

**THE
BRITISH SOCIETY
OF RHEOLOGY**

BULLETIN — No. 2, 1967

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REPORT OF A CONFERENCE ON THE RHEOLOGY OF BUILDING AND ROAD MATERIALS

by G. H. TATTERSALL

This conference, held on 4th and 5th April 1967 at Stephenson Hall in the University of Sheffield, was the first to be organised by the Society to deal with this particular topic. Perhaps this represents something of an omission in view of the fact that the building industry is by far the largest in the country, in terms of annual capital investment, and some two thousand million square yards of roads are laid every year.

Materials such as metals, timber and polymers may properly be considered under the heading "building materials," but the conference was intended to cover only those materials whose rheological properties are important on the site in the process of building, so those dealt with were fresh concrete, bitumens and grouts. The conference was attended by about 50 people, including several from the Continent, and University, Research Association and Industry were all well represented.

The Chairman of the first session, on concrete, was Professor J. K. Page, Professor of Building Science in the University of Sheffield, who commented on the importance of rheological studies in contributing to the establishment of new techniques and the improvement of old ones in these major industries.

The first paper was a review by Dr. G. H. Tattersall (University of Sheffield) on "The workability of concrete and the rheology of cement pastes," which began with a discussion of the difficulty of defining workability, and a rapid survey of existing tests, none of which was adequate and most of which had been used only by their inventor. Single point tests were unsatisfactory in principle and nothing was to be gained by the proposing of new ones. The experimental work of Dellyes, Tattersall, Papadakis and Ish-Shalom and Greenberg on structural breakdown of cement pastes and slurries was reviewed and later conflicting results of Tirona and Nessim and Wajda were mentioned. Relevant work of Green and Weltman on printing inks, and of Kuroiwa and Nakamura on materials such as carboxymethyl cellulose was also considered.

Dr. P. E. Halstead (Cement and Concrete Association) spoke on "Cement Chemistry and Rheology" and showed by microphotographs taken at various time intervals the effect of water on individual cement grains and the occurrence of preferred points of attack. He emphasised the importance of the gypsum in considering rheological properties and pointed out that since gypsum may be dehydrated by the cement grains or by free lime present, the constituents of cement

will vary with its age. False set was due to rapid hydration of the hemihydrate and the loose structure produced could easily be destroyed, while flash set was due to rapid hydration of C_3A which would not take place so long as SO_4^{--} ions were available to permit the formation of ettringite. The tobermorite formed by hydration of the C_3S and C_2S had a specific surface of the order of 10^6 sq.cm/g and probably material of clay like fineness was deposited between the grains. Under shearing forces the period of plasticity of cement paste could be prolonged to about four hours but at longer times the paste was no longer coherent.

Professor A. R. Cusens and Dr. J. Harris (University of St. Andrews) presented a paper on "The mechanical properties of cement pastes in oscillatory shearing motion" in which they described experiments with a rheogoniometer whose cone had a diameter of 3", an angle of 5° and was truncated by 0.008" at the apex. Both cone and plate were covered with a grade 120D emery paper. The paste used was of ordinary Portland cement with a W/C of 0.3 and the frequencies of oscillation ranged from 1.0 to 15.8 c.p.s. Values of viscosity obtained from stress readings of the fundamental wave were plotted against time and at the higher rates of strain (3.28 and 7.80 reciprocal seconds peak values) indicated a noticeable breakdown of the material followed by a building up, but at lower strain rates (1.62 and 0.61) the early breakdown did not occur. A plot of viscosity at any particular time against strain rate amplitude gave a single curve for all frequencies, while yield stress was independent of frequency.

In his paper on "The flow forming of fresh concrete," Mr. J. G. D. Morgan (Blaw Knox Ltd.), described experiments to determine the flow pattern under the conforming plate of a slip form paver. The inner faces of the side forms were covered with a thin coat of white paint and the resulting aggregate scratch patterns, which were clear and consistent, showed the flow streamlines. The results correlated with hydrodynamic theory if corrections were made to allow for finite aggregate size and compaction.

The last paper of the session was on "The vane method of measuring the mobility of fresh concrete" by Dr. A. G. B. Ritchie (University of Strathclyde) and described the use for concrete of an empirical test similar to that used for the site investigation of saturated cohesive soils. A paddle consisting of a cruciform arrangement of four thin rectangular blades is immersed in the concrete and the maximum torque it can support is measured. The apparatus should be useful in a practical study of striking times.

