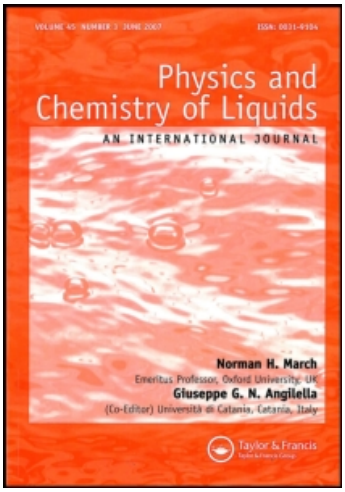

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Hg_2Tl is an Intermetallic Compound

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Hg_2Tl is an Intermetallic Compound

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By means of a toroidal oscillating viscometer, the shear viscosity of some mercury-thallium alloys has been measured in the composition range 33–33.5 atomic percent thallium and over the temperature range from 13.5–16.5°C. Some discussion of the experimental results is given in terms of liquid coordination number.

1 INTRODUCTION

In previous papers[1,2,3] the viscosity of Hg–Tl amalgams has been investigated using a special kind of toroidal oscillating viscometer. In previous paper,[3] we found a maximum at 28.6 atomic percent Tl at the temperature of 14.5°C. It remained to prove if it was an absolute maximum. For this reason, we have performed some accurate measurements on the viscosity of Mercury–Thallium alloys, both as a function of composition and temperature, as suggested by Ref. 4

2 EXPERIMENTAL APPARATUS

The toroidal oscillating viscomer used in the present investigation is the same as employed in Refs 1, 2, 3.

3 EXPERIMENTAL RESULTS

The viscometer dampings have been measured for each alloy composition (33; 33.1; 33.3; 33.5 atomic percent Tl) at different temperatures, from 13.5°C to 16.5°C, and the fluctuation are every 0.25°C.

For each damping the viscosity has been calculated using formula (1) of Refs 1, 2, 3, which for convenience is written below:

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

In the above formula $I = 27845{,}61$ c.g.s. is the total moment of inertia of the system obtained by putting onto the crucible some calibrated disks; T, T_0 are the periods with and without liquid, respectively, δ, δ_0 are the logarithmic decrements with and without liquid, respectively; ρ is the density of liquid, η is the viscosity of the liquid; $a = 0.348$ cm is the inner radius of channel; $R = 2.69$ cm is the radius of the torus; q is the dimensionless parameter given by: $a(2\pi\rho/\eta T)^{1/2}$; G_1, G_2, G_3 are universal functions of q.

The analysed experimental results are plotted in Figures 1, 2, 3. In Figure 4 the solid lines represent the dependence of η on the alloy composition, in the neighbourhood of the maximum.

In Figure 5 the maximum at 33.3% at Tl at 13.5 C.

In Figure 6 the maximum at 28.6% at. Tl at 14.5°C. In Figure 7 the maximum at 29.5% at. Tl at 14°C. In Figure 8 the phase diagram.

4 DISCUSSION OF THE EXPERIMENTAL RESULTS

a) Hg–Tl amalgam viscosity behaviour as a function of temperature confirms Ref. 5 hypothesis, that is we are in presence of discontinuous changes of the coordination numbers of the liquid that is to say of phase transitions quite similar to the polimorphous transitions of the solid state.

b) Viscosity versus amalgam composition shows a maximum at 33.3 atomic percent Tl at the temperature of 13.5°C. This is due to a pre-freezing phenomena which can indicate the influence of the forces that lead to the formation of the intermetallic compound Hg_2Tl, "Mercury Hermithallide",[4] in the solid state.

c) At 33.1 atomic percent Tl, at the temperature of 13.5°C is a minimum.

d) From papers[2,3] results that there are a maximum at 29.5% Tl at 14°C and a maximum at 28.6%. Tl at 14.5°C.

e) The "very flat maximum"[4] is, as a matter of fact, a composition of many maximums.

It remains to investigate the Hg–Tl amalgam viscosity from 25% at. Tl to 28.6% at. Tl, at the temperature from 13.5°C to 16.5°C, to determine the absolute maximum.

