

**THE
BRITISH SOCIETY
OF RHEOLOGY**

BULLETIN — No. 4, 1967

Hon. Secretary :

DR. B. S. NEUMANN,
Laporte Industries Ltd.,
Nutfield Road,
Redhill, Surrey.

Hon. Editor (Bulletin) :

DR. D. W. HADLEY,
J. J. Thomson Physical Laboratory,
Whiteknights,
Reading, Berks.



Dr. Scott Blair with the President



Dr. Scott Blair replies to the toast

CONFERENCE DINNER, SHRIVENHAM, SEPTEMBER 1967

COUNCIL 1967-68

President: PROFESSOR A. CHARLESBY, D.Sc., Ph.D., A.R.C.S., F.Inst.P., Physics Dept., Royal Military College of Science, Shrivenham, Swindon, Wilts.

Hon. Secretary: BARBARA S. NEUMANN, Ph.D., Laporte Industries Ltd., Nutfield Road, Redhill, Surrey.

Hon. Treasurer: R. J. COLE, B.Sc., C.Eng., F.R.I.C., A.M.I.Chem.E., Paint Research Station, Waldegrave Road, Teddington, Middx.

Hon. Membership Secretary: K. WALTERS, M.Sc., Ph.D., Dept. of Applied Mathematics, University College of Wales, Penglais, Aberystwyth.

Hon. Editor (Abstracts): B. WARBURTON, B.A., School of Pharmacy, University of London, Brunswick Square, London, W.C.1.

Hon. Editor (Bulletin): D. W. HADLEY, B.Sc., Ph.D., A.Inst.P., J. J. Thomson Physical Laboratory, University of Reading, Whiteknights, Reading, Berks.

Hon. Secretary (Research Committee): A. T. J. HAYWARD, M.Sc. (Eng.), A.M.I.Mech.E., F.Inst.Pet., Fluids Group, National Engineering Laboratory, East Kilbride, Glasgow.

Ordinary Members of Council:

K. M. BEAZLEY, B.Sc., M.Sc., Ph.D., F.Inst.P., English Clays, Lovering, Pochin and Co. Ltd., St. Austell, Cornwall.

A. GRAHAM, M.Sc., D.I.C., Dept. of Mechanical Engineering, Imperial College, London, S.W.7.

J. HARRIS, B.Sc., Ph.D., Postgraduate School of Studies in Chemical Engineering, University of Bradford, Bradford, 7.

G. H. TATTERSALL, M.Sc., Ph.D., F.Inst.P., Materials Laboratory, Dept. of Building Science, The University, Sheffield.

R. W. WHORLOW, B.Sc., A.R.C.S., A.Inst.P., Physics Dept., University of Surrey, Battersea Park Road, London, S.W.11.

CHANGES IN COUNCIL MEMBERSHIP

The Officers of the Society are unchanged from last year, but the Council has bidden farewell as Ordinary Members to Mike Culpin and Colin Mill. Both have given sterling service to the Society as Officers, Ordinary Members of Council, and as Conference Secretaries. The present, and future, Councils will no doubt call on occasions upon their stores of experience, but we wish them a less strenuous life on the Society's behalf during the next few years. Thank you for your services during the years when the Society has grown from a small Club to its present thriving condition.

New Members of Council are Dr. K. M. Beazley and Dr. J. Harris. Ken Beazley joined the Society in 1959. He was educated at University College, Hull, where he obtained B.Sc. and M.Sc. degrees; since 1957 he has been employed as a physicist with English Clays, Lovering, Pochin and Co. Ltd., St. Austell. In 1966 he was awarded a London external Ph.D. for rheological work carried out during his normal employment, and has recently become a Fellow of the Institute of Physics. All users of Rheology Abstracts must recognise the initials K.M.B., which appear in association with an exceptionally large number of journals. Dr. Beazley's reply to a request for additional personal information was as follows: "Components of domestic stress tensor: one wife; eight-year-old twin sons, non-identical (i.e. $T_{11} \neq T_{22}$). Occupations during own relaxation time: gardening (mainly concerned with feeding seedlings to slugs); practical child psychology; Methodist local preacher; languages." [To which the Editor might add: versifying; and learning to type.]

John Harris has been a member of the Society since 1958. He is endowed with the rarely found capacity for being both a theoretical and an experimental rheologist. In addition to his many published original papers Dr. Harris has, as participants at the Society's meetings will be aware, a strong interest in the teaching of rheology, and is at present involved in yet another aspect of the science by virtue of his post as Conference Secretary for the April 1968 meeting on Experimental Rheology. After graduating in Mechanical Engineering at University College, Swansea, Dr. Harris changed departments, and obtained a Ph.D. in Chemical Engineering for work on the flow of macromolecular solutions. Until recently he held a Lectureship in Mechanical Engineering at Queen's College, Dundee, but has now joined the staff of the Postgraduate School of Studies in Chemical Engineering, University of Bradford.

THE BRITISH SOCIETY OF RHEOLOGY

REPORT OF THE HONORARY SECRETARY, 1966-67

The year being reviewed was the first year of office of our new President, Professor A. Charlesby. A new Secretary and Treasurer were also installed and the Committee has been renamed the Council to conform with current usage in societies of similar status. Furthermore, the new Rules adopted at the last Annual General Meeting came into force. All this, however, did not interfere with the smooth running of the Society, and I am pleased to be able to report on a year of steady progress in all fields of activity.

I shall deal with the various points under the same headings as used by my predecessor in his report for 1965-66.

I. Finance

Our financial position has improved significantly and our Balance is better than it has been in previous years. The Treasurer will show in detail which are the factors contributing to this improvement. There is no doubt that the most important items on the income side are the sum received from the publishers of Rheology Abstracts, while the subscriptions of our members take only second place, with the income from our various conferences coming third. All these have increased during the current year. We had no heavy items of expenditure, with the exception of the payment of income tax debt for the previous two years, and this was the last payment on that account since during the year we succeeded in our aim of getting registration as a charity.

Last year we had some ideas of putting up the subscription fee, and this year again the Council discussed whether to put a suggestion to this effect before you. This may sound out of place when I have just stated that our financial position is quite good, as it is, but, in fact, we expect to spend more on the Bulletin and all our regular costs will also go up. There is a good case to be made out for trying to make the membership subscriptions pay for all the administrative expenses and the Bulletin, while using the extra income earned for us largely by our abstractors, conference organisers and contributors for such luxuries as prizes, special projects, etc. On the other hand, keeping the subscription low attracts a very substantial section of scientists whose main interest is not in rheology, but who are experts in rheology none the less. After considering all these points, the Council decided that the advantages of keeping the subscription at the present low level were overwhelming, so we are not going to ask you to vote for a rise in the fee this year.

II. Membership

There has been a good increase during the year and our membership now stands at approximately 500.

A very interesting survey of our members' interests and employment was made by Drs. Cheng and Hadley, based on the 1966 list of members, and I am sure that many of us have spent a long time browsing through the mass of information provided. I was particularly fascinated by the fact that almost exactly a quarter of our members are university professors, or departmental heads in a research institute or managers of industry. Cause and consequence relationship is, of course, not revealed.

III. Research Committee

The Secretary of the Research Committee is reporting separately on the year's activities and, in particular, on the outcome of the Gold

Medal competition. Although it was decided not to make the award, the response was not considered to be disappointing from the point of view of quality, and we feel that more publicity will bring in the type of work the Research Committee had in mind.

IV. Meetings Held

We had a good year of meetings, partly jointly with other societies and partly on our own.

- (a) Measurement of Rheological Parameters and their Applications to Some Common Foodstuffs.

Joint meeting with the S.C.I. Oils and Fats Group, London, 16th November, 1966 (evening). This was a short meeting with only two papers. Most of those attending were S.C.I. members.

- (b) Rheology and Texture of Foodstuffs.

Joint meeting with the S.C.I. Food Group, London, 5th and 6th January, 1967. This meeting was very well attended with about 190 registrations. Eighteen papers were presented.

- (c) Rheology of Building and Road Materials.

Sheffield, 4th and 5th April, 1967. Although this was considered to be a rather specialised subject, the interest shown by our members was quite good. About 50 people attended and 10 full-length papers were read.

- (d) Non-Newtonian Flow through Pipes and Passages.

Shrivenham, 19th–21st September, 1967. (See separate report.)

For the first time this year, we tried out a new system whereby time is allocated at each conference for unscheduled contributions or short papers on miscellaneous topics. We believe that this idea will catch on: there is undoubtedly always an interest in "news", whether it is on the central subject of the conference or not.

V. Meetings Projected

- (a) Haemorheology and Microcirculation.

Joint meeting with the British Microcirculation Society. One day meeting. London, 10th February.

- (b) Experimental Rheology.

Bradford, April 1968.

The autumn meeting 1968 will probably deal with Alternating Stresses. Proposals have been made to hold a joint meeting with the Plastics Institute in the spring of 1969.

VI. Publications

The Abstracts and the Bulletin have continued to appear. Two new abstractors were recruited and the number of journals covered increased by ten. The Bulletin contained reports of conferences other than those held by the Society, some short articles and news items. It is hoped that our members will in future undertake to write articles of general rheological interest for the Bulletin: the Editor would be pleased to receive some, between 1,000 and 5,000 words in length.

We had no other publications during the year, but the papers presented at the Loughborough Conference last year are due to come out shortly in a book form (published by Macmillian & Co.).

The papers given at the Foodstuffs Symposium will be issued as a S.C.I. Monograph, due to be ready this year.

We decided that, as a general rule, we shall continue submitting our conference papers to *Rheological Acta*, unless special arrangements are made to issue them as Monographs or books; but the latter method is not favoured in principle.