In the time allowed for short contributions Mr. N. May (BPB Industries Ltd.) discussed work on gypsum slurries using the falling plate consistometer, which has some similarity to the concrete slump test. Dr. G. H. Tattersall gave preliminary results of experiments on sedimentation of cement pastes in a concentric cylinders viscometer.

Using a radioactive tracer technique he had found in one case that a paste of original W/C 0.32 could, after shearing, have values of W/C of 0.33 at the top of the cylinders and 0.29 at the bottom.

The afternoon session was devoted to alternative visits to the Swinden Laboratories of United Steel Co.'s Ltd. and to the plant of Ready Mixed Concrete (East Midlands) Ltd., and in the evening members of the conference also visited the Departments of Building Science and Architecture of the University of Sheffield.

The third session, on Wednesday morning, was on bitumen and opened with a review paper by Mr. A. Please (Road Research Laboratory) on "Dense bituminous mixtures for modern roads." After a description of the structure of modern roads the importance of rheological considerations was discussed and empirical tests described. In the spreadability test an inverted truncated cone of material is dragged under a blade and the force required measured, roller is used and the void content measured as a function of the number of passes.

Mr. G. Lees (University of Birmingham) began his paper on "The contribution of the aggregate to the structural stability of bituminous mixtures" by discussing the behaviour of mixtures on the road and pointing out that no single laboratory test was sufficient to assess this behaviour; the situation seemed to be as unsatisfactory as that for concrete discussed earlier in the conference. The influence of aggregate and binder on triaxial parameters was discussed in detail and results of flexural tests were presented. Evidence suggested that aggregate interlock played a major role in determining strain at failure.

Dr. P. S. Pell and Mr. I. F. Taylor (University of Nottingham) in their paper on "Fatigue of bituminous road materials" described an experimental method, similar in principle to one much used on steels, in which sinusoidally varying stresses are imposed on a sample by rotating it as a cantilever which is subjected to a constant force applied at its free end in a constant direction at right angles to the axis of rotation. The number of cycles to failure was a simple power function of the stress amplitude and results were presented for the effects of type and grading of coarse aggregate, filler content, bitumen grade and content, and voids. Measurements had also been made of the dynamic modulus, so strain amplitude could be calculated and was shown to be the important criterion for fatigue failure.

A paper on "Determination of the viscoelastic properties of bituminous concrete" by Monsieur G. Sayegh (Laboratoire Central des Ponts et Chaussées), in the unavoidable absence of the author, was, at short notice, presented by Mr. K. A. Lammiman (Esso Research). Experiments had been carried out in which a sinusoidal force was

applied longitudinally to a cylindrical specimen and the resulting longitudinal and transverse deformations were measured by means of resistance strain gauges. A phasemeter measured the phase difference between the applied force and the two deformations in turn. It was found that bituminous concrete exhibited linear viscoelastic behaviour only for strains below 2×10^{-5} but its behaviour at strains in excess of this could be calculated if a deviation factor was known. Poisson's ratio was a real number which was a function of frequency and temperature and ranged from 0.5 to 0.22.

In the final session, Dr. R. A. Scott (Cementation Ltd.) gave a paper on "Rheological aspects of grouts and grouting." He pointed out that while the chemical grouts based on synthetic polymer systems behaved as true solutions, the cement and clay grouts were non-Newtonian in character. Although the yield value of a cement grout may be very low because W/C ratios as high as 10 and 20 were used, it nevertheless was a most important factor when the grouting of materials with a fine pore structure was considered. A detailed consideration of the rheological properties of grouts in relation to their use was given. If the viscosity of a grout is greater than that of the water it is replacing in a porous medium it is possible to obtain a smooth and stable advancing surface and an actual example was shown to illustrate this point.

Mr. M. H. Yates (Fullers Earth Union Ltd) made a short contribution in which he gave results of rheological measurements on cement grouts modified by the addition of bentonite; he had used both a rotation viscometer and a cone penetrometer.

This was a useful conference but perhaps the main impression to be gained from it is that although interesting work is being done, the number of research workers in the field is far too small. Concrete, bitumen and grouts are the basic materials of major industries and their rheological behaviour is of very great practical importance. One hopes that work will be stimulated and that this conference is the forerunner of many on this topic.

It is hoped that some or all of the papers presented at this conference will be published but arrangements have not yet been completed. An announcement will be made in the Bulletin.

