THE HISTORY

OF

THE SOCIETY OF RHEOLOGY

from

1924 - 1944

Compiled By

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THE SOCIETY OF RHEOLOGY

Facts in regard to the early history of the Society.

Compiled by Eugene C. Bingham of Lafayette College

Dr. Edward Hart was a very versatile person but, were he alive today, he would disclaim credit for the important part which he played in the formation of this Society; yet in 1924, now twenty years ago, when he had completed fifty years in the Faculty of Lafayette College, it was proposed to hold a HART CELEBRATION, and that was the beginning. A Fellowship Fund for research of $10,000 had already been collected and many notable men and scientific societies were invited to participate. Historical papers were given by Dr. William H. Nichols, President of the General Chemical Company and by Dr. Edgar F. Smith, Provost of the University of Pennsylvania. The paper by Dr. Nichols had to do with the manufacture of chemicals in America, in which both he and Dr. Hart were interested. Dr. Smith spoke on "Fifty Years of Chemistry in America", which was peculiarly appropriate, because the American Chemical Society was approaching its fiftieth birthday, and seven ex-presidents of that society and several Charter Members were present. It had no publicity at the time, but it should now be noted with gratitude that Dr. Nichols quietly handed to President MacCracken on that occasion a check for $25,000 for the purpose of scientific research.

To give a research flavor to the meeting, which began on Friday, October 17, a Plasticity Symposium was scheduled for the following day. It seemed then, as indeed it does now, like a temeritous, one may even say a temerarius undertaking, to organize such a meeting. At a meeting of physicists, a paper on viscosity was known to bring an expression of boredom to the faces of many who were experts in fields such as radioactivity or spectroscopy. Among physical chemists a paper on viscosity served as a breathing spell, but was heard without comment or discussion. Of course, no apology was made or expected. Perhaps the feeling was best expressed by Dr. J. C. W. Frazer, who once asked, "Why would one ever think of working in the field of viscosity?" The obvious reply was, "It is possibly less risky and certainly more exciting to develop a new claim where the indications are full of promise than it is to explore old and perhaps exhausted workings in the hope of finding some nuggets which have been overlooked." The Faraday Society had held a valuable symposium on viscosity, but none had ever been held on plasticity. In fact little was known about it. The first thing was to see if papers could be secured.

The results were surprising. Thirteen papers were secured covering the flow of single crystals, clay, gelatin and cellulose derivatives, viscose, starch paste, dental impression compound and dental creams. There was much discussion, and too little time. The meeting was like an orphan asylum on Christmas morning. No arrangement was considered for another meeting. The papers were published together in the Journal of Physical Chemistry, 29, 1200-89 (1925), so the subjects need not be given here. The names of the authors are of interest, however, since the interest of several has continued: H. N. Holmes, W. P. Davey, W. D. Bancroft, L. E. Jenks, W. H. Herschel and R. Bulkley, S. R. Sheppard and E. K. Carver, R. H. Bogue, C. S. Venable, C. Bergquist, F. G. Breyer, W. S. Crowell and A. Saunders, Jr., E. Moness and P. M. Giesy, E. C. Bingham.

The committee of the National Colloid Symposium, to meet at the University of Michigan in 1927 with E. C. Bingham a member, set aside one session to be a Plasticity Symposium. Six papers were arranged for, and they were published in Colloid Monograph 5, 219-73 (1928). The authors were F. L. Browne and Don Brouse, S. E. Sheppard, E. K. Carver and R. C. Houck, P. M. Giesy and S. Arzoomanian, H. E. Phipps, J. K. Speicher and C. H. Pfeiffer and E. C. Bingham.

