

BULLETIN



**BRITISH SOCIETY
OF RHEOLOGY**

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CONTENTS

Page

The Early History of Rheology G. W. Scott Blair.	...	...	...	1
Reports on Bradford Conferences, April 1968. J. Harris and W. L. Wilkinson ; D. W. Hadley.	...	...	...	5
Mismanagement. P. Lamb.	...	...	...	10
Reclassification of Interests of Members.	...	...	...	12
Rules of Gold Medal Competition 1969	...	...	...	13
Letter (in verse) to the Editor. Z. Rigbi.	...	...	...	15
Victorian Branch Affairs.	...	...	...	15
A Rheologist's Bookshelf.	...	...	...	16
Announcements ; Notes and News.	...	...	...	18
E(n)ditorial	...	...	...	19
New Members	...	...	...	22

THE EARLY HISTORY OF RHEOLOGY

G. W. SCOTT BLAIR

I have been asked by the Editor to write a short article on this subject, although I have little to add to what is written in my book "A Survey of General and Applied Rheology". But the second edition of this book has long been out of print and it is felt that a recapitulation might be of interest to some members.

I will take "rheology" to mean the study of the deformation of matter, including flow, with the usual reservations that we are concerned only with studies related to the behaviour and/or constitution of the "matter" (i.e. not including such subjects as pure hydro or aerodynamics or classical theory of elasticity). We normally also limit the term "matter" to atoms and molecules and are not concerned with electrons, but this does not affect the early history, since no one thought of particles smaller than atoms, whose very name means "unbreakable".

The steady flow of water was appreciated from the earliest times (for example, the Sumerians took as their unit of weight the amount of water that flowed out of a standard vessel in unit time); and water-clocks are very ancient. The first trace, however, that I can find of an appreciation of changes in what we now call the viscosity of water would seem to be an invention made by Amenemhet, "Knight and Keeper of the King's Seal", who served several Pharaohs about the middle of the 16th Century B.C. (The story is told in a paper by Höppler¹.) The "clock" was of a pattern already well known to the Egyptians and consisted of a conical vessel with a hole in the bottom. As the water flowed out during the course of the night, the diminishing head was compensated for by the reduced cross-sectional area and this was so arranged that the depth of water was diminished linearly with time. Fig. 1, taken, with permission, from Höppler's paper, shows the analogy with the modern Engler viscometer. What is interesting is that the angle of the cone, which was reconstructed from its broken pieces found in Amenemhet's tomb, would not have given the required linear relation if the viscosity of water were constant; and further, assuming no great change over the centuries in the wide variation in temperature during the Egyptian night, Höppler found that the variation of viscosity with temperature corresponded well with Amenemhet's "correction" in the angle! No doubt this experiment in primitive rheology was empirical; but it presumably worked, or Amenemhet would not have kept his job, or even perhaps his head, for so long. The Greek philosophers discussed many abstract problems connected with rheology but we know of no experiments. Had he not confused viscosity with density, Aristotle would have come near to a primitive derivation of Stokes' Law for the fall of a sphere through a liquid. He wrote: "A body will move through a given medium in a given time and through the same distance in a thinner medium in a shorter time in proportion to the thickness of the hindering media. Consider water and air: it will

move through air faster than through water by just as much as air is thinner and less corporeal than water". But he did not appreciate that what he means by "thinner" is the combined effect of a greater difference in the densities of the falling body and the liquid and the lower viscosity of the latter.

In my opinion, the use of Heraclitus' dictum "panta rhei" as a motto for rheologists is really a kind of pun. He did not mean that everything flows if you wait long enough, an idea which is much nearer, as Reiner² has pointed out, to the Prophetess Deborah's remark that "the mountains flow before the Lord". Heraclitus seems to have meant simply that everything is in a state of flux (*cf.* Brownian movement), in contrast to Parmenides who taught that all motion was an illusion. Parmenides was an atomist and believed that the whole space must be filled with atoms: there could be no empty spaces between them, because empty space would contain nothing and "no thing" is impossible. He foresaw the problem of dilatancy in rightly concluding that, unless there are empty spaces, atoms cannot move or change places. He likewise denied the possibility of "opposite properties": thus, if there is a property "hardness", there cannot also be "softness", because "soft" implies "not hard" and not-things are not things. All this was somewhat crippling to any possibility of serious rheological thinking.

The Indians were much more flexible than the Greeks and they developed not only an atomic theory but a very much clearer idea of molecules (as we should call them) than did the latter. Little is known about what contacts there may have been, if any, between Greek and Indian philosophers.

The Indians believed that all matter was built up from five characteristic materials (or properties): earth-substances (heavy, rough, hard, opaque, etc.); Ap-substances (liquid, cold, slippery, etc.); Tejas-substances (hot, dry, clear, rarified, luminous, etc.); Vāya-substances (light, cold, transparent, rarified, etc.); and Akasa*-substances (light, rarified, elastic and capable of transmitting sounds). They believed that the physical properties of all materials depended on the proportions of these components within them. Later writers associated Ap-substances to what is translated as "viscid" but the term is probably used in its original sense, to mean "sticky". The distinction between "viscous" and "sticky" comes much later in the history of rheology. Prasāstapāda (about 3rd Century A.D.) discussed the flow of liquids under gravity but pointed out that the nature of the flow depended on the different kinds of atoms. He and his contemporaries also discussed capillary rise in soils and in plants, and the elastic properties of bow-strings, tooth, bone, horn, etc.

The Indians also classified errors in observation as due to three causes: defect in a sense organ, defect observation caused by inade-

* I obtained this information from Seal's "Positive Science of Ancient Hindus" (Longman, London, 1915). In this book, this word is given as "Akāsara" but an Indian friend has told me that this is incorrect.

