anomalous behaviour of the liquid in the second viscometer, which is coupled to the first, can be very clearly demonstrated. The demonstration included the behaviour of magnetic liquids. The British Food Manufacturers' Research Association showed the 'Shirley Consistometer' in which the torque required to rotate vanes in the liquid is measured. N. A. de Bruyne showed a Gelation Timer (made by Techne (Cambridge) Ltd.) in which a disc is given a simple harmonic motion in the setting resin. The weight of the disc is sufficient to ensure that the connecting link in the drive is in tension as long as the resin is fluid. As soon as the resin has become a gel of sufficient strength to support the weight of the disc, the link is put in compression. This is used to operate a switch and relay which signals the point of gelation. A. G. Ward showed photographs of the Absolute Concentric Cylinder Viscometer, used either as a Couette or a Searle type instrument. This instrument is particularly suitable for concentrated polymer solutions.

E. W. J. Mardles and E. Bielak demonstrated the use of a parallel plate plastometer for the control of the consistency of greases when only small quantities are available. W. F. O. Follet and A. H. Cross showed drawings and photographs of a very interesting apparatus for the measurements of total stress in rubberlike materials. The material is sheared between a cone and a plate, and both the torque and the vertical thrust are measured.

For harder materials W. Lethersich demonstrated the instruments described in his lecture for measuring the elasticity modulus and internal friction of dielectric materials over a wide range of frequency. E. B. Atkinson and H. A. Nancarrow presented their extrusion apparatus (as described at the Bristol Conference) in which a Hounsfield Tensometer has been adapted to secure the extrusion of thermoplastics over a range of pressures and temperatures. The British Iron and Steel Research Association showed diagrams of the application of the Andrade constant stress device to the study of the high

temperature rheology of steel. The apparatus, designed by P. Feltham has been applied to mild steel in the austenitic range, 950—1400°C. Industrial Distributors Ltd. (Diamond Research Department) showed the double cone hardness tester and the micro-abrasion tester, which they have designed. The latter is of particular interest in enabling the effect of direction to be studied.

Discussion on Rheological Instruments and Apparatus.

Dr. S. Whitehead, who took the chair, expressed the thanks of the Club to Dr. Topping and the Governors of the Polytechnic for the facilities placed at the disposal of the Club.

Dr. A. H. Nissan in the first paper mentioned the difficulties of securing satisfactory apparatus for all but the simplest materials. It was not always true that an approximate measurement would serve for industrial purposes. For instance in using viscosity to determine paper pulp concentrations, the accuracy for low pulp concentrations required to be very high. Although relative viscosities may with difficulty be measured to 0.1% it is only possible to measure absolute viscosities to 0.3% and more commonly to 1%.

Some of the unsatisfactory features of present rheological studies could be the result of (a) preoccupation with orthodox hydrodynamics, which was inapplicable even in its assumptions, for many systems; (b) the tendency to develop theories in advance of precise quantitative experiments; (c) the idea that the behaviour of the most complex materials can be reduced to two constants.

The need was for accurate quantitative study of precisely defined systems and for apparatus to enable this to be done.

The second paper by Dr. W. Lethersich gave an instance of precise experimental methods in use.

The dynamic properties of dielectrics were studied using a method for suddenly applying a constant shear stress to a tubular specimen. The apparatus employed was described and records of the oscillation produced when the stress was applied were shown. The dynamic shear modulus of the material could be calculated from the frequency of the oscillations, and the viscosity from their rate of decay. The frequency could be altered by adding brass rings of known inertia to the specimen; the range of frequencies covered was from 30 to 3000 cycles/sec.

Another apparatus was described in which a sinusoidal stress could be applied directly to the specimen by rotation of a spring. The stress-time and strain-time relation could be plotted directly for very low frequencies (10^{-4} — 10^{-2} cycles/second) and recorded for frequencies up to 1 cycle/second. The amplitude of oscillation enabled the dynamic modulus to be calculated and the angle of lag between the stress and strain curves gave the viscosity.

The rheological properties of many dielectrics at any given frequency can be expressed in terms of a single Kelvin element, (parallel spring dash-pot) the spring having a modulus G and the dashpot a viscosity η . G is found to increase linearly with the logarithm of the frequency and the product $\eta \times$ frequency is constant over the frequency range 10^{-4} —3000 cycle/second. This was shown to be in accord with the assumption that there are many such elements and that the number having relaxation time between τ and $\tau + d\tau$ (where $\tau = \eta/G$) is proportional to $1/\tau$. The rheological properties of such a material at any frequency are completely specified by the dynamic modulus and viscosity at that frequency.

In the discussion Dr. Gross, from Rio de Janeiro, mentioned the determination of the distribution of relaxation times from the creep function, irrespective of the physical model of the behaviour of the systems. Dr. Scott Blair emphasised the need for means of developing an idea for an instrument, which has been tested in the form of a prototype, into the best form for use and manufacture. He asked whether the Scientific Instrument Research Association was not able to do this. Dr. Whitehead said that S.I.R.A. would do such work if the need was clearly expressed. Dr. Nissan and Mr. Wookey discussed

the measurements of little practical use which were done as routine measurements and then filed away. Dr. Scott Blair pointed out how few tests really corresponded with the properties requiring measurement. Other members took part in the discussion and emphasised the need for sound methods of test.

A. G. WARD.

POSTSCRIPT

Cambridge Meeting, Thursday and Friday 13 and 14 April.

Members of the Club who attended the Cambridge meeting held jointly with the Society for Experimental Biology were well rewarded by the great value and interest of the sessions and events. Demonstrations in the Zoological laboratory were particularly interesting to both biologists and rheologists. The social events included teas in the laboratory and a coffee party at Kings College on Thursday evening.

At the colloquium on Friday morning when Mr. A. G. Ward deputised for the president, papers were read by Mr. F. A. Glover, of the National Institute for Research in Dairying, on the Rheology of Cervical secretions and by Mr. J. Pryce Jones on the thixotropy, elastic recoil, "spinnbarkeit" and other properties of honey. Dr. N. A. de Bruyne demonstrated an absolute viscometer for thick liquids and a gelation timer for catalysed resins. Mr. L. A. Steiner also described and demonstrated several different kinds of viscometers covering a wide range of viscosity and amounts to micro quantities.

In the afternoon session under the chairmanship of Dr. E. C. Bate-Smith the following papers were read on the subject of the rheology of living systems:—

M. G. M. PRYOR (Cambridge). Viscous elastic systems.

F. C. CRICK (Cambridge). The magnetic particle method of studying cytoplasm.

Sir NIGEL BALL (London). The transport of organic compounds in plants.

