

BRITISH RHEOLOGISTS' CLUB



Hon. Sec.:

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FARNBOROUGH, HANTS.

Hon. Editor :

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RESEARCH IN DAIRYING,
SHINFIELD, READING.

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CLUB NOTES.

THE BULLETIN.

The Editor is most grateful to members who have responded to his appeal in the last *Bulletin* for more abstractors. It should have been made clear, however that the Editor does not receive copies of journals for abstracting and that abstractors must therefore be responsible for finding the journals which they volunteer to abstract for themselves. The following journals are still without abstractors:— J. Math. Phys., J. Chem. Educn., Coll. Symp. Mon., Chem. Weekblad., Coll. J. U.S.S.R., J. Exper. Theor. Phys. U.S.S.R., Proc. and Bulls. Acad. Sci. U.S.S.R., Chem. and Met. Engng. All agric. and soil journals except Soil Sci. and Dairy journals, *Keramicheskii Sbornik*, Oil and Soap. Any offers will be gratefully received.

Foreign Members.

In war-time when the Club was started, it was thought advisable to restrict membership to those interested in Rheology working in Britain or the British Commonwealth. There is no longer any need for this geographical distinction and the Committee is now glad to consider applications for membership from foreign countries. It is with great pleasure that we welcome a number of distinguished rheologists from abroad to our membership and a still greater pleasure that some of them were able to attend the London Conference.

Decentralisation of the Club.

The Committee feels that, although the time has not yet come to start Branches of the Club in the Provinces, there should be more activities outside the London Area. It is hoped that groups of members will form *ad hoc* Committees to organise joint meetings of the Club with branches of other scientific societies in their localities. Although all members would, of course, be welcome, these meetings would be especially planned to meet local needs. Local representatives might be appointed to the Committee of the Club to keep us in touch with members in other parts of the country in much the same way that Mr. W. A. Richardson now represents the Manchester area. In this way it should be possible to extend the activities of the Club without increasing the burden of work on the Hon. Secretary and Committee.

The London Conference.

The Conference held at Bedford College, London, was most successful and the Committee wishes to express its thanks to all who helped to make it so. It is hoped that the proceedings will be available in book form within a few months. A limited number of advance copies (unbound) of the proceedings of the Oxford Conference (1944) were available and were all disposed of. Final publication of this book—"Essays in Rheology"—is also expected in a few months' time.

An interesting exhibition of apparatus was shown at the Conference, details of which cannot be included here for lack of space.

Future Meetings.

A joint meeting of the Club with the Midland Section of the Institute of Physics will be held in Birmingham on Friday, February 28th, and Saturday, March 1st, 1947. The subject will be Hardness of Solids. At 6 p.m. on the Friday, Dr. E. Orowan will read a paper on the theory of Solids at the Edmund Street part of the University, and on the Saturday morning, Dr. H. O'Neill and others will be speaking on the measurement of hardness at the Physics Department, Edgbaston. Details will be circulated to members shortly.

The arrangements for the other meetings foreshadowed in the last *Bulletin* are progressing satisfactorily.

LIST OF NEW MEMBERS SINCE SEPT., 1946.

DR. G. E. VAN GILS ...	Rubber Stichting Julianalaan 134 Delft, Holland.
MR. L. B. KNOLL ...	St. Edmund Hall, Queen's Lane, Oxford. Interests: Metals.
DR. H. DE BRUIJN	Central Lab., Dutch State Mines, Geleen, Holland. Interests: Rheology of suspensions and high polymers; rheological measurements.
DR. S. FORDHAM ...	37 Eglinton Street, Saltcoats, Ayrshire. Interests: Plastic explosives and concentrated polymer solutions; thixotrometers and penetrometers.
MR. A. HARDMAN ...	Adhesive Tapes, Ltd., Manor Way, Boreham Wood, Herts. Interests: Rubber and adhesives.
THE EARL OF HALSBURY	11 Taptinville Road, Sheffield, 10. Interests: Metals, clays, oils and greases.
MR. J. P. PARKE ...	15A Pine Avenue, Bebington, Cheshire.
MR. A. HORSLEY ...	Messrs. John Mackintosh & Sons, Ltd., Halifax, Yorks. Interests: Chocolate, fats, syrups, etc. Hardness, viscosity and thixotropy.
MR. L. F. COOLING	Building Research Station, Bucknalls Lane, Garston, Watford. Interests: Natural clays and silts; shearing resistance and long-term deformation.

RECEIPTS AND PAYMENTS ACCOUNT for the year ended 30th September, 1946.

Receipts.								£	s.	d.
Subscriptions	...	...	...	...	...	...	...	205	15	0
Donations, etc.	...	...	...	...	...	...	...	28	4	7
Balance carried forward from 1944-45	...	...	...	...	...	...	...	233	19	7
								46	12	1
								£280	11	8

Payments.								£	s.	d.
Stationery and Printing	...	...	...	...	...	...	...	99	3	2
Postage	...	...	...	...	...	...	...	19	11	2½
Honoraria (Office Help)	...	...	...	...	...	...	...	59	5	0
Hire of Rooms, expenses of Meetings	...	...	...	...	...	...	...	26	12	6
Sundries	...	...	...	...	...	...	...	22	8	5½
Balance carried forward to 1946-47	...	...	...	...	...	...	...	227	0	4
								53	11	4
								£280	11	8

Audited and found correct.

(Sgd.) R. LESSING. 27th September, 1946.

CORRESPONDENCE.

My dear Scott Blair,

Some time ago you asked me to jot down my recollections of how the Club came into being, and something of its first few years. Please take these jottings as my hurried attempt to meet your request—I never could resist them. One can never tell who in the future will peruse these scribbles and what they will read into them. If they do no more than help to keep something of that delightful informal spirit with which we started, I shall be more than pleased. Here, then, is my own story :—

It was a fine summer afternoon in 1940 and, feeling somewhat exhausted by the difficult war conditions of evacuation to Reading, I went a little way into the country with my wife. Begrudging the few hours away from the temporary office of the Institute of Physics, I consoled myself by fulfilling a long-standing promise to visit Scott Blair's laboratory at the National Institute for Research in Dairying, at Shinfield, some three miles out of Reading. He explained to me the difficulty he was having in devising suitable instruments for measuring the rheological properties of the secretions from the uterine cervix of the cow, which he thought might prove a useful early test for pregnancy—a matter of great importance to the dairy industry during the war. It immediately occurred to me, from what he said, that this problem was very similar to V. G. W. Harrison's, who was trying to measure the rheological properties of printing inks. In the normal course of my work as Secretary of the Institute of Physics, I therefore gladly arranged for these two to meet. That meeting must be taken as the first meeting of the Club, that it was of mutual benefit seems certain, for they came to me and asked if there were not a few more interested in these problems, and that I should bring them all together. There were the paint industry people, the oil and tar people, and so on, and we thought there might be twenty or more who would like to lunch together two or three times a year to 'swop

yarns,' and to arrange to visit each other's labs. We three appointed ourselves a Committee, having decided to form a Club, which should have no rules and no formalities like scientific and learned societies—indeed, a Club, where one could speak as freely as in the lab. The Committee was to meet either in my attic room in the University of Reading (the old red building) or in Scott Blair's drawing-room. The latter were the more successful meetings since we had the great advantage of Mrs. Scott Blair's wisdom and teas, not to mention Wolfgang, the dog, who was always present. Harrison came over from Guildford on his motorbike—dressed as for Arctic exploration, which was no doubt necessary. The Board of the Institute of Physics permitted the clerical work for the Club to be done in its temporary office for the first few years of its existence, so long as it did not interfere too much with official work. When it did, Mrs. Lang came to the rescue and cut the stencils for the Bulletins and Abstracts, which were then rolled in my office. The Committee meetings were great fun—as we all had a goodly dose of Committee work in our daily work we were glad to have these most informal meetings, breaking all the rules of procedure. Later when we found that the Club was shockingly successful, and we were in danger of founding yet another scientific Society, with its publications and office problems, we thought it wise to make the Committee more representative of the Club, so Treloar and Broome joined us. They thought it time we had a Chairman and I had the honour of being pushed into that office. This I was glad to accept, for I confess I used to try out techniques learnt from Chairmen I had seen at work during the last ten years. Perhaps some less biased pen than mine will record something of the Committee's thereafter.

As the Club grew in numbers and status, its office work grew. There was the idea, for example, of producing duplicated copies of translations of original classical rheological papers; in particular one by Pochettino which ran to many pages of typescript. This was done in odd times in my office and was very troublesome. Indeed, in 1942, the time had clearly come to take the Club's activities more seriously before they become a menace and I discussed the matter with the Officers of the Institute of Physics and the Club. The upshot was that the Institute continued its support for another year when Scott Blair and Harrison agreed to carry on, with such help as they could get. The Club by then was the proud possessor of a Post Office Account and a rubber stamp, which were used effectively to persuade Miss Mary Milligan, a friend of the Scott Blairs', to do the office work for a very modest fee, but the Institute's duplicator and addressing machine continued to be of service to the Club for a while.

In the 'Reading' days the Club tackled such trying problems as 'Pi,' and the classification of deformations of materials. It may have been a case of 'fools rush in where angels fear to tread,' but we did enjoy ourselves! Exchange of views was frank and free and often I regret to say I felt that the experts knew no more about what was being discussed than I, as Chairman, did—and said so. In view of the later developments, I am not so sure that the old adage 'there is many a true word spoken in jest' is not applicable in this instance!

I hope that Scott Blair and Harrison will add to these notes, and fill in the parts I have missed and modify any exaggerations. They must not fail to say something about the first week-end Conference, when the Scott Blairs were able to re-live the early scenes of their Oxford romance in her old College—St. Hilda's—in which the Conference was held.

H. R. LANG.

[Dr. Harrison and I have nothing to add but we welcome this opportunity of putting on record the very informal way in which the Club had its beginnings, nor shall we forget the debt we all owe to Dr. Lang, and to the Institute of Physics for their invaluable help in the early days of our Club.—EDITOR.]

RHEOLOGY ABSTRACTS

416. Stress-Rupture Characteristics of Various Steels in Steam at 1200°F.

J. T. AGNEW, G. A. HAWKINS and H. L. SOLBERG. *Trans. Amer. Soc. Mechanical Engineers.* 68, 309, 1946.

The authors give results of tests in which small specimens of steel were exposed in tension in a steam atmosphere at 1200°F. (648°C.) until fracture occurred. The materials used were of the following types:—low-carbon steel; 0.5 per cent. molybdenum steel; chromium-molybdenum steel (2.25/0.9 per cent.); two chromium-molybdenum-silicon steels containing respectively, 4.83 and 9.5 per cent. of chromium; stainless steels of the low-carbon 12 per cent. chromium, 25-20 chromium-nickel and 18-8 chromium-nickel types; 5 per cent. chromium steel containing 0.5 per cent. each of molybdenum and titanium.