VII. Overseas Liaison

As in previous years, we have continued exchanging information with various foreign societies and we publicised their meetings in the Bulletin.

We have also been in contact with the organisers of the International Congress of Rheology to be held in Kyoto, Japan, in October 1968 and sent out their first circular to all our members. The fares are naturally high, in the order of £300 if group travel can be arranged, but we hope that a number of our members will be able to attend.

VIII. British National Committee on Materials

Our President represents the Society on this Committee.

B. S. NEUMANN
(Honorary Secretary)
Redhill.

September, 1967.

BRITISH SOCIETY OF RHEOLOGY RESEARCH COMMITTEE REPORT FOR PERIOD 1st JANUARY, 1966—30th JUNE, 1967

1. Introduction

To enable up-to-date reports to be presented at the Annual Conference of the Society in September each year, future Annual Reports will cover a period of 12 months ending on 30th June each year. Since the last Annual Report related to the calendar year 1965, it is necessary for this report to cover an 18-month period, from 1st January, 1966, to 30th June, 1967.

2. *Membership*

At the beginning of the period the composition of the Committee was as follows:

Dr. R. Roscoe (Chairman)
Mr. R. J. Cole
Dr. E. R. Howells
Dr. J. R. A. Pearson
Professor J. F. Raffle
Mr. A. T. J. Hayward (Secretary).

Dr. P. Feltham and Dr. R. L. Whitmore joined the Committee in March 1966, and Dr. J. P. Berry, Dr. M. F. Culpin and Mr. P. Lamb joined it in October 1966. Mr. Cole and Dr. Howells retired from the Committee in June 1966, and Dr. Roscoe in June 1967. Dr. Whitmore resigned in June 1967, because of his removal overseas.

After serving the Committee very ably for two years as its first Chairman, Dr. Roscoe relinquished this office at his own request in October 1966. He was succeeded by Professor Raffle.

The Committee met six times during the period, in March, June and October 1966, and in January, May and June 1967.

3. *Joint Working Party on Non-Newtonian Flow*

This Working Party is sponsored jointly by the Institution of Chemical Engineers and the Society. The Research Committee is represented on the Working Party by Dr. Pearson and Mr. Hayward. During the period the Working Party completed a new scheme of classification for rheological research on fluids, and arrangements are being made for it to be adopted provisionally in Rheology Abstracts.

4. *Classification of Research in Rheology of Solids*

In view of the success which has attended the efforts of the Joint Working Party to devise a scheme of classification for research on fluids, the Committee has started to draw up a parallel classification for solids. When this is finished the two classifications together should provide a complete information retrieval system for the whole field of rheology.

5. *Research Medal*

In September 1966 the Society's first gold medal competition was announced. Entries were invited for the award to be made in September 1967 for "the best contribution to the solution of an industrial problem by the application of fundamental rheological knowledge". Seven entries were received, but it was the unanimous opinion of the Committee that none was deserving of the award.

6. *Survey of Research in Progress* £

During 1966 the Committee co-operated with the National Engineering Laboratory in the preparation of a new survey of research in progress in Britain. Attempts were made to obtain complete coverage, with the result that almost twice as much information was gathered in the 1966 survey as in the 1964 survey. The results of the survey have again been published as a NEL Report, which is available on request from the National Engineering Laboratory.

7. *Members' Enquiry Service*

The services of the Research Committee are available to all members of the Society free of charge, in answering queries of a scientific or technical nature relating to any aspect of rheology. During the period the Committee considered problems submitted by five members.

8. *Review Articles*

The Committee has attempted to instigate the writing of review articles on rheological topics. During the period several members agreed to prepare articles of this type.

9. *Other Topics Discussed*

The Committee has also considered the possibility of pinpointing important gaps in the knowledge, methods of encouraging rheological research in the medical field, the need for a central store of rheological information, the use of computerised information retrieval systems, and methods of improving liaison with foreign rheological societies, but so far has been unable to make any positive recommendations relating to these topics.

A. T. J. HAYWARD

September 1967.

BRITISH SOCIETY OF RHEOLOGY
BALANCE SHEET as at 30th JUNE, 1967

	£	s.	d.	£	s.	d.
GENERAL FUND						
As at 1st July, 1966				1,014	17	9
Add: Refund of Conference Float ...				50	0	0
				1,064	17	9
Add: Excess of Income over expenditure for the year to date ...				175	19	5
				£1,240	17	2
<i>Represented by:</i>						
ASSETS						
P.O. Savings Bank Account	—	—	—			
Cash at Lloyds Bank Ltd.						
Deposit Account ... £1,529 8 4						
Current Account ... 156 11 3						
				1,685	19	7
Cash in hand				10	0	0
				1,695	19	7
 Less CURRENT LIABILITIES						
Taxation—Income Tax and Corporation Tax to 30th June, 1966 ...				366	2	9
Sundry Creditors				88	19	8
				455	2	5
 NET ASSETS						
				£1,240	17	2

(Signed) R. J. COLE, *Hon. Treasurer*

We have examined the above Balance Sheet and annexed Revenue Account together with the books and vouchers of the Society and certify them to be in accordance therewith. We have not inspected the membership records.

The Market Hall,
Redhill, Surrey.
31st August, 1967.

ALFRED SIMMONS & Co.
Chartered Accountants

REVENUE ACCOUNT for the year ended 30th JUNE, 1967

INCOME

	£	s.	d.	£	s.	d.
<i>Annual Subscriptions</i>				456	14	8
<i>Entrance Fees</i>				34	11	4
<i>Rheology Abstracts and Bulletins</i>						
Publisher (Abstracts)	845	4	5			
Bulletin Subscriptions	2	0	0			
	847	4	5			
Less Production and Distribution Cost ...	380	13	4			
				466	11	1
<i>Conferences</i> —net income per schedule ...				147	11	11
<i>Investment Income</i>						
Bank Deposit Interest	47	14	6			
P.O.S.B. Interest	6	16	1			
				54	10	7
				£1,159	19	7

EXPENDITURE

	£	s.	d.	£	s.	d.	£	s.	d.
<i>Administration</i>									
Clerical Services	103	10	4						
Printing and Stationery	16	10	0						
Postages	25	18	3						
				145	18	7			
<i>General Expenses</i>									
Travelling									
Officers and Council	91	13	0						
Research Committee	104	4	1						
	195	17	1						
Insurance	6	0	0						
Professional Services	50	0	0						
Sundries	3	4	0						
				255	1	1			
<i>Intermittent Items</i>									
Awards	127	10	3						
Publications	—	—	—						
				127	10	3			
<i>Taxation</i>				366	2	9			
<i>Capital Items</i>									
Emblem design and block	44	7	6						
Medal die	45	0	0						
				89	7	6			
							984	0	2
EXCESS OF INCOME OVER EXPENDITURE							£175	19	5

SUMMARY OF CONFERENCES

For the year ended 30th June, 1967

Net Income

			£	s.	d.	£	s.	d.
Colloid (Joint, London) ...	...	...	56	6	0			
Polymer (Loughborough) ...	...	...	86	18	1			
Building (Sheffield) ...	...	...	33	19	7			
						177	3	8

Net Expenditure

Miscellaneous (Maidenhead) ...	...	...	18	7	11			
Food (Joint, London) ...	...	...	3	13	10			
1967 Conference (Shrivenham) ...	...	...	7	10	0			
						29	11	9

Overall Net Income

£147 11 11

NOTES

- (1) The amount shown for the Society's share of the profits from Rheology Abstracts, i.e., £845 4s. 5d., actually received during the financial period covered by the accounts, represented approximately 18 months' accrual.
- (2) Taxation of £366 2s. 9d. shown was Income Tax and Corporation Tax owing from 1964-65 and later periods. The Society became a Registered Charity as from 14th September, 1966, and no further tax will be due for fiscal periods after that date.

RHEOLOGY ABSTRACTS IN 1967

A record number of more than 700 abstracts was published, in addition to book reviews and abstracts of papers presented at B.S.R. conferences. Several additional, both existing and new, journals are now being covered, and some new abstractors have been recruited. Several long-established abstractors have, however, decided to take a well-earned respite, and others have resigned due to change of employment. Since the Society depends on Rheology Abstracts for a major part of its income, as full as possible a coverage of all relevant literature is of the utmost importance. Abstractors for the following journals are required immediately, and anyone willing to cover one or more of these publications should contact Mr. B. Warburton, School of Pharmacy, University of London, Brunswick Square, London, W.C.1, as quickly as possible.

Chem. and Process Engng.

Japan Journ. Appl. Phys.

Journ. Colloid Sci.

Journ. Japan Phys. Soc.

Journ. Roy. Soc., Edin.

Kolloid Zeits.

Macro. Chem.

Macro. Phys.

Z. Phys. Chem., Frankfurt

Z. Phys. Chem., Leipzig.

Mr. Warburton would be pleased to hear of further journals which on occasions contain articles of rheological interest.

The Society is deeply indebted to the following who have served as Honorary Abstractors during the year. Mr. B. Warburton (Editor), Mr. E. R. Ballantyne, Dr. W. H. Banks, Dr. K. M. Beazley, Dr. D. C-H. Cheng, Dr. M. F. Culpin, Mr. C. B. Duckham, Mr. S. L. Finn, Mr. N. Gay, Dr. M. J. Groves, Dr. D. W. Hadley, Dr. J. A. Hersey, Dr. P. Howard, Miss E. P. Humphreys, Mr. J. F. Hutton, Mr. H. A. Johns, Dr. A. S. Lodge, Prof. J. Oldroyd, Dr. J. R. A. Pearson, Dr. R. N. F. Pinfold, Dr. R. S. Porter, Mr. D. R. Reid, Dr. R. Roscoe, Dr. G. W. Scott Blair, Mr. G. R. Southern, Dr. H. W. Thomas, Dr. K. Walters, Dr. R. E. Wetton, Mr. R. W. Whorlow, Mr. N. Wilson, and Dr. E. J. Mardles, who again compiled the Subject Index.