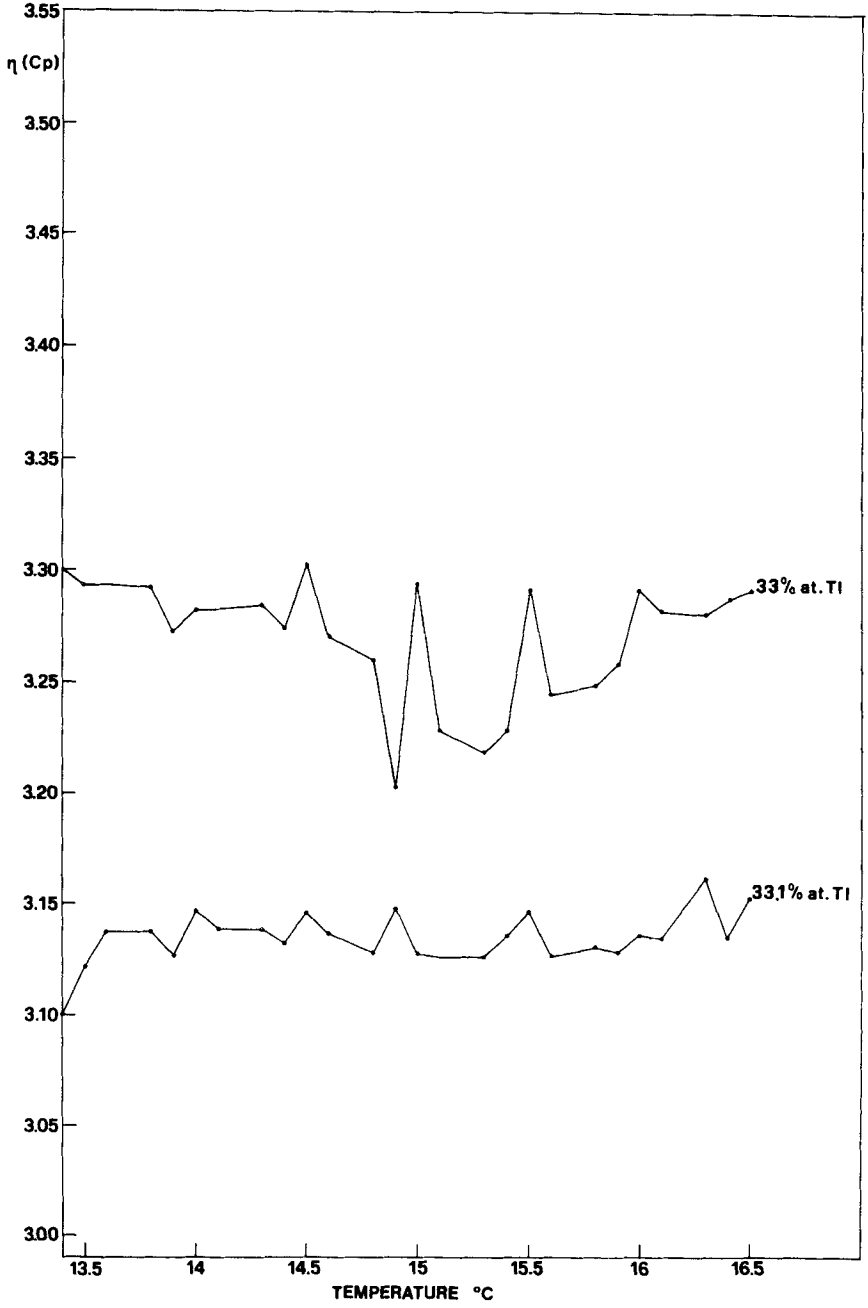

FIGURE 1 Viscosity of Hg-Tl alloys versus temperature.

