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THE
BRITISH SOCIETY
OF RHEOLOGY

BULLETIN — No. 4, 1965

Hon. Secretary :

MR. R. J. COLE,
Paint Research Station,
Waldegrave Road,
Teddington, Middlesex.

Hon. Editor (Bulletin) :

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

HERBERT H. LANG

If any one man could claim to be founder of our Society, it would be Herbert Lang, whose recent death came as a sad shock to his many rheologist friends. He was not himself a rheologist but, as Secretary of the Institute of Physics, he and his Staff were evacuated during the war to Reading, where I had the privilege of seeing much of him. At the most critical moment in the war (1940) Lang noticed that his friend Dr. V. G. W. Harrison and I, though working on materials as apparently unlike as printing inks and bovine cervical mucus, had many problems in common. He introduced us to each other and the three of us decided that, though it seemed an unsuitable time to start a new Society, some sort of informal group should be formed among people whose work, during the war, had to do with complex rheological problems. The first meeting, held in Reading under the Presidency of Sir Geoffrey Taylor, made it clear that the need was greater than we had expected and the British Rheologists' Club was founded.

In the early days, meetings of our little "Committee" of three were held on Saturday afternoons at my house, some two miles from where Lang was living. His deep religious convictions did not allow him to travel by bus on Saturday and he would walk the four miles, wet or fine. Harrison and I soon came to appreciate a man of sterling qualities, unshakable integrity and fine organising ability. His splendid work as Secretary had, I am sure, much to do with the rapid expansion of the Institute of Physics. Combined with these invaluable qualities, was a delightful sense of humour and an intense interest in other people's problems. The British Society of Rheology has lost, not only its true Founder, but a very real friend.

G. W. SCOTT BLAIR.

RHEOLOGICAL PROBLEMS IN THE HANDLING OF FRESH CONCRETE

by G. H. TATTERSALL

Concrete is one of the major modern building materials but most of it is made on the site under conditions such that the degree of control possible in a factory cannot be achieved. To obtain economically the quality required, a considerable degree of technical knowledge and skill is needed, and the task could be made easier if more were known about the rheological properties of the material.

Concrete consists of a mixture of coarse aggregate, fine aggregate, and cement in proportions of the order of 4:2:1 with a quantity of water equal to about half the weight of cement. The aggregates are chemically inert and usually consist of natural gravels and sands or crushed rock. The coarse aggregate particles may range in shape from almost spherical to elongated or angular and lie in size between the $3/16$ " sieve and the $3/4$ " or $1\frac{1}{2}$ " sieve, although sometimes the upper limit may be higher; the fine aggregate is the material which passes the $3/16$ " sieve but is retained on the 100 sieve. A typical grading curve of the combined coarse and fine aggregate is shown in Figure 1.

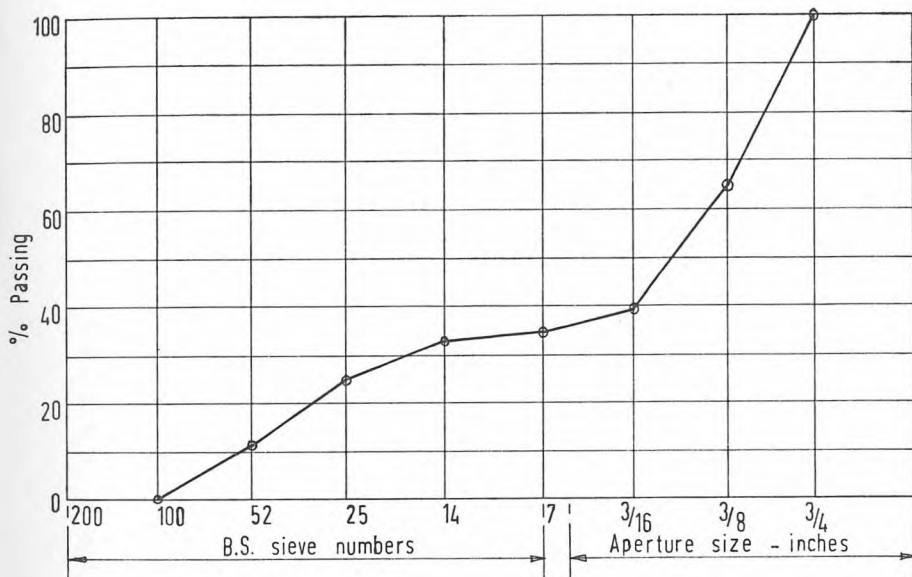


Fig. 1. Typical Grading Curve for Combined Aggregates.