G. CAUSEY and E. PALMER (London). An investigation of the fluid properties of mammalian axoplasm.

L. E. R. PICKEN (Cambridge). Rheological problems in the growth of insect scales and bristles.

The discussion at both sessions extended well beyond the allotted time and indicated the great value of the joint meeting. After tea members visited the Low Temperature Research Station under the guidance of the Director, Dr. E. C. Bate-Smith, where demonstrations were given on the measurement of rigidity of muscle, structural changes in eggs during storage, the physical properties of liquids, of liquids concerned in heat exchange and on other aspects of the work carried out at the Station.

E. W. J. MARDLES.

International Colloquium on Rheological Problems in Biology.

A Colloquium has been arranged by the International Union of Rheology to discuss such topics as the mechanics of muscle, the translocation of sap in plants, circulation of the blood, etc. bringing together workers in botany, physiology, medicine, zoology and rheology.

The colloquium will be held at the University, Lund, Sweden, on July 26th, 27th and 28th, 1950. Particulars are available from Dr. P. Eggleton, the University, Edinburgh.

RHEOLOGY ABSTRACTS

NOTE.—The initials following the Abstracts are those of the abstracting member except for the following abbreviations for abstracts reproduced 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, Packaging and Allied Trades Research Association.
SCI. ABSTR.	Science Abstracts.
B.S.A.	Building Science Abstracts.

1562. Propagation of transverse waves in viscoelastic media.

F. T. ADLER, W. M. SAWYER AND J. D. FERRY. *J. Appl. Phys.*, 1949, **20**, 1036.

In calculating elastic constants of viscoelastic media from transverse wave propagation, it has been customary heretofore to assume a plane disturbance in a medium of infinite extent. Equations have now been derived for conditions which approach much more closely the experimental arrangement, namely, propagation from a finite source plate in a rectangular cell, and representative numerical calculations have been made. The new theory shows that the finite dimensions of cell and source should have very little influence on the wavelength as determined from observations of strain double refraction, but the attenuation should be perceptibly different from that of the plane wave case. Experimental data confirm these conclusions. Nevertheless, the simple plane theory is adequate within present experimental error for the majority of cases. Only in certain specified ranges of mechanical consistency will it be necessary to apply corrections taking into account the sizes of the cell and source.

AUTHORS.

1563. Plastic flow of unmaturred linoleum.

ANON. *Paint, Oil Col. J.*, 1950, **117**, 364.

A brief account of the Rheology Symposium held by the recently formed Linoleum Research Council. The extrusion and testing of linoleum compositions is discussed.

V.G.W.H.

1564. Paper under impact conditions.

O. ANDERSSON AND B. STEENBERG. *Svensk Papperstidning*, 1950, **1**, 1 (In English).

The rheological behaviour of paper is dependent on the rate of deformation to such an extent that the impact strength cannot be evaluated from results of experiments carried out at a low rate of deformation. A theoretical basis for the study of paper behaviour under high rates of deformation is presented. The propagation and reflexion of shock waves in materials exhibiting Hookean and non-Hookean behaviour are examined. The rupture energy, possibilities of measuring it and the critical rate of deformation are discussed. The stress-strain curve of paper cannot be recorded directly at high rates of straining and the true stress-strain curve under these conditions is hard to calculate: a trial-and-error method may be used, but is tedious. The application of this preliminary work to the interpretation of experimental results is to be shown in a later paper.

V.G.W.H.

1565. The Reh binder effect.

E. N. da C. ANDRADE AND R. F. Y. RANDALL. *Nature*, 1949, **164**, 1127.

Experiments on the effect of a 0.2% solution of oleic acid in non-polar paraffin in reducing the mechanical strength of cadmium single crystals are described. The results indicate that the Reh binder effect is due to a disintegrating action of the agent on the oxide film which in its original condition strengthens the crystal and not to any penetration of the liquid deep into the crystalline micro cracks, as supposed by Reh binder.

E.W.J.M.

1566. Two model laws on highly viscous fluids.

A. H. M. ANDREASEN. *J. Soc. Glass Technol. (Trans.)*, 1949, **33**, 163.

The following model laws have been established: Froude's, relating inertia and gravity forces; Reynolds', relating inertia and viscosity forces; Cauchy's, relating inertia and elasticity forces; and Weber's, relating inertia and surface forces. Generally, the laws are valid only when kinds of force other than those in question can be neglected. The author induces further model laws relating (1) viscosity and gravitational forces and (2) viscosity and surface forces. Deductions from these laws agree with experience in glass-working.

B.C.R.A.

1567. The phenomenon of the hardening of glass.

G. M. BARTENEV. *J. Tech. Phys., USSR*, 1948, **18**, 383. *In Russian*.

A theory of the mechanism of the hardening of glasses and the part played by the T_g point is presented. The case of hardening of a glass sheet is treated as an example, cooling from either side according to Newton's law being assumed. It is shown that for regular cooling the internal stresses have a nearly cosinusoidal distribution. The dependence of the internal stresses during the hardening process on the hardening (max.) temp. was experimentally investigated, and it could be shown that the degree of hardening, from a certain temp. onwards, becomes constant. This agrees with the theory. The depth of the neutral layer and the ratio of the surface stresses to the internal stresses were also determined, and both found to agree with theory.

SCI. ABSTR.

1568. The dissipation of frictional heat.

H. BLOK. *Voordrachten Kon. Inst. v. Ingenieurs (the Hague)*. 1950, **2**, 84.

Two kinds of heat dissipation are considered, viz.: primary and secondary dissipation. The paper deals nearly exclusively with primary dissipation, particularly with its influence on the maximum temperature in the source of heat generation. As an example heat generation in a Couette type viscometer, used for measuring oil viscosity at high rates of shear, is treated.

P.G.M.

1569. Methods of measuring soil consistency.

G. B. BODMAN. *Soil Sci.* 1949, **68**, 37.

In this review the emphasis is on the macrotype of consistency measurement and the method of interpretation necessary for consistency evaluation. Methods are grouped and dealt with according to the kind of deformation to which the soil is subjected in the measurement and the type of apparatus used.

B.C.R.A.

1570. A preliminary examination of the thixotropy of some sedimentary rocks.

P. G. H. BOSWELL. *Quart. J. Geol. Soc.*, 1949, **104**, 499.

Although the thixotropic behaviour of geological materials (made manifest by the isothermal, reversible, gel-sol-gel transformation) has been utilized in many industries, the thixotropy of naturally occurring sediments appears to have been but little studied. The results of a preliminary examination of a representative series of unconsolidated rocks are therefore presented. Excepting coarse clean sands and gravel, all sediments prove to be capable of assuming the thixotropic state, the degree of thixotropy depending on grain-size, grading, mineralogical composition and the presence of electrolytes.

Thixotropic values and their range are given for a large selection of sediments from Britain and abroad, and notes are added on the problems presented by some of the more interesting materials. B.C.R.A.