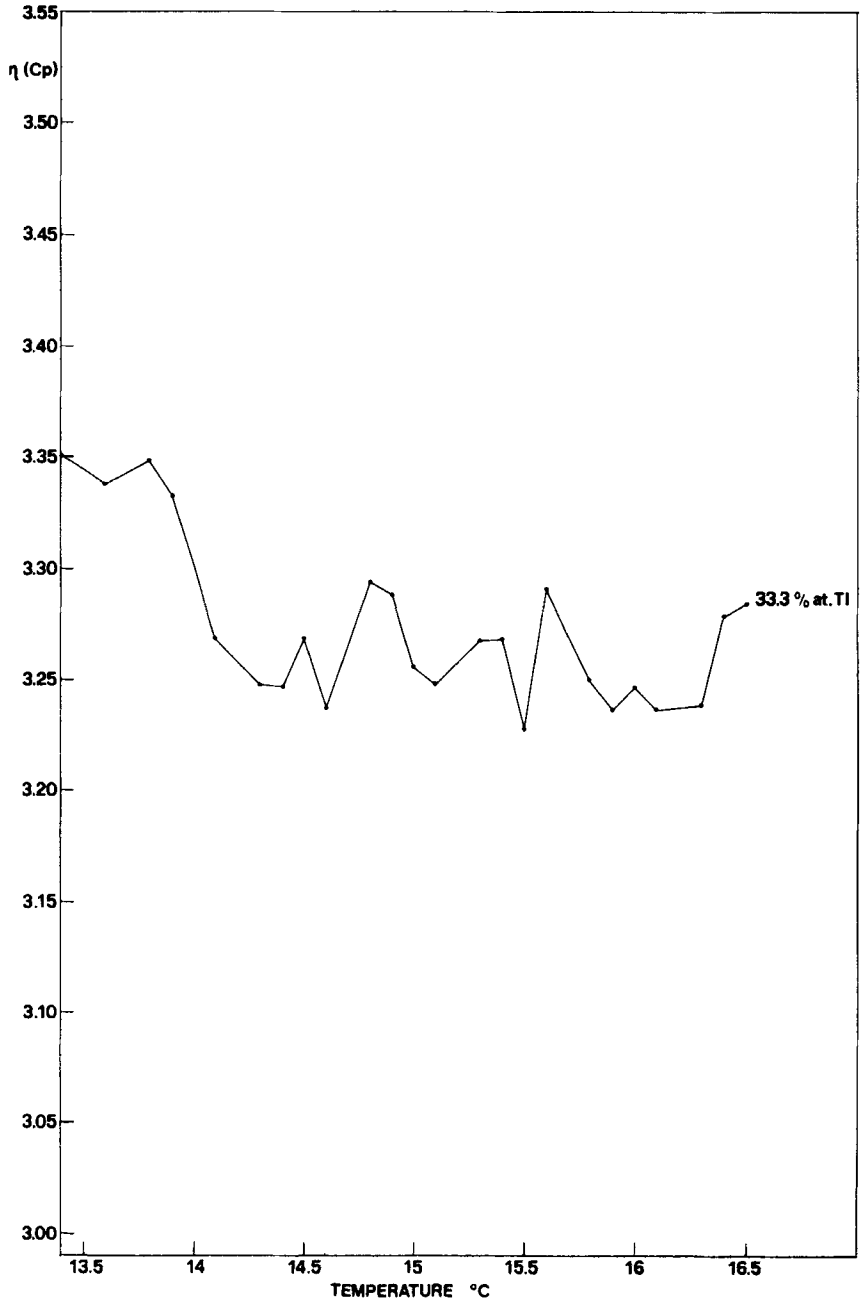

FIGURE 2 Viscosity of Hg-Tl alloys versus temperature.

