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大阪工業試驗所報告
第四回第十號

REPORTS
OF
THE IMPERIAL INDUSTRIAL LABORATORY
OSAKA, JAPAN

DISPERSOIDOLOGICAL INVESTIGATIONS.

By Prof. Dr. *P. P. von Weimarn* and *Collaborators*

III

The Precipitation of Silver Sulphate as a Beautiful Illustration of *P. P. von Weimarn's* Laws of Precipitation of Substances.

By
Shikazo Otsuka.

Vol. IV. No. 10.

IMPERIAL INDUSTRIAL LABORATORY,
Department of Agriculture and Commerce.
OCTOBER, 1923.

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THE PRECIPITATION OF SILVER-SULPHATE AS A BEAUTIFUL ILLUSTRATION OF *P. P. VON WEIMARN'S* LAWS OF PRECIPITATION OF SUBSTANCES.

by Shikazo Otsuka.

I. Introduction.

P. P. von Weimarn was the first to carry out systematical investigations into the processes of precipitation of various solid substances from solutions.*

On the ground of these comprehensive investigations, Prof. *P. P. von Weimarn* has been able to establish the general laws by which the processes of precipitation are regulated.

In one of his recent works "Kolloides und kristalloides Lösen und Niederschlagen" (Kyoto 1921)** an easily comprehensible graphic illustration has been given by Prof. *P. P. von Weimarn* to the laws governing the precipitation from solutions of solid bodies produced by way of chemical reactions (Vide: Diagrams appended to pages: 99, 122 and 678 in the above indicated work).

A diagram similar ⁂ to that of Prof. *P. P. von Weimarn* has been reproduced in the present paper (Plate I).

In this diagram the abscissae are the concentrations of the reacting solutions while the ordinates are the maximum dimensions (lengths) of the crystals of the precipitates.

The curves L_1, L_2, L_3 correspond to the cases when the solubilities of the substance undergoing precipitation are respectively: L_1, L_2, L_3, the relation among them being $L_1 > L_2 > L_3$.

It may be gathered from an examination of the diagram that with the decrease in solubility of the substance the curves shift both downwards and towards the left, and consequently, in the cases of relatively well-soluble substances, all the curves already belong to the microscopical or even the macroscopical domain.

*See the articles by Prof. *P. P. von Weimarn* in the Journ. of the Russ. Chem. Soc. beginning in 1906 and in Kolloid-Zeitschr. (also Kolloidchem. Beihefte) beginning in 1907.

**P. P. von Weimarn.* Kolloides und Kristalloides Lösen und Niederschlagen, 80, 743 pages, Kyoto 1921.

⁂ A diagram of this kind has been given by Prof. *P. P. von Weimarn* e. g. in his papers published in "Kolloidchem. Beihefte" for the year 1923: "Ueber den Einfluss der Konzentration der reagierenden Lösungen auf die Korngrösse von Kristallen der Niederschläge" and "Studien über dispersoide Synthese des Goldes". Koll.-Zeitschr. 1923.

As to the effect of time on the changes in magnitude of the crystals, this is a factor which sooner or later causes the curves with a maximum (type L) to turn into curves without a maximum (type t_n), and the greater the interval as calculated from the moment when a precipitate has first been observed the higer is the position on the diagram occupied by the curves we are now considering, that is to say, the curves of the type t_n.

Prof. *P. P. von Weimarn* has suggested to the writer to construct a similar diagram for the precipitation of silver sulphate by applying aqueous and alcoholic-aqueous reacting solutions (30% and 60% of alcohol).

This work was accomplished in 1922 by the writer under Prof. *P. P. von Weimarn's* guidance.

In the case under consideration the same condition exists as in the case of Prof. *P. P. von Weimarn's* diagrams, for we have:

L Ag_2SO_4 in water > L Ag_2SO_4 in 30% alcohol > L Ag_2SO_4 in 60% alcohol.

Since, however, the solubility in water of the silver sulphate (and also in a mixture of water with alcohol) is relatively great (in Prof. *P. P. von Weimarn's* diagram the value of L_1 amounts to about 10^{-4} gram per 100 grams of the solvent), it becomes clearly evident that in the case of the silver sulphate the curves of the type L must, in agreement with Prof. *P. P. von Weimarn's* theory, be situated with their greater parts within the microscopic domain.

In addition to this, it should be emphasized that the writer was able to study the process of precipitation of silver sulphate during one year only, and so he was not in a position to investigate the phenomena of precipitation from very slightly supersaturated solutions; this accounts for the fact that the transition of curves of the type L (with a maximum) into curves of the type t_n (without a maximum), as they have been observed by the writer, does not actually occur during those particular periods of time which have been plotted in the diagrams below.*

*For more details, especially in theoretical aspects, see *P. P. von Weimarn* and *S. Otsuka*. "Niederschlagungsgesetze an einem Beispiel der Fällung von Silbersulfat aus wasserigen und alkoholisch-wasserige Losungen". This paper is to appear in the near future in "Kolloidchemiche Beihefte".

Confining himself to the above brief introduction, the writer proceeds to a brief exposition of the experimental part of his work.

II. Experimental.

In the experiments, silver sulphate was precipitated by the following reaction:

$$2AgNO_3 + MnSO_4 = Ag_2SO_4 + Mn(NO_3)_2,$$

by maintaining the condition, for the volume of the reacting solution, that the product of V (the volume of the reacting solution) and C (the concentration of the reacting solution) should be nearly constant,* as shown in the following tables. (Table 1—3)

As for the materials, pure commercial silver nitrate was used with manganous sulphate, twice recrystallised by precipitation from the saturated solution by alcohol,

Table 1.
Aqueous solution.

Concentration	Volume of silver nitrate solution.		Volume of manganous sulphate solutions.
7N.	4cc.	⟵ ⟶	4cc.
6N.	4cc.	"	4cc.
4N.	6cc.	"	6cc.
2N.	12.5cc.	"	12.5cc.
N.	25cc.	"	25cc.
0.8N.	30cc.	"	30cc.
0.4N.	60cc.	"	60cc.
0.2N.	125cc.	"	125cc.
1/7N.	175cc.	"	175cc.
1/10N.	250cc.	"	250cc.