POLYMER PHYSICS CONFERENCE

A meeting on "Orientation in Solid Polymers" was held at Bristol on 10th-11th April 1967 under the auspices of the British Polymer Physics Group. Well over a hundred delegates including several from overseas, heard 21 papers delivered within an overall time span of 23 hours; despite the mental indigestion engendered by such a rich and varied menu it became obvious that the structural intricacies of

solid polymers are becoming less confusing, and that in certain cases mechanical properties can be related to general features of the structure.

A few years ago the picture of polymer physics was one of islands of knowledge surrounded by a stormy sea of confusion. Now even though the seas may not always be tranquil most of the islands appear to be capable of communicating with one another. Most textbooks of polymer science still consider at length the mechanical properties of only amorphous materials, but, as the meeting emphasised, one can now begin to deal quantitatively not merely with partially crystalline polymers, but even with those showing an overall preferred orientation.

The session devoted to structural studies began with complementary papers by A. Pennings (Netherlands) and A. Keller, M. J. Machin and F. Willmouth (Bristol University) discussing the elongated fibrillar bodies resulting when polyethylene is crystallised under stress. These units, which appear in the form of platelets threaded on a central axis several hundred Å in mean diameter, were called "shish-kebabs" by Dr. Keller. Nitric acid treatment removed the outer platelets and attacked the original core, to show that it too consisted of platelets threaded on a smaller core, which might be no more than 50Å diameter. (Unfortunately this structure was called a "micro-shis-kebab"!) There was evidence that the central axis showed an extended chain configuration, and possible means by which such structures were formed were discussed. It was a pity that no mention was made of the apparently similar intercrystalline links discovered by Keith and his co-workers at Bell Laboratories, U.S.A.

Two papers from Queen Mary College, London, discussed the changes in structure observed when rubber and polyethylene were stretched. The experiments, which were carried out over a wide temperature range, formed an extension of the work published previously by Andrews et al. When natural rubber is stretched below -120°C . hydrogen is evolved; further work is necessary to discover the nature of the chemical reaction involved.

Other particularly interesting papers in the "structure" session were those by Hay and Keller (Bristol University) and Bassett (Reading University). The former described evidence for the hko twinning processes originally proposed by Peterlin in polyethylene, and demonstrated how the Frank, Keller and O'Connor twinning mechanism could account for the transverse orientation sometimes observed in drawn materials. Dr. Bassett discussed the interpretation of moiré patterns observed under the electron microscope, due to slight differences in orientation between successive layers in a polymer single crystal. Using this elegant method it was deduced that mixed

stacking sequences predominate both in poly-oxymethylene and polyethylene. There was no evidence for the folds in folded chain crystals being long and irregular.

Professor Takayanagi (Kyushu University) gave an interesting paper on the dynamic mechanical behaviour of oriented polymer sheets and single crystal mats, together with an explanation in terms of a simple model based on relaxation processes of crystalline and amorphous regions in various series—parallel arrangements.

The second session of the meeting heard evidence that one could now begin to interpret, and not merely describe, the mechanical properties of certain oriented semi-crystalline polymers. Examples were the convincing explanation by N. McCrum (Oxford University) of the high temperature relations of polyethylene in terms of a model of crystalline and amorphous structure; and the findings of Gupta, Stachurski and Ward (Bristol University) that the anomalous room temperature behaviour of the elastic compliances of oriented polyethylene diminished and finally disappeared as the temperature was lowered, suggesting the existence of non-affine deformation processes, possibly involving slip and twinning mechanisms.

Two reports on slip bands in oriented polymer films, by Rider and Hinton (Surrey University) and Brown and Ward (Bristol University), demonstrated the application of metallurgical knowledge to polymer physics, and also gave a warning that apparent similarities in appearance do not imply that similar mechanisms are responsible for deformations in metals and polymers. Possible explanations in molecular terms were given to account both for the rotation of the optic axis in the slip region and the deviation of the line of the slip band from the initial draw direction.

Although the remaining papers described less novel features they demonstrated that problems are being tackled consistently over a wide range of physical conditions using a variety of techniques.

One must, in conclusion, mention the entertaining exposition by A. May (Smith and Nephew) of the development of a non-woven fabric from sheet polyethylene. The original discovery was made accidentally, but an enormous amount of technological effort was needed to transform an *effect* into an *economic* material.

An overall impression is of polymer physics being a thriving, adult, science, in which the physicists, chemists and technologists have now been joined by metallurgists, with this combination extending the concepts of physical metallurgy to give a quantitative account of both polymer structure and behaviour. Because the materials are so complex many man-years of continued effort are required to unravel the dependence of performance on structure. The present evolutionary stage is thus one in which the individual researcher is being replaced by the large team working on problems of common interest.