Full particulars of stress-rupture results are given, and the nature of the fractures of the respective steels is critically discussed.

A straight-line relationship between stress and time-to-rupture, on log-log co-ordinates (postulated by earlier investigators for tests in air) was confirmed in the steam tests, but a break in the stress-rupture line, reported in some other papers, was not observed by the present authors.

The tests indicate that for the small specimens of the nine materials tested, the stress required to produce rupture at 1200°F. in steam in 10,000 hours or longer is higher than that required at 1200°F. in air. The type and characteristics of the scale formed on the stress-rupture specimens was found to affect the position of the stress-rupture line on log-log co-ordinates. It is pointed out that the slope of the stress-rupture line is important in gauging the suitability of a material for prolonged service at high temperature. Although a material showing a low value of slope might appear less suitable at short rupture periods, for longer periods it might be superior to material showing better properties for the shorter times.

Percentage elongation is considered to be a more accurate criterion of ductility, over long periods, than reduction of area values. In general, ductility (percentage elongation) tended to decrease with time in all the materials tested: brittle fracture is favoured by longer times and lower stresses rather than by higher stress for shorter periods.

Nickel Bull. 19, 163, 1946.

417. The Theory of Permanent Set at Elevated Temperatures in Natural and Synthetic Rubber Vulcanisates.

R. D. ANDREWS, A. V. TOBOLSKY and E. E. HANSON. *J. Appl. Phys.* 17, 352, 1946.

A molecular theory is developed to describe the permanent set in natural and synthetic vulcanised rubbers subjected to constant extension. It is based on the consideration of molecular scission and cross-linkage taking place simultaneously, and distinguishes between cross-linking in the strained and unstrained states, respectively. It is found that the amount of permanent set is determined by the ratio of the number of chains formed in these two states and the amount of the elongation. Experiments on stress relaxation with continuous and intermittent loading support the theory.

L.R.G.T. (*vide* abstr. 297).

418. Fatigue of Glass under Static Loads.

T. C. BAKER and F. W. PRESTON. *J. Appl. Phys.* 17, 170, 1946.

Static loading tests were run on glass and porcelain rods 7/32" in diameter for times ranging in duration from 0.01 second to 24 hours, by using specially designed

apparatus. It was found that glass can support for 0.01 second about 3 times the stress that would break it in 24 hours. The effects are generally the same for all glassy materials. Porcelain showed the effect somewhat less than glass. It appeared that absorbed moisture and gases reduced the strength.

AUTHORS' ABSTRACT (*vide* abstr. 73, 150 and 453).

419. Comprehensive Laboratory Testing of Instrument Lubricants.

G. E. BARKER, G. E. ALTER, JR., C. E. MCKNIGHT, J. R. MCKLVEEN and D. M. HOOD. *A.S.T.M. Bulletin*. No. 139, 25, 1946.

A description of laboratory tests, using not more than 1 oz. of specimen, employed during the investigation and development of new synthetic lubricants for fine instruments. It is claimed the laboratory determinations correlate well with operational experience. Viscosity was determined by A.S.T.M. Tentative method of test for kinematic viscosity (D 445 -42 T) using the modified Ostwald viscometer. Measurements were made at 100, 32 and -40°F., and sometimes at -60 and -80°F. "Oiliness" was rated from the coefficient of friction of steel on sapphire, lubricated, determined by a pendulum method.

E.W.J.M.

420. Errors in Viscometry due to Surface Tension.

G. BARR. *Proc. Phys. Soc. Lond.*, **58**, 575, 1946.

In viscometers of the Ostwald type used for the determination of kinematic viscosities relative to water, surface tension causes a reduction of the head available and increases the time of flow. The correction is not proportional to the surface tension and earlier estimates of the correction are shown to be suspect. Two methods are proposed for eliminating the correction during the calibration of viscometers.

SCI. ABSTR.

421. Theory of Elastic Forces.

O. C. DE BEAUREGARD. *C.R. Acad. Sci., Paris*. **222**, 477, 1946.

The author applies his definition of covariant force [*C.R. Acad. Sci., Paris*, **221**, 473 (1945)] to the forces in the body of a fluid, produced by a force-field at the boundary of the fluid. The proper-mass of a drop of fluid is not conserved under these conditions.

SCI. ABSTR.

422. On the Formula for the Energy of Deformation in the case of Finite Deformations.

P. BERGEOT. *C.R. Acad. Sci., Paris*. **218**, 824, 1944.

The integral formula for the energy is deduced in a special case where a system of constraints is defined in the deformed medium.

SCI. ABSTR.

423. Micro-hardness Testing.

E. B. BERGSMA. *Metal Ind., Lond.*, **69**, 109, 1946.

The method permits precision hardness testing of such specimens as fine wires, thin strip, foil and the individual grains of a microstructure. The instrument may be used in studying surface layers and diffused areas. Hardness maps of cold worked metal may be plotted with greater detail and more accuracy. The tester described was designed for use with any standard inverted microscope, with slight modifications to the attaching device to suit various types of stage and objective holder. Methods of indentation and scratch testing are outlined and applications of the instrument are discussed.

SCI. ABSTR.

424. A New Method for the Determination of the Elastic Constants of Isotropic Media.

S. BHAGAVANTAM and B. R. RAO. *Proc. Indian Acad. Sciences.* **23**, 254, 1946.

Using a tourmaline wedge and a frequency range of 3 to 16 megacycles per second the characteristic transmission frequencies of several plates of glass, steel, brass and platinum have been studied by the method of ultrasonic diffraction.

The exact mechanism by which the shear mode in the plate is communicated as a longitudinal wave to a liquid medium is unknown, but the examination of plates of different edges has shewn that the edge couplings of the plates are probably the cause.
E.W.J.M.

425. Elastic Behaviour of the so-called Bourdon Pressure Gauge.

C. B. BIEZENO and J. J. KOCH. *Proc. Ned. Akad. Wet.* **44**, 779, 914 (1941).

A mathematical theory of the Bourdon gauge enabling deformation and stresses in the Bourdon tube to be calculated, and taking into account both the flexural stiffness of the tube wall and the so-called "flattening" of the tube as described by von Kármán is developed. Very high stresses are produced by relatively low pressures, and proportionality between stress and strain is violated at pressures for which the gauge is said to be designed. Hence many ruptures occur; elastic hysteresis is observed.
SCI. ABSTR.

426. Tension Testing at Elevated Temperature.

T. M. BLACKMON, P. R. NOURSE and E. H. PLESSET, *Bull. Amer. Soc. Test. Mater.* (No. 140). **32**, 1946.

A simple and inexpensive method of heating tension specimens by resistance heating, a method of measuring specimen temperatures, and two types of extensometers and the associated electronic equipment for use with a Baldwin-Southwark recorder, have been developed. In addition, a technique has been established for determining the time load at fracture of ductile specimens.
SCI. ABSTR.

427. The Plastic Deformation of Non-Cubic Metals by Heating and Cooling.

W. BOAS and R. W. K. HONEYCOMBE, *Proc. Roy. Soc. A.* **186**, 57, 1946.

Small steel cylinders coated on the inside with Sn-base and Pb-base bearing alloys were heated and cooled by immersion in oil. After a few cycles between 30° and 150°C. cracking was noticed on the surface of the Sn-base bearing but the Pb-base bearing was unchanged, even after a large number of cycles. It is shown that this plastic deformation in the case of Zn, Cd and Sn is due to the anisotropy of thermal expansion in the crystals of non-cubic metals. In certain metals, grain boundary migration is associated with the deformation. The persistence of the lattice distortions is shown by X-ray photographs and also by recrystallisation subsequent to the cyclic treatment. Some possible theoretical and practical implications of the phenomenon are discussed. The order of magnitude of the stresses set up on heating and cooling of non-cubic crystals is estimated.
SCI. ABSTR.

428. Notes on the Rate Process Theory of Viscous Flow.

A. BONDI. *J. Chem. Phys.* **14**, 591, 1946.

An attempt is made to separate the entropy and energy of activation for viscous flow, and to interpret these quantities in terms of fundamental molecular processes. From this study evidence is derived concerning the forces between molecules. The general picture resulting is that viscosity is not a "bulk" property, but is determined by a small concentration of loosely-bound molecules; it is not much dependent on the structure of the liquid.
L.R.G.T. (*vide* abstr. 398).

429. **A Definition of Plasticity.**

R. C. L. BOSWORTH. *Nature*, **157**, 447, 1946.

Plasticity has been defined qualitatively as "that property which enables a material to be deformed continuously and permanently without rupture during the application of a force which exceeds the yield value of the material." From this a dimensionless quantitative definition is deduced as follows:

For a solid stress $\tau = f(\sigma)$, where σ = strain

„ „ fluid „ $\tau = f\left(\frac{d\sigma}{dt}\right)$

Therefore for a plastic body $\tau = f\left(\sigma, \frac{d\sigma}{dt}\right)$

This may be written $\tau = f\left(\frac{d^\alpha \sigma}{dt^\alpha}\right)$ where $0 < \alpha < 1$.

Hence plasticity might be defined as the relative stress-change required to change α from 0 to 1. Since both these values may be approached asymptotically, a more practical definition is "the reciprocal of twice the relative stress-change required to change the exponent α from $\frac{1}{4}$ to $\frac{3}{4}$. To measure plasticity in terms of this definition a different stress is applied to different samples of material, and in each case the strain σ is measured as a function of the time. Curves of $\log \sigma$ against $\log t$ are then drawn. Beyond the yield point these curves will have positive slopes. The initial values of the slope $\left(\frac{d \log \sigma}{d \log t}\right)$ is then plotted against the stress, τ . Let $\tau_{\frac{1}{4}}$ be the value of τ required to give a slope of $\frac{1}{4}$ and let $\tau_{\frac{3}{4}}$ be that required to give a slope of $\frac{3}{4}$. Then a suggested definition of plasticity is: $\frac{\tau_{\frac{3}{4}} + \tau_{\frac{1}{4}}}{\tau_{\frac{3}{4}} - \tau_{\frac{1}{4}}}$, which is dimensionless. Examples of the practical application of this definition are given.

B.R.R.A.