Table 2.
30% alcoholic aqueous solutions.

Concentration.	Volume of silver nitrate solutions.		Volume of manganous sulphate solutions.
N.	25cc.	⟵ ⟶	25cc.
0.8N.	30cc.	"	30cc.
0.4N.	60cc.	"	60cc.

*P. P. von Weimarn, Zur Lehre von den Zuständen der Materie, 83. Verlag von Th. Steinkopff, Dresden 1914.

0.2N.	...	...	...	125cc.	" 125cc.
1/7N.	...	...	...	125cc.	" 125cc.
1/10N.	...	...	...	250cc.	" 250cc.
1/15N.	...	...	...	375cc.	" 375cc.
1/20N.	...	...	...	500cc.	" 500cc.
1/25N.	...	...	...	625cc.	" 625cc.
1/30N.	...	...	...	750cc.	" 750cc.
1/35N.	...	...	...	875cc.	" 875cc.

Table 3.

60% alcoholic aqueous solutions.

Concentration.				Volume of silver nitrate solutions.		Volume of manganous sulphate solutions.
1/10N.	...	...	...	250cc.	←	250cc.
1/20N.	...	...	...	500cc.	"	500cc.
1/35N.	...	...	...	875cc.	"	875cc.
1/50N.	...	...	...	1250cc.	"	1250cc.
1/80N.	...	...	...	2000cc.	"	2000cc.
1/100N.	...	...	...	2500cc.	"	2500cc.

In the table "←" shows that manganous sulphate solutions were added to silver nitrate solutions and "→" shows the reverse.

According to Prof. *P. P. von Weimarn*, the form and size of crystals of the precipitates are influenced by the conditions given below.

1. Concentration of reacting solutions, C.
2. Solubility of precipitate in the solvent, L.
3. Time from the beginning of the crystallisation, T.

Thus the writer investigated the influences of C, T, and L upon the form and size of crystals of silver sulphate; of course, after being thoroughly mixed to-gether, the reacting solutions were allowed to stand quietly, to avoid any change in the precipitate due to an external cause such as stirring. The experiments were all carried out at the room temperature. Plates 2-5 are all results of addition of manganous sulphate solutions to silver nitrate solutions: the reverse addition will be discussed later on. In the diagrams the concentrations of the reacting solutions are taken as the abscissa and the sizes of the crystals (measured along the longer axis of the crystals in m. m.) are taken as the ordinate.

The precipitates were examined at the following stages, namely T_0, T_0 + five minutes, T_0 + ten minutes, T_0 + twenty minutes, T_0 + forty minutes, T_0 + one hour, T_0 + three hours, T_0 + one day, T_0 + one week, T_0 + one month, T_0 + two months and T_0 + six months after the mixing of the reacting solutions. Here T_0 shows the time which is necessary to take out the precipitates from the mixture on the object glass, and bring it under the microscope to examine.

Plate 2 illustrates the relation between the concentration of the reacting solutions and the size of the crystals in aqueous solutions.

The data for the curve T_0 and corresponding microphotographs of the crystals are given in Table 4 and Figs. 1-8.

As may be seen from Table 4 and microphotographs, when the dilution of the reacting solution is increased, the size of the crystals becomes larger, reaching a maximum (here at 0. 8N). Then it becomes smaller again as the solution is further diluted.

Table 4. Observations of T_0 curve of Plate 2.

Concentration of reacting solutions.	Microscopic enlargement.	Natural size. (m. m.)	Remarks.
7N-2N.	750.	1/200-1/100.	Small crystals are precipitated immediately. Fig. 1-4.
N	750.	$\frac{3}{100}$ $\frac{4}{100}$	Small crystals are precipitated immediately. The form of crystals becomes long. Fig. 5.
0.8N.	750.	5/100-7/100.	Small crystals are precipitated immediately Fig. 6.
0.4N-0.2N.	750.	1/100-1/500.	White turbidity can be seen. Under a microscope minute crystals are found. Fig.7-8.
1/7N-1/10N.	—	—	No. turbidity nor microscopic crystals are found.

The changes in size of the crystals of the precipitates of silver sulphate which took place with lapse of time may be seen from the diagram (Plate 2) and also from the microphotographs: Figs. 8-15, (0.2N), Figs. 7, 16-21, (0.4N), and Figs. 22-24 (1/7N).

The changes in size of the crystals with time in the concentrated solutions are shown by microphntographs: Figs. 1, 25-27,

(7N), Figs. 28-38, The result of the exmination at one hour after the beginning of the reaction is shown in Table 5 and microphotographs: Figs. 25, 28, 31, 34, 36, 41, 22, 13.

The result of the examination at two months after the beginning of the reaction is shown in microphotographs: Figs. 14, 21, 23, 26, 29, 32, 37, and the result of the exmination at six months after the beginning of the reaction is shown in microphotographs: Figs. 24, 27, 30, 33, 35, 38, 39.

The relation between concentration, time and the size of crystals in aqueous solutions, is summarised in Table 6.

Table 5. Observations of T_0+1 hour curve.

Concentration of reacting soutions.	Microscopic enlargement.	Natural size. (m. m.)	Remarks.
7N-2N.	750.	1/100-2/100.	Figs. 25, 28, 31, 34.
N.	750.	5/100-7/100.	Fig. 36. Forms of crystals are long.
0.8N.	750.	7/100-8/100.	Form of crystals is quite similar to Fig. 6.
0.4N-0.2N.	625.	30/100-35/100.	Maximum at this curve. The form of crystals is completely rhombic. Figs. 40-41, 13, 20.
1/7N.	750.	1/100.	White turbidity can be seen. Under a microscope many small particles can be seen. Fig. 22.
1/10N.	—	—	No turbidity nor microscopic particles can be found.

Table 6. (Dimensions in m. m.)