Considering the complexity of polymer structure it was surprising that no speaker expressed regret at often having to use insufficiently characterised samples. It would be of enormous benefit if, as suggested at a recent Plastics Institute Symposium (Loughborough, March 1966) it were possible for all interested workers to obtain well-characterised standard samples of the polymers of general interest.

Whilst the opinions expressed in this review are entirely those of its author, the assistance of Dr. I. M. Ward is acknowledged in correcting factual errors and making helpful suggestions.

D. W. HADLEY.

(I have a copy of abstracts of papers presented at the above meeting which may be borrowed by any member interested. Ed.)

THE BULLETIN

The Editor will be pleased to receive articles of general rheological interest for publication in the Bulletin. Articles between 1,000 and 5,000 words in length and containing up to six diagrams will be considered for publication. Authors receive 20 free reprints and may obtain further copies at a nominal price.

Some time ago several members promised to think about writing review articles for the Bulletin. Would they please now consider putting their thoughts on to paper?

A recent development has been to report conferences of interest to rheologists, but not organised by B.S.R. Any further conference reports of this nature would be welcomed.

As a further service to members, advertisements for situations vacant or required will be inserted in the Bulletin free of charge. If members' establishments are advertising for additional staff please bring this service to the notice of those concerned. Members' sales, wants and requests for information can also be advertised in a similar manner. Notices should be received by the Editor before 20th February, May, August or November to ensure publication in the earliest Bulletin.

VICTORIAN BRANCH ACTIVITIES

Two meetings and a lecture course have been held during the first half of 1967. On 1st March Mr. D. H. Morton (Aust. Paper Manuf. Ltd.) spoke on the structure, composition and rheology of regenerated cellulose films. The effects of plasticisers and water on rheological

properties were discussed, and examples of choice of rheological properties to suit particular applications were given. A theory was described which explained relevant characteristics on the basis of hydrogen bonding and chemical equilibrium of plasticisers.

A panel and discussion on Terminology and Classification of Rheological Properties was held in conjunction with the Standards Association of Australia on 7th June. It is hoped to publish a report of the discussion in a future Bulletin.

Co-operation with the University of Melbourne Extension Committee resulted in a course of 10 lectures entitled "Measurement of Viscosity and Viscoelasticity." The lectures, which adopted a practical approach, included discussions on instrumentation and interpretation of results.

FRENCH RHEOLOGICAL TERMINOLOGY

As the result of comments made by members of this Society the Council of Groupe Français de Rhéologie have amended and clarified the following of rheological terms previously published.

11. *Distorsion* (Distortion). This term is used in two different senses:

- (a) The variation of the angle formed between two segments issuing from a common point, which were perpendicular before deformation. Called also "*glissement*" (see 13c).
- (b) Deformation without change of volume. [It is recommended that the term "*distorsion*" be reserved for the angular variation (a), and that the term "*déformation isochore*" be used for a deformation without change of volume.]

30. *Fluage*. In the case of solids: delayed deformation not recoverable at unloading. The delayed recovery is zero.

Note. The term "*fluage*" is often used in a wider sense to indicate the delayed deformation of a solid under the action of a constant force or stress (English equivalent: creep). However, when it is possible to separate the recoverable and non-recoverable parts of the delayed deformation it is recommended that the term "*fluage*" be reserved for the non-recoverable part.

34. *Durcissement* (Hardening). The elevation of the yield point following a previous mechanical action. In case of possible confusion with hardening arising from other causes one may speak of "*rhéodurcissement*" (work hardening).

NOTES AND NEWS

Provided that a minimum of 15 members are interested a reduced rate air trip could be arranged for the International Congress of Rheology, Tokyo, October 1968. The fare would be approximately £320 compared with a normal economy class return of £460. Already four members have expressed interest. Further enquiries to the Editor.

Dr. L. R. G. Treloar, a Past-President and member of the Society since 1940, has been appointed to a Chair of Polymer and Fibre Science at Manchester Institute of Science and Technology.

The Institution of Chemical Engineers has published in the form of a book entitled "The Storage and Recovery of Particulate Solids," the report of a working party under the chairmanship of Mr. P. L. Baldwin. Copies of the report (price £1 16s. 6d., including postage) may be obtained from the Institution at 16, Belgrave Square, London, S.W.1.

The Bundesanstalt für Materialprüfung (Federal Institute for Testing Materials), 1 Berlin 45 Dahlem, Unter den Eichen 87, Germany, has published a bibliography of Wear, Friction and Lubrication. The four volumes, which cost 100DM, contain more than 10,000 references to work published during the past 20 years.