Twelve abstractors attended a meeting on 31st October held to discuss the proposed introduction of a classification scheme for liquids in Rheology Abstracts Volume 11. After deciding that the new scheme might mean harder work, but would certainly produce improved abstracts, the meeting adjourned to a lunch provided at the Belgravia Restaurant.

DR. & MRS. G. W. SCOTT BLAIR GUESTS AT SOCIETY'S DINNER

In 1966 Professor Markus Reiner, one of the founders of modern rheology, was the Society's guest. In 1967 the guest of honour at the Annual Dinner was Dr. George Scott Blair, one of the pioneer

British rheologists and a founder of our Society. Professor Charlesby, in introducing Dr. Scott Blair, paid tribute both to his work in advancing rheological science and for his efforts on behalf of the Society—of which he is a past-President, and in which he still plays an extremely active role.

In thanking the Society for honouring his wife and himself in this manner, Dr. Scott Blair remarked that although he was about to retire from his post as Head of the Physics Department at the National Institute for Research in Dairying, he still intended to lead an active rheological career. On hearing of his plans one felt that Dr. Scott Blair will now be working even harder than before. Early in 1968 he will be leaving Reading to move to a Thames-side cottage at Iffley, from which, amongst other business, he is to operate a rheological consultancy practice.

(Photographs taken at the Dinner are reproduced on the inside front cover.)

NON-NEWTONIAN FLOW THROUGH PIPES AND PASSAGES

British Society of Rheology Annual Conference

Royal Military College of Science, Shrivenham

19th-21st September, 1967

The main programme consisted of the following 20 papers:

1. J. J. Benbow and A. Ovenston, Some Effects of Die Geometry on the Extrusion of Clay-like Material.
2. M. Brocklebank and J. M. Smith, Laminar Velocity Profile Development in Straight Pipes of Circular Cross-Section.
3. P. C. Buechley, J. A. Derby and L. L. Melton, A Device to Measure Fictional Pressure Reduction of Fluid in Turbulent Pipe Flow.
4. D. C-H. Cheng, The Measurement of the Viscosity of Purely Viscous non-Newtonian Fluids under Isothermal and Steady Shearing Conditions.
5. D. C-H. Cheng, J. B. Davies, A. G. Dodson and R. J. French, The Flow of Various non-Newtonian Fluids in Pipelines containing Fittings and Flowmeters.
6. P.-L. Chow and E. Saibel, Decay of Homogeneous Turbulence for a Visco-elastic Fluid in the Final Period.
7. A. Evans, Blood Viscosity and Circulatory Diseases.
8. D. Fitzgerald, Drag Reduction in Central Heating.
9. J. Harris, The Correlation of non-Newtonian Turbulent Pipe-Flow Data.
10. W. M. Jones and J. L. Maddock, Flow of Visco-Elastic Fluids Through Tubes and Porous Beds.

11. R. S. Lenk, A Generalised Flow Theory.
12. H. J. M. A. Mieras, The Reliability of Capillary Rheometer in the Study of Elastic Effects in Polymer Melt Flow.
13. D. R. Oliver and W. C. MacSporran, Turbulent Suppression in Dilute Polymer and Solutions.
14. D. R. Oliver and A. Young Hoon, Two-Phase non-Newtonian Flow.
15. J. R. A. Pearson, On a Continuum Treatment for non-Homogeneous Fluids in Pipe and Channel Flow.
16. N. E. Shaw, The Control of Circulation in Bones.
17. J. Voadlo, Axial Flow of a Visco-Plastic Continuum in a Circular Tube.
18. K. Walters and H. A. Barnes, The Flow of Viscous and Elastico-Viscous Liquids through Straight and Curved Pipes.
19. A. White, Turbulence Suppression and Drag Reduction with Macromolecular Additives.
20. D. A. White, Axisymmetric Flow of non-Newtonian Fluids through Stratified Porous Media.

The Conference also featured a special session in which the following short papers reported interesting developments in the progress of current work :

1. F. L. D. Cloete, The Allocation of Energy Terms in the Flow of Fluid-Solids Mixtures through Pipes.
2. A. G. Fabula, Non-Steady Elongational Flow Experiments with Polymer Solutions.
3. A. T. J. Hayward and J. D. Isdale, The Rheological Properties of Polymolecular Liquid Films Adjacent to Solid Boundaries.
4. A. I. Miller and M. Streat, Density Measurement of Flowing Solids-Water Mixtures.
5. W. M. Price, Particle Interaction in Suspension Flows.

During this session, Dr. H. Giesekus showed a film of the flow of a polymer solution from capillary slits and tubes. An exhibition of equipment relevant to the subject of the Conference was supported by only one example, that of a new version of an orifice flow meter developed at Warren Spring Laboratory.

The topics discussed ranged very widely from pure rheology to the applied and engineering (including medico-engineering) aspects of the subject, both purely-viscous and elastico-viscous fluids being considered. The actual materials involved included polymer melts and solutions, soap solutions, clay suspensions, starch suspensions, fluid mixtures of solid-liquid suspensions and gas-liquid two-phase systems, as well as idealised fluid models. The types of flow passages

described, in addition to pipes, were fluid jets, curved pipes, pipe fittings, flow meters, extrusion dies, porous media, central heating systems, blood vessels and bones.

The Philosophy of Rheological Analysis

Pearson considered what might be called the philosophy of the analysis of the rheological behaviour of complex fluids. He discussed the relation between the three approaches of micro-rheology, continuum mechanics and phenomenological rheology that are usually used, and illustrated their application with examples taken from papers already presented at the Conference. He deplored the fact that experimentalists are generally expected to provide an explanation of their observations. When they do so, the explanation is often no more than a re-definition of the problem in terms of a different method of approach. Pearson advocated that experimentalists should concentrate on providing good and reliable experimental data, which he recognised as being difficult enough in its own right, and leave the explaining to theoreticians who by training are in a better position to do so. Pearson also considered the position of the concept of structure in fluids. He pointed out the existence of the theory of anisotropic fluid of Ericksen and the recently developed concept of polar fluids, but noted the difficulties involved in relating theory to experiment and traced its cause to "integration over past times". He suggested that one way of overcoming this is to use the present value of structure which could be determined experimentally. Pearson gave no specific examples, but it seems that the theory of thixotropic behaviour described by Cheng and Evans could be an instance of this approach.

In his generalised flow theory, Lenk mixed micro-rheology with phenomenological rheology. He described a universal flow curve that consists of different portions depicting respectively Newtonian, pseudoplastic, "second Newtonian", and dilatant (sic) behaviour, and interpreted these in terms of molecular processes involved. In practice, with specific materials, the relative importance of the different processes determined which pattern of the flow behaviour is prominent in its flow curve. It was claimed that the notions involved can be applied to flow defects in polymer melt extrusion and to sheet formation by the calendering process. The argument in this paper was qualitative, and although the universal flow curve made a tidy picture, it is not obvious whether the notions involved constitute any real advance in the understanding of rheological behaviour.

The Measurement of Rheological Properties

The problems of the interpretation of experimental data in viscosity measurement were discussed by Cheng, whose paper was a mixture of new results and an annotated bibliography of existing work. Fifteen different flow situations (including the well-known ones often used for viscometers) were examined to see whether the

shear stress—shear rate relation can be obtained directly from experimental quantities without the prior assumption of a fluid model, and how the experimental data can be treated to eliminate the effect of wall slippage, non-ideal flow at the end and edges of actual viscometers and flow instability at high velocities. Although the interpretation for viscosity is applicable to both purely-viscous and elastico-viscous fluids alike, the two classes of fluids are different in that the end and edge effects and flow instability depend very much on whether the fluid is elastic or not. In the paper only references related to purely-viscous fluids were specifically reviewed.

The use of a cone-and-plate viscometer, incorporating a guard ring to eliminate edge effects, for the measurement and comparison of the viscosity of blood from normal subjects and patients was described by Evans.

The problem of the direct measurement of yield stress in a viscoplastic fluid was discussed by Vocadlo. In particular he mentioned the problem of stress variations in a moving sphere method and wall slippage in coaxial cylinders. He also discussed the well known but often ignored curvature of the flow curve of visco-plastic fluids near zero shear rate and proposed a model, which will no doubt become known as the Vocadlo fluid, to deal with this feature and showed how the parameters involved can be obtained from capillary and rotational cylinder viscometers. The model was found to be valid for suspensions of thoria, clay and kaolin.

The measurement of the elastic and normal stress properties was discussed by several authors. Mieras examined the use of the end effect in capillary rheometers but concluded that viscous and elastic effects cannot be conclusively distinguished. He was successful, however, in the calculation of the normal stress from die-swell data using a simple molecular model, the results agreeing well with that obtained on the Rheogoniometer. The jet thrust method and the apparatus developed at the University of Birmingham were again described in the paper by Oliver and MacSporran. In a short paper, Fabula described two new methods, based on the elongational flow at the suspended syphon and orifice flow, for the measurement of elastic properties, and indicated the complex calculations required for the interpretation of experimental results.

All these methods were aimed at the determination of the basic property of a fluid, but in general it is seen that the interpretation of data is not always above reproach. In marked contrast, the Friction Reduction Meter, described by Buechley, Derby and Melton, is very much a practical fluid tester. It is simple in construction and in use, but is capable, without complicated data treatment, of providing a rapid assessment of the drag reduction properties of fluids under field and industrial conditions and of the prediction of pressure drop in equipment.