Time. / Conc.	T_0	T_0+5 min.	T_0+10 min.	T_0+20 min.	T_0+40 min.	T_0+1 hour.	T_0+2 months.	T_0+6 mon.
7N-2N	$\frac{1}{100}$	—	—	—	—	$\frac{1}{100}$	$\frac{2}{100}$	$\frac{2}{100}-\frac{3}{100}$
N	$\frac{3}{100}-\frac{4}{100}$	—	—	—	—	$\frac{5}{100}$	$\frac{5}{100}-\frac{7}{100}$	$\frac{7}{100}$
0.8N	$\frac{5}{100}-\frac{7}{100}$	—	—	—	—	$\frac{8}{100}$	—	—
0.4N	$\frac{2}{100}$	$\frac{4}{100}$	$\frac{15}{100}$	$\frac{20}{100}$	$\frac{21}{100}$	$\frac{25}{100}$	$\frac{30}{100}$	$\frac{32}{100}$

0.2N	$\frac{1}{200}$	$\frac{1}{100}$	$\frac{4}{100}$	$\frac{15}{100}$	$\frac{20}{100}$	$\frac{32}{100}$	$\frac{40}{100}$	$\frac{45}{100}$
$\frac{1}{7}$N	—	—	—	—	—	$\frac{1}{100}$	$\frac{55}{100}$	$\frac{80}{100}$

The result of the investigation of the precipitates of silver sulphate in 30% alcoholic aqueous solutions will be discussed now. Plate 3 shows the relation between concentration and size of the crystals measured at the following stages; viz: T_0, T_0 + five minutes, T_0 + ten minutes, T_0 + twenty minutes, T_0 + forty minutes, T_0 + one hour, T_0 + three hours, T_0 + one day, T_0 + two months, T_0 + six months after the mixing. T_0 shows the time which is necessary to take out precipitates from the mixture on the object glass and bring it under the microscope to examine. As will be seen from Plate 3, this relation is quite similar to that in the case of aqueous solutions.

The result of the observations in T_0 curve in Plate 3 is given in Table 7 and microphotographs: Figs. 42-49.

Table. 7. Observations of T_0 curve.

Concentration of reacting solution.	Microscopic enlargement.	Natural size. (m. m.)	Remarks.
N- 0.4N.	750.	1/100-1/500	Small crystals are precipitated immediately. Figs. 42-44.
0.2N.	750.	2/100-1 100	Form of crystals becomes long Fig. 45.
1 7N.	750.	2/100-3/100	Form of crystals is long. Some of them are connected each other along the longer axis. Fig. 46.
1/10N.	750.	1/100	White turbidity can be seen immediately. Under a microscope small completely rhombic crystals can be seen. Fig. 47.
1/15N-1/20N.	750.	1/200-1/800	No turbidity can be found immediately. Under a microscope many particls can be found. Figs. 48-49.
1/25N-1/35N.	—	—	No turbidity can be seen with the naked eye, nor can particles be seen with a microscope.

The alternation with time in both the size and form of

crystals in 30% alcoholic aqueous solutions is similar to that in the aqueous solutions : See : Figs. 47, 64-70, 48, 71-77, 49, 78-82, 83-91.

The result of the observations of the T_0 + one hour curve is as follows.

Table 8. Observations of T_0 + one hour curve.

Concentration of reacting solutions.	Microscopic enlargement.	Natural size. (m. m.)	Remarks.
N-0.4N	750	1/500-2/100	Figs. 50, 53, 56.
0.2N	750	2.5/100	Form of crystals is long. Fig. 59.
1/7N	750	3/100	Fig. 62.
1/10N	750	15/100-17/100	Fig. 62.
1/15N	625	22/100	Form of crystals is completely rhombic. Fig. 75.
1/20N	625	22/100	Fig. 82.
1/25N	750	1/200	White turbidity can be seen. Under a microscope many small particles can be seen. Fig. 83.
1/30n-1/35N	—	—	No microscopic particles can be found.

The above result can be summarised as in Table 9.

Table 9. (Dimensions in m. m)

	T_0	T_0+5 min.	T_0+10 min.	T_0+20 min.	T_0+40 min.	T_0+1 hour.	T_0+3 hours.	T_0+1 day.	T_0+2 months.	T_0+6 months.
N	1/800	—	—	—	—	1/500	—	—	2/100	2/100 – 3/100
1/4N	1/100 – 2/100	—	—	—	—	2.5/100	—	—	3/100 – 4/100	4/100 – 5/100
1/7N	2/100 – 3/100	—	—	—	—	3/100	—	—	4/100	7/100
1/10N	1/100	4/100	10/100	10/100 – 15/100	15/100	15/100 – 17/100	—	—	18/100	25/100

1/15N	1/500	2/100	2.5/100	10/100 – 11/100	18/100	22/100	—	—	30/100	35/100
1/20N	1/800	1/100	1.5/100	9/100	15/100	22/100	—	—	34/100	40/100
1/25N	—	—	—	—	—	1/200	15/100	24/100	39/100	45/100
1/30N	—	—	—	—	—	—	9/100	24/100	45/100	50/100

Plate 4 is the result of investigation of the precipitates in 60% alcoholic aqueous solutions. In this case, the result is also quite similar to that in the case of aqueous solutions and 30% alcoholic aqueous solutions. The result of the observations of the T_0 curve is given in Table 10 and microphotographs: Fig. 94.-98.

Table 10. Observations of T_0 curve.

Concentration of reacting solutions.	Microscopic enlargement.	Natural size. (m. m.).	Remarks.
1/10N-1/20N	750	1/600-1/800	Fig. 94-95. Small crystals are precipitated immediately. They settle down on the bottom of the flask in about twelve hours after the mixing.
1/35N	750	1/150	Fig. 96. Small crystals are precipitated immediately. They settle down on the bottom of the flask in about twenty hours after the mixing.
1/50N	750	1/100	Fig. 97. White turbidity can be seen immediately.
1/80N	750	1/800	Fig. 98. No. turbidity can be seen immediately. In half an hour after the mixing the turbidity can be found, and at forty hours after the mixing all the crystals settle down on the bottom of the flask.
1/100N	750	—	No. turbidity can be found with the naked eye, nor can microscopic particles be found under the microscope. An hour later, white turbidity can be seen. It took about seventy hours before all the crystals settled down on the bottom of the flask.

