

The Temperature, Pressure and Volume Coefficients of the Viscosity of Fluids

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interchange involving the radioactive chlorine would give a positive value. Under the circumstances we feel that it is conservative to say that the amount of interchange which occurred is less than that necessary to give a difference of ten in the count. In other words, less than 10/350 or 0.029 of the chlorine reacted. As the total light absorbed was four times that necessary to dissociate all of the chlorine we can say that the quantum yield of the interchange process at room temperature is certainly less than 0.007.

The data which have been presented show that even in the most favorable case, chlorine in carbon tetrachloride, we cannot account for a high efficiency of a photodissociation process by assuming that the dissociation products react with the solvent. In the earlier paragraphs we have shown that the hypothesis that the rates of dissociation and recombination are both reduced

by the same factor so that the concentration of atoms in the photostationary state is comparable with that in the absence of a solvent is not tenable under the experimental conditions which have prevailed in most investigations. It seems necessary to assume, therefore, that the primary action of the light on a molecule must be of comparable efficiency in solution and in the gas phase if we have a close correlation between the behaviors of the two systems. The effect predicted by Franck and Rabinowitch should appear if we work with light of such frequency that the energy is just enough to bring about a dissociation. Even under such conditions it will not be observed experimentally unless the reaction mechanism is such that the active intermediates produced by the light are removed by some other reaction than a homogeneous recombination. A search is being made for a suitable reaction.

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The Temperature, Pressure and Volume Coefficients of the Viscosity of Fluids

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Since $(\partial\eta/\partial T)_p$ and $(\partial\eta/\partial T)_V$ are both positive for dilute gases and both are negative for ordinary liquids, they must be zero at some intermediate density. From data in the literature it is shown that these two coefficients do not become zero at the same state of the fluid, but that the former becomes zero at lower densities than does the latter. On this basis any state of a fluid can be placed in one of six categories, or loci, which are characterized by the signs and relative magnitudes of the two viscosity temperature coefficients. By the use of general mathematical equations relat-

ing four variables, the signs of the viscosity pressure and viscosity volume coefficients are deduced for the six loci. It is shown that the fluidity and volume of a normal liquid are linearly related for volume changes up to about 10 percent, as both properties are varied with the pressure at constant temperature, i.e., that $(\partial\varphi/\partial V)_T$ is a constant. This is analogous to Batchinski's relation, according to which $(\partial\varphi/\partial V)_p$ is a constant. From data in the literature it is shown that $(\partial\varphi/\partial V)_T$ is about $\frac{2}{3}$ to $\frac{3}{4}$ of $(\partial\varphi/\partial V)_p$, in agreement with relations deduced in this paper.

THE viscosity of a homogenous fluid is a function of the state only, just as are the pressure, temperature, and volume, and any of these four variables is fixed by fixing any two of the others. The commonest equations of state are those involving p , T and V , but formally at least, an equation relating p , T and η could equally well be called an equation of state. The volume pressure and volume temperature coefficients are well known to be negative and positive numbers, respectively, for any phase, gas, liquid or solid. The corresponding coefficients of

viscosity are however not so simple nor so well known, for instance the viscosity temperature coefficient is positive for gases and negative for ordinary¹ liquids, but its transition from the one sign to the other has never been investigated.

The following pages discuss all the viscosity coefficients of the four dimensional surface p - T - V - η for all fluid phases from the dilute gas to the highly compressed liquid. The data

¹ The term ordinary liquids will be used in the early part of this paper to mean a liquid below its normal boiling point. Later a more precise definition will be given the term from a viscosity standpoint.

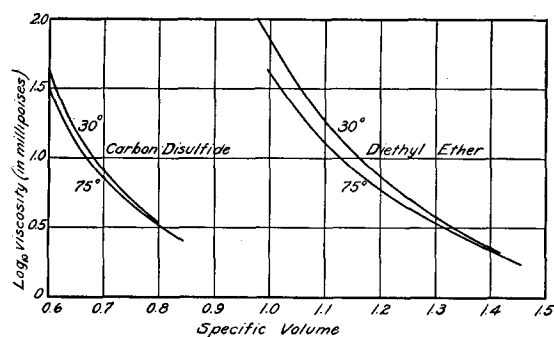


FIG. 1. Log viscosity specific volume isotherms for carbon disulfide and diethyl ether (from Bridgman). This figure is essentially the same as Fig. 8 in Bridgman's paper.

necessary for such an investigation were not available previous to the comprehensive work of Bridgman² on the viscosity of liquids under pressure and Stakelbeck's³ work on the viscosity of carbon dioxide in the critical region.

