

RHEOLOGY BULLETIN

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IT HAS BEEN SUGGESTED by the American Institute of Physics that the membership of the five Founder Societies be informed of a serious situation created by one of the C.I.O. affiliates, which goes by the name of the Federation of Architects, Engineers, Chemists, and Technicians, and which is said to be definitely under the control of Communists acting under orders from Moscow. It appears that this organization attempts to include in its membership, physicists, chemists, laboratory assistants, laboratory helpers, engine operators, plant operators, technicians, glass blowers, boiler room operators, shift repairmen, store-room men, janitors, night watchmen, and window washers; in fact, everyone in an industrial research or development laboratory except the Director of Research and Development.

The following is quoted from NEWS EDITION, American Chemical Society, Vol. 19, Page 733, July 10, 1941. All references to chemists apply equally well to physicists, of course.

On April 24 a letter was received from the Chairman of the California Section of the American Chemical Society informing the Secretary's office of a very serious situation existing at Emeryville, California, in an attempt, which seemed to be gaining headway, to force professional men (including all research workers below the rank of department heads) to join a closed shop union within the Federation of Architects, Engineers, Chemists, and Technicians, a C.I.O. affiliate. A number of letters were also received from individual members urgently requesting the AMERICAN CHEMICAL SOCIETY to come to the assistance of the beleaguered chemists.

Information was obtained as rapidly as possible, and on June 11 the following letter was sent to all members of the AMERICAN CHEMICAL SOCIETY in Emeryville:

AMERICAN CHEMICAL SOCIETY

Office of the Secretary

Washington, D. C.

1155 Sixteenth St., N. W.

July 2, 1941

Dear Fellow Member:

This letter is being sent to every member of the AMERICAN CHEMICAL SOCIETY with address at Emeryville, Calif. Any other member employed by the Shell Development Co. will be sent a copy on request.

I have received many letters asking that the AMERICAN CHEMICAL SOCIETY assist its members to resist coercion to join the Federation of Architects, Engineers, Chemists, and Technicians, a C.I.O. affiliate. This union is endeavoring to organize the laborers in the

Shell plant, and is including professional men, but I have been furnished very little information as to what is taking place.

Members will find an editorial on "The Profession of Chemists" in the May 1939 issue of "Industrial and Engineering Chemistry". A history of the negotiations with Joseph E. Seagram and Sons and the American Federation of Labor appears in the NEWS EDITION of April 10, 1939. Your attention is called particularly to the following two paragraphs:

"So far as our information goes, agreements signed by the Congress of Industrial Organization (C.I.O.) have exempted all chemists or engineers engaged in research work. Owing to the difficulty in interpreting this clause, we are informed that it has been administered to exempt graduate chemists and chemical engineers. No instance has come to our attention of any attempt by the American Federation of Labor to force graduate chemists or chemical engineers, engaged in the practice of our profession, to join a labor union, with the single exception the details of which are to follow.

"The AMERICAN CHEMICAL SOCIETY, of course, takes no stand against any chemist or chemical engineer, of his own volition, joining either of these organizations, but it is strongly opposed to his being compelled to do so. Chemistry is a profession and not a craft or trade. Professional standing and status which have taken years of study and thousands of dollars' expenditure to acquire must be conserved. The above-mentioned labor organizations appear to have no desire to incorporate in their membership any of those directly connected with management, which is the situation as regards most professional employees."

The Directors definitely went on record against the association of professional chemists and chemical engineers with a union, thereby being rated as laborers and losing their status as professional men. The Directors unanimously approved the acts of the Secretary and voted to authorize him to proceed with negotiations to the end that the status of professional men employed as such by Joseph E. Seagram and Sons, or any other employer adopting a similar policy, be fully protected.

In this respect, it is necessary that this office be provided with far more definite information than it now possesses. I shall be grateful if you will inform me as to:

1. The exact situation in Eemeryville, as you see it, regarding the coercion of professional men into the F.A.E.C.T.
2. What form of coercion has been used on you.
3. Whether or not you have joined this union.

Please send me the names of any graduate chemists who have joined, with their degrees and the institutions which granted them, and information as to whether or not they are members of the AMERICAN CHEMICAL SOCIETY.

I understand that an argument has been used to the effect that chemists should join this union in order that they might become managers when the plant is taken over by the F.A.E.C.T. Have you been subjected to this argument?

In order that you may proceed with full knowledge of conditions, this union has been denounced as communistically controlled on page 13 of House of Representatives Report No. 1476 before the 3rd Session of the 76th Congress. I am sending you herewith a speech by Martin Dies, as printed in the CONGRESSIONAL RECORD for March 21, 1941, page A1388, covering the details of its organization and organizers, which can leave no doubt of its complete communistic character. It will indicate to you the nature of the control to which you will be subjected should you become a member.

In the event that the Shell Development Co. consents to a closed shop, with this union as sole bargaining agent, and includes its professional men (which I cannot conceive to be possible), every chemist who is a member of the union will very distinctly jeopardize his future. Nothing could be more fatal to the chemist, the engineer, the doctor, or the lawyer than the loss of professional status. The SOCIETY, of necessity would be obliged to inform the chemical departments of every college and university, as well as the chemists of America, as to the conditions to which their graduates would be subject should they accept employment with any corporation that would consent to any such fate for its professional men.

Your individual reply will be appreciated. Definite information is badly needed.

CHARLES L. PARSONS, Secretary

As a result of that letter, a number of replies were received which transmitted much information. One of these letters, signed by four members of the SOCIETY, is so comprehensive that it is published here in part for the information of our members.

The undersigned are officers of an organization known as the "Four Horsemen", composed of graduate chemists, physicists, and engineers, employed by the Shell Development Co. at Emeryville, Calif. The sole purpose of this organization is to resist the unionization of members of the group by the Federation of Architects, Engineers, Chemists, and Technicians. It is wholly independent of the company in every respect.

In its early proselyting the union met with considerable success among the laboratory helpers and assistants and with some even among

higher ranking workers. Numerous reasons may be advanced for this, but certainly of importance are the prounion sentiments of the West Coast and the comparative isolation of Emeryville from American chemical industry. When this success became apparent, four interested research chemists joined together in an effort to crystallize opinion among those opposed to being represented by the union. The self-titled "Four Horsemen" were soon joined by other interested persons and the group began to collect signatures to antiunion statements. It soon became apparent that the union had a considerable majority in the helper-assistant group but that the situation was not nearly so favorable to the union in the chemist-junior chemist group.

In its negotiations with the company the union finally did recognize some distinction between graduate scientists and other workers and consented to a two-unit election on this basis. This point, together with the dispute over one or two-unit representation is clearly set forth in the company's bulletin of June 4. The upper, or first, unit proposed by the company consists of 124 chemists, physicists, and engineers and 56 junior chemists, junior physicists, and junior engineers. From this group of 180, the "Four Horsemen" obtained 90 signatures to the statement, "We, the undersigned, hereby state that while we approve of the principles of collective bargaining, we do not believe our own best interests are served by affiliation with the F.A.E.C.T." There are also known to be a few further sympathizers with this viewpoint who, however, refused to commit themselves. It was therefore apparent that the union could not carry an election in "unit one". The company subsequently stiffened its position and an impasse in the negotiations was reached (see the union and company bulletins of June 4). The union discharged its negotiating committee and took a strike vote. It is reliably reported that the strike motion was voted "tabled" by a large majority.

This is the situation at present. It has been reported that a new union negotiating committee has been formed, and negotiations may be resumed with the company, possibly with the object of forcing an election on the "single unit" basis.

In answer to your specific question, we would state that there has been no direct coercion of professional men, into the F.A.E.C.T. There has been, however, a real threat that a majority of the professional men could be coerced into the union if a single-unit election were held; the opinion of the professional men would be overruled by the relatively large number of helpers and assistants who have joined the union.

Signed by four members of the
AMERICAN CHEMICAL SOCIETY
Berkeley, Calif., June 17, 1941.

With the facts fully in hand, and after receiving authority from the Executive Directors (unanimous approval of the full Board has since been received), the following letter was sent by air mail to the Chairman of the California Section with a copy to each member in the Shell Development Co.

AMERICAN CHEMICAL SOCIETY
Office of the Secretary

Washington, D. C.
1155 Sixteenth St., N. W.
June 27, 1941

Dr. T. D. Stewart, Chairman
California Section, A.C.S.
Berkeley, Calif.

