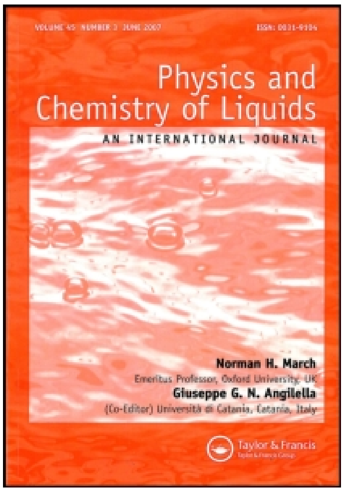

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M. Bosco Masera[a]
[a] Istituto di Fisica Sperimentale del Politecnico di, Torino

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Viscosity of the Melting Point Hg-Tl Amalgam at 30 at. Percent. Tl

M. BOSCO MASERA

Istituto di Fisica Sperimentale del Politecnico di Torino

Details of the experimental measurements of the viscosity of the melting point of a Hg–Tl amalgam at 30 atomic percent Tl are reported.

In the present note we describe the measurements of the viscosity of the melting point of Hg–Tl amalgam at 30 at. percent. Tl[1] In the oscillating crucible viscometer[2,1] the Hg–Tl amalgam at 30 at. percent Tl is contained in a toroidal channel (Figure 1; inner radius $a = 0.348$ cm, torus radius $R = 2{,}69$ cm) for which the theory is able to relate the observed damping coefficient δ to the coefficient of viscosity of the amalgam η. The result of the theory is:

$$\frac{T(\delta - \delta_0)\sqrt{2}}{4\pi^3 a^2 R^3 \rho}\left(1 + \frac{T^2}{T_0^2}\right) = G_1(q) - \delta G_2(q) + \frac{a^2}{R^2} G_3(q) \qquad (1)$$

where $I = 28.346{,}53$ u.c.g.s. is the moment of inertia of the oscillating system; T, T_0; δ, δ_0 are the periods and the logarithmic decrements with and without liquid respectively; G_1, G_2, G_3 are universal functions of $q = a(2\pi\rho/\eta T)^{1/2}$ tabulated in Ref. (2) and ρ is the liquid density. The terms containing G_2 and G_3 act only as a small perturbation and the main features of the instrument are sufficiently described by the function $G_1(q)$ (see Figure 2).

It is clear that the logarithmic decrement must approach zero both for $\eta \to 0$ and for $\eta \to \infty$, therefore the decrement must show a maximum at some intermediate value of viscosity. As a consequence, two possible regimes of oscillation are possible namely:

1) the zone at the right of the maximum of $G_1(q)$, where an increase of viscosity, due to a lowering of temperature, causes an increase of δ;

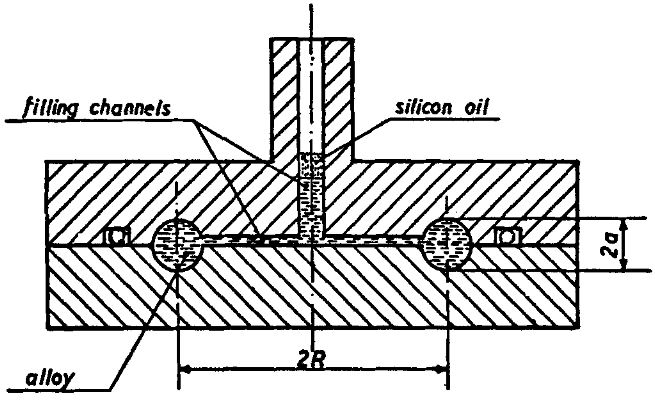

FIGURE 1 Schematic drawing of the toroidal viscometer.

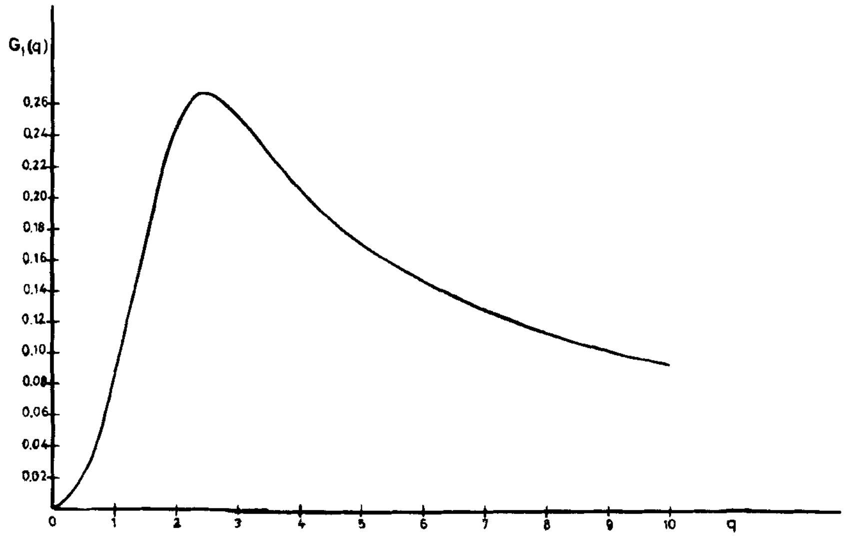

FIGURE 2 Diagram of the function $G_1(q)$ versus $q = a(2\pi\rho/\eta T)^{1/2}$.

2) the zone at the left of the maximum, where an increase of η results in a decrease of δ.