The relation between the concentration time and size of crystals is summarised in Table 11.

Table 11. (Dimensions in m. m)

Time. / Conc.	T_o	T_o+1 hour.	T_o+1 week.	T_o+1 month.
1/10N	1/800	1/500	1/250	1/200
1/20N	1/500	1/250	1/200	1/200
1/35N	0.6/100	0.7/100	0.1/100	1/100
1/50N	1/100	1.5/100	—	—
1/80N	1/800	5.5/100	6/100	7/100
1/100N	—	1/800	9/100	10/100

Plate 5 is the illustration of the relations among Plate 2, Plate 3 and Plate 4. In Plate 5 the scale divisions on both axes are not uniform. The size of crystals measured six months after the beginning of the reaction in the three mediums is given in Table 12.

Table 12. (Dimensions in m. m.).

	Aqueous solution.	30% alcoholic Aqueous solution.	60% alcoholic Aqueous solution.
7N — 2N	$\frac{1}{100} - \frac{2}{100}$	$\frac{2}{100}$	
N	$\frac{4}{100} - \frac{8}{100}$	$\frac{3}{100}$	
0.4N	$\frac{32}{100}$	$\frac{6}{100}$	
$\frac{1}{2}$N	$\frac{80}{100}$	$\frac{25}{100}$	$\frac{1}{200}$
$\frac{1}{10}$N	—	$\frac{40}{100}$ *	$\frac{1}{200}$
$\frac{1}{20}$N	—	—	$\frac{7}{100}$
$\frac{1}{80}$N	—	—	$\frac{10}{100}$

*At the concentration $\frac{1}{30}$ N, after 6 months, – $\frac{50}{100}$ m.m.

In aqueous solutions the maximum size of the crystals is about $\frac{5}{10}$ m. m., in 30% alcoholic aqueous solutions $\frac{5}{10}$ m. m. and in 60% alcoholic aqueous solutions $\frac{1}{10}$ m. m. It should be here recalled that the solubility of silver sulphate in aqueous, 30% alcoholic aqueous and 60% alcoholic aqueous solutions represents a decreasing series.

The precipitates formed by adding silver nitrate solutions to manganous sulphate solutions will be examined now. In this case also the curves are almost similar to those of the case when manganous sulphate solutions are added to silver nitrate solutions, only near the maximum point of the curve, T_o the size of the crystals is somewhat different.

Plates 6-7 show the relation of the size of crystals in both cases. In the plates, dotted lines are the result of crystallezation on adding silver nitrate solutions to manganous sulphate solutions, and thick lines are those of the reverse case.

The result of the examination of the precipitates formed by adding silver nitrate solutions to manganous sulphate solutions is given in microphotographs: Figs. 1-4. are quite similar to Figs. 112-115. But the size of the crystals in Figs. 5-7 is somewhat larger than that of Figs. 116-118.

From the fact shown above, it can be concluded that, on addition of silver nitrate solutions to manganous sulphate solutions, one can often see smaller crystals at first than in the reverse case. But as time goes on, the crystals become larger, and some time afterwards they become of the same size.

III. Summary.

By way of comparison of the diagram obtained by the writer (Plate 6.) with the general diagram (plate 1) given by prof. *P. P. von Weimarn*, the well-defined conclusion suggests itself that the precipitation of silver sulphate from aqueous and alcoholic-aqueous solutions affords one more beautiful illustration to the general laws of the precipitation of substances, the laws discoverd by prof. *P. P. von Weimarn*.

In conclusion the writer wishes to express his sincere thanks

to Prof. *P. P. von Weimarn* for his valuable suggestion and kind instruction, and to Prof. *Y. Osaka* for his kind interest taken in the course of the work.

PRECIPITATES OF SILVER SULPHATE IN AQUEOUS SOLUTIONS.

I. Silver Nitrate solution ⟵ Manganous Sulphate solution.

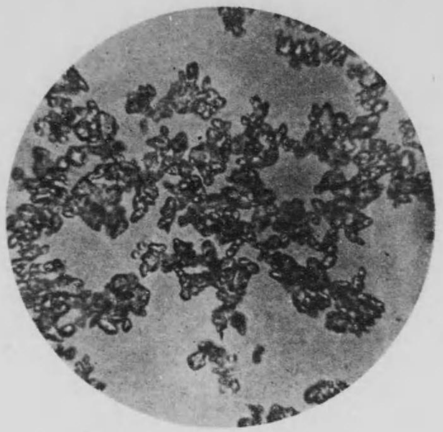


Fig. 1. 7 N. T_o. × 750.

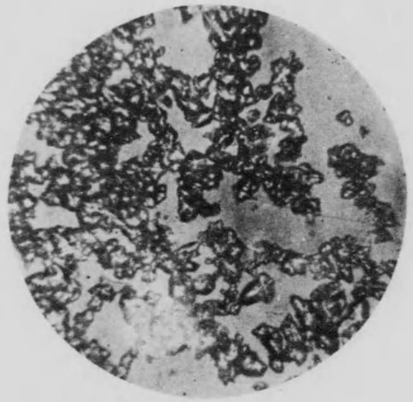


Fig. 2. 6 N. T_o. × 750.

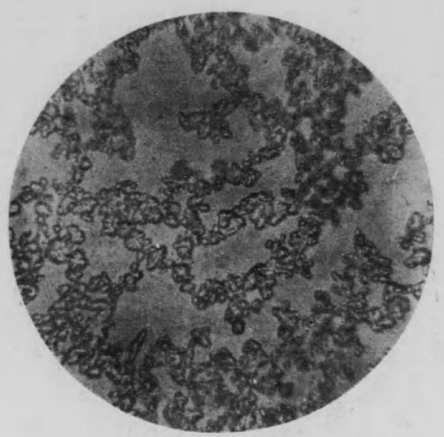


Fig. 3. 4 N. T_o. × 750.

