

THE
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No.12

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Three additional contributions have been received which extend our report on the Eleventh Annual Meeting.

The first is an abstract of Dr. Herschel's discussion of concrete in the Symposium on Rheology in Science and Industry. The second is the paper which was presented by Dr. Hunter in the same symposium and the third is Professor Bingham's, "The Theory of Polishing," which is a part of his paper, "Neglected Fields of Rheology."

CONSISTENCY OF CONCRETE

Winslow H. Herschel
National Bureau of Standards

In the cement industry, several methods are used to determine the required amount of mixing water. Neat cements are compared at equal resistance to penetration, mortars are often compared at equal "flow", while concretes are selected of equal "slump". In these tests the reading is affected by both wetness and shear resistance, so that the true difference between two materials may be obscured by a difference in wetness. Talbot and Richart (U. of Ill. Eng. Exp. Sta. Bull, 137 Oct. 1923) suggest comparing the amount of mixing water with that required for maximum density, which must be determined by interpolation on a very flat curve. In effect they propose a scale of wetness.

I have used a wetness scale based on the amount of water absorbed by the dry material. On this scale, wetness, expressed as per cent saturation, is equal to 100 times the amount of mixing water, divided by the amount absorbed. To make the absorption test, the dry mix is placed in a container with perforated bottom. The container is supported somewhat above the level of water in a pan, water being raised to the bottom of the container by a piece of coarse cloth, so that the mix absorbs water by capillarity only. The surface of the mix changes color when the water reaches it. The mix is then allowed to drain to constant weight, and the amount of water absorbed is determined. This method has the advantage as compared with that of Talbot and Richart that interpolation is not required. Tests of the relations between shear resistance and wetness of concrete by Herschel and Pisapia have given results similar to those of Kurt Walz (Deutscher Ausschuss für Eisenbeton, Heft 91, p. 32; 1938).

THE INFLUENCE OF APPLIED STRESSES ON THE PHYSICAL PROPERTIES OF RAYONS

Dr. A. Stuart Hunter,
Rayon Dept., E. I. duPont de Nemours and Co.

The measurable physical properties of rayon and other textile yarns are more dependent on the past history of the yarns than is often appreciated. For example, temporary applied stresses occurring during textile handling may impose new properties that often are taken to be characteristic of a given yarn, yet these properties may change appreciably if the yarn be wet out in hot water and allowed to dry without tension. A distinction should be made between the temporary and permanent deformations which may occur in a yarn as the result of applied stress.

In order to clarify the description of the physical changes which can take place in a yarn as the result of applied stresses, certain terms are defined as follows:*

1. **Percent Elongation**—The percent to which a yarn is lengthened immediately before the removal of a stress.

2. **Percent Stress Deformation**—The percent increase in length of a sample which has been elongated by the application of a tensile stress and allowed to recover or relax under specified conditions. (Measurements are made after a 5 minute period of relaxation.)

3. **Percent Strain Shrinkage**—The percent decrease in the length of a yarn brought about by a specified boil-off treatment. (The samples are boiled off for 4 minutes at 210°F. in a 1% olive oil soap solution. They are given a one minute rinse in hot water. The measurements are made on properly conditioned samples which have been dried without restraint. Calculations are based on the length of the original sample.)

4. **Percent Permanent Deformation**—The stress deformation (2) minus the strain shrinkage (3) plus the strain shrinkage of the original sample. (This addition of the strain shrinkage in the original yarn recognizes the possibility of a degree of strain within a yarn which may be a normal characteristic of a commercial product.)

Table I illustrates the relationship between these terms. The figures presented show what happens to the apparent physical properties of viscose and acetate yarns as the result of imposing different de-

* These concepts are embodied in the 1939 A. S. T. M. Standards on Textile Materials.

** Summary of paper presented before Society of Rheology, Washington, D. C., October 10, 1939.

degrees of stretch for three minute periods. Observe that when the viscose rayon is stretched 4.5%, it shows itself to be 3.1% longer, due to stress deformation. Its denier drops four points its strength goes up and its breaking point elongation is less. For all intentions and purposes you appear to have a different yarn. These new properties tend to be permanent as long as the yarn remains dry. If, however, this yarn is given a boil-off treatment in hot water, the strains placed in the yarn by the act of stretching are relaxed. In the case under description, one finds a strain shrinkage of 2.4%, leaving a permanent deformation of 1.4%.*

The acetate rayon acquires a much lower stress deformation from a similar 4.5% stretch. Its permanent deformation is lower. Acetate rayon is more elastic than viscose rayon under low stresses.

The effects from a 15% stretch are different. The stress deformation in the acetate rayon is now slightly greater. Its permanent deformation is over twice that of the viscose yarn. The acetate rayon is more plastic than the the viscose rayon under high stresses.

Plate I illustrates how stretching a yarn changes the stress-strain curve that may be obtained from it. When the strains of these stretched yarns are relaxed as by the described boil-off treatment, the stress strain curve of the original yarn is re-acquired.

The longer a yarn is held in the stretched condition, the greater the resulting stress deformation. Plate II shows the relationship between the percent stretch and the resulting stress deformation as the time of stretching is increased to 100 hours. The same amount of stress deformation is produced by 7% stretch acting for one second as results from a 3% strtch lasting for three hours.

Plate III illustrates the effects of 3-minute stresses on silk as well as on acetate and viscose rayons. In this graphic presentation, the elastic recovery, stress deformation, strain shrinkage, and permanent deformations are inter-related. Consider the case of the silk, after it has been stretched 9% for 3 minutes. Upon the removal of the stretching forces it springs back elastically about 4½% leaving a 4½% stress deformation. When boiled off, the sample shrinks 3% more. It is still 1% longer than its original length and since the sample had no strain shrinkage as received, this value constitutes the permanent deformation brought about by having stretched the sample 9% for 3 minutes.