430. **The Flow of a Viscous Fluid in an Elastic Tube: a Model of the Femoral Artery.**

H. BRANSON. *Bull. Math. Biophys.* **7**, 181, 1945.

The solutions of the differential equations for the flow give a description of some aspects of the flow of blood in the femoral artery. The parameters influencing the speed of the pulse wave, the pressure and the velocity for non-pulsating and pulsating flow are exhibited. The relation between pressure and velocity is considered. For pulsating flow the slope of the pressure/fluid-velocity curve is equal to the pulse wave speed multiplied by the density of the blood. SCI. ABSTR.

431. **The Tensile Properties of several special Steels and certain other Materials under Pressure.**

P. W. BRIDGMAN. *J. Appl. Phys.* **17**, 201, 1946.

The tensile properties of a number of steels under high hydrostatic pressures (up to 30,000 kg. per sq. cm.) were examined. No uniformly satisfactory criterion for rupture could be discovered, the most nearly satisfactory being the value of mean hydrostatic tension. The criterion of maximum shear stress fails badly, as does also any function of strain components.

Whilst aluminium, copper, bronze and brass showed increased ductility under pressure, antimony, arsenic, tellurium, borax glass, cast iron, limestone (uncovered) and Carbaloy showed no plastic deformation before breaking by bending under pressure, though Carbaloy was plastic in simple compression.

L.R.G.T. (*vide* abstr. 247).

432. Studies of Plastic Flow of Steel, especially in Two-Dimensional Compression.

P. W. BRIDGMAN. *J. Appl. Phys.* **17**, 225, 1946.

Steel blocks were subjected to two perpendicular compression stresses in such a way that 2-dimensional flow was produced. The values of the principal stresses indicated that the condition of isotropy of flow was not satisfied. Time effects in the rate of flow were observed. The quantities which determine the strain-hardening are discussed, but no entirely satisfactory method for relating flow in the 1-dimensional and 2-dimensional compressions respectively, was found.

L.R.G.T. (*vide* abstr. 247).

433. The Effect of Hydrostatic Pressure on Plastic Flow under Shearing Stress.

P. W. BRIDGMAN. *J. Appl. Phys.* **17**, 692, 1946.

Measurements of the forces required to drive a punch through steel plates are made at hydrostatic pressures up to 30,000 kg./cm.². As in corresponding tensile experiments, the ductility is greatly increased by the hydrostatic pressure, but the phenomena reveal certain differences. These differences are connected with the greater possibility of self-healing in the shear test.

L.R.G.T.

434. Recent Work in the Field of High Pressures.

P. W. BRIDGMAN. *Rev. Mod. Phys.* **18**, 1, 1946.

A comprehensive review covering the years 1930-45. In all, 674 references are listed, and the work separated into the following sections: technique; mechanical effects of pressure, of which the volumetric effects are the most important, because most simple, including here phase changes; thermal, magnetic, electrical and optical effects; chemical and biological effects.

SCI. ABSTR.

435. On the Theory of Liquids.

H. C. BRINKMAN. *Physica, 's Grav.* **7**, 747, 1940.

Using Eyring's concept of free volume (1937) a difference-equation for the free energy of liquids is derived. This equation yields a formula for the compressibility of liquids which contains only one constant, viz., the volume of the molecules in the closely packed state *b*. A satisfactory agreement between theory and experiment is obtained, while *b* has nearly the same value as deduced from Van Wijk's and Seeder's theory of viscosity.

SCI. ABSTR.

436. On the Application of Viscosity Data to the Determination of the shape of Protein Molecules in Solution.

J. M. BURGERS. *Proc. K. Ned. Akad. Wet.* **43**, 425, 645, 1940.

In continuation of previous work, formulae for the specific increase of the viscosity of suspensions of elongated particles are supplemented by expressions for cases where the particles (1) have the form of oblate ellipsoids of revolution, or (2) can be represented by a few rigidly connected spheres. In particular, systems comprising 4 spheres arranged at the corners of a square, 8 spheres at the corners of a cube, or 2 rigidly connected spheres, are discussed. It is assumed throughout that all positions of the particles are equally probable. An elongated rotational ellipsoidal shape of protein molecules does not fit experimental sedimentation data sufficiently well; discrepancies remain if it is assumed that molecules of this shape are hydrated or have the form of oblate ellipsoids of revolution. Model systems consisting of 2 spheres, or 8 spheres at the corners of a cube, fit the experimental data equally well; a prismatic system is also satisfactory.

SCI. ABSTR.

437. **Some Considerations on the development of Boundary Layers in the case of Flows having a rotational component.**

J. M. BURGERS. *Proc. Ned. Akad. Wet.* **44**, 13, 1941.

The influence of centrifugal forces upon the flow in boundary layers formed in parts of rotating pumps or ventilators is discussed mathematically.

SCI. ABSTR.

438. **The Flow of Boiling Water through Nozzles, Orifices and Pipes.**

J. G. BURNELL. *J. Instn. Engrs., Aust.* **18**, 41, 1946.

Reviews the published mathematical and experimental work and presents fresh data. For the discharge through nozzles, a formula is derived having a logical physical basis and agreeing closely with all the experimental data. For the flow in pipes, experimental data are presented giving discharges greater than those calculated from simple thermodynamic theory, the explanation being that the water and steam in the flashing mixture flow at different velocities.

SCI. ABSTR.

439. **Tackiness of GR-S and other Elastomers.**

W. F. BUSSE, J. M. LAMBERT, and R. B. VERDERY. *J. Appl. Phys.* **17**, 376, 1946.

Tests for the adhesion or tackiness of unvulcanised rubber and rubber-coated tapes are described and discussed, as well as experiments designed to improve self-adhesion is GR-S (butadiene-styrene) synthetic rubber.

L.R.G.T.

440. **A Relation between Refractive Index and Viscosity of Liquids.**

A. S. CHAKRAVARTI. *Current Science.* **15**, 105, 1946.

A combination of the Lorentz and Lorentz equation for molecular refractive power :

$$\frac{n^2-1}{n^2+2} \cdot \frac{M}{d} = r$$

with Newton Friend's rheochor equation : $\eta^{\frac{1}{2}} \cdot \frac{M}{d} = R$

where n is refractive index, η viscosity, r and R respectively denoting the molecular refractive power and rheochor (which can be calculated from atomic and structural constants) leads to a relation between n and η which was found to fit in with data for a number of unassociated liquids.

E.W.J.M.

441. **On Velocity Correlations and the Solutions of the Equations of Turbulent Fluctuation.**

P. Y. CHOU. *Quart. Appl. Math.* **3**, 38, 1945.

Three difficulties in the author's previous theory are overcome. The pressure fluctuation is derived from the equations of turbulent fluctuation and is expressed as a function of the velocity fluctuation, the mean velocity inside the fluid volume and the pressure fluctuation on the boundary. The decay terms are also put into simpler forms. A general equation of vorticity decay for the determination of Taylor's scale of micro-turbulence is derived. The turbulence problem may be reduced to a set of non-linear partial integro-differential equations. The difficulties arising in an attempt to solve these are discussed. The alternative method adopted is to solve the equations of turbulent fluctuation by setting up the differential equations satisfied by the velocity correlation functions of different orders. This method was initiated by Kármán and Howarth. Various applications of the theory of turbulence have been made.

SCI. ABSTR.

442. Pressure Flow of a Turbulent Fluid between two Infinite Parallel Planes.

P. Y. CHOU. *Quart. Appl. Math.* **3**, 198, 1945.

A continuation of previous work. The mean velocity distribution is found by two methods. The first is based upon the equations of mean motion and of double correlation. Good results are obtained in the theory of the spread of turbulent jets and wakes. The second method uses the equations of mean motion and both the equations of double and triple correlation by neglecting terms involving quadruple correlations. This is permissible to a first approximation in treating turbulent flow problems even though there is a wall present. The relation of the present theory to some known experimental data is discussed.

SCI. ABSTR.

443. Evaluation of Dispersions by a Novel Rheological Method.

F. K. DANIEL and P. GOLDMAN. *Ind. Eng. Chem. Anal. Ed.* **18**, 26, 1946.

A technique for the rapid evaluation of dispersions and dispersing agents is presented. The test comprises mixing the dry powder with the dispersing solution, measuring the amount of liquid required to produce two characteristic and reproducible consistencies, and observing the rheological phenomena of the mixture. A good dispersion displays active dilatancy at high-powered concentrations. A poor dispersion or flocculate is plastic over a wide range of concentrations and never displays any flow tendencies. A fair dispersion displays passive dilatancy at high concentrations and visible thixotropy at lower powder concentrations. B.R.R.A.

444. Elastic Properties of Cork : 1, Stress Relaxation of Compressed Cork.

S. L. DART and E. GUTH. *J. App. Phys.* **17**, 314, 1946.

Using an automatic recorder, the relaxation of stress in cork under compression was observed at temperatures from 30° to 200°C. The stress was a linear function of log time, even to the point where the stress had decayed to zero, and the log (decay time) was a linear function of temperature. L.R.G.T.

445. Experiments on the Radial Variations of Critical Velocity of Water in Tubes of Circular Cross Section.

D. L. DESHPANDE. *Proc. Indian Acad. Sciences.* **23**, 37, 1946.

Using the same procedure as Osborne Reynolds, the author planned to determine at what point in the cross section of a tube through which water flows with streamline flow motion, this motion breaks down and becomes turbulent. The position of the dye filament was varied radially and the mean velocity in the tube increased until eddy formation was observed. It was found that the breakdown first occurs at a distance from the centre of the pipe, ranging from 0.60 to 0.67 of the tube radius. From this point the turbulence spread both inwards and outwards to the walls. E.W.J.M.

446. The Pseudo-Plastic State.

W. DEUTSCH. *Phil. Mag.* **36**, 115, 1945.

An equation, in parametric form and based on Maxwell's relaxation law, is developed, expressing the abnormal viscosity of a pseudo-plastic body as a function of the shear gradient. The equation shows good agreement with experimental data obtained using a special liquid of viscosity 300 poises and rigidity approximately 480 dynes per sq. cm. It is argued that the distinction between "Newtonian" liquids and pseudo-plastic materials is merely an artificial one, and that all liquids have in a certain degree form-elasticity, which in the case of, say, water or low

viscosity oils, cannot be observed with ordinary shearing strains or by impressed oscillations.
B.R.R.A.