Ordinary Portland cement is a powder of specific surface about $3,000 \text{ cm}^2/\text{g}$ and is composed mainly of calcium silicates which react with the water to form hydrates, a process which is observed macroscopically as the setting and hardening of the concrete. It is a process which continues for a long time and concrete continues to gain strength for years. Contrary to popular opinion therefore, the setting of concrete is not a drying out process and indeed extensive evaporation must be prevented.

However, the quantity of water needed for the hydration is only about one quarter of the amount of cement by weight, and any excess over this quantity causes a drop in the potential strength of the hardened concrete. For medium strength concretes, the strength attainable at a given age is a function only of the water/cement ratio and is given approximately by Abram's Law $S=A/B^x$, where S is the compressive strength, A and B are constants and x is the water/cement ratio. Thus the greater the value of the ratio, the lower the strength. It does not follow, however, that the water content can be restricted to the quantity needed for hydration because a mix designed on this basis would be quite unworkable.

Workability is the term used to describe the flow properties of fresh concrete: it is concerned with the ease with which the material can be placed in the mould and with its ability to flow into all the recesses, and between reinforcement which may be quite congested. Another essential requirement is that the concrete must be capable of being fully compacted; that is, all air voids must be removed. The presence of air has a marked effect on the strength of concrete; 5% air causes a 30% loss in strength.

The workability of a concrete mix obviously depends on a number of factors, among them the properties of the aggregate. The particular shape is important in that, other things being equal, a rounded aggregate will give a more workable mix than an angular or flaky aggregate, not only because of the greater ease of relative movement of the particles but also because they have a lower specific surface and therefore require less cement paste to coat them. An aggregate containing a smaller proportion of fine material will produce a more workable mix, within limits, for the same reason, but there must be sufficient fine material to fill the voids between the coarse particles, and the tendency for segregation must be avoided by the choice of a suitable particle size distribution.

Workability also depends, of course, on the water content and it can be increased by increasing the water/cement ratio, but there is a limit beyond which "bleeding" and sedimentation occur, and it must be remembered that an increase in water/cement ratio results in a drop in the potential strength of the hardened concrete.

There are thus two conflicting requirements:

- i. to keep the water/cement ratio low for good potential strength;
- ii. to provide adequate workability so that the concrete can be placed satisfactorily, can cover and penetrate reinforcement, and can be fully compacted.

To some extent these requirements can be reconciled by increasing the cement content so that the water content can also be increased while keeping the water/cement ratio at a reasonable value. However it is uneconomical to use more cement than is absolutely necessary because cement is by far the most expensive constituent of the mix, and in addition the use of too rich a mix can cause excessive shrinkage, and other troubles.

As has already been mentioned, workability is affected not only by water content but also by the shape and particle size distribution of the aggregate. A great deal of systematic experimental work has been carried out to study the relationships between the strength of hardened concrete and the factors which may be varied in making the mix, and on the basis of the results of this work methods of mix design have been established.¹

The process of mix design may be summarised as follows.

- i. Decide what mean strength the concrete is required to reach at a given age. In making this decision the design strength and the variability of the product are the factors taken into account.
- ii. Using the strength-water/cement ratio curve find the corresponding water/cement ratio.
- iii. Decide what workability is required after considering the circumstances in which the concrete is to be placed.
- iv. Taking into account the workability and the grading and particle shape of the aggregate decide, with the help of tables, the aggregate/cement ratio.

This illustrates the need for a good and reliable method for assessing the consistency or workability of concrete. At present, for the purposes of mix design, workability is specified only in descriptive terms ranging from "extremely low" to "high," and for each grade examples are given of circumstances for which concrete of that particular workability would be suitable. The only quantitative assessments are based on the slump test and the compacting factor test described below.

Another problem arises from the fact that it is not usually practicable to use dry aggregate, and moreover the water content is likely to be very variable, so it is correspondingly difficult to know just how much water has been put into the mixer. It would be a great advantage to be able to control the mix in terms of its workability and in fact this is what is done in practice, but often only on a subjective basis.