It is believed that the utilization of this system of physical description will be of assistance in differentiating between temporary and permanent physical properties of textile yarns.

* Perm. Def.=St. Def. - Str. Shr. + Str. Shr.
4.5 0

$$1.4 = 3.1 - 2.4 + 0.7$$

TABLE I

THE EFFECT OF 3 MINUTE STRESSES ON RAYON

Stretch %	Stress		Physicals		Strain		Permanent		Physicals	
	Def. %	Den.	Ten. g.p.d.	Elong. %	Shrinkage %	Def. %	Den.	Ten. g.p.d.	Elong. %	
Acetate Rayon—100-32-4										
0	0	101	1.77	24.8	0.7	0	102.0	1.77	24.8	
4.5	3.1	97	1.79	20.5	2.4	1.4	101.0	1.72	24.5	
9.0	6.3	94	1.81	15.0	4.9	2.1	100.0	1.70	23.0	
15.0	10.7	90	1.88	11.0	8.3	3.1	98.0	1.68	21.5	
Viscose Rayon—100-40-3										
0	0	104	1.44	24.4	1.3	0	105.0	1.45	25.4	
4.5	1.9	102	1.37	20.6	2.4	0.8	104.5	1.40	24.0	
9.0	6.3	98	1.46	15.7	3.3	4.3	101.0	1.47	21.1	
15.0	11.9	93	1.61	9.3	5.4	7.8	98.0	1.56	19.1	

DU PONT RAYON COMPANY

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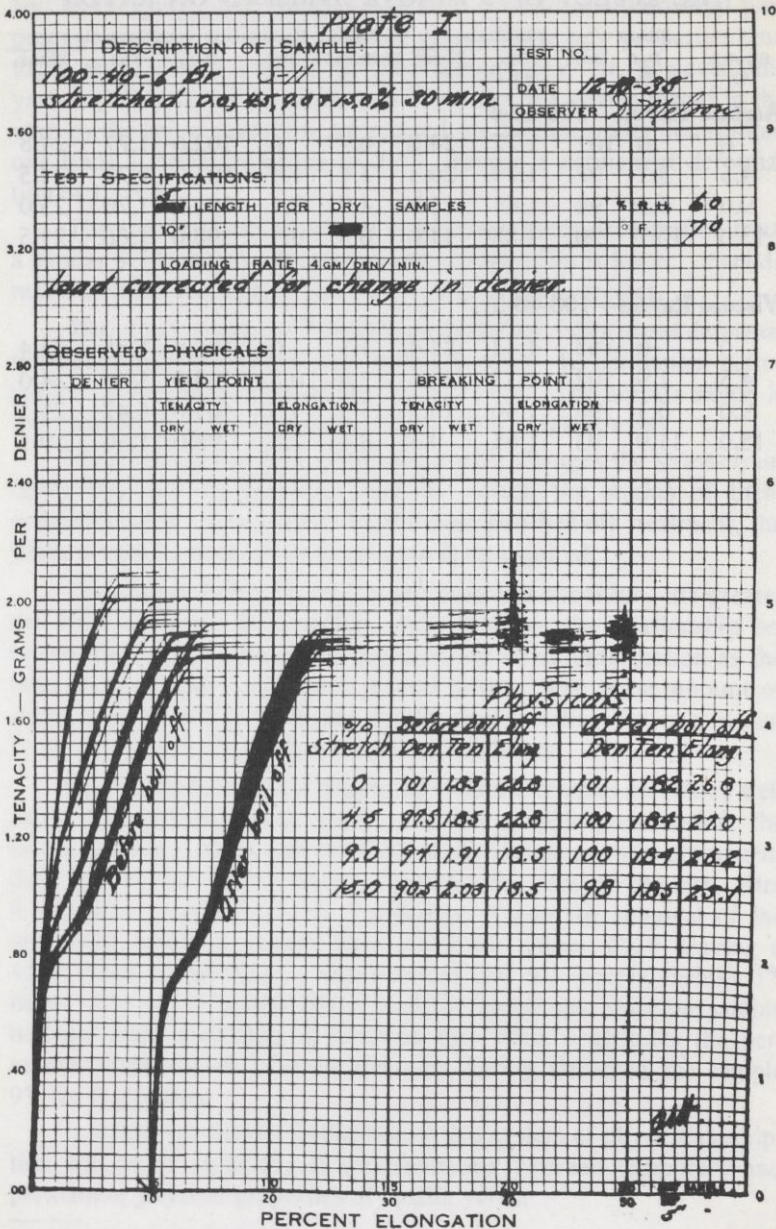


