On the Relation between the Colours and the Micro-Structures of Some Binary and Ternary Silver Alloys, with Visible Rays

By

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The relation between the colours and micro-structures in some binary and ternary silver alloys is reported in the present paper. It was found that the relation in the case of the ternary alloys can only be explained through that of the binary alloys and has no prior importance from the scientific point of view.

I The Ag-Al System

For the binary alloys in the Ag-Al system 12 samples having known structures according to the author's[1] diagram were selected as given in Tab. I.

Table I

Alloy	Wt-% Al	Atom-%Al	Structure
I	100.00	100.00	Al
II	61.27	86.30	ϵ+eutectic
III	30.60	63.72	eutectic
IV	17.98	46.61	α $AlAg_2$+eutectic
V	11.18	34.34	α $AlAg_2$
VI	9.53	28.88	β
VII	7.74	25.04	α $AlAg_3$
VIII	6.77	20.94	α $AlAg_3$+saturated mis.
IX	2.51	9.30	α
X	9.58	29.67	β
XI	7.00	23.07	a $AlAg_3$+saturated mis.
XII	0.00	0.00	Ag

An electric lamp of 200 watts was used as the light source. The arrangement for the experiments was just the same as that used hitherto in this laboratory. The C line of the hydrogen spectrum with a certain time of exposure being taken as unit, the black-

1) Reported in "The Sexagint" Kyoto (1930), dedicated to Prof. M. Chikashige for his sixtieth birthday.

ening of a plate for the same wave length reflected by the 12 samples was compared to it, the time of exposure being changed in many ways for the same opacity as determined by means of Hartman's micro-photometer. The corresponding times are recorded and tabulated togeter with their reciprocals in Tab. 2. The photograms of the spectrum with the same opacity at the C line are reproduced in Plate 1, from which the blackening was measured to a distance of 2 mm. from the C line of the hydrogen spectrum. It was then converted into another form as shown in Fig. 1. The lengths of the spectrum were measured from this figure as annexed to the end of Tab. 2.

Table 2

Alloy	Time of exposure for the same blackening in seconds						Intensity of reflection	Length of spectrum in mm.
	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Exp. 5	Mean		
I	10	9	9	9	9	9.2	10.9	22.7
II	16	18	15	15	16	16.0	6.3	21.6
III	28	25	26	27	25	26.0	3.8	21.1
IV	19	18	19	20	18	18.8	5.3	22.5
V	15	12	13	15	16	14.0	7.1	21.4
VI	—	9	9	9	9	9.0	11.1	22.4
VII	7	6	8	7	6	6.8	14.9	22.5
VIII	10	10	12	11	—	10.9	9.4	18.5
IX	12	12	11	11	11	11.4	8.8	20.3
X	9	9	10	9	10	9.4	10.6	21.1
XI	8	8	8	8	8	8.0	12.5	19.9
XII	5	6	6	5	6	5.6	17.9	22.3

On the basis of these data the curves of reflection and its intensity are obtained as shown in Fig. 2.

From the curves, we see that the intensity of reflection of the silver is rapidly diminished on the addition of the aluminium, till it attains a minimum at the middle of the series of the solid solution, beyond which the intensity is again increased through the influence of the compound $AlAg_3$, where it has a maximum. The curve then falls down rapidly to the second compound $AlAg_2$, where we have a break, and continues gradually to fall to a minimum at the eutectic.

The curve of reflection runs generally in a smooth horizontal line, except the part of the two compounds, of which $AlAg_3$ is characterised by a maximum and $AlAg_2$ by a minimum.