The discussion can best be begun by considering the viscosity temperature coefficients. It is well known from kinetic theory and experiment

TABLE I. Viscosity of liquid and gaseous carbon dioxide (from Stakelbeck) (viscosity in millipoises).

atmos. <i>p</i> \ <i>t</i> °C	0	10	20	30	40
5	0.139	0.142	0.146	0.149	0.157
10	0.143	0.144	0.149	0.151	0.159
15	0.147	0.145	0.151	0.153	0.161
20	0.151	0.149	0.154	0.160	0.167
25	0.155	0.153	0.156	0.160	0.167
30	0.162	0.157	0.159	0.163	0.170
35	0.994	0.162	0.162	0.167	0.174
40	1.042	0.171	0.167	0.171	0.177
45	1.067	0.857	0.174	0.175	0.182
50	1.091	0.897	0.182	0.180	0.187
55	1.111	0.936	0.192	0.187	0.193
60	1.132	0.964	0.728	0.196	0.200
65	1.149	0.990	0.765	0.210	0.208
70	1.167	1.011	0.799	0.228	0.219
75	1.184	1.034	0.829	0.523	0.234
80	1.198	1.056	0.856	0.574	0.260
85	1.211	1.075	0.882	0.619	0.303
90	1.225	1.094	0.906	0.659	0.367
95	1.238	1.112	0.927	0.694	0.436
100	1.249	1.129	0.948	0.727	0.497
105	1.260	1.144	0.967	0.758	0.547
110	1.272	1.159	0.986	0.785	0.588
115	1.283	1.174	1.004	0.812	0.623
Vapor pressure (in atmospheres)					
	34.38	44.41	56.50	71.14	—

² Bridgman, Proc. Am. Acad. Arts Sci. **61**, 57 (1925-26).

³ Stakelbeck, Zeit. ges. Kalte-Industrie **40**, 33 (1933).

that $(\partial\eta/\partial T)_V$ and $(\partial\eta/\partial T)_p$ are equal and positive for dilute⁴ gases. It is also well known from experiment that $(\partial\eta/\partial T)_p$ is negative for ordinary liquids. Faust⁵ claimed to have shown that $(\partial\eta/\partial T)_V$ was zero for carbon disulfide and ether in the range 0° to 40° and 1 to 3000 atmospheres, but his data show that $(\partial\eta/\partial T)_V$ is in reality a small negative number in both cases. Bridgman's² results over a much wider range show definitely that $(\partial\eta/\partial T)_V$ is negative for ordinary liquids, but that it becomes smaller in absolute value as the volume is increased. This is shown in Fig. 1, drawn from Bridgman's data. The largest volumes in the figure are for 75° under the vapor pressure of the liquid at 75°. It appears that the curves will cross and $(\partial\eta/\partial T)_V$ become zero at a volume not much greater than the largest in the figure. It can be concluded from this that the smallest volume at which $(\partial\eta/\partial T)_V = 0$ is the volume of the liquid under its own vapor pressure at a temperature probably closer to the normal boiling point than to the critical temperature.

Since $(\partial\eta/\partial T)_V$ and $(\partial\eta/\partial T)_p$ are both positive for dilute gases and both are negative for ordinary liquids, it is obvious that they both decrease algebraically as the volume is decreased, each becoming zero at some intermediate density.