It is now necessary to explain why Dr. Markus Reiner came to Layfayette College in 1928. He had two years earlier published an equation of flow of suspensions, based upon elasticity which was the same as an equation of Buckingham based upon experimental data of Bingham and Green, working with zinc oxide suspended in oil. Dr. Buckingham had been the member of the Editorial Committee of the National Bureau of Standards to pass on the publication of Bull. 276 on the Laws of Plastic Flow. The measurements then encountered difficulties due to several possible causes, e.g. seepage, slippage, thixotropy, settling and evaporation of suspending medium. By using zinc oxide in oil and an improved apparatus the difficulties were reduced. It became evident to Bingham and Green that the starting pressure varied with the radius of the capillary, but a little thought showed that the shearing stress at the wall should be a constant and that proved to be the case. This discovery made possible the integration of Buckingham. Reiner accepted the explanation of plasticity as being a complex property made up of yield value and mobility. He came to Lafayette College to work on problems of flow (particularly on the mathematical theory), as well as to meet American scientists in that field. This resulted in an invitation to the Third Plasticity Symposium for December, 1928. There were two papers by Reiner and one each by S. E. Sheppard and R. C. Houck, D. V. Gregory, G. M. Rassweiler and K. C. Lampert, W. P. Davey, D. R. Wiggam, W. H. Herschel, E. O. Kraemer and R. V. Williamson.

These eight papers make up the papers published in the October 1929 number of the Journal of Rheology.

It was at this Third Plasticity Symposium that the decision to form a permanent organization was reached, and the following committee appointed to form the permanent organization: Ernest Ashton, Eugene C. Bingham, W. W. Buffum, W. P. Davey, G. S. Haslam, Winslow H. Herschel, Harry N. Holmes, A. Stuart Hunter, Elmer O. Kraemer, H. M. Kraner, S. E. Sheppard, and David R. Wiggam from America; Marcel Brillouin, Herbert Freundlich, Ernest A. Hauser, James Kendall, H. R. Kruyt, Wolfgang Ostwald, L. Prandtl, Markus Reiner, O. Scarpa, Jean Timmermans, and A. Van Rossen from Europe. At this meeting, E. C. Bingham proposed that the word RHEOLOGY be used for the circumlocuxtion - the science devoted to the study of the deformation and flow of matter. W. H. Herschel said, "I have always wondered what I am. I know now that I am a RHEOLOGIST". Physics, Geology and Astronomy offered three possible suffixes, but with the advice of Dr. John R. Crawford, our choice was preferred, and W. O. Ostwald pronounced it "Ein ausgezeichnetes wort". Webster's Dictionary gives the pronounciation: re-ol-o-ji, as in rheostat.

The preliminary meeting was called to coincide with the meeting of the American Chemical Society at Columbus, Ohio on April 29, 1929. The Chemical Foundation, through Mr. W. W. Buffum, had become interested in the organization and played an important part in the proceedings. E. C. Bingham was elected as temporary chairman and A. Stuart Hunter as Secretary. The name of the Society and its scope were decided upon, and a preliminary constitution drawn up. It was agreed to hold the first meeting for organization at the National Bureau of Standards on December 19 and 20, 1929. Hence, the above description has entirely to do with the gestation period of the Society, whose natal day is therefore December 19, 1929.

The Constitution and By-Laws were duly adopted and the officers elected: Wheeler P. Davey, President; E. O. Kraemer and W. H. Herschel, Vice Presidents; A. Stuart Hunter, Secretary; E. C. Bingham, Editor; S. E. Sheppard, Assistant Editor; and W. W. Buffum, Treasurer and Business Manager. At this first meeting, action was taken for the purpose of securing a better absolute standard of viscosity and a committee was appointed on definitions. The Journal of Rheology was started as a quarterly of about 500 pages. Membership was fixed at $3.00 per year, including the Journal.

The American Physical Society began to take a serious interest in the subject of rheology at about this time. Its Bulletin for April, 1931 announced the new publication, PHYSICS,

to begin in July at $7.00 per year. At the Washington meeting of that Society held in April, a so-called "Colloid Program" included eleven papers, most of them of interest to rheologists. At about this time, Dr. Karl T. Compton addressed a letter to the Society of Rheology in reference to the proposed formation of the American Institute of Physics, in order to consolidate the work in the various branches of Physics being carried on in America, in the American Physical Society, the Optical Society of America, the Acoustical Society of America and the Society of Rheology. After due consideration, our Society joined in this undertaking. Our Society was not strong enough to render much help, but the intimate relation between theoretical and applied rheology is a pattern that the older Physics hoped to regain. W. W. Buffum also became Manager of the Institute of Physics. With the selection of Henry A. Barton as full-time Manager, and with editorial offices and staff where business and editorial work could be carried on, a period of efficiency and prosperity began. It was quite obvious that the Journal of Rheology could not continue without a subvention. Since PHYSICS was willing to publish articles of rheological interest, the two journals were joined in 1933 with joint editors. Later PHYSICS was changed in name and scope to APPLIED PHYSICS and Elmer Hutchisson was made Editor.

