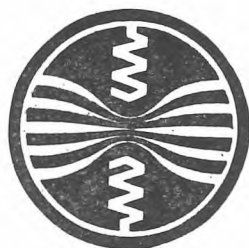


BULLETIN



BRITISH SOCIETY OF RHEOLOGY

1976, Vol. 19, No. 4

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Hon. Editor:

M. CAMINA,

Paint Research Association,
Waldegrave Road,
Teddington,
Middlesex.



FOREWORD

We have the pleasure of introducing Dr. J. Benbow of I.C.I. as the President of our Society for the 1976-78 term of office. He has been a member of the Society since 1949, so needs no introduction. We hope his term of office will be smooth but active. At the same time we regret the departure from the Council of two long-serving members. Ken Walters leaves as retiring President; he has served the Society extremely well and his experience and interest have left their mark. Mike Hobbs has served on the Council for six years, four as Editor of the *Bulletin*. His place on the Council has been taken by Dr. M. Sherriff, whom we welcome.

There has been a huge outcry over the last year about the lowly status of the engineer in British Society. This explains so the argument goes, why the brightest youngsters do not opt to practise engineering in Industry. This implies that the poor performance of British industrial production is the fault either of engineers now working in industry or to a lack of engineers. Two reasons have been suggested for this state of affairs: poor pay, and academic scientific snobbery. The first is easily rectified but is the second reason justified?

OFFICERS AND MEMBERS OF COUNCIL 1976-77

President: DR. J. J. BENBOW, I.C.I. Ltd., Agricultural Division, Billingham, Teesside.

Secretary: MR. F. N. COGSWELL, I.C.I. Ltd., Plastics Division, Welwyn Garden City.

Treasurer: DR. D. R. OLIVER, Department of Chemical Engineering, University of Birmingham, Birmingham.

Membership Secretary: DR. T. E. R. JONES, School of Mathematical Sciences, Plymouth Polytechnic, Plymouth.

Abstracts Editor: DR. D. MARSHALL, Institute of Polymer Science, Loughborough University of Technology, Loughborough.

Bulletin Editor: MR. M. CAMINA, Paint Research Association, Teddington, Middlesex.

Ordinary Members:

DR. K. M. BEAZLEY, 44 Brockstone Road, Boscoppa, St. Austell PL25 3DP.

DR. D. C-H. CHENG, Warren Spring Laboratory, Stevenage.

MR. T. C. DAVENPORT, B.P. Research Centre, Sunbury-on-Thames, Middlesex.

MR. A. EVANS, Department of Surgery, Royal Victoria Infirmary, Newcastle-upon-Tyne.

DR. J. FERGUSON, Department of Fibre Science, University of Strathclyde, Glasgow.

DR. M. SHERRIFF, Department of Pharmaceutical Chemistry, School of Pharmacy, Brunswick Square, London.

MINUTES OF THE 36TH ANNUAL GENERAL MEETING

The 36th Annual General Meeting of the Society was held at the Institution of Electrical Engineers, London, on Friday, October 1, 1976. The President, Professor Walters, took the chair at 17.30. Twenty-seven members were present.

1. *The Minutes of the 35th Annual General Meeting* held at Loughborough on September 17, 1975, were read, adopted as a correct record and signed. There were no matters arising from the Minutes.

2. *The Secretary* reported on the activities of Council and the Society during the past year.

1975-76 had been an active year for conferences and many meetings were already being planned for the next two years. The Autumn 1975 meeting on "Polymer Rheology and Plastics Processing" had been a joint meeting with the Plastics and Rubber Institute and was attended by 180 delegates. The scientific content of the meeting had proved more controversial than usual. Dr. Marshall was to be congratulated on the smooth running of the administration at Loughborough. The annotated Proceedings had appeared in November 1975 and were available from the Plastics and Rubber Institute. "Colloid Rheology" was the subject of our Spring 1976 meeting held at Bristol in conjunction with the Faraday Division of the Chemical Society. Dr. Warburton had carried out the Society's share of the organization of this meeting assisted by Mr. Camina, and their efforts had been rewarded by the exceptionally good attendance of 120. The Plastics and Rubber Institute supported by several other Societies including the British Society of Rheology had sponsored the Third International Conference on "Deformation, Yield and Fracture of Polymers" at Cambridge during the Spring. Dr. Mills represented the Society by acting as Technical Secretary of the organizing committee. Many members of the Society had contributed to or participated in the VIIth International Congress on Rheology. The Society had made travel grants of £40 each to six research students in connection with this meeting and group travel arrangements had provided a worthwhile financial saving for other members. By contrast with these highly successful meetings the number of delegates, 35, attending the Autumn meeting on "Future Developments in Rheology" in London was disappointing considering the importance of the subject matter and the distinction of the speakers. A formal dinner planned to follow the meeting had been cancelled for lack of support. Next year we are looking forward to the Joint Meeting with the Italian and Dutch Societies in Pisa, April 13-15, 1977, entitled "Polymer Processing and Rheometry." The Italian Society has the organization well in hand and Canterbury Travel has offered to arrange delegates' travel on advantageous terms. Dr. Ferguson assisted by Dr. Hudson and Dr. Petrie will be organizing next year's Autumn meeting on "General

Rheology and Stretching Flows" to be held in Edinburgh, September 6-11, 1977. This meeting coincides with the Edinburgh Festival. Plans for 1978 are still amorphous and may include a Spring Meeting with the Faraday Division of the Chemical Society on "Rheological Behaviour and Molecular Properties" suggested by Dr. Warburton and a Joint Meeting with the Society of Rheology in Plymouth during August to be organized by Dr. Jones. The emphasis of the Society's meetings are clearly placed on collaboration: collaboration with our sister societies broadening our members range of contacts, and collaboration with other disciplines and technologies.

Professor Walters and Dr. Oliver have represented the Society in dealings with the International Committee on Rheology. Professor Kubat is the new President of this Committee and Dr. Tschogel is the new Secretary: both are members of this Society as well as their national Societies. The VIIIth International Congress on Rheology will be held in Italy in 1980.

Dr. Cheng had represented the Society on the British National Committee on Materials. However the Society has not been able to give or derive sufficient mutual benefit from its association with this body to justify imposing on a delegate's time in future. We have discontinued our association with that Committee.

A working party of the President, Professor Pearson, Dr. Marshall and the Secretary had held a meeting with the Director of Polymer Engineering of the Science Research Council as a result of which the working party had formulated and submitted to the Director a programme of rheological research to support his other programmes, together with suggestions for how that programme could be implemented. Professor Pearson and the Secretary are serving as representatives of the Society on the Director's Processing, Properties and Performance Advisory Committee. When the Director publishes his programme the working party will draw it to the attention of those members who could contribute to it. The working party will also assist the Director wherever it can.

Professor Wilkinson (Chairman of the Science Research Council Non-Newtonian Flow Panel) has invited the Society to assist in planning the activities of an S.R.C. Rheometry Laboratory at the Rutherford Laboratory.

The latter two activities in collaboration with the Science Research Council are new to the Society and Council seeks the advice and guidance of members as to how these contacts should be developed.