Dear Dr. Stewart:

I have your letter of June 12 and a number of other communications from members employed by the Shell Development Co. bearing upon my communication to them of June 11. I have received very clear and complete statements about the situation in Emeryville, including various documents issued by the F.A.E.C.T., from December 10, 1940 to June 1941, and two mimeographed communications dated May 16 and June 5, from the Shell Development Co. to its employees. No word of any kind has been directly or indirectly received from the Shell Development Co. itself or its executive officers, nor was any expected since, under certain present interpretations of law, the right of free speech is denied to an employer in labor controversies.

I am limiting my comments on these communications to the following definite misstatements of fact in the F.A.E.C.T. leaflets:

(a) "In passing it may be mentioned that the chemists at the American Viscose Company are unionized." This is not true. Not only have they not been unionized, but the C.I.O. union, which is the bargaining agency does not accept them in its membership.

(b) "The Government recently brought suit against the American Medical Association and won its case that the practice of medicine is a "trade" and not a "learned profession". A.C.S. please take note." This is not true. Before the case is won, it has as yet to pass through two courts; nor will the American people ever believe that chemists, chemical engineers, other graduate engineers, and physicians are "tradesmen" even if the Supreme Court reverses its former decision that:

Although the study of chemistry is the study of a science, yet a chemist who occupies himself in the practical use of his knowledge of chemistry as his service may be de-

manded may certainly at this time be fairly regarded as in the practice of a profession.

(c) The leaflets deny that the AMERICAN CHEMICAL SOCIETY is interested in the material as well as the professional improvement of its members. This is not true, as any interested party, member, or nonmember, can readily determine by reference to the pamphlet entitled, "The American Chemical Society—What It Is Doing for Chemists and Chemical Engineers", which has been issued by the SOCIETY. Copy is available to anyone on request.

Unquestionably there is countrywide sentiment among employers and employees against union affiliation of professional men. A professional chemist, lawyer, engineer, or physician in transferring his bargaining rights to such an organization as the F.A.E.C.T. is acting in a manner which very definitely is not typical of his American colleagues, and if he does so he must be prepared to accept their estimate of his professional status.

I have not been furnished with, nor have I seen, any denial of the Communist affiliation of the international president, or the national organization director of the F.A.E.C.T. nor specifically as individuals the other leaders of this organization accused of such affiliation by the Honorable Martin Dies in his speech of March 21, 1941. In view of the recent defense industries strikes under proven communistic leadership, those who aid their destructive schemes against all industry are open to just suspicion as to their real Americanism.

Perhaps the most serious problem is the threat to the continued success, if not the very existence, of one of our leading research organizations, the Shell Development Co. Its accomplishments in the development of knowledge are of worldwide significance. Should the F.A.E.C.T. gain control, the company can scarcely hope to keep its really valuable men or be able to replace them with others. This is especially true with the present abnormal demand for talent of this type. I cannot believe that the professional chemists, physicists, and engineers employed by the Shell Development Co. will consent to be forced into a closed shop organization where at any time they can be outvoted by the proposed "second voting unit" consisting of the following groups: "Laboratory assistants, laboratory helpers, engine operators, plant operators, technicians, glass blowers, boiler room operators, shift repairmen, storeroom and curator's department, janitors, night watchmen, window washers and the company's category of 'Miscellaneous' dated May 14, 1941. This group, which is quoted from an F.A.E.C.T. leaflet, has by far the voting majority in the union and can be easily shepherded by the leaders into full control of the professional minority. Can a pure research corporation hope to survive under such nonprofessional domination?

For at least four years the F.A.E.C.T. has attempted to organize chemists in a number of industrial plants, including the plants of two large petroleum refineries, but as yet has not succeeded in enrolling any noticeable number of professional men; nor has this office received any approval of its activities from a scientific man of recognized standing.

This communication has been unanimously approved by the Executive Committee of the Board of Directors, by the SOCIETY'S Counsel, and by all Directors so far heard from—a two-thirds majority.

CHARLES L. PARSONS, Secretary

Since the above letters were mailed, other communications have been received from Emeryville. No one reports direct threats of physical violence, but the letters all indicate a natural expectation that the chemists will become professionally declassé if they join the union. A very definite apprehension, if not fear, exists as to what will happen to them if they do not. This psychology appears to have been engendered by the frequently used strong arm methods of unions on the Pacific Coast, by visits to individuals at their homes in the evening by two or three organizers, but more especially by insinuations, not direct threats, such as the following which was printed in the F.A.E.C.T. bulletin of April 21, 1941:

“Friction between assistants and supervisors will be avoided if the latter ponder well the consequences to themselves and their work if they continue to maintain a neutral or antagonistic attitude toward the union.”

Five members of the SOCIETY, four graduates of one institution, have been identified as having joined the F.A.E.C.T.

This information is published in order that the membership may fully understand conditions to which any one of them is apt to be subjected and the position of the AMERICAN CHEMICAL SOCIETY in regard to any attempt to coerce its members into any form of closed shop unionization. This is a professional organization, and the membership must make every effort to see that it so remains.

CHARLES L. PARSONS, Secretary

July 5, 1941

SPEECH OF HONORABLE MARTIN DIES

Abstracted from the appendix of the CONGRESSIONAL RECORD for March 21, 1941. page A1388.

MR. DIES. Mr. Speaker, today I wish to bring to the attention of the House another case of Communist leadership in a C.I.O. union

which operates in some of our vital defense industries, including all of our navy yards. I present to you a purely factual statement concerning the Communist Party membership of Marcel Scherer, who is the national organizational director of the Federation of Architects, Engineers, Chemists, and Technicians. Scherer is by no means the only Communist who occupies a leading position in this important union of technical men. In fact, the union as a whole is under the complete domination of the Communist Party. The importance of this latter fact can hardly be overemphasized when we remember that the absolute loyalty of technical men who are employed in our defense industries is essential to our national security.

Architects, engineers, chemists, and technicians occupy strategic bottleneck positions in American industry. Hence they are particularly important for the successful execution of the national defense program. The attitude, affiliations, loyalties, and general trustworthiness of those engaged in these occupations is a matter of paramount significance. The following inquiry is concerned only with those who are organized in the Federation of Architects, Engineers, Chemists, and Technicians, affiliated with the Committee for Industrial Organization and claiming a membership of 8000. The F.A.E.C.T., according to information supplied by its official organ, TECHNICAL AMERICA, and various mimeographed publications, has established contact or contractual relations with the chief navy yards and with numerous industrial plants engaged in producing supplies for military purposes.

In a letter sent to Mr. Charles Edison, Secretary of the Navy, and in a telegram sent to President Roosevelt on April 10, 1940, the F.A.E.C.T. defended its claim to the right of collective bargaining in American navy yards. It is therefore pertinent to determine just who and what the F.A.E.C.T. represents and what are its real purposes in organizing these establishments.

MARCEL SCHERER, a Biography

The man who has been the actual and most active organizing head of the F.A.E.C.T. is Marcel Scherer, its national organizational director. Mr. Scherer was one of its charter members and general organizer of the New York chapter, the largest and most influential chapter in the federation, for two years. (See third F.A.E.C.T. annual convention program, Detroit, Mich., October 7, 8, 9, and 10, 1937, p. 9). Here in a brief biographical sketch, he is described as having been "dismissed from high school for pacifism during the war". Mr. Scherer was an active member of the Young People's Socialist League at Erasmus Hall High School in New York City, and in 1919 engaged in student agitations at the City College of New York. He joined the

Communist Labor Party at that time and later the Communist Party. In 1931 he was Communist candidate for alderman from the 37th aldermanic district in Brooklyn.

To establish Mr. Scherer's past and present connection with the Communist Party of the United States, the testimony of Benjamin Gitlow, former candidate for Vice President on the Communist ticket; Joseph Zack, former member of the central executive committee of the Communist Party; Maurice Malkin, member of the Communist Party; and John P. Frey, president of the Metal-Trades Department of the American Federation of Labor, before the Committee on Un-American Activities (vol.1, p. 101; vol. 7, p. 4709; vol. 9, p. 5456; vol. 9, p. 5770) is further cited. In a letter to this committee, published on page 11 of September 1938 issue of TECHNICAL AMERICA, official organ of the F.A.E.C.T., Mr. Scherer makes no denial of the charge that he is a Communist.

