

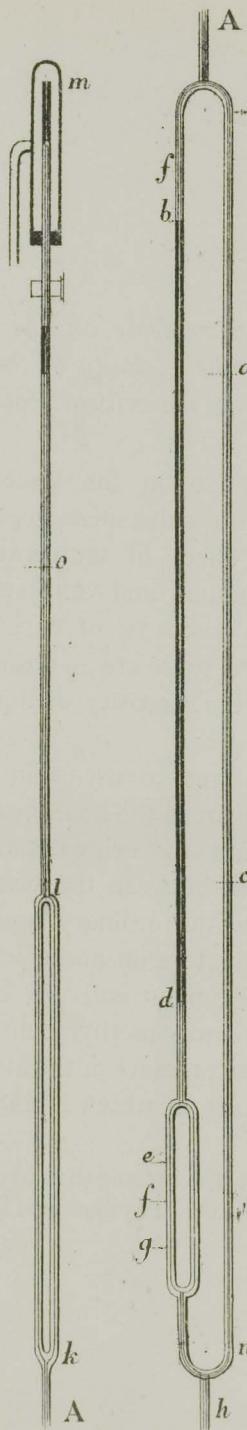
Dr. L. M. J. STOEL. *Measurements on the influence of temperature on the viscosity of fluids between the boiling-point and the critical state.*¹⁾

Most investigations hitherto made on the viscosity of liquids deal with the influence of substances in solution. In a few cases only the effect of temperature and pressure was examined. WARBURG and VON BABO²⁾ excepted, who investigated the viscosity of carbonic acid about the critical temperature, there are no observations, as far as I know, about the viscosity of liquids above the boiling-point.

The aim of my investigation was to ascertain the change of viscosity of a liquid between the boiling-point at the atmospherical pressure and the critical temperature; in order to fill up the gap between the examinations of the liquid state below the ordinary boiling-point, as made by several investigators on one side and those of the critical state by WARBURG and VON BABO on the other. The liquid I chose was methyl chloride, which boils at — 23° C under the pressure of the atmosphere, and the critical temperature of which is 143° C.

¹⁾ Dissertation, Leiden, Febr. 1891. The investigation has been published in extenso also by prof. GRAETZ, *Physikalische Revue* I, p. 513, 1892.

²⁾ Wied. Ann. 17, pag. 390, 1882.



4

The apparatus consists chiefly of two vertical glass tubes *b g* and *i n* (as shown in the fig.) at a small distance from each other, connected at the top and at the bottom forming thus a long-drawn *O*. The whole apparatus is made of thick glass, the inner diameter of the branch *i n* being about 2,5 mM. while the other branch contains a wide reservoir *e g* of 7 mM. diameter and a capillary tube *b d* of 0,2 mM. bore and 55 cM. length. From *h* downward goes a tube, the open end of which is fitted into the pressure-cylinder of a Cailletet-apparatus, so that mercury can be forced into the instrument from below. To this purpose the just mentioned pressure-cylinder is connected with a second vessel containing mercury, on the surface of which a high pressure can be applied by means of compressed carbonic acid or air; the use of compressed air necessary as the pressure

5

of saturated vapour of methyl chloride near the critical point amounts to 65 atmospheres.

From the top of the *O*-shaped tube upwards goes a vertical tube *k l m*, which is at first left open and provided with a special arrangement *o m* for cleaning purposes and for exhausting the air and distilling methyl chloride into the apparatus (the tube being cooled by a mixture of solid carbonic acid and alcohol) but afterwards is closed by melting it at *o*.

The part *k l* has the same diameter as *e g*, its bulk being about twice that of the whole *O*-shaped apparatus, as it must be able to contain the whole quantity of liquid in the apparatus.

The apparatus described is placed within a glass cylinder of the same height, which forms part of a circulation-arrangement in which absolute alcohol, cooled within a spiral by a mixture of solid carbonic acid and alcohol, is made to circulate, or water of the desired temperature or finally heated glycerine. By this method experiments could be made between -23° C. and $+123^{\circ}$ C.

At the beginning of an experiment the level of the mercury stands just below the *O*-tube, that of the liquid methyl chloride stands a little way in the reservoir *k l*, while the upper part of the apparatus contains only the vapour of the liquid. Now, when the mercury is forced up, it soon rises into the tube *i n*; by regulating the supply of mercury, its level is kept at one of the marks *a* or *c*, while the mercury introduced from below slowly forces up the methyl chloride from the reservoir *e g* through the capillary tube to *k l*.