1976 had seen the launching of a new journal of prime rheological interest. The *Journal of Non-Newtonian Fluid Mechanics* is edited by Professor Walters.

The Secretary is particularly pleased when his post includes letters from members seeking information or introductions between those involved in industrial and academic research.

3. *The Treasurer* reported that the income of the Society during the last financial year was £2,694 and that expenditure was £1,769, leaving a gain for the year of £925. This gain is largely due to successful conferences, Rheology Abstracts and investments. The net assets of the Society are £6,281. A full report is appended.

A new activity was making grants to research students to assist in travelling to the International Congress at Gothenburg. Mr. Dobson proposed and Dr. Marshall seconded a motion that "Council is empowered, at its discretion, to use a sum of money each year to make travel grants to research students to assist them in attending overseas meetings, preference being given to authors of papers." The motion was carried without dissent. The meeting recommended that a suitable sum for the next year would be £250 and that no single grant should exceed £50.

"Council, noting the increasing number of international and joint meetings, sought the authority of the A.G.M. to award travel grants from the funds of the Society to the President or other nominee of Council to ensure that the Society is properly represented at such meetings." Mr. Hutton spoke against this resolution. While he was in favour of assisting the less affluent members of the Society he did not consider it appropriate to subsidize senior members in this way. The present healthy state of the finances was due to conference receipts and that healthy state was due to those who attended conferences not to those who organized them. Mr. Hutton was supported by Dr. Culpin in calling for a reduction in conference fees. Dr. Marshall replied that profits were made from conferences when they were attended by more delegates than expected by the organizers: the high attendance at recent conferences was partially attributed to their outstandingly low cost. Mr. Davenport pointed out that approximately one-third of the delegates at each conference were non-members and that they paid a higher rate. Dr. Oliver pointed out that it could be embarrassing for the Society if a senior member was not able to be present at overseas joint meetings and that the Society's willingness to contribute to his travelling expenses could weight significantly with his employer, who would still contribute the bulk of his expenses. Professor Ulbrecht proposed and Dr. Ferguson seconded that "the resolution should be amended to apply to the Pisa Conference in 1977 only." The resolution was amended by nine votes in favour and one against and was passed as amended by seventeen votes in favour to three against.

Mr. Hutton and Professor Ulbrecht suggested that a good way of spending the Society's funds would be to invite distinguished rheologists from abroad to give lectures. Council was instructed to investigate this possibility and empowered to act on that proposal if appropriate.

Mr. Hutton congratulated the Treasurer for his good stewardship to which the meeting added its full support.

4. *The Membership Secretary* reported that the membership of the Society remained nearly constant at 575, 359 of whom were domiciled in the United Kingdom and 116 overseas. During the year 41 new members had been elected and Professor Douglas and Dr. Neumann had also been awarded Honorary Membership of the Society. There had been six resignations and at present 41 members were in arrears with their subscriptions.

5. *The Editor of the Bulletin* reported that it had been his unhappy task to have to prepare obituaries for Professor Reiner and Professor Weissenberg during the year. The Editor was trying to reduce the delay which existed between proof reading and the appearance of the *Bulletin*. He would still like to see an improved balance between technical and news items and would especially welcome short papers from members.

6. *The Editor of Abstracts* apologized for the delays which had attended the preparation of Abstracts this year. The three remaining issues would appear before December 31. The format changes should result in a saving of £800 each year though this incurred the loss of the bold type and the righthand register. The content per page was also reduced so that 20–25% more pages would be used. This experimental format would be reviewed after a further year. The Editor expressed his gratitude to his abstractors, without whom Rheology Abstracts would not exist. During the year he had been able to recruit three new abstractors though he had lost one leaving 32 as the abstracting strength. Food journals were now covered again but there is plenty of work for new abstractors.

7. *The President* thanked all officers and Council for their services and particularly Dr. Hobbs who was retiring from Council.

8. *Election of Council*

There were no nominations for posts on Council other than those nominated by the retiring Council. The following were therefore declared elected to serve:

<i>President</i>	...	...	...	...	...	Dr. J. J. Benbow
<i>Secretary</i>	...	...	...	...	...	Mr. F. N. Cogswell
<i>Treasurer</i>	...	...	...	...	...	Dr. D. R. Oliver
<i>Membership Secretary</i>	...	...	...	...	...	Dr. T. E. R. Jones
<i>Editor of Abstracts</i>	...	...	...	...	...	Dr. D. E. Marshall
<i>Editor of the Bulletin</i>	...	...	...	...	...	Mr. M. Camina, Dr. K. M. Beazley, Dr. D. C-H. Cheng, Mr. T. C. Davenport, Mr. A. Evans, Dr. J. Ferguson, Dr. M. Sherriff

9. Dr. Benbow proposed a vote of thanks to the retiring President, Professor Walters. The Society was fortunate indeed to have had the advice and guidance of such a distinguished scientist during the last two years. The proposal was carried with acclaim.

There being no further business the meeting closed at 18.35.

F. N. Cogswell,
October 2, 1976.

REPORT OF THE HON. TREASURER FOR THE YEAR 1975-76

We are continuing on the same firm financial basis as for previous years, making a gain of £924.99, after paying six students a total of £240.00 to assist with expenses in travelling to Gothenburg.

The Conference Account does not include our share of the gain from the joint meeting at Bristol in April (with the Faraday Division of the Chemical Society), though it does include £65.45 of our expenses in running this meeting. I was hoping to have received exact information about the proceeds by now, but in its absence I am allowing the profits to assist next year's Conference Account, which may be less healthy owing to the lack of a full meeting in Autumn 1976. Dave Marshall and his helpers are to be congratulated on the success they made of running the joint meeting with the Plastics Institute at Loughborough in Autumn 1975, a most enjoyable meeting which provided the profit shown in this year's account.

Subscriptions and Entrance Fees maintain their satisfactory high level, whilst our share in the profits of publication of Rheology Abstracts has bounced back up to £611.63 from £334.93. This improvement follows our meeting with Pergamon in July last year, but is based on the old method of production. The photo-lithographic process recently introduced (with hard work by the Editor) has already reduced our directly-paid costs and we await the results for a full year with interest. The *Bulletin* production costs are gradually rising (a further bill is expected) and we shall review this situation in the light of our experience with the Abstracts production process.

Expenditure has been held steady—£1,546 last year compared with £1,528 this year—since the "Payments to Students" are not recurrent expenditure. The increase under the heading of Membership Secretary stems largely from increased Postal Charges. Expenditure on meetings of the Polymer Processing Sub-Committee is now replacing that on the National Committee for Materials.

Last December, the Society acquired Wandsworth Borough Council Bonds of value £2,500, for five years at $12\frac{5}{8}\%$ per annum. We also changed the terms of our Brentwood Bonds, of value £1,500, to 12%

per annum for two years. Our income from investments has now risen to over £600 per annum, though this will appear only in a full year's account.

Our overall position is a good one and we can continue with certain expenses which arise from time to time, an example being the assistance in travelling expenses to Conferences for students or other nominees of the Society.