A post-graduate school on "The Rheology of Disperse Systems" is to be held at the School of Pharmacy, University of London, 29/39, Brunswick Square, London, W.C.1, from 1st-5th April 1968. Each morning will be allocated for lectures and discussions, and each afternoon for practical work and tutorials.

Lecturers include: Professor J. D. Ferry (Wisconsin); Professor J. F. Raffle (Loughborough); Dr. R. Roscoe (Newcastle); Mr. P. Sherman (Unilever); Professor A. G. Ward (Leeds); Mr. R. W. Whorlow (Surrey). Subjects to be discussed are: theory and experiment in the rheology of disperse systems; linear and non-linear relationships; methods of measurement; theory of viscoelasticity; gels, suspensions, pastes and emulsions.

Further information, and application forms, from The Director, Department of Pharmaceutical Sciences, The Pharmaceutical Society of Great Britain, 17, Bloomsbury Square, London, W.C.1.

The British Polymer Physics Group will hold its Third Conference at Shrivenham, 12th–14th September 1967. There will be sessions on Morphology, Molecular Structure, Mechanical Properties and Solution Properties of Polymers. Details may be obtained from: Dr. I. M. Ward, H. H. Wills Physics Laboratory, Royal Fort, University of Bristol, Bristol 2.

The Institution of Chemical Engineers has set up a working party on High Temperature Chemical Reaction Engineering. The study, which is being confined to processes operated over the range from 600°C. to 2,000°C., has been broken down into the following sub-groups: reactor design; process metallurgy; containment; materials of construction; furnace design; basic thermodynamic and kinetic data; instrumentation and design. Enquiries should be addressed to: Mr. T. R. Jenkins, c/o Inst. of Chem. Engs., 16, Belgrave Square, London, S.W.1.

The Institute of Physics and the Physical Society is organising a conference on "Stress Analysis In Bio-engineering" to be held at University College, London, on 20th–22nd September 1967. The meeting will discuss whole or part body reactions to passive or dynamic force systems. Further details from: Meetings Office, 47, Belgrave Square, London, S.W.1.

The Institution of Chemical Engineers is to hold a joint meeting with the U.S. and Canadian Institutes in Montreal, 22nd–25th September 1968. Sessions of probable interest to rheologists include those on: fluidisation; granular materials; mixing; agglomeration processes; high strength whiskers, filaments, flakes and films. For further details, or suggestions of papers, contact the Institution at 16, Belgrave Square, London, S.W.1.

The name of Mr. R. W. Whorlow was omitted by accident from the list of those contributing to Rheology Abstracts published in an earlier Bulletin.

Several readers of Rheology Abstracts have reported that their libraries were unable to borrow copies of Cahiers du Groupe Français de Rhéologie using the normal inter-library loan services. This non-availability was a cause for regret, since the journal contains reports of much interesting and useful work not always reported elsewhere. The National Lending Library for Science and Technology has now been informed of the existence of "Cahiers," and in future there should be a copy available for loan in the normal manner.

ELECTION OF NEW COUNCILLORS

The Annual General Meeting will elect two members of Council to replace Dr. M. F. Culpin and Mr. C. C. Mill, both of whom are due to retire under Rule 5 (b) iii

The Council's nominations for the vacancies are Dr. K. M. Beazley, M.Sc., Ph.D., A.Inst.P., of English Clays Lovering Pochin and Co., St. Austell, and Dr. J. Harris, B.Sc., Ph.D., of Engineering Dept., Queen's University, Dundee.

Any further nominations should be sent, together with the names of proposer and seconder, and the written approval of the member proposed, to the Hon. Secretary before the Annual General Meeting.

A MATERIALS DATA SYSTEM FOR THERMOPLASTICS

In an attempt to collate in a uniform manner the available information on all commercial thermoplastics, Materials Data Ltd., of Farnham, have announced an information system for these materials. The materials themselves form the basis of the system, which will consist of about 2,000 data sheets of three types: (a) raw materials; (b) semi-finished forms; (c) continuation sheets, one for each manufacturer, giving properties of each grade of material produced. Because of lack of physical properties data based on common test methods, card selection is based primarily on processing, finishing and chemical properties. Queries and answers regarding the suitability of a material under particular conditions are printed on the relevant sheet, and hence the user need not refer back to another part of the system.

Obviously the lack of standard test methods means that the system is far from ideal, but for those who can afford the annual rental of £105 it will provide a much-needed service.