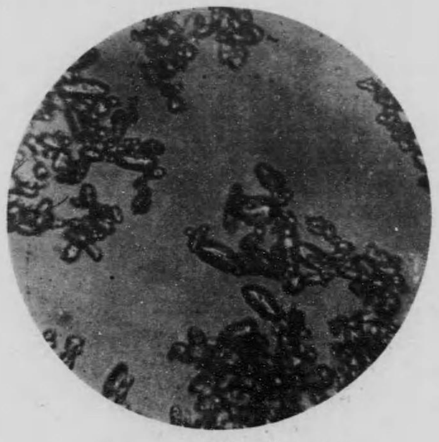


Fig. 4. 2 N. T_o. × 750.

Fig. 5. 1 N. T_o. × 750.

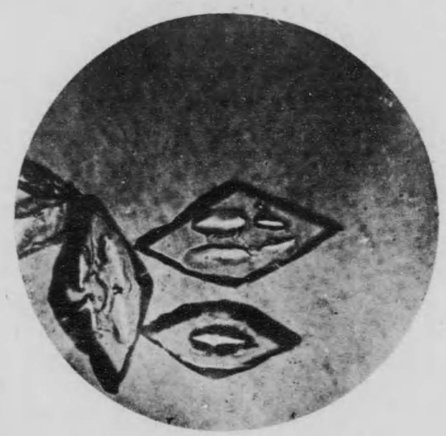


Fig. 6. 0.8 N. T_o. × 750.

Fig. 7. 0.4 N. T_o. × 750.

Fig. 8. 0.2 N. T_o. × 750.

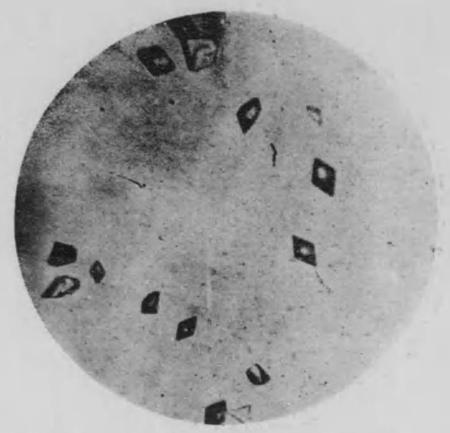


Fig. 9. 0.2 N. T_o. + 5 min. × 750.

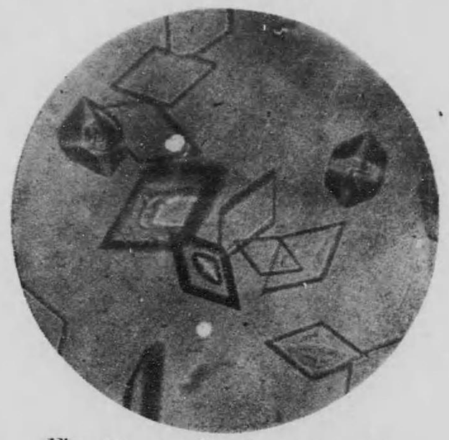


Fig. 10. 0.2 N. T_o. + 10 min.

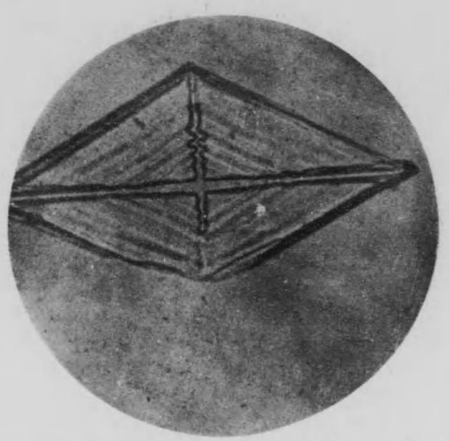


Fig. 11. 0.2 N. T_0. + 20 min. × 750.

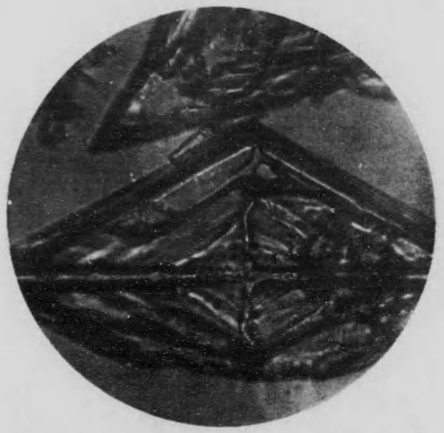


Fig. 12. 0.2 N. T_0. + 40 min. × 750.

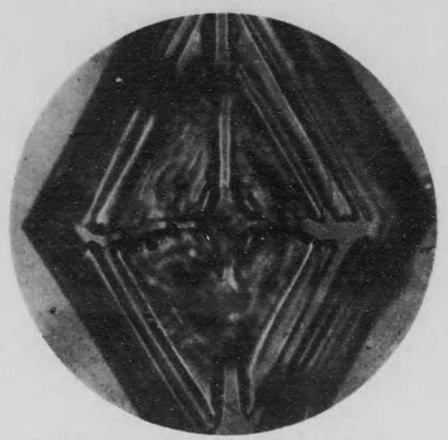


Fig. 13. 0.2 N. T_0. + 1 hour. × 625.

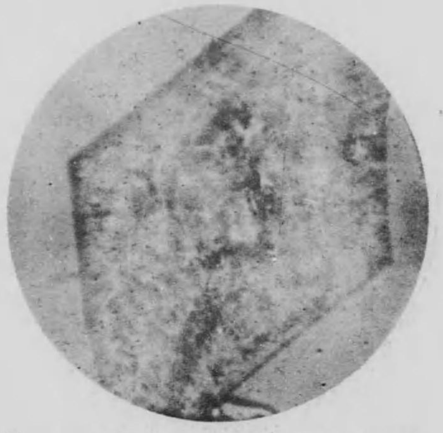


Fig. 14. 0.2 N. T_0. + 2 months. × 500.

Fig. 15. 0.2 N. T_o. + 6 months. × 500.