The activities of Mr. Scherer should by no means be imputed to any individual proclivities or designs, for Mr. Scherer, as already indicated, is a member of a highly disciplined organization, the Communist Party of the United States. The following testimony of Joseph Zack, former member of the central executive committee of the Communist Party, at a hearing of the Committee on Un-American Activities, held on September 30, 1939 (hearings, vol. 9, p. 5453), is significant in this connection:

"The Soviet Government will utilize its American organization for whatever purpose they find convenient or necessary at all times. While I was in charge of the Trade Union Unity League I was once asked to supply an engineer, a chemist, who would personally have qualifications capable, and let us say, talk to other engineers higher in the profession than himself, in this instance, specifically, certain engineers of du Pont. I was asked to do that by Max Bedacht, who was then in charge of this phase of their secret activity. Well, I recommended a certain individual, and I was asked to meet the OGPU agent in charge of this branch of their activities, and I introduced him to him."

Our committee has been informed by an authoritative source that Marcel Scherer was one of those selected for this type of work.

Leaders of the F.A.E.C.T.

Other leaders and active members of the F.A.E.C.T. have been identified with the Communist Party or with Communist-controlled "front" organizations:

Walter N. Polakov, contributing editor of Technical America, 1938, signer, open letter for closer cooperation with the Soviet Union. Ray Aversa, Detroit organizer, F.A.E.C.T., Russell McNutt, F.A.E.C.T. representative to the America Youth Congress (see TECHNICAL

AMERICA, September 1938, p. 6)., Ives D. Jacquier, New York City, F.A.E.C.T. organizer on W. P. A. projects.

Leonard Sparks writer of the pamphlet, "How to Win Jobs", published by section 1, Communist Party, New York City, on the basis of data furnished by the Federation of Architects, Engineers, Chemists and Technicians.

Jules Korchien, secretary of F.A.E.C.T.; member, provisional committee for Washington Committee for Democratic Rights (see letterhead, February 2, 1940); consulting architect for the Soviet Government in Moscow and more recently housing expert for PM and Federal Housing Authority; member, board of directors Inter-Professional Association.

Lewis Alan Berne, president F.A.E.C.T.; endorser, American Congress for Peace and Democracy (see letterhead, January 6-8, 1939):

Simon Breines, organizer, F.A.E.C.T., New York, housing division; Friends of the Soviet Union, contributor (Soviet Russia Today, December 1938, p. 12).

Bernard J. Stern, contributing editor, TECHNICAL AMERICA, F.A.E.C.T. organ; contributor, SOVIET RUSSIA TODAY, May 1935, page 24; writer under the name of Bennett Stevens for International Publishers, a Communist publishing house (hearings, vol. 7, p. 4929).

Boris Z. Borise, organizer, F.A.E.C.T., Los Angeles, Calif.; influential member of the Communist Party of California.

Paul Pinsky, F.A.E.C.T., California; influential member of the Communist Party of California.

William Feinberg, F.A.E.C.T. organizer, Detroit.

Nathan Sparer, structural draftsman in the Brooklyn Navy Yard, cited as a Communist (New York Times, June 26, 1929).

Samuel Nesin, organizer, chemist section, F.A.E.C.T.; Communist candidate for New York State Assembly sixth assembly district, Bronx, New York City.

Aaron Gelman, youth division, F.A.E.C.T.

Lena Davis, state secretary, Communist Party of New Jersey.

MEMBERSHIP CAMPAIGN

The society of Rheology is in the midst of a campaign to obtain new members. An enlarged Society will be able to serve the members more effectively than is possible at present. The Society is already moving forward—note the increased scope and quality of the Bulletin and the strong program for the October Meeting.

The membership committee invites the fullest possible cooperation at this time from the membership at large. Experience has shown that the most effective way to obtain new members is by personal contact of interested members with their friends. Let each member, therefore, get in touch with his friends IMMEDIATELY and explain the advantages of membership in the Society. This is both an opportunity and an obligation.

BRITISH RHEOLOGIST'S CLUB

Bulletin No. 2, issued by this club in June, has been received. It gives an account of their meeting in London on June 21st at which time they conducted a discussion of concentric ring viscometers. Perhaps the entire discussion can be printed in some future issue of Rheology Bulletin.

The following four paragraphs appear among their "Club Notes" section:

Membership

The membership of the club is now 89 of whom more than half live in the London area. It is for this reason that the first three meetings of the club are all taking place in or near this area.

American Co-operation

We are glad to note an appreciative paragraph about the club in the November (1940) number of the "Rheology Leaflet" of the American Society of Rheology. Co-operation with our American colleagues is most welcome and we hope to keep in touch with them especially when the very difficult and controversial questions of nomenclature and definition are being discussed.

Public Interest in Rheology

It is significant that "John O' London's Weekly" should devote a whole page to an article by J. Harley-Mason entitled "Rheology—A New Science". Many club members would wish they knew as much about thixotropy as the author would have us believe is in fact known. This growing appreciation of the existence of Rheology as a Science in industry is, it will be remembered, one of the objects of our club. Next time you are asked by a layman "what is Rheology" you can escape an involved discussion, if you will, by suggesting the purchase of a copy of "John O' London's Weekly" for 9th May, 1941.

Classical Papers on Rheology

Following the example of our American colleagues, we have decided to translate and issue to members, from time to time, classical papers on rheology which, on account of the difficulty in getting the originals, have probably not been as widely read as they deserve. A little known paper by Pochettino forms the first of this series and is being circulated to members with this number of the bulletin. We are indebted to Dr. V. G. W. Harrison for the translation. Suggestions for further papers will be welcomed.

A copy of this translation of the Pochettino paper "On the Properties of Plastic Bodies", *Nuovo Cimento* 1914, Vol. 8, P. 77. has been received and it too might be published at some later date if permission to reprint can be obtained from the British Rheologist's Club and the translator.

In the June 14, 1941 issue of *Chemistry and Industry*, Page 447, appears an article by G. W. Scott Blair on "**Rheology Applied to Cheese-Making.**" An apparatus has been designed and constructed by two collaborators which measures the firmness of cheese, butter and other soft solids. The author describes the rheological aspects of the various steps in cheese making and shows how important it is to measure these properties during manufacture. The following equation is proposed:

$$\psi = S\sigma^{-1}t^k$$

or $\log \psi = \log S - \log \sigma + k \log t$

where

S = Shearing stress

σ = Shearing strain

t = Time

ψ = Firmness

Readers of the Rheology Leaflet will remember the paper of Scott Blair and Coppen, Rheology Leaflet No. 11, Page 11, 1939, on Psycho-Rheology in which ψ was used to indicate the property of firmness.

CORRELATED ABSTRACTS CONCRETE AND CEMENTS

Effect of Temperature and Pressure on the Rheological Properties of Cement Slurries. R. Floyd Ferris, *Am. Inst. Mining Met. Eng. Tech. Pub.* No. 1207 (1940.) An apparatus is described for determining the effect of high pressure as well as the effect of temperature upon the rate of stiffening of cement slurries. Such slurries are

used in oil wells and when these become deep, both temperature and pressure are apt to be quite high. Working at pressures as high as 5000 psi. and at temperatures as high as 220 deg. F. marked increases in stiffening rate were observed, with both factors producing accelerations. The apparatus was calibrated with liquids, but the great difference in behavior between viscous liquids and slurries was appreciated, so that use of the term "poises" could only be nominal. The effect of continued stirring upon the compressive strength of the slurries was determined. At first, continuing stirring increased the strength to a maximum, but as stiffening progresses, continuing stirring damaged the structure. Agitation beyond the "limit of mobility" which occurs at 40 "poises" hurts the strength. Another phenomenon was noted; after a certain degree of stiffening, the slurry sheared off around the periphery and rotated as a plug around the paddle wheel.

Method of Measuring the Consistency of Refractory Mortars.

Ind. Eng. Chem. News Ed **19**, 390 (April 10, 1941). The Refractories Fellowship at Mellon Institute under S. A. Phelps has proposed an apparatus for testing the consistency of refractory mortars. These materials are quite thixotropic, requiring special precautions. The mortar is placed in a cylinder raised 1-16 inch above a flow table. A weight on top of the mortar falls as the flow table is raised and allowed to fall and the distance is a measure of the consistency. This method is more sensitive than manual testing.

A Device for Studying the Workability of Concrete.