447. Theory and Application of the Parallel Plate Plastometer.

G. J. DIENES and H. F. KLEMM. *J. Appl. Phys.* 17, 458, 1946.

By the adoption of a mathematical criterion for separating elastic and viscous components of deformation, a theory is developed for the determination of viscosity from measurements with the paralleled plate plastometer, in the region 10^4 to 10^9 poises. The viscosity of a number of high polymers is studied by this means.

L.R.G.T.

448. Glue-line Stresses in Laminated Wood.

A. G. H. DIETZ, H. GRINSFELDER and E. REISSNER. *Trans. Amer. Soc. Mech. Engrs.* 68, 329, 1946.

From an examination of glued timbers undergoing changes in moisture content, it appears that delamination most frequently occurs on reduction of the moisture; during such a dehydrating phase shrinking and checking of the wood takes place. Experiments and field trials indicate that thin laminations are better than thick for glueing, and wood species with low moduli are better than those with high moduli. Adhesives must be employed which have high shearing strength and high tensile strength perpendicular to the glue line if laminated beams are to be dependable in service.

SCI. ABSTR.

449. On Dimensional Analysis and the Presentation of Data in Fluid-Flow Problems.

E. R. VAN DRIEST. *J. Appl. Mech.* 13, A34, 1946.

The method and application of dimensional analysis are discussed, making use of the fundamental concept of function. The π theorem is restated and proved in general form. Pipe friction, drag of spheres, and flow through Venturi meters are examples used to illustrate the rearrangement of dimensionless products of a relationship to obtain the most convenient form for presentation of data.

SCI. ABSTR.

450. The Dynamic Elastic Limit and its relations to the Structural States of a Metal.

A. FOTIADI. *C.R. Acad. Sci., Paris.* 222, 475, 1946.

Specimens subjected to alternating torsion or flexure at 50 c/s show evolution of heat, increase of deformation and diminution of transmitted couple when the surface stress exceeds a certain amount, the same for all three phenomena, called the *dynamic elastic limit*. For homogeneous specimens the limit (in kg/mm^2) is proportional to the Vickers hardness and the breaking strength, with proportionality factors 0.1 and 0.32 in torsion and 0.175 and 0.56 in flexure respectively. For inhomogeneous (for example 2-phase or case-hardened) specimens it is always less than the values given by these factors.

SCI. ABSTR.

451. Theory of Rheological Properties of Dispersions.

H. FRÖHLICH and R. SACK. *Proc. Roy. Soc. A.* 185, 415, 1946.

A set of differential equations describing the properties of flow of substances showing elastic recovery is derived. These equations contain 3 parameters which, in the case of dispersions, may be calculated from the properties and concentration of the components. The physical model forming the basis of the macroscopic theory which is given is this: the dispersion consists of independent solid micelles embedded in a viscous fluid, and the micelles are considered to be elastic spheres while the fluid is treated according to classical hydrodynamics.

SCI. ABSTR.

452. The Elastic Behaviour of Dry and Swollen Rubbers.

G. GEE. *Trans. Faraday Soc.* **42**, 585, 1946.

The problem of the internal energy and entropy changes accompanying the extension of rubber is dealt with both experimentally and theoretically.

L.R.G.T.

453. The Fatigue Modulus of Glass.

J. L. GLATHART and F. W. PRESTON. *J. Appl. Phys.* **17**, 189, 1946.

The decline in the breaking strength of glass with an increase in the length of time it is under stress has been noted by various experimenters. Based on the experimental results of T. C. Baker, an empirical relationship is obtained which indicates that the reciprocal of the breaking stress is a linear function of the logarithm of the duration of the stress. Certain implications of this relationship are discussed.

AUTHORS' ABSTRACT.

454. Apparatus for Dynamic Tests on Insulating Materials under Pulsating Stresses up to 25 tons/sq. in.

L. GOSLAND and J. S. VOSPER. *Rep. Brit. Elect. Allied Industr. Res. Ass. Ref. L/T159*, 14 pp. 1946.

The apparatus employs the electromagnetic forces between current-carrying conductors in air. A peak thrust of 1.25 tons is obtained from a peak current of 47 kA. Strain is recorded by an oscillograph actuated by changes in current caused by change of capacitance. The applied force pulsates at 100 c/s and is maintained for periods of 0.1–0.2 sec. Six tests on pressboard and S.R.B.P. board made with the apparatus are reported and the results discussed. Reference is made to the limitations of the apparatus, owing to the mass of the moving members, and the relatively large yield of the samples which make it difficult to design a system having a natural frequency substantially greater than that of the applied stress.

SCI. ABSTR.

455. Strains and Stresses in Nitro-Cellulose Films.

J. S. GOURLAY. *Aircraft Engineering*, **18**, 296, 1946.

An investigation into the curling of doped fabric from the standpoint of the bending of thin plates by edge couples. The magnitude of the uniform tension is proportional to the weight of colloid deposited per unit area.

E.W.J.M.

456. The Buckling of Flat Rectangular Plywood Plates.

A. E. GREEN and R. F. S. HEARMON. *Phil. Mag.* **36**, 659, 1945.

The general equations governing the buckling of a thin rectangular plate of any aeolotropic material under the action of stresses along its edges are set up and the stability equation is solved by a double-Fourier-series method both for simply supported edges and for clamped edges. The results are applied to plywood plates, cut at any angle to the grain, and the main numerical results are given for plates of mahogany 5-ply, with all the plies of equal thickness. Pure compression and pure shear are considered. The influence of plywood structure, of wood species and of other edge conditions are briefly discussed.

SCI. ABSTR.

457. The Effect of Thixotropy on Plasticity Measurements.

H. GREEN and R. N. WELTMANN. *J. Appl. Phys.* **15**, 414, 1944.

Laboratory procedures are described whereby plastic viscosity and yield value can be recorded at a known "thixotropic level" and the coefficients of thixotropic breakdown calculated. "Thixotropic level" is indicated by the down-curve side of a thixotropic hysteresis loop. It is concluded that the effect of thixotropic breakdown on rheological measurements is to shift the position of the flow curve.

B.R.R.A. (*vide* abstr. 203).

458. **Equations of Thixotropic Breakdown for the Rotational Viscometer.**
H. GREEN and R. N. WELTMANN. *Ind. Eng. Chem. Anal.* **18**, 167, 1946.

Fundamental principles of the thixotropic hysteresis loop and equations of thixotropic breakdown as produced by the rotational viscometer are presented. The work has practical applications in printing and in all other types of coatings where changes in consistency may effect the quality of the manufactured product. The equations developed give the relationship between consistency and rate or duration of shear applied to the material and enable calculation of plastic viscosity and yield value for any rate of shear that is desired.

AUTHOR'S ABSTRACT (*vide* abstr. 141 and 203).

459. **A New Approach to the Theory of Relaxing Media.**
M. S. GREEN and A. V. TOBOLSKY. *J. Chem. Phys.* **14**, 80, 1946.

A molecular theory of relaxing media is presented which gives an expression for the stress in terms of the strain history. At any given time the strain history produced a distribution in internal strains which for mechanical properties can be characterised by a limited number of internal strain parameters. The second law of thermodynamics is used to define dissipation of energy at constant temperature and explicit expressions for dissipation of energy for any strain history are obtained. Inasmuch as relaxation during straining causes an essential reorganisation of structure which is in fact the cause of dissipation, the kinetic theory of elasticity is extended to non-isotropic networks, A tensor expression for the stress-strain-time relations is thereby developed.

AUTHORS' ABSTRACT.

460. **Significance of the Equation of State for Rubber.**

E. GUTH, P. E. WACK and R. L. ANTHONY. *J. Appl. Phys.* **17** 347, 1946.

The physical significance of stress-strain curves and of isometrics obtained by the relaxation method is discussed and clarified. Stress-strain curves taken at various temperatures give the correct dependence of stress upon temperature if they are taken sufficiently fast so that stress relaxation does not mask the temperature dependence. Isometrics obtained after previous relaxation of the sample are shown to depend upon duration and temperature of the relaxation by a numerical factor only. The basis for this behaviour is the factorisation of the stress into a factor depending upon extension and temperature only which corresponds to the equation of state, and another factor depending upon the temperature T^* and the duration of the relaxation process. For simple stress relaxation, the same factorisation holds with T^* equal to T . A general theory is formulated for time dependent elastic phenomena by generalising Boltzmann's theory. The theory explains why factorisation does not hold for creep, in agreement with experiment.

SCI. ABSTR.

461. **The Triaxial Apparatus. An Instrument for the Study of the Deformation and Fracture Strengths of Soil and Ice.**

R. HAEFELI and C. SCHAEERER. *Schweiz. Bauztg.* **128**, 51, 65, 81, 1946.

The principles of shearing theory for open and closed systems are discussed, and two types of apparatus are described for the construction of shear diagrams which are based upon cyclic and triaxial mechanisms respectively. The former measures the strength directly, and the latter derives its data from differences between applied vertical and horizontal tensions. The mathematical theory of the testing of plastic substances is set out, and a full description of the triaxial apparatus is given with an account of its historical development. Experimental data for various plastics are included, with a bibliography and numerous diagrams. SCI. ABSTR.

462. Electrostatic and Tensile Properties of Rubber and GR-S at Elevated Temperatures.

R. S. HAVENHILL, H. C. O'BRIEN and J. J. RANKIN. *J. Appl. Phys.* **17**, 338, 1946.

This paper describes a new apparatus for measuring electrostatic contact potentials on various materials at elevated temperatures. The electrostatic charge acquired by a steel ball rolling down the surface of a rubber test specimen on a heated inclined plane is measured. The contact potentials of both rubber and GR-S was found to become highly negative at high temperatures. This apparent "boiling off" of electrons and resultant disruption of electrostatic attractive forces within the material is much greater for GR-S than for rubber and probably accounts for the much greater decrease in tensile strength of GR-S over rubber at high temperatures, and is further confirmation of the electrostatic contact potential theory of reinforcement. By the further application of this theory suitably dispersed compounding materials, which are in effect highly positive at elevated temperatures, such as certain proteins, finely divided silica and sodium silicate, have been found to increase substantially the hot tensile strength of GR-S compounds. SCI. ABSTR.

463. Theoretical Aspects of Viscosity and Flow-Birefringence in Solutions of Macromolecular Substances.

J. J. HERMANS. *Physica, 's Grav.* **10**, 777, 1943.

According to current ideas the molecules of high-polymers in solution are randomly kinked. Assuming that the shape of the molecule is characterised by the distance between the two ends, the continuous change of shape may be described by a *diffusion process*. A force is introduced, acting between the two ends of the molecule, thus maintaining a stationary distribution of the distance; it is thus possible to study the diffusion of the one end of the molecule with respect to the other in those cases where the equilibrium distribution is upset as a result of streaming. A new stationary distribution is arrived at, from which the viscosity and the birefringence of flow may be calculated. The formula obtained for the viscosity confirms Staudinger's rule, while that for the birefringence of flow agrees with Signer's empirical rule. SCI. ABSTR.