In another short paper, Hayward and Isdale described their investigation into the use of the ball and ring apparatus for the determination of lubricant properties at solid boundaries. They demonstrated very convincingly that effects that were previously attributed to the formation of polymolecular films at solid boundaries could well be due to the presence of dirt particles in the liquid used, thus illustrating that in drawing any conclusion from an experiment, one must necessarily make certain assumptions. If the assumptions are made consciously, they can at least be tested to see whether they are valid. But, assumptions are often implied and remain unnoticed; these can lead to erroneous conclusions. Significant advances of any well-developed field of knowledge can only be achieved through the recognition of such hidden assumptions.

Non-Newtonian Flow in Pipes

Different aspects of the flow in pipes (which as everyone knows, unless further qualified, are straight, long, cylindrical tubes of circular cross-section and smooth walls) were discussed at the Conference. Vocadlo presented the solution of the axial flow of a new fluid model. Brocklebank and Smith, using an optical tracer technique, studied the development of a laminar velocity profile from a flat velocity profile for non-Newtonian fluids of various degrees of pseudoplasticity and elasticity. Walters and Barnes studied the flow of viscous and elastico-viscous fluids through straight as well as curved pipes. They used the simple but ingenious method of curving plastic tubing round wooden shapes of varying curvatures to obtain different radius-to-pipe-diameter ratios.

Cheng, Davis, Dodson and French presented energy loss data for the flow of various clay and starch suspensions in straight pipes as well as through pipe-fittings and flowmeters. Their aim was to generalise from the pilot-scale experiments so that industrial pipeline systems can be designed through a knowledge of the rheological properties of the fluid to be handled. Harris reviewed the different correlations of non-Newtonian turbulent pipe flow data. These can be divided into two groups: in one the turbulent flow data are correlated using the laminar flow or other viscometric data (such as those due to Dodge and Metzner, and Thomas); while in the other the turbulent flow data of different pipe diameters are correlated among themselves (for example, Bowen) and the results can be used for scale-up. Harris questioned the validity of the former correlations from dynamic similarity considerations and concluded that the correlation due to Bowen is to be preferred. He therefore advocated that pipeline design should be based on pilot-scale experiments and not viscometric measurements. There are of course a number of establishments at which pilot-scale tests may be carried out, but as the industrial engineer knows, there are a number of reasons why viscometric tests are in fact more suitable than pilot-scale tests.

Two-phase gas-liquid flow in pipes was extended by Oliver and Young Hoon to the cases in which the liquids were non-Newtonian, both elastic and not. In particular, plug flow and annular flow regimes were studied. The differences in the pressure drop, hold-up and heat transfer characteristics between Newtonian and non-Newtonian fluids were reported.

The flow of solid-liquid systems was discussed in several short paper. Price described particle migration and interaction in Poiseuille flow and illustrated, with the aid of a cine-film, the existence of the Segre-Silberberg peak, the Yearn wall peak in which particle chains are formed and the particle free layer at the tube wall. Cloete considered the effect of differential velocities between particles and liquid in turbulent flow on the particle concentration and pressure drop. An additional term relating to the frictional drag between liquid and particles appears in the equation relating pressure drop to the hydrostatic head in the tube. This means that the latter two quantities cannot be legitimately equated for the determination of the density of the suspension. A gamma-ray adsorption method for the measurement of density was described by Miller and Streat, who showed how the design of a suitable system can be carried out.

Destabilisation and Drag Reduction Phenomena

Another aspect of pipe flow is the flow of dilute polymeric solutions which give rise to the phenomena of destabilisation and drag reduction. At present these are considered to be anomalous behaviour and are treated as curiosities, but in the course of time they will no doubt be recognised as behaviour typical of elastico-viscous fluids. Seyer and Metzner pointed out, in their recent publication, that drag reduction phenomena can be related to the elastic property, for example in the form of the dimensionless Deborah number. However, it seems that with the present techniques available for the measurement of elastic properties, drag reduction phenomena could be by far the most sensitive method for very dilute solutions. At the Conference there was great interest in these phenomena. In addition to pipe flow, the stabilisation and drag reduction in rough pipes and submerged jets (A. White), in curved pipes (Walters and Barnes) and in porous beds (Jones and Maddock) were described. Most of the papers were concerned with attempts at explaining the phenomena. Chow and Saibel considered the decay of homogenous isotropic turbulence in an infinite domain of an Oldroyd type fluid and showed the importance of elasticity. Walters and Barnes considered the stability of Poiseuille flow and showed that both normal stress (second order) and non-Newtonian viscosity (third order) effects lead to destabilisation. Jones and Maddock interpreted the phenomena in terms of relaxation lengths and the molecular energies involved. Oliver and MacSporran showed that destabilisation is related to the ratio of fluid inertia to elasticity in addition to Reynolds number.

A. White showed that drag reduction phenomenon has its source in both the sub-layer and the bulk effects of the pipe flow.

The practical exploitation of the drag reduction phenomenon in central heating systems was considered by Fitzgerald. He considered the benefits of the application and described experiments designed to determine relevant design data. Cheng et al, also initiated work to obtain energy loss data for pipe-fittings. However, the whole project was overshadowed by the rapid degradation of the polymeric additives and subsequent loss of drag reduction achieved. During the discussion other materials such as fibrous particles, nylon rods, and even coal particles were named as likely replacements.

Blood Circulation in Man and Animals

The Conference was allowed a glimpse into the medical world, in which bio-rheology is finding increasing and important applications, by two papers on blood circulation. Evans was able to relate the changes in blood viscosity to variations in the composition of the blood and indicated how the finding can be used to account for Raynaud's disorder of peripheral circulation in which the finger becomes cold and blue on exposure to cold. Shaw used a heated thermocouple technique to detect changes in blood flow and used a Statham transducer to measure pressure in the medullary cavity of bone. Although the device measured neither actual flow rate nor the direction of flow, it is nevertheless useful in indicating changes of blood flow as a result of various nervous or pharmacological stimulations.

Other Non-Newtonian Flows

Benbow and Ovenston studied the extrusion of an alumina-bentonite-water mixture through square-entry dies and conical dies and were reasonably successful in adapting existing theories to correlate their results. In his film, Giesekus showed the flow behaviour of a polymer solution through capillary slits and tubes at various entry angles and shapes. The development of various modes of complex flow patterns was clearly shown as the flow rate was increased. The findings have obvious application in polymer melt extrusion.

In his paper, D. A. White extended his work on non-Newtonian flow in porous media to the case of axisymmetric flow and included the presence of stratified surface.

The Warren Spring Laboratory flow meter exhibited at the Conference was of the B.S. Standard orifice type, the novel feature being the use of flexible bellows for the detection of pressure drop in place of the usual pressure tappings, which tend to become blocked with fluids containing solid particles or paste-like materials.

The Conference was attended by about 120 members and visitors, of whom some 15% were from abroad, coming from places as far apart as California and Czechoslovakia. The keen interest provoked by the papers presented at the Conference was clearly demonstrated by the lively and at times heated discussions that took place both in and outside the technical sessions. The papers will not be published by the Society but some had already appeared in print in scientific journals. The accommodation was in Halls of the Royal Military College of Science and the participants were well looked after, well fed and, for some, no doubt, well exercised between the common rooms and bedrooms and between the Halls and the lecture theatre. The Conference Dinner, presided over by Professor A. Charlesby and having Dr. and Mrs. G. W. Scott Blair as honoured guests, proved to be a memorable occasion, at which the overseas visitors were initiated into the rite of passing port in the direction of the rising sun. (But, was it done for the ladies to have toasted the gentlemen?) The meeting was unanimously acknowledged to be a great success, and thanks must be due to Dr. M. F. Culpin and the administrative staff of the College who shared the arduous task of organising the Conference.

D. C.-H. CHENG.

SYMPOSIUM ON POWDER FLOW AND STORAGE

Postgraduate School of Studies in Powder Technology

University of Bradford

12th-13th September, 1967

The Symposium, arranged by Mr. J. C. Williams, the Chairman of the Postgraduate School of Studies in Powder Technology, University of Bradford, was attended by well over a hundred participants, including more than 10% from European countries. The delegates ranged from acknowledged experts in the field to engineers who, without any previous expertise in powder behaviour, were required to design a hopper or other powder handling equipment. Previous meetings on the subject of the properties and the flow of powders and granular solids include one that took place under the auspices of the British Society of Rheology in April 1965 at the University of Nottingham and another organised by the Institution of Mechanical Engineers in March 1967 in London. Several future meetings have been projected for 1968 in North America: one is co-sponsored by the American Society for Testing of Materials and the Illinois Institute of Technology at Chicago on 20th to 23rd May; another is being arranged jointly by the American Institute of Chemical Engineers, the Canadian Society for Chemical Engineering and the (British) Institution of Chemical Engineers and will be held in Montreal on 22nd to 25th September; the third is being

sponsored by the American Society of Mechanical Engineers, Materials Handling Engineering Division, and will be held in Boston, Massachusetts, on 21st to 22nd October. Apart from these formal meetings, the Research Committee of the Institution of Chemical Engineers also set up a working party on the Storage and Recovery of Particulate Solids in 1963 under the Chairmanship of Mr. P. L. Baldwin. The findings of the working party have recently been issued in the form of a report of the same title (edited by Mr. J. C. Richards), in which published work in the field of powder technology is summarised and critically discussed. All these activities show the growing importance of the behaviour of powders and bulk solids in all aspects of modern technology. This has come about not just because of the increase in the volume of powders and granular materials that is being handled by industry, but also by the need to understand and to control powder handling processes as the amount of automation in industry increases.