TABLE II. Molal volume of carbon dioxide (from Amagat).

atmos. p	0°C	0	10	20	30	40
30	560.0	611.0	—	—	—	—
35	48.0	489.0	535.0	575.0	—	—
40	47.6	395.0	442.0	480.5	517.0	—
45	47.2	52.3	367.0	407.0	442.0	—
50	47.0	51.3	304.5	347.0	381.0	—
55	46.7	50.5	246.5	296.0	331.0	—
60	46.5	49.9	56.8	249.5	288.0	—
65	46.3	49.4	55.65	205.0	250.0	—
70	46.1	49.0	54.7	150.5	215.5	—
75	45.9	48.7	53.8	65.4	183.0	—
80	45.75	48.4	53.05	62.4	151.5	—
85	45.6	48.2	52.5	60.6	114.8	—
90	45.5	48.0	52.0	59.25	84.9	—
95	45.35	47.8	51.55	58.05	74.0	—
100	45.2	47.7	51.2	57.1	69.2	—
105	45.1	47.55	50.9	56.35	66.5	—
110	44.9	47.4	50.65	55.7	63.8	—
115	44.8	47.2	50.45	55.1	62.3	—

⁴ The term dilute gas will be used to mean a gas for which the kinetic theory prediction of the pressure independence of viscosity is true.

⁵ Faust, Zeits. f. physik. Chemie **86**, 479 (1914).

TABLE III. *The coefficients of viscosity of fluids.*

Locus	State	Temperature Coefficients	Pressure Coefficients	Volume Coefficients
I	Dilute gases	$\left(\frac{\partial \eta}{\partial T}\right)_p +, \left(\frac{\partial \eta}{\partial T}\right)_v +,$ $\left(\frac{\partial \eta}{\partial T}\right)_p = \left(\frac{\partial \eta}{\partial T}\right)_v$	$\left(\frac{\partial \eta}{\partial p}\right)_T = 0, \left(\frac{\partial \eta}{\partial p}\right)_v +,$ $\left(\frac{\partial \eta}{\partial p}\right)_T < \left(\frac{\partial \eta}{\partial p}\right)_v$	$\left(\frac{\partial \eta}{\partial V}\right)_T = 0, \left(\frac{\partial \eta}{\partial V}\right)_p +,$ $\left(\frac{\partial \eta}{\partial V}\right)_T < \left(\frac{\partial \eta}{\partial V}\right)_p$
II	Compressed gases	$\left(\frac{\partial \eta}{\partial T}\right)_p +, \left(\frac{\partial \eta}{\partial T}\right)_v +,$ $\left(\frac{\partial \eta}{\partial T}\right)_p < \left(\frac{\partial \eta}{\partial T}\right)_v$	$\left(\frac{\partial \eta}{\partial p}\right)_T +, \left(\frac{\partial \eta}{\partial p}\right)_v +,$ $\left(\frac{\partial \eta}{\partial p}\right)_T < \left(\frac{\partial \eta}{\partial p}\right)_v$	$\left(\frac{\partial \eta}{\partial V}\right)_T -, \left(\frac{\partial \eta}{\partial V}\right)_p +,$ $\left(\frac{\partial \eta}{\partial V}\right)_T < \left(\frac{\partial \eta}{\partial V}\right)_p$
III	Intermediate densities	$\left(\frac{\partial \eta}{\partial T}\right)_p = 0, \left(\frac{\partial \eta}{\partial T}\right)_v +,$ $\left(\frac{\partial \eta}{\partial T}\right)_p < \left(\frac{\partial \eta}{\partial T}\right)_v$	$\left(\frac{\partial \eta}{\partial p}\right)_T +, \left(\frac{\partial \eta}{\partial p}\right)_v +,$ $\left(\frac{\partial \eta}{\partial p}\right)_T = \left(\frac{\partial \eta}{\partial p}\right)_v$	$\left(\frac{\partial \eta}{\partial V}\right)_T -, \left(\frac{\partial \eta}{\partial V}\right)_p = 0,$ $\left(\frac{\partial \eta}{\partial V}\right)_T < \left(\frac{\partial \eta}{\partial V}\right)_p$
IV		$\left(\frac{\partial \eta}{\partial T}\right)_p -, \left(\frac{\partial \eta}{\partial T}\right)_v +,$ $\left(\frac{\partial \eta}{\partial T}\right)_p < \left(\frac{\partial \eta}{\partial T}\right)_v$	$\left(\frac{\partial \eta}{\partial p}\right)_T +, \left(\frac{\partial \eta}{\partial p}\right)_v +,$ $\left(\frac{\partial \eta}{\partial p}\right)_T > \left(\frac{\partial \eta}{\partial p}\right)_v$	$\left(\frac{\partial \eta}{\partial V}\right)_T -, \left(\frac{\partial \eta}{\partial V}\right)_p -,$ $\left(\frac{\partial \eta}{\partial V}\right)_T < \left(\frac{\partial \eta}{\partial V}\right)_p$
V		$\left(\frac{\partial \eta}{\partial T}\right)_p -, \left(\frac{\partial \eta}{\partial T}\right)_v = 0,$ $\left(\frac{\partial \eta}{\partial T}\right)_p < \left(\frac{\partial \eta}{\partial T}\right)_v$	$\left(\frac{\partial \eta}{\partial p}\right)_T +, \left(\frac{\partial \eta}{\partial p}\right)_v = 0,$ $\left(\frac{\partial \eta}{\partial p}\right)_T > \left(\frac{\partial \eta}{\partial p}\right)_v$	$\left(\frac{\partial \eta}{\partial V}\right)_T -, \left(\frac{\partial \eta}{\partial V}\right)_p -,$ $\left(\frac{\partial \eta}{\partial V}\right)_T = \left(\frac{\partial \eta}{\partial V}\right)_p$
VI	Liquids under most conditions (see Fig. 2)	$\left(\frac{\partial \eta}{\partial T}\right)_p -, \left(\frac{\partial \eta}{\partial T}\right)_v -,$ $\left(\frac{\partial \eta}{\partial T}\right)_p < \left(\frac{\partial \eta}{\partial T}\right)_v$	$\left(\frac{\partial \eta}{\partial p}\right)_T +, \left(\frac{\partial \eta}{\partial p}\right)_v -,$ $\left(\frac{\partial \eta}{\partial p}\right)_T > \left(\frac{\partial \eta}{\partial p}\right)_v$	$\left(\frac{\partial \eta}{\partial V}\right)_T -, \left(\frac{\partial \eta}{\partial V}\right)_p -,$ $\left(\frac{\partial \eta}{\partial V}\right)_T > \left(\frac{\partial \eta}{\partial V}\right)_p$