Dr. D. R. Oliver,
Hon. Treasurer.

BRITISH SOCIETY OF RHEOLOGY

BALANCE SHEET as at June 30, 1976

ASSETS

Brentwood U.D.C. 12% Bond	1,500.00
Wandsworth Boro. Council 12½% Bond	2,500.00
Trustee Savings Account	1,607.94
Cash at Lloyds Bank	
Deposit Account	306.92
Current Account	425.67
	732.59
	£6,340.53

Less

CURRENT LIABILITIES

59.90	
	59.90
	£6,280.63

NET ASSETS

Represented by:

General Fund as at July 1, 1975	5,218.91
Add Excess of Income over Expenditure for Year	924.99
Add Trustee Savings Bank Interest	136.73
	£6,280.63

CONFERENCE ACCOUNT

Gain on Autumn 1975 (Loughborough) Meeting ...	520.00
Less Expenses Spring 1976 (Bristol) Meeting ...	65.45
Additional Cost of Book (Cambridge Meeting)	8.95
	74.40

Net Income shown in Revenue Account	£445.60
--	---------

July 12, 1976
smd

REVENUE ACCOUNT for the year ended June 30, 1976

EXPENDITURE		
1975	Committee Expenses (mainly travel)	1976
476	Council	379.28
6	B.N.C.M.	2.10
0	Polymer Processing Sub-Committee ...	38.46
0	Lunch for Director of Polymer Engineering	24.20
482		444.04
687	<i>Bulletin</i> —Production Costs	613.93
104	<i>Abstracts</i> —Production Costs	83.30
	Expenditure by Officers: —	
56	Secretary	42.34
15	Treasurer	19.47
160	Membership Secretary and Circulation ...	277.55
231		339.36
27	Professional Fees	32.40
15	Insurance	15.50
	Payments to Students for Travel to Gothenburg	240.00
0		
1,546 *	(*Plus 392-Membership list)	1,768.53
708	Excess of Income over Expenditure for Year	924.99
		<u>£2,693.52</u>
INCOME		
1,255	Annual Subscriptions and Entrance Fees ...	1,269.37
335	Publisher— <i>Rheology Abstracts</i>	611.63
13	<i>Bulletin</i> Subscriptions	49.00
0	Advertising and assistance in circulation ...	65.00
	Investment Income	
101	Bank Deposit Account Interest	71.38
104	Brentwood Bond	113.62
0	Wandsworth Bond	47.77
783	Conferences—Net Gain	445.60
5	Miscellaneous Income	20.15
		<u>£2,693.52</u>

July 12, 1976
smd

PERSONAL NOTES

Dr. J. J. Benbow

John Benbow graduated at the University of Wales with first class honours (Physics) in 1949 and was awarded a D.Sc. in 1961. After a brief period of research on armaments he began working in rheology at the Shirley Institute, Manchester, in 1949. In 1951 he joined I.C.I. at the Akers Research Laboratories, Welwyn, moving in 1957 to the Plastics Division and subsequently to his present location at Agricultural Division, Billingham, in 1964. He was appointed an I.C.I. research associate in 1971.

Since Benbow joined the B.S.R. in 1949 he has explored many areas of rheology and devised numerous experimental techniques. He investigated the visco-elasticity of organic glasses over a wide frequency range and related this flow behaviour to molecular structure. Later he examined several aspects of the rheology of molten polymers including their strain recovery, dynamic visco-elasticity, extrusion behaviour and the flow instabilities exhibited by extrudates.

His work at the Agricultural Division of I.C.I. has been mostly concerned with catalyst fabrication processes. Part of this was to investigate the factors relating the pressure needed to extrude ceramic pastes to extrudate velocity and die geometry. This basic research subsequently led to the invention of a die for making multi-cellular catalyst supports. Benbow has also investigated the compaction, plastic flow and agglomeration that occur during catalyst pelleting. In the past few years he has studied several rheological factors relating to the manufacture of biological materials.

For relaxation he designs and makes silver jewelry and table ware. His outdoor activities are walking on the Yorkshire Moors and gardening.

FUTURE DEVELOPMENTS IN RHEOLOGY

The Autumn 1976 meeting of the Society was held at the Institution of Electrical Engineers, London, on Friday, October 1. Considering the importance of the subject matter—which was effectively our jobs tomorrow—and the eminence of the speakers, the attendance of thirty-five, about six per cent of the Society's membership, was disappointing. The speakers, two from industry and two from university, had been invited to look ahead to future developments in rheology. The picture leaves no room for complacency, what we have achieved in the past has been less than perfect, what we must set our minds to in future are more difficult tasks still.

Mr. Davenport, Research Co-ordinator for B.P., took the hard view of industry which is in business for profit and only research which was profitable would continue. Industry had the job of working with complex materials in complex situations and even the most

sophisticated computer could only utilize a simple model—like the Casson equation—for material behaviour. In plant design the emphasis in the past had been on capital cost, today emphasis had also to be placed on energy saving and personnel costs. One aspect of growing importance was instrumentation which must be robust and simple. Problems associated with bulk handling and maintaining properties in continuous flow processes were common to all industries, transportation costs were rising so fast that we are already seeing the pipeline replacing the lorry in the transport of road building materials. For his own speciality, the energy industry, Mr. Davenport saw the challenge of new material systems, slurries of coal and oil, and tar sands which would require new rheological appreciation and new engineering design. Rheology, he suggested, was now moving out of its Grecian golden age where “everything flows” into its technological Roman phase where “everything that is hard is, *with difficulty*, softened.”

Dr. Challis, Director of Polymer Engineering of the Science Research Council, is clearly one of Mr. Davenport's Romans. Technology is the business of fulfilling need, he declared and continued that this can only be achieved by a systems approach to design and what Dr. Challis wanted was not new things but that we should be clever with what we have. Polymers are not well regarded by engineers, they are difficult to understand and poor understanding breeds distrust. What Dr. Challis is seeking is a translation of the rheological properties of polymers into engineering language and what he needs first is a translator who speaks both languages. Questioned by Professor Ulbrecht, University of Salford, the Director agreed that until that translation was made the money which had been invested in research into polymer processing at universities must be regarded as wasted. It was suggested from the floor that instead of bemoaning the complex properties of polymers the engineer should be educated to appreciate and utilize those properties, in the simplest case it is the non-Newtonian properties of polymers which make them processable at all and in films and fibres it is their orientability which provides their remarkable properties, but, Dr. Challis rejoined, without simple descriptive texts and properly documented case histories these properties would never be fully exploited by designers. Dr. Challis ended by casting down the gauntlet when he declared that “we have enough rheological information all that we needs is to translate it for the designer”—the two speakers who followed were not slow to accept the challenge.