At *e*, *f* and *g* marks have been engraved to which

reading-microscopes with cross-wires are focused; with the aid of a registering-instrument the moments are recorded at which the rising mercury-level reaches these marks; tenths of seconds can thus be measured with accuracy and even hundredths can be estimated.

As in the upper part of the apparatus always remains a space filled with vapour, the pressure at the top of the capillary tube is only a little greater than the maximum vapour-pressure at the temperature of the experiment. The excess of pressure at the bottom is measured by the height of the mercury-column in the tube *in*.

In the manner, indicated by WARBURG for his experiments on carbonic acid, I investigated the influence which the compressibility of the methyl chloride and the variation of viscosity with change of density can possibly have in my experiments and the corrections required by them. In this investigation it became clear to me that by neglecting these corrections an error can be made of 0,5% at the utmost. The formula by which, taking no account of these corrections, the coefficient of viscosity can be calculated, is as follows:

$$\mu = \frac{g \pi r^4 (\tau - s_0) T \log e}{8 q l A},$$

in which g = acceleration of gravitation.

r = radius of the capillary tube.

τ = density of mercury.

s = " of methyl chloride.

T = time of passage of the liquid.

e = base of the Nep. log.

q = cross-section of the reservoir *efg*.

l = length of the capillary tube.

$$A = l \frac{a_A}{a_B} = l \frac{H - h_1}{H - h_2}, \text{ if we denote}$$

by H the constant height of the mercury in the branch *in* during each experiment and by h_1 and h_2 , the height of the marks g and e , measured from an arbitrary horizontal plane.

The expression here given for μ must be corrected for the differences which the pressures show from the values they should have according to POISEUILLE's law. By the great difference in diameter of the reservoir *efg* and the tube *in* there remains an uncertainty in the recorded pressures, caused by capillary depression, so that the difference of the pressures from those following from POISEUILLE's law cannot accurately be determined from my experiments. If this were the case, it would be possible to calculate absolute values for the coefficient of viscosity from the recorded times of passage and the dimensions of the apparatus. These we might also obtain by using the same tube for experiments with a fluid of known viscosity.

But even without this, the non-corrected times of passages T give a sufficient idea of the variations of the internal friction with temperature.

Expressed in seconds they can with sufficient accuracy be represented by the empirical formula:

$$\log T = \frac{896 - T}{250}$$

in which T denotes the absolute temperature. This appears from the following table, taken from my dissertation.

$T - 273$	T (observed)	T (calculated)	Difference in percents.
- 28°	408.50	401.79	+ 1.7 p.Ct.
- 20.75	379.91	375.84	+ 1.1
- 11.3	339.41	344.51	- 1.5
+ 0.75	305.72	308.32	- 0.8
10.8	280.21	281.06	- 0.3
19.0	259.81	260.62	- 0.3
27.8	236.17	240.33	- 1.7
35.9	220.995	223.05	- 0.9
45.2	204.595	204.74	- 0.1
55.8	186.58	185.69	+ 0.5
66.6	169.99	168.41	+ 1.1
75.2	157.59	155.31	+ 1.5
85.4	143.46	141.78	+ 1.2
93.45	133.38	131.64	+ 1.2
104.3	120.88	118.80	+ 1.8
110.7	112.68	112.00	+ 0.6
122.95	97.06	100.04	- 3.0

The times of passage I observed also satisfy approximately the relation :

$$\mu p^{\frac{1}{3}} = \text{Const.},$$

in which μ is the coefficient of viscosity when the liquid is under the pressure of its own vapour and p the vapour-pressure.

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No. 3.

Dr. R. SISSINGH. On Kerr's Magnetooptic Phenomenon in the case of Equatorial Magnetization of Iron.

(Translated from: Natuurk. Verhandel. Kon. Akad. v. Wetensch. Amsterdam. Deel 28. 1890.)

Because there appeared a translation of the somewhat abridged paper (Wied. Ann. Bd. 42 p. 115. (1891)) in Phil. Mag. (5). Vol. 31. p. 293. 1891, a reprint seems unnecessary.