The chemical Foundation gave to the National Bureau of Standards a sum of money to facilitate and hasten the work on the standard of viscosity which they had agreed to undertake. With this money John R. Coe was employed. A preliminary report has been made in PHYSICS 4, 274 (1933), but regrettably, the work has never been brought to completion and this has tended to prevent other efforts being started to accomplish this greatly needed task.

The second meeting was held in Easton, Pennsylvania. Eighty-six persons registered and twenty-six papers were presented. The third meeting was held in Rochester, New York on December 29, 1931, with thirty-seven scientific papers. Our Society became affiliated with the A. A. A. S. and we met with them in Atlantic City in 1932, but the arrangement did not prove helpful, because our own program was too crowded to enable us to make much use of their papers and evidently we gained very little attendance from the many other groups. More important, however, is the fact that the A. A. A. S. moves around the country widely, while our experience has demonstrated the greatest rheological interest to be around New York.

In 1933 the Society was very hospitably entertained in Pittsburgh, where we learned much about the work that Westinghouse is doing on the rheology of metals with exp ensive, long-time measurements of creep.

Here the following new officers were elected: Melvin Mooney, President; A. Stuart Hunter, Vice President; E. C. Bingham, Second Vice President; Wheeler P. Davey, Editor; R. L. Peek, Jr., Secretary-Treasurer. It is of interest to report here that the Chemical Foundation made a total contribution to our Society of $10,701.72 (Treasurer's Report, 1933). The dues were raised to $6.00 per year, but Dr. Tate of the American Institute of Physics reported in 1934 that the costs for rheology papers ($1,797) was considerably more than the amount received from subscriptions ($1,544.33). With the raising of the dues in 1932, there was an immediate drop in membership from 204 in 1932 to 119 in 1933, which continued to the low point of 78 in 1936. The Rheology Leaflet was started at the suggestion of Dr. Davey, as was the student membership.

The Sixth Meeting of the Society was held in the pleasant surroundings of the Franklin Institute in Philadelphia, arranged for by the genial W. H. Fulweiler. Time of the meeting was changed from Christmas Week to October 19 and 20.

During these years the Society was constantly trying to agree upon rheological definitions. The discussion was carried on in an even more lively manner in the American Society for Testing Materials, which has had a committee for many years on Consistency, Plasticity and Related Properties, with E. C. Bingham as Chairman. The conceptions of rheological properties, such as consistency, plasticity, hardness, workability, tackiness, shortness, malleability, etc. in numerous industries and the home have been essentially different. Through long usage, numerous methods have developed for estimating these properties even though the methods might be purely empirical. If these methods lacked theoretical basis and they could not be correlated with each other, it was inevitable that the attempt to secure uniform definitions would give rise to debate. Such debate need not be considered profitless if it can be shown that, after all, there are but a very few fundamental rheological properties and that these can all be measured in units about which there can be no argument. If the public come to feel that this is true, rheology can bring about a great clarification. It will then appear that the spawning over our entire system of controls of numberless empirical "properties" will be considered not so much the hand-maiden of industry, but the very devil himself.

The so-called "National" viscometers (Engler in Germany, Redwood in England and Saybolt in America) afforded an interesting relic of the Stone Age in measurement. They were well intrenched, but they were crude, very inaccurate, often time-consuming and lacking completely in flexibility. The results were not fully convertible from one to the other and the results whether expressed in degrees or seconds meant neither degrees nor seconds, but merely

a number. Realizing the situation, the World Petroleum Congress meeting in London through Dr. Guy Barr of the National Physical Laboratory, arranged a meeting on "Viscosity and Its Expression and invited E. C. Bingham, Chairman of the A. S. T. M. Committee to present a paper on that subject and preside over the symposium. This meeting is of importance in the history of rheology, because, as reported in Volume F, page 543, the following resolutions were proposed and adopted unanimously. They were:

"1. That viscosities should be expressed in C. G. S. units.