The judgment depends on observing the behaviour of the concrete in the mixer, squeezing a handful, and so on, and on this basis concretes are described in terms such as "semi-dry" and "plastic" but there is no guarantee that a given description means the same thing to different people. Nevertheless, an experienced man working with reasonably constant materials, can achieve a fair degree of consistency in producing a particular mix, and this subjective method is still in wide use even when it is supplemented by a more objective test.

Very many workability tests have been proposed but few could claim to be anything but crude empirical tests with no theoretical background, and few have gained anything approaching general acceptance. They fall mainly into six classes.

i. Flow tests in which the concrete is made to flow by jiggling it, on a table, along a trough, or in a specially shaped container.

ii. Penetration tests in which the penetration of spheres, cylinders, cones, etc., has been measured, either under their own weight or under added load, and either while the concrete is static or is being shaken or jiggled.

iii. Deformation tests in which the deformation of a mass is measured either under its own weight as in the slump test described below, or in which a deforming force is applied to the concrete container which either has flexible sides or is hinged at the joints.

iv. Drop tests where a given mass of concrete is dropped and the height or spread of the resulting heap is measured.

v. Compacting tests in which the density of concrete compacted in a standard manner is measured.

vi. Mixer tests in which the forces exerted by the concrete during mixing, on the mixer or its blades are measured.

All the above are single point tests and therefore unless they have been designed to work at rates of shear similar to those to be met in the placing of the concrete they are doomed to failure from the start. The most that can be hoped for is that they might be satisfactory over a limited range.

Two empirical tests which are in common use today and are described in British Standard 1881² are the slump test and the compacting factor test. The former consists in filling, in a standard manner, a mould which is in the shape of a hollow frustrum of a cone (height 12", base diameter 8", top diameter 4") and measuring the amount by which the concrete slumps when the mould is removed in an upwards direction. Results range from zero slump to a collapse, and sometimes a so-called shear slump may be obtained when half of the cone of concrete breaks away. (Figure 2.)

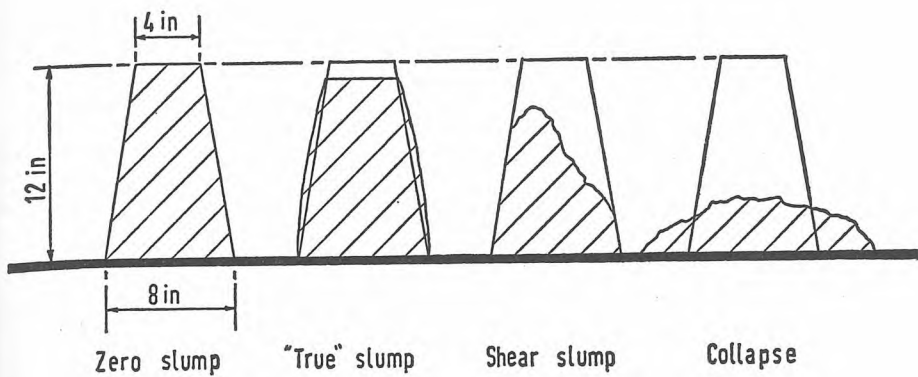


Fig. 2. Slump Test.

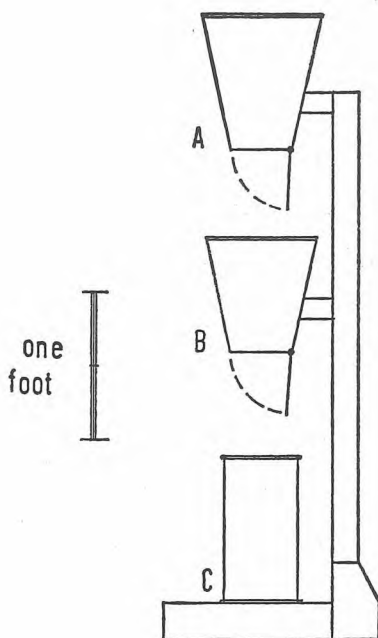


Fig. 3.
Compacting
Factor
Apparatus.

The compacting factor test, as its name implies, is intended primarily to assess the ability of the mix to compact. It was argued that the important parameter was the amount of work per unit mass needed to produce full compaction, but, since this is generally difficult to measure its inverse is measured instead; that is, the degree of compaction produced by a given amount of work. The standard amount of work is imparted to the concrete simply by dropping it from a standard height in an apparatus of the form shown in Figure 3. Concrete is loaded gently into the top conical hopper A and is allowed to fall into the hopper B by opening the trap door. The trap door of hopper B is then opened and the concrete allowed to fall further into the cylinder C which it fills to overflowing. After striking off level with the top of the cylinder the mass of concrete filling the cylinder is found and is compared with the mass required to fill it when sufficient work is done to ensure full compaction. The ratio of the former to the latter is called the compacting factor and ranges in value from about 0.7 to 1.0.