Authors and titles of the papers are as follows:

1. D. F. Bagster and J. Bridgwater, Measurement of the Force needed to Move Mixer Blades through a Bed of Cohesionless Powder.
2. B. Bedenig, G. Merten and W. Rausch, Investigations on Pressure Distribution Within a Pebble Bed.
3. A. H. Birks and J. C. Williams, The Effect of Anisotropy on the Failure Conditions of Particulate Solids.
4. W. Bruff and A. W. Jenike, A Silo for Ground Anthracite.
5. J. O. Cutress and R. F. Pulfer, X-ray Investigations of Flowing Powders.
6. R. Farley and F. H. H. Valentin, The Effect of Particle Size Distribution upon the Strength of Powders.
7. M. F. Handley and M. G. Perry, Stresses in Granular Materials Flowing in Converging Hopper Sections.
8. A. W. Jenike, Quantitative Design of Mass-Flow Bins.
9. H. Matthée, The Segregation of Bulk Materials in Hoppers—Theoretical Considerations and Experimental Investigations.
10. W. Reisner, The Behaviour of Granular Materials in Flow Out of Bins, Bunkers and Silos.
11. W. Schrämle, On the Measurement of the Flow Properties of Cement Powders.
12. E. M. Walker, Evidence for a Basis for Bunker Design.
13. J. C. Williams and A. H. Birks, The Comparison of the Failure Measurements of Powders with Theory.

With one exception all dealt with problems and techniques associated with the design of storage hoppers.

The Theoretical Basis for Storage Hopper Design

The theoretical basis for the design of storage hoppers was separately discussed by Jenike and by Walker. Jenike, drawing on more than ten years of experience, outlined the different types of flow patterns in the discharge of powders from hoppers and pointed out the advantages of a mass-flow hopper, which he defined as one in which the whole of the content is in motion whenever any of the powder is drawn out. He then reviewed the theoretical basis for the design of these hoppers. A simplified theory was developed by Walker for the same purpose and it differed from that of Jenike only in the detailed treatment of certain features. Nothing essentially new was reported by either speaker. Their work had been critically reviewed, together with other theories due to Gardner and Richmond, in the Report of the working party mentioned earlier.

Specific aspects of the design of storage hoppers are (i) the properties of powders; (ii) the stress fields in the hopper that determined both the actual strength and the flow behaviour of the powder in the hopper; and (iii) the velocity field. These topics were considered separately by different papers.

The Determination of Powder Properties

The instruments widely used for the measurement of powder properties are the Jenike Flow Factor Tester and the Tensile Strength Apparatus; the latter has been previously described by Ashton, Farley and Valentin. These were again used in obtaining the data discussed in the papers by Farley and Valentin, by Schrämle and by Williams and Birks. The last authors showed, from the study of titanium dioxide and a penicillin powder, that it is possible to convert the family of yield loci obtained using these instruments to give one master curve by plotting the reduced quantities $(\sigma + T)/\sigma_L$ and τ/σ_L , where σ and τ are the normal and shear stress defining each yield locus, T the tensile strength for a powder of the same state of compaction and σ_L is the end of the yield locus. They found that on a log-log plot the reduced stresses form a straight line, thus confirming the power law curve given previously by Ashton *et al.* at the Nottingham Meeting. Further, they found that when $\log T$, $\log (\sigma_L + T)$ and $\log (\sigma_c + T)$, where σ_c is the consolidating stress, were plotted against the density or voidage, the resulting straight lines all have the same slope, which is characteristic of the powder used. Williams and Birks measured σ_L not by trial and error as originally suggested by Jenike but by using simultaneous measurement of volume change as the powder sample was sheared, σ_L being the condition at which the volume change is zero.

The effect of particle size on the parameters defining the yield locus was reported by Farley and Valentin. Their experimental data were obtained on several size fractions of five materials of different physical

and chemical nature, the particle size distribution being determined using a Coulter Counter. The index of the power law yield locus was related to the volume-surface mean diameter of the particle size by a correlation which did not seem to depend strongly on the nature of the material concerned. Although no definite correlation was established between the tensile strength and particle size, it was found that the cohesion or shear strength at zero normal stress is proportional to the tensile strength, again with the value of the constant of proportionality apparently not being related to the nature of the material concerned.

It seems possible that the generalisations and correlations discussed in the two papers above could be more generally applicable than the narrow range of materials studied would indicate. In which case the time and effort at present required for the determination of powder properties could be very much reduced.

Birks and Williams reported several phenomena associated with the Jenike Flow Factor Tester that cannot be explained if the powder mass is assumed to be isotropic. The theory of anisotropic media, given by Nadai in "Theory of Flow and Fracture of Solids", was invoked to account for these phenomena. However, since it is generally recognised that conditions in a shear cell are far from uniform, it seems that the anomalous phenomena could well be explained by the simpler course of non-uniformity rather than anisotropy.

The use of the instruments named above for the practical use of routine control of flowability in the cement industry was discussed by Schrämle. He showed that because of the long measuring time, the manpower required, the large sample size and the need for air conditioning, these instruments are not suitable for this purpose. There is a clear need to develop a robust tester which can be readily and reliably used on the shop floor.

Walker described the measurement of flowability characteristics using a new instrument consisting of a ring shear cell in which the powder sample can be subjected to unrestricted amounts of shearing strain. A basis for bunker design can then be established.

Recent developments in the furnishings for powder testing laboratory were also described by Jenike. These include a consolidation bench with individual rubber covers to preserve moisture conditions of the powder when undergoing time consolidation, and a shaker which is used to reproduce the effect of vibration on the flowability of powder.

Stress Fields in Hoppers

Several techniques for the measurement of stress fields in hoppers were described. Walker used a system of pressure transducers, faced with the same material as the hopper walls, mounted flush with the

walls. Handley and Perry used the radio pill technique including a modification which enabled the position of the pill to be monitored during the test. Bedenig, Merton and Rausch used specially designed probes which were essentially rods of small diameter with a pressure sensing tip. These probes were introduced into the pebble bed and the resistance of the bed was measured. Pressure measurements were also carried out by Reisner.

Different shapes of hoppers and containers were used in these studies. Each showed that the pressure distributions were different for a filling bed and for a flowing mass of powder. In the former, the pressure increases steadily towards the bottom of the bed, but in the latter the pressure rises to a maximum in the powder mass, usually at the junction of the vertical and the convergent sections of the hopper. The pressure distributions agreed well with the theoretical predictions of Jenike and Walker.

Walker further showed that, if a small bleed of powder was taken from the hopper at intervals during the filling operation, a pressure distribution appropriate to a flowing bed was obtained which persisted even when the powder was left standing over long periods. This procedure could be usefully employed to minimise consolidation at the exit of the hopper if the storage is to last for an appreciable length of time.

Velocity Fields in Hoppers

The velocity field in hoppers can be deduced from the use of the radio pill technique and Handley and Perry showed that, in the vertical section of their mass flow hopper the radio pill travelled with a steady speed, but near the junction and in the convergent section it accelerated and travelled with increasing speed towards the exit of the hopper. Similar observations of the limit of mass flow as the powder level in the hopper approaches the convergence section were made by Reisner using two dimensional model hoppers of different geometries and using various materials under a variety of conditions. Cutress and Pulfer also made visual and X-ray observations on the flow of oil-coated polystyrene powder in a similar hopper. They observed lines of low powder density forming and moving during flow, which became stationary when the flow was stopped artificially or by arching. Comparison of these lines with the theory seemed to indicate that they lay along the direction of slip. The observations of Cutress and Pulfer and of Reisner had been recorded on cine films which were shown at the meeting.

Discharge Rate from Hoppers

This important aspect is seldom discussed but must be of vital importance in industry. The problem was briefly touched on by Reisner, who had collected a large number of references of previous work, which were characterised by the remarkable disagreement

between the results obtained by different authors. Reisner discussed his findings on the effect of hopper geometry and dimensions and the properties of materials on the discharge rate. He also described several methods of improving the flow out of hoppers. Another factor that critically affects discharge rate from hoppers is air, as was clearly demonstrated by the performance of a mass flow hopper designed to handle fine calcined anthracite described by Bruff and Jenike. The rate of discharge was greatly increased when a small amount of air was pumped into the hopper above the exit.

Segregation of Powders

One of the advantages of the use of mass flow hoppers is that the powder in the hopper does not segregate during flow. However, segregation will occur with certain materials during the filling of the hopper and after discharge. Mathée, who had studied problems of segregation, discussed the physical effects that have to be taken into account in any theoretical treatment and reported qualitative experimental observations related to some of them. The importance of dimensional analysis in the scale up from model study to industrial installations was indicated.

Force on a Blade Moving Through a Powder Bed

The only paper that did not deal with the problems associated with the design of hoppers was presented by Bagster and Bridgwater. They measured the force factor on a vertical blade moving horizontally in a bed of cohesionless powder and studied the influence due to geometric factors, powder properties and speed of the blade. The results were correlated semi-empirically using dimensional analysis and results of soil mechanics. The operation is basic in a large number of industrial processes and the study could be very profitably extended to include powder flow rate and cohesive powders.

There were lively discussions of all the papers, and it has been arranged that together with the discussions they will be published in a future issue of *Powder Technology*. Much interchange of ideas and experience among the delegates also took place outside the formal sessions. It is obvious that the field of powder behaviour is an area where much ignorance still exists and, despite the growing industrial importance, not sufficient research is being done. On the other hand, it seems that, with the foundation already laid by the pioneering workers, great advances in the understanding of powder behaviour are possible. The British Society of Rheology could well foster this growth by, for example, sponsoring another meeting on this subject in two or three years' time, when new results should be available.

D. C.-H. CHENG.

AMENDMENTS TO CONSTITUTION

The following alterations to the Constitution were approved at the Annual General Meeting, September 1967.