"2. That it is desirable that results should be expressed as kinematic viscosities, but that specific gravities should be reported in addition.

"3. That international cooperation is necessary to insure the same values of units of kinematic viscosity in different countries."

Today absolute measurement in centipoises (or centistokes) is making its way, and since it is at the same time relative to water at 20° C., it can mean something to anyone. Both the Society of Rheology and the American Society for Testing Materials have adopted definitions. There is nothing mystical about them as they are a compromise in each case and no doubt they could and should be changed gradually. But Maxwell was quite an up-to-date rheologist, so changes may be largely devoted to amplification. The World Petroleum Congress did not discuss the adoption of some one instrument. No such instrument is needed, provided only that C. G. S. units are measured with the requisite precision.

During the period we are discussing, symposia of Applied Mechanics were held at New Haven and at Lafayette, Indiana. The American Mechanical Engineers also maintained a Committee on Viscosity, of which Dr. Nadai was Chairman, and which held widely attended meetings. The American Society for Testing Materials has held two symposia of Consistency, the first in 1917 and the second in 1937. The papers of the second have been bound up separately and sold as a bulletin. Dr. Nadai's "Plasticity" appeared in 1931 as an Engineering Societies' Monograph.

In the "First Report on Viscosity and Plasticity" prepared by the Committee for the Study of Viscosity of the Academy of Sciences of Amsterdam, it is related that they accepted the suggestion of Dr. G. E. Hale to found a committee on instruments and methods of research, a nd say in the preface, "The subject of viscous and plastic deformation seemed particularly well suited to provide a theme that could bring together scientists from rather

various domains of physics, chemistry and biology ..... Though it cannot be said that the study of viscosity has ever been neglected , still it appears, particularly when taken in its wider sense as being connected with all kinds of reversible and non-reversible deformations, that it has received a great impetus rather recently." (page 2). It goes on to describe the work of the Society of Rheology.

The Eighth Meeting of the Society was held at the Bell Telephone Laboratories in New York on October 30. Our Society has never tried to get in the local press at the meetings to convince the public that Rheology should be classed as a "Humanity", but as the Roving Reporter of the New Yorker was struck by the unfamiliar name Rheology, he "roved" into our meeting instead of into that of the Merchants Association. He must have been "taken for a ride" because he remained all day and came back on Saturday for the concluding session. He, too, got the picture of the waifs in the Orphanage on Christmas morning, and he was impressed that "everything flows" is not as trivial as Cole Porter's declaration that "everything goes". He even told the public that there were two hundred in attendance and the Society had a balance of $426.03. (New Yorker, November 23, 1936, pp. 61-71)

The Ninth Annual Meeting was held on October 22-23, 1937 at Akron, Ohio. The Tenth Annual Meeting was held on December 29-30, 1938 at Pittsburgh, Pennsylvania at the Mellon Institute, with Dr. E. E. Tillotson as official host. At Akron the following officers were elected: A. Stuart Hunter, President; J. H. Dillon, First Vice President; H. H. Ewell, Second Vice President; W. P. Davey, Editor; H. F. Wakefield, Associate Editor; H. R. Lillie, Secretary-Treasurer. At this meeting also the publication of the Rheological Memoirs by E. C. Bingham was approved. The first number was a translation by W. H. Herschel of the paper by Poiseuille entitled, "Experimental Investigations Upon the Flow of Liquids in Tubes of Very Small Diameter", with critical notes by the Editor. The leaflet was edited by W. P. Davey and W. H. Fulweiler.

When the Society of Rheology was organized in Washington in December, 1929, there was present as a Charter Member Dr. George W. Scott Blair of England, who had come to this country to become acquainted with rheologists here. In 1938 he published his "Industrial Rheology" under the imprint of J. and A. Churchill, Ltd., in London, and Blakiston's Son and Company in Philadelphia, as well as a German edition with an introduction by W. O. Ostwald. More recently he has brought out "A Survey of General and Applied Rheology" in 1943, Sir Issac Pitman and Sons, 1944.

Another development which must be mentioned in any history of Rheology is the formation of the British Rheologists' Club, c/o

The Institute of Physics, at the University, Reading, England. The president is Professor G. I. Taylor; Dr. G. W. Scott Blair, Honorary Secretary and Dr. V. G. Harrison, Honorary Treasurer.