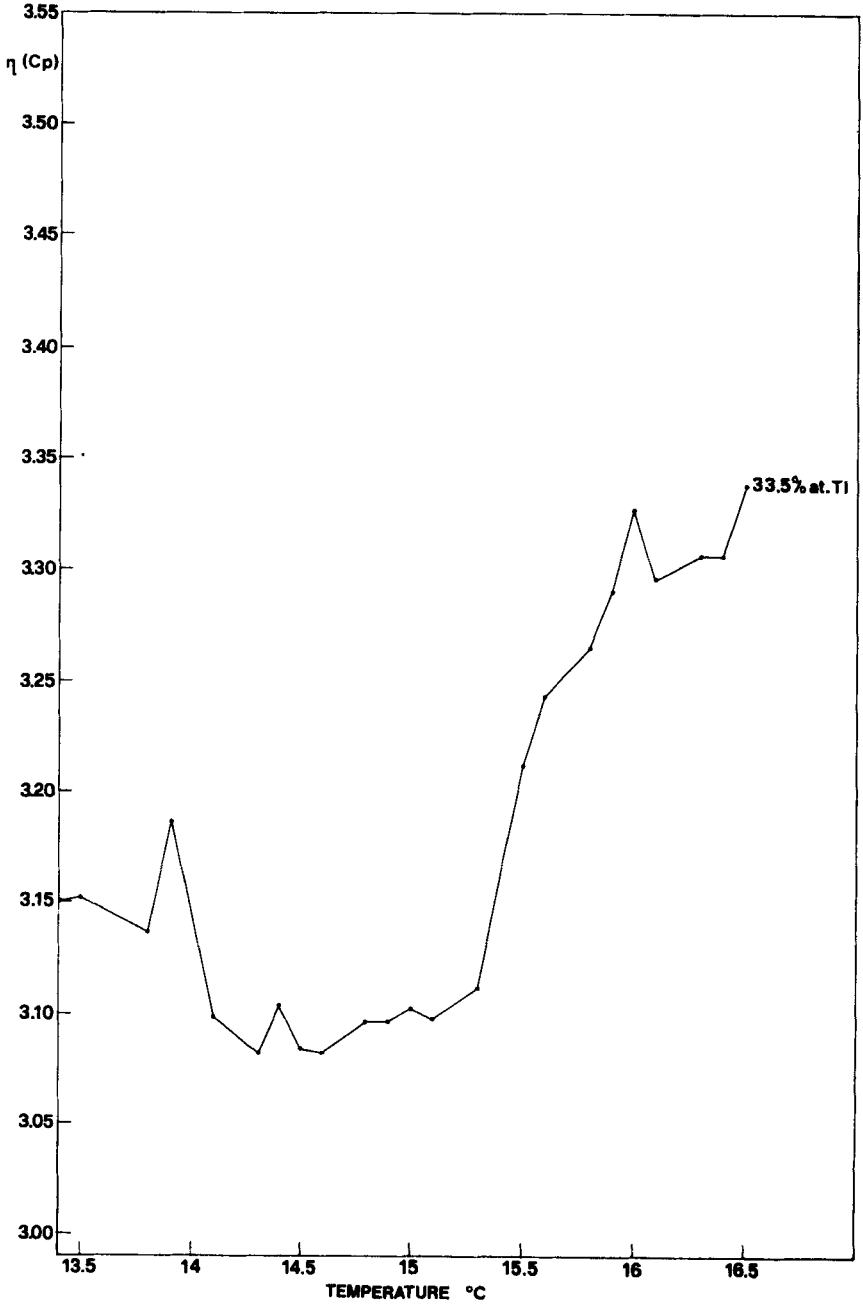

FIGURE 3 Viscosity of Hg-Tl alloys versus temperature.