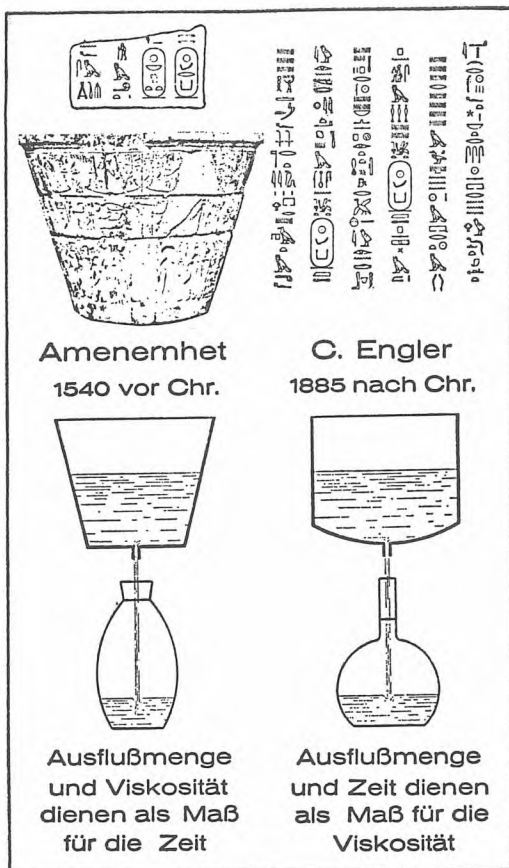


Fig. 1

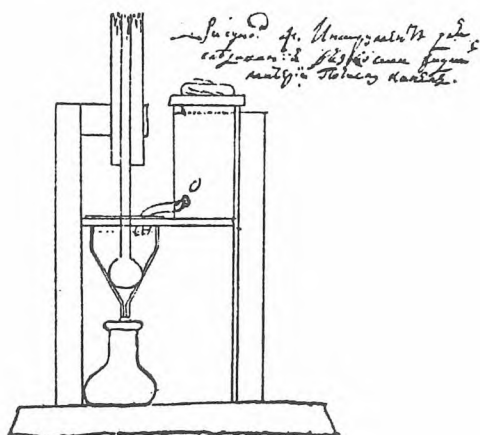


Fig. 2

quate presentation of the stimulus and the disturbing influence of mental predisposition. (For further information on earlier Indian physics, see my lecture.)³

The Romans added little to the speculations of the Greeks but Lucretius, certainly under Greek influence, wrote his famous poem "De rerum natura". Two quotations (from Rouse's translation) are of interest:

"For water moves and flows with so very small a moving power because it is made of small rolling shapes. But, on the other hand, the nature of honey has more cohesion, its fluid is more sluggish and its movement more tardy; for the whole mass of its matter coheres more closely assuredly because it is not made of bodies so smooth or so delicate and round".

"For whatever things fall through water and through fine air, these must speed their fall in accordance with their weights, because the body of water and the thin nature of air cannot delay each thing equally but yield sooner, overcome by the heavier".

Vergil appreciated that vines required soils having what we should call the right physical properties.

Following the fall of Rome, I can trace no rheology until the time of Leonardo da Vinci (1452–1519). The Arabs and the Jews, working together in complete harmony for many years, especially in Spain, kept culture alive, but I do not think that they were interested in rheology: likewise Christian Monasteries.

Leonardo studied hydrodynamics rather than rheology: the flow of water through orifices and channels and, in the middle of the 16th Century Bernard Palissy,⁴ though famous as a potter, was also much interested in agricultural soils and flour doughs. He appreciated the different properties of clays needed for different ceramic purposes and commented that "there are more kinds of clay and clay soils than man can name". He also criticised "the Latins" (presumably Vergil) for referring to soils as "fat". Soils are not "viscous", but paste-like since, on mixing with water, pastes (or doughs: the word is the same in French) behave much as do clays and soils. It would seem that the real distinction that he is making is between aqueous ("paste-like") and oily systems and that by "viscous", he means the latter.

It has been suggested that Francis Bacon, when a young man in Paris, may have attended and learned much from Palissy's lectures there; but the latter was so unpopular because of his unorthodox theological views that Bacon would not have mentioned this.

In 1638 Galileo discussed in his "Discourses Concerning Two New Sciences", the cohesion of ropes, the causes of fracture in solids and the stressing of beams. In the year of his death, Isaac Newton was born, and Hooke and Newton may be said to have opened the door to modern rheology. The "early history" is now over; but one more landmark may be of interest. Newton did not measure viscosity

of liquids. Probably the first viscometer was that used by the versatile Russian, Lomonosov.

Volarovich⁵ shows a picture, reproduced in Fig. 2, of this viscometer, somewhere between a capillary and an orifice instrument but singularly modern in appearance, as described by Lomonosov in 1751.

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5. Volarovich (M. P.) 1954 *Kolloidn. Zhur.* 16 227.

CONFERENCE ON EXPERIMENTAL RHEOLOGY

University of Bradford, 17th–19th April, 1968

A number of advances in the experimental techniques of rheology have been made during the past few years, and it seemed an appropriate time to stage another conference devoted to these aspects. Early in the organisation of the conference it was decided that the field of reference should not be drawn too narrowly, but that it should include such topics as data handling, including machine programmes, and also laboratory organisation and management; it was felt that these factors can contribute significantly to the success of an experimental programme.

In the event there were only two contributions on the topic of management. The application of rheology in industry is not entirely a technical problem, and the possibility was that we might have obtained a transformation of the usual discussion, with an exposure of some of the real problems hitherto obscured by the purely technical aspects. This did not occur. Some considered that the management of rheology is the same as the management of any other science, the implication being that this solved the problem. But more extensive arguments are required to demonstrate this, and no doubt some in the Society would be interested to learn something about the management of R. and D.

The organisation of the conference was itself of an experimental nature. Discussion at the conference sessions was scaled down considerably and informal evening discussions were introduced. This scheme enabled more time to be allocated to the reading of papers, and allowed a number of discussions to proceed simultaneously in the evening with a more efficient use of time. It also enabled those who might hesitate to hold forth in a full session to speak their mind in a more informal atmosphere.

Up to the present time the evolutionary process in the experiment appears exceptionally piecemeal. It is likely that in the future more regular meetings on experimental techniques will be held, with

associated exhibitions of instruments as at Bradford. The lowest common denominator would be that developments in instrument technology would be more apparent, improvements in technique could be discussed, and "gaps in knowledge" detected. In other terms the experimental philosophy could be refined and made more explicit.