We must now mention the important "Monograph of Viscometry" by Dr. Guy Barr of the National Physical Laboratory, published by the Oxford University Press in 1931. This book contains 318 + XIV pages devoted to viscometry, i.e., rheological measurements and instruments. One may feel that the literature contains a plethora of instruments, but to select a convenient instrument which is also accurate for measuring matter in all three states as well as the colloidal condition, from the temperature of liquid helium to that of molten glass, perhaps in an amount as small as the living cell or perhaps as gross and unmanageable as a concrete mix, is a real problem for which, Dr. Barr's Viscometry is very useful.

The Second Report on Viscosity and Plasticity by the Committee of the Academy of Sciences in Amsterdam appeared in 1938 under the imprint of Nordemann Publishing Company (now the Interscience Publishers, Inc., 215 Fourth Avenue, New York). The volume was followed by a Third Report before the War started. These volumes are all published in English. The Chapter by Dr. Houwink prompted Dr. Houwink to publish his monograph on "Yield Value". He has also published a volume on technical rheology in German, "Physikalische Eigenschaften und Feinbau von Naturund Kunst Harzen", under the imprint of the Akademische Verlags gesellschaft" in Leipzig, in 1934.

In 1936 P. Evans and A. Reid published a monograph of 263 + XXX pages on the subject of Drilling Muds. This was published first as the December number of the Mining and Geological Institute of India, Vol. XXXII. It is distributed by the Institution of Petroleum Technologists, Aldine House, Bedford Street, Strand, London.

In 1939 H. L. Roder published in English, under the imprint of H. J. Paris in Amsterdam a monograph of 86 + XIV pages on "Rheology of Suspensions, A Study of Dilatancy and Thixotropy".

The Eleventh Meeting of the Society brought us back to the National Bureau of Standards where the Society was organized (1939). The Twelfth Meeting met at the American Museum of Natural History in New York with Dr. Roy Minor as host, with his charming wife (October 18-19, 1940). In 1941, we met with the other societies of the American Institute of Physics and the following new officers were elected: Herman Mark, President; W. F. Fair, Jr., First Vice President; P. J. Flory, Second Vice President; Nelson W. Taylor, Editor; H. F. Wakefield, Publishing Editor; R. B. Dow, Secretary-Treasurer. The two following meetings were also held

in New York.

Dr. Mark had long been a member of this Society when he came to this country. His outstanding reputation in the work pertaining to highpolymers, caused the Polytechnic Institute of Brooklyn to become a center for the discussion of the Rheology of Highpolymers, a series of three or more symposia being held under the auspices of the Society of Rheology. Considering the importance to the nation of synthetic rubber, nylon and other synthetic textiles as well as the various plastics, the interest displayed is not surprising. We were merely in a fortunate position as to time, place and personnel. This report can in no way better give the reader an idea of the importance of all of these conferences than by giving a list of the important volumes emanating from Interscience Publishers, Inc. with Dr. Mark as a member of their Editorial Board. Vol. I., "Collected Papers of Wallace H. Carothers on Polymerization", Edited by H. Mark and G. S. Whitby with a biography of Carothers by Roger Adams, 1940. Vol. II "Physical Chemistry of Highpolymers", by H. Mark, 1940 and Vol. IV "Natural and Synthetic Highpolymers" by Dr. K. H. Meyer of Geneva, Switzerland, who has long been a member of this Society.

Thus we have come to the end. It was stated in the Constitution that our object is the advancement of fundamental and practical knowledge of Rheology by meetings "not determined by national boundaries", by publication of a journal designed to disseminate knowledge of rheology and to promote its application. In spite of our small membership and both depression and war, there has been a spread of knowledge as evidenced by the books on this new subject. The generous assistance of the Chemical Foundation, of the American Society for Testing Materials in appropriating money for a study of the application of Rheology in industrial control work, of the John and Mary R. Markle Foundation for assistance to carry our a study of the rheology of blood and of numerous others who have aided both investigation and publication are evidence of the readiness of the public to support rheology when the need is demonstrated.

Lafayette College
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Prepared by the direction of the Society of Rheology.