PLATE II
EFFECT OF TIME OF STRETCH
ON
STRESS DEFORMATION

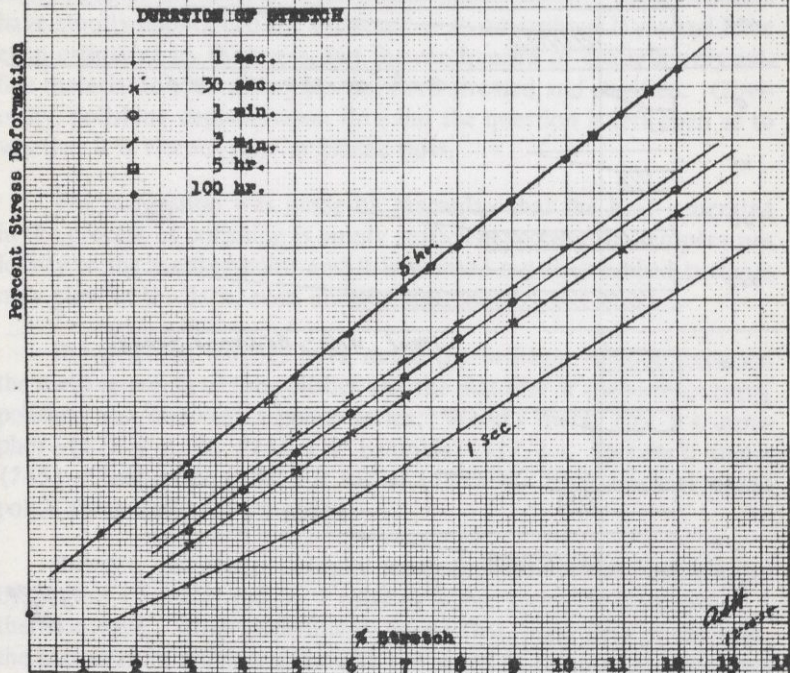
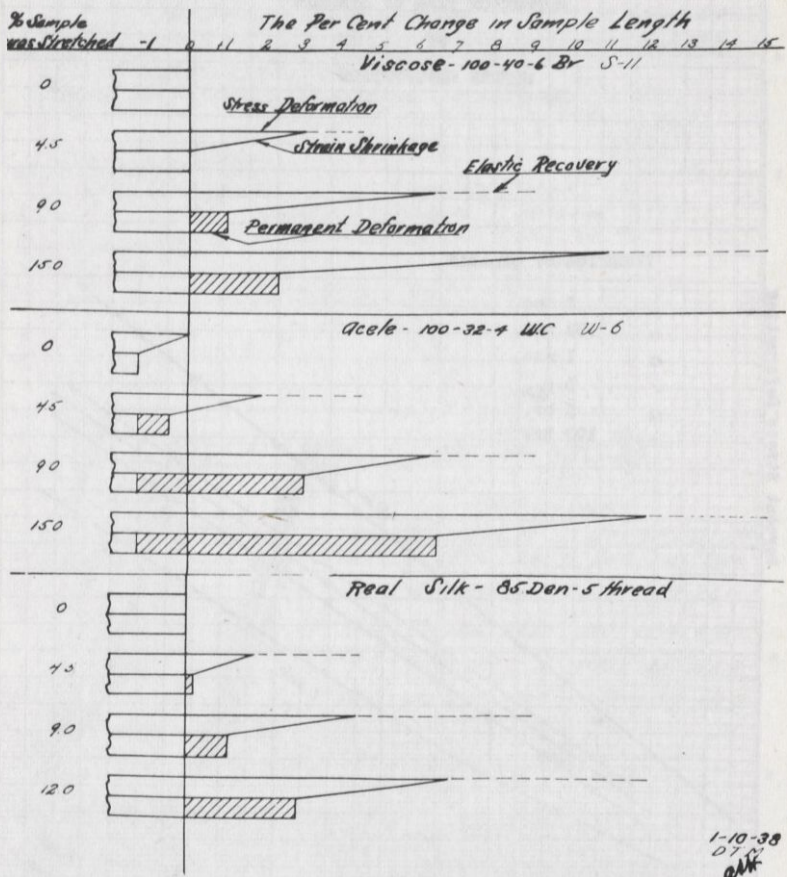


Plate III
The Effect of 3 min Stresses on Textile Yarns.

60% R.H., 70°F



1-10-38
 D.P.C.
 aak

THE THEORY OF POLISHING

By Eugene C. Bingham

Grinding results in a furrowed surface and polishing has been thought to be the reduction in size of the irregularities by means of finer hard particles until they become imperceptible. This theory of tearing the surface down to a plane is quite insufficient, for Rayleigh noted that scratches disappear suddenly over considerable areas, which he called "patches". Beilby went further and described the process as one of **flow**, the material of the ridges being flowed over into the grooves, which was actually proven by etching a polished surface and restoring the grooves which existed there at the beginning of the polishing process.

An animated discussion in regard to the nature of the surface layer has resulted from a study of polished surfaces with X-rays and the less deeply penetrating electron-rays, the question at issue being as to whether the surface layer is amorphous or not. Some workers have stoutly maintained the existence of an amorphous layer and have even estimated its thickness, but the mechanism of changing crystalline material to amorphous has not been stressed and clarified. Obviously, polishing depends upon flow but the question is left open as to whether it is viscous flow or plastic flow.

The suggestion was made by Macaulay that the heat generated in the process of polishing is amply sufficient to raise the temperature locally to the melting-point and it is pointed out that rubbed surfaces may glow in the dark, even under water.

Bowden and Hughes have noted the intimate relation between the melting-points of the polisher and the material of the surface being polished and obtained a polish series:—Wood's metal (69) < camphor (178) < tin (232) < oxamide (417) < speculum metal (745) < lead oxide (888) < nickel (1452). Each material would polish those earlier in the series.

Bowden and Ridler actually measured the surface temperature by having a vertical rod on a rotating plane form the elements of a thermocouple. Their experiments prove that, regardless of the load, the temperature rise increases with the speed of rotation and becomes constant at the melting point of the metal. Even well-lubricated surfaces showed a temperature elevation of several hundred degrees. These experiments therefore prove that in the final stages of polishing, there is a flow of the material which is viscous rather than plastic or a process of tearing.

THE MEASUREMENT OF THIXOTROPY

Harvey A. Neville
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The apparent viscosity of many colloidal systems and suspensions is a composite of two independent effects:

- (1) The normal or fluid viscosity* which is independent of rate of shear,
- (2) The thixotropic viscosity which decreases with increasing rate of shear.

Measurements made upon such a system under a single set of conditions do not permit the analysis of the viscosity into the two component factors and will not, therefore, predict the flow characteristics of the system under another set of conditions.