Professor Wilkinson, Professor of Chemical Engineering at Bradford and Chairman of the Science Research Council Non-Newtonian Flow Panel, took characterization as his theme. It is insufficient to measure only that which it is convenient to measure and present characterization methods are inadequate at both very low shear rates,

such as are relevant to the flow of paint films or of oils through porous rocks, and also at very high rates such as occur in atomization or coating processes: extrapolation was no longer to be tolerated with increasingly critical problems of design. Another area is the study of elongational flows, the relevance of which is rapidly gaining acceptance, but which are experimentally difficult both in handling and in interpretation. The increasing importance of polymers posed new problems particularly the definition of properties of materials where those properties were manifestly transient. In plastics processing, flow during solidification processes intimately affected product properties but had received very little attention. Dr. Berry, Director of R.A.P.R.A. (another Roman?) suggested that the engineer would prefer to use a derived rather than a fundamental parameter and asked how this new information was to be used. The engineer in Professor Wilkinson intimated that not all engineers thought alike. Professor Wilkinson announced that the Science Research Council is sponsoring work at the Rutherford Laboratory aimed at developing a new range of rheometer designs which he hoped would be taken up by instrument manufacturers.

Professor Walters, Professor of Applied Mathematics at Aberystwyth and President of the Society, showed us our first equations of the day perhaps as much from a spirit of mischief as from any expectation of educating us. The study of theoretical rheology had developed rapidly in the last twenty-five years. Oldroyd had set the scene for continuum studies to develop equations of state and that work had culminated in the definitive statements of Coleman and Noll which had proved too complicated for practical use. So far the search for simplicity was unsuccessful and this study having given a basic framework within which we all worked would offer diminishing returns in future. An alternative approach based on the study of microstructure had been formulated by Batchelor while other theoretical rheologists drew their inspiration from perturbation theory. In the past most theoretical work had been based on simple geometries: future developments would consider more complex geometries, but not more complex equations of state, and they would concentrate on materials with long memories. The solutions of such problems must have predictive value. As an example of this approach Professor Walters discussed the flow of an elastic fluid round an L-shaped channel showing the stress histories and orientation patterns which were induced. What more could the Roman designer of an injection moulding tool for plastics processing require except that the solution should be printed in red when his design produced an orientation which would cause unacceptable service properties in his final product?

If we learn one thing as rheologists it is the difficulty of predicting what will happen in a changing environment. The Society is indebted

to the four speakers who made their predictions: all agree that there will be change and we will ignore the forces causing those changes at our peril. All the speakers appeared to support Mr. Davenport's simile that rheology is moving from its "Greek" to its "Roman" period. Perhaps this was also an unspoken warning—we all know who came after the Romans.

A. Macedonian

RHEOLOGY AND POLYMER ENGINEERING

by Dr. A. A. L. Challis

Let me start by defining the area covered by polymer engineering; it is that system of processes and operations which start with the polymer (in the case of thermosets with the pre-polymer) and finishes with the fabricated polymer in the hands of the user, hopefully performing its function.

Polymer engineering covers therefore a series of highly interactive steps; first the definition and analysis of the need to be fulfilled, then the definition of the performance of the article required to meet the need. Next follows the conceptual and detailed design stage. This seminal stage must include the selection of the optimum materials both from the point of view of the performance of the article and of satisfactory and economic fabrication. This aspect of the central design operation leads naturally on to prototyping of the problems of fabrication on the commercial scale with its constant balance between quality and rate of output. The final step is to market and sell, this closes the circle for all too often when you attempt to sell you really begin to understand the need for the first time. If you did not get the first step right some very brutal and expensive education will follow.

You may well say that this seems to be a very broad view of the engineer's function, and this I would accept. The definition of an engineer I like is that he is the man who can do for a penny what any fool can do for two pence. If a technologist is not in the business of fulfilling need, then I do not know him.

Secondly, you may well say that all these aspects of polymer engineering would be much wider than anything S.R.C. has yet attempted to support, and indeed this is so. The new Polymer Engineering Directorate is already straining at the bounds of established S.R.C. activity and some things within the system defined above cannot be directly helped by P.E.D., but we can and will reach out to other organizations which could act. Thirdly, you may well say that what has been described is the systems approach to design; and I would most enthusiastically concur. I will return several times to design. Design is the heart of engineering as a whole and not just

polymer engineering but I believe it is the main feature of polymer engineering where the greatest efficiencies lie and this carried through to the industry based on it. If polymer fabrication could get the design aspects right then, so to speak, many of the other troubles and worries would be subsumed. My theme to you is that the deep and wider interaction which ought to occur between polymer rheology on the one hand, and both the conceptual and detailed design steps for polymer articles on the other, has not occurred, is not occurring and must be made to occur.

Your final comment on the definition might well be that it is inadequate since it does not specify and does not emphasize the powerful interaction between the polymer making steps and the fabrication steps. This is a just and powerful criticism but I ask you to bear with me as part of a creative process needed to counteract the very bad start in life made by polymer engineering. Make no mistake—polymers and polymer engineers are not well regarded by engineers in general. There is a feeling that they represent an easy and even a lazy and sloppy way out of problems, but in practice the apparently easy solution is counter-balanced by failures from mysterious and difficult to understand causes; or at least difficult to understand in terms of the behaviour of metals. This leads on to a lack of confidence and to polymer not being considered with other materials of construction and use. There is also the feeling that polymers are the chemist's domain and most engineers retreat from chemistry. Allied with this is the feeling that failure in service is best met not by more careful thought about function design and fabrication, but by pushing the chemist back into the laboratory to emerge a little later, eye glinting, "eureka" on his lips with new wonder polymer, code number 79423. After a short delay—like five years—while commercial production gets going, code number 79423, now named Wunderene, goes into the same weary old ill-considered design and gives an article that performs just about adequately.

Three messages need driving home: firstly, that the end of the wonder polymer era is in sight. New commercially valid polymers will appear, but their influence on the scene will be minor, rather than as in the past, major. Secondly, polymers are very difficult materials to design in and represent a challenge to the engineer's skill and knowledge which few have been able to meet. They should be presented to young engineers as a challenge for them to meet which their predecessors and teachers have not met. Thirdly, the volume of polymers as materials of construction and use is now about the same as the volume of metals. A simple view of the total energy content of most fabricates, shows that the overtaking of metals by polymers will be accelerated by expensive, and ultimately genuinely short supplies of oil reinforced by costly coal and the slow progress of nuclear power.

These points are perhaps worthy of a little more elaboration. The wonder polymer situation is best shown by the present position of the big six—the polyethylenes, polypropylene, polystyrene, polyvinylchloride, the polyesters and the nylons. I have six good dinners lined up in the years up to 1994 based on odds at evens that none of them will have been displaced by any other thermoplastic. A similar bet placed on thermosets or elastomers would not be so secure. Why is this so? Surely a new thermoplastic capable of being made at equal cost on equal scale could win the day on the basis of a fairly marginally better performance. Not so, a simple technological economic evaluation of the period of some years required to reach equal scale shows that equal final price needs properties roughly twice as valuable to the user if the exploiter is not to be out of pocket by many hundreds of millions of pounds irrecoverable at the final profit margin. Where the properties are only about equal or slightly better then the same sort of analysis shows that the equal scale price or cost must be about half. A very tough entry fee and one unlikely to be met without something close to a near miracle in property improvement. The speciality high performance plastics and the so-called engineering plastics are a different case but on the whole an overpopulated area lacking elbow room. A new-comer here could easily bankrupt its exploiter.