Under ordinary conditions there is no continuous gradation of densities available, and so it is in the critical region where such intermediate densities do exist that the change of sign must be sought. The most important point to be decided is whether or not $(\partial \eta / \partial T)_v$ and $(\partial \eta / \partial T)_p$ become zero under the same conditions. The last paragraph pointed out the approximate location of the change of sign for $(\partial \eta / \partial T)_v$. Inspection of Table I compiled from Stakelbeck's data on the viscosity of carbon dioxide shows that $(\partial \eta / \partial T)_p$ is zero along a locus 10 or 15 atmospheres less than the condensation pressure. The zig-zag line in the table is drawn between the pressures

where the vapor pressures lie, i.e., it is the condensation line. Furthermore comparison of Table I with Table II taken from Amagat⁶ shows that in the liquid region below the condensation line $(\partial \eta / \partial T)_v$ is positive and not negative as it is for liquids under ordinary conditions i.e. farther removed from the critical point. These data show that on the basis of the sign and relative magnitude of the two viscosity temperature coefficients a given state of a fluid can be placed in one of six categories, or loci, as shown in the first three columns of Table III.

In Table I Stakelbeck's data have been

⁶ Amagat, Ann. chim. phys. [6] 29, 68 (1893).

changed from kg sec. per meter² and kg per cm² to millipoises and atmospheres in order to compare with Phillips'⁷ earlier, but less extensive measurements in the same region. The excellence of the agreement between these two investigators gives justification for basing such important conclusions on Stakelbeck's data. Phillips' data on the volumes of carbon dioxide also agree very well with those of Amagat.

In the further development we shall use the general mathematical equations relating four variables any two of which may be taken as independent:

$$(\partial\eta/\partial p)_V = (\partial\eta/\partial p)_T + (\partial\eta/\partial T)_p(\partial T/\partial p)_V, \quad (1)$$

$$(\partial\eta/\partial T)_V = (\partial\eta/\partial T)_p + (\partial\eta/\partial p)_T(\partial p/\partial T)_V, \quad (2)$$

$$(\partial\eta/\partial T)_p = (\partial\eta/\partial T)_V + (\partial\eta/\partial V)_T(\partial V/\partial T)_p, \quad (3)$$