1571. Friction and adhesion of clean metals.

F. B. BOWDEN AND J. E. YOUNG. *Nature*, 1949, **164**, 1089.

The observation is made that for two separate pieces of metals heated by high-frequency induction to the point of evaporation in a vacuum of about 10^{-6} mm mercury, then allowed to cool nearly to room temperature and brought into frictional contact without disturbing the vacuum, the process of relative motion itself leads to a very great increase in the true area of contact. The claim is made that the "coefficient of friction" may rise to 100 or more although it would appear as if the "coefficient of friction" lacked definition outside the range of the validity of Amontons' law. The contact was found to have the bulk strength of the metal by measuring the normal force required to separate the metals and deducing the area of contact from photomicrographs. R.S.

1572. An electrical viscometer.

A. R. BOYLE. *J. Sci. Instrum.*, 1950, **27**, (2), 41.

A simple electrical viscometer has been designed enabling instantaneous indications of viscosities of liquids at any point in an industrial plant. The transmitter unit consists of a two-phase electric motor operated from single-phase mains and so designed and constructed that large variations of current in one phase are produced by small changes in viscous drag on the rotating part. The indicator unit is essentially an ammeter in one of the motor phases and is directly calibrated in viscosity units. Models have been designed for operation within pipe lines and containers up to high pressures and high temperatures (about 250°C) and for rapid testing of samples. AUTHOR.

1573. Note on some plastic flow effects in steel.

O. H. CLARK AND E. M. LYMAN. *J. Appl. Phys.*, 1949, **20**, 884-5.

The plastic flow effects which take place when two steel rods are pressed together at right angles are studied. The deformations produced are evaluated by the use of interference fringes. Elastic recovery effects are calculated, using Prussian blue as an indicator to reveal recovery. Measurements are reported for deformations between (a) like cylinders, (b) cylinders of different hardness. The measuring error is of the order of half a light wave. SCI. ABSTR.

1574. The flow of glass.

R. W. DOUGLAS. *J. Soc. Glass Technol. (Trans.)*, 1949, **33**, 138.

The expression $\eta/T = Ae^{B/T} (1 + Ce^{D/T})$ has been derived for the viscosity of glass as a function of temperature assuming that the flow of glass is controlled by the Si-O-Si bonds and that flow can occur when an oxygen atom has two positions available to it. The factor in brackets arises from the change of atomic configuration with temperature. In atomic arrangement the structure of water is very similar to that of fused SiO_2 and, as first check on the theory, it was shown that the above expression can be fitted very accurately to the observed values of viscosity of water as a function of temperature. Moreover, the experimental values of A and B were found to be in close accord with those predicted. The trend of the values of the constants when Na_2O is added to Si_2O was discussed qualitatively on the basis of published data on soda-silica glasses. In every case the qualitative predictions were confirmed and again the magnitudes of A and B were of the right order. It is emphasized, however, that from the point of view of checking theoretical predictions the available data are scanty and the agreements obtained do no more than indicate that the theory is not incompatible with the observations. A series of viscosity-temperature measurements at many temperatures over the largest possible range of viscosities on a few soda-silica glasses spread over the range 10-50% soda would enable a more critical evaluation of the theory to be made. AUTHOR.

1575. Dynamic properties of polymeric materials.

B. A. DUNELL AND A. V. TOBOLSKY. *J. Chem. Phys.*, 1949, **17**, 1001.

A model with a rectangular distribution of relaxation times on a log plot leads to a simple relation between $\eta_{dyn}\omega$ and ϵ_0 (strain at which stress relaxation occurs) if the stress relaxation/log time curve is linear. The calculated values of $\eta_{dyn}\omega$ are compared with experiment for rubber and various textile fibres. SCI. ABSTR.

1576. The flow of mild steel in the A_3 -range, 950-1400°C.

P. FELTHAM. *Nature*, 1950, **165**, 489.

The transient and quasi-viscous rates of the plastic flow of a 0.006% C steel were measured under constant stress in vacuo. The ranges of stress and strain-rate were 80-280 kg/cm² (about $\frac{1}{2}$ -2 tons/sq. in. and 3.5×10^{-5} - 7.0×10^{-3} sec⁻¹. Both types of flow were interpreted by dislocation mechanisms, and theoretical relationships for the rates of strain obtained on the basis of the dislocation theory combined with the theory of molecular rate processes were found to give good agreement with the experimental results. P.F.

1577. Onset of turbulent flow in certain arrays of particles.

J. W. FOX. *Proc. Phys. Soc. B*, 1949, **62**, 829.

Reynolds' number has been found for the onset of turbulence in water flowing through a perfectly packed hexagonal array of uniform spheres. Experiments have also been carried out on an imperfectly packed array of the same spheres and on an array of irregular particles (marble chips). A satisfactory differential manometer, which enables differences of head of the order of 0.01 mm of water to be readily determined, is described. AUTHOR.

1578. Residual lattice strains in mild steel.

R. I. GARROD. *Nature*, 1950, **165**, 241.

Experiments are described to test the Greenough-Heyn hypothesis to explain creep recovery. The explanation involves the assumption that in a randomly oriented polycrystalline aggregate deforming under, for example, a tensile stress, some grains, in which the glide planes and glide directions are suitably oriented with respect to the stress direction, will yield before their neighbours which have different orientations. In consequence, if the applied stress is removed, strains with a high yield-tension will be left in tension, and those with a low yield-tension in compression. It was found that all the X-ray patterns from different radiations for both normal and oblique incidence exhibited uniform break-down of the grains for the same value of previously applied stress. The effect was not confined to surface layers. Evidence was obtained of small but detectable residual strains for previously applied stresses well below the normal yield point. E.W.J.M.

1579. Use of method of falling spheres for the characterisation of structural viscosity and thixotropy.

S. A. GLIKMAN, N. Y. VLADYKINA AND T. M. PEREPELOVA. *Doklady Akad. Nauk, USSR*, 1949, **67**, 483. *Chemical Abstracts*, 1949, **43**, 8235.

Falling sphere methods are recommended in preference to capillary-flow and rotation methods of measuring structural viscosity and thixotropy. V.G.W.H.

1580. The application of multiple factor analysis to industrial test data.

R. HARPER, A. J. KENT AND G. W. SCOTT BLAIR. *Brit. J. Appl. Phys.*, 1950, **1**, 23.

The technique known as Multiple Factor Analysis is outlined and its relevance to problems of industrial physics is discussed. In particular, the method is applied to the analysis of a set of rheological and electrical tests on a set of plastics. Three "factors" are sufficient to account for all the observed relationships between the ten tests. Three numerical solutions have been evaluated, one involving non-orthogonal "factors" presenting the simplest solution for interpretation. All the solutions are linear transformations of one another. AUTHORS.