Rule 3 (d). Continue after present text: "A member retiring from normal employment after more than 20 years' membership is eligible to become an Honorary Member".

Rule 5 (b) is amended as follows: "(iii) a member shall not be eligible to serve on Council for more than four years successively without filling an executive office *or serving as the Secretary of the Research Committee*" (new text in italics).

SYMPOSIUM ON HAEMORHEOLOGY AND THE MICROCIRCULATION

It is hoped that as many members as possible will attend this one-day joint meeting with the Microcirculation Society (details on back cover), which is being held on a Saturday so as not to interfere with normal working hours. The preliminary list of papers indicates that the majority of the participants are interested in the general problem of flow of complex fluids through narrow channels, and so the symposium should be of interest to nearly all those who supported the Shrivenham meeting in September 1967.

ABOUT THE CONFERENCE ON EXPERIMENTAL RHEOLOGY

17th-19th APRIL, 1968

In some ways the conference to be held in the spring of 1968 with its special commitment to the laboratory aspects of rheology and the introduction of considerations of the management function, is dissimilar from those previously arranged by the B.S.R. It is for this reason that the following notes have been written by way of an introduction.

A suitable end-point in a particular rheological research programme might be the comparison of a set of theoretical predictions with a set of real data. This confrontation between the real and the theoretical is often the substance of papers in the scientific press, although at times the two distinct worlds are so interwoven in the argument that they are barely distinguishable. The refinement and rematching of the two entities is part of the continuous development of rheology.

In the theoretical treatments available in the literature, the progress of the discussion from the premises to the predictions is usually fairly adequately covered (apart from associated computer pro-

grammes). It is, however, usually much less easy to adequately treat the progress of the experimental work from the origins of the apparatus to the set of real data presented in a form suitable for comparison with the set of theoretical predictions. Beyond a brief outline the experimental apparatus generally speaking receives no special attention, far less is there treatment of the way it was developed. Quite often therefore there is an imbalance between the extent of the treatments of the experimental and theoretical aspects as a result of extensive abridging in favour of the theory, probably due to editorial requirements. This is in some ways unsatisfactory as one is bringing together two worlds of equal status; the real is no less important than the theoretical and the apparatus with which the real is manipulated ranks with that with which the theoretical is manipulated.

The Conference at the University of Bradford is devoted to all those aspects, including successful management, which in some way contribute to obtaining a relatively unblemished signature of nature. Since the actual experimental apparatus cannot be exhibited in the literature in the way that the theoretical can be exhibited, it may well be that a periodic conference including a live exhibition may be a more appropriate vehicle for discussing and displaying developments than a journal. If this proves to be the case the Conference could well be the forerunner of regular meetings on this theme with the intention of placing the evolution and treatment of laboratory aspects on the same footing as the theoretical, namely a rational one.

J. HARRIS

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JOURNALS AVAILABLE FOR LOAN

The Society receives from time to time complimentary copies of journals of rheological interest. The list below gives the principal journals available, any of which may be borrowed by members, on the understanding that the borrower pays postage. Application should be made to Mr. R. W. Whorlow, Dept. of Physics, University of Surrey, Battersea Park Road, London, S.W.11. In addition odd copies of other publications are available. Full details of these are obtainable either from Mr. Whorlow or the Editor (Bulletin).

Berichte der Deutschen Rheol. Ges. (1961-65), Vol. 20-29.

Bull. Brit. Hydromechs. R.A. (1961-65), Vol. 10 (5)-14 (1).

Cahiers du Gpe. Français d'Etudes de Rhéol. (1957-61), Vol. 2-6.

Cahiers du Gpe. Français d'Etudes de Rhéol. (1965-67), Vol. 1 (1-4).

J. Japan Soc. Test. Mat. (later, J. Soc. Matl. Sci. Japan) (Special Rheology Issues), 1959-66, Vol. 8-15.

Rep. Prog. Poly. Phys. Japan (1959-65), Vol. 2-8.
Rheol. Bull. (U.S.A.) (1964-67), Vol. 33-36.
Trans. Soc. Rheol. (U.S.A.) (1957-67), Vol. 1-11.
Scientia Sinica (1963-66), Vol. 12-15.
Science Abstracts China (1963-65), Vol. 1-3.

RHEOLOGY; SCIENCE OR ART?

(The following verses were recently found in a shipment of china clay. They have been translated from the Cornish by an anonymous correspondent.)

Showing non-rheologically oriented visitors around one's laboratory, or explaining rheological concepts to a non-rheologically inclined colleague both require the exercise of patience with a capital "P"—whence the following.

1. If you're anxious for to shine in the scientific line,
As a man of learning wide,
You must get up all the germs of all the viscometric terms,
Both the pure and the applied.
You must puzzle through the pages of the writings of the sages
With the scientific mind.
And discourse without compunction on the meaning of a function
Of the transcendental kind.
And ev'ryone will say,
As you while the hours away—
"Why, if this young man knows all *that* much about rheology,
Why, what a most exceptionally well-read man this bright young
man must be."

2. If you're eager to impress then you must talk of "normal stress",
Or other themes you may select.
Or enhance your reputation with a simple demonstration
Of the Weissenberg effect.
When they look at your viscometer or rheogoniometer,
You'll score a hit, it's true.
But although you might confess it then you'd better not express it,
That they don't mean much to you.
And ev'ryone will shout,
As you churn the flow curves out—
"Now, if all that young man's instruments work complicatedly,
What a competent and practical and sound young man this sound
young man must be."

3. Your reports should all be written so that the reader will be smitten
 With a sense of ignorance.
 Use a vector or a tensor and you'll make him feel much denser—
 Or at least you'll stand a chance.
 Then a good abbreviation gives an air of desperation,
 If he doesn't know what it's for.
 And work really does look neater with a "delta" or an "eta",
 Or a "sigma" or a "tau".
 And ev'ryone will say,
 As they throw the thing away,
 "Now, if this young man can write reports that just seem Greek
 to me—
 How completely unintelligible this young man—this *strange* young
 man must be."
 "Longfellow".

NEWS FROM SOCIETY OF RHEOLOGY, INC. (U.S.A.)

The Transactions of the Society, started in 1957 as a means of reprinting papers presented at the Society's meetings, has adopted a new policy to widen its coverage of rheological science. The journal which in 1965 and 1966 appeared twice yearly, consisted of three issues in 1967. From 1968 it will appear quarterly, and will no longer contain primarily papers presented at a S.R. meeting. The Editor (Prof. R. R. Myers) will consider manuscripts submitted at any time, which will be refereed in the normal manner. Authors will receive 50 reprints of published papers plus a further 50 on payment of a publication charge of \$15 per page.

The B.S.R. receives a complimentary copy of Trans. Soc. Rheol., which is available for members to borrow.

The Bingham Medal for 1967 was awarded to Dr. Hershel Markovitz of the Mellon Institute, Pittsburgh, for rheological work over the past seventeen years, characterised by an almost unique mixture of experimental and theoretical activities.

The 38th annual meeting of the Society took place in Washington, 23rd-25th October, 1967. Seven sessions were held, covering viscoelastic theory, viscoelastic experiments, non-linear effects in fluids, normal stress experiments, rheo-optics, normal stress and flow, and other topics. Invited papers were given by B. N. Brockhouse (McMaster Univ.) on "The phonon spectra of crystals and their relation to mechanical and thermal properties", and by W. MacKnight (Univ. of Massachusetts) on "Dynamic mechanical and infra-red studies of ethyl methacrylate copolymers and their salts". Abstracts of papers presented during the meeting may be borrowed from the Editor, B.S.R. Bulletin.

NOTES AND NEWS

The Twelfth International Congress of Applied Mechanics will be held at Stanford, California, U.S.A., 26th-31st August, 1968. In addition to five invited lectures approximately 300 contributed research papers will be presented. Those who wish to present papers should submit 500-word summaries and 100-word abstracts before 2nd February, 1968. Further information on the Congress is obtainable from P.O. Box 5789, Stanford, California 94305, U.S.A.

The Inst. Chem. Eng. is holding a joint conference with the West German VTG/VDI in Brighton, 24th-26th April, 1968, on the Engineering of Gas-Solid Reactions. All four technical symposia, the titles of which are: Characteristics of solid particles relevant to gas-solid reactions; The physical behaviour of gas-solid systems; The technical design and performance of industrial equipment; and Experiences with the operation of industrial process equipment, contain papers of rheological interest. Further information and registration forms can be obtained from V.D.I./I.Chem.E. Meeting, The Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1.

The Pharmaceutical Society of Great Britain is sponsoring a Post-graduate School on the Rheology of Disperse Systems, to be held at The School of Pharmacy, Brunswick Square, London, W.C.1, 1st-5th April, 1968. Each morning is allocated for lectures by eminent rheologists and each afternoon is set aside for practical work and tutorials. Details from The Pharmaceutical Society, 17 Bloomsbury Square, London, W.C.1.

A symposium on "The Physical Properties of Liquids and Gases for Plant and Process Design" will be held at N.E.L., East Kilbride, 20th-21st March, 1968, with the object of improving communications between users and producers of data. Information will be presented on mixtures and less well defined systems as well as on pure substances, both in the single phase and multiphases. Further information from S. W. Turner, British Hydrocarbon Chemicals Ltd., Grange-mouth, Stirlingshire.

A tripartite Chemical Engineering Conference will be held in Montreal, Canada, 22nd-25th September, 1968. Sessions of interest to rheologists include those on Fluidisation, Granular Materials, Mixing, Agglomeration processes, High strength whiskers, filaments, flakes and films. Information may be obtained from Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1.

