ELASTICITY IN LIQUIDS

A SYMPOSIUM on elasticity in liquids, arranged under the auspices of the British Society of Rheology, was held on March 27 in the Department of Science of the Durham Colleges in the University of Durham. Mr. J. E. Caffyn organized the details of the meeting.

Prof. J. E. P. Wagstaff welcomed the members to Durham, and the morning session then opened with Prof. G. S. Rushbrooke in the chair. Dr. R. Roscoe first read a paper on elastic relaxation and flow in suspensions, in which he referred to the early experiments of Schwedoff on relaxing sols. The method involved placing a gelatine solution in a co-axial cylinder viscometer, suddenly applying a shear by twisting the torsion head which supported the inner cylinder and observing the stress on the system as it relaxed slowly. Schwedoff considered that the stress fell off exponentially; but later workers do not confirm this. Dr. Roscoe has found, however, by repeating their experiments, that departure from the exponential decay is a feature of viscometers with a wide gap between the cylinders. By writing down the flow equations for such an apparatus, he is able to deduce a form of decay for the stress which agrees with experiment.

In the second part of his paper, Dr. Roscoe discussed the relation between rate of shear and shear stress, under steady conditions. Equations of flow have been developed by a generalization of Maxwell's method, which reduce to Bingham's equation in the case of steady flow. The cause of observed departures from Bingham's equation was discussed.

Dr. S. Thornton, speaking on the rheological behaviour of some dispersions of solid particles in liquid media, considered the effect of particle concentration on the relative viscosity of suspensions of rigid non-flocculating particles, and he developed a general expression applicable not only to spherical particles, in agreement with Einstein's well-known equation, but also to non-spherical particles of a limited type over a limited range of concentration. After a brief review of the experimental work on this subject, he stressed the need for checking the absence of flocculation of the particles and for ensuring the validity of any corrections applied. He explained briefly the technique for measuring the absolute viscosity of thixotropic materials which do not exhibit elastic behaviour, and gave results for some special cases.

Dr. E. G. Richardson described some experiments now in progress on the relationship between shear and bulk viscosity. Stokes first deduced a formula for the absorption of plane waves in a gas, the theory making the coefficient (α) proportional to the square of the frequency (f) and the kinematic viscosity (ν). In many liquids α/f^2 is constant (with frequency) but has a value much greater than that of Stokes's formula, if the shear viscosity is substituted for ν. It has been suggested that the bulk, or dilatational viscosity, should be included in ν when the propagation of ultrasonic waves is concerned. One experiment, suggested by Eckart, for the determination of bulk viscosity is based on the mensuration of the acoustic streams in the neighbourhood of a vibrating source, and a study of this is being made using hot wires to measure the streaming velocities in various fluids at frequencies from 1 c./s. to 1 Mc./s.

Another method is to study the absorption of ultrasonics in capillary tubes, wherein plane waves are propagated in the centre of the tube and shear waves in the acoustic boundary-layer near the walls. Some initial results in both experiments were quoted.

In the afternoon session, with Dr. J. G. Oldroyd in the chair, J. E. Caffyn and R. M. Underwood described a new method for delineating velocity profiles in visco-elastic liquids. This involves the delineation of the motion of isolated oil drops, suspended in the liquid under test flowing along a tube 1 cm. in diameter, by double-flash photography from two perpendicular directions. From the double exposure of the oil drop on the photograph, the velocity at different radial distances from the axis of the tube can be estimated (and incidentally any deviation from axial flow detected), and hence the velocity profile at the site of the photographs to be constructed. Examples in water (for calibration purposes) and in an ammonium oleate sol were shown. In the visco-elastic fluid the velocity distribution, in accordance with the theories of Oldroyd and of Reiner and Rivlin, is still parabolic.

The final paper, by Dr. A. S. Lodge, considered some theories of the Weissenberg effect, and dealt with the distribution of transverse pressure in a rotating cone-and-plate viscometer, when the interspace is filled with a visco-elastic liquid in which components of stress perpendicular to the direction of shear are set up. The paper was theoretical and dealt with the fluid in stationary laminar incompressible flow, for which the general stress determinant was constructed. The difference between stress components (zero in a Newtonian fluid) give rise to the Weissenberg effect, as Dr. Lodge showed. Having calculated these differences for various radial distances in the cone-and-plate apparatus, he can compare the theory with the measurements of Roberts, who erected a series of manometers from the centre to the rim of the cone above the rotating plate and so was able to measure the transverse (vertical) stress distribution in a number of visco-elastic liquids. In the discussion on this paper, Dr. K. Weissenberg pointed out that Roberts's experimental results agree with his own calculation of the stress distribution.

MATHEMATICAL ASSOCIATION

ANNUAL GENERAL MEETING IN SHEFFIELD

THE annual general meeting of the Mathematical Association was held in the University of Sheffield during April 8–11. At a reception given by the University on April 8, Dr. J. M. Whittaker, the vice-chancellor, welcomed the members, among whom was his father, Sir Edmund Whittaker, honorary member of the Association and president in 1919.

On April 9, following the business meeting, the president, Mr. K. S. Snell (Harrow School), gave his address, his subject being "School Mathematics To-day and To-morrow". Mr. Snell began with a speculation on the probable content of the school curriculum fifty years hence, suggesting that many topics now regarded as well outside the school range would by then have become commonplaces of the

grammar-school curriculum. He then went on to examine present-day tendencies, to discuss which items might be emphasized and which might be allowed to fall into oblivion. One way in which much time might be set free for the development of the school course in mathematics would be to reform the British weights and measures—those tables which demand for their acquisition a great deal of time and effort—and Mr. Snell made a strong plea for the adoption of a suitable metric system in Britain.