1581. **Mathematical principles of rheology.**

H. HENCKY. *Research*, 1949, **2**, 437.

The inadequacy of the classical theory of elasticity is noted; classical kinematics must be expanded and the equations of equilibrium extended. It is considered that a synthesis of elasticity and hydrodynamics must be achieved. Some of the principles involved are examined mathematically.
B.C.R.A.

1582. **The Instron tensile tester.**

H. HINDMAN AND G. S. BURR. *Trans. Amer. Soc. Mech. Engrs*, 1949, **71**, 789.

The instrument incorporates an electronic weighing system employing bonded-wire strain gauges for recording the load applied to the sample under test. Full scale sensitivities may be obtained extending from 2g to 1000 lb. Single fibres may thus be tested as well as materials of high ultimate strengths. Accuracy of $\pm 0.5\%$ or less is claimed. A range of crosshead speeds from 0.02 to 20 in/min. is available, and the motion may be started, stopped and reversed almost instantly, either manually or automatically. As far as possible, precautions are taken to ensure that the stress-strain curves obtained are characteristic only of the material under test, and not influenced by the testing machine. The construction of the apparatus is described in detail and its performance illustrated by load-elongation curves for various fibres, fabric and paper, yarn, pliofilm and adhesive tests.
V.G.W.H.

1583. **The problem of paper strength.**

S. N. IVANOV. *Bumazh. Prom.*, 1948, **23** (6), 6. *Chemical Abstracts*, 1949, **43** (22), 9443.

A formula is presented for the calculation of paper strength, R , in kg., from fundamental considerations as follows:

$$R = M\pi dls/8 \times [(n-1)/n] = KM\pi d^2p/4,$$

where M is the number of fibres in the transverse section of the test piece of paper in the Schopper dynamometer, d is the average diameter of fibres in the paper in mm, l is the average lengths of the fibres in the paper in mm, s is the cohesive strength in kg/sq mm as calculated by the formula

$$s = 0.002\sqrt{8100 - (100-g)^2}$$

where g is the Schopper-Riegler degree of beating, n is the number of layers of fibre in a thickness of paper, K is a coefficient indicating the percentage of the fibre involved in the break, and p is the tensile strength of the fibre in kg/sq mm. The value of the second term of the equation was assumed to be 20% of the first term. Close agreement was obtained between calculated and experimental results and this formula is proposed for the manufacture of paper of definite strength characteristics on the paper machine.

P.A.T.R.A.

1584. **Elasticity measurements on piezo-electric crystals by the method of Schafer and Bergmann.**

F. JONA. *Helv. Phys. Acta*, 1949, **22** (4), 397. *In German*.

The elastic constants of KDP, Rochelle salt and NaClO_3 , are obtained from ultrasonic diffraction patterns. They differ somewhat from the constants calculated from the resonance frequencies of bars and plates, but an explanation of the discrepancies is suggested.
SCI. ABSTR.

1585. **Elasticity and rupture of concrete and stone at constant rates of loading.**

R. JONES. *Nature*, 1950, **165**, 39.

Experiments are described in which 4in. side cubes are loaded to failure by compression, an ultrasonic pulse being propagated at intervals through the specimens and the time of transmission of the leading edge of the pulse measured. With concrete cubes and increasing load, the longitudinal wave velocity, measured vertically, remained sensibly constant up to failure. In the horizontal direction the velocity remained constant

up to only a fraction of the ultimate failing load and thereafter decreased with increasing load. The decrease was attributed to internal rupture along vertical planes. Various behaviours with stone from different sources are described. E.W.J.M.

1586. Analysis of the temperature coefficient of shear modulus of aluminium.
T. S. KÊ. Letter in *Phys. Rev.*, 1949, **76**, 579.

Measurements were made of the frequency of torsional vibration of an Al single crystal within the temp. range 20-450°C and it was found the temp. coeff. of the shear modulus ($d \ln G/dT$) was $-6.8 \times 10^{-4} \text{ deg.}^{-1}$. It was deduced that this temp. coeff. is given by the relation: $d \ln G/dT = (\partial \ln G/\partial \ln V)_T \cdot d \ln V/dT + (\partial \ln G/\partial T)_V$. Work by other authors gives $(\partial \ln G/\partial \ln V)_T = -5.64$ and the average volume expansion coeff. is 8.0×10^{-5} from which the first term on the right-hand side of the above relation comes to -4.5×10^{-4} , and thus $(\partial \ln G/\partial T)_V = -2.3 \times 10^{-4}$. The explicitly temp.-dependent term thus contributes more than $\frac{1}{3}$ of the total temp. coeff., from which it is deduced that the shear modulus is not a sole function of volume. SCI. ABSTR.

1587. Note on the interpretation of multiple factor analysis.
A. J. KENT. *Brit. J. Appl. Phys.*, 1950, **1**, 28.

The Multiple Factor Analysis of the preceding paper (see Abstract 1580) shows that the tests described therein each measure some combination of three fundamental factors, each factor representing a property or quasi-property of the material. The present note indicates one way in which this knowledge may be developed, the vector model being interpreted in terms of current ideas on high-polymer molecules. These lead to considerations of the grouping of the vectors of the vector model which indicate that the two most important factors may be the freedom of rotation of the carbon-carbon polymer chain linkages and the polar nature of the plasticizers. This conception is shown to agree with the whole structure of the vector model. AUTHOR.

1588. Plastic deformation and destruction of polycrystalline metals in tension.
II. The elongation curve of pure metals.

G. N. KOLESNIKOV AND OTHERS. *J. Tech. Phys., USSR*, 1949, **19** (1), 62. In Russian.

An investigation of the stress-strain diagrams of Sn, Cd, Zn, Mg, Pb, Al, Cu and α -Fe at temps. ranging from 78°K to within 0.8° of the temp. of fusion or phase-change. It is found that in the majority of cases the stress strain curves of the pure metals fall into two groups of "low temp." and "high temp." metals respectively. The "high temp." stress-strain curve is specially investigated.

INDEX AERONAUTICUS. (From SCI. ABSTR.)

1589. Investigation of fractures produced by transient stress waves.
H. KOLSKY AND A. C. SHEARMAN. *Research, Lond.*, 1949, **2**, 384.

The fractures obtained in Perspex of various shapes, when small charges of lead azide are detonated on the surfaces, are described and shown to be explainable by considering the reflections of the stress pulses at the free surfaces. Possible uses of this method of testing are suggested. SCI. ABSTR.

1590. The viscosities of binary liquid mixtures: monofluorodichloromethane and acetone.

J. R. LACHER, C. H. WALDEN AND J. D. PARK. *J. Amer. Chem. Soc.*, 1949, **71**, 3026.

The viscosities of binary liquid mixtures of CHCl_2F and acetone have been measured for several mole fractions and over a temp. range of -80 to 0° . The results are discussed in terms of the activated complex theory of Eyring for viscous flow. AUTHORS.