The 1968 programme of the Society of Glass Technology contains the following meetings: Joint Conference with British Ceramic Society, Sheffield, 1st-3rd April; Eighth International Congress on Glass, London, 1st-6th July. The season's lecture programme includes: Refractories, Sunderland, 12th March; Review of research

and development in the glass industry, St. Helens, 9th February; and Glass fibre, manufacture and use, Stirling, 13th February. Details of all meetings from the Secretary, Thornton, 20 Hallam Gate Road, Sheffield S10 5BT.

A symposium on Lubrication and Lubricant Rheology, organised jointly by ASME-ASTM-ASLE, will be held at University of Michigan, U.S.A., 18th-20th March, 1968. Information from Professor W. O. Winer, Dept. of Mech. Engng., 225 West Engng Building, University of Michigan, Ann Arbor, Michigan 48104.

The Editor has received from Imperial College a pamphlet entitled Science of Materials, listing the 1966-67 publications on materials research in the science and engineering departments of the College.

If sufficient support is forthcoming members can fly to Japan for the International Rheology Congress at a return fare of £320, compared with the normal tourist rate of £470. Will members interested, who have not already done so, please let the Editor know before 10th February.

Dr. G. W. Scott Blair will be available for rheological consultations, after 1st February, at his private address: Grist Cottage, Ifley, Oxford.

RHEOLOGY IN FRANCE

In France, as in Britain, rheology is thriving. Comparison of the membership lists of Groupe Français de Rhéologie published April 1965 and May 1967, shows that total membership has increased from 156 to 238. Of these 70 are Institutions or Companies, compared with 37 in 1965. The number of overseas members has increased from five to 28—including the British National Lending Library, thus enabling members of B.S.R. to borrow the extremely useful and well-produced "Cahiers du G.F.R." through normal inter-library loan services. (The Editor (Bulletin) also has a loan copy available.)

A Section Lyonnaise has just been formed to cater for rheologists living in that region of France. The the opening meeting, held at Villeurbanne on 17th November 1967, C. Smadja spoke on "The influence of morphology on the mechanical properties of semi-crystalline polymers."

A further set of rheological definitions (numbers 56-65) has now been approved by the Council of G.F.R., and literal translations into English are given below—together, where appropriate, with what appears to be the equivalent English term (the G.F.R. is not responsible either for the translation or the English equivalent).

In addition, provisional definitions 66-78, proposed but not yet approved by Council, are translated for the benefit of rheologists who might wish to comment on the terminology. All comments should be sent to M. B. Persoz, 68 Bld. St. Michel, Paris, 6, France.

56. *Fluidification*. In a flow where the rate of deformation $\dot{\epsilon}$ (or the stress σ) is maintained constant, the apparent viscosity is dependent on $\dot{\epsilon}$ (or σ) and on the length of time t for which that rate of deformation (or stress) is applied. One says that there is softening if for a certain time interval t the apparent viscosity is a decreasing function of $\dot{\epsilon}$ (or of σ). In case of possible confusion with other reasons for diminution of apparent viscosity one says *rhéofluidification*. The use of the term structure viscosity in place of *rhéofluidification* is not advised.

When the $\dot{\epsilon}$ or σ curve of a softening liquid has an asymptote which cuts the axis at a finite distance one uses in English the term pseudo-plastic. (Softening.)

57. *Epaississement*. One says that there is thickening if, in the conditions of definition 56, for a determined time interval t the apparent viscosity is an increasing function of $\dot{\epsilon}$ (or σ). In case of confusion with other causes of increase of apparent viscosity one uses the term *rhéopaisissement*.

58. *Fluidification stable, progressive, dégressive*. Softening is called stable, progressive or regressive as, when time t is increased, the apparent viscosity remains invariable, increases or decreases.

59. *Thixotropie et antithixotropie*. For softening bodies (cf. 56) one says that they have thixotropy if:

- (i) $\dot{\epsilon}$ (or σ) being maintained fixed, the apparent viscosity is a decreasing function of the duration of flow;
- (ii) the body recovers its initial state after a long enough rest.

One says that there is antithixotropy when the apparent viscosity is an increasing function of the duration of flow, and when the body recovers its initial state after a long enough rest.

The reversible transformation $\text{gel} \rightleftharpoons \text{sol}$ is an example of thixotropy.

When the body does not recover its initial state entirely after a long enough rest one speaks of partial thixotropy or antithixotropy.

60. *Epaississement stable, progressif, dégressif*. Thickening is called stable, progressive or regressive as, when time t is increased, the apparent viscosity remains invariable, increases or decreases.

The use of the term dilatant to designate a stable thickening fluid has been rejected (cf. 62).

The use of the term rheopectic to designate a progressive thickening fluid is not recommended (cf. 61).

61. *Rhéopexie*. One meets the term used with two different meanings:

- (a) Solidification of a thixotropic system under the effect of a gentle and regular movement;

(b) *Epaississement progressif* (cf. 60).

The first meaning was that for which the word was coined; the use of rheopexy in sense (b) is not recommended.

62. *Dilatance*. The property which some bodies have of increasing their volume under the action of a state of simple shear stress (cf. 63).

As an example, a sand compacted more than a certain amount shows dilatancy when deformed in the presence of water; the increase in volume of the pores (from which the dilatancy results) produces a liquid tension resisting the deformation and gives a behaviour more or less analogous to that of a thickening body. In an example where the two phenomena are connected one must not confuse dilatancy (a property concerning volume deformation) with thickening (a property concerning apparent viscosity).

63. *Cisaillement simple*. A state of stress in which one of the principal stresses is zero, the two other being equal and of opposite sign. (Simple shear.)

64. *Hystérésis*. A magnitude q which depends on the system of loads Q exerted on a body is said to have produced hysteresis when the curves q, Q , relative to loading and unloading (cf. 65) do not coincide.

When q is strain one has strain hysteresis, due perhaps to viscosity or plasticity. The term elastic hysteresis is commonly used in this case, but is not recommended because the adjective elastic leads one to believe that there is not a permanent deformation.

Progressive or regressive thickening gives rise to strain rate hysteresis

65. *Charge et décharge*.

Charge=monotonic increase of a system of loads;

Décharge=monotonic diminution of a system of loads.

66. *Comportement*. Manner in which the deformations of an element of a body correspond to the imposed stresses (or the stresses to the deformations). (Behaviour.)

67. *Histoire d'une variable*. The set of values of that variable x for all times τ less than the present time t .

Notation: $x \begin{matrix} t \\ -\infty \end{matrix} (\tau)$

68. *Equations de comportement*. Equations connecting the values at time t of stresses, strains and their derivatives of all orders with respect to time; possibly the history of certain variables and time t itself. (Equations of state.)

69. *Représentation fonctionnelle du comportement*. One can take as independent variables either strains or stresses. Each of the

dependent variables y is a functional of values of the independent variables x in the interval $-\infty, t$; that is to say can depend not only on current values $x(t)$ and their derivatives with respect to time, but also on the history of the variables (and possibly time t itself). One writes:

$$y(t) = \mathcal{F} \left[x \left(\underset{-\infty}{t} \right); x(t); \dot{x}(t); \dots; t \right] - \infty < \tau < t$$

70. *Corps vieillissant.* A body whose properties depend on its age; time t figures explicitly in the equations of state and in the functionals $\mathcal{F}$ of 69.

71. *Comportement linéaire au boltzmannien.* The behaviour is linear if the functionals $\mathcal{F}$ are linear; that is to say such that:

$$\begin{aligned} \mathcal{F} \left[x_1 \left(\underset{-\infty}{t} \right) + x_2 \left(\underset{-\infty}{t} \right); x_1(t) + x_2(t); \dots; t \right] = \\ \mathcal{F} \left[x_1 \left(\underset{-\infty}{t} \right); x_1(t); \dots; t \right] + \mathcal{F} \left[x_2 \left(\underset{-\infty}{t} \right); x_2(t); \dots; t \right] \end{aligned}$$

and

$$\mathcal{F} \left[\lambda x \left(\underset{-\infty}{t} \right); \lambda x(t); \dots; t \right] = \lambda \mathcal{F} \left[x \left(\underset{-\infty}{t} \right); x(t); \dots; t \right]$$

if λ is constant.

72. *Essai de retard.* An experiment in which, on a body in equilibrium when $t < t_0$, one exerts at time t_0 a stress which is thereafter held constant and one measures the deformation which results at different times $t > t_0$. (Creep test.)

73. *Fonction de retard.* In the case of a linear system (71): relation $f(t, t_0)$ between the deformation measured at time t in a creep experiment and the stress applied at time t_0 .

For non-ageing bodies (70) this relation depends only on the difference $t - t_0$.

74. *Essai de relaxation.* An experiment in which, on a body in equilibrium when $t < t_0$, one imposes at time t_0 a deformation which is thereafter held constant and one measures the stress which results at different times $t > t_0$. (Stress relaxation experiment.)

75. *Fonction de relaxation.* In the case of a linear system (71): relation $r(t, t_0)$ between the stress measured at time t in a stress relaxation experiment and the deformation imposed at time t_0 .

For non-ageing bodies (70) this relation depends only on the difference $t - t_0$.

76. *Essai harmonique*. An experiment in which, on a body in equilibrium when $t < t_0$, one measures the deformation (or the stress) produced by a sinusoidal stress (or deformation) function applied from time t_0 ; or more generally in all experiments where the controlled variable is a periodic function of time. (Dynamic experiment.)

77. *Accommodation*. In a dynamic experiment one has *accommodation* if, when time t increases, the variations of the uncontrolled variable y tend to become periodic, of the same period as the controlled variable x . The coordinates x, y describe in the limit a closed cycle, whose area, to a good approximation, is the energy dissipated during a cycle.