Each of the above viscosity elements has its proper significance to the qualities and applications of many industrial products, among which are clay slips, paints, cements, sizes for leather and textiles, printing inks and pastes, and sprays for various purposes. It is important, therefore, to discover the existence of thixotropy in any such system and to obtain a quantitative measure of it.

The Occurrence of Thixotropy

The earlier studies of thixotropy were concerned principally with colloidal sols and gels such as those of ferric oxide, aluminum oxide, and gelatine. A comprehensive resume of this work with appropriate literature references has been provided by Freundlich (2).

McMillen (12) first investigated thixotropic phenomena in paints, the importance of which was further discussed by Gamble (4), Pryce-Jones (13, 14) has described a number of systems which exhibit thixotropy and has also given particular consideration to its occurrence in paints. Hauser (8), (9) and his coworkers have published a series of articles on the thixotropic properties of bentonite suspensions. Numerous additional examples of thixotropic behavior have been reported in recent scientific literature.

Goodeve (5) classified the systems in which thixotropy is commonly observed somewhat as follows:

- (1) Solutions in Newtonian liquids of lyophilic substances whose molecules are of great length, e.g., gelatine, starch, and many synthetic polymers.

- (2) Suspensions of solid particles such as pigments in oils, clays in water.

* This is greater than the viscosity of the liquid medium due to the added effect of the dispersed phase.

(3) Concentrated emulsions of oil droplets in water; foams of gas bubbles in water (both with stabilizing agents).

(4) Some pure liquids containing simple molecules, e.g., vegetable oils such as castor oil. This class is apparently confined to those liquids known to associate and to temperatures not too far above the melting points of the substances.

Pryce-Jones (13) urges the view that the "thixotropic state" can be assumed by a very large number of materials under appropriately chosen conditions and that the phenomenon should be associated with the colloidal environment rather than with the intrinsic properties of the dispersed particles.

The Nature of Thixotropy

The term thixotropy was originally used to designate an "isothermal, reversible sol-gel transformation," although Freundlich (3) in his interesting monograph on this subject explicitly states (p. 4) . . . "it is not necessary, for instance, that the gel is a gel in the true sense of the word, containing only ultramicroscopic particles; concentrated suspensions with much larger particles, having dimensions up to 1μ and more, pastes of clay, etc., also may show an extremely pronounced thixotropic behavior. . . . One is further dealing with thixotropy when concentrated sols, for instance gelatine, become less viscous and elastic on shaking or stirring, but assume the original values of viscosity and elasticity when left to rest."

In suspensions which exhibit thixotropy Freundlich (*loc. cit.*, 3, p. 18) associates this property with loose packing, large volume of sedimentation, isothermal plasticity, and non-dilatancy. Gamble (4) likewise pointed out the probable identity of thixotropic and plastic properties in paints. However, Pryce-Jones (14), while noting that the viscosity is a function of the rate of shear in both plastic and thixotropic types of colloidal systems, emphasized this further distinction: viscosity in plastic systems is independent of the duration of shear and of the past history of the system, while in thixotropic systems the viscosity is dependent upon both.

By extension, thixotropy now includes more generally any "isothermal, reversible **decrease** in viscosity with increase in rate of shear" (7). Goodeve (5) considers the thixotropic state as intermediate between the highly dispersed sol state and that of coagulation.

Freundlich (*loc. cit.*, 3, p. 14) states that solvation is of paramount importance to thixotropy and may alone account for its occurrence in systems where any electrical effects must be absent. He concludes that thixotropic behavior is most likely due to a marked

affinity between the particles and the liquid, causing the formation of rather thick layers of liquid around the particles. These particles may swell, and the swollen and solvated particles interlock, while the amount of liquid between them is sufficient to allow a thixotropic behavior when the orientation of the particles is mechanically disturbed.

Von Buzagh(1) comments as follows (p. 152): "The most striking fact about thixotropy is that it is an isothermal change, it being possible for the system to be either solid or liquid at the same temperature without altering its volume. If the liquefied system is examined under the ultramicroscope it is seen that the particles are in rapid Brownian movement. On solidification the movement of the particles ceases. It is not possible to see with the ultra-microscope whether the particles alter their distances from each other on solidification of the system, but it is certain that the particles in the solidified system are not in contact."

A further quotation from von Buzagh (*loc. cit.* p. 159) summarizes a general view which is perhaps completely applicable only to aqueous systems: "The fact that far-reaching forces act between disperse particles enables thixotropic phenomena to be easily understood. If, for instance, a ferric oxide sol is treated with a small quantity of an electrolyte, the electric charge of the particles is reduced; the thickness of the solvated shell, however, does not vary appreciably. This means that a more or less strong attracting force arises between the particles, and yet the particles cannot make actual contact since this is prevented by the lyosphere and the electric repelling force which, in a weakened form, is still present. The solvated shells merge into one another to some extent, so that the Brownian movement of the particles is inhibited. The particles can then, at the most, only oscillate or rotate about their central positions. In this way the entire system acquires a certain rigidity and elasticity. The solidification proceeds at a finite rate. . . . If a system, solidified by thixotropy in this way, is shaken, the equilibrium condition is disturbed, the fused solvated shells between the particles are torn apart, and the system liquefies anew.

"If a sol is treated with a large quantity of electrolyte, the particles may . . . lose not only their electrical charge, but their entire lyosphere. . . . Under these conditions no gelatinous structure is formed, but a coagulum . . . no longer liquefiable by shaking.