Emphasis has been laid on the fact that a lower limit to the water/cement ratio is imposed by the necessity of providing adequate workability; however it is found that this lower limit can be reduced if vibration is used in placing and compacting the concrete; that is a lower workability is acceptable. If a vibrating force, of frequency usually in the range 50 to 300 c/s, is applied to a relatively dry mix, the material at first subsides then appears to fuse or liquefy and will flow easily between reinforcement and into the corners of the mould. A final stage follows in which the concrete compacts and air is expelled. By this means it is possible to use a concrete that would be unworkable by hand so low water/cement ratios may be chosen and correspondingly high strengths obtained. It is now common practice to employ vibration for this purpose, the vibrations being produced sometimes electromagnetically, but more usually, mechanically, by a rotating eccentric mass.

The details of the method of application of the vibration depend of course on the particular circumstances. If a precast concrete product, such as a kerb or a lamp standard, is being made in a factory, the mould may be placed on a vibrating table, but for laying a concrete road a tamping bar with a vibrator attached to it may be used. For other in situ work a vibrator may be attached to the formwork or a "poker" vibrator may be immersed in the concrete itself. A poker vibrator consists of a steel tube 1" to 2½" diameter and some 18" long, in which is mounted a rotating eccentric driven through a flexible shaft by an electric or compressed air motor or a petrol engine.

A great deal of work has been done in attempts to establish criteria that are generally applicable for assessing the effectiveness of vibrators, and the influence of frequency, amplitude and centrifugal

force have been studied. It was at one time suggested that maximum acceleration alone, which for sinusoidal motion is proportional to the product of the amplitude and the square of the frequency, was sufficient to characterise the system but this soon turned out not to be so, and necessary ranges and limits for amplitude and frequency separately have been recommended. The matter is not by any means settled but there has been a trend towards the use of higher frequencies, at least for poker vibrators.

The compacting factor test can be used with concretes suitable for vibration but other workability tests specifically for such concretes have been devised, of which perhaps the best known is the VB Consistometer.³ In this test a slump cone of concrete is formed inside a cylindrical container of larger diameter which is mounted on a vibrating table. The time of vibration required to cause the concrete to assume the cylindrical shape is measured and is multiplied by the ratio of the final to the initial volume to allow for the compaction that has taken place.

No satisfactory theory of the mechanism of flow of concrete under vibration has yet been proposed.

Since concrete consists of inert particles embedded in a matrix of cement/water paste, it is obviously useful to investigate the properties of the paste itself. Experiments with coaxial cylinder viscometers have been carried out by several investigators^{3, 4, 5, 6, 7}, and hysteresis curves have been obtained. No reversibility of the breakdown was detected, at least over times greater, by a factor of two or three, than the time required for the breakdown experiment. At constant rate of shear, the torque T decays to an equilibrium value T_e according to the equation $T - T_e = (T_0 - T_e)\exp(-Bt)$ where t is time, T_0 is the value of T when $t=0$, and B is a constant at constant rate of shear.⁴

Ish-Shalom and Greenberg⁶ have investigated the effect on the rheological properties of the paste, of the chemical composition of the cement and its specific surface, mixing conditions and temperature of hydration. They found that when tests were carried out after a short time of hydration normal hysteresis loops were obtained, but when hydration had been allowed to proceed for a much longer period the down-curve was to the right of the up-curve. They called this latter phenomenon "anti-thixotropy" following Dellyes who had made similar observations. On one occasion, in an experiment on a paste with an intermediate time of hydration, they found the down-curve and up-curve to be superimposed.

Evidence of the occurrence of a structural breakdown of cement paste under shear is obviously important to a consideration of the effect of vibration on fresh concrete, but recent work⁸ has suggested that in rotation viscometer experiments with cement pastes, sedimentation may play a greater part than has hitherto been suspected.

The above summary mentions only the more important rheological problems arising with fresh concrete. Additional topics include problems of pumping concrete, the use of surface active agents, and properties of special mixes.