464. Viscometry. I. The Flow of Starch Pastes. Part IV. A New Consistometer for Starch Pastes and some results obtained with it.

R. S. HIGGINBOTHAM. *Shirley Inst. Memoirs.* **20**, 1946. *Textile Technology Digest*, **3**, 205, 1946.

An instrument for measuring the consistency of starch pastes uses a stirrer with a paddle-type rotor driven through a dynamometer. Torque is read from a quadrant balance. The torque in gram-cms. is called the consistency. Measurements are given for 10% pastes of maize, tapioca, farino, sago, oxidised, and acid-treated starches. Results are reproducible to 1% for unmodified starch. A sample of 170 cc. is required. Large differences in consistency are found for various starches in 10% pastes, some prepared at 90° and some at 99°C. After one to six minutes, consistency reaches a maximum corresponding to maximum swelling of the granules: thereafter it decreases to a steady value reached in forty to fifty minutes. The relation between these consistency values and apparent viscosities determined by other instruments and the effect of non-Newtonian flow characteristics are discussed. P.A.T.R.A.

465. Problems in Fracture of Metals.

J. H. HOLLOMON and C. ZENER. *J. Appl. Phys.* **17**, 82, 1946.

A general discussion of problems of fracture in metals is given, with suggestions for future research into the mechanism of fracture. These include a study of the variations of strain, rate of strain, stress-distribution and temperature.

L.R.G.T. (*vide* abstr. 519).

466. **Film-lubrication between Spherical Surfaces : With an application to the Theory of the Four-Ball Lubricant Testing Instrument.**

J. HOWLETT. *J. Appl. Phys.* **17**, 137, 1946.

Assuming Newtonian viscous flow at all points, the problem of determining the flow between two spheres, one fixed and the other rotating, placed close together in a large volume of liquid, is solved. The solution is applied to the analogous case of the 4-ball lubricant tester, in which one sphere rotating about a vertical axis is pressed against 3 stationary spheres in contact on a horizontal plane and immersed in the lubricant. If it is assumed that the hydrodynamical theory of lubrication is valid only for films of thickness exceeding a critical value, it is then possible to calculate the conditions of operation within which the theory is applicable; in general the maximum loading on the moving sphere is found to be of the order of a few hundred grams weight.

L.R.G.T.

467. **Plastic Deformations near Notches.**

F. K. T. VAN ITERSON. *Proc. Ned. Akad. Wet.* **45**, 112, 1942.

The lines of plastic glide in the neighbourhood of holes and notches of various shapes are sketched. The treatment is mainly qualitative, but expressions for the maximum stress are given in some cases.

SCI. ABSTR.

468. **Contribution to Plasticity Theory.**

F. K. T. VAN ITERSON, *Versl. Ned. Akad. Wet. Afd. Natuurk.* **52**, 5, 1943.

Plastic flow occurs in consequence of 3-dimensional stress, and in 2-dimensional plasticity problems, the principal stress normal to the section under consideration must be taken into account. Expressions are derived for the shearing and normal stresses on the 8 faces of an elemental octahedron, with its axes in the principal directions. Plastic flow commences as soon as the shearing stress (which is a function of the principal stress differences only) attains a value $\tau = \sqrt{2}\sigma_r/3$, or the elongation caused by the shearing stresses attains a value $\epsilon = \sigma_r/G$, or the distortion energy $A'' = \sigma_r^2/6G$ (σ_r is the elastic or flow limit). An equation is often required in plane or rotatory problems to determine the principal stress normal to the section under consideration. It is proved that in this case the stress adjusts itself to one of the two other principal stresses, so that two of the three are equal.

SCI. ABSTR.

469. **A Power Law of the Viscosity of Liquids.**

W. J. JONES and S. T. BOWDEN. *Phil. Mag.* **36**, 705, 1945.

Homopolar liquids whose viscosities have been determined over a wide range of temperature are considered and a study of the experimental data shows that the viscosity, η , can be related to the temperature by a power law of the form: $\eta - c = a(1 - T/T_c)^n$, where c , a , n are specific constants of the liquid and T_c is the critical temperature. The relation between the surface tension, viscosity and density of a liquid is also considered, especially in the case of a dioxan and benzene.

SCI. ABSTR.

470. **Creep of Neoprene in Shear under Static Conditions.**

W. N. KEEN. *Trans. Amer. Soc. Mech. Engrs.* **68**, 237, 1946.

Gives the creep characteristics of neoprene and natural-rubber vulcanisates. Mechanical test data obtained in both compression and shear tests on the vulcanisates are reported.

SCI. ABSTR.

471. **Elastic Loss and Relaxation Times in Cross-Linked Polymers.**

J. G. KIRKWOOD. *J. Chem. Phys.* **14**, 51, 1946.

The outlines of a theory of elastic loss in cross-linked polymers are developed on the basis of the ideas underlying the theory of dielectric loss of Fuoss and Kirk-

wood and the 3-dimensional network model of rubber structure proposed by James and Guth. The relaxation time distribution function for elastic loss is given in the approximation of free internal rotation of chain segments of the net. The influence of intermolecular hindering torques and network restraints on the relaxation time spectrum is discussed, but explicit calculations are postponed for a later report.

SCI. ABSTR.

472. Investigations on the Rapid Deformation of Aluminium.

W. KISTLER. *Schweiz. Arch. angew. Wiss. Tech.* **12**, 169, 1946.

In very rapid deformation, such as cold-extrusion of tubes, Al shows an extraordinary plasticity, flowing almost like a liquid ("Kaltspritzverfahren"). X-ray examination shows that the glide planes and glide directions are the same as in slow deformation, resulting in a fibre structure with $[112]$ along the tube axis and $[110]$ tangent to the tube wall. The externally-measured plastic deformation a^* is proportional to the mean plastic deformation of the crystallites $\bar{a}$; the factor can be obtained from the yield stresses of single crystals and of polycrystalline aggregates, or from the strain hardenings. Both methods give $a^*=0.08\bar{a}$ for Al. The process is discussed in terms of Becker's theory and the increase in plasticity is attributed to heating up during rapid deformation.

SCI. ABSTR.

473. A Characteristic of the Mechanical Properties of Liquids obtained by Blowing-off Radially a Liquid Layer in a Plane Parallel Slit.

M. KOUSSAKOV and K. KRIM. *Acta Physicochim., U.R.S.S.* **20**, 548, 1945.

The liquids tested by this method were all oils, and it is stated that the single experiment allows the viscosity and yield-value to be measured and the anomalous viscosity to be characterised quantitatively. Experimental details are given and the results obtained are discussed.

B.R.R.A.

474. The Behaviour of Macromolecules in Inhomogeneous Flow.

H. A. KRAMERS. *J. Chem. Phys.* **14**, 415, 1946.

A mathematical approach to the problem of flow in polymers composed of linear or branched molecules, from statistical considerations.

L.R.G.T.

475. Capillary Flow in the Soldering Process and some Measurements of the Penetration Coefficients of Soft Solders.

A. LATIN. *J. Inst. Met.* **72**, 265, 1946.

The rate of influx of a liquid into a capillary space under the action of surface tension depends upon the "penetration coefficient," which thus gives a measure of ease of penetration. The theoretical basis upon which measurements of the effective penetration coefficient of solders may be made is dealt with, and some indications are given of its application to soldering operations. Experimental work on a wide range of soft solders under different conditions on tinplate and copper is described, and the results show the influence of composition and other factors upon solderability. The results indicate that, although the solderability of low-tin solders cannot be expected to be as great as that of the higher-tin solders, they have adequate solderability to justify confidence in their use for joint-forming on the materials and under the conditions studied.

SCI. ABSTR.

476. Flow Lines in a Continuous Melting Glass Furnace as Determined by Cobalt Oxide and pictured on Colour Photographs.

V. W. LENZ. *J. Amer. Ceram. Soc.* **29**, 8, 1946.

The results of a study of glass flow in a direct-fired, continuous melting tank can be used to establish control testing schedules and tank dimensional relationships.

Three primary convection spirals are indicated. Normal convection currents produce good mixing. The methods used in making the study are explained. The use of a colouring agent and colour photographs as a means of recording the results are presented as a new technique for studies of this type. B.R.R.A.

477. The Necking of Tensile-Test Specimens.

J. D. LUBAHN. *Trans. Amer. Soc. Mech. Engrs.* **68**, 277, 1946.

The strains encountered in long rectangular tensile-test bars of the Al alloys 24S-O and 24S-T have been investigated. The theoretical conceptions previously advanced regarding the necking of tensile-test bars, have been confirmed experimentally. SCI. ABSTR.

478. The General Relations for Flow in Solids and their application to the Plastic Behaviour of Tire Cords.

W. J. LYONS. *J. Appl. Phys.* **17**, 472, 1946.

From published data on various materials the normal creep relation appears to be of the form :

$$e = e_1 + at + b \log t$$

where e is the total strain at time t . For relaxation of stress the normal relation is

$$\sigma = \sigma_1 + \beta \log t$$

where σ is the stress at time t and σ_1 , that at unit time. A theoretical interpretation of both these formulae is derived from the reaction-rate theory of plastic flow. Data for creep in cotton and rayon are presented and analysed. L.R.G.T.

479. A New Graphical Method of Representing Strength Characteristics.

A. MELDAHL. *Brown Boveri Rev.* **31**, 260, 1944.

It is possible to represent the three main stresses as rectangular space coordinates, every different state of stress corresponding to a different point in space. For any given material all states of stress which give the same resultant stress (elastic limit, rupture limit, etc.) will then lie on a surface in this space. It is suggested that these strength surfaces be represented axionometrically, the isometric projection being used for this purpose, i.e., with three axes of equal scale, the shape of the surfaces being given by contour lines. It is shown by means of some examples, how the strength characteristics of both isotropic and anisotropic materials can be clearly and completely represented in this manner. This method of representation is claimed to give a deeper insight into the strength characteristics of materials. B.R.R.A.