T. C. Powers and E. M. Wiler. Am. Soc. Testing Mat. **Preprint** (1941). When solids are suspended in liquids, the system does not deviate at first very much from the laws of liquid flow. But as more solids are added increasing deviations from liquid behavior are encountered. In thick pastes the properties are closer to those of solid systems. This means that in the study of rheological properties of cement slurries, putties, etc., it is important to confine the movement in the system. Otherwise the ability of the system to deform plastically is very soon exceeded, dilatancy occurs, followed by actual shearing. An apparatus is described, consisting of concentric cylinders. The outer cylinder can be rotated through a small and controllable arc at a definite speed. The movement of the inner cylinder, as well as that of the outer one, are recorded on a moving chart driven by a synchronous motor. To secure adequate mixing of the thick slurries studied, a kitchen mixer operating at high speed and provided with a tight cover was found to be suitable. Vibration was used in placing to get a more uniform condition. The slurries studied indicated the presence of a small but definite yield point. The initial movement produced a different record from subsequent ones, due to the aligning of some of

the asymmetric particles to offer less resistance to the flow. A tremendous amount of work remains to be done on this difficult problem, but this is a very interesting method of attack and should yield valuable results.

F. O. Anderegg.

RUBBER

Hysteresis Tests on Tire Compounds. Mackay, Anderson and Gardner, *Rubber Chemistry and Technology*, Vol. 14, p. 421 (1941).

In this paper, a rather extended study of the rate of heat generation or rubber stocks by means of the Goodrich flexometer is described. The temperature rise was investigated as a function of time of cure, amplitude of compression, frequency, load, type of carbon black, accelerator, antioxidant and sulfur contents. Comparison of flexometer and indoor tire test results indicated a fairly accurate correlation. An optimum cure was found at which the temperature rise of the flexometer was a minimum. This finding is interesting in the light of similar minimum in the internal friction, which has been found by other workers.

It is shown that, whereas certain so-called "resilient" accelerators do give more efficient gum stocks than does mercaptobenzo-thiazole, exactly the reverse is true in high black tread stocks. A tread stock was milled for various times and the temperature rise measured as a function of time of milling. It was found that the temperature rise increased with milling time progressively, as did also the static and dynamic compressions. No account was taken of the fact that the machine operated under constant load in interpreting these latter data. In general, however, the work is quite complete and the results accurately analyzed.

The Creep of Natural & Synthetic Rubber Compounds in Shear. Hahn and Gazdik, *Rubber Chemistry & Technology*, Vol. 14, p. 434 (1941).

Creep, expressed in percentage of original shear deflection, was measured for several different and synthetic stocks under constant shear force. The use of a spring loading system which required periodic adjustment was justified by the necessity of conserving space in the testing oven. Tests were run at 80° F. and 140° F. for periods as long as 900 days.

It was found that the relative creep of various stocks at 140° F. and 80° F. varied greatly, indicating the futility of attempting to predict high temperature performance from room temperature creep tests. When the per cent creep was plotted against the logarithm of the time, a distinct upward curvature of varying radius was observed. In most cases, the per cent creep vs. log time curves could be represented by a

series of connected straight lines of different slopes. Thus, the fallacy of attempts to predict long-period creep from short-period tests was pointed out. The compounding formulae of the stocks are not given and the number of stocks chosen for test was rather limited. Nevertheless, the paper is a distinct contribution, especially for the practical engineer.

Properties of Some Synthetic Rubbers. Sebrell and Dinsmore, *India Rubber World*, Vol. 103, pp. 37-40 and 45-50 (1941).

X-ray diffraction pictures of normal and stretched rubber and synthetic rubber are illustrated. It was found that, while natural rubber, Vistanex and Neoprene showed the formation of a "fiber diagram" upon stretching, the butadiene polymers did not. This failure of the latter to exhibit "crystalline fiber diagrams" is explained on the basis of the predominance of cross-linkages in the molecular structure and possible non-uniform distribution of the two substances forming the copolymer.

A number of charts are presented for stocks based on natural rubber and various synthetics, giving a number of conventional physical properties. The difficulties encountered in processing the butadiene polymers are illustrated by comparison of their low extrusion plasticity indices with those of natural rubber and Neoprene at 92° C. In presenting these data, the extrusion pressure is given, but, unfortunately, the size and shape of the extrusion die are omitted.

A forced vibration tester operating at constant static deflection, frequency and periodic impressed force is described. This equipment, although similar to that of Naunton & Waring (*Trans. Inst. Rubber Ind.* Vol. 14, p. 340 (1939),) appears to have several advantages over the latter, since it operates with constant static deflection and gives amplitudes sufficiently large for measurement with a travelling microscope. Values of the dynamic modulus and internal friction, calculated from a simple differential equation (assuming velocity damping and Hookean elasticity) are presented. Unfortunately, all results were obtained with samples in a room temperature chamber, so that the relative values of these quantities have a somewhat limited application to service condition. For example, it has been found by other workers that the internal friction decreases much more rapidly with increasing temperature for some polymers than for others. While this paper is subject to some criticism, in that it is lacking in detail, the amount of interesting, and in some cases, new information presented makes the paper very worth while.

J. H. Dillon.

BITUMINOUS MATERIALS

Mention has been previously made of the triple capillary viscometer of Anderson, Wright and Griffen (1). A somewhat similar instrument has recently been described by Canon and Fenske (2), in which they employ a series of bulbs connected by a capillary tube, the system having been precalibrated, so that the viscosity may be calculated directly from the observed time of flow. The authors suggest that this viscometer may be used for shearing rate studies by the application of external pressure. It appears to the writer that this instrument, as well as the triple capillary viscometer, might present difficulties in filling and in cleaning. It has also occurred to the writer that adaptation of the sample cup and supporting tubular sleeve of the Koppers viscometer to these types of instruments using capillaries and bulbs in series, with application of external pressure or vacuum instead of gravity flow, might make such viscometers less fragile, and far more suitable for easy filling and cleaning.

Another improved capillary viscometer is described by Ruh, Walker and Dean (3), which would seem to be easier to fill and clean (2) than the instruments mentioned above. Since its proposed use concerns measurement involving capillary fall it could not be used for opaque bituminous materials unless modified to permit capillary rise.

Rigden (4) has recently offered a simplified rotating disc viscometer for use over the range of 10 to 10^4 poises. A disc, immersed in small sample tins containing bituminous material, is rotated by weights hanging over pulleys. The instrument is corrected for friction effects, and is calibrated with materials of known viscosity to get conversion factors, after which it may be used to determine the viscosities of road tar, asphaltic road oils, bituminous materials to which fillers are being added, and similar materials during cutting back or blending to a desired consistency. Although precise results would presumably not be obtained with this device, it might be better for routine or plant control determinations than the empirical viscometers now in use which require larger samples, longer times of measurements, are more difficult to clean, and furnish results in varied uncorrelated units over different limited portions of this consistency range. Finney and Walcznski (5) in a paper on the properties of slow curing asphaltic oils give an excellent presentation on the evaluation and suitability of the Koppers capillary rise viscometer previously mentioned in these reviews, (6) and also furnish a large amount of data on the viscosities and temperature susceptibilities over wide temperature ranges for these materials. In this connection the work of Lews and Halstead earlier referred to (1) affords an interesting comparison.

The survey by Eckert (7) on recent periodical literature on bituminous materials will be of use to many interested in the field, especially the portion covering physical properties (Part II, Section B, pp. 416-425) which deals in part with publications describing the rheological properties of bitumens.

- (1) Rheology Leaflet No. 15.
- (2) Ind. and Eng. Chem., Anal. Ed. 13, No. 5, 299 (1941).
- (3) Ind. and Eng. Chem., Anal. Ed. 13, No. 5, 346 (1941).
- (4) J. Soc. Chem. Ind. 60, No. 1, 18 (1941).
- (5) Proc. Assoc. Asphalt Pav. Tech. 12, 233 (1940).
- (6) Rheology Leaflet No. 11.
- (7) Proc. Assoc. Asphalt Pav. Tech. 12, 386 (1940).

W. F. FAIR, Jr.

LINEAR POLYMERS.

Some Properties of the Solid Paraffins on Ruthenium Catalysts from Carbon Monoxide and Hydrogen at High Pressures with Special Reference to the Hitherto Unknown Highest-Melting Constituents.
Helmut Pichler and Herbert Buffleb, *Brennstoff Chemie*, **21**, 285 (1940).

The synthetic hydrocarbon was separated into five fractions with suitable solvents. Densities at 20° and 150°, molecular weights (by boiling point elevation) and viscosities at 150° and 180° were determined with the following results.