Let me suggest an analogy with metals and metallurgy, always a safe and instructive thing to do with polymers. The periodic table contains 50 odd metals, about half of these you could go out and buy and about half of these buy easily in many grades. Half again are made in very large tonnages and enormous varieties. The metallurgist and designer in metals faced with the problem design, does not sigh deeply that the Almighty was remiss over that periodic table, and what he needs is a new metal element. On the contrary, he sets to work with his tool kit labelled “alloying,” “heat treatment,” “hot and cold working,” “surface treatment” and last but not least better and cleverer design until the problem is solved.

Man has made about 100 polymers in sufficient quantity to be reasonably sure that the measured properties bear some slight relationship to what they might be. For about half of these the properties stated are reasonably accurate. About half again, i.e. 25 or so, can be bought commercially and about 12 of them in quantity with half of them making up the big six available in enormous variety of grades if needed. When faced with a problem why does the polymer scientist and the polymer technologist take a leaf out of the metallurgical book and be clever with what he already has?

But let me return to design. As a material of construction and use polymers are awful. They are weak, floppy and often unhappily brittle in combination with being floppy. They have a narrow temperature range of performance and often show a sharp change of performance

with a few degrees. Finally, they have some very nastily time dependent properties and a memory for their previous form and for the experiences they have gone through in fabrication. The fabricates sit there looking inscrutable with all their faults hidden under the smooth surface and difficult to detect. Why on earth does anyone use them? Well, they generally have low corrosion but this is balanced by the nasty phenomenon of stress corrosion occurring. The answer is that they have one supreme property not measured by any single property parameter—an ease or facility of fabrication. In one operation which can be rapidly repeated can come an article of great complexity, high precision and high surface finish, ready for use. Alternatively large single articles can be made by methods happily resembling those of childhood play things.

The design challenge of these awful materials is in fact reinforced by their ease of fabrication. The cost of fabrication rarely exceeds the cost of the material. This is not true with metals. The fabrication is usually several times the cost of the metal and the use of a little more metal can often ease the expensive metal fabrication process so most metal articles are in fact over designed. The polymer article by contrast must be of minimum weight and therefore must be up against some limiting property. All polymer articles have to be designed as though they are aeronautical components and this is not unconnected with the fact that some of the most competent designers in the field were trained originally as aeronautical engineers.

Let us look at the design problem through the engineering designer's eyes. In metal he has a range of helpful texts—materials handbooks and design handbooks. He has relatively simple mathematics and he can work mostly treating his material as elastic. Worries about creep and brittle failure are secondary effects where there is much case history to guide him. In polymers these familiar and well tried props are missing. The material is not elastic, it is visco elastic. The mathematics are more complex. It is no use arguing that an engineering designer should be able to handle simple tensor mathematics—most of them cannot and great pressure would be required to persuade designers that they must have this tool. The materials handbooks available are unfamiliar, case histories seem to be lacking. The design treatises available are at one and the same time both incredibly simple and horribly complex. There are simple things all too often followed by “do put in the largest possible radiuses,” “do not change section unless you must.” At the other end there are nasty bits about flow induced orientation; how do I know if I have got that, and why does it matter? The idea that such fabrication induced artifacts might be helpful is out of sight for most designers.

Surely a translation is necessary and is possible. The rheologist's language can be translated into the engineer's language. Surely ways can be found round the mathematical difficulties. Surely we can

gather case histories both black and white to give the designer some confidence that the ground has seen human foot before. Translations need a translator and he must be able to think, understand and communicate in both languages. A rare being, yet this has been done in the admittedly simpler case of rubber—see Peter Lindley's brilliant little monograph published by M.R.P.R.A., or the late Bob Payne's textbook. Of course rubber design is simpler. It is elastic just like metal but more so.

You as rheologists must come half way on this one and then the further mile. Is there amongst you the translator I seek? Is my belief right that much of the rheology needed to give the designer his requirements is already available? Am I right in thinking that the translation exercise once mounted would point to lacunae, the filling of which would not only be scientifically interesting but socially valuable? If rheologists do not progress here, engineers will continue to be trained to meet the materials balance of the past, not that of the next 25 years, and the polymer fabrication industry will continue to give some cause for plastics to be a dirty word. The problem is urgent.

The Seventh International Congress on Rheology

August 23–27, 1976

Chalmers University of Technology, Gothenburg, Sweden

By D. C.-H. Cheng

The Seventh International Congress on Rheology was held on August 23–27, 1976 at the Chalmers University of Technology, Gothenburg, Sweden. It was attended by some 450 delegates from 26 countries, many of whom were accompanied by their wives and children. Over four and a half days of working sessions, 29 invited papers and about 240 contributed papers were presented, on some days in five parallel sessions plus "poster sessions," of which more anon. In contrast with previous Congresses, the Proceedings were distributed to the delegates on registration. The volume contains 673 pages and weighs more than 1.71 kg ($3\frac{3}{4}$ lb.). There was an exhibition of rheological testing equipment, at which a dozen or so European and American companies took part, and a book exhibition. The technical sessions were well interspersed with a programme of social activities. There was a separate ladies programme.

The contingent from U.K. totalled more than 50, plus wives. They converged on Gothenburg by all means: air, boat, train and car, some camping along the way. Twenty or so took advantage of the group travel facility arranged by the British Society of Rheology and arrived in the early afternoon of Saturday. There was ample time to scout round the city for eating places, to explore the sights on a 24-hour tram/bus ticket, going as far as the archipelago, or to take

a boat trip and visit the island Fortress of Elfsborg, before settling down to the business of the Congress. The invited papers from U.K. were by Professors Jim Oldroyd, Ken Walters and Anthony Pearson and Sam Hutton. Others among us contributed another 25 papers. It was regrettable that the U.K. representation at the exhibition of rheological instruments was particularly weak. There was only some sort of a presence by one well-known manufacturer. The omission was partly compensated by Deimos Ltd. of Canterbury, who demonstrated a new combined torque and thrust piezoelectric transducer attachment for use on the Weissenberg Rheogoniometer.

The scientific papers presented at the Congress covered the usual wide range of topics. They were divided rather loosely into the following categories: theory, methods, fluids, suspensions, metals, polymers (solids, elastomers, melts and solutions), concrete, food, biorheology and, as any sensible classification system must have, miscellaneous. (Shop-talk overheard at a lunch table: "What are you working on?" The answer: "Food!") Some papers on viscosity measurements on gases were included in the "methods" category and properties of powders appeared in "concrete." It proved exceedingly difficult for the conscientious delegate to choose between the many papers that interested him/her because so many of them were presented in parallel sessions. However, the availability of the Proceedings was a help, providing more details than the title and an abstract would and so allowed the delegate to be more discriminating and to make a better choice of which papers to attend. For this report, therefore, I can only say something of those topics that reflected my personal interests.