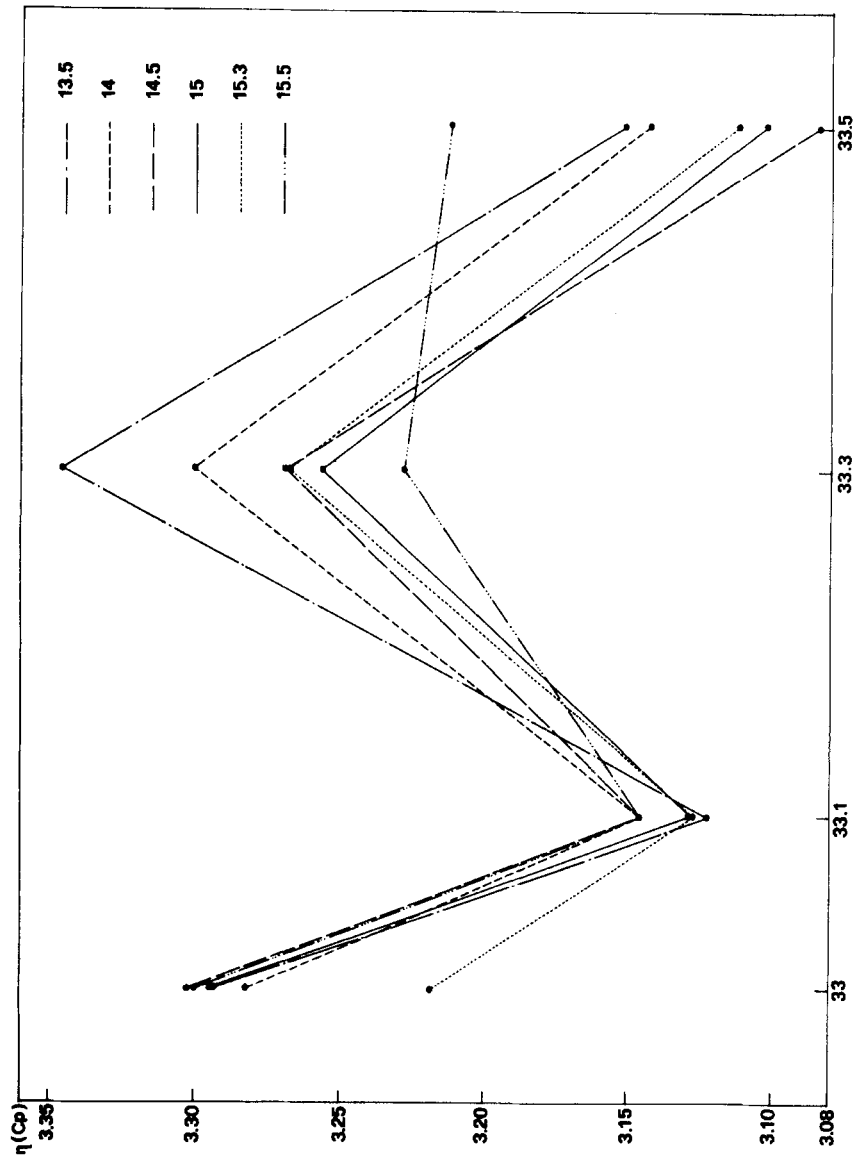

FIGURE 4 Viscosity versus amalgam composition in the neighbourhood of the maximum.