Fraction	Density		Viscosity	
	at 150°C.	Av. Mol. Wt.	at 150°C. in cst.	at 180°C. in cst.
2	0.765	760	6.06	4.0
3	0.778	1,750	28.6	16.6
4	0.783	6,750	870	410
5	0.786	23,000	35,600	15,800

The ratio of the viscosities at the two temperatures increases somewhat with molecular weight, but seems to approach a limit of about 2.2, which corresponds to an activation energy of about 10,000 cal. for the elementary process responsible flow. These results confirm the earlier conclusions of Ewell (*J. App. Physics*, **9**, 252 (1938)) and Flory (*J. Am. Chem. Soc.* **62**, 1057 (1940)) that this elementary process involves displacement of only a small portion of the polymer chain. Recently Kauzman and Eyring (*J. Am. Chem. Soc.*, **62**, 3113 (1940)) have reiterated the same point of view, although in earlier work Ewell and Eyring (*J. Chem. Phys.*, **5**, 726 (1937)) had considered that large molecules flow as single units.

P. J. FLORY.

PLASTICS

The Flow Properties of Thermo-plastics I. W. G. Wearmouth, *Brit. Plastics*, **12**, 377-9, (1941). In this report the author describes

the use of a Williams type parallel plate plastometer to obtain the yield value of thermo-plastic materials. A pellet is compressed under varying pressure and temperature until it reaches its limiting thickness. The yield value f is obtained from the following equation.

$$f = \frac{3\pi^{\frac{1}{2}} P \theta_L^{\frac{1}{2}}}{2 V^{\frac{1}{2}}}$$

P = compressive force
 θ_L = Limiting Thickness
 V = Volume of pellet

While this may not give an entirely satisfactory yield value it does reveal some very interesting differences between various types of base resins such as polyvinyl acetate acetal and methylal, polyvinyl chloride, polystyrene, methyl methacrylate resins, and several cellulose derivatives. Curves are presented showing the influence of temperature upon the yield value.

Evaluation of Resinous Flow, F. J. Biondi and L. T. Work. *Modern Plastics*, **18**, No. 12. 57-61 (1941). The parallel plate method is adapted to the study of the flow characteristics of the thermo-setting phenol formaldehyde plastics. A simple apparatus is described. There is a very comprehensive review of the many complex factors involved in any investigation of thermo-setting materials. Six of these factors have been varied and their influence upon flow is shown by sets of curves.

The following letter is placed in the *Plastics* section for it concerns the review of the article "Plasticity of Molding Compounds" which appeared on page 12 of *Rheology Bulletin* No. 2.

Dear Mr. Wakefield,

Many thanks for permitting me to comment on your remarks in the *RHEOLOGY BULLETIN* for May.

I shall have to plead guilty to your charge that I used the word "plasticity" improperly in my discussion of the multicapillary die. The offense is particularly heinous when it is recalled that the A.S.T.M. definition of plasticity, which you use to confound me, was written by the accused himself, in collaboration with Mr. R. L. Peek. Furthermore, the particular A.S.T.M. committee meeting which officially adopted the definition was presided over by none other than myself.

Perhaps the cruelest cut of all was your reference to Webster. Your words carried the unmistakable implication that Nathaniel was a

better plastics man than I. Well, perhaps he was; I don't see how he could be much worse.

Seriously, I cannot agree with your statement that nothing can be done about misuse of words in the plastics industry. We should retain the classical definition of "plasticity" and find another term to describe the results of empirical flow tests. Since they are designed primarily to determine "moldability" by integrating temperatures, pressures and other factors related to commercial molding practice, perhaps that term could be used notwithstanding that the correlation between actual moldability and results of our various flow tests is not too good.

You were misinformed regarding my conceding the difficulty of obtaining reproducible data with the multicapillary apparatus. Our A.S.T.M. round-robin tests demonstrated very good reproducibility within the individual cooperating laboratories. Reproducibility between laboratories was poor. Similarly unsuccessful was our attempt to obtain concordant results between several laboratories using the Rossi-Peakes flow tester. The general situation was summed up by Mr. L. M. Debing of Monsanto Chemical in a recent letter to all the committee members when he wrote "... we are getting nowhere fast on the problem of setting up a standard test method for determining flow ...". While this is the bare truth as of the present, the future, to me at least, looks very promising. It can be stated beyond any reasonable doubt that the average plastics technician has learned in the last few years more about flow phenomena than the previous entire stock of knowledge from the beginning of the industry. Out of this will come some progress.

Yours very truly,

ROBERT BURNS.

Bell Telephone Laboratories

LETTERS TO THE EDITOR.

July 10, 1941.

Dr. A. Stuart Hunter
F. I. duPont de Nemours & Company
Buffalo, New York
Dear Sir:

I recently suggested to you a method by means of which those who really need papers presented before our Society may obtain them in full at little or no inconvenience or expense to the Society of Rheology by making use of the Bibliofilm Service made possible by the cooperation of fifty learned societies giving this service at cost. The Bulletin would publish abstracts of papers giving the American Documentation Institute number and the price, one cent per page plus

twenty cents if articles are not running together. This would give the member who had the use of a "Reader", all of the papers he desired for less than cost of membership in the larger societies. A small reader costs \$1.50; a large one costs as much as a typewriter, but the larger libraries have them for the use of their patrons.

Photoprints can be obtained at five cents a page, if a reader is not available. This method is regularly used by a number of leading scientific journals who find this the only solution to the problem of condensing long articles. Tables, photographs, formulas, may all be copied. The films are easily stored compactly and indexed.

You have asked me to write to each member of the Executive Committee. I am doing this and am enclosing a copy of a folder describing the Microfilm in more detail. The important thing is that without cost to us, we are obtaining in effect a Journal of Rheology with as much included as the Editor sees fit to take.

It seems to me that one of the great reasons for trying out this form of publication is it adds to the value of our Society membership and Bulletin so that our membership will be enlarged and money be made available for enlarging the Bulletin itself. How many members or libraries would wish to purchase Microfilms of all of the papers, I have no idea, but the mere fact that anyone can, when needed, obtain any article, adds greatly to the value of the Society to the individual member. A letter from the A.D.I. heartily approves of this plan.

Respectfully yours,

EUGENE C. BINGHAM.

**A Note on
The Volume and Distribution of Rheological Literature Reviewed in
Twelve Numbers of Chemical Abstracts.**

Eugene C. Bingham.

Rheological literature is scattered so that it is comparatively hard to find. In twelve recent numbers of Chemical Abstracts I find abstracts of rheological interest in eighteen of the different divisions. In only a few cases are there cross references. This is a little confusing, for a paper on the viscosity of water would not be found under the Division 14 headed "water etc." but probably under No. 2 "Physical Chemistry"; the viscosity of liquid aluminum is not found under Physical Chemistry but in Division IX under Metallurgy etc. The viscosity of castor oil might fall in No. 2 Physical Chemistry; if the paper was devoted to lubrication, it might be found in No. 22 with "Petroleum, Lubricants etc." or with Fats, Fatty Oils in No. 27 but there is practically no chance of its being found under "Organic Chemistry" No. 10 or "Pharmaceuticals etc." No. 17. Sodium chloride would seem

to offer a simple case. It would seem to fall under "Inorganic Chemistry" or for its solutions "Physical Chemistry" or possibly "Analytical Chemistry". As a matter of fact the creep or slow flow of halite will probably be found under "Metallurgy and Metallography" or possibly under Mineralogical Chemistry" No. 8.

Heraklitus would tell us that since everything flows, we should have expected this confusion. Rheology cannot be classed under water or Petroleum because it is not a substance; it cannot properly be classed under Physical Chemistry or Metallurgy because it is neither of them. It is a distant branch of knowledge. There is a division devoted to the transportation of matter "Electrochemistry" No. 4 but no division for Rheology. It may be supposed that the reason for this is the paucity of papers of rheological interest. This is not the case as can readily be demonstrated. In 4663 columns of Chemical Abstracts, I find 288 abstracts of rheological interest or exactly 24 abstracts per number. For several years the number per year has been around 500. A few days ago I counted the number of abstracts in the different divisions, not counting the patent abstracts and found twenty divisions for which the average came to this figure of 24 by chance. The figure is of no importance other than to show that two-thirds of the divisions do not average a larger number of papers reviewed than Rheology could and Rheology has helped to swell their average.

It will be of interest to present a table to show which divisions of Chemical Abstracts receive the majority of the papers of rheological interest. Perhaps most persons would expect "Petroleum, Lubricants and Asphalt" to rank first whereas it is a poor third and "Metallurgy and Metallography" ranks first with "Physical Chemistry" a close second. Eighteen of the thirty divisions are represented which is 60 per cent.