In the plenary lecture on the history of the International Committee on Rheology, future activities of the Committee were considered. It was suggested that one activity might be to compile an international definition of rheological terms. Now, many national societies, standards institutions and individual workers have already attempted to draw up glossaries over the past decades without their efforts gaining universal acceptance. One wonders whether further endeavours will be worthwhile. Maybe it is not possible to have once-and-for-all definitions in a fast developing field. Workers are bound to want to extend and widen the meaning of terms as the understanding of the subject widens and deepens. It seems clear that no definition or classification system can be perfect unless the subject matter has been fully exhausted and is dead. Perhaps it would be more useful to have a sort of encyclopaedic treatment of the more important terms, surveying how they are used in the literature. Such a compilation could be readily up-dated so as to keep up with advances.

Many papers were concerned with the use of rheological measurement in the study and elucidation of the molecular nature and processes of materials. Network theory of polymers, thixotropic structures and microrheology of suspensions received the usual atten-

tion. There were a few papers specially on gel properties and a new topic called "kinetorheology," which attempted to incorporate the effect of chemical reaction into the description of rheological behaviour. This latter development could prove to be a new growth point in rheology because of its wide potential applicability to materials that age or otherwise change with time: Foodstuffs, concrete and biorheological fluids, just to name those covered in this Congress.

The discussion of molecular theories prompts another thought. It is that in many instances rheological measurements can be interpreted for use in engineering design without the need to get involved in a detailed understanding of the molecular nature of materials. This is so with Newtonian viscosity; and non-Newtonian flow curves can be obtained using the explicit formulae method. Single-structured thixotropic data can be resolved into constant-structure flow curves and rate equations which can be used to predict start-up pressures and flows in pipelines (There was a paper on this topic in the Congress); with linear viscoelasticity, the relaxation time spectrum can be deduced from either dynamic testing or creep or stress relaxation experiments and can then be used to calculate behaviour under other testing or flow conditions. But this is not so with rheologically complex materials such as multi-structured thixotropy, non-linear viscoelasticity and chemically-reacting, ageing or otherwise changing materials. It seems at present that measurements on these materials need molecular interpretation to make sense and to be able to be translated from the viscometric flow conditions to flow situations of engineering interest. Will the engineer therefore need to pay more attention to molecular theories? But the problem with molecular theories is that, while they give some insight into rheological behaviour, they often do not model measurement data sufficiently accurately for engineering purposes. Will it be possible with further research to develop test procedures and data interpretation that would obviate molecular interpretation and allow measurements to be used directly in design calculations even for these complex materials?

The theoretical sophistication of the papers in the Congress varied very widely. On the one hand there were those that conducted their discussions in terms of tensors and matrices, condensing six equations into one and putting forth new concepts in concentrated form. On the other hand there were those that managed to curve fit their data with model flow curves or viscosity-concentration relationships. What the authors did, have their uses, but the workers were not helped by the proliferation of model equations that exist in the literature or that can be generated with or without theoretical considerations. Often two workers having obtained data on the same or similar materials cannot readily compare results, because each had fitted the data to different equations. It is obvious that it would be useful to have some inter-

national agreement on standardized data treatment and curve fittings so as to facilitate comparison of results and interchange of ideas.

There was a decided sparsity of papers on normal stress effects. In fact the term "normal stress" did not appear in any of the titles. It would appear that the phenomenon that was introduced by Weissenberg at the First International Congress at Scheveningen has begun to play itself out. The impetus needed from industrial application to keep it in the forefront of research has not come about. It has not passed into engineering practice and engineers do not use it, far less to need it, in the design of processing equipment. In its place the study of elongational flow is gaining popularity. But one can foresee that the growth of interest could be slow in the absence of a commercial instrument for elongational testing of fluids. In the way that the study of normal stresses was pushed forward by the development of the Weissenberg Rheogoniometer, a ready-to-use elongational viscometer would no doubt change the pace.

The dual rôle of rheology as a tool for the study of molecular behaviour and as the basis of engineering design has already been touched on. It is understandable that the majority of papers should be devoted to the former at a scientific conference as opposed to an engineering one. At the Congress, even those papers that discussed the hydro-dynamical aspects (flows round bodies and flows through complex channels) tended to carry a scientific connotation. It was difficult to see how the work done could be applied to industrial processing problems. The one area of engineering rheology that was reasonably well covered was polymer processing. Several invited papers and numerous contributed papers dealt with extrusion, drawing, injection moulding and processing of multi-phase materials. Interesting though the results were, and one can readily appreciate their potential usefulness, at the moment they provide only a qualitative guide-line to the engineer. There is a long way to go yet before they would become translated into design manuals that the engineer would keep at his elbow for instant and constant reference.

I come now to "poster sessions," the new concept in conducting scientific conferences that was tried out at the Congress. It is stated to be capable of allowing 120 papers to be presented in the time and space that would be enough for the presentation of only about a dozen papers with the conventional lecturing session. All that is required is an open hall or a suite of rooms. Authors are allocated space and boards on which to display textual materials to illustrate the main points of his paper, with accompanying diagrams, charts, photographs, data, etc. He remains with the display for a definite period to answer questions and expand on the material. Visitors can go directly to the papers which interest them and discuss details with the author. With the many obvious advantages over conventional

sessions, poster sessions have been well received whenever tried during the past few years and favourably reported upon.

About a third of the papers at the Congress were scheduled for presentation in poster sessions. The venture was regrettably only partially successful. Some authors did not bother to take part. They either did not appreciate the advantages or were still clinging to the well-worn lecture presentation, maybe even thinking that being scheduled for poster sessions was being relegated to being also-rans. Others did not take the trouble to prepare their display, either posting up slip-slop material or leaving the preparation to a few last minute scrawls. They would have had difficulty attracting even those visitors that were interested in the subject. Another reason why the poster sessions were not an unqualified success was probably because of the clash with the many interesting invited papers and the remaining two-thirds of the contributed papers that were being presented in the lecture theatres. The authors were unable to desert their stands at the poster rooms. The audience was torn between missing the lectures or having to make a dash from the theatre to the poster rooms for a hurried discussion before the poster sessions closed.

For those who took the trouble to prepare their presentation in advance and for those who attended the poster sessions and took part in the discussions, it can be said that the theoretical advantages were borne out in practice. Quite a few stands were crowded three or four deep over the whole of the poster periods. One or two continued well past their allocated time. There will be those that would advocate that all future conferences should be conducted in poster sessions. And, of course, if professional exhibition advice were used, the display can be made even more eye-catching and colourful and might even attract those visitors who do not in the first instance have an interest in the work.

There was a full social programme for the delegates, that was also enjoyed by the ladies in addition to their own programme of sight-seeing, visits, and gastronomical and shopping trips. The social programme started with an open-house party on the previous Sunday and ended with a farewell party in the Friday afternoon during which schnaps and beer flowed quite unrestrained by rheological principles. In between there was a cocktail party at the Börsen City Hall, when the Mayor of Gothenburg presented a brief history of the city and the university; a rather pointless but glorious excursion across the sea to Fredrikshaven, which describes itself as the "puppy among Danish towns". The boat trip was thoroughly enjoyed by the great majority if not everyone: many enthusiasts persisted in talking shop during the trip and so incurring the displeasure of their wives; then there was the Congress Banquet at the sea's edge at Långedrag.