480. The Three Coefficients of Viscosity of Anisotropic Liquids.

M. MIESOWICZ. *Nature.* **158**, 27, 1946.

The flow of an anisotropic liquid influences the orientation of the molecules ; on the other hand, the viscosity depends on the orientation. Values have been obtained for the viscosity of *p*-azoxyanisol and *p*-azoxyphenetol with molecules previously oriented by a magnetic field for the 3 directions : molecules parallel to the direction of flow ; molecules parallel to the velocity gradient ; molecules perpendicular to the two former directions. The results are compared with those of earlier investigators. SCI. ABSTR.

481. On the Rôle of Third Moments in Isotropic Turbulence.

M. D. MILLIONSHTCHIKOV. *C.R. Acad. Sci., U.R.S.S.* **32**, 619, 1941.

The development of the theory of isotropic turbulence due to Kármán, Millionshtchikov and others is briefly traced. Following a previous paper, it is shown that the larger the viscosity of a liquid, the wider the scope of a theory which neglects

inertia terms, whereas an increase of the intensity of initial perturbations limits the applicability of such a theory. SCI. ABSTR.

482. A Viscometer for Measurements during Thixotropic Recovery: Results with a Compounded Latex.

M. MOONEY. *J. Colloid Science*. 1, 195, 1946.

An instrument is described for measuring the viscosity of a liquid immediately after an abrupt reduction of the shearing stress to a very low value. A hollow cylinder on a torsion suspension is immersed in the liquid contained in a narrow annular channel. The inner wall of the channel is rotatable with respect to the outer wall, and by this rotation the liquid is stirred or sheared. After the stirring is stopped, the viscosity is measured by photographically recording the rotation of the hollow cylinder, driven by a nearly constant torque applied through the torsion suspension. Measurements were made on a commercial compounded rubber latex containing 47.5% total solids. Immediately after stirring, the latex is a Newtonian liquid with a viscosity of 0.05 poises. Thereafter the viscosity increases at an initial rate and to an ultimate value both of which decrease as the shearing stress for measuring the viscosity is increased. The steady viscosity is attained in approximately 10 seconds. The observed extremes in steady viscosity were 11 and 0.5 poises, corresponding to the shearing stresses 1.3 and 10.7 dynes/cm.². The experimental data are fitted by theoretical curves based on the following assumptions. All aggregates of solid particles are broken up by the stirring. During subsequent thixotropic recovery, loose aggregates are formed which contain considerable amounts of trapped water. The rate of aggregation follows Smoluchowski's theory of slow coagulation, but both the coagulation rate constant and the per cent. volume of water in the coagulates vary with the applied shearing stress. The relative viscosity of the suspension of aggregates follows an empirical law. B.R.R.A.

483. Measurement of Rheological Properties of Cheese.

Het Bepalen van Rheologische Eigenschappen van Kaas.

H. MULDER. *Hoorn Exp. Sta., Report*. No. 51 (12) C, 1945.

Cheese cylinders are compressed between parallel plates, without compensation of load to allow for cross-sectional changes. Experimental method and interpretation of results are similar to those of Davis [*J. Dairy Res.*, 8, 245 (1937)]. Cylinders are of 4 cm.² area and 1.5 cm. height. Tests are on Gouda, Edam, curd, etc. Strains (Cauchy formula) are divided into elastic and viscous components and viscosities ($\eta \sim 1 - 10 \times 10^8$ poises) and Young's moduli ($E \sim 10^6$ dynes/cm.²) are calculated. Permanent deformations under constant load are found proportional to time of loading. After 10 min. loading, the deformations, total, elastic and permanent, are all proportional to applied load. As an empirical measure of "Unyieldingness" ("stugheid," lit. "stubbornness"), Mulder takes pressure (g/cm.²) $\div 2 \times$ total strain after 10 sec. Relaxation times are calculated ($t_r = 3\eta/E \sim 800 - 3000$ sec.). Relaxation can be perceived in subjective squeezing tests but firmness assessed subjectively depends not on relaxation but on immediate elastic deformation.

Loads required to break samples are measured and related to Young's moduli. G.W.S.B.

484. Influence of Strain Rate and Temperature on the Mechanical Properties of Monel Metal and Copper.

D. J. McADAM, G. W. GEIL and D. H. WOODARD. *Amer. Soc. Testing Materials, Preprint* 54, 1946.

Over a period of some years the Bureau of Standards has carried out a general study of the factors involved in the fracture of metals. The results of the investiga-

tion have been reported in a series of papers, to which reference is given by the present authors.

The earlier reports have dealt with the influence of the stress-system, temperature, and amount of plastic deformation, on breaking stress and other mechanical properties, but the effect of rate of strain had not previously been considered in detail. The paper now published discusses the relation between rate of creep, temperature, flow-stress, breaking-stress and ductility, and also presents a general survey of the influence of strain-rate and temperature on the mechanical properties of Monel and of oxygen-free copper, over the range -188°C. to the melting points of the two materials. Both materials were tested in the cold-worked and the annealed conditions.

A creep test under constant load may be divided into three stages. In the first stage, the creep-rate decreases; in the second stage it is nearly constant; in the third stage it increases. In many conditions of temperature and creep-rate the third stage of creep begins when the rate of work-hardening falls below a certain value. The evidence presented in this paper indicates, however, that the third stage sometimes begins with the formation of microscopic cracks, which are predominantly intercrystalline. Cracking occurs when the rising true stress reaches a technical cohesion-limit determined by the temperature, strain-rate, and amount of plastic deformation. Progressive disintegration begins at that stage and continues to complete fracture.

Both the second-stage flow-stress and the cohesion-limit increase with decrease in temperature and with increase in the rate of strain. Decrease in temperature or increase in strain-rate raises the cohesion-limit to a greater extent than the flow-stress, and, in consequence, ductility increases.

In the earlier papers the authors had shown that technical cohesion-limit and flow-stress are similarly affected by the stress-system, by the amount of plastic deformation or by temperature. In the present paper it is demonstrated that the two strength-indices are similarly affected by rate of strain. The test data recorded for the two materials studied are reported in an extensive series of graphs and photographic illustrations. A *bibliography* of 31 items is appended to the paper.

NICKEL BULL.

485. Flow of Water through very Narrow Channels.

A. H. NISSAN. *Nature*. 157, 267, 1946.

In these experiments dry air was passed through highly impervious limestone and sandstone cylindrical specimens, and the necessary measurements of pressure, rates, temperatures, etc., taken. It was found that flow of air under such conditions exhibited certain anomalies which led to the belief that there is a sub-viscous regime of flow. The anomalies are, briefly: (a) The rate of flow (corrected for viscosity) is not linear with pressure, but at low rates follows a curve; (b) When the rate is increased, a straight line is obtained for the curve relating the rate of flow to the pressure, but this straight line does not pass through the origin upon extrapolating backward; (c) The permeability of a sample calculated from the flow of air was not constant but varied in a complex manner with the rate of flow. This is, of course, a corollary of (a) above. To summarise: flow appears to follow two mechanisms: (i) ordinary hydrodynamic flow in surface-free systems; (ii) sub-viscous regime flow where the molecules adsorbed at the surface exchange places under distinctly different laws from those observed in non-boundary conditions. In very narrow channels the second form of flow becomes a significant portion of the total flow.

B.R.R.A.

486. **Strömungsoptische und viskometrische Untersuchungen über den lösungsstand von Casein. (Flow-optical and Viscometric Experiments on the Condition of Solution of Casein.) I.**

H. NITSCHMANN and H. GUGGISBERG. *Helv. Chem. Acta.* **24**, 574, 1941.

(The second part of this work has already been reviewed.—Abstr. 214.)

Three separate effects of salts on casein solutions are discussed.

(1) An electro-viscous effect at low salt concentrations.

(2) A change in the degree of dispersion of casein at high salt concentrations.

(3) A more complex effect which is observed only in double refraction measurements and not in viscometry.

It is concluded that whereas the particles of casein are long and narrow in shape they do not have the open-fibre form such as has been studied by Staudinger.

A large mass of data concerning the effects of various salts on the specific viscosity of casein solution and on particle shape is given, and these data are discussed in relation to the usual well-known modification of the Einstein formula.

There is a brief reference also to similar work on tobacco mosaic virus and other materials.

G.W.S.B.

487. **Tensile Strength Test of Paraffin Waxes.**

F. W. PADGETT and R. B. KILLINGSWORTH. *Paper Tr. J.*, **122**, TAPPI Sect., 201, 1946.

The practical value of the test in controlling and maintaining uniformity and quality of such waxes is to distinguish between low, medium and high tensile strength waxes. In evaluating overall performance, analytical data and other physical tests should also be taken into account. The limitations of the test are discussed, and the Perkins, modified Tinius-Olsen, Kalichevsky, and American Can Co. methods are described. All give satisfactory results if working conditions (e.g., time and temperature of ageing the wax test pieces, temperature of the test, rate of application of the load, etc.) are strictly standardised.

SCI. ABSTR.

488. **Calculation of Viscosities of Organic Liquids.**

A. N. PLANOVSK and V. V. KAFAROV. *Kimicheskaya Prom.*, No. 8, 19, 1944.

The method of calculation is based on Souders' work and his equation $\log \log \mu = K(d/M) - 2.9$, where μ is the viscosity in millipoise, d is specific gravity, M is molecular weight, and K is a constant depending on the substance. K is given by $\Sigma An + \Sigma p$, where A is the number of individual atoms in a given molecule, n is the numerical value of a constant for a given atom, and p is a correction for certain groupings and structural characteristics. The n values for hydrogen, oxygen, nitrogen, chlorine, bromine, iodine, and carbon and certain values for p are tabulated.

P.A.T.R.A.

489. **Theory of the Elastic After-effect and the Diffusion of Carbon in Alpha-Iron.**

D. POLDER. *Philips Res. Rep.* **1**, 5, 1945.

Snoek's theory is worked out in more detail. The effect is calculated when a single crystal is submitted to a simple stress in an arbitrary direction; agreement with experiment is satisfactory. From the time of relaxation, by means of which the relaxation phenomena in a state of alternating stress can be described, the coefficient of diffusion of carbon in α -Fe is calculated and is compared with that of γ -Fe.

SCI. ABSTR.

490. **Internal Friction and Plastic Extension of Zinc Single Crystals.**
T. A. READ and E. P. T. TYNDALL. *J. Appl. Phys.* **17**, 713, 1946.

Data are presented on the internal friction of zinc single crystals subjected to oscillating longitudinal stress. The decrement shows only slight rise with stress amplitude, even with stresses exceeding the static elastic limit. Experimental results are also given relating to the elastic and creep properties in slow-speed tensile tests.

L.R.G.T.