Div.	Number of abstracts	Name
1	9	74 Metallurgy and Metallography.
2	2	71 Physical Chemistry.
3	22	26 Petroleum, Lubricants and Asphalt.
4	1	19 Apparatus.
5	26	18 Paints, Varnishes and Lacquers.
6	13	15 Chemical Industry and Misc. Prods.
7	23	14 Cellulose and Paper.
8	11	14 Biological Chemistry.
9	30	13 Rubber.
10	20	6 Cement and other Building Materials.
11	19	4 Glass, Clay Products etc.
12	—	14 Fats, Textiles, Foods, Glue etc.

It is freely admitted that not only do rheological papers touch many different fields but it is realized that many papers contain only a small amount of material which is primarily of rheological character. The question is then as to how to make abstracts most available to rheologists. The author suggests that a division be devoted to abstracts which are primarily of rheological interest, but if a paper on a rheological problem deals with asphalt, paint, rubber or clay a cross reference be placed in the appropriate place. If such a division were formed, it would include certain papers that at present are not abstracted in Chemical Abstracts. Aside from this, the cost of the change would not be very great.

PROGRAM

ANNUAL MEETING OF THE SOCIETY OF RHEOLOGY

October 24 and 25, 1941

at the

Hotel Pennsylvania, New York City

ONE HUNDRED YEARS OF RHEOLOGY, THE POISEUILLE CENTENARY

Friday Morning

Invited Program

9:00-9:45 Registration.

1. 9:45-10:00 The Poiseuille Centenary, E. C. Bingham, Lafayette College, Easton, Pa.
2. 10:00-10:30 The Rheology of Tobacco Mosaic Virus, M. A. Lauffer, The Rockefeller Inst. for Medical Research, Princeton, N. J.
3. 10:30-11:00 Some Rheological Properties of Glass, N. W. Taylor, The Pennsylvania State College, State College, Pa.
4. 11:00-11:30 Plasticity of Clays, E. A. Hauser and A. L. Johnson, Massachusetts Institute of Technology, Cambridge, Mass.
5. 11:30-12:00 Creep of Metals at High Temperatures, S. Dushman, The General Electric Company, Schenectady, N. Y.
6. 12:00-12:30 The Dislocation Theory of Plastic Flow in Solids, F. Seitz, University of Pennsylvania, Philadelphia, Pa.

Joint Luncheon with Acoustical and Optical Societies.

Friday afternoon.

7. 2:15-2:45 Viscosity and Fractionation of High Polymers, T. Alfrey, A. Bartovics, and H. Mark, Brooklyn Polytechnic Institute, Brooklyn, N. Y.
8. 2:55-3:25 Relation Between Viscosity of Solutions and Physical Properties of High Polymers, R. Simha, Columbia University, New York City.

9. 3:35-4:00 The Viscosity of Gelatin in Non-Gelating Solutions, E. O. Kraemer and C. B. Messer, Biochemical Research Foundation, Philadelphia, Pa.
10. 4:10-4:30 Workability of Broken Solids, F. O. Anderegg, Owens-Illinois Glass Company, Newark, Ohio.
11. 4:40-5:00 Physical Properties of Molten Materials as Revealed by Viscosity Studies on Slags, L. B. Wyckoff, Union Carbide and Carbon Research Labs., Inc. Niagara Falls, N. Y.

Joint Dinner with the Optical Society which awards the Ives' Medal (time to be announced).

Saturday Morning.

12. 9:00-9:20 Stress-Strain Relations in the Plastic State Under Combined Stresses, E. A. Davis, Westinghouse Electric and Mfg. Company, East Pittsburgh, Pa.
13. 9:30-9:50 Viscosity-Temperature-Pressure Relations of Hydraulic Oils, R. B. Dow and F. S. Veith, The Pennsylvania State College, State College, Pa.
14. 10:00-10:30 Comparison of Viscosity Measurements and A.S.T.M. Penetration Tests on Coal Tar Residues, W. F. Fair, Jr. and E. W. Volkman, Mellon Institute for Industrial Research, Pittsburgh, Pa.
15. 10:30-10:50 The Viscosity of Roofing Pitches, W. F. Fair, Jr. and E. W. Volkman, Mellon Institute for Industrial Research, Pittsburgh, Pa.
16. 11:00-11:20 Concerning Yield Value in Viscosity Measurements, P. S. Roller and C. K. Stoddard, U. S. Bureau of Mines, College Park, Md.
17. 11:30-12:00 "Fundamental Principles for the Nomenclature of Deformation", J. M. Burgers, R. N. J. Saal and C. B. Biezeno, Trans. Acad. Sci. (Amsterdam) section 1, vol. 18. Abstract by E. C. Bingham, Lafayette College, Easton, Pa.

Annual Business Meeting.

ABSTRACTS OF PAPERS.

Paper No. 1—**The Poiseuille Centenary.**

E. C. Bingham, Lafayette College, Easton, Pa.

One hundred years ago Poiseuille was completing his great paper on viscous flow which established the law of laminar flow of fluids. The work was begun in 1829, several preliminary publications were made but the final paper appeared only in 1846. The work was so contrary to the established ideas of flow gained in hydraulics that several years were consumed by a committee which reviewed the paper and initiated experiments to check the results.

A few years ago attempts were made to give the credit for this important work to a German who had published a brief paper in 1839. It is fitting at this time that we pay honor to Poiseuille to whom the world has given credit for the discoveries he made one hundred years ago—so exact, complete in detail, as well as revolutionary.

Paper No. 2—**The Rheology of Tobacco Mosaic Virus.**

Max A. Lauffer

The Rockefeller Institute for Medical Research,
Princeton, New Jersey.

Indirect physical studies, involving, among other things, the behavior during flow, provided the first indication that the particles of tobacco mosaic virus are rod-shaped bodies. The dimensions were estimated to be 12×400 μ . More recently, pictures made with the electron microscope definitely established the essential correctness of this result, for they have shown the virus particles to be rod-shaped bodies about 15×280 μ .

Solutions of tobacco mosaic virus exhibit double refraction of flow to a very marked extent. At very high dilutions, the relaxation time of the double refraction is a small fraction of a second, but at concentrations as great as one percent, the relaxation time may be almost infinite. Solutions of the virus as concentrated as $1\frac{1}{2}$ or 2% separate spontaneously into two phases, a denser more concentrated liquid crystalline or birefringent phase, which falls to the bottom of the container, and a lighter isotropic phase. When solutions of the virus are centrifuged at very high speeds, a liquid crystalline or birefringent pellet is formed. Such a pellet has many of the gross physical characteristics of a gel. Indeed, even one per cent solutions of the virus show considerable resistance to deformation and a certain amount of elasticity.

Solutions of the virus as dilute as .02% exhibit anomalous viscosity. On theoretical grounds, this behavior could be due to a certain

amount of rigidity within the solutions or to the orientation of rod-like particles in a flowing stream. Although the anomalous viscosity exhibited by concentrated solutions is probably due to rigidity, the studies of Robinson show that in very dilute solutions it can be accounted for entirely in terms of the orientation of rod-like particles.

It has often been suggested that, because of its interesting optical properties, tobacco mosaic virus would serve as an ideal indicator for the study of the general problem of flow of aqueous liquids. Although there can be no doubt that this suggestion could be realized in the hands of a careful investigator, it must be born in mind that the very presence of these virus particles in a solution will tend to modify the flow properties of the solvent. If the virus is not used judiciously, the extent of such modification might easily be sufficient to render questionable any conclusions drawn concerning the behavior of the solvent.

Paper No. 3. **Some Rheological Properties of Glass.**

By Nelson W. Taylor

Department of Ceramics, The Pennsylvania State College,
State College, Pennsylvania

Glass when cooled rapidly from melting temperatures preserves to some degree the molecular structures characteristic of the high temperature. At room temperature these structures may persist indefinitely, but at annealing temperatures molecular rearrangements occur and elastic adjustments also take place.

The factors governing rates of annealing of glass are discussed, with particular regard to the rate of silicate polymerization. The nature of elastic aftereffects in glass is described and some analogies with "memory" effects in rubber and with dielectric polarization and absorption in glass are pointed out.