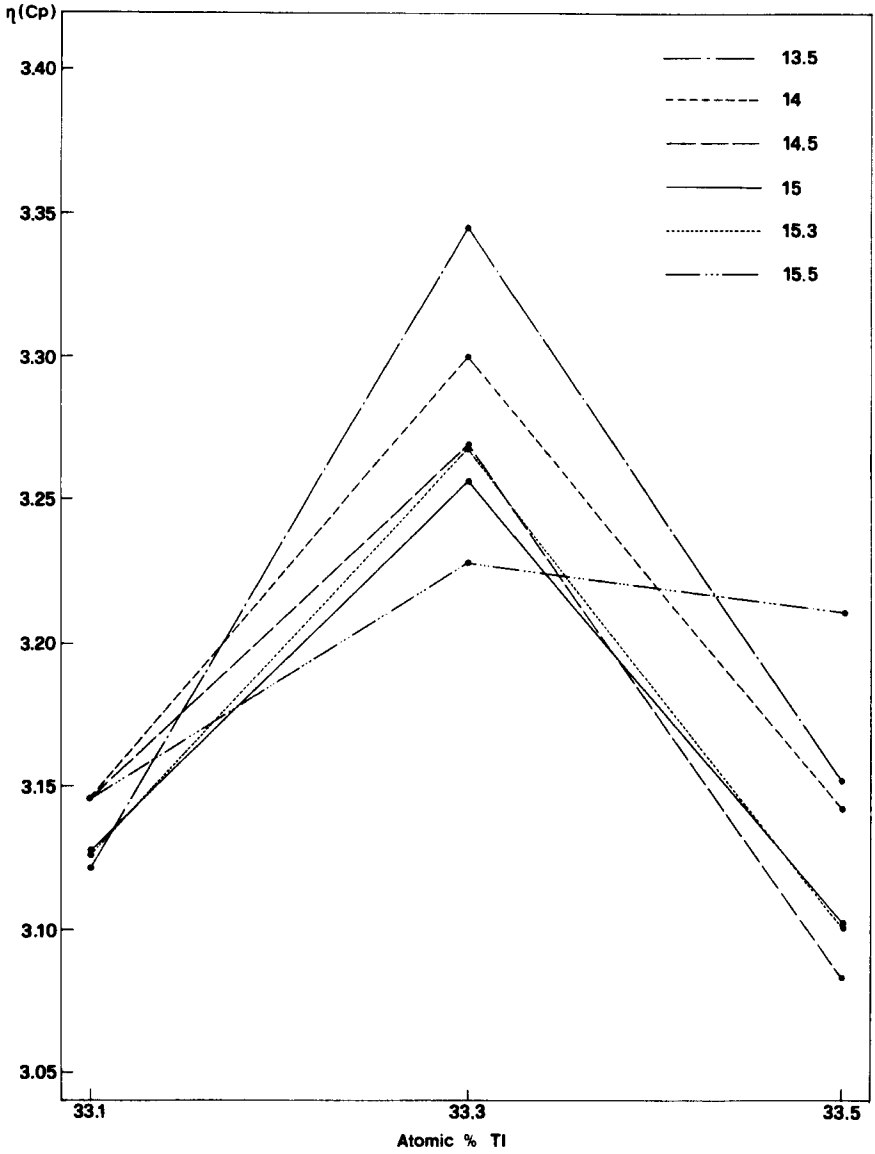

FIGURE 5 Maximum at 33.3% at. Tl at 13.5°C.