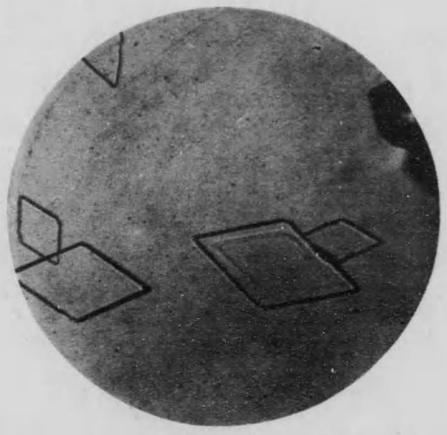


Fig. 16. 0.4 N. T_o. + 5 min. × 750.

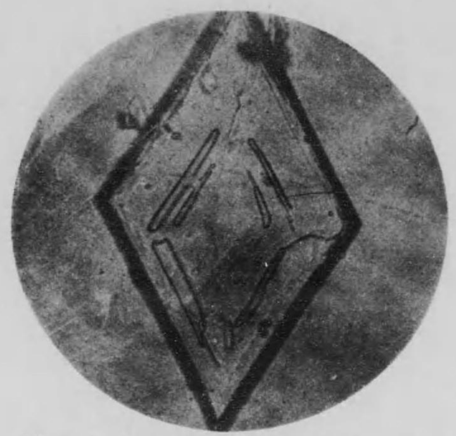


Fig. 17. 0.4 N. T_o. + 10 min. × 750.

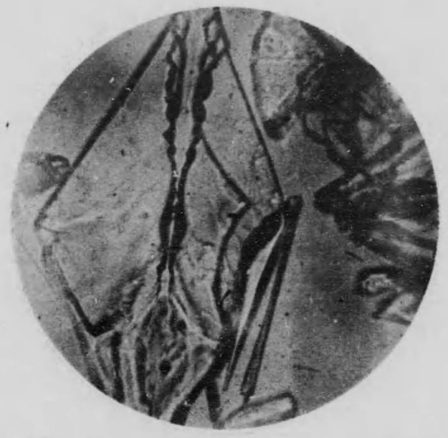


Fig. 18. 0.4 N. T_o. + 20 min. × 750.

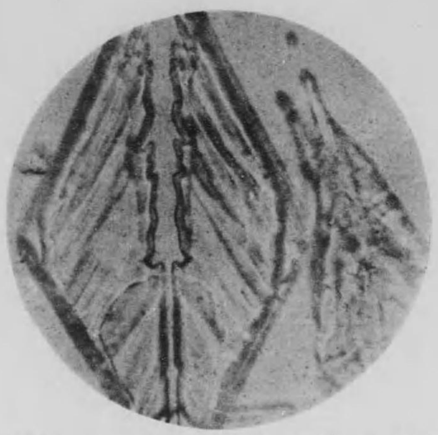


Fig. 19. 0.4 N. $T_{0'}$ + 20 min. × 750.

Fig. 20. 0.4 N. $T_{0'}$ + 1 hour. × 625.

Fig. 21. 0.4 N. $T_{0'}$ + 2 months. × 625.

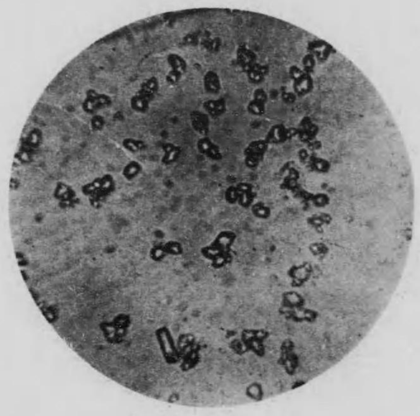


Fig. 22. $\frac{1}{7}$ N. $T_{0'}$ + 1 hour. × 750.

Fig. 23. $\frac{1}{7}$ N. T_o. + 2 months. × 500.

Fig. 24. $\frac{1}{7}$ N. T_o. + 6 months. × 218.

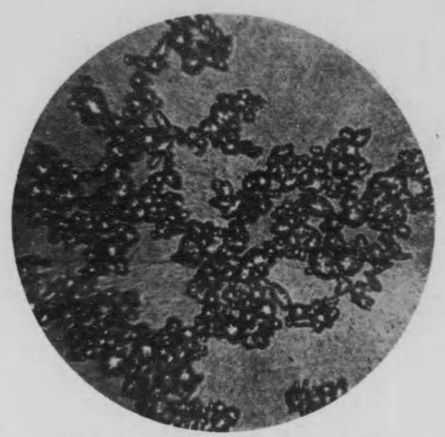


Fig. 25. 7 N. T_o. + hour. × 750.

Fig. 26. 7 N. T_o. + 2 months. × 750.

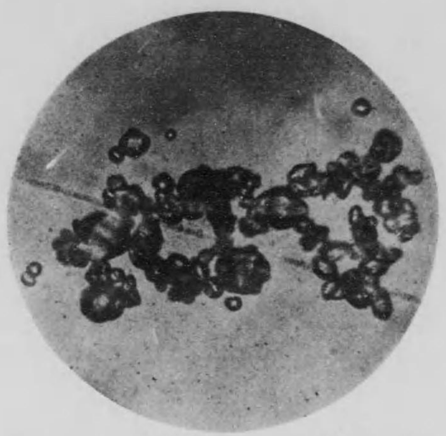


Fig. 27. 7 N. T_o. + 6 months. × 750.

Fig. 28. 6 N. T_o. + 1 hour. × 750.

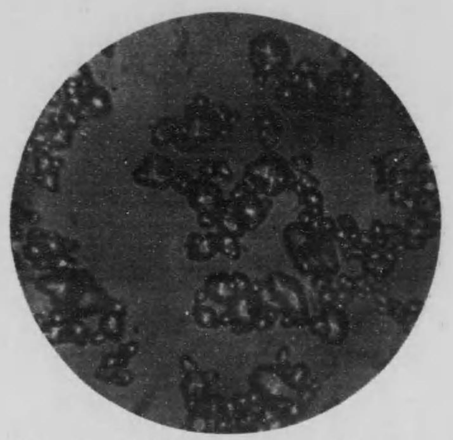


Fig. 29. 6 N. T_o. + 2 months. × 750.