Paper No. 4. **PLASTICITY OF CLAYS**

By E. A. Hauser and A. L. Johnson (1)

A theoretical discussion dealing with the plasticity of clays from a physico-collodial standpoint, based on modern concepts of the nature and source of the charges associated with the collodial system is presented. By definition, plastic substances display a yield value and it is shown how the attraction-repulsion forces acting between the clay particles in the system and the ion distribution in the dispersion medium can account for the higher or lower forces required to produce

shear, that is, high or low yield points. A detailed discussion of these forces shows the relation between the charge on the particle, the hydration and type of the absorbed ions to the yield point of the system. Since a large net charge is responsible for repulsion forces being set up between particles, less force would be required to produce shear. Thus, kaolinite in highly dispersed or peptized condition is not truly plastic since little or no yield point is present in the system. So peptized kaolinite is best illustrated by the formation of clay-OH-Na particles. In the proper medium this results in the deflocculation of the system; it follows that the formation of $(\text{Clay OH})_2 \text{Ca}$, $(\text{Clay OH})_3 \text{Al}$ or Clay OH-H particles would cause an increase in the yield point of the system since the net charge decreases in the same order. Thus the Clay OH-H form of kaolinite should be the most plastic form of this material.

The effect of structure is discussed in the light of the formation of the colloidal "double layer" due to the preferential adsorption of ions. Surface area and its relation and effect on the attraction-repulsion forces present between particles in laminar, fibrillar and corpuscular systems is analyzed. Finally, the plasticity of other members of the clay group as well as some of the non-plastic minerals is discussed and correlated with modern physico-colloidal concepts.

The effect of viscosity on the plastic properties of clay systems is pointed out and changes in viscosity correlated with the ion distribution in the entire system.

In conclusion suggestions are offered how the present concept can best be applied to the manufacture of clay products of various types including the most recent developments.

(1) Dept. of Chem. Eng. and Div. of Ceramics, Mass. Inst. of Tech., Cambridge, Mass.

Paper No. 5. **Creep of Metals at High Temperatures.**

Saul Dushman

Research Laboratory, General Electric Company,
Schenectady, New York

It is well known that the rate of creep of metals increases with both stress and temperature. In general there exists a certain range of temperature for any one metal, in which the rate of flow at constant temperature and stress is constant for a long period until rupture occurs. For these conditions it is possible, as shown by W.

Kauzmann and, independently, by the author, to develop, on the basis of Eyring's theory of molecular reaction velocities, a relation for rate of creep as a function of temperature (T) and stress (W) which is of the form,

$$\frac{dl}{ldt} = r = r_0 \exp(\Delta S^*/R) \exp(-Q_0/RT) \cdot 2 \sinh(aW/RT) \dots \dots \dots 1$$

where ΔS^* = change in entropy
 R = Molar gas constant
 Q_0 = "activation" energy

and a and r_0 are constants for any one metal or alloy.

Since the value of aW/RT is usually greater than 3, the last factor in the above equation can be replaced by $\exp(aW/RT)$. Hence, at constant temperature, a plot of $\log_{10} r$ against W should yield a straight line having the slope

$$s = a/(2.30 RT) \dots \dots \dots (2)$$

$$= a/(4.578T)$$

Furthermore, if these straight lines are extrapolated to $W = 0$, we obtain the values of $\log \bar{r}$, where

$$\bar{r} = r_0 \exp(\Delta S^*/R) \exp(-Q_0/RT) \dots \dots (3)$$

and a plot of $\log \bar{r}$ versus $1/T$ gives the value of Q_0 .

Assuming r_0 to be the same order of magnitude as the Debye characteristic frequency, values are obtained for ΔS^* , the change in entropy.

In order to test the validity of this theory, observations were made under two sets of experimental procedures. In one set, V-shaped filaments of different ferrous alloys, with the weight suspended from the center of the V, were heated, by passing current through them, in an atmosphere of nitrogen. In the case of metals and alloys, which exhibit creep at temperatures of 500° C and lower, straight filaments were suspended in a furnace which could be maintained at constant temperature.

Observations were made on 18-8 alloys, pure platinum, aluminum, and an alloy of copper and nickel. In all of these cases the observations are, in general, in satisfactory agreement with the deductions of the theory. The paper will give the actually observed values of the creep constants and discuss the inferences to be drawn from these observations regarding the mechanism of creep in metals under conditions of "plastic flow".

Paper No. 6 **The Dislocation Theory of Plastic Flow in Solids**

Frederick Seitz, Physics Department,

University of Pennsylvania, Philadelphia, Pennsylvania.

The most promising attack on the problem of mechanism for plastic flow in solids is based on the concept of dislocations, proposed by Taylor, Orowan and others. The fundamental problems relating to the existence of dislocations and their properties will be discussed from the standpoint of the atomic theory of solid bodies. In addition, the field of application of the theory of dislocations will be surveyed briefly.

Paper No. 7. **Viscosity and Fractionation of High Polymers**

By Turner Alfrey, A. Bartovics and H. Mark,

Brooklyn Polytechnic Institute

The fractionated precipitation of different high polymers—polystyrene, rubber, polyvinyl acetate and cellulose acetate—was followed by specific viscosity measurements of the system, in which precipitation took place. Measurements were carried out in different solvents, at different concentrations and different temperatures. The results seem to indicate that precipitation of a long chain compound occurs at a critical degree of solvation, which can be correlated with a certain intrinsic viscosity. This critical solvation depends upon the chain length, the intermolecular forces between the chains and the solvent and upon the flexibility of the chains. The dependence upon chain length determines the effectiveness of fractionation; it is influenced by the two other factors.

With the aid of these measurements an attempt is made to sketch a theory of fractionation, which at the same time takes into account energy changes (G. V. Schultz) and entropy changes (K. H. Meyer) during precipitation.

Furthermore it seems possible to offer an explanation for the variation of the Staudinger-constant (K_m -constant) with temperature and solvent.

Paper No. 8. **Relation Between Viscosity of Solutions and Physical Properties of High Polymers.**

Robert Simha

Dept. of Chemistry, Columbia University, New York, N. Y.

The investigation of high molecular weight compounds, in particular the determination of molecular size, shape and weight, requires at present the combined use of several independent methods, such as

ultracentrifugal analysis, measurement of osmotic pressure and/or viscosity in solution. The applicability of viscosity measurements in dilute solutions of high polymers to the determination of size and shape of particles suspended therein will be discussed. In this connection the fact that the kinetic units of the solute are large compared with those of the (low molecular) solvent is of fundamental importance for the quantitative treatment because it allows the application of hydrodynamic methods. They have proved so far to be the most effective.

It is possible on this basis to formulate quantitative and in some cases qualitative relationships between specific viscosity and concentration for sphere-like and elongated particles under different external conditions, such as type of flow, degree of orientation in the flow, internal flexibility due to internal free rotation of the suspended macromolecules and degree of solvation.

The hydrodynamic interpretation gives originally only the dimensions of the solute molecules. If an additional relationship between geometrical size and molecular weight, or between viscosity and molecular weight is available, then viscosity determinations represent a simple means for measuring the latter quantity. Staudinger's empirical rule provides such a means. Its significance and range of validity will be discussed.

The theory is used for the evaluation of data on proteins, cellulose derivatives and polystyrenes. The results are compared with those obtained from sedimentation measurements. Discrepancies can be partially ascribed to the different behavior of flexible macromolecules in viscosimeter and ultracentrifuge. Synthetic polymers are usually inhomogeneous in size, so that viscosity measurements give average values only in these cases. It is pointed out how from a knowledge of the molecular weight distribution the corresponding size distribution and the relation between size and molecular weight can be found semi-empirically from viscosity measurements on homologous series.

Paper No. 9. **The Viscosity of Gelatin in Non-Gelating Solutions**

By Elmer O. Kraemer and Charles B. Messer

Biochemical Research Foundation, Philadelphia, Pa.

The viscosity behavior of gelatin in solutions which prevent gelation below the usual gelation temperature has been investigated in order to determine to what extent the gelatin can be considered to exist in these solutions as molecular dispersions. The agents used to prevent gelation included urea, thiourea, formamide, potassium thio-

cyanate and potassium iodide. Viscosity is a very sensitive indicator of aggregative tendencies, and by comparison of the effects of temperature and of concentration on viscosity, it is possible to show that these agents under suitable conditions give molecular dispersions whereas in their absence, under otherwise the same conditions, aggregation or gelatin would occur. The results are correlated with ultracentrifuge results for similar solutions.