REFERENCES

- ¹ See, for example, Design of Concrete Mixes, Road Note No. 4, H.M.S.O., 1950, and, Concrete Mix Design, J. D. McIntosh, Cement & Concrete Association, 1964.
- ² Methods of testing concrete British Standard 1881-1952.
- ³ Bahrner, V. Zement, 29, 102-6, 1940; Betong (1) 27-38, 1940.
- ⁴ Dellyes, R. Revue des Matériaux de Construction (466/469), (486), 1954.
- ⁵ Tattersall, G. H. Nature 175, 166, 1955; Brit.J.Appl.Phys. 6, 165, 1955.
- ⁶ Ish-Shalom & Greenberg S.A. Proc. 4th Internat. Symp. on Chemistry of Cement, 1960.
- ⁷ Bombléd J. P. Rheologie du Béton Frais, CERILH, 1964.
- ⁸ Tattersall G. H. Lecture at Building Research Station, 22nd September, 1965, and work to be published.

ANNUAL CONFERENCE 1965

This year for the first, and it is to be hoped the only, time it was found necessary to cancel the Annual Conference because of lack of support.

It was hoped that the inclusion of a session on general topics of rheological interest would attract those members of the society who have at times remarked that their interests are never catered for. Instead it would appear that few members have interests outside their own specialised fields; or if they have, they find expenses very difficult to obtain.

The Conference attracted a total of 20 papers, four of which came from U.S.A. and one from France. Unfortunately it attracted only a further 20 delegates who did not intend to present papers. The organising committee felt it unfair to expect guests to travel from overseas to address such a small gathering, and so had no option but to abandon the Conference.

Does this upset imply that the form of the Annual Conference should be modified in future years? If you have firm views on the subject please write to the Editor, who will be pleased to print all contributions.

Conferences for the coming two years are already being arranged, but if there is a topic of rheological concern which you know would interest a substantial group of members please inform the Secretary, so that the feasibility of a conference can be discussed. The Annual Conference 1966 will probably be based on a suggestion already received.

REPORT OF THE HONORARY SECRETARY 1964-65

Another very active year in the society's affairs can be recorded.

- I. *Finance.* The financial outlook of the society has substantially improved following successful negotiations with Pergamon Press Limited on royalties (see also Treasurer's Report).
- II. *Constitution.* Amendment to the Rules may be required in the near future as a result of changes in financial and tax outlook. The officers of the Society are studying this question and will be making recommendations.
- III. *Membership.* At 27th August 1965 stood at 467.
- IV. *Register of Members.* A new Register of Members is being prepared.
- V. *Research Committee.* *As approved at the 1964 Annual General Meeting, the Research Committee of the Society was set up during the year.

- VI. *Joint (Institution of Chemical Engineering/British Society of Rheology) Working Party on Non-Newtonian Flow.*
 *The Working Party responsible jointly to the Research Committees of the Institution and the Society (as envisaged at the 1964 Annual General Meeting) was established during the year.
- VII. *Conferences Held.* Flow of Powders and Granular Solids, Nottingham University, 6th-8th April 1965.
- VIII. *Conferences Projected*
- (a) Chemistry and Rheology of Water Soluble Gums and Colloids—One day joint meeting with the Colloid and Surface Chemistry Group of the Society of Chemical Industry) 28th March 1966.
 - (b) Rheology of Foodstuffs (Joint meeting with the Food Group of the Society of Chemical Industry). The date has not yet been fixed, but is likely to be in the spring of 1967.
 - (c) Physical Basis of Rheology (possibly a joint meeting with the Institute of Physics or Faraday Society). The date has not yet been fixed.
 - (d) A conference on Rheology in Civil Engineering Industry (or Building Science) is likely to be held in 1967 at Sheffield University.
- IX. *British Standards Institution.* Following recommendation by the Research Committee and approval by the Executive Committee, the British Standard Institution has been asked to undertake production of a British Standard Glossary of Rheological Terms and Symbols.
- X. *Publications*
- (a) The Society's own established publications, Rheology Abstracts and the Bulletin have continued to appear regularly and in improved forms.
 - (b) "Rheological Research in Britain 1964—a survey made jointly by the British Society of Rheology and the National Engineering Laboratory" (A. Y. McLean and A. T. J. Hayward; N.E.L. Report No. 165) has been published since the 1964 Annual General Meeting.
 - (c) The proceedings of the 1965 Nottingham conference on the Flow of Powders and Granular Solids will shortly appear as *Rheologica Acta* 1965, 4, No. 3.
 - (d) The Proceedings of the 1964 Paints Conference are in the hands of *Rheologica Acta* and expected to be in print soon.