491. **The Pressure Distribution on a Body in Shear Flow.**
M. RICHARDSON. *Quart. Appl. Math.* **3**, 175, 1945.

A method is given for calculating the pressure distribution on an infinite cylindrical body immersed in a two-dimensional shear flow. It is an integral equation method and a direct attack on the boundary value problem for the stream function is avoided. An example is given, in which the contour of the cross section of the body is a circle.

SCI. ABSTR.

492. **Flow of Fluids through Porous Plugs and the Measurement of Specific Surface.**

P. J. RIGDEN. *Nature*. **157**, 268, 1946.

Using compressed powder plugs having channel widths of the order of 1 micron, concordant flow results were obtained for the flow of both air and liquids, provided a correction was made for slip at the walls. The validity of the correction term was investigated over a wide range of pressure in a modified Lea-Nurse form of apparatus.

B.R.R.A.

493. **A Photographic-Viscometric Apparatus and Technique.**

J. L. RILEY and G. W. SEYMOUR. *Ind. Eng. Chem. Anal.* **18**, 387, 1946.

An apparatus and procedure for the accurate determination of flow times of dilute solutions in the Ostwald-type viscometer have been developed. Means of measurement and control of the viscometric variables have been designed on the principle of making approximately equal contributions to the final error. A unique feature of the apparatus is the automatic timing device. Motion pictures are made of meniscus transits in the viscometer and of the virtual image of an accurate, electronically operated clock. Times of transit are interpolated from the pictures to 0.001 second. Corrected flow times of three or four check runs for each of three cellulose acetate solutions in dioxane ranging from 0.01 to 0.3% concentration fall within a time range of 0.005%.

AUTHORS' ABSTRACT.

494. **Internal Friction in Engineering Materials.**

J. M. ROBERTSON and A. J. YORGIADIS. *J. of Applied Mechanics*. **13**, A173, 1946.

An account of some experiments using a torsional oscillation technique in which the damping capacity (property of a solid which results in energy absorption when it is stressed cyclically) of solid engineering materials was measured. Empirical relations are presented for the variation of internal friction with stress amplitude in the range of engineering stresses. The author concludes that the internal friction in materials, as represented by the damping capacity, is independent of the frequency, is proportional to the third power of the stress amplitude and is due only to the distortion of the material. A bibliography of 29 references is given.

E.W.J.M.

495. **Failure of Ductile Metals in Tension.**

G. SACHS and J. D. LUBAHN. *Trans. Amer. Soc. Mech. Engrs.* **68**, 271, 1946.

The forming of a neck in a tensile-test specimen is due to the fact that, when the load passes through a maximum, a slight increase of the strain at one particular

location results in this becoming weaker than the remainder of the specimen ; all further strain then concentrates at this location. The conditions leading to this kind of instability, called "necking," are investigated and graphical constructions are given for the cases of pure tension of a test specimen, biaxial tension of a flat sheet, thin-walled tubes and spheres subjected to internal pressure and a plate with a circular hydraulically formed bulge. The constant volume condition of the specimen is combined in the investigations with the relations $dF = 0$ and $dp = 0$ respectively, where F is the tensile load and p the internal pressure. The graphical solutions are based either on ordinary stress/strain diagrams or, preferably, on curves in which stresses are plotted against the so-called natural or logarithmic strain $\epsilon = \log (1 + e)$, where e is the ordinary strain. SCI. ABSTR.

496. Finite Strain in Aeolotropic Elastic Bodies. II.

B. R. SETH. *Bull. Calcutta Math. Soc.* 38, 39, 1946.

Previous work is extended and these problems are solved: (1) Torsion of a circular cylinder; (2) a spherical shell under uniform normal traction; (3) a cylindrical shell under uniform normal traction. SCI. ABSTR.

497. Method of Notching Impact Test Specimens.

S. E. SIEMEN. *A.S.T.M. Bulletin.* No. 139, 45, 1946.

A description of a tool (carbide-tipped cutter in milling machine) and technique developed by the author for eliminating the difficulties associated with the machining of the standard 45 degree angle notch having a radius at the root, of 0.010 inch. E.W.J.M.

498. A Note on the Equations of Plane Plastic Flow.

I. N. SNEDDON. *Phil. Mag.* 36, 629, 1945.

A possible approach to 2-dimensional problems of plastic flow by the methods of Stevenson is suggested. The method is illustrated by finding the solutions of some well-known problems. One of these is the so-called "vertical flow" in a plastic mass. SCI. ABSTR.

499. The Elastic Stresses produced in a thick Plate by the application of Pressure to its free Surfaces.

I. N. SNEDDON. *Proc. Camb. Phil. Soc.* 42, 260, 1946.

The method of Hankel transforms introduced in a previous paper is used to calculate the normal displacement of a point on the free surface of a semi-infinite elastic medium, part of the plane boundary of which is deformed by the pressure of a rigid body. Terezawa's solution of this problem is obtained as a special case of a more general theory which is then applied to the case where the elastic medium is bounded by 2 parallel planes a finite distance apart, normal pressures being applied to these free surfaces. The analysis is later simplified by assuming the applied pressures are symmetrical about a central plane; this problem was treated in 2 dimensions by Filon and the 3-dimensional solution is now given. SCI. ABSTR.

500. Effect of small Quantities of Carbon and Nitrogen on the Elastic and Plastic Properties of Iron.

J. L. SNOEK. *Physica, 's Grav.* 8, 711, 1941.

The elastic after-effect on Fe was investigated by means of a torsion pendulum suspended by an Fe wire, or of a compound pendulum suspended by an Fe strip. Damping other than that due to elastic after-effect was avoided by enclosing the apparatus in a vacuum or an atmosphere of hydrogen, and applying a constant magnetic field to suppress magnetic hysteresis effects. The enclosure was made of silica so that the suspension could be heat treated without disturbing it. For "pure"

Fe (carbon removed by annealing in moist H_2 at 700–800°C.) the logarithmic decrement is practically constant in the temperature range -50° to $+100^\circ C$. Iron containing interstitial C or N shows a maximum in the decrement at about room temperature, the values being indistinguishable from those for pure Fe towards the ends of the temperature range. The height of the maximum depends on the amount of C or N present, and this can be adjusted conveniently by annealing at 600°C. in H_2 containing a known percentage of CO or NH_3 . The shape of the curve can be predicted from previous measurements on magnetic after-effect, and the agreement is good. Measurements were also made on cold-worked samples containing known amounts of C or N. The curves are more complex, and the maximum is shifted to higher temperatures ($\sim 200^\circ C$). The results are discussed in the light of Gorski's theory that C and N atoms tend to migrate from regions of compression to regions of tension. SCI. ABSTR.

501. Several After-Effect Phenomena and related Losses in Alternating Fields.

J. L. SNOEK and F. K. DU PRE. *Philips Tech. Rev.* **8**, 57, 1946.

Two mechanical examples of after-effects are first discussed, viz., (a) the after-effect in a loaded beam in which, after the initial bending, there is a slow increase to a new equilibrium position; the explanation is given in terms of thermal diffusion due to differences of temperature set up in the original bending; (b) a torsional after-effect observed, for example, in Fe only when small amounts of C and N impurities are present; the explanation in this case is one of slow diffusion of the impurities. The problems of dielectric and magnetic after-effects are considered and are shown to be closely related to these mechanical examples. The ferromagnetic after-effect is accounted for by means of a tension set up in the solid, and a discussion is given of the means by which it may be investigated and separated out from other effects such as eddy currents and hysteresis. SCI. ABSTR.

502. The Theory of Plasticity—An Outline of Work done in Russia.

W. W. SOKOLOVSKY. *J. Appl. Mech.* **13**, A1, 1946.

A summary of an address given in Moscow in June, 1945. Equations expressing the state of strain beyond the elastic limit have been given by several authors. Expressions have been obtained for the components of deformation expressed through the stress components; and the inverse expressions have been given both in the case of ideal plasticity (Mises condition) and in the case of strain-hardening according to the Schmidt condition. A new theory of viscous materials has been evolved which, in addition to the Saint-Venant hypothesis, assumes that the maximum shearing stress in flow is always greater than a certain constant and depends linearly on the maximum rate of shear. The theory of stability beyond the elastic limit has also been developed. The elasto-plastic bending of shells and plates and the plastic states of plane strain have received a good deal of attention. A bibliography of relevant Russian literature is appended. SCI. ABSTR.

503. Poisson's Ratio of some Structural Alloys for Large Strains.

A. H. STANG, M. GREENSPAN and S. NEWMAN. *J. Res. Nat. Bur. Stand.* **37**, 211, 1946.

Values of Poisson's ratio, as well as ordinary stress-strain properties, for tensile strains as high as 18% were determined on sheets of aluminium alloys, chrome-molybdenum steel plate, and structural and fully killed low-carbon steel plate. Poisson's ratio (ν) is taken to be the ratio of the "lateral contraction" to the "axial strain," and in general increases, reaches a maximum and then decreases with increasing axial strain. All tests were performed at room temperature, with the

exception of six made at -44°C . on the fully-killed carbon steels. The paper is illustrated by 2 photographs and 18 graphs showing stress and ν plotted against axial strain.
V.G.H.W.

504. Stress-time Temperatures Relation in Polysulphide Rubbers.

M. D. STERN and A. V. TOBOLSKY. *J. Chem. Phys.* **14**, 93, 1946.

Various polysulphide rubbers are subjected to continuous and intermittent stress-relaxation and creep under constant load tests at varying temperatures. From the energy of activation involved in the relaxation process it is concluded that the type of bond breakage responsible for the relaxation is nearly the same in all the rubbers examined. Possible mechanisms of bond breakage are discussed.
L.R.G.T.

505. Non-linear Theory of Elasticity with small Deformations.

E. STERNBERG. *J. Appl. Mech.* **13**, A53, 1946.

Previous investigations of non-linear theory of elasticity have been concerned largely with the problem of finite deformations. In this paper the assumption of "infinitesimal" deformations is retained, whereas Hooke's law is replaced by a general 2nd-order approximation of non-linear stress-strain laws. Applications to uniaxial tension and compression as well as torsion of right circular cylinders are considered in detail. The results obtained indicate 2nd-order effects which were previously unnoticed because of the early linearisation of the extended stress-strain relations.
SCI. ABSTR.

506. "Plastic" Transverse Contraction of a Longitudinally Strained Metal.