Twenty-six papers and three research notes were presented, and are listed at the end of this article. There were nine exhibitors of instruments. The four session Chairmen were: Professor W. R. A. D. Moore (University of Bradford), Dr. L. Grunberg (N.E.L.), Professor A. R. Cusens (University of Dundee), and Professor K. Weissenberg (Royal Institution).

We were fortunate that Professor Weissenberg accepted the invitation to attend the conference as a guest, even though this entailed breaking a lecture tour on the Continent. A number of the participants were glad of the opportunity of consulting Professor Weissenberg on technical matters.

Full papers

1. "Management of applied rheological research", J. J. Benbow (I.C.I. Ltd., Agricultural Division).
2. "Management of rheological work in industry", P. Lamb (I.C.I. Ltd., Plastics Division).
3. "Rheological characterisation of minimum cost", M. S. Bancroft and J. M. Smith (University College, Swansea).
4. "A torsional creep apparatus and a torsional pendulum with accurate temperature control", C. W. v. d. Wal, C. J. Nederveen and G. A. Schweppert (T.N.O., Delft).
5. "End effects and particle migration effects in concentric cylinder rheometry", D. J. Highgate and R. W. Whorlow (University of Surrey).
6. "Bituminous materials testing equipment", P. J. Valayer (Esso Research, France) (read by K. Lammiman).
7. "Applications of correlation techniques", M. Rae (University of Dundee).
8. "An automatic laboratory viscometer", D. C. H. Cheng (Warren Spring Laboratory).
9. "An instrument for measuring jet thrust", J. A. Spence (University of Dundee).
10. "The jet thrust method of measuring normal stress", D. R. Oliver and W. C. MacSporran (University of Birmingham).
11. "The evolution of the Brabender Farinograph", H. G. Muller (University of Leeds).
12. "Calibration and use of the Epprecht Rheomat", G. P. Pearson, W. R. Moore (University of Bradford).
13. "Tensile deformations in molten polymers", F. N. Cogswell (I.C.I. Ltd., Plastics Division).

14. "An apparatus for measuring the viscoelastic properties of gels in the audio-frequency range", R. Roscoe (University of Newcastle).
15. "The measurement of frequency response characteristics applied to oscillatory testing in rheology", J. D. Watson (Solartron Electronics Ltd.).
16. "The oscillatory testing of pharmaceutical semi-solids using a transfer function analyser", B. Warburton and S. S. Davis (School of Pharmacy, London).
17. "A low frequency high-speed correlator", O. E. Ibrahim (University of Dundee).
18. "Conversion of dynamic into transient properties and vice versa", L. C. E. Struik and F. R. Schwarzl (T.N.O., Delft).
19. "An apparatus to measure the dynamic viscoelasticity of polymer welts", S. Raha and J. C. Weeks (I.C.I. Ltd., Plastics Division).
20. "Normal stress measurement", A. Kaye (University of Manchester).
21. "The measurement of melt stress relaxation in the Weissenberg rheogoniometer", J. Batchelor, J. D. Berry and F. Horsfall (Rubber and Plastics Research Assn.).
22. "A new viscometer for textile printing pastes", R. S. Higginbotham and J. K. Slack (Cotton, Silk and Man-Made Fibres Assn.).
23. "A small-scale capillary viscometer for polymer melts", N. J. Mills (I.C.I. Ltd., Petrochemical and Polymer Laboratory).
24. "The measurement of stiffness in human joints", R. Goddard, D. Dawson, M. D. Longfield and V. Wright (University of Leeds).
25. "The rheological behaviour of human joints", P. S. Walker, D. Dawson, M. D. Longfield and V. Wright (University of Leeds).
26. "The Instron rheometer", G. R. Murfitt (Instron Ltd.).

Research notes

1. "A laboratory viscometer-gelation timer", G. B. Hodgetts and D. E. Norman (C.I.B.A. (ARL) Ltd.).
2. "Solid propellant rheology", H. J. Buswell, J. F. Moloney and G. S. Pearson (Min. of Tech., Aylesbury, Bucks.).
3. "The classification and retrieval of rheological information", A. T. J. Hayward (N.E.L., East Kilbride).

J. HARRIS; W. L. WILKINSON
(University of Bradford).

SYMPOSIUM ON TURBULENCE SUPPRESSION

University of Bradford, 16th April, 1968

There has been a recent large upsurge of interest in the phenomenon described by Dr. B. A. Toms some twenty years ago, when it was noted that the addition of a high molecular weight polymer to a solvent could reduce the level of turbulence in flow through a tube, and this effect was reflected in the reduction of pressure drop per unit length at a given flow rate below that which was obtained in the pure solvent. The effect has now become known as the "Toms phenomenon".

About fifteen years after the initial discovery it was found in U.S.A. that the addition of certain grades of polyethylene oxide to water in trace quantities, some 20 p.p.m., would produce the same phenomenon.

The symposium, run by the University of Bradford in association with Union Carbide Chemicals Co., was intended to familiarise those who may be interested in the phenomenon with some of the experimental work, together with a description of the results obtained—and also expose some of the current thinking on the subject.

Five papers were presented:

1. "Physical properties of dilute solutions of drag-reducing additives", G. E. Gadd (N.P.L.).
2. "Practical applications of the Toms effect", B. Mansfield (Union Carbide (U.K.) Ltd.).
3. "Some laboratory tests on water jets", E. D. Henley (British Rail).
4. "Turbulent pipe flow of dilute polymer solutions", J. Cleaver (University of Liverpool).
5. "Studies of the flow characteristics of dilute polyox solutions", A White (Hendon Tech.).

During the symposium dinner the guest of honour, Dr. B. A. Toms, gave an address which effectively placed in perspective the work up to the present time.

J. HARRIS; W. L. WILKINSON
(University of Bradford).

Some Comments on the Bradford Conference

A combination of pressure of other work, modesty, and the impartiality expected of a Conference Secretary, has caused Dr. Harris's account of the Bradford Conference to be largely factual. A few biased comments might, therefore, be in order to assist fanning any latent flames of controversy. The meeting was obviously a success: there were well over a hundred participants, all of whom appreciated

the good organisation, and the high quality of the meals provided. For some members the meeting will be memorable for providing their first opportunity of viewing colour television (the programmes are not much better than those in black and white, but there is a much higher probability of something getting out of adjustment).