"All conditions which increase the electrical charge on the particles and thicken the solvated shells must therefore have a liquefying effect on thixotropic gels. All conditions which favor a discharging of the particles and reduce the thickness of the solvated shell must tend to solidify the system. The presence of a solvated shell of a certain thick-

ness is always an essential condition of liquefiability by mechanical means."

In any disperse system the opposing forces of attraction and repulsion determine the state of the system. If repulsive forces predominate a stable dispersion obtains; if the repulsion is destroyed, attractive forces induce coagulation and separation of the dispersed phase; in an intermediate condition the dispersed units may be brought together to an equilibrium distance of minimum potential energy and rendered motionless in a thixotropic gel by the balancing of repelling and attracting forces. These several conditions may be represented graphically in terms of potential energy versus distance between particles

Goodeve(5) has critically reviewed the various theories of thixotropic gel structure and concludes that only the "scaffolding" theory is capable of explaining all the experimental observations. According to this theory the gel consists of a network of particles, linked into chains and cross chains, extending through the whole gel and providing complete molecular binding from one wall of the container to the other. He cites as proof of the continuous scaffolding structure the observation of McDowell and Usher (11) that gels of carbon black in non-conducting organic liquids conducted the electric current when allowed to stand, but ceased to do so when stirred. In the scaffolding theory the advantages of anisotropic particles in regard to thixotropic properties are emphasized, and the observable tendency of materials such as bentonite and vanadium pentoxide to form visible or microscopic rods or threads is offered as evidence that the forces of attraction at the ends of such particles are much greater than they are at the sides. In contrast to the lysosphere theory, the scaffolding theory assumes direct contact between the particles at certain points.

Definite rates of formation and breaking of links between particles in thixotropic systems are predicated by Goodeve and are utilized to develop his quantitative treatment of thixotropy referred to in the following section of this paper.

Methods of Measuring Thixotropy

The various methods by which it has been attempted to obtain a measure of thixotropy may be briefly classified as involving the determination of:

- (1) Time required for gelation.
- (2) Yield value of gel.
- (3) Relaxation against torsion.
- (4) Deviation from Poiseuille's law of capillary flow.
- (5) Viscosities at different constant rates of shear.

Methods of the first four classes, although often providing valuable information relating to certain aspects of thixotropic behavior, are largely means of detecting the phenomenon qualitatively or, at best, yield only relative estimates of thixotropic effects.

Freundlich and his students have obtained many results of interest by observing the time of setting of thixotropic sols in narrow test tubes. This is merely the time required for the system, made fluid by shaking, to reach that state where it will no longer flow when the tube is carefully inverted. While this procedure is extremely simple and arbitrary, it is adapted, for example, to determining the influence of added reagents upon the thixotropic system. Hauser devised a mechanical means of inverting the tubes.

McMillen (12) determined yield values against torsion applied in small steps. Gamble (4) used a torsion cylinder or paddle and obtained relaxation-time curves. Pryce-Jones (13) made an "electromagnetic thixotrometer" which he described as a combination of a Helmholtz galvanometer and an oscillating disk viscometer. By this means he determined relaxation or time-deflection curves and recorded these photographically for a great many systems. In this apparatus, as in others of the torsion type, the shearing force decreases continuously as the deflection decreases. A true liquid gives a time-deflection curve which is logarithmic, while the curves for thixotropic systems depart to varying degrees from this standard.

The methods of these investigators fail to give a definite measure of thixotropic viscosity because any disturbance modifies the thixotropic condition and it is therefore impossible to maintain a constant rate of shear. Only the positively-driven Couette type of viscometer provides a constant shear in thixotropic systems, and with an instrument of this type the apparent viscosity observed depends upon the rate of rotation of the outer cylinder and the width of the annular space between the two cylinders. This viscosity measurement is then the composite of two effects as stated in the first paragraph of this paper.

Goodeve and Whitfield (7) attacked the problem of separating the thixotropic viscosity from the residual viscosity in such measurements by assuming that at any given rate of shear an equilibrium state is reached in which the rate of formation of the linkages building up the thixotropic structure is equal to the rate at which these linkages are being broken. In order to derive a quantitative definition of thixotropy in absolute viscosity units they set up equations to express these two opposing effects in terms of a variable x . The equilibrium value of x was obtained by equating these expressions. When simplified for high rates of shear or weak structures, this value of x is a constant

factor divided by the variable rate of shear and the viscosity equation for a thixotropic system therefore has the form

$$\eta = \eta_0 + \theta/s$$

where η is the observed apparent viscosity, η_0 is the residual viscosity, θ is the "coefficient of thixotropy" (a constant for a particular system) and s is the shear. This equation denotes a linear relationship between apparent viscosity and the reciprocal of shear. If the observed viscosity is plotted against the reciprocal of shear, the coefficient of thixotropy is the slope of this line (at high shearing rates) and the intercept of the extrapolated curve on the viscosity axis (at $1/s = 0$ or infinite shear) gives the residual viscosity.

Following this theoretical treatment there remained the problem of devising a satisfactory instrument by which viscosities could be measured at varied constant shearing rates. While steady and continuous shear can best be obtained in the Couette (coaxial cylinder) type of viscometer, it is not convenient to vary the speed or annular distance in this instrument. To meet this need Goodeve and Whitfield (7) developed an apparatus of the Couette type in which the cylinders were replaced by coaxial cones, the inner cone being movable vertically relative to the outer one and the opposite surfaces of the cones being machined to the same angle. A second form of this apparatus was later described by Goodeve (6). The original papers should be consulted for complete descriptions, diagrams and directions for the use of these instruments.

In this type of apparatus the outer cone is driven at constant speed and the different rates of shear are obtained by varying the distance between the cones. These authors state that the possibility of turbulent flow at high shearing rates is greatly reduced when coaxial cones are used rather than coaxial cylinders.