- XI. *Overseas Liaison.* Closer relations with rheologists overseas (particularly U.S.A. and France) have been developed during the year—our Australian friends continue to be active.
- XII. *British National Committee on Materials*
The British Society of Rheology was invited to join the British National Committee on Materials during the year. The Society is represented on this committee by its President, Professor A. J. Kennedy.

* *Appendix*

Constitution of Research Committee

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

Constitution of Joint Working Party

Professor J. F. Richardson (Chairman)
Mr. J. M. Smith (Secretary)
Dr. J. R. Bourne
Mr. A. T. J. Hayward
Dr. M. J. Kelly
Mr. K. Lammiman
Dr. J. R. A. Pearson
Dr. F. Valentin
Mr. R. J. Cole (Papers only)

R. COLE,
Honorary Secretary.

ANNUAL GENERAL MEETING 1965

The Annual General Meeting, postponed from its original date because of the cancellation of the Annual Conference, was held at the Society for Visiting Scientists, Albermarle Street, London, on 27th October 1965. Twenty members were present, just sufficient to form a quorum.

Mr. R. W. Whorlow retired as Editor of Rheology Abstracts. Mr. B. Warburton of London University School of Pharmacy was then elected as the new Editor.

Dr. K. Walters of Dept. of Applied Mathematics, University College, Aberystwyth, was then elected as Membership Secretary, in place of Dr. G. H. Tattersall, who had completed his term of office.

Dr. Tattersall and Mr. Whorlow must be thanked for their sterling efforts on behalf of the Society over the past four years.

THE BRITISH SOCIETY OF RHEOLOGY
ACCOUNTS FOR THE YEAR ENDING 30th JUNE, 1965

		INCOME							
1963/64					1963/64				
£		£ s. d.			£		£ s. d.		
678	Balance in hand 1.7.64 ...	481	10	7	286	Printing and postage of			
372	Subscriptions	446	16	10		Bulletins and Abstracts ...	219	1	9
343	Meetings	1,240	15	11	306	Committee and administrative			
—	Royalties on sales of Rheo-					expenses	201	5	5
	logy Abstracts	597	1	0	325	Meetings	973	1	1
—	Sale of advertisement space	5	5	0	4	Income Tax	5	8	6
	in Bulletin				—	Refunds of overpayments of			
13	Interest on Post Office Sav-					subscriptions	17	2	0
	ings Bank Account	9	12	10	481	Balance at 30.6.65	1,365	3	5
		£2,781	2	2			£2,781	2	2

19th July 1965 (Signed) G. K. JONES,
Hon. Treasurer.

7th August 1965 (Signed) ALAN G. WARD,
Hon. Auditor.

WHAT IS RHEOLOGY?

Members of the Society may be divided into two groups: those who have no concern for, and only a vague idea of, what rheology means; and those who know precisely what it means—this latter group sometimes appears to consist of a large number of sub-groups, each containing one member.

Members of the general public, on the other hand, have no idea of the meaning at all. The Editor of the Bulletin can be assured of receiving at least twice a year cuttings from journals (both general and technical) which refer to the rheology of viscous materials. "London Letter" in *The Guardian* confessed complete ignorance of rheology, claiming that the word was not in the dictionary. This claim was refuted by a lexicographer from Oxford (naturally) and the Bulletin Editor also attempted a little enlightenment. (His letter served one useful purpose by recruiting a new member of the Society.)

Those members who are concerned with the foundations of rheology should note that it is hoped to hold a one-day meeting on "The Physical Basis of Rheology" some time during 1966. In a few hours it will doubtless be impossible to settle problems of many years standing, but at very least the meeting will serve to examine and clarify the existing situation.

BRITISH SOCIETY OF RHEOLOGY, VICTORIAN BRANCH

The following officers have been elected for the year 1965-66:

Hon. Branch Secretary: Mr. J. C. Godfrey.

Hon. Branch Treasurer: Mr. R. E. Price.

Committee Members: Mr. B. D. Craven, Mr. D. Delatycki, Mr. J. S. McN. Gourlay.

Branch Auditor: Mr. O. G. Ingles.