K. H. SWAINGER. *Nature*. **158**, 165, 1946.

The "plastic" strain of a specimen under simple tensile loading is the part which does not disappear when the load is removed. The ratio transverse/longitudinal plastic strain, previously estimated at 0.5, was measured for duralumin. It reached a value 0.42 at the corner of the stress/strain curve and then fell to a constant value 0.37. This value indicates that volume changes occur in the plastic component of the strain as well as the elastic part.
SCI. ABSTR.

507. On the Application and Derivation of the new Viscosity-Temperature Relationship of Liquids.

M. S. TELANG. *J. Phys. Chem.* **50**, 373, 1946.

The author's relation :

$$I/\eta = A/(T_c - T)^{3/10} - k$$

(T = temperature, T_c = critical temperature, A and k constants), is tested for 20 liquids, including both organic and inorganic. Unassociated liquids generally fit the formula over the whole range of temperatures, but those in which there is probably association or dissociation varying with temperature show departures in the corresponding temperature range.

The theoretical interpretation of the formula is discussed, and the relation between the author's formula and other proposed viscosity formulae is dealt with in considerable detail.
L.R.G.T.

508. The Behaviour of Water under Hydrostatic Tension. I.

H. N. V. TEMPERLEY and L. G. CHAMBERS. *Proc. Phys. Soc., Lond.* **58**, 420, 1946.

A review of the literature reveals very considerable differences in the values of critical tension obtained by different methods. Two methods are studied in detail : the Berthelot method, which makes use of the difference in expansions of glass and

water, and the Reynolds centrifugal method. High pressures are apparently required to persuade water to stick to glass under subsequent tension. A modification of the Berthelot method gives results in much better agreement with other methods. Examination of the Reynolds method shows that account must be taken of the fact that water does not move as a rigid body. Although this has no appreciable effect on the pressure distribution, it does imply a considerable stirring of the water, and any small bubbles would tend to be brought near the region of greatest tension. The flow of water in constricted tubes is also studied. It is concluded that if tension is applied statically, ordinary water can stand tensions of the order of 40 atm, even if it is not perfectly air-free. Water nearly saturated with air has been shown to stand tension up to 6 atm.

SCI. ABSTR.

509. The Behaviour of Water under Hydrostatic Tension. II.

H. N. V. TEMPERLEY. *Proc. Phys. Soc., Lond.* **58**, 436, 1946.

A further examination of the Berthelot method of producing tensions in liquids has been made. The critical tension of water has been measured by a method which does not assume that the extensibility and compressibility of water are equal, and other evidence in confirmation of this assumption has been obtained. It is concluded that high pressures are necessary in the Berthelot tube to force the final gas bubble to dissolve in a reasonable time, and that this fact is probably due to the low rates of diffusion of gases through liquids. It is also concluded that there is a large discrepancy between the theoretical and the observed strength of water.

SCI. ABSTR.

510. The Elasticity of a Network of Long-Chain Molecules. III.

L. R. G. TRELOAR. *Trans. Faraday Soc.* **42**, 83, 1946.

The simplest treatment of the elasticity of a network of long-chain molecules, corresponding to a vulcanised rubber, makes use of an approximate formula to represent the probability of a given end-to-end distance for the molecular chains. By using the accurate formula derived by the author (*Trans. Faraday Soc.*, **42**, 77, 1946), and calculating the network entropy corresponding to the strained and unstrained states, stress-strain curves are derived for the cases of simple elongation, and of 2-dimensional extension. These curves, which reproduce the essential features of the curves for vulcanised rubber, show the modulus of elasticity to vary inversely with the chain length, whilst the maximum extensibility is proportional to the square root of the chain length.

AUTHOR'S ABSTRACT (*vide abstr.* 147).

511. Hysteresis and related Elastic Properties of Tire Cords.

H. WAKEMAN and E. HAROLD. *J. Appl. Phys.* **17**, 698, 1946.

A method of evaluating mechanical hysteresis, elastic modulus, and growth rate of a yarn or cord subjected to cyclic loads in a fatigue test is described. The test is applied to seven typical tire cords—one Nylon, two rayon, and four cotton cords including both high stretch and low stretch cords. Results are presented showing the effect of cycle number, moisture content, temperature, and load range on the elastic properties of each of the cords tested. The influence of cyclic loading on the stress-strain curve is also discussed. It is concluded that moisture content is the dominant factor influencing the elastic properties of tire cords and that the heat produced by mechanical hysteresis of the tire cord contributes appreciably to the heat build-up observed during heavy duty service.

AUTHORS' ABSTRACT.

512. Fatigue Failure of Rayon Tire Cord.

R. C. WALKER and W. E. ROSEVEARE. *J. Appl. Phys.* **17**, 482, 1946.

Experiments on tire cords under oscillating stress are made under various con-

ditions of frequency, temperature and humidity. Fatigue breakdown appears to be due to a process of crack growth, and is fundamentally the same in rubbers, metals and textiles.

L.R.G.T.

513. The Design and Correction of Dies. IX. Auger Design affects Clay Flow.

L. R. WHITAKER. *Brick Clay Rec.* 107, 48, 1945.

In order to produce better knitting together of the layers of clay on leaving the auger, treatment of the discharge end of the main thread and wing is considered. The first method is to corrugate the end of the thread, while the second method is to level the end of the thread to a sharp edge. Bridges for hollow-ware dies should be placed in the zone of greatest pressure, i.e., adjacent to the auger, in order to produce effective knitting of the clay column after passing over the bridge bars. Various bridge designs to promote even flow and reduce bridge cracking and the location of the bridge to produce even flow of materials to the die and eliminate strains and laminations in the ware, are considered.

B.R.R.A.

514. Flow in a Radial Direction between Two Plane Surfaces.

A. VAN WIJNGAARDEN. *Versl. Ned. Akad. Wet. Afd. Natuurk.* 52, 29, 1943.

The radial laminar flow of an incompressible viscous liquid between two parallel plane surfaces is considered. Use is made of the equations and methods applied in the investigation of boundary layer flow. It is supposed that the field is limited by a cylindrical boundary, situated either internally, in the case of outward flow, or externally, in the case of inward flow. By choosing an appropriate form of expansion for the stream function and for the velocity in the plane midway between the two parallel walls, it is possible to resolve the partial differential equation into an infinite system of ordinary differential equations, a solution of which can be constructed valid for small distances from the limiting cylindrical surface. A corresponding development can be obtained for the pressure.

SCI. ABSTR.

515. Simple Method of Determining Poisson's Ratio.

R. J. WILKINS. *Engineering.* 162, 52, 1946.

When a thin-walled vessel is subjected to direct stress a relation exists between the stress, volumetric strain (v/V), modulus of elasticity of the material (E) and Poisson's ratio ($1/m$). A brass tube has the ends closed to form suitable grips and so that coloured water can be used to indicate the volume changes. Side tubes at the ends lead to an adjusting screw and a graduated glass tube respectively. The tube is stressed in a tensile machine and the load is plotted against the change in liquid level. The value of E required to calculate $1/m$ from the slope of this graph is found by a separate extensometer experiment. The method is more accurate than calculations from known values of E and C (modulus of rigidity) and is very suitable for instructional purposes.

SCI. ABSTR.

516. Residual Stresses in Welded Structures.

W. M. WILSON and C. C. HAO. *Bull. Univ. Ill. Engng. Exp. Sta.* (No. 361), 1946.

The residual stresses are caused by the normal thermal shrinkage of the weld metal and the fused base metal being resisted by the adjacent base metal. These stresses and their distribution are theoretically analysed and the following conclusions are drawn: At loads below the yield point the deformation is greater, and at loads above the yield point it is smaller for longitudinally welded specimens than for unwelded specimens. If the load is released and the specimen re-loaded elastic deformation occurs. The yield point of the welded plate is approx. that of the average yield point of the metal across the welded plate, and is higher than that of

the unaffected base metal. Tests made with plates 5 in. and 12 in. wide longitudinally butt-welded verified these conclusions. For wider specimens similarly welded, the plastic elongation proved to be markedly greater than for narrow ones. Strength and elongation of these wider plates showed no great differences if welded manually or by the Unionmelt process, and whether or not stress-relieved by heat treatment. For narrow and wide specimens the plastic elongation of the whole welded specimen is greater than that of a cut-out strip containing the weld. Specimens with circular welded seams showed bi-axial residual stresses and these were analysed. A limited number of fatigue tests were also made. SCI. ABSTR.

517. Mechanism of Creep in Metals.

W. A. WOOD and H. TAPSELL., *Nature*. **158**, 415, 1946.

Under normal static loading of a poly-crystalline metal specimen, the grains break down into randomly orientated crystallites; with a single crystal specimen, however, the crystallites are approximately parallel. It has been found that a polycrystalline specimen, subjected to the slow continuous deformation known as "creep," shows parallel orientation of the crystallites, i.e., it deformed as though it were a single crystal. SCI. ABSTR.

518. A Thermodynamic Criterion for the Fracture of Metals—A Criticism.

C. ZENER. *Phys. Rev.* **70**, 225, 1946.

It is pointed out that in Saibel's criterion one quantity (the "strain energy" at fracture) is usually dependent on the conditions of test, whereas the others are invariable thermodynamic factors. Furthermore, the "strain energy" is very structure-sensitive, which the other factors are not. SCI. ABSTR.

519. Problems in Non-elastic Deformation of Metals.

C. ZENER and J. H. HOLLOMON. *J. Appl. Phys.* **17**, 69, 1946.

Problems in the non-elastic deformation of metals are discussed generally, and topics upon which further research would be valuable are suggested. These include the development of slip bands and phenomena of strain-hardening.

L.R.G.T. (*vide* abstr. 465).

REVIEW

Traité de Plasticité pour l'Ingénieur.

F. K. T. VAN ITERTSON. *Vaillant-Carmanne, Liège*, 1944.

The plasticity of metals and of other ductile materials is the subject matter of Van Itertson's book which can be read with benefit even by those whose knowledge of technical French is limited.

Written for students, the presentation is comparatively simple, although a full treatment is given to plastic deformations, first in two dimensions and then in three. The fundamental principles of Hencky, St. Venant and Maxwell are quoted extensively.

The book is divided into 22 short chapters and includes the treatment of a plastic mass under a number of industrially important conditions such as the deformation of a wedge, the drawing of a wire (by considering the case of two concentric cylinders, one of which moves axially), the analysis of the Brinell method of impressing a sphere on the surface of a material which is plastic under stress, problems of torsion, increase of hardness of worked steel, and many others.

The fact that 118 figures, mostly diagrams, are displayed on only 180 pages illustrates the method of treatment. An index of the symbols used is included, a practice which can be warmly recommended.

L. A. STEINER.