The relegation of most discussion until an evening session had some disadvantages; the opportunity that discussion sometimes provides for picking up unexpected information was lost if you considered yourself not enough of an expert to go along to an evening session; but more important, there was not enough time provided between papers to gather one's thoughts together. Consequently mental indigestion slowly set in, enabling only the most hardy participants to listen to all the papers. At this meeting titles were not always as adequate a guide to contents as they might have been, and so it was possible to miss an important paper during one's recovery period. (At least one delegate profited from the necessity to seek an hour's peace away from the lecture hall. He wandered along to Bradford market, and there picked up a remarkable book bargain.)

As at most conferences the standard of papers and their presentation was widely variable—and as usual the memory of the very poor contributions lingered as long as that of the very good. Perhaps it was because one or two papers showed almost complete ignorance of some of the basic problems of rheology that led one prominent member of the Society to request that some means be found of keeping such papers out in future. The errors in these contributions were, however, obvious neither from titles nor abstracts, and a requirement for the submission of full preprints would prevent the reporting of current work. Equally it is not possible to audition intending speakers for lecturing manner!

The complainant's strictures applied to only five papers altogether, giving a pass rate of about 80%—which must be considered satisfactory for a rapidly developing science. Unless the existing situation deteriorates one can, I think, continue to rely on the acuteness of the Conference Secretary and the reasonableness of the contributors. It is comforting to think that some, at least, of the offending speakers at the present meeting must have benefited greatly from the critical, but not angry, reception that they received.

One's major reaction to the meeting is an awareness of the rapid development of quantitative experimental techniques, with the rheogoniometer no longer being the only expensive and complicated equipment. (Much good work is still, however, performed with relatively simple and inexpensive apparatus.) We might not yet know all the answers; but we have enough equipment to help us to get many of them eventually.

It is really invidious for one who missed part of the Conference to mention any names—but I hope that contributors whose names do not appear will not think that their papers were thought unworthy.

For papers describing original techniques a particularly memorable contribution was that by F. N. Cogswell on tensile deformation in molten polymers. Not only was it a report of good work, which one can envisage developing for a considerable time, but it was also presented with enthusiasm. The papers describing developments in dynamic testing were also of great interest, and it was welcome to hear biorheologists again taking part in a non-specialised conference. It is perhaps in the biological field that rheology is showing the greatest rate of growth.

A paper need not of necessity be original to be worthwhile; the contribution on normal stress measurements by A. Kaye being a case in point. There was nothing new, and yet it was a useful contribution, since all the available, often conflicting, data were assembled and discussed, and the existing techniques were critically reviewed.

There is room for a little lighter relief at all conferences, and time was provided for two, completely different examples. Dr. Muller gave a fascinating lightning historical survey of the Brabender Farinograph, under its many aliases (could the *Bulletin* cope with the number of illustrations necessary to print this type of talk?); and Mr. Lamb ended his talk on management with some cautionary remarks which are reprinted in the following article.

The associated exhibition of commercial and other apparatus added to the usefulness of the meeting. This was a welcome innovation, deserving a repeat in a couple of years' time—when I hope that the exhibition will be larger and integrated more closely into the meeting.

Dr. Harris deserves congratulations for the single-handed organisation of such a complex meeting, which he developed from the original idea to the successful conclusion.

D. W. H.

MISMANAGEMENT

By P. LAMB (I.C.I. Ltd., Plastics Division)

At the Bradford Conference of the British Rheology Society in April I gave a paper on "The management of rheological work in industry". In an effort to stimulate by considering the problem from a fresh point of view, part of the talk was devoted to the principles of mismanagement, those principles that have carried some of our more skilled and less scrupulous mismanagers into high positions in universities, the civil service and industry. The main points made were as follows:

Handling subordinates

1. Be friendly, but remember that the purpose of the friendship is to further your career and not his. In management jargon this shows "a proper degree of ambition".

2. Ensure that they communicate only through you. This is known as “keeping firm control over your section”.

3. Identify the good ones early so that you can take a special interest in their work and get your own name onto it. If their work is really good, it may be worth criticising the prose style and copying out in your own handwriting before passing it upwards. You will be known as “a good judge of men”.

4. Encourage your staff to “stand on their own feet” by avoiding strong support for their plans. Also “keep them on their toes” by implying suppressed dissatisfaction and doubts for the success of their programme.

5. In recruiting check above all for loyalty and conformity, then for schools, games and a firm handshake. You should now be able to show “leadership”.

6. Do not criticise your staff. You must aim to transfer difficult subordinates and this is much easier if there is no criticism on record. Also you will be proved good at handling staff problems and your rivals will be proved bad.

Handling bosses

1. Play golf/squash/bridge well enough to lose an exciting match.

2. If your boss held your job before you, do not modify his procedures. In fact he may wish to go on doing your job, in order to feel useful and in order to keep you “in your place”.

3. Produce ambitious long-term plans, always having in reserve an explanation for their failure.

4. Suppress your sense of humour, unless at the expense of outsiders.

5. In discussing your subordinates make vague criticisms by saying they “need close supervision” or “lack leadership or personality”. If they turn out well, you take the credit, while if they turn out badly, you prove yourself a good judge of personality.

Avoiding black marks

1. Do not stay in one job too long. You cannot indefinitely avoid responsibility for your mistakes.

2. Always think twice before saying yes. A missed opportunity is soon forgotten, but a positive blunder is remembered. This applies particularly in spending capital, not so strongly when only your subordinates’ time is involved.

3. Avoid new equipment or techniques—you will not understand them as well as your subordinates.

4. When things go wrong, blame if possible an ex-employee, otherwise the unions, the government or the Board.

RECLASSIFICATION OF INTERESTS OF MEMBERS

In their survey of B.S.R. membership (B.S.R. Bulletin, 1967, No. 1) D. C.-H. Cheng and D. W. Hadley criticised the existing classification scheme: it contained (to use the N.E.L. terminology) a mixture of "Materials" and "phenomena", and many different interests could be subsumed under a single heading. There was no indication whether rheology was a full-time occupation or merely a fringe activity for a particular member, or whether that member's interests lay mainly in technology or in basic scientific principles.