$$(\partial\eta/\partial V)_p = (\partial\eta/\partial V)_T + (\partial\eta/\partial T)_V(\partial T/\partial V)_p, \quad (4)$$

$$(\partial\eta/\partial p)_T = (\partial\eta/\partial p)_V + (\partial\eta/\partial V)_p(\partial V/\partial p)_T, \quad (5)$$

$$(\partial\eta/\partial V)_T = (\partial\eta/\partial V)_p + (\partial\eta/\partial p)_V(\partial p/\partial V)_T, \quad (6)$$

$$(\partial\eta/\partial V)_T = (\partial\eta/\partial p)_T(\partial p/\partial V)_T, \quad (7)$$

$$(\partial\eta/\partial V)_p = (\partial\eta/\partial T)_p(\partial T/\partial V)_p, \quad (8)$$

$$(\partial\eta/\partial p)_V = (\partial\eta/\partial T)_V(\partial T/\partial p)_V, \quad (9)$$

where $(\partial V/\partial T)_p$, $(\partial T/\partial p)_V$, $(\partial T/\partial V)_p$ and $(\partial p/\partial T)_V$ are all positive, and $(\partial V/\partial p)_T$ and $(\partial p/\partial V)_T$ are both negative.

It is well known from kinetic theory that $(\partial\eta/\partial p)_T$ is zero and that $(\partial\eta/\partial p)_V$ is positive for dilute gases. Also it is well known from experiment that $(\partial\eta/\partial p)_T$ is positive for ordinary liquids. From Eq. (9) $(\partial\eta/\partial p)_V$ is negative for ordinary liquids, since $(\partial\eta/\partial T)_V$ is negative and $(\partial T/\partial p)_V$ is positive. It is obvious therefore that $(\partial\eta/\partial p)_T$ must increase from zero as the volume decreases, and that $(\partial\eta/\partial p)_V$ must decrease as the volume decreases, becoming equal to $(\partial\eta/\partial p)_T$ and equal to zero at intermediate densities. Eq. (1) shows that $(\partial\eta/\partial p)_V = (\partial\eta/\partial p)_T$, when $(\partial\eta/\partial T)_p = 0$ (locus III). Eq. (9) shows that $(\partial\eta/\partial p)_V = 0$, when $(\partial\eta/\partial T)_V = 0$ (locus V).

From Eqs. (7) and (8), respectively, it is seen that $(\partial\eta/\partial V)_T = 0$ and $(\partial\eta/\partial V)_p$ is positive for dilute gases. The same relations show that both coefficients are negative for ordinary liquids.

⁷ Phillips, Proc. Roy. Soc. **87A**, 48 (1912).

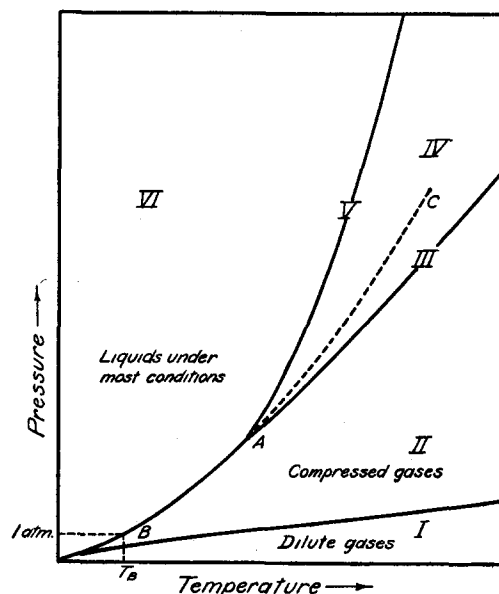


FIG. 2. Schematic "phase diagram" for viscosity. The Roman numerals designate the viscosity loci as defined in Table III. B is the normal boiling point, C is the critical point, and BAC is the vapor pressure curve. Locus IV extends on both sides of AC.

From Eq. (5) it is seen that $(\partial\eta/\partial V)_p = 0$, when $(\partial\eta/\partial p)_V = (\partial\eta/\partial p)_T$ (locus III). From either Eq. (4) or (6) it is seen that $(\partial\eta/\partial V)_T = (\partial\eta/\partial V)_p$ when $(\partial\eta/\partial p)_V$ and $(\partial\eta/\partial T)_V$ are zero (locus V). The last two paragraphs enable us to complete the construction of Table III.