1591. The variation of the adiabatic elastic constants of KCl, NaCl, CuZn, Cu and Al with pressure to 10,000 bars.

D. LAZARUS. *Phys. Rev.*, 1949, **76**, 544.

The adiabatic velocities of sound for longitudinal and transverse waves in single crystal specimens of 5 cubic solids have been measured as a function of pressure to 10,000 bars, using a pulse technique [1 bar = 10^6 dynes]. The elastic constants calculated from these data in general agree well with previous measurements obtained for zero pressure elastic constants and compressibilities. With increasing pressure the anisotropy increases in crystals which are not closest-packed, but decreases in closest-packed structures. Consideration of the exchange force between nearest neighbours gives a qualitative explanation for this effect. Comparison of the present measurements with previous measurements of the variation of elastic constants with temp. indicates that the elastic moduli cannot be considered functions of volume alone but must depend explicitly on the temp.

AUTHOR.

1592. The measurement of the coefficient of internal friction of solid rods by a resonance method.

W. LETHERSICH AND H. PELZER. *Brit. J. Appl. Phys.*, 1950, **1**, 18.

A theory is given and an expression derived relating amplitude of vibration with frequency for a rod subjected to alternating mechanical stress. The coefficient of internal friction of the material can be deduced providing the internal friction is small as for example with metals. With plastics the internal friction is larger, so that a correction must be applied which can be expressed in the form

$$\eta/E = (\delta f / 2\pi f^2) (1 + 2\delta f / f)$$

The physical basis from which the fundamental equations are derived is discussed and the relation between longitudinal and tangential viscosity is deduced. An expression has also been derived which enables the volume viscosity to be determined should experiments show the existence of volume viscosity.

AUTHORS.

1593. A generalization of the stress-strain relation in viscous-elastic solids.

F. LEVI. *Ric. Sci.*, 1949, **19**, 368. *In Italian.*

A model of a viscous-elastic solid is suggested in which the substance is assumed to be homogeneous as far as external forces are concerned, while, to determine the stress-strain relation in any fibre, the fibre is considered to be made up both of a number of longitudinal elastic elements and a number of viscous-elastic ones, uniformly distributed in the section. For the latter it is further assumed that if ϵ_0 is the viscous deformation under unit stress and ϵ that under any stress σ , $d\epsilon/dt = \sigma d\epsilon_0/dt$.

SCI. ABSTR.

1594. An elastic theory of dislocations.

E. H. MANN. *Proc. Roy. Soc. A*, 1949, **199**, 376.

The stresses in a crystal can be calculated by supposing the slip bands replaced by dislocations of a more general type than Volterra dislocations. The mathematical theory is developed by assuming that only the stresses acting across the surface of the "cut" of an idealized dislocation are continuous across the cut.

J.G.O.

1595. Rheological properties of polystyrene below 80°C.

B. MAXWELL AND L. F. RAHM. *Industr. Engng Chem.*, 1949, **41**, 1988.

A study by means of stress relaxation tests at various elongations and temps. and by creep tests at various loads and temps. The results indicate that there are two mechanisms of stress relaxation and creep. The first is the slipping of chain segments and the second is crazing. A new method of measuring crazing is described, and detailed studies of the relation of crazing to time, temp., stress and strain are reported. It is concluded that a specific critical elongation must be reached before crazing takes place. This elongation is independent of temp. but is affected by certain organic solvents.

AUTHOR.

1596. The plastic behaviour of solids.

A. MCCANCE. *J. Iron Steel Inst.*, 1949, **163**, 241.

This paper is the text of the Fourth Hatfield Memorial Lecture. The view that plastic behaviour is a degenerated elastic behaviour and can therefore be studied by extending the theory of elasticity is considered untenable. Transition from elastic to plastic conditions takes place at the elastic limit, but the stress at which this transition takes place depends on the conditions. It now seems highly improbable that a definite elastic limit exists in a pure crystal; in multigranular material or in ionic crystals, however, a true elastic limit can exist. The significance of these modern views on stress/strain relationships is examined mathematically and with the aid of experimental results on metals.

B.C.R.A.

1597. A note on the notch effect of metals.

K. MINAMIOZI AND H. OKUBO. *J. Franklin Inst.*, Jan. 1950, p.49.

The theory of elasticity shows that the stress concentration around a diametral hole in a round bar under tension increases with decreasing hole diameter to a limiting value of about 3. On the other hand fatigue tests of metals show that the strength of a bar with a very small diametrical hole does not differ perceptibly from that of an undrilled one. This discrepancy is explained by the inapplicability of the theory of elasticity relating to homogeneous materials to metals containing regions of stress concentration of the same order of magnitude as the grain-size. Experimental results obtained on drilled specimens of steels and aluminium are given and interpreted.

P.F.

1598. Flow properties of dispersions of calcium soaps in hydrocarbon oil.

G. B. MOSES AND I. E. PUDDINGTON. *Canad. J. Res. B*, 1949, **27**, 616.

The flow properties of dispersions of calcium soaps in hydrocarbon oils have been studied over a range of temp. from 35° to 90°C, and rates of shear from 500 to 16 000 sec⁻¹ by extrusion through a capillary plastometer. The thixotropy of the system falls as the temp. is increased to 50°C and then rises to a max. at 65°C, after which it falls regularly. This behaviour is due to the thermal weakening of the thixotropic bonds, followed by a strengthening of these bonds due to incipient swelling on the surface of the soap. As the surface of the soap particles continues to swell, cohesion of the particles increases to such an extent that breakdown does not take place and the coeff. of thixotropy falls to very small values. The coeff. of thixotropy found by this method bears a linear relation to the hardness of the dispersion as determined by a falling cone.

AUTHORS.

1599. Mechanical properties of metals.

N. F. MOTT. *Physica*, 1949, **15**, 119.

A short account of the dislocation theory of the properties of metals. Slip, work hardening, impurities, recrystallization and recovery and grain boundary effects are considered.

SCI. ABSTR.

1600. A new method for measuring the fluidity, viscosity and surface tension of melted enamels, glass and metals.

A. NEVOTNY. *Zpr. Čsl. Keram. Sklár. Společ.*, 1949, **25** (1), 63.

The method is based on accurate observation of the behaviour of a drop of molten glass formed at the end of a heated rod. An equation is given from which the viscosity and surface tension can be calculated. The apparatus described is considered to have adequate accuracy and is applicable up to viscosities of 10⁻⁵—10⁻⁶ poises. The apparatus is simple and rapid. Its design is patented.

B.C.R.A.

1601. Models for research in the steel industry.

M. P. NEWBY. *Internat. Chem. Engng*, 1950, **31**, 63.

The use of models in studying problems of flow of liquids and gases, such as liquid steel and furnace gases, is discussed and illustrated.