Now, of all the activities that go to make up an international gathering perhaps the Banquet is the one that will mark the gathering and

one by which a participant will remember the conference. The Fourth International Congress had its clambake on the beach which was recorded photographically for all time in the Proceedings. The Fifth was notable by the half-a-dozen or so wine and liquor glasses at the Banquet table, all of which were kept topped up right through the feast; beer was also served to one delegate who requested it. The Sixth International Congress was memorable by the top table being physically floors above the rest of the congregation and speeches, delivered in triplicate in the three official Congress languages *and* before food, which the communal singing of the jingle used to signify times-up at the technical sessions was unable to stop. At the present Congress, the diners were welcomed by a dinner-jacketed, top-hatted as well as flat-capped band, fed on shrimps, file of deer and a surprise, with the accompaniment of a second dance band, cabaret and speakers each out-doing the other with being witty and amusing. After a recess during which the top table was cleared away, coffee and liqueurs were served with dancing until well past mid-night.

It was undoubtedly a well organized and successful Congress. Professor Josef Kubát, Dr. Carl Klason and their team of helpers are to be congratulated and thanked for the effort they have put into the preparation and running of the Congress.

For the next time, the Italian Society of Rheology has issued an invitation, which has been accepted by the International Committee on Rheology, to be host to the Eighth International Congress. The venue would be Naples or in the surroundings. Professor Gino Astarita promises that a trip to the island of Capri would be organised. Everyone now looks forward to this future meeting with eager expectations.

JOINT MEETING ON POLYMER PROCESSING AND RHEOMETRY PISA APRIL 13-15, 1977

Travel Grants for Students

At the last Annual General Meeting it was decided that the Society should make a sum of money available to assist students engaged on research in rheology to attend the Joint Meeting at Pisa. Members of the Society, who are full-time students, may apply in writing to the Secretary to be considered for an award and that application should be endorsed by the student's supervisor. The amount and number of the awards will be at the discretion of Council. Applications should be made as soon as possible and not later than March 1, 1977. Preference will be given to authors and co-authors. Please notify the Secretary of nominations.

Travel Arrangements

CANTERBURY TRAVEL with the permission of the British Society of Rheology have pleasure in offering Inclusive arrangements to participants and or their families or friends to attend the above Meeting. Details of our tour are set out hereunder:—

Available on an individual basis

TOUR "A"

Sunday	April 10	London/Pisa	AZ 317	depart 08.45.hrs. arrive 10.45.hrs
Saturday	April 16	Pisa/London	BE 387	depart 15.40.hrs arrive 17.40.hrs.

An allotment of accommodation is held at the Hotels Roma and Duomo which are within 10 minutes walking distance from the Abbazia di S. Zeno where the Meeting will take place.

COST:—

HOTEL ROMA		HOTEL DUOMO	
Twin without bath	£130. 75.	Twin with bath	£157.00.
Single without bath	£136. 75.	Single with bath	£170.50.

IMPORTANT:— If at least 10 persons travel out and back on the above specified flights and subject to our being able to obtain contracted group air fares, the following prices will apply.

HOTEL ROMA		HOTEL DUOMO	
Twin without bath	£ 99. 70.	Twin with bath	£125. 95.
Single without bath	£105. 70.	Single with bath	£139. 45.

ALTERNATIVE ACCOMMODATION:—

If delegates have already secured accommodation or would prefer an alternative hotel, we shall be pleased to incorporate their reservation or requirements in our Inclusive Package and provide the benefit of the Special Air Fare. Please complete our booking form accordingly.

Please notify secretary for further details. Latest date for booking 15. 2. 77.

CALL FOR PAPERS

1977 Annual Conference in Edinburgh

The 1977 Annual Conference will be held in Edinburgh from the September 7-9. The title is "General Rheology and Stretching Flows." Those wishing to present papers on either side of these topics should send summaries to Dr. J. Ferguson, before January 1, 1977.

The Conference will be held in the University of Edinburgh. Accommodation has been booked in the Pollock Halls of Residence close to the centre of the city. The Edinburgh Festival will be in progress and it is intended to send society members details of events and booking forms.

Drag Reduction

The Second International Conference on Drag Reduction to be organised by B.H.R.A. Fluid Engineering will be held at St. John's College, Cambridge, England, from August 31 to September 2, 1977. Offers of papers are invited.

In any system or process where fluid is pumped over some distance, drag forces and friction can be a problem. By improving performance, drag-reducing agents can offer considerable savings to a wide range of industries. Papers will be welcomed on all aspects of drag reduction including additives, their selection and preparation; the problems of degradation; and additive removal. Submissions on design methods, effects of drag reduction on internal flow configurations, and economic aspects will be considered and contributions covering new techniques and applications are also sought.

Authors should submit titles and synopses by November 30, 1976 and manuscripts will be required by April 1977.

Further details are available from the Organizing Secretary, 2nd Drag Reduction Conference, B.H.R.A. Fluid Engineering, Cranfield, Bedford MK43 0AJ, England; telephone Bedford (0234) 750422, telex 825059.

Courses

THE PRINCIPLES AND PRACTICE OF FLOW MEASUREMENT

Five-Day Course

March 7-11, 1977

Conference Section:—

National Engineering Laboratory, East Kilbride, Glasgow
G75 0QU. Telephone: East Kilbride 20222 Ext. 433.

A course for engineers, plant designers, plant operators, and anyone concerned with the purchase, use and calibration of flowmeters.

This is not a course for flow measurement experts, but for the ordinary engineer who wants to know how to choose the right flowmeter for his particular needs, and how to get the best out of it when he has it. No previous knowledge of the subject will be assumed.

An important feature of the course will be practical sessions where course members will be able to participate in the testing and cali-

bration of flowmeters, using N.E.L.'s comprehensive facilities which are among the best in the world.

To enable individual attention to be given to course members the number of places will be limited to 40. Early registration is therefore recommended.

The fee is £90 plus 8% V.A.T. (V.A.T. Reg. No. GD 255). This includes lunch and refreshments each day and a course dinner, but does not include accommodation.

Synopsis of Course

Elements of pipe flow.

Basic properties of measuring instruments.

Construction and performance of the principal types of flowmeter: differential pressure, positive displacement, turbine, vortex-shedding, fluidic, electromagnetic, ultrasonic, insertion, and mass-flowmeters, etc.

Choosing the right flowmeter for the job.

The importance of correct installation of flowmeters.

Trouble shooting.

Data collection, processing and storage.

Secondary instrumentation, and integrated metering systems.

How to calibrate flowmeters with liquids and gases.

Special techniques of flow measurement: tracer methods, cross-correlation, laser velocimeters, velocity integration.

Special problems: pulsating flow, two-phase flow, viscous liquids, cryogenic liquids.

Flow measurement standards.

How N.E.L. can help the engineer.

FUTURE MEETINGS

B.H.R.A. FLUID ENGINEERING

SECOND EUROPEAN CONFERENCE ON MIXING

Wednesday, March 30, 1977. St. John's College, Cambridge

Session A

The Organizers reserve the right to make such alterations to the programme that become appropriate.