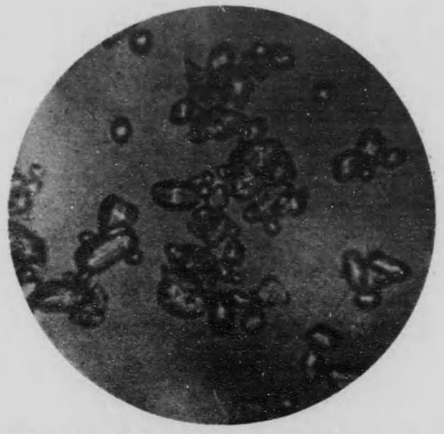


Fig. 30. 6 N. T_o. + 6 months. × 750.

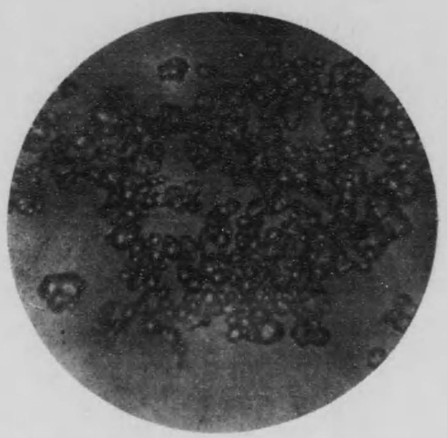


Fig. 31. 4 N. T_o. + 1 hour. × 750.

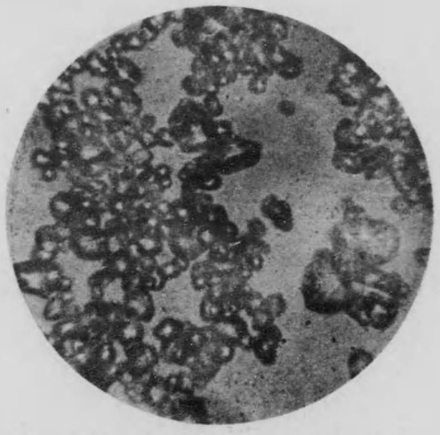


Fig. 32. 4 N. T_o. + 2 months. × 750.

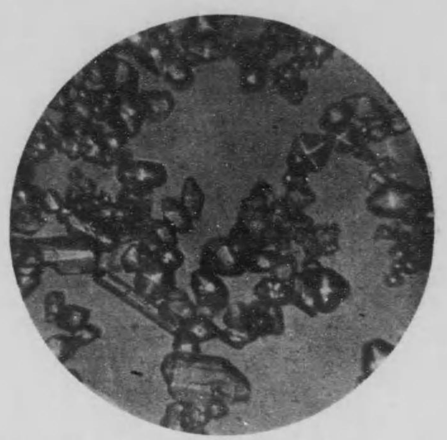


Fig. 33. 4 N. T_o. + 6 months. × 750.

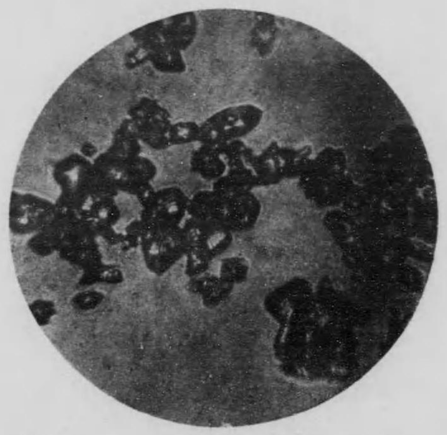


Fig. 34. 2 N. T_o. + 1 hour. × 750.

Fig. 35. 2 N. T_o. + 6 months. × 750.

Fig. 36. N. T_o. + 1 hour. × 750.

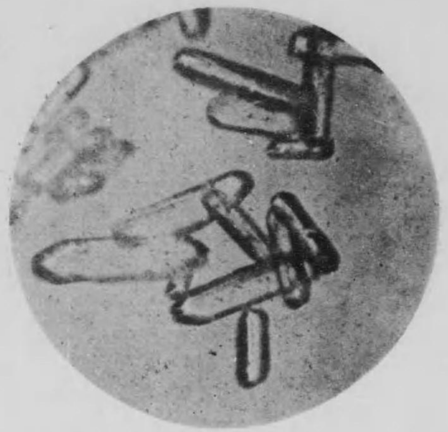


Fig. 37. N. T_o. + 2 months. × 750.

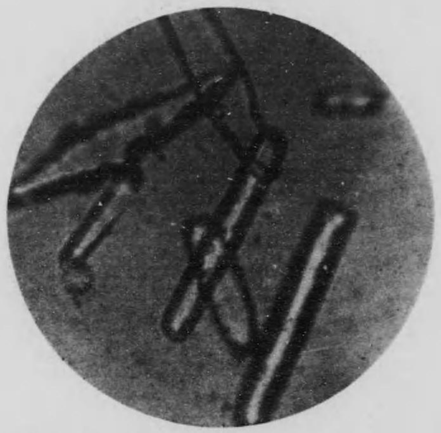


Fig. 38. N. T_o. + 6 months. × 750.

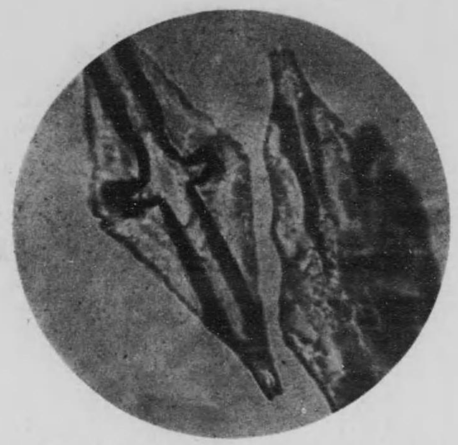


Fig. 39. 0.8 N. T_o. + 6 months. × 750.