Fig. 1

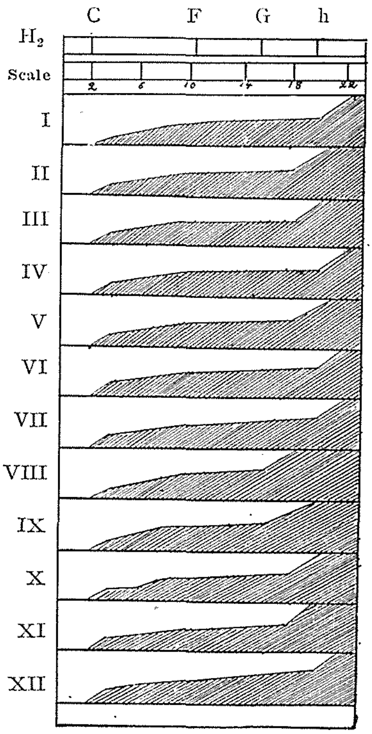
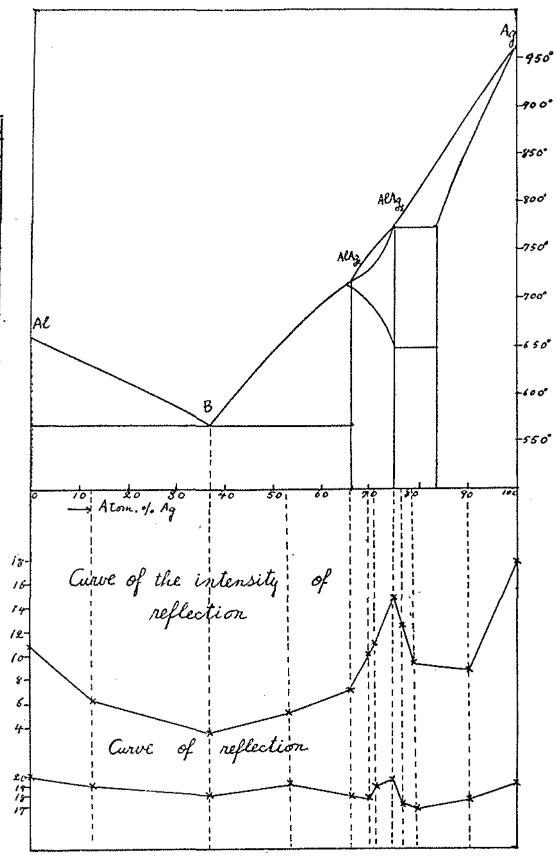


Fig. 2



Summary

1. The curve of intensity of reflection has a maximum at the compound $AlAg_3$, a break at $AlAg_2$, and a minimum at the eutectic.

2. The curve of reflection runs generally horizontally, but with a maximum at the compound $AlAg_3$ and a minimum at the compound $AlAg_2$.

II The Ternary System of Ag-Al-Zn

10% Zn-Section

The samples given in Tab. 3 were selected for investigation according to the author's[2)] diagram.

The comparison of the intensity of reflection was made at the C line, the time of exposure required for the same blackening on the panchromatic plate being thus sought. Comp. Plate III. These results and also the lengths of the spectrum as measured from Fig. 3 are brought together in Table 4.

Table 3

Alloy	Wt.-%			Structure
	Ag	Al	Zn	
I	90	—	10	α
II	88	2	10	α
III	85	5	10	α+β
IV	80	10	10	β
V	70	20	10	β+eutec.
VI	60	30	10	Al+eutec.
VII	50	40	10	Al+eutec.

Table 4

Alloy	Time of exposure for the same blackening in seconds				Intensity of reflection	Length of spectrum in mm.
	Exp. 1	Exp. 2	Exp. 3	Mean		
I	9	9	8	8.6	11.6	20.0
II	10	9	10	9.6	10.4	21.3
III	11	10	11	10.6	9.4	21.6
IV	11	11	11	11.0	9.1	22.8
V	14	14	14	14.0	7.1	21.4
VI	25	26	24	25.0	4.0	21.3
VII	20	22	20	20.6	4.8	21.2