V.G.W.H.

1602. Rectilinear flow of non-Bingham plastic solids and non-Newtonian viscous liquids. I.

J. G. OLDROYD, *Proc. Camb. Phil. Soc.*, 1949, **45** (4), 595.

The stress-rate of shear relationship, expressed in parametric form, for incompressible and isotropic materials leads to a single second-order differential equation for rectilinear flow with zero pressure gradient. Complete solutions determine all possible velocity distributions and one corresponding to a 4-fold infinity of stress-rate of shear relationship is established.

SCI. ABSTR.

1603. On the formulation of rheological equations of state.

J. G. OLDROYD. *Proc. Roy. Soc. A*, 1950, **200**, 523.

The invariant forms of rheological equations of state for a homogeneous continuum, suitable for application to all conditions of motion and stress, are discussed. The right invariance properties can most readily be recognized if the frame of reference is a co-ordinate system convected with the material, but it is necessary to transform to a fixed frame of reference in order to solve the equations of state simultaneously with the equations of continuity and of motion. An illustration is given of the process of formulating equations of state suitable for universal application, based on non-invariant equations obtained from a simple experiment of structural theory. Anisotropic materials, and materials whose properties depend on previous rheological history, are included within the scope of the paper.

AUTHOR.

1604. Elasto-plastic problem of the non-biharmonic plastic state.

O. S. PARASYUK. *Dokl. Akad. Nauk, USSR*, 1948, **63** (4), 367. *In Russian.*

An infinite plane with a circular aperture is under external forces applied to the contour of the aperture and extending along two rectangular directions to infinity. A plastic zone is assumed to exist around the aperture. The two possible biharmonic cases were solved by Galin and Mikhlin, respectively. The problem requires the determination of a contour surrounding the plastic zone (within which Mikhlin's solution obtains) and of 2 holomorphic functions satisfying certain conditions. It is assumed that the external region of the contour of the z -plane admits of a representation on the external region of the unit circle by means of the ζ -function. The given conditions are transformed accordingly, and on Harnack's theorem, written in form of a contour integral, thus enabling the solution of the problem to be found by complex integration. When one of the 4 arbitrary constants is assumed to vanish, the solution degenerates to Galin's solution.

SCI. ABSTR.

1605. The static coefficient of friction and the area of contact.

R. C. PARKER AND D. HATCH. *Proc. Phys. Soc. Lond. B*, 1950, **63**, 185.

An apparatus was constructed with a towed optical flat as the frictional element which was moving along a rigidly mounted optical flat under a normal load exerted by either a lead or indium hemisphere. The observation had been made previously that the area of contact between hemispheres made from material of low yield point, such as lead or indium, is a function of the arithmetic sum of the magnitudes of the curvatures of the two surfaces. The area of contact of materials such as lead may also be varied, independent of normal load, by a hysteresis effect which is exhibited on increasing and decreasing the normal load. Application of a tangential force less than the limiting value of the force of static friction appears to give rise, for these soft metals, to a growth of both the real and apparent contact areas and to produce a relative displacement of the surfaces. It is shown for lead that the apparent area of contact varies linearly with the normal load (up to 3 kg.-wt.) and that the frictional force (up to about 100 g.-wt.) is a linear function of the apparent area of contact.

R.S.

1606. Deformation resistance in the plastic flow of polycrystalline metals.

P. O. PASHKOV. *J. Tech. Phys., USSR*, 1949, **19** (2), 261. *In Russian.*

Experimental and mathematical analysis of the problem indicates the possibility of obtaining a single standard of strength for considerable plastic deformation and any condition of stressing. A suitable method of strength analysis is developed and verified on a number of examples of 2- and 3-dimensional stress problems, and expressions are given for hardness, torsion, etc., considerably widening the scope of strength analysis under conditions of compound stress. INDEX AERONAUTICUS. (*From Sci. ABSTR.*)

1607. Improved apparatus for measuring viscosity of glasses in annealing range of temperature.

J. P. POOLE. *J. Amer. Ceram. Soc.*, 1949, **32**, 215.

An instrument is described that has been found to be a valuable and precise tool for the measurement of viscosity in the annealing range of temperature. The outstanding feature of this apparatus is its high thermal inertia that makes it possible to maintain thermal equilibrium without auxiliary temperature-control equipment. B.C.R.A.

1608. Systematic study of effect of oxide constituents on viscosity of silicate glasses at annealing temperatures.

J. P. POOLE AND M. GENSAMER. *J. Amer. Ceram. Soc.*, 1949, **32**, 220.

Experimental low-temperature viscosity data obtained by the fibre-elongation method are presented for simple three- and four-component alkali-alkaline earth— Al_2O_3 - SiO_2 glasses. In this study Na_2O , K_2O , CaO , MgO , SrO , BaO , and Al_2O_3 were systematically substituted molecularly for SiO_2 and for each other. A wide range of compositions was studied, including most commercial silicate glasses. Factors, formulae and charts derived from experimental data are presented that predict the viscosities of Na_2O - CaO - Al_2O_3 - SiO_2 glasses within about 1%. B.C.R.A.

1609. Low-temperature viscosity of alkali silicate glasses.

J. P. POOLE. *J. Amer. Ceram. Soc.*, 1949, **32**, 230.

Using an improved technique, precision measurements of viscosities in the annealing range of temperature were made on Na-, K-, and Na-K-silicate glasses containing from 10 to 40 mol % alkali. The viscosities of certain of those glasses that contain both Na_2O and K_2O reach minima and the temperature coefficients of viscosity, which are nearly equal for the Na_2O and the K_2O glasses, become considerably smaller. These conditions may explain the practical advantages of certain glasses containing both Na_2O and K_2O . B.C.R.A.

1610. Stress-strain-time apparatus for fiber testing.

C. H. REICHARDT, H. SCHAEVITZ AND J. H. DILLON. *Rev. Sci. Instrum.*, 1949, **20**, 509.

A stress-strain apparatus for testing individual fibres is described. The apparatus employs a ring dynamometer in conjunction with a linear variable differential transformer. A constant rate of elongation apparatus is fully described and a schematic diagram of a constant-rate-of-loading apparatus is discussed. The use of linear variable differential transformers allows simple a.c. amplifiers to be employed and thus removes many of the difficulties involved in d.c. bridge circuits. Load ranges from 50 g to 1 g per 10 chart inches can be obtained with a sensitivity of several mg. By changing the size of the ring dynamometer employed, an apparatus giving the greater load ranges necessary to test yarns can be constructed. AUTHORS.