The relations thus deduced for locus IV may be confirmed by referring to Tables I and II, for example that $(\partial\eta/\partial T)_V$ and $(\partial\eta/\partial p)_V$ are both positive instead of negative as for liquids in locus VI. All of Stakelbeck's data for liquid carbon dioxide are in locus IV, but at higher pressures or at lower temperatures carbon dioxide would undoubtedly show the behavior of locus VI.

Fig. 2 shows schematically the approximate location of the six loci for a normal liquid. Locus III and locus V are univariant loci, i.e., they are fixed by specifying one external variable. In an exact sense locus I may also be such a unique locus, located at zero pressure (neglecting slippage, of course). Most measurements of the viscosity of gases have been made at moderate pressures and hence always in loci I and II, and most measurements on liquids have been made at temperatures below the normal boiling point

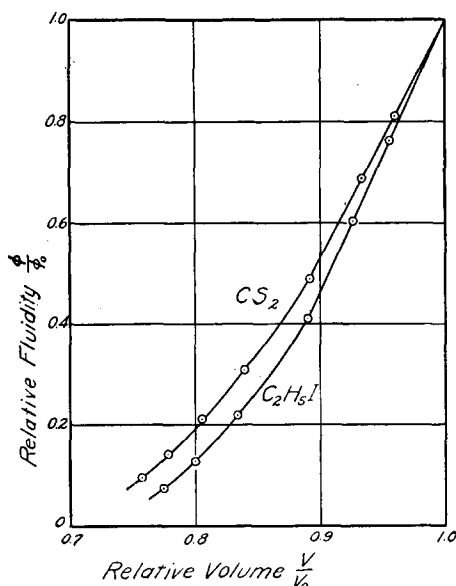


FIG. 3. Relative fluidity relative volume isotherms at 30° for two representative normal liquids, CS₂ and C₂H₅I.

and hence in locus VI. It is notable that locus IV occupies a range of intermediate densities that includes both liquid and gas phases adjacent to the condensation line. The exact location of the boundary curves for any particular substance would require a knowledge of the viscosity over a range of temperatures and pressures from the normal boiling point and one atmosphere up to the critical temperature and pressure.

Bridgman's² data show that the viscosity increases with pressure at an increasingly rapid rate, so that at high densities $(\partial\eta/\partial p)_T$ is very large, in fact it appears as though it would approach infinity at extremely high pressures (although freezing would undoubtedly occur first). At very high pressures where $(\partial\eta/\partial p)_T$ is a very large positive number, the other coefficient at constant temperature and the two coefficients at constant pressure become very large negative numbers, as follows:

(1) From Eq. (7) it is seen that $(\partial\eta/\partial V)_T$ becomes very large when $(\partial\eta/\partial p)_T$ is very large.

(2) From Eq. (4) it is seen that $(\partial\eta/\partial V)_p$ is always numerically larger than $(\partial\eta/\partial V)_T$ in locus VI, but the difference becomes small at very high densities since the term $(\partial\eta/\partial T)_V \times (\partial T/\partial V)_p$ does not change greatly with density.

(3) From Eq. (8) it is seen that $(\partial\eta/\partial T)_p$ be-

comes very large when $(\partial\eta/\partial V)_p$ is very large. However, the two coefficients at constant volume, $(\partial\eta/\partial T)_V$ and $(\partial\eta/\partial p)_V$ remain relatively small numbers even at very high densities as shown by Eqs. (1), (2), (3) and (5).

THE FLUIDITY COEFFICIENTS

Fluidity, defined as the reciprocal of the viscosity, is represented by ϕ . Since $d\phi = -d\eta/\eta^2$ all the relations in Table III are the same for the fluidity coefficients only with all signs reversed, and all inequalities reversed.