The new classification, drawn up by a sub-committee consisting of Dr. Cheng, Dr. Hadley and Mr. R. W. Whorlow, has the aims of (i) assisting Council to plan a programme that will be of maximum benefit to members; (ii) enabling members to contact other rheologists having specific interests.

New features of the revised classification are the preliminary questions (1-4) indicating the extent to which rheology enters into a member's work, together with an extended list of interests (5) based essentially on materials. The object of this list is to give a more even and useful division of interests than in the existing classification—but to achieve completeness without too much complexity certain compromises have been rendered necessary.

Answers to questions (1), (2) and (3) will be printed in the membership list in lower-case letters before the list of major interests (5), which will be in capitals. Replies to (4) will probably not be used in the membership list, but will be kept for reference, and may assist in a future membership survey or in planning future programmes.

Typical entries would be:

Smith, A. B.	f, t, s, F, N.
Smythe, Y. Z.	p, e, a, B, I.
Sykes, W.	f, et, a, C, D.

BRITISH SOCIETY OF RHEOLOGY CLASSIFICATION OF RHEOLOGICAL ACTIVITIES

It would be helpful to the Society for organising its meetings and publications so that they are of maximum benefit to members if you would complete the questionnaire below. Your replies will be entered in the published Membership List.

Place ticks in appropriate boxes.

1. Is most of your work of rheological concern? (f); or ☐
Does rheology enter into your work only occasionally? (p) ☐
2. Are your rheological interests mainly ☐
 - (t) Theoretical ☐
or
 - (e) Experimental ☐
or
 - (et) Theory and experiment ☐

3. Are your rheological interests mainly ☐
 (s) Pure science ☐
 or ☐
 (a) Technology ☐
 or ☐
 (sa) Pure and applied science ☐
4. Do you have a secondary interest in branches of rheology which you have not indicated in the list of major interests below? Yes ☐
No ☐
5. Which materials in the list below are of major concern to you? ☐
- A Metals, alloys ☐
 - B Composites (e.g. fibre-reinforced resins) ☐
 - C Solid polymers ☐
 - D Molten or dissolved polymers ☐
 - E Natural fibrous materials (e.g. cotton, paper, wood, wool) ☐
 - F Liquid—liquid systems (e.g. emulsions) ☐
 - G Liquid—solid systems (e.g. suspensions, slurries) ☐
 - H Particulate solids (e.g. granules, powders, fluidised beds) ☐
 - I Glasses, ceramics ☐
 - J Oils, greases ☐
 - K Building and road materials ☐
 - L Foodstuffs ☐
 - M Biological materials (e.g. blood, tissue) ☐
 - N Theoretical materials ☐
 - O Other materials (*please specify*) ☐

THE BRITISH SOCIETY OF RHEOLOGY MEDAL FOR APPLIED RHEOLOGICAL RESEARCH— 1969 COMPETITION

The British Society of Rheology wishes to encourage workers, both in industry and in the universities, to make greater practical use of rheological science. To this end it is proposed to award a gold medal once every three years for the application of rheological science to the study of industrial problems.

The first medal was to have been awarded in 1967, but none of the applications then submitted was successful. The competition is now being reopened under revised rules. Applications should be sent to the Secretary of the Society's Research Committee at the address below, not later than 1st April, 1969. All those who have carried

out work of an appropriate character during the past few years are eligible to apply, whether members of the Society or not.

An important provision of the new rules is that anyone may nominate another person for consideration for the award. By this means it is hoped that those workers who would not apply on their own behalf will not be excluded from the competition.

Entrants are asked to make a brief submission showing how they have attempted to solve a problem of industrial importance, not by trial-and-error methods but by the logical application of rheological science. Since the judges will be concerned mainly with an entrant's approach to a problem, the work submitted need not necessarily be of great commercial value or of profound scientific content.

RULES

1. The medal will be awarded by the British Society of Rheology, acting on the recommendation of its Research Committee, to the entrant who is deemed to have made the best contribution to the solution of an industrial or technological problem by the application of rheological science.
2. Any persons, other than members of the Research Committee of the British Society of Rheology, shall be eligible to enter for the award if they have carried out research or development work of a rheological character within the United Kingdom. Work done in any other country may be held to qualify only if it is done on behalf of some section of British industry.
3. Entries should preferably be from individuals. Only in cases where an approximately equal part has been played by two or more workers will a joint entry be accepted.
4. Persons wishing to enter the competition should submit a concise account of their work (three copies) to the Secretary of the Research Committee. This should not exceed about 500 words, and should indicate:
 - (a) the industrial or technological problem,
 - (b) the rheological principles employed,
 - (c) the manner of applying those principles to the problem,
 - (d) the extent to which the problem has been solved by the work described.
5. The entry may be accompanied by supporting evidence (three copies) in the form of one or more publications or reports giving a more detailed account of the work. If any supporting evidence is published jointly by the entrant and one or more co-authors, it must be accompanied by a statement, signed by both the entrant and the co-authors, of the parts played by both parties.
6. Entries will be accepted on the understanding that the winning entry as described in Clause 4 will be published by the Society in one of its journals or elsewhere. If the supporting evidence has

not previously been published, and if the author so wishes, the Society may agree to publish this also.

7. The Research Committee will send particulars of the competition to all persons known to be doing work that might be suitable for consideration. Suggestions of suitable workers may be made by anyone, and should be received by the Secretary of the Research Committee before 31st December, 1968.
8. The Committee may recommend that no award be made if it considers that none of the entries is of sufficient merit.
9. The award will be announced at the Society's Annual General Meeting in September 1969, and entries must be submitted not later than 1st April, 1969.

DR. J. P. BERRY,

Acting Secretary to the Research Committee
Rubber & Plastic Research Association,
Shawbury,

Shrewsbury, Shropshire.

(It would be appreciated if members would bring this announcement to the notice of colleagues who are not members of the Society. —Editor.)