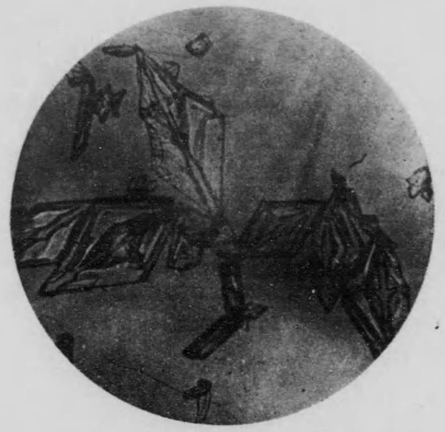


Fig. 40. 0.4 N. T_o. + 1 hour. × 218.

Fig. 41. 0.2 N. T_o. + 1 hour. × 218.

PRECIPITATES IN 30% ALCOHOLIC AQUEOUS SOLUTIONS.

II. Silver Nitrate Solution ⟵ Manganous Sulphate Solutions.

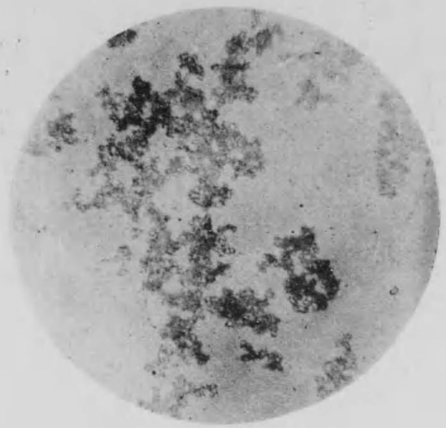


Fig. 42. 1 N. T_o. × 750.

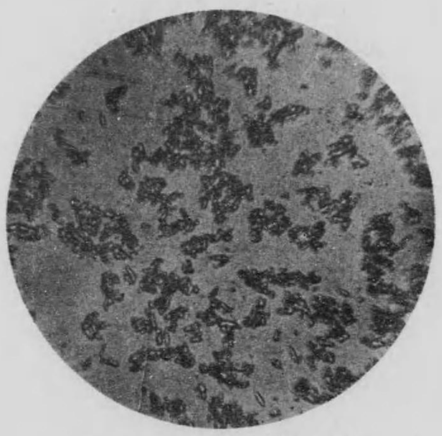


Fig. 43. 0.8 N. T_o. × 750.

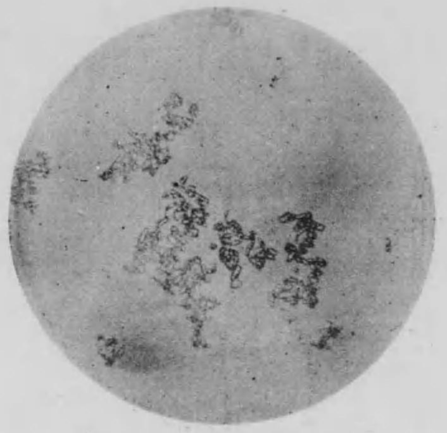


Fig. 44. 0.4 N. - T_o. × 750.

Fig. 45. 0.2 N. T_o. × 750.

Fig. 46. $\frac{1}{7}$ N. $T_o \times 750$.

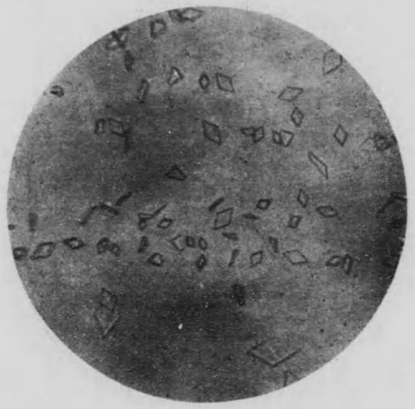


Fig. 47. $\frac{1}{10}$ N. $T_o \times 750$.

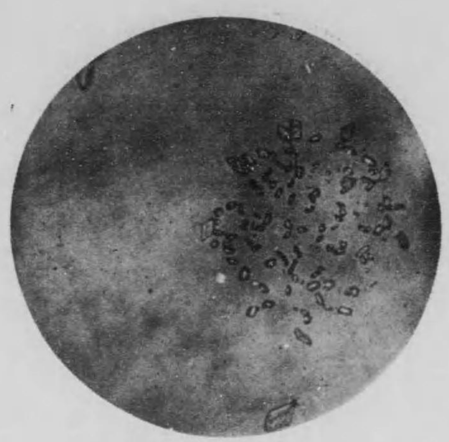


Fig. 48. $\frac{1}{15}$ N. $T_o \times 750$.

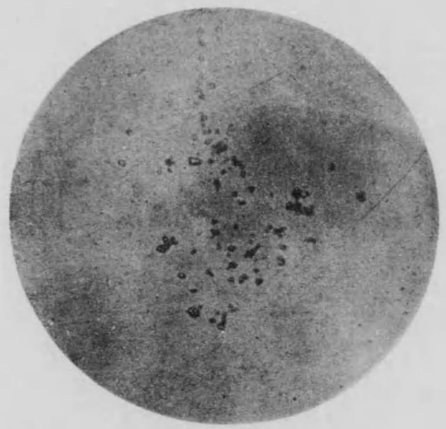


Fig. 49. $\frac{1}{20}$ N. $T_o \times 750$.

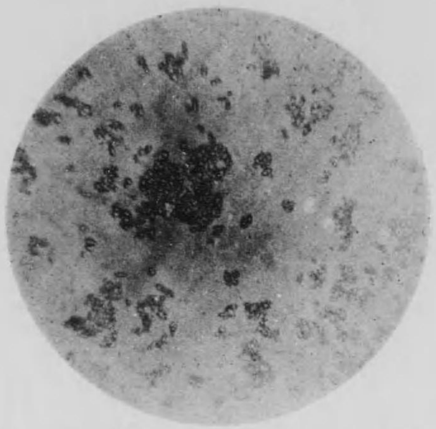


Fig. 50. N. T_o. + 1 hour. × 750