It is especially important to emphasize the asymptotic behaviour of $G_1(q)$ in the two distinct zones. For $q \to \infty$ the theory shows that

$$\delta - \delta_0 \sim \sqrt{\eta} \tag{2}$$

while for $q \to 0$ the appropriate formula is

$$\delta - \delta_0 \sim \frac{1}{\eta} \tag{3}$$

TABLE I

$(\theta \pm 0.01)$°C	$\delta 0.10^{-4} \pm 0.3 \cdot 10^{-5}$	$\delta 0.10^{-3} \pm 0.3 \cdot 10^{-5}$	$(T \pm 0.2)$ sec	$(T_0 \pm 0.2)$ sec	$(\rho \pm 0.003)$ gr/cm^3	q	$(\eta \pm 0.02)$ cp
12.00	3.23112	8.2680	12.305726	12.102428	12.931084	1.490	3.602
12.25	3.23431	8.6347	12.294462	12.113531	12.930569	1.530	3.419
12.50	3.23750	9.0050	12.272358	12.102584	12.930053	1.580	3.211
12.63	3.23909	9.1490	12.274018	12.102622	12.929796	1.600	3.131
12.75	3.24068	8.8448	12.25935	12.102661	12.929538	1.560	3.298
13.75	3.25337	8.8335	12.257724	12.102972	12.927477	1.555	3.319
15.13	3.27069	8.8095	12.259350	12.103399	12.924643	1.550	3.339
15.25	3.27226	8.7485	12.255465	12.103438	12.924386	1.545	3.361
15.50	3.27539	8.7455	12.253421	12.103516	12.923870	1.545	3.362
20.50	3.33699	8.6066	12.255429	12.105069	12.913565	1.525	3.448
23.00	3.36707	8.5960	12.255285	12.105846	12.908413	1.520	3.469

This has a remarkable consequence on the sensitivity of the intrument, because, in the right-hand zone, a relative change $\Delta\eta/\eta$ of viscosity results in a relative change of damping given by

$$\frac{\Delta(\delta - \delta_0)}{\delta - \delta_0} \simeq \frac{1}{2}\frac{\Delta\eta}{\eta} \tag{2'}$$

while, in the left-hand zone, we get

$$\frac{\Delta(\delta - \delta_0)}{(\delta - \delta_0)} \simeq \frac{|\Delta\eta|}{\eta} \tag{3'}$$

i.e., the sensitivity here is twice the previous one.

The zone described by Eq. (2) corresponds to the oscillation regime in which all the previous (spherical, cylindrical) viscometers fixed their working point. In fact, Eq. (2) is exactly the kind of relationship which is at the basis of all modern experimental works on viscosity.[3] The geometry of the torns allows a full and rigorous discussion of the hydrodynamical problem even in the $q \to 0$ zone, where Eq. (3') applies.

The experimental data (see Table I) of the viscosity of Hg–Tl amalgam at 30 at. percent Tl are in the zone at the right of the maximum of $G_1(q)$.

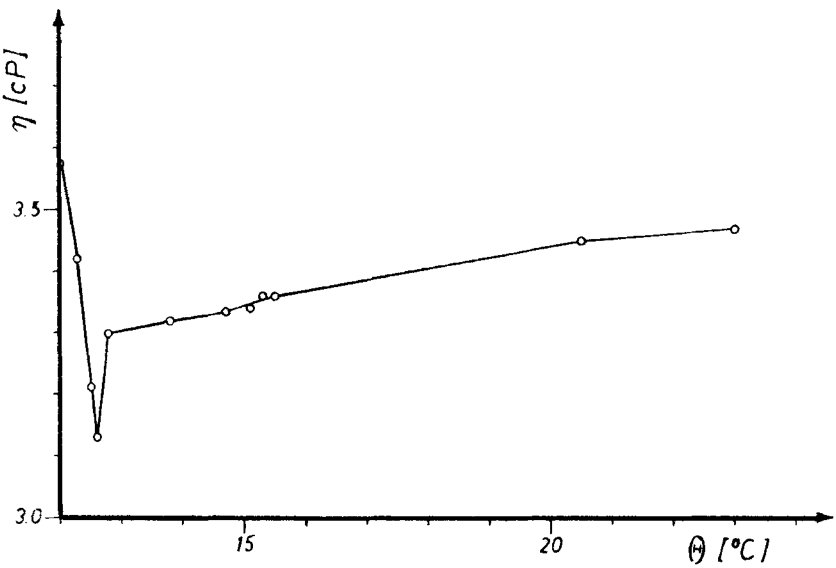

FIGURE 3 Viscosity η versus temperature Θ°C.

From the two experimental points at $\theta = 15.50$ and 12°C it is also possible to check the sensitivity of the instrument. In fact we get

$$\frac{\Delta(\delta - \delta_0)}{\delta - \delta_0} = \frac{4.74}{79.50} = 0.0596 \quad \frac{|\Delta\eta|}{\eta} = \frac{0.24}{3.60} = 0.0667$$

from which

$$\frac{\Delta(\delta - \delta_0)}{\delta - \delta_0} = 0.9 \frac{|\Delta\eta|}{\eta}$$

This confirms Eq. (3′), which however is strictly true only in the limit $q \to 0$. For the usual viscometers, where Eq. (2′) applies, we would obtain a numerical coefficient <0.5.

After these accurate tests we confirm the precision of experimental measurements and we award the viscosity $\eta = 3.13$ cp. of the melting point of the Hg–Tl amalgam at 30 at. percent Tl a minimum (see Figure 3), while in the zone at the right of the maximum of $G_1(q)$ will correspond to the melting point viscosity a maximum, as the literature asserts (see Ref. 5).

SUMMARY

The determination of the viscosity, with an oscillating crucible viscometer, of the melting point of Hg–Tl amalgam at 30 at. percent. Tl is reported. This determination is executed in the zone at the left of the maximum of $G_1(q)$, that is the small q zone, where the instrument sensitivity is double that in the high q zone. In that point we have found a minimum in perfect accord with the maximum we should have found in the high q zone, as in Ref. (5).

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