The volume coefficients of fluidity of liquids are of particular interest since the constant B in Batchinski's⁸ relation

$$\phi = A + BV \quad (10)$$

is a fluidity volume coefficient. Batchinski tested this equation with Thorpe and Rodger's⁹ viscosity temperature data for 47 liquids and density temperature data by Thorpe, Young and others, all at atmospheric pressure. All the normal liquids gave straight lines when plotted ϕ vs. V . This test showed that fluidity and volume are related linearly as both properties vary with the temperature at constant pressure, i.e., it was a test of the equation

$$\phi(T) = A + BV(T) \quad (11)$$

and $(\partial\phi/\partial V)_p$ is a constant. The volume range tested was that between 0°C and the normal boiling point, approximately a 10 percent change, for the 47 liquids of Thorpe and Rodger, and to temperature above the normal boiling point for benzene, ethyl acetate and ether from the data of Heydweiller.¹⁰ Batchinski did not make this precise a statement of his relation, in fact he tacitly assumed that the fluidity is a linear function of the volume as both properties are varied by varying either temperature or pressure or both simultaneously, i.e., that

$$\phi(p, T) = A + BV(p, T). \quad (12)$$

This statement of the relation implies that the fluidity is a function of the volume only, and

⁸ Batchinski, Zeits. f. physik. Chemie **84**, 643 (1913). This relation can be put into several forms. In the form used here V is the molal volume, and A and B are constants.

⁹ Thorpe and Rodger, Trans. Roy. Soc. (London) **185A**, 307 (1894).

¹⁰ Heydweiller, Ann. d. Physik **59**, 193 (1896).

TABLE IV. Fluidity volume coefficients of liquids.

Liquid	$(\partial\phi/\partial V)_p$ at 1atmos.	$(\partial\phi/\partial V)_T$ at 30°
CS ₂	28.0	22.9 ¹
CCl ₄	13.7	10.8
Ether	23.6	23.0 ¹
C ₂ H ₅ Br	23.0	17.3
C ₂ H ₅ I	18.4	11.9
<i>n</i> -C ₅ H ₁₂	22.5	17.0
<i>n</i> -C ₆ H ₁₄	18.0	14.4
<i>n</i> -C ₈ H ₁₈	13.2	9.1
C ₆ H ₆	22.05	14.2
C ₆ H ₅ Cl	—	12.5
C ₆ H ₅ Cl	—	9.4
Acetone	28.7	24.7

¹ Faust's data give for CS₂, 23.6 at 20° and 19.8 at 40°, and for ether, 21.1 at 20° and 19.4 at 34°.

that $(\partial\phi/\partial p)_V$ and $(\partial\phi/\partial T)_V$ are both zero. This is not true as we have seen, for both these coefficients are small positive numbers for liquids in locus VI. Eq. (12) is therefore not true.

Batchinski has tested Eq. (11). The analogous relation

$$\phi(p) = A' + B'V(p) \quad (13)$$

has never been tested. The only data available for such a test are those of Bridgman² and Faust,⁵ neither of which were available at the time of Batchinski's paper. These viscosity data

under pressure and also the volume data (from Bridgman and Amagat) are not nearly as accurate as the data at atmospheric pressure used by Batchinski to test Eq. (11). Making allowances for these possible inaccuracies the relation appears to be true for all normal liquids tested. Fig. 3 shows a plot of $\phi/\phi_0(p)$ vs. $V/V_0(p)$ for two representative liquids, carbon disulfide and ethyl iodide, at 30° from Bridgman's data (ϕ_0 and V_0 are the fluidity and molal volume at atmospheric pressure). It is seen that $(\partial\phi/\partial V)_T$ is constant over a limited volume change, up to about 10 percent. The numerical value of $(\partial\phi/\partial V)_T$ is gotten by multiplying the slope of the curve at any point by ϕ_0/V_0 , which for the linear part of the curve gives 22.9 for CS₂ and 11.9 for C₂H₅I.

According to Table III, $(\partial\phi/\partial V)_p$ should be greater than $(\partial\phi/\partial V)_T$ in locus VI. Table IV gives $(\partial\phi/\partial V)_p$ at atmospheric pressure in the temperature range between 0°C and the normal boiling point taken from Thorpe and Rodger's data, and $(\partial\phi/\partial V)_T$ at 30° in the pressure range from 1 to 500 kg/sq. cm calculated from Bridgman's data. V is the molal volume in both cases. It is seen that $(\partial\phi/\partial V)_T$ is about 2/3 to 3/4 of $(\partial\phi/\partial V)_p$ in most cases.