RHEOLOGICAL OPPORTUNITIES IN U.S. UNIVERSITIES

The University of Massachusetts has inaugurated an advanced degree programme in Polymer Science and Engineering. University and research fellowships are available, and students may enrol for M.S. and Ph.D. courses. Further information may be obtained from Professor R. S. Porter, Goessmann Laboratory, University of Massachusetts, Amherst, Massachusetts, 01002, U.S.A.

The Department of Agricultural Engineering, Pennsylvania State University, organises a graduate programme in the area of agricultural rheology, with emphasis on food rheology. There are vacancies for a post-doctoral research associateship and several graduate assistantships. For further details contact Professor N. N. Mohsenin, Department of Agricultural Engineering, Pennsylvania State University, University Park, Pennsylvania, 16802, U.S.A.

New Members

NAME AND ADDRESS	INTERESTS
J. A. Brydson, F.P.I., A.I.R.I., A.N.C.R.T., 22 Manor Drive, Southgate, London, N.14. National College of Rubber Tech., Holloway, London, N.7.	General (th. and expt.), rubbers, polymers, emulsions, suspensions.
G. E. Gadd, M.A., Ph.D., 42 Pagoda Ave., Richmond, Surrey. Ship Div., N.P.L., Faggs Road, Feltham, Middx.	Polymer solutions.
M. C. Phillips, B.A., Thornton Res. Centre, P.O. Box 1, Chester.	General (th. and expt.), rubbers, polymers, polymer solutions, glasses, ceramics.
G. A. Tabbernor, B.Sc., Paviors Road, Chasetown, Walsall, Staffs. Mander Bros., P.O. Box 9, Old Heath Road, Wolverhampton, Staffs.	General (th. and expt.), rubbers, polymers, emulsions, suspensions, paints, inks.
J. T. Bergen, B.S., M.S., Ch.E., 600 Wilson Drive, Lancaster, Penna., U.S.A. (17604). Res. and Dev. Center, Armstrong Cork Co., Lancaster.	General (expt.), rubbers, polymers, polymer solutions, glasses, ceramics, building and road materials.
C. E. Chaffey, Ph.D., Pulp and Paper Res. Inst. of Canada, 3420 University Street, Montreal 2, P.Q., Canada.	Rubbers, polymers, polymer solutions.
T. Gillespie, B.Sc., M.Sc., Ph.D., D.Sc., 906 East Park Drive, Midland, Michigan, U.S.A. Phys. Res. Lab., Dow Chemical Co., Midland.	General, rubbers, polymers, emulsions, suspensions, etc., biorheology.
J. M. de Man, Chem.Eng., Ph.D., 11610-75 Avenue, Edmonton, Alta., Canada. Dept. of Food Sci., Univ. of Alberta, Edmonton.	Emulsions, suspensions, food, biorheology.
C. Meier, Chem.Eng., Weinbergstr. 97, 8006 Zurich, Switzerland. Contraves AG., Schaffhauserstr. 580, 8052 Zurich.	General (expt.), rubbers, polymers, emulsions, suspensions, etc., building and road materials, biorheology.
D. V. Boger, B.S., M.S., Ph.D., Dept. of Chem. Eng., Monash Univ., Claxton, Victoria, Australia.	Viscoelasticity, rheogoniometry.
J. L. Dick, 108 Clarendon Street, Ballarat, Victoria, Australia.	Printing inks.
P. M. C. Goss, B.Mech.E., 57 Aberfeldie Street, Moonee Ponds, Victoria, Australia.	Suspensions, emulsions, confectionery.

Passfield Research Laboratories require a Physicist. A Graduate with at least 2nd Class Honours degree, preferably with some experience in rheology, is required for basic and applied research mainly into polymer melts, but also adhesives, surface coatings and printing inks. Successful candidate encouraged to take higher degree.

Excellent working conditions in ideal setting in Hampshire. Contributory Pension Scheme. Housing assistance provided. Applicants are invited to write, giving curriculum vitae, in full confidence to:— The Administrator, Metal Containers Limited, Passfield Research Laboratories, Passfield, Liphook, Hampshire.

THE BRITISH SOCIETY OF RHEOLOGY

Annual Conference 1967

**NON-NEWTONIAN
FLOW THROUGH
PIPES AND PASSAGES**

R.M.C.S. SHRIVENHAM

19-21 SEPTEMBER

Conference Secretary : Dr. M. F. Culpin,
8, Broadway,
Pontypool,
Monmouthshire.