Paper No. 10. **Workability of Broken Solids.**

By F. O. Anderegg

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Something like a billion tons of broken solids are being worked into place every year, hence the laws governing the workabilities are of importance. Among such systems of broken solids are found; Portland cement concrete and mortar, bituminous concrete, and the mixes for forming brick and tile, refractories, and white ware. The bridging tendency of broken solids has to be overcome and the best way of doing this is by having the proper gradation of sizes, ranging from coarse to very fine. The smaller particles act as ball bearings over which the larger ones will roll into place. The best workability is obtained with fractions, separated by American sieves, having a definite ratio. This same series of sizes also is capable of producing a good packing also. The shapes of the particles obviously affect the ease of rolling and packing. The more nearly spherical they are, the less the amount of fines required to promote rolling and to fill the voids. In all these systems the fines extend down to about one micron or lower. Generally speaking, the amount of the fines required is largely controlled by the extent of the voids among the coarse particles.

In the application of these systems a liquid is also present, usually water. A film of liquid is absorbed on the surface of the solids, which participates very helpfully in the application. Even in making a dirt fill, maximum density is obtained only with an optimum water content. Where an hydraulic cement is involved, part of the water reacts with the cement, but the excess water forms a flexible cushion around each solid particle. This cushion gives the system its plastic properties. If the specific surface of the system is low, then the lack of plastic property has to be made up by adding more water. This excess or "free" water helps float the particles into place. It is necessary for the placing operations, but thereafter it is a nuisance. It distends the system and reduces the mechanical strength. Often it exudes or "bleeds" to the top as the solids settle, resulting in the development of a system of continuous capillaries. Such capillaries permit and en-

courage the ingress of corrosive solutions, including acid, winter rain-water.

Air entrapped in the mix improves workability, the bubbles acting as very mobile cushions, to improve the ease with which the system may be deformed. If the bubbles are quite small, an appreciable amount of water may be immobilized on their surfaces, to improve plasticity and to reduce bleeding. Certain organic reagents are effective in very small amounts in aiding such froth formation. The bubbles do not usually connect to form a capillary system. They have a beneficial effect on durability of concrete and mortar by cushioning the forces developed during ice formation. Their discrete character means that the ingress of corrosive solutions is reduced. The amount of permissible froth formation is limited by the deleterious effect on the mechanical strength. In certain products, such as highest quality tile, brick and whiteware, the amount of entrapped air is kept to a minimum, necessitating application of special means in forming.

Paper No. 11. **Physical Properties of Molten Materials as Revealed
By Viscosity Studies On Slags.**

By L. B. Wyckoff

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Niagara Falls, N. Y.

This paper will be designed to cover the relation between viscosity and other physical properties such as melting points, reacting temperature, crystal formation, peritectic phases, primary and secondary phases, possible compounds which do not show crystals on solidifying but affect viscosity and other physical properties. It will be shown that constitutional diagrams which closely approximate melting point diagrams can be developed from viscosity data.

Paper No. 12. **Stress-Strain Relations in the Plastic
State Under Combined Stresses**

By Evan A. Davis, Research Engineer,

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The object of most of the testing work done in the past in the field of combined stresses has been to determine a suitable theory of strength. Thus, if $\sigma_1, \sigma_2, \sigma_3$ are the three principal stresses where $\sigma_1 > \sigma_2 > \sigma_3$, the investigators have been interested in the effect

of the magnitude of the intermediate stress σ_2 upon the state of stress at which yielding takes place. Some studies have been made of the effect of this intermediate stress, σ_2 , upon the principal strains ϵ_1 , ϵ_2 and ϵ_3 . Tests in these cases are scarce and differ in their results. The aim of the present paper is to make a further study of these relations. Soft copper bars in the shape of hollow cylinders will be tested under combined tension and internal pressure. The ratio $\frac{\sigma_2}{\sigma_1}$, ($\sigma_3 = 0$), will be kept constant during each test but for different tests this ratio will be varied from 0 to unity. The results of these tests should be helpful in pointing out what to expect in the case of creep under combined stresses where the relations between the three principal stresses and the three principal strain rates are of importance.

Paper No. 13. **Viscosity-Temperature-Pressure Relation of Hydraulic Oils**

By R. B. Dow and F. S. Veith

The Pennsylvania State College, State College, Pa.

The viscosity of four commercial hydraulic oils has been studied as a function of temperature and pressure over an experimental range extending from 130° to 10° F, and from atmospheric pressure to $30,000 \text{ lbs/in}^2$. The pour points of these oils were about -40° F and the Viscosity Indices were between 120 and 142. It was found that both the temperature and pressure changes could be adequately expressed on the A. S. T. M. Viscosity-Temperature Chart D341-39, the log log kinematic viscosity varying linearly with the log of the temperature at constant pressure. For a family of these lines the slope decreases slowly with increase of pressure, the decrease amounting to about 75% over a pressure range of $10,000 \text{ lbs/in}^2$.

Paper No. 14. **Comparison of Viscosity Measurements and A.S.T.M. Penetration Test On Coal Tar Residues.**

By W. F. Fair, J., and E. W. Volkman

The Mellon Institute for Industrial Research, Pittsburgh, Pa.

The industrial chemist who examines the asphaltic and coal-tar residues commonly used for protective coatings, for roofing and waterproofing purposes determines the apparent viscosities of these materials by the A.S.T.M. Penetration Test. Many attempts have

been made to correlate the results of this test with absolute viscosity measurements. The formula established by Saal has been accepted by many investigators as a reliable relationship as long as the materials under test do not show anomalous flow properties. A theoretical analysis of the empirical formula confirms the validity of its general form. The results of a number of viscosity determinations and the corresponding penetration values of various pitches exhibiting viscous flow are presented and correlated on double logarithmic coordinate paper. The Saal formula seems reasonably reliable above penetration values of about 60 decimillimeters. Below this value considerable deviations are apparent. This is not surprising since the standard penetration needle is not a simple cylindrical stem but consists of a cylindrical shank with a truncated cone of 54 decimillimeter length.

Paper No. 15. **The Viscosity of Roofing Pitches**

By W. F. Fair, Jr., and E. W. Volkmann

The Mellon Institute of Industrial Research, Pittsburgh, Pa.

The viscosities of the less fluid bituminous materials are usually determined at elevated temperatures under which conditions the consistencies may be convenient for estimation with empirical or capillary type viscometers. To determine the viscosity of such materials at lower temperatures a simplified falling co-axial cylinder viscometer was devised, following the recommendations of Traxler and co-workers. Results obtained for a group of roofing pitches indicate that these pitches exhibit viscous flow at 250°C., and have better temperature susceptibilities below their softening points than at higher temperatures. Viscosities calculated from the Saal viscosity-penetration relation do not agree with the results obtained with the falling cylinder viscometer.

Similar studies on special pitch distillate demonstrate that this material changes upon standing with progressive increase in apparent viscosity and probable development of yield values.

Paper No. 16—**“Concerning Yield Value in Viscosity Measurement”**⁺

By Paul S. Roller* and C. Kerby Stoddard**

U. S. Bureau of Mines, College Park, Md.

It has been demonstrated on the basis of axiomatic connotation of rate of shear as variable that yield stress in a viscosity diagram is theoretically impossible. No valid experimental evidence has ever in

fact been found for such a condition, while on the other hand a number of observers have inferred empirically that the T - σ curve passes through the origin of co-ordinates in the case of suspensions that would come under the "yield value" hypothesis. The rigid character of structural suspensions, and yield stress in particular, are properly measured on a stress-strain basis only. We have considered the stress-strain and viscosity suspensions as the proper condition at zero rate of shear, that while shear stress is zero, the viscosity is infinite.

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** Research Fellow, U. S. Bureau of Mines in Cooperation with the University of Maryland.

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Paper No. 17. **Fundamental Principles for the Nomenclature of Deformation**

The Viscosity Committee of the Academy of Sciences has this year printed a 44-page bulletin entitled, "Fundamental Principles for the Nomenclature of Deformation," by J. M. Burgers, R. N. J. Saal and C. B. Biezeno. It is published as Section One of Volume 18 of the **Transaction of the Academy of Science**. Due to the present conditions, the publication is in Dutch.

The authors distinguish five different yield values, viz., elastic deformation, creep, viscous flow, accelerating flow and rupture. They introduce several terms which are new such as aliminary flow and deciatoric stresses, firmo-viscosity, dynamic and static hysteresis. Liquids are divided into

1. hardening liquids
2. perfect liquids
3. true liquids
 - a. Newtonian
 - b. non-Newtonian
4. excessive liquids

Solids show a purely elastic deformation at sufficiently small shearing stresses. The total shear γ is the sum of the elastic shear γ_e and the permanent shear γ_p .

Abstract by E. C. Bingham,
Lafayette College, Easton, Pa.

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Mr. H. R. Lillie, Secretary
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