The influence of viscosity on micromixing in a continuous stirred tank reactor.

J. R. Bourne, U. Moergeli and P. Rys, ETH, Switzerland.

An evaluation of impellers for use in the Viscous Regime.
K. J. Molineux, P. J. Flagg and N. Sampson, Lightin Mixers Ltd., U.K.

Laser Doppler measurements of turbulence in a standard stirred tank.

X. B. Reed, Jr., M. Princz and S. Hartland, ETH, Switzerland.

The effect of agitator geometry and speed on yield in batch reactors.

D. J. Tookey and D. C.-H. Cheng, Warren Spring Laboratory, U.K.

The numerical prediction of flow patterns around perpendicular stirrer blades for non-Newtonian power-law fluids.

E. T. Sweeney, B.H.R.A. Fluid Engineering, and M. A. Patrick, University of Exeter, U.K.

Session B

An investigation of the quality of mixing in an in-line mixer.

W. L. Wilkison and M. J. Cliff, University of Bradford, U.K.

Liquid-liquid mixing during flow through scale-models of water-supply reservoirs of irregular shape.

R. B. Whittington, Liverpool University, U.K.

Mixing in water treatment—dispersion of small chemical quantities into large liquid flow.

M. Creissels and P. Jonquieres, Société des Procédés SEM, France.

Micromixing in a jet-stirred flow system.

T. Wood and N. H. Hop, University of Sydney, Australia.

Application of inhomogeneity moments for characterization of mixing processes.

T. Blickle, Hungarian Academy of Sciences, Hungary.

Axial dispersion in fixed beds.

M. F. Edwards and T. Helail, University of Bradford, U.K.

Resident time distribution of viscous fluids in a static mixing unit.

G. Schutz, F. Streiff and P. Mathys, Sulzer Brothers Ltd., Switzerland.

Gas mixing in fluidized beds near minimum fluidization.

D. J. Crann, University College of Swansea, U.K.

Session C

Mixing of air and fuel in the inlet tract of petrol engines.

J. R. Goulbourn and D. W. Hughes, Queen's University of Belfast, N. Ireland.

Visualization study of liquid droplets in a gas stream.

J. T. Turner, University of Manchester, U.K.

Thursday, March 31, 1977

Session D

Ordered or random mixing: choice of system and mixer.

J. A. Hersey, C. W. Yip, Institute of Drug Technology Ltd., Australia.

Energetic efficiency of mixing operations.

P. Le Goff, CNRS-ENSIC, France.

Simplified approach to a particulate case of mixing in a mass-flow bin.

A. Mickiewicz and A. Wlodarski, Institute of Industrial Chemistry, Poland.

Hopper blending methods.

C. Schofield and D. Tookey, Warren Spring Laboratory, U.K.

The limiting mixture quality values for an agglomerating particulate mixture.

M. Coelho and N. Harnby, University of Bradford, U.K.

A distribution index and its application to a static powder mixer.

M. H. Cooke and J. Bridgwater, University of Oxford, U.K.

Session E

Drop size distribution in agitated liquid-liquid vessel.

A. Gozal and H. Angelino, Institut National Polytechnique de Toulouse, France.

Drop size and drop size distribution for liquid-liquid dispersions in agitated tanks of square cross-section.

J. C. Godfrey and V. Grilc, University of Bradford, U.K.

Mixing-disguised chemical selectivities.

P. Rys, E. Crivelli, F. Nabholz and R. J. Ott, ETH, Switzerland.

Session F

Use of laser-dropller anemometry to study turbidity current formation.

T. L. Shaw, University of Bristol, U.K.

Density transients during solid-liquid mixing.

M. Greaves and C. A. Economides, University of Bath, U.K.

Finite-stages with backflow model as applied to solid-phase mixing.

M. E. Abou-El-Hassan, Cairo University, Egypt.

Mixing of coarse coal-water slurries.

R. R. Faddick, Colorado School of Mines, U.S.A.

Friday, April 1, 1977

Session G

Gas dispersion in mixing vessels.

P. H. Calderbank, University of Edinburgh, U.K.

Dispersing of gas in viscoelastic liquids.

J. Ulbrecht et al, University of Salford, U.K.

Deteriorating mixing quality and yield losses on scaling-up gas-liquid reactors.

R. Mann, UMIST, and J. C. Middleton and I. B. Parker, I.C.I. Ltd., U.K.

Gas hold-up in agitated aqueous solutions of strong inorganic salts.

V. Machon, J. Vlcek and V. Kudrna, Prague Institute of Chemical Technology, Czechoslovakia.

Development of a self-inducing disperser for gas/liquid and liquid/liquid systems.

C. Koen, Consulting Engineer, France.

The effects of scale of geometry on floodings, recirculation and power in aerated vessels, A. W. Nienow and D. J. Wisdom, UCL, and J. C. Middleton, I.C.I. Corporate Lab., U.K.

Scale-up of agitated gas-liquid reactors for mass transfer.

J. M. Smith and K. van't Riet, Delft University of Technology, Netherlands, and J. C. Middleton, I.C.I. Corporate Lab., U.K.

Session H

Electrohydraulic mixing in bubble columns.

D. P. Simpson, Electricity Council Research Centre, U.K.

Liquid-phase mixing in bubble columns.

E. L. Smith, M. Fidgett and S. Shayegan, The University of Aston in Birmingham, U.K.

Liquid mixing in two phase flow.

J. H. Hills, University of Nottingham, U.K.

Registration details will be available from:—

ORGANISING SECRETARY

**BHRA FLUID ENGINEERING CRANFIELD BEDFORD
MK43 0AJ ENGLAND.**

TELEPHONE: BEDFORD 750422

(STD CODE 0234)

TELEX: 825059

NOTE

The Membership Secretary has taken over all records of membership addresses including those for Rheological Abstracts. Will members changing addresses *make sure* they notify the Membership Secretary.

Membership of International Committee of Rheology—Omission.

In the paper entitled "A brief history of the International Committee on Rheology" published in the Bulletin Vol. 19, No. 3 1976, Nederlandse Reologische Vereniging should have been included among the members of the I.C.R.

APPLICATION FOR MEMBERSHIP—SEPTEMBER 1976

Dr. Stanley John Bryan, B.Sc.Chem., Ph.D. p,e,a,D,F,G,H.	Donald Macpherson & Co. Ltd., Radcliffe Road, Bury BL0 9SJ.
David Malcom Cobb, C. & G. Tech. Cert. f,e,a,G,O.	Donald Macpherson & Co. Ltd., Radcliffe Road, Bury, Lancs.
Dr. Christopher J. Coleman, B.Sc.(London), A.R.C.S., Ph.D., A,C.	Applied Mathematics Dept., University College of Wales, Aberystwyth.
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1977

January 27. "Mould Making 77."

February 15-16. "Large Plastic Components."

March 30-April 1. 2nd European Conference of Mixing.

April 13-15. "Polymer Processing and Rheometry."

September 7-9. General Rheology and Stretching Flows, Edinburgh.