LETTER TO THE EDITOR

You Rheologists now try too late
To change your sorry fate.
Better keep to your flow,
And watch extrudates grow,
And leave poems to the Poet Laureate.

Z. RIGBI,

13 Adam Hachohen Street,
Haifa, Israel.

B.S.R. VICTORIAN BRANCH

The speakers at a branch meeting held at Melbourne University on 5th June, 1968, were Mr. C. H. C. Smith (Shell Chemical Co.) and Mr. J. Shaw (A.C.I. Laminex Industries).

Mr. Smith began his paper on "Some Techniques and Applications of Epoxy Resins" with a brief account of the nature, history and production of these materials. A simple presentation of the chemical background led to an appreciation of some applications in the fields of surface coating, casting, laminating and adhesives, and to an understanding of the mechanical properties of the cured resins.

Mr. Shaw then spoke on "The Molecular Structure and Physical Property of Epoxy Resins". Dynamic rigidity and damping factor

as functions of temperature were correlated with the molecular structure of a three-dimensional epoxy-amine network, thus permitting an understanding of both the mechanical properties and the influence on them of the molecular structure.

A joint meeting of the branch and the Victorian Group of the Institution of Chemical Engineers was held at Clunies Ross House, Parkville, on 30th July, 1968. Four papers were presented on "Mixing and Flow of Non-Newtonian Fluids", together with a display of rheological instruments. The speakers and topics were: "Extrusion of Polymers", Mr. B. Brown (Nylex); "Pipe Flow of Viscoelastic Fluids", Dr. D. Boger (Monash University); "Mixing of Non-Newtonian Fluids", Mr. K. Hall (C.S.I.R.O.); "Flow of Fibre Suspensions", Dr. H. Higgins (C.S.I.R.O.—D.F.P.).

A working committee of the branch submitted in 1967 a draft standard on rheological terminology for consideration by the Australian Standards Association, and the Association has now nominated a committee to study this draft.

In addition to an introduction, the draft contains sections dealing with Basic Definitions, Experimental Conditions, Material Properties and a Glossary of Rheological Terms. A particularly interesting feature of the draft is that the scheme of classification of material properties, based on the response to certain idealised tests, is indexed by a four-digit code number. The first digit, determined from stress relaxation at constant rate of shear, distinguishes between liquids and solids. The second digit denotes either zero rate, gradual or instantaneous relaxation. The third digit distinguishes whether the effects of strain history are permanent, temporary or zero. The final digit indicates whether the relation between stress and strain (or strain rate) is linear or follows a particular pattern of non-linearity.

A RHEOLOGIST'S BOOKSHELF

At least three books by members of the Society have been published in recent months. The first, using alphabetic order of author's surname, is R. S. Lenk's "Plastics Rheology", published by MacLaren and Sons, London. Mr. Lenk is known to many members for his contributions, both formal and in discussion, to the Society's conferences. His wide interests stem from his graduating both in chemistry and zoology, before subsequently becoming an applied rheologist and a teacher.

The present book is an expansion of lectures given to B.Sc. students at Borough Polytechnic, and is intended to help fill the enormous gap existing between specialised, often highly mathematical, monographs and textbooks of polymer chemistry. Of the five chapters devoted to the flow of liquids three are of general interest, with the remaining two, on melt fracture and extruder design, dealing specifically with plastics. The three chapters on solids treat small deformations, large deformations and dynamic testing, using the behaviour of plastics to illustrate more general principles.

I would query the attribution to Thales of Miletus of the tag "panta rhei". Dr. Scott Blair's attribution to Heraclitus, which seems based on firmer ground, from what is known of the lives of both philosophers, is culled from an editorial comment in *Journal of Rheology*, volume 1, no. 1. Chapter and verse for the original statement would be welcomed (in English, please; not classical Greek).

The dust jacket of "Plastics Rheology" consists mainly of the flow-line part of the B.S.R. emblem (used without acknowledgment); and very effective it looks too, in orange and white on a blue background.

P. Sherman, another very well-known member of the Society, is the Editor of "Emulsion Science", published by Academic Press.

Mr. Sherman, who is Manager of the Rheology Section, Unilever Research Laboratory, Welwyn, is so well known both as contributor to, and organiser of, conferences on rheology and food science as to need no further introduction. He has been invited to act as a Sessional Chairman at the International Congress in Kyoto, and will subsequently be making a lecture tour in Japan.

Whilst all members having a concern with emulsions will discover much of interest in the present volume, they will find the chapter on rheological properties of emulsions, written by Mr. Sherman, of particular value. The discussion includes experimental techniques, analysis of non-Newtonian data, factors influencing rheological properties, and ageing effects. Interpretation of data is on a molecular level, rather than by continuum mechanics or a purely phenomenological approach.

The third book again illustrates the wide interests of rheologists. It is "Rheology of the Circulation" by Professor R. L. Whitmore, published by Pergamon Press. Prior to his appointment at the University of Queensland, Australia, Professor Whitmore was a Reader in the Department of Mining Engineering, University of Nottingham, where his interests in the flow of suspensions through pipes extended to a study of the very much more complex problems of the circulation of the blood. His book gives a concise explanation of the required rheological concepts, together with the necessary circulation physiology. The rheological properties of blood and its constituents are fully described so far as they are known, as also are the geometrical and viscoelastic characteristics of the blood vessels. Special emphasis is given to the peculiarities of blood flow in narrow vessels, and areas in particular need of research are pinpointed.

The above notes are intended to be informative rather than critical, and it is hoped to review all three books in forthcoming issues of *Rheology Abstracts*. Any member whose book has recently been published, but is not mentioned above, should not feel that he has been neglected deliberately. The Editor sees only a limited sample of publishers' catalogues, and it would be a great help if he could be informed of any forthcoming books of rheological interest.

D. W. H.

ANNOUNCEMENTS; NOTES AND NEWS

A conference on Mechanical Properties and Design will be held at the University of Surrey, Guildford, Easter 1969. The meeting will be a joint venture of the Society and the Materials Science Club. Offers of contributions should be made to Mr. R. W. Whorlow, Department of Physics, University of Surrey, Battersea Park Road, London, S.W.11, or to Dr. J. P. Berry, Rubber and Plastics Research Association, Shawbury, Shrewsbury, Shropshire.