78. *Angle de perte et module complexe*. In the case of linear behaviour (71) and a dynamic experiment (70) there is *accommodation* (77) and the variations of the uncontrolled variable tend to become sinusoidal with the same period as the controlled variable, but with a different phase. One may then put $\epsilon = \epsilon(m) \cos \omega t$; $\sigma = \sigma(m) \cos (\omega t + \phi)$. σ designates stress, ϵ the strain with which it is associated in the expression for work, ω is the frequency of the oscillations, $\sigma(m)$ and $\epsilon(m)$ are the amplitudes of the oscillations.

L'angle de perte is the phase difference ϕ between stress and strain. The energy dissipation per cycle, per unit volume, is

$$\Delta W = \pi \sigma(m) \epsilon(m) \sin \phi.$$

Le module complexe is the complex number $(\sigma(m)/\epsilon(m)) \exp. i \phi$. It is generally frequency dependent. The real part of the complex modulus is called *module de conservation* (storage modulus), the imaginary part *module de perte* (loss modulus). The inverse of the complex modulus is called the complex compliance. The real part is the storage (*conservation*) compliance; the imaginary part the loss compliance.

Some English rheologists may feel that on occasions immediate clarity has been sacrificed to obtain a definition that is mathematically rigorous. One interesting point is the use of the term *essai de retard*. In English we talk of retardation spectra, and yet refer to the experiments by which they are obtained as creep experiments. It is certainly more consistent to refer to retardation experiments, and keep the term creep for purely plastic deformation processes.

In discussions with Dr. G. W. Scott Blair the following points arose.

56. Softening. Why introduce time as a variable only to discard it later?

61. Rheopexy. The definition ought to refer to an increased rate of solidification rather than just to solidification. Any thixotropic material will begin to thicken if the shear rate is reduced.

59-62. G.F.R. are to be congratulated on their efforts to prevent confusion between shear thinning and thixotropy, and antithixotropy, shear thickening, rheopexy and dilatance.

63. Simple Shear. Any definition ought to refer to the rotational component.

64. Hysteresis. From the definition it appears that *élastique* is confined to the meaning ideal elasticity.

77. *Accommodation*. In what rheologically useful experiments do stress and strain not have the same period? The definition refers to energy dissipated, i.e., the imaginary part of the coordinates, but not to the real part.

New Members

NAME AND ADDRESS	INTERESTS
R. J. Akers, B.Sc., Ph.D., 17 Belvoir Dr., Loughborough, Leics. Chem. Engng. Dept., Loughborough University of Technology.	General, emulsions, suspensions, etc.
E. W. Billington, B.Sc., M.Sc., Ph.D., F.Inst.P., 30 Old Hadlow Rd., Tonbridge, Kent. R.A.R.D.E., Fort Halstead, Nr. Seven- oaks, Kent.	General, metals, rubbers, polymers, emulsions, suspensions.
R. G. H. Boyes, A.M.I.C.E., Innstead, Newdigate, Dorking, Surrey. Laporte Industries Ltd., Nutfield Rd., Redhill, Surrey.	Rubbers, polymers, polymer solutions, building and road materials.
H. J. Buswell, B.Sc., Grad.Inst.P., Vier, Sandy Lane, Southmoor, Abing- don, Berks. Rocket Propulsion Est., M.O.T., West- cott, Aylesbury, Bucks.	General (th. and expt.), plastic pro- pellants.
N. Casson, B.Sc., 13 The Stewarts, Bishop's Stortford, Herts. Bank of England Printing Works, Langston Rd., Loughton, Essex.	Polymer solutions, emulsions, suspen- sions, paints, inks, lubrication.
T. C. Davenport, B.Sc., A.Inst.P., A.F.Inst.Pet., 8 Lynwood Close, Woodham Lane, Woking, Surrey. British Petroleum Co. Ltd., Res. Cent., Sunbury-on-Thames, Middx.	General (th. and expt.), emulsions, suspensions, paints, inks.
D. Fitzgerald, M.A., B.Sc., Ph.D., M.Inst.F., 12 Arthur Rd., Wokingham, Berks. Heating and Ventilating R.A., Old Bracknell Lane, Bracknell, Berks.	Non-Newtonian fluids, drag reduction.
D. C. Flack, B.Sc., Ph.D., Cigale, Strange Garden, Dark Lane, Aldwick, Bognor Regis. Sangamo Controls Ltd., North Ber- sted, Bognor Regis.	
J. D. Gemmell, M.Sc., 23 Rathen Rd., Withington, Man- chester 20. Turner and Newall Asbestos Fibre Lab., Turner's Asbestos Cement Co. Ltd., Trafford Park, Manchester 17.	Rubbers, polymers, building and road materials.
W. K. Gregson, 32 Park Rd., Sale, Ches. Ferranti Ltd., Moston, Manchester 10.	General.

NAME AND ADDRESS	INTERESTS
T. E. R. Jones, B.Sc., Maesawelon, Queensway, Llandovery, Carms. 79 Pantycelyn, Penglais, Aberystwyth.	General (th. and expt.), rubbers, polymers, polymer solutions.
J. A. Lione, 20 Hatherley Rd., Walthamstow, Lon- don, E.17. Gestetner Ltd., Tottenham, London, N.17.	General (expt.), emulsions, suspen- sions, printing inks.
D. May, B.Sc., A.Inst.P., 12 Leverton Court, Melton Rd., West Bridgford, Nottingham. B.P.B. Industries (Res. and Dev.) Ltd., East Leake, Loughborough, Leics.	Building and road materials.
P. H. Nelson, M.I.Mech.E., "Bydown", Bluehouse Lane, Limps- field, Surrey. Blue Circle Group, Portland House, Stag Place, London, S.W.1.	General, suspensions, emulsions.
W. M. Oliver, B.Sc., L.R.I.C., 6 Lansdowne Ave., Slough, Bucks. Science Dept., Slough College, William St., Slough.	Emulsions, suspensions, paints, inks.
M. E. Painter, B.Sc., 6 Laburnam Close, Clough Hall, Kids Grove, Stoke-on-Trent, Staffs. Johnson-Matthey Ltd., Wm. Clowes St., Burslem, Stoke-on-Trent.	General, paints printing inks, ceramics.
G. S. Pearson, B.Sc., Ph.D., Tioga, Wendlebury, Bicester, Oxon. Min. of Tech., Rocket Propulsion Est., Westcott, Aylesbury, Bucks.	Solid propellants.
W. M. Price, B.Sc., Kelvin Gve., Pengais Tce., Aberyst- wyth. Physics Dept., U.C.W., Aberystwyth, Cards.	Emulsions, suspensions, biorheology.
P. R. Saunders, B.Sc., Whistlefield, Sutton Place, Abinger Hammer, Dorking, Surrey. B.F.M.I.R.A., Randalls Rd., Leather- head, Surrey.	General (th. and expt.), rubbers, poly- mers, polymer solutions, emulsions, suspensions, confectionery.
Y. S. Su, B.Sc., Ph.D., A.M.A.I.Ch.E., 75A Appleby Lodge, Wilmslow Rd., Manchester 14. Dept. of Chem. Engng., University of Salford, Salford 5, Lancs.	General, rubbers, polymers, polymer solutions, emulsions, suspensions, etc.
D. Tabor, Ph.D., Sc.D., F.R.S., 8 Rutherford Rd., Cambridge. Surface Physics, Cavendish Lab., Cambridge.	General (th. and expt.), metals, rub- bers, polymers, lubrication, friction, wear.

NAME AND ADDRESS	INTERESTS
P. Townsend, B.Sc., 85 Tir Capel, Llanelli, Carm. s. Dept. of Appl. Maths., U.C.W., Aberystwyth.	Theory.
A. Ungar, M.A., B.Sc., B.M., B.Ch., 9 Charlton Place, London, N.1. School of Pharmacy, Brunswick Sq., London, W.C.1.	Biorheology.
A. White, B.Sc., M.Sc., 84 Geary Rd., Dollis Hill, Willesden, London, N.W.10. Hendon College of Technology, The Burroughs, Hendon, London, N.W.4.	General (expt.), polymer solutions, suspensions.
D. A. White, M.A., Ph.D., Commonwealth Hall, Cartwright Gardens, London, W.C.1. Dept. of Chem. Engng., University College, Torrington Place, London, W.C.1.	General, rubbers, polymers, polymer solutions.
M. Michael, Flat 6, 29 Charnwood Rd., E. St. Kilda, Victoria, Australia. Nylex Corp., Nepean Highway, Mentone 3194.	Polymers.
W. J. Beek, Dr.Ir., Nassaulaan 13, Delft, Netherlands. Lab. voor Fysische Tech., Prins Bernhardlaan 6, Delft.	Rubbers, polymers, emulsions, suspensions, glasses, ceramics, etc.
A. H. Bloksma, Ph.D., Englaan 4, Wageningen, Netherlands. TNO, Lawickse Allee 15, Wageningen.	General (expt.), rubbers, polymers, polymer solutions, confectionery.
E. J. Broekers, St.(Fys.), Kraaiensteinlaan 39, Arnhem, Netherlands. K.E.M.A., N.V., Utrechtseweg 310, Arnhem.	General (expt.), suspensions, etc.
A. G. Fabula, Ph.D., 40 S. Michillinda Ave., Sierra Madre, Calif. 91024, U.S.A. Naval Undersea Warfare Center, Pasadena, Calif., 91107.	General, polymers, polymer solutions.
D. B. Holmes, B.A., M.Sc., Dr.Eng., Persijnlaan 64, Delft, Netherlands. Lab. voor Fysische Tech., Prins Bernhardlaan 6, Delft.	General (expt.), polymers.