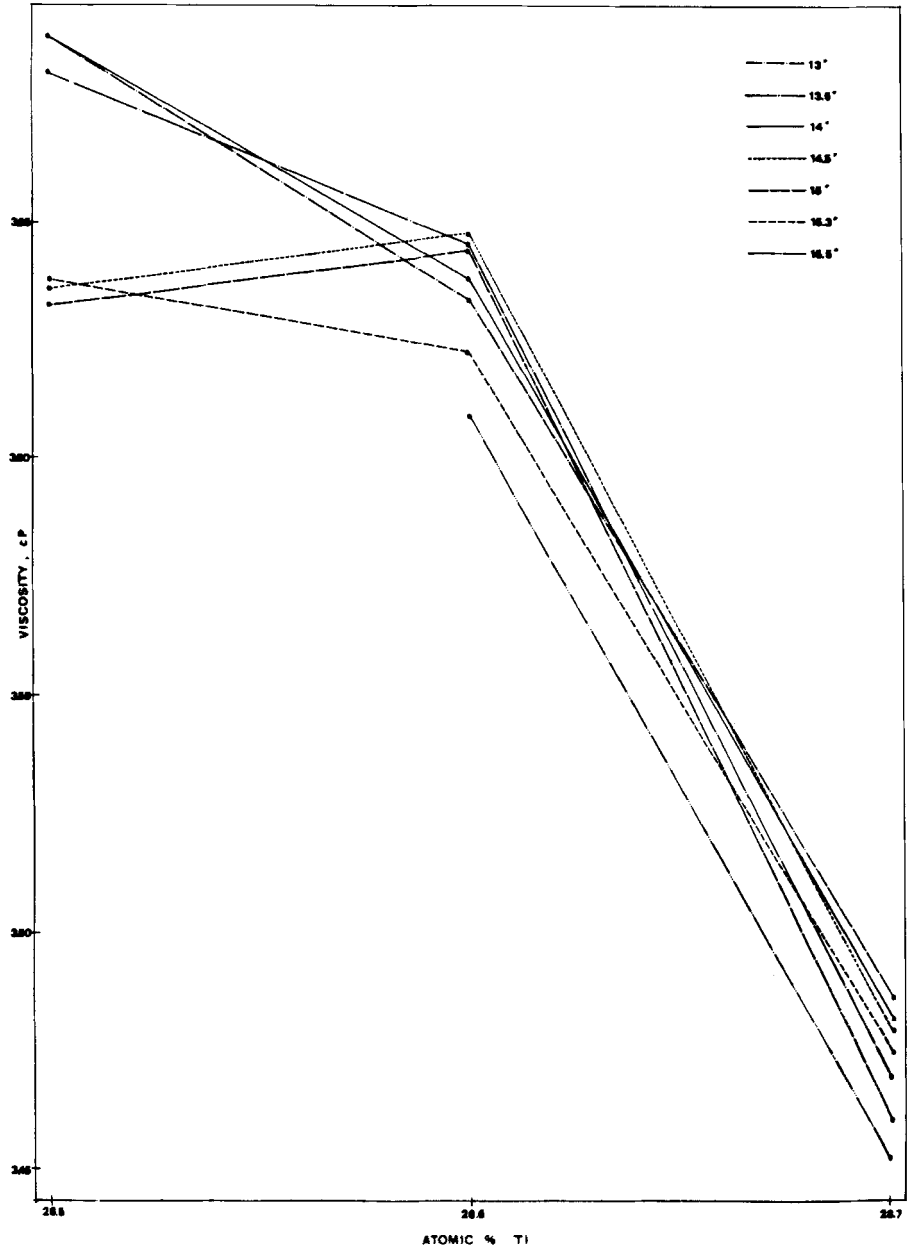

FIGURE 6 Maximum at 28.6% at. Tl at 14.5°C.

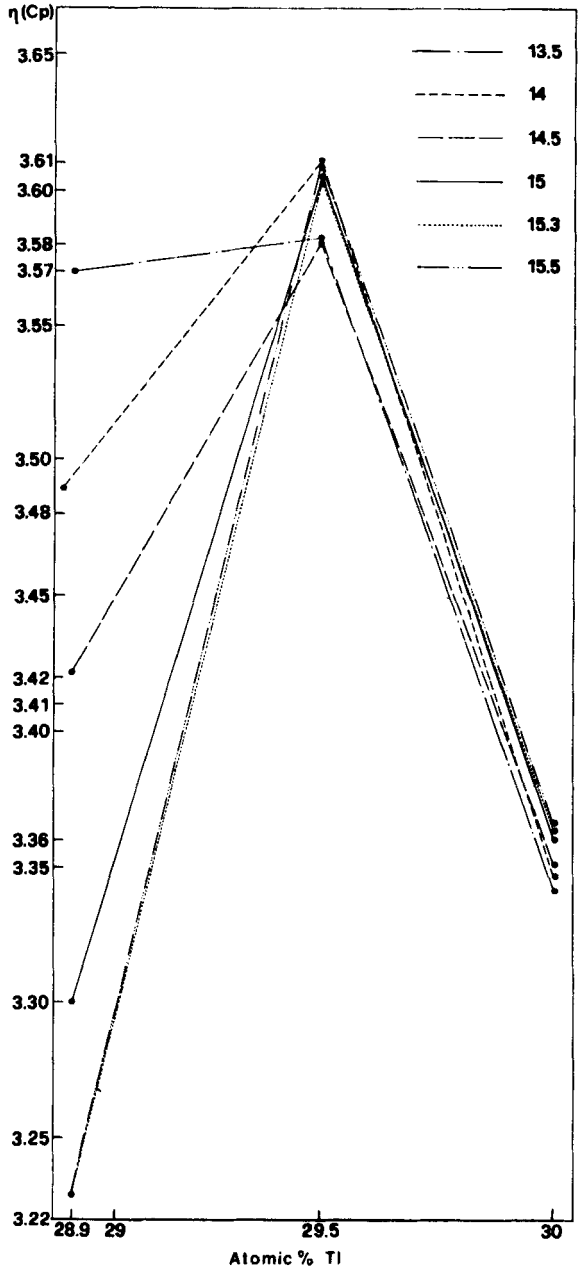

FIGURE 7 Maximum at 29.5% at. Tl at 14°C.