Measurements with the cone thixotrometer on suspensions of carbon black in mineral oils were reported by Goodeve and Whitfield (7) and provide confirmation of their theory. They also found agreement with this theory in the results of other previous observers made on several systems by means of a Couette viscometer operated at different angular velocities.

A slightly modified form of the instrument described by Goodeve and Whitfield (7) was made in this laboratory* and is now in operation. A torsion wire, mirror, and circular scale were found to be more satisfactory than the spring and dial as a means of measuring the deflection of the inner cone. The accompanying diagram (Fig. 1) shows

* By Mr. Thomas G. Harris, Devoe & Reynolds Co. Research Fellow, Lehigh University.

the essential features of this apparatus. The outer cone is driven by a constant-speed (80 rpm) electric phonograph motor through a reduction gear of 4/1 ratio. Other speeds may be provided for by substituting a different driving gear.

In Fig. 2 are shown some preliminary results obtained with this apparatus for a mineral oil (non-thixotropic) and for seven different types of paint. Except for a thorough stirring, these paint samples were tested just as obtained from the commercial containers. In regard to these results, it is intended here only to point out that the apparent viscosity measurements on each sample fall very closely on a straight line and that, although the pigment-volume ratio in all these paints is very nearly the same, the several paints exhibit very different coefficients of thixotropy. The degrees of thixotropy as indicated by the different slopes of these curves are in general agreement with the known characteristics of the corresponding paints.

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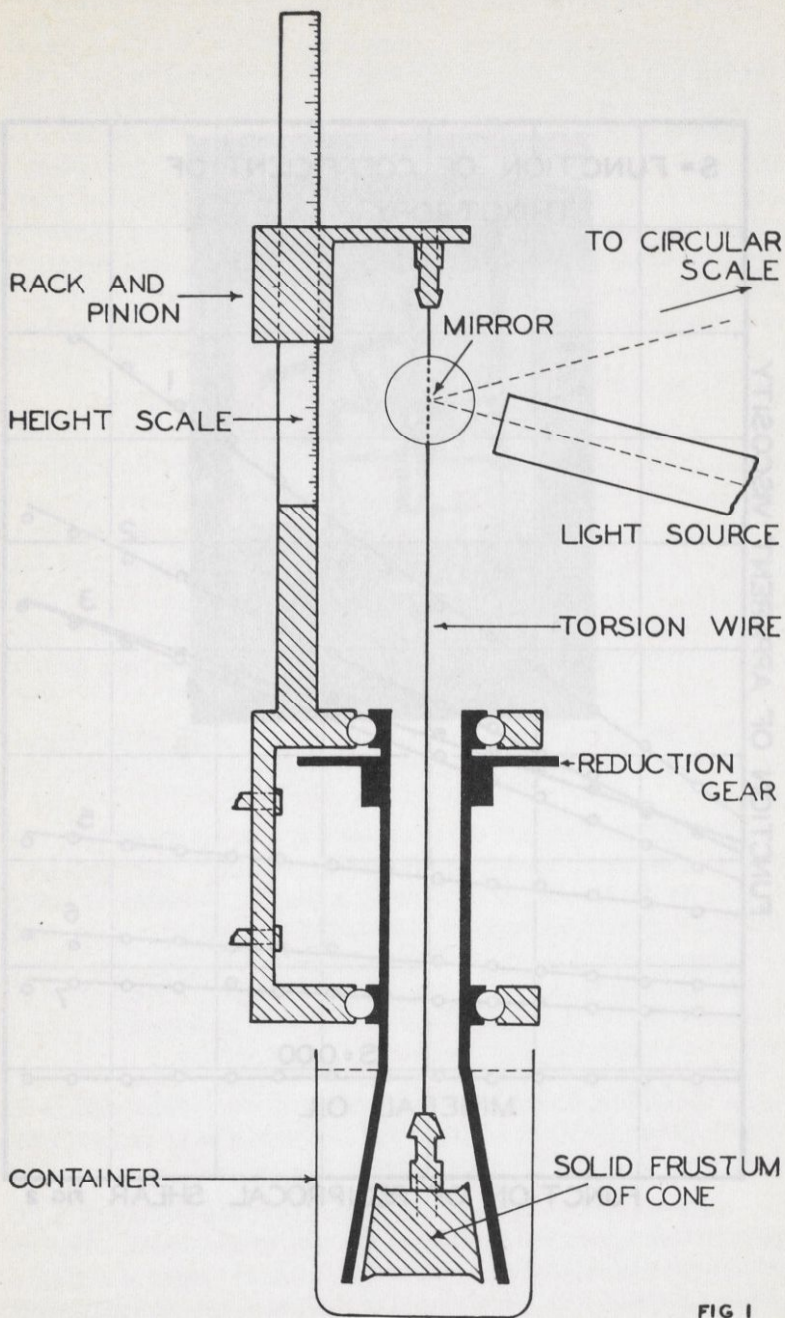