Fig. 4

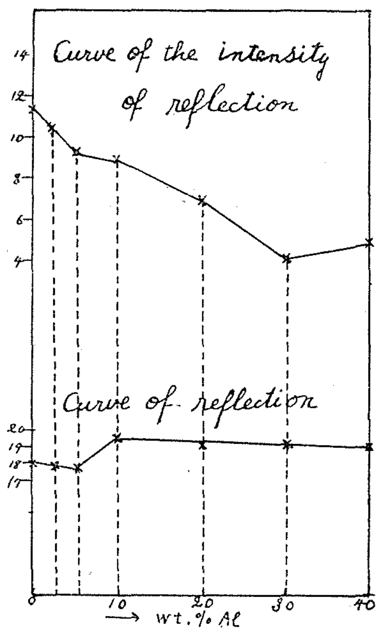
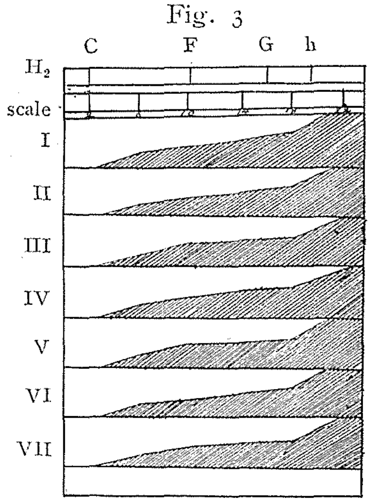


Fig. 3



On the basis of the data above given, the curves in Fig. 4, were

2) These memoirs, **13**, 91 (1930)

drawn.

With respect to the curve of the intensity of reflection, we see that the addition of the up to 5% of aluminium to the Ag–Zn system causes a considerable reduction in the intensity, and that a further addition causes the reduction to proceed quite slowly, till it reaches a minimum at 30% Al, corresponding to the eutectic of the Ag–Al system. The breaks at 5% Al and 10% Al are due to the influence of the binary compounds $AlAg_3$ and $AlAg_2$.

The curve of reflection has also two breaks at the 5% Al and the 10% Al alloy, caused by the compounds $AlAg_3$ and $AlAg_2$.

Summary

1. The curve of the intensity of reflection has two breaks at the 5% Al and the 10% Al alloys and a minimum at 30% Al.

2. The curve of reflection has a minimum at the 5% Al alloy and a break at the 10% Al alloy.

III The Ternary System of Ag-Cu-Zn

30% Zn-Section

The 10 samples given in Tab. 5 were selected for the investigation according to the author's[3] diagram,

The times of exposure for the same opacity and their reciprocals were sought, and arranged as in Tab. 6.

Table 5

Alloy	Wt.-%			Structure
	Ag	Cu	Zn	
I	—	70	30	α
II	2	68	30	α
III	10	60	30	α+eutec.
IV	20	50	30	α+eutec.
V	30	40	30	α+β
VI	40	30	30	β
VII	50	20	30	β
VIII	60	10	30	β
IX	68	2	30	α+β'
X	70	—	30	α+β'

Table 6

Alloy	Time of exposure for the same blackening in seconds					Intensity of reflec-tion	Length of spect-rum in mm.
	Exp. 1	Exp. 2	Exp. 3	Exp. 4	Mean		
I	9	9	9	9	9	17.8	9.2
II	9	8	9	9	8.6	18.6	10.1
III	9	10	10	9	9.6	16.7	12.3
IV	10	10	10	10	10	16.0	13.8
V	9	9	10	10	9.6	16.7	15.1
VI	8	9	8	9	8.6	18.6	15.9
VII	8	8	8	8	8	20.0	16.5
VIII	8	8	9	8	8.3	19.3	17.9
IX	9	9	10	9	9.3	17.2	20.4
X	9	9	10	10	9.6	16.7	21.3

3) These memoirs, **12**, 347 (1929)

The blackening with respect to the same wave length was measured from the photograms Plate II. These results were sketched as in Fig. 5, from which the lengths of the spectrum were sought as given in Tab. 6.