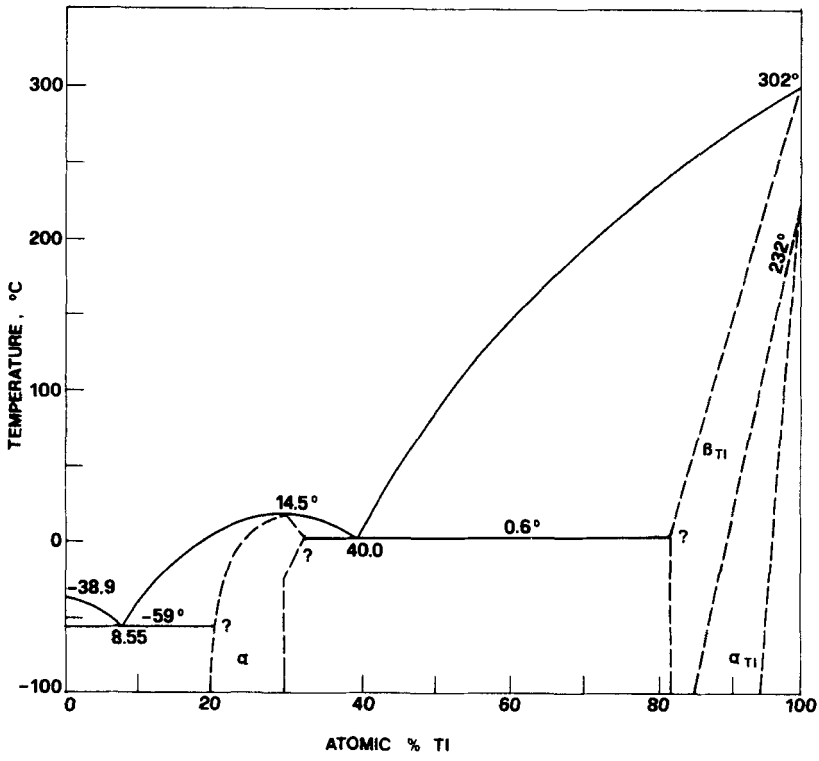

FIGURE 8 Phase diagram.

SUMMARY

Using an oscillating viscometer, accurate measurements on the Hg–Tl amalgam viscosity have been performed, at various temperature, ranging from 13.5°C to 16.5°C and for different amalgam compositions.

It has been found that the Hg–Tl amalgam viscosity behaviour as a function of temperature confirms the hypothesis, that is we are in presence of discontinuous changes of the coordination numbers of the liquid, that is to say of the phase transitions quite similar to the polimorphous transitions of the solid state. At 33.1 atomic percent Tl, at the temperature of 13.5°C there is a minimum.

Viscosity versus amalgam composition shows a maximum at 33.3 atomic percent Tl at the temperature of 13.5°C. This is due to a pre-freezing phenomena, which can indicate the influence of the forces that lead to the formation of the intermetallic compound Hg_2Tl in the solid state.

TABLE I

Temperature °C	at.28.9% at.Tl[a]	at.29.5% at.Tl	at.30% at.Tl	at.33% at.Tl	at.33.1% at.Tl	at.33.3% at.Tl	at.33.5% at.Tl
13,5	3,570	3,583	3,341	3,293	3,122	3,345	3,152
14	3,489	3,611	3,347	3,282	3,146	3,300	3,143
14,5	3,422	3,581	3,354	3,302	3,146	3,269	3,084
15	3,300	3,605	3,360	3,294	3,127	3,256	3,103
15,3	3,229	3,604	3,363	3,218	3,126	3,268	3,112
15,5	3,229	3,610	3,366	3,301	3,146	3,228	3,212

[a] (CP) is the viscosity of the Hg–Tl amalgam.

The "very flat maximum" shown by the phase diagram is really a composition of many maximums. It remains to investigate the Hg-Tl amalgam viscosity from 25% at. Tl to 28.6% at. Tl, at the temperature from 13.5°C to 16.5°C, to determine the absolute maximum.

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