A meeting on Practical Rheology in Polymer Processing is being organised jointly by the Society and the Plastics Institute, and will be held in London, 17th–18th April, 1969. Prospective authors should contact Mr. R. W. Whorlow at the address above, if they have not already done so.

The Annual Conference of Groupe Française de Rhéologie will be held on 30th October, 1968, at l'Institut Textile de France, 35 Rue des Abondances, 92 Boulogne-sur-Seine, 1e. The subject is "Rheology in Relation to Structure" and the opening speaker will be Professor J. D. Ferry. Further details, including the full programme, can be obtained from M. B. Persoz, Groupe Français de Rhéologie, 68 Boulevard Saint-Michel, 75 Paris (6e).

A conference on Engineering Design Problems in Plastics will be held at Cranfield, 6th–8th January, 1969. Topics include: engineering properties; the effect of processing on properties; and engineering design methods. For further information contact Mr. J. N. Ratcliffe, The Plastics Institute, 11 Hobart Place, London, S.W.1.

An International Conference on Structure, Solid Mechanics and Engineering Design in Civil Engineering Materials will be held at Southampton University, 21st–25th April, 1969. The main topics will be internal structure and micromechanics of material systems; structure and mechanical properties; and engineering design. The Conference Secretary is M. Te'eni, Department of Civil Engineering, Southampton University, Southampton SO9.5NH.

An International Conference on Interfaces will take place in Melbourne, Australia, during August 1969. Discussion will be limited to interfaces between condensed phases, at least one of which is crystalline. Topics to be considered include structure; behaviour; migration; interfaces under stress; and effects on bulk properties. Further details from: Dr. P. M. Robinson, C.S.I.R.O., Division of Tribophysics, University of Melbourne, Parkville, Victoria 3052, Australia.

I.Chem.E. have appointed Mr. J. E. Porter of Newcastle University to an Industrial Research Fellowship with the objects of identifying the aspects of heat transfer with highly viscous liquids which give rise to difficulty in the design of heat-exchange equipment, and suggesting research items for the solution of problems which arise in industrial situations.

Members may find the Data Items, produced by I.Chem.E. on a non-profit basis, of assistance in their work. Data Items consist of a collation and critical evaluation of published and unpublished work, published in a form immediately usable by engineers.

Available, or forthcoming, Items include: Approximate viscosity of some common liquids; Forced convection heat transfer in circular tubes (three parts); and Dynamic viscosity of water substance. Prices range from 9s. to 27s. for each Item. Enquiries should be made to: Engineering Sciences Data Unit, 251-259 Regent Street, London, W.1 (Tel.: 01-437 4894).

A course of twelve lectures on "Industrial Applications of Rheology" is to be held at the University of Salford on 29th and 30th May, 1969. It is being arranged in collaboration with the Manchester and District Advisory Council for Further Education and will include speakers from various sections of industry. Further particulars may be obtained from Dr. K. D. Bogie, Department of Mechanical Engineering, University of Salford.

E(N)DITORIAL

My term as Editor began in an unorthodox manner, and shall terminate likewise, with a leading article at the end. The past four years have seen attempted development in the scope of the *Bulletin*, and a consequent stagnation in my academic career. Development was made possible only by the more than doubling of the Society's income due to revenue now received via *Rheology Abstracts*, and members should be grateful to those, particularly the then Hon. Treasurer and Editor (Abstracts), who negotiated the agreement.

Although increased income makes possible developments in all fields (witness the activities of the Research Committee), the ever-growing size of the Society brings many problems for its (honorary) Officers. Present income is insufficient to employ paid staff, and those holding office need to devote more and more time to running the Society's affairs. Staff could be employed only if there were a substantial increase in the annual subscription—a (never-considered) move which would probably reduce the membership to a level small enough to manage comfortably having only honorary officers!

The efforts involved in running B.S.R. might be lighter if more members took an active role, instead of merely receiving *Bulletin* and *Abstracts*, and occasionally attending conferences. Did you realise that the annual subscription scarcely covers the cost of producing and distributing B.S.R. *Bulletin*, and that all other benefits of membership depend entirely on the Hon. Editor (Abstracts) and his team of about thirty abstractors? More help with *Abstracts* is always welcome; either in covering new journals or in lightening the load on existing abstractors.

Occasionally (completely reasonable) enquiries are received, asking why certain articles have not been covered in *Abstracts*, when others of very similar content have been included. This state of affairs may sometimes arise because different people hold different opinions on how far the scope of rheology extends; an abstractor who is not a full-time rheologist may tend to interpret the bounds more liberally than one who is. Sometimes, however, relevant papers are missed unintentionally. If there are any papers which merit inclusion in *Abstracts*, but have for any reason been omitted, do not hesitate to inform the Hon. Editor (*Abstracts*)—preferably by enclosing an abstract in the standard form.

Abstracts is the main bringer of income to the Society; *Bulletin* is the greatest spender. Is the expenditure (of time in addition to money) worth while? Enquiries usually bring the answer “yes” or “sometimes”, but answers are received only from the active minority of members. I think the answer ought to be “not worth while” if only about a hundred members bother to read the *Bulletin*. Even supposing that not more than one hundred members take much notice of the *Bulletin* at present, would more be interested if the standard became more consistent?

There is no doubt that some of the articles in recent years have been really good. At times I wonder whether they might not be worthy of more permanent presentation in the form of a Rheological Miscellany. But it has not always been possible to persuade anybody to actually write an article; or a promised article has failed to materialise, with the result that in the final two days before press date there has emerged a frantic scribble of editorial padding.

Please help. If you think that what you are doing might be of interest to other rheologists, write a general interest article about it for the *Bulletin*. Another idea, stolen from *Materials Science Club Bulletin*, would be to print *short*, annotated, selected bibliographies of *important* papers in particular branches of rheology. Any member who has recently carried out such a literature survey is asked to send along his bibliography, preferably grouped under a few general headings. Publication of these lists of references could save other members a great deal of time and effort.