1611. The normal-stress coefficient in solutions of macro-molecules.

R. S. RIVLIN. *Trans. Faraday Soc.*, 1949, **45**, 739.

In a previous paper it has been shown that if the stress components at a point of a fluid depend only on the state of flow in a small element about that point at the instant considered, then in general, two physical parameters are required to define completely the flow properties of the fluid. One of these is the viscosity and the other will be called the

normal-stress coefficient. Each of these may or may not be dependent on the state of flow. In the present paper a method similar to that adopted by Kramers to calculate the intrinsic viscosity of a high-polymer solution has been employed to calculate its normal-stress coeff. It is shown that appreciable values of the normal-stress coeff. may be expected in concentrated solutions and that its non-vanishing results from the orientation of the molecules in the flowing solution.

AUTHOR.

1612. The determination of the bend strength and bend creep of ceramic materials.

J. P. ROBERTS AND W. WATT. *Trans. Brit. Ceram. Soc.*, 1949, **48**, 343.

Test-pieces measuring 3.2 in. long, of square cross-section and 0.016 in. side, were subjected to bending by equal couples in a test rig which was machined from magnesite, brick and incorporated sintered corundum knife-edges. Full details of the test rig, its manipulation and scope are given. Bend strength at room temperature and at 1,000°C and bend creep properties at 1,000°C. of sintered corundum were studied. Some observations on corundum single crystals, sintered beryllia, pyrophyllite and a commercial mullite material are included. Points of special interest concerning the preparation of sintered corundum are noted.

B.C.R.A.

1613. Birefringence in rubbers.

D. W. SAUNDERS. *Nature*, 1950, **165**, 360.

The birefringence of a thin strip of a peroxide vulcanizate elongated under a known load was measured using crossed Nicol prisms and a Babinet compensator. The relation between the stress and the birefringence was found to be linear and reversible up to strains of about 100% and the stress-optical coefficient was $2.05 \times 10^{-10} \text{ cm}^2/\text{dyne}$. This compares well with the value obtained by extrapolating the results of Thibodeau and McPherson to zero combined-sulphur content.

E.W.J.M.

1614. An application of the theory of quasi-properties to the treatment of anomalous strain-stress relations.

G. W. SCOTT BLAIR AND J. E. CAFFYN. *Phil. Mag.*, 1949, **40**, 80.

The idea of quasi-properties proposed in an earlier paper is extended to cover anomalous strain-stress relations. Just as the Newtonian definition of equality of time intervals may be said to depend on the consistency of the magnitude of the vector c , so any definition of equality of forces, if independent of Newtonian time, must depend on the directional character of c . In the light of these implicit definitions, it is seen that the significance to be attached to fractional differential coefficients of strain with respect to stress is somewhat different from that put forward in the earlier paper for fractional strain-time differentials. Certain experiments on relaxation of plastics at constant stress were selected on account of their exceptional divergence from the Nutting relaxation law and it was shown that for the less serious anomalies an equation integrated from the strain-stress fractional differential in some cases fitted that data better than the corresponding strain-time equation. For extreme anomalies an integrated form of the previously proposed double fractional differential equation, reduced to four variables, is shown to fit the data admirably. It is claimed that, when the aim is to relate the complex rheological behaviour of materials to the results of tests in which their firmness is assessed subjectively by handling, it is better to express the data in terms of quasi-properties rather than by classical methods used to study the structure of materials. The circumstances under which it is practicable to express the Nutting equation and its fractional differential derivatives in a simple dimensional form are discussed.

B.C.R.A.

1615. Sensitivity of clays to remoulding.

A. H. V. SMITH AND I. EVANS. *Nature*, London, 1949, **164**, 319.

The degree of sensitivity of a clay to remoulding is defined as the ratio of the compressive strength undisturbed to the compressive strength remoulded. The degree of

sensitivity appears to be related to the Atterberg limits of a clay and the relative consistency in which it is found in its natural state. Sensitivity is thought to be due to damage to a highly developed mechanical structure produced after sedimentation by slow consolidation of the clay, and to a temporary disarrangement of the orderly pattern of clay particles, adsorbed cations and orientated water molecules. B.C.R.A.

1616. Long-time tension and creep tests of plastics.

C. E. STAFF, H. M. QUACKENBOS AND J. M. HILL. *Mod. Plastics*, 1950, **27** (6), 93.

Thermosetting and thermoplastic materials were maintained under constant load at 25° and 75°C for periods ranging from 1000-14500 hours. Creep was measured with electric strain gauges, and from its course an estimate is made of the maximum stresses that can be sustained for five years by thermosetting materials. An examination is made of the accuracy and precision of the electric strain gauge in measurements of creep.

AUTHORS.

1617. On the magnitude of the mechanical component of solid friction.

C. D. STRANG AND C. R. LEWIS. *J. Appl. Phys.*, 1949, **20**, 1164.

Horizontal relative motion between the friction elements was obtained by towing the lower specimen with a fine lead-screw arrangement at a velocity of 0.0062 in/min, while the upper specimen was restrained from moving horizontally, but was permitted to move vertically. The vertical motion of the upper specimen was detected by the tracer head of a profilograph. The force of total friction was obtained by removing the tracer point, holding the lower friction element stationary, and towing the upper friction element over the lower. The towing or friction forces were measured with a steel dynamometer ring on which was mounted a Wheatstone bridge of resistance wire strain gauges. The percent mechanical lifting work of total frictional work was found to be less than 10. The conclusions were drawn that the measurable surface irregularities which comprise the engineering surface finish have only a small part in causing resistance to "dry" sliding. The coefficient of "dry" kinetic friction is essentially independent of the surface roughnesses that constitute the ordinary engineering surface finish. If lifting of the top friction element by the interlocking of asperities is to contribute more than a small part of the total friction or resistance to sliding, it must arise with high frequency vertical motions of less than a few microinches. If the resistance to sliding is considered to be caused by the interlocking of extremely small asperities on the surfaces of the larger irregularities which constitute the ordinary surface finish, the process by which the very small asperities are formed must be such as to leave a non-directional distribution of these small asperities. R.S.

1618. Elastico-plastic straining when the principal stresses rotate.

K. H. SWAINGER. *Nature*, 1950, **165**, 360.

A discussion on the relative merits of different theoretical approaches to the problem of post-yield straining of metals. To obtain correct predictions one must consider plastic increment-strain components and elastic total-strain components attained incrementally. E.W.J.M.

1619. Non-coaxiality of principal normal stresses and the strain ellipsoid in the classical theory on infinitesimal deformation.

K. H. SWAINGER. *Nature*, 1950, **165**, 169.

A fundamental assumption in the classical theory on infinitesimal deformation in isotropic substances is that equations involving differential relative spacial displacements reduce to principal normal strains only when the co-ordinate axes are in the principal normal stress directions. This is shown to be incorrect since the reference axes as used in the classical theory are fixed in space and independent of the deformed body, so the spacial displacement contains a component due to "rotation-of-the-body-as-a-whole" even when this rotation is only infinitesimal. E.W.J.M.