From these results, the curve of the intensity and that of reflection were drawn as shown in Fig. 6.

As may be seen from Fig. 6, the curve of the intensity of reflection rises on up to 2% of silver being added to the alloys in the Cu-Zn system, falls down at 20% Ag and then again rises at 50% Ag, where the curve has a maximum. The minimum corresponds to the binary eutectic Ag+Cu and the maximum

Fig. 5

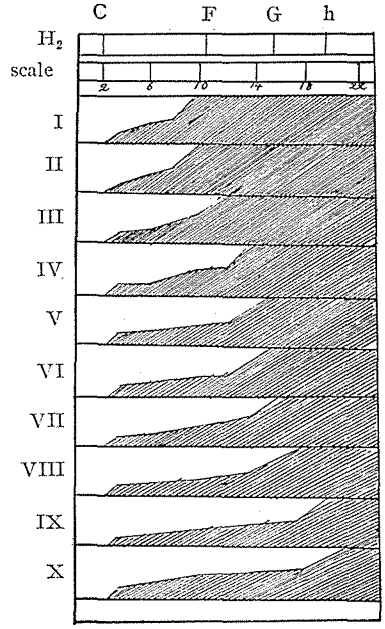
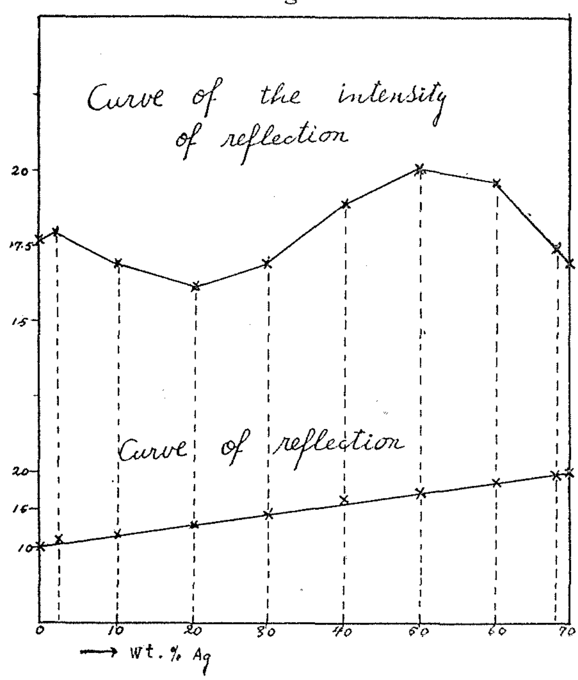


Fig. 6



corresponds to β.

The curve of reflection, i. e. the lengths of the spectrum, rises regularly and almost in a straight line from the Cu-Zn system to the Ag-Zn system.

Summary

1. The curve of the intensity has a minimum at 20% Ag and a maximum at 50% Ag.

2. The length of the spectrum increases from the Cu-Zn system to the Ag-Zn system quite regularly.

In conclusion, the author desires to express his indebtedness to Prof. Dr. M. Chikashige for his kind guidance and valuable advice during the course of the investigation. The author's thanks are also due to Mr. S Nagai, Director of the Mint, for his kind permission of the silver in stock for the use as materials in this investigation.

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Plate I

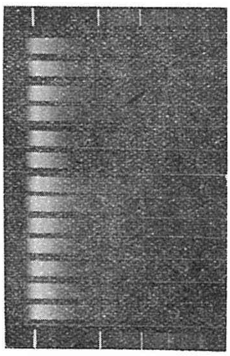

Plate II

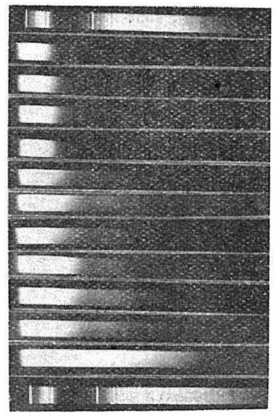

Plate III