Although it is possible that my successor may feel differently, I consider that a spare-time Editor should be allowed to edit, and not have to act as roving reporter, foreign correspondent and gossip columnist in addition. Would you be prepared, for example, to keep an eye on publishers' announcements; or collect advance notices of forthcoming meetings of other institutions and organisations? Anybody willing to help out in any way should contact the current Hon. Editor (*Bulletin*).

Whoever, at a particular time, might be collecting advance notices of conferences and meetings would welcome receiving more of them. The emergence of a duplicated *Supplement* to the *Bulletin* means that three months' notice is no longer required. It takes only 4d.

and five minutes to post off a notice, and I can vouch that in the past such effort has been much appreciated by several members.

The grumbles and pleas are now at an end, and I would like to finish as Editor by thanking *all* who have assisted with the *Bulletin* since mid-1964; particularly contributors of articles or news items. One name must, however, be singled out. Without the aid of George Scott Blair as contributor, translator, error corrector, source of contacts, and Hon. Deputy Editor in all but name, the *Bulletin* would frequently have taken on a mean and slipshod appearance.

Final thanks must be shared between the secretarial staff at the J. J. Thomson Laboratory, for their essential spare-time assistance, and our printers, Messrs. Fletcher of Farnborough, who have accepted almost illegible hand-written copy and have submitted to the insertion of whole articles at the proof stage.

One last word to all readers. Have you considered becoming Hon. Editor (*Bulletin*) in 1972?

NEW MEMBERS

NAME AND ADDRESS	INTERESTS
J. C. Blenkinsop, F.R.I.C., "Sunnycroft", Wath, Ripon, Yorks. Pozament Cement Ltd., Bowcliffe Hall, Boston Spa, Yorks.	Building and road materials.
J. M. Broadbent, B.Sc., "Kimberley", 7 James Close, Llanon, Cards. Appl. Maths. Dept., University Col- lege, Penglais, Aberystwyth, Cards.	General (expt.), polymer solutions.
A. C. Burnett, B.Sc. Flat 3, 7 Park Street, York. Products Res. Dept., Rowntree & Co., Ltd., Cocoa Works, York.	General, emulsions, suspensions, con- fectionery.
B. S. Chawla, B.Pharm., Ph.D., 69 The Ridgeway, London, W.3. Glaxo Labs., Pharmacy Unit, Green- ford, Middx.	
R. W. Higman, 13 Lyndale, Broom Barns, Stevenage, Herts. Warren Spring Lab., Stevenage.	General (expt.), polymers, polymer solutions, emulsions, suspensions, confectionery, etc.
D. C. Joliffe, 1 Westlees, Reigate Road, Hookwood, Horley, Surrey. Sangamo Controls Ltd., North Ber- sted, Bognor Regis, Sussex.	
A. J. Jones, B.Sc., 44 Glanwern Avenue, Newport, Mon. Min. of Defence (Army), R.O.F., Glascoed, Usk, Mon.	General, metals, polymers, powders.
D. Mendel, M.B., B.S., M.R.C.P., 41 St. Austell Road, London, S.E.13. St. Thomas' Hospital, London, S.E.1.	General (expt.), biorheology.
F. Moore, M.Sc., 96 The Avenue, Harpfields, Stoke-on- Trent, Staffs. British Ceramic Res. Assn., Queen's Road, Penkhull, Stoke-on-Trent.	General, suspensions, glasses, cera- mics.
G. P. Pearson, B.Sc., M.Sc., A.R.I.C., F.S.D.C., "Marlowe", 18 Fairway, Tranmere Park, Guiseley, Nr. Leeds, Yorks. School of Polymer Sci., University of Bradford, Bradford 7, Yorks.	General, polymers, emulsions, suspen- sions, etc.
G. T. Peterson, B.Sc., 72 Hurlingham Road, Fulham, Lon- don, S.W.6. W. R. Grace Ltd., Elveden Road, Park Royal, London, N.W.10.	Emulsions, suspensions, pharmaceu- ticals.
J. C. Scott, B.Sc., Grad.Inst.P., 29 St. Paul's Avenue, London, N.W.2. Acoustics Group, Physics Dept., Imperial College, London, S.W.7.	General, polymers, tribology, bio- rheology.

NAME AND ADDRESS	INTERESTS
J. E. White, B.Sc., M.B., M.R.C.P., 33 Haverfield Gardens, Kew, Richmond, Surrey. St. Thomas' Hospital, London, S.E.1.	Biorheology.
W. L. Wilkinson (Prof.), M.A., Ph.D., A.M.I.Chem.E., 2 Beech Mount Close, Baildon, Shipley, Yorks. School of Chem. Eng., University of Bradford, Bradford 7, Yorks.	General polymers, polymer solutions, emulsions, suspensions, etc.
J. D. Willis, B.Sc., Ph.D., Apt. 8, 4 Selbourne Road, Worcester. I.M.I. Ltd., Summerfield Res. Station, Kidderminster, Worcs.	Rocket propellants.
R. Wills, B.Sc., 150 Clare Road, Maidenhead, Berks. T. de la Rue International Ltd., Lower Cookham Road, Maidenhead.	Polymer solutions, suspensions, printing inks.
W. E. Fisher, Chem.Dip. R.M.I.T., c/o ANZ Bank, P.O. Box 41, 3088, Australia. c/o Food Processing Res. Centre, U.N. Dev. Prog., Box 913, Khartoum, Sudan.	Food rheology.
N. J. Pritchard, M.A., D.Phil., Crabethstraat 23, Maasshuis, Netherlands. Unilever Res. Lab., Olivier van Noortlaan 120, Vlaardingen, Netherlands.	General, polymers, polymer solutions, emulsions, suspensions, biorheology, detergents.
J. L. White, B.Ch.E., M.Ch.E., Ph.D., Apt. D-4, 1161 Keowee Avenue, Knoxville, Tennessee, U.S.A. Dept. of Chemical and Metallurgical Engng., Univ. of Tennessee, Knoxville.	General, polymers, polymer solutions.
G. Zemp, Zurich 57, Friedheimstr. 26, Switzerland. Contraves A.G., 8052 Zurich.	General