Dr. Grossman will continue as President for a further year.

The Annual Meeting was addressed by R. T. Straughan and M. J. Jordan (Olympic Tyre and Rubber Co.) on the subject of "The Physical Properties of Rubbers."

Mr. Straughan explained the flow behaviour of unvulcanised rubber in terms of Eyring's theory, and then discussed the phenomena of creep, recovery, stress relaxation, set and hysteresis. The effects that these phenomena have on processing in the tyre industry were mentioned.

Mr. Jordan compared the similarities and differences between those strength properties in which failure arose from initial cuts, and those which depended on the presence of microflaws. The similarity in failure mechanisms was matched by a partial similarity in the tem-

perature and rate dependence of these strength properties to that of viscoelastic properties, thus providing a means of increasing strength values by reducing stress concentrations around deliberate or inherent flaws.

The papers were followed by a lively question time.

NEWS FROM GROUPE FRANCAISE DE RHEOLOGIE

The secretary of G.F.R. (Monsieur B. Persoz) has made the following comments regarding the translations of rheological definitions which appeared in B.S.R. Bulletin No. 3, 1965.

"In France also the word 'facette' is used in crystallography, but no confusion is possible. It would be most suitable to choose the English term 'facet,' which resembles most closely the French word."

Three printing errors crept into the list of definitions. They were:

4. Sollicitation mécanique;
10. Dilatation;
12. Etat de déformation.

The Annual Conference will be held in Paris on 12th May 1966. The general theme will be "Problèmes énergétiques en rhéologie." It is hoped that some members of the B.S.R. will be interested in presenting papers at, or attending, the conference. Further information can be obtained from M. Persoz, at 68 Boulevard St. Michel, Paris, 6e.

The first number of the new series of "Cahiers du G.F.R." was published in October 1965. A copy of the journal has been placed in the B.S.R. collection, and may be borrowed by members. All papers in "Cahiers" will be noted in Rheology Abstracts.

JOURNALS AVAILABLE ON LOAN

The Society receives complimentary copies of journals produced by several overseas organisations concerned with rheology. The journals listed below may be borrowed by members, normally for up to one month, on the understanding that the borrower pays postage both ways.

Application should be made to Mr. R. W. Whorlow, Dept. of Physics, Battersea College of Technology, London, S.W.11.

Berichte der Deutschen Rheologischen Gesellschaft, Vols. 20-28 (1961-65).

Bull. British Hydromechanics Res. Assn., Vol. 10, no. 5 (1961)-14, no. 1 (1965).

Cahiers du Groupe Francais d'Etudes de Rhéologie, 2-6 (1957-61).

Cahiers du Groupe Francais de Rhéologie, *1*, no. 1 (1965).

J. Japan Soc. Test. Matls. (Special Rheology issues), Vol. 8, no. 67; 9, 79; 10, 92; 11, 104 (1959-62).

J. Soc. Matl. Sci., Japan (Special Rheology issues), 12, 116; 13, 128; 14, 139 (1963-65).

Rep. Prog. Polymer Physics in Japan, 2-8 (1959-65).

Science Abstracts, China

(a) Mathematical and Physics Sciences, 1-3 (1963-65).

(b) Technical Science, 1-3 (1963-65).

(c) Chemistry and Chemical Technology, 1-3 (1963-65).

Scientia Sinica, 12-14 (1963-65) (Vol. 13 incomplete).

THE BINGHAM MEDAL 1965

The (U.S.) Society of Rheology has awarded the Bingham Medal for 1965 to Dr. Eugene Guth of the Oakridge National Laboratory. The award was made for scientific investigations covering a period of nearly 30 years, during which Dr. Guth has been mainly responsible for the kinetic theory of rubber-like elasticity in its present quantitative form. A further important contribution to rheology has been Dr. Guth's work on the extension of the Einstein formula for the viscosity of a suspension of spheres.

DR. HERMANN STAUDINGER

One of the pioneers of polymer science, Dr. Hermann Staudinger, died at Freiburg on 8th September 1965, at the age of 84.

Dr. Staudinger was awarded the Nobel Prize for Chemistry in 1953, for his fundamental work, carried out more than 30 years previously, on the physical chemistry of high polymers, particularly cellulose and other fibre forming materials. In 1932 he suggested the use of viscosity to measure the molecular weight of polymers, a method now of great practical importance.