FIG 1

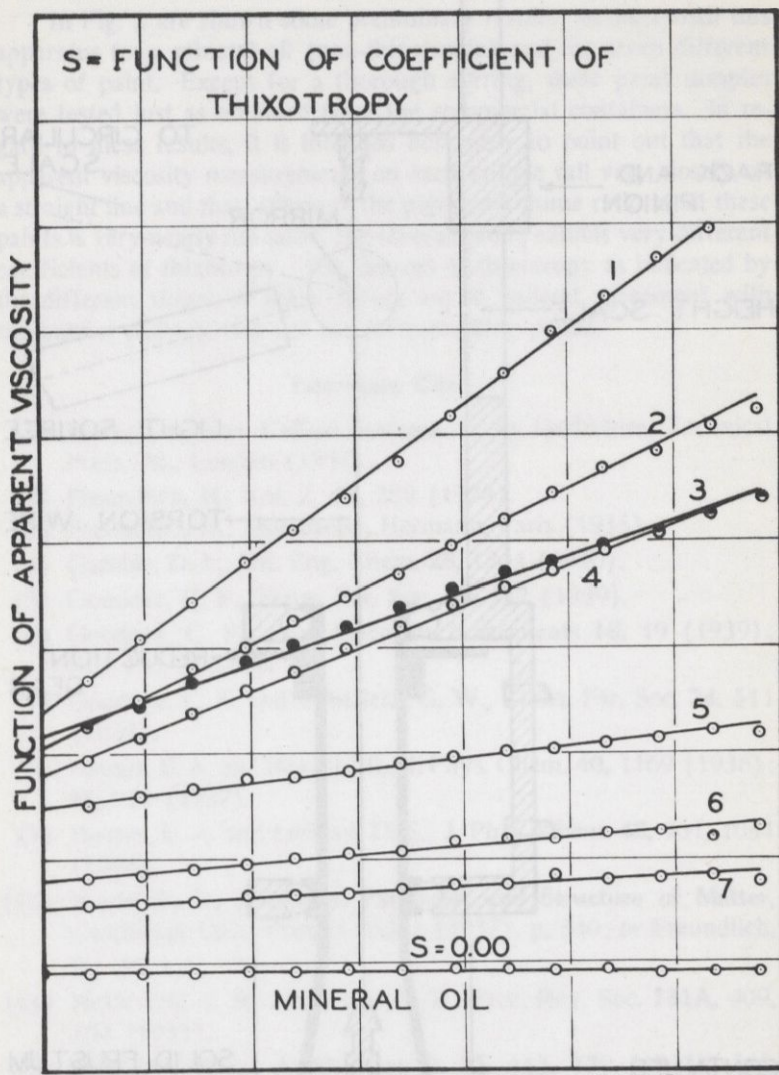
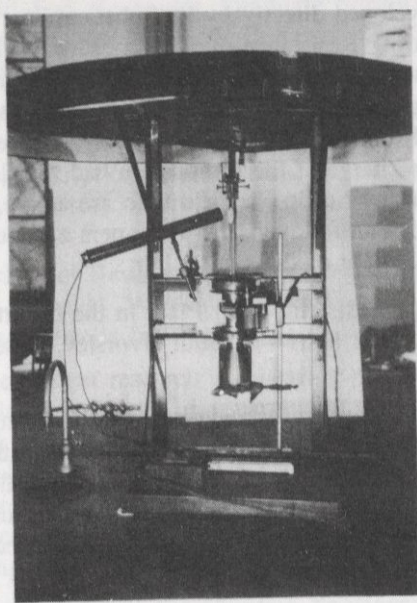


FIG 2

A. J. T. M. SYMPOSIUM ON SHEAR TESTING OF SOILS

An outstanding technical feature of the 1958 A. J. T. M. Symposium was the Symposium on Shear Testing of Soils, organized under the auspices of the Society's Committee on Soil Testing. The Symposium was held at the University of California, Berkeley, California, on October 10-11, 1958. The Symposium was held in the University of California, Berkeley, California, on October 10-11, 1958. The Symposium was held in the University of California, Berkeley, California, on October 10-11, 1958.



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A. S. T. M. SYMPOSIUM ON SHEAR TESTING OF SOILS

An outstanding technical feature of the 1939 A. S. T. M.'s annual meeting was the Symposium on Shear Testing of Soils arranged under the auspices of the Society's Committee D-18 on Soils for Engineering purposes and developed directly by its Subcommittee on Methods of Testing for Shearing Resistance of Soils, headed by F. J. Converse, Assistant Professor of Civil Engineering, California Institute of Technology. Working closely with Professor Converse was G. P. Tschebotareff, Assistant Professor of Civil Engineering, Princeton University. The committee in charge of the symposium had the close cooperation of outstanding authorities in the field who are active in the work of Committee D-18. The following list of papers and authors will indicate the general content of the symposium:

Torsion Shear Tests and Their Place in the Determination of the Shearing Resistance of Soils—M. Juul Hvorslev, Research Engineer, Harvard University.

Reviews various apparatus and discusses the practical advantages and the sources of error in the results obtained with this type of test as compared with other types of shear tests. The following are covered: Translatory shear tests, rotary shearing apparatus, triaxial shear tests, torsion shear test on solid cylindrical test specimens, torsion shear tests on ring-shape samples.

Some Practical Aspects of Soil Shear Testing—Gregory P. Tschebotareff, Assistant Professor of Civil Engineering, Princeton University.

Discusses correlation of shear test data. Stresses and indicates that there should be strict discrimination between (1) shear tests performed for the purpose of numerically estimating the actual shearing resistance of different types of undisturbed soils under varying field conditions, and (2) shear tests performed for the purpose of selection of the most suitable soil by means of comparison of the shearing properties of different disturbed soils to be used as an engineering material in the field under identical conditions of recompaction.

Principles of Triaxial Shear Tests—C. A. Hogentogler and E. S. Barber, Senior Highway Engineer and Junior Highway Engineer, respectively, Public Roads Administration.

Purposes of tests, types of soil investigated, and laboratory facilities, necessitated procedures and equipment which varied widely in some respects and yet had enough in common to suggest use of simplified apparatus with interchangeable parts to satisfy all the requirements. The essential features of such apparatus are described in detail

and provide for two general methods of tests—the “closed” system and the “open” system.

A Triaxial Compression Apparatus for the Determination of the Stress-Deformation Characteristics of Soils—John D. Watson, Research Fellow in Soil Mechanics, Graduate School of Engineering, Harvard University; now Assistant Professor of Civil Engineering, College of Engineering, Duke University.