1620. The instability of liquid surfaces when accelerated in a direction perpendicular to their planes. I.

G. I. TAYLOR. *Proc. Roy. Soc. A*, 1950, **201**, 192.

It is shown that, when two superposed fluids of different densities are accelerated in a direction perpendicular to their interface, this surface is stable or unstable according to whether the acceleration is directed from the heavier to the lighter fluid or vice versa. The relationship between the rate of development of the instability and the length of wave-like disturbances, the acceleration and the densities is found, and similar calculations are made for the case when a sheet of uniform depth is accelerated. AUTHOR.

1621. Flow phenomena in rubber. II. Flow curves for GR-S rubber.

L. R. G. TRELOAR. *Trans. Instn Rubb. Ind.*, 1949, **25**, 167.

The flow of GR-S rubber at various temps. has been examined by means of the biconical rotor type of Mooney plastometer. Unlike the natural rubber previously studied (*ibid.*, 1948, **24**, 92), the shape of the flow curves was consistent with the Ostwald-de Waele relation. Values of activation energy for flow, determined from the temp. coeff. of flow rate (at constant stress), averaged 10.2 kcal./mole. AUTHOR.

1622. A new theory of plastic flow.

D. TRIFAN. *Quart. Appl. Math.*, 1949, **7**, 201.

The stress-strain relation $s_{ij}^* = 2G_0 \epsilon_{ij}^* - p(E)E^* \epsilon_{ij}$ is assumed, where s_{ij} is the stress deviation, ϵ_{ij} the strain tensor, E the strain intensity, $p(E)$ an arbitrary function and an asterisk indicates differentiation with respect to the time; for unloading $s_{ij}^* = 2G_0 \epsilon_{ij}^*$. The stress-strain curve for simple tension is expressed as a power series of the strain and the form of $p(E)$ is deduced. The boundary value problem for the strain rates corresponding to given surface velocities is formulated, uniqueness proved and the associated minimum principle discussed. A comparison is made with a plastic deformation theory which assumes $s_{ij} = 2G' \epsilon_{ij}$ where G' is the secant shear modulus and is a function of the strain-intensity. SCI. ABSTR.

1623. Rheological properties of greases containing calcium.

G. V. VINOGRADOV AND K. I. KLIMOV. *J. Tech. Phys., USSR*, 1948, **18**, 355. *In Russian.*

A method is described and results are reported of a study into the elasto-plastic properties of solidols. Properties considered included: the character of the elastic deformations under constant and varying loads; the conditions for determining the strain modulus of greases; creep phenomena and elastic after-effect, yielding and solidification under strain, elastic hysteresis and thixotropy; influence of temperature changes on the kinetics of the deformation of the greases; yield limit and plastic deformations. The conditions for determining limiting stresses and strains (yield limit) of greases in capillaries and in an apparatus with a co-axial cylinder arrangement were defined and the influence of the flow-parameter of the grease on these conditions found. (Bibliography of 46 entries.) SCI. ABSTR.

1624. A parallel plate viscometer for printing inks.

A. VOET AND J. S. BRAND. *Mod. Lithography*, 1949, **17** (10), 100. *Amer. Ink Maker*, 1949, **27** (10), 46.

A parallel plate viscometer has been developed for routine testing of the viscosity of printing inks. An ink drop of definite weight or volume is placed between two acrylate plates. When the block separating the plates is removed, the rate of spreading of the ink drop is measured. The paper discusses the effect of added pressure, temperature, etc. on the rate of ink drop spread. From the data information may be obtained concerning the "length" of the ink under shearing stress, as well as the viscosity of the ink.

P.A.T.R.A.

1625. Rotational slip—a new deformation process in crystals.

H. WILMAN. *Nature*, 1950, **165**, 321.

Rotational slip in crystals is defined as the slipping of one part of a crystal on a neighbouring part, so that the two atomic sheets which slide over one another are densely populated planes, as in translational slip. They are rotationally displaced about an axis normal to their plane to one of a series of definable new positions where metastable equilibrium can occur. From electron-diffraction photographs from cadmium iodide, silver, etc. many cases are illustrated of spot patterns showing close agreement with azimuthal displacement values. Macroscopic rotational slip on cleavage planes was easily shown in potassium ferrocyanide trihydrate and gypsum. E.W.J.M.

1626. On determination of elastic constants from natural frequencies of bending vibration.

J. R. WUOLIJOKI. *Publ. State Inst. Tech. Res. Finland*, 1948, (6), 3. *In English*.

It is assumed that an elastic bar has been brought into free bending vibration and some of its natural frequencies have been measured. With the aid of these frequencies the modulus of elasticity in tension and compression and the shear modulus can be determined for the material of the bar. A method is set forth for determining the moduli mentioned and the necessary computation chart for it is given, based on bars representing 3 different slenderness ratios. The method is illustrated by a numerical example based upon a test series.

AUTHOR.

BOOK REVIEW

STRENGTH OF MATERIALS.

By F. V. WARNOCK. Seventh edition. Sir Isaac Pitman and Sons, Ltd., London. 15/-.

In preparing a text-book on the strength of materials, an author has an enormous mass of information at his disposal, relating to both the theoretical and experimental sides of a subject which touches that of metallurgy, on the one hand, and the theory of structures on the other. Hence the task involves a process of selection, and in this Professor Warnock has been largely guided by the requirements of students reading for the university degree of B.Sc. in engineering or for the associate-membership examination of the senior professional institutions. Beginning with the idea of stresses and strains, he passes on to the simple mechanical properties of metals, and then applies the theory in the case of thin cylinders, spheres and pipes. A chapter on moments of inertia and the ellipse of inertia preceeds a group of five chapters dealing with various aspects of the beam theory: bending moments and shearing forces, stresses in beams, slope and deflection, fixed and continuous beams, and beams with large initial curvature. While due attention is paid to the useful method of finding beam deflections from the moment of inertia of the bending moment diagram, the same cannot be said of Macaulay's method. The author's appreciation of the fact that a book of this type stands or falls by the method of presentation rather than by the matter presented is indicated by the commendably light mathematical training required to cover the prescribed course of study, which includes also the torsion of shafts, columns and struts, thick cylinders and spheres, as well as rotating discs and the transverse vibration of slender shafts. Chapter XV, occupying 70 pages, contains an instructive introduction to the work of testing materials, and to the machines and apparatus employed for the purpose; but the practical value of the descriptive matter to the engineer would have been enhanced by the inclusion of sections on the electrical-resistance strain gauge and on the measurement of strain by brittle lacquer coating. The phenomenon of creep of metals is discussed with special reference to the effect of carbon, molybdenum and other elements on the creep of steels. In the present edition, the worked examples have been extended, and a new chapter added on the principles of the photo-elastic method of stress analysis.

Engineering.