Dr. Staudinger quickly realised the significance of his discoveries, and was one of the first scientists to appreciate the role that plastics would come to play in modern industry.

NOTES AND NEWS

The proceedings of the B.S.R. conference on "Flow of Powders and Granular Solids," held at Nottingham, April 1965, have been published as *Rheologica Acta*, Vol. 4, No. 3.

Members of the society may obtain these proceedings at the special rate of DM26.80 (postage included) instead of DM 32.40.

Orders should be sent, before 15th February 1966, to:

Dr. Dietrich Steinkopff Verlag,
Postfach 1008,
6100 Darmstadt, Germany.

A course of six lectures on "Plasticity Theory with Applications to Metal Forming Processes," by Dr. B. Lengyel, will be held at Battersea College of Technology, commencing 12th January 1966 at 6.30 p.m. Further particulars from: The Secretary (Rheology Courses), Battersea College of Technology, London, S.W.11.

The Institution of Mechanical Engineers has arranged the following meetings:

14th January	London	Fibre reinforced materials.
15th-16th March	London	The planning of mechanical engineering departments of universities and colleges of technology.
13th-15th April	Liverpool	Thermodynamics and fluid mechanics group convention.
12th-14th May	Holland	Lubrication and wear group convention.

Details in all cases from: The Information Officer, 1 Birdcage Walk, London, S.W.1.

The winter meeting of the (U.S.) Society of Rheology will be held at the U.S. Naval Post Graduate School, Monterey, Cal., 31st January -2nd February 1966. The meeting follows the winter Gordon Conference, to be held the preceding week at Santa Barbara.

Information from: R. Beyer, United Technology Corp., P.O. Box 358, Sunnyvale, California.

The Fifth U.S. National Congress of Applied Mechanics will be held at the University of Minnesota, 14th-17th June 1966. Details from: R. Plunkett, 117 Aero. Engng. Building, University of Minnesota, Minneapolis, Minnesota 55455.

New Members

NAME AND ADDRESS	INTERESTS
J. P. Berry, B.Sc., Dept. of Polymer and Fibre Science, Manchester Coll. of Sci. and Tech., Sackville Street, Manchester 1. 20 Lancelot Rd., Peel Hall, Manches- ter 22.	General, polymers, fibres.
P. G. Campbell, B.Sc., A.R.I.C., Cert.Ed., Milk Marketing Board, Central Lab., Thames Ditton, Surrey. 14 Boltons Close, Pyrford, Woking.	Dairy products, measurement tech- niques.
I. H. Day, B.Sc., Polymark Ltd., Jeddo Rd., London, W.12. 92 Scotts Rd., Southall, Middx.	Printing inks, polymer solutions.
G. J. Douglas, Beit Hall, Imperial College, London, S.W.7. 83 High Rd., Wormley, Herts.	Visco-elastic liquids.
G. Martin, A.C.S.M., Consolidated Beryllium Ltd., P.O. Box 5, Marble Hall Road, Milford Haven, Pembs. "The Manse," Thornton, Milford Haven.	General, metals, emulsions, suspen- sions, ceramics.
A. Spencer, M.Sc., A.R.I.C., Gestetner Ltd., Tottenham, London, N.17. 68 North Way, London, N.W.9.	
E. B. Greenhill, M.Sc., Ph.D., Monsanto Chemicals (Aust.) Ltd., Somerville Road, West Footscray, Victoria, Australia. 41 Harrington Ave., North Balwyn, Victoria.	Suspensions, emulsions, rotational viscometry.
G. Brownlie, B.Sc., The Glidden Co., Research Center, 12430, Elmwood Ave., Cleveland, Ohio, U.S.A. 325 Cornwall Rd., Rocky River, Ohio 44116, U.S.A.	General, polymers, emulsions, suspen- sions, paints.
J. L. S. Wales, B.Sc., D.A.E., Centraal Lab. T.N.O., Julianalaan, Delft, Holland. Brittenburg 7, Leiderdorp, Zuid Holland.	General, polymers.

Mr. W. E. Young, of National Adhesives Ltd., Ajax Avenue, Slough, died
early in 1965.

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JOINT MEETING

on

**“Chemistry and Rheology of
Water Soluble Gums and Colloids”**

LONDON

28th MARCH, 1966

Details from :

MR. B. Warburton,
School of Pharmacy,
University of London,
Brunswick Square,
London, W.C.1.