This paper covers: volume changes in cohesionless soils under load; disadvantages of the direct shear test; early development of triaxial apparatus; description of the present triaxial compression apparatus, giving typical test results; shearing strength and cohesionless materials.

A Comparison of Results of Direct Shear and Cylindrical Compression Tests—Donald W. Taylor, Assistant Professor of Soil Mechanics, Massachusetts Institute of Technology.

Summarizes recent research on shearing properties of sand and describes especially two types of apparatus in common use; namely, the direct shear machine and the cylindrical compression or triaxial machine. The following are covered in the paper: direct shear machine, cylindrical compression machine, scope of the comparisons, maximum friction angle comparisons, stress-strain curve comparisons, critical void ratios comparisons, the equal strength void ratio.

Some Investigations of the Shearing Resistance of Cohesionless and Cohesive Materials—D. M. Burmister, Assistant Professor of Civil Engineering, Columbia University.

Describes tests on Ottawa sand and a Detroit clay to determine the consistency of results using different types of apparatus and different procedures.

The Shearing Resistance of Soil; Its Measurement and Practical Significance—W. S. Housel, Associate Professor of Civil Engineering, University of Michigan; Research Consultant, Michigan State Highway Department.

The author emphasizes logical conceptions of shearing resistance of cohesive soils which would clarify points at issue in the conflicting viewpoints on this important subject. The following are covered: Cohesive soils, shear tests for cohesive soils, and practical application of shear test results.

The Effects of Internal Hydrostatic Pressure on the Shearing Strength of Soils—L. W. Hamilton, Associate Engineer, Bureau of Reclamation.

Points out that the development of a physically sound explana-

tion of the causes of variations in results of shear testing has resulted in a concept that internal hydrostatic pressure or hydrostatic pressure in the pore water (hereafter called "pore pressure") has an extremely important bearing upon the shearing strength of soils and that each of the factors mentioned above may cause variations in pore pressure and thus cause differences in the shearing resistance of the soil. The paper discusses concept of pore pressure and its effects on shearing strength of soils, test results which indicate presence of pore pressure, attempted measurements of the pore pressures, and triaxial shear machine.

All engineers, highway officials, university faculty members, construction engineers, and others concerned with problems in the field of soils for engineering purposes will find this publication of distinct interest.—128 pages, heavy paper binding, 6 by 9 in. Prices: \$1.25; to A. S. T. M. members, 75 cents.

MISCELLANEOUS NOTES OF INTEREST TO RHEOLOGISTS

Announcement has been made by Dr. Eugene C. Bingham, professor of research at Lafayette College, that Dr. Raymond Rollin Roepke, a graduate of Kansas State College, has been awarded the fellowship under the John and Mary Markle Foundation for work at Lafayette on a problem connected with the flow of the blood. Dr. Roepke is the first to be appointed since the fellowship was founded and will begin his work here on April 1.

Dr. Roepke received the degree of B. S. in chemistry in 1933 and M. S. in 1934 from Kansas State College. During the following year he was engaged in biochemical analysis at Kansas State, and then began research work at the Mayo Clinic in Rochester, Minn., on a Mayo Foundation in biophysics. He later worked under a Shevlin Fellowship at the University of Minnesota, from which institution he received his Ph.D. degree in 1938, biophysics being his major subject and biochemistry his subordinate subject. He is now engaged as a research assistant at the University of Minnesota, where he has been making an intensive study of the physiology of circulation, respiration, etc. He is engaged at present upon a research upon intestinal absorption. He has published several papers, his doctorate being on the osmotic properties of the blood by a thermo-electric method, with Dr. E. J. Baldes, of the Mayo Foundation, as his adviser. He is busily engaged at the Foundation at present.

Explaining the work that Dr. Roepke will do at Lafayette, Dr. Bingham said that many scores of papers have been devoted to work

on the flow of the blood, but it is still a matter of great doubt whether the flow follows the classical law of Newton. The heart is a powerful muscle, Dr. Bingham said, and unlike the other muscles it can never have long periods of rest. Unfortunately, it is often overworked and in increasing numbers of cases it fails entirely. In certain cases the resistance of the flow of blood is known to increase as in polycythemia where the number of blood cells is considerably and pathologically increased. It has been noticed that under such conditions the heart may be enlarged as though it were required to do much more work than under normal conditions. A knowledge of the effect upon the viscosity of the blood of the various constituents may offer information of use to the medical profession.

TWELFTH ANNUAL MEETING

Preliminary announcement: A two day program is planned for the 1940 meeting of the Society of Rheology which will be held at the American Museum of Natural History on the 18th and 19th of October. There will be sessions of invited and contributed papers, an outstanding tour, and social meetings. Members are urged to send in their abstracts of papers as early as possible to: Dr. R. B. Dow, Department of Physics, The Pennsylvania State College, State College, Pennsylvania, Chairman of Program Committee.

It is hoped that there will be a large representation from industrial and academic circles.

APPLICATION

Mr. H. R. Lillie, Secretary
Research Division
Corning Glass Works
Corning, N. Y.

I hereby apply for membership in the Society of Rheology for the year as follows:

- [] Sustaining membership (including subscriptions to both **Journal of Applied Physics** and **R. S. I.** \$25.00 or more
- [] Regular membership (including subscription to **Journal of Applied Physics**) \$6.00 (foreign, \$6.50)
- [] Associate membership \$2.00 (foreign, \$2.50)

All members receive a subscription to the Rheology Leaflet.

Please also enter my subscription for the following additional periodicals published by the American Institute of Physics:

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..... at \$

I enclose \$ to cover the above.

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