Prof. A. G. Quarrell (Department of Metallurgy, University of Sheffield) then gave a paper on "Metallurgy—Craft and Science", describing the combination of craftsmanship and scientific investigation required in the production of high-quality steel; by the courtesy of Firth Brown, Ltd., a colour film showing modern methods of steel production was shown to the audience.

On April 10 the proceedings opened with a discussion on "Infinity", in which Prof. A. G. Walker (University of Liverpool) elucidated the concept of infinite numbers, and Dr. C. Hamill (University of Sheffield) spoke on the meaning and place of infinity in geometry. In the succeeding discussion some members thought that a simple account of these topics might be presented to a sixth form; but others urged that this was a subject which should be reserved exclusively for the university course.

The next paper, "The Mathematics Division, N.P.L.: its Work and Equipment", was to have been given by Dr. E. T. Goodwin, the superintendent of the Mathematics Division in the National Physical Laboratory; in his absence, through illness, Dr. L. Fox, the deputy superintendent, spoke on this topic, describing the range of machines, from the hand-operated adding and multiplying machines up to the A.C.E. electronic computer. Dr. Fox also dealt with the part played by the mathematician in analysing and systematizing the problems submitted to the Division before handing them over to the computing machines.

In the afternoon of the same day, a long and lively discussion was held on a subject which has greatly concerned the Association in recent years : "From Primary School to Secondary School". The opening speakers were Mr. L. B. Birch (deputy director, Sheffield University Institute of Education), Mrs. E. M. Williams (principal, Whitelands Training College) and Mr. M. W. Brown (headmaster, Charlton Secondary School). It was urged that free activity is the only method which will enable the average child to understand the mathematical processes of the primary-school range; but some secondary-school teachers feared that the freedom of activity might encourage the child to avoid hard work and might lead to a state in which pupils arriving at the secondary school would not have the firm grasp of fundamentals required for the school programme. In return, it was argued that understanding must precede technical skill and that manipulatory techniques are much more rapidly acquired if genuine understanding and appreciation of mathematical principles have been fostered in the primary school. But no easy solution to the practical problem of applying modern ideas to classes of forty or fifty children was put forward. In the evening, Dr. S. Vajda (Admiralty Research Laboratory) gave a paper on the "Theory of Games", a subject which, initiated mainly by John von Neumann in the 1920's, has proved to have wide applications to economics and also to the highly important war-time study of operational research.

The final paper, on April 11, was by Mr. J. F. Hinsley (chief radiologist and physicist, Edgar Allen and Co., Ltd.), who chose as his subject "From Examination Question to Industrial Problem". Here Mr. Hinsley showed that certain familiar examination questions concerning the motion of a particle, usually thought of as possessing only academic interest, are in fact of very considerable practical value in the design and testing of cement-making machines.

The new president of the Association is Prof. T. A. A. Broadbent, of the Royal Naval College, Greenwich.

SCOTTISH BRANCH OF THE SCIENCE MASTERS' ASSOCIATION

ANNUAL MEETING IN EDINBURGH

THE Scottish Branch of the Science Masters' Association held its annual meeting during April 7–10 at the Heriot-Watt College, Edinburgh, under the presidency of Dr. H. G. Nisbet, principal of the College. In his address, on "Some Applications of Physics in the Fuel and Oil Industry", Dr. Nisbet described the various methods of cleaning and grading coal, using such principles as flotation and electro-static attraction. The difficulty of efficient cleaning becomes greater as the size of the coal particles decreases, and he attributed much of the dirtiness of our coal to-day to the increased proportion of very small particles in coal won by modern mechanized techniques. Turning to liquid fuels, Dr. Nisbet explained how 'knocking' or 'pinking' is due to abnormal rates of flame propagation, which can be corrected by the use of suitable catalysts such as tetra-ethyl lead. He next dealt with the problem of making efficient use of the fuel resources of Great Britain, and ended with a plea for more chemical engineers who, by increasing this efficiency, could help the country to maintain its place as a leading industrial nation.

Mr. R. M. Sillito, of the University of Edinburgh, gave an excellent lecture-demonstration on "Sound in Schools", with special reference to the new Scottish Leaving Certificate syllabus. He ended by asking that school pupils should be trained in the habit of precise quantitative thinking, which, he maintained, is far more valuable as a basis for university work than mere factual knowledge.

Two consecutive lecture-demonstrations on "A Theoretical and Practical Approach to the Teaching in the M.K.S. System of Electrical Units" were then given by Mr. F. A. Meier, of the University of London Institute of Education. This again had special significance in view of the new Leaving Certificate syllabus, both as regards the M.K.S. system itself and also as regards the approach via electromagnetic induction instead of magnetometry. His demonstrations of home-made apparatus, much of it being designed on original principles, were most impressive. Mr. Meier stressed the point that the new system and approach are far easier than the old, provided we can rid ourselves of our preconceived notions.

In a lecture on "School Astronomy" given at the City Observatory, the director, Mr. N. G. Matthew, asked science masters to try to make time for some astronomy in an admittedly crowded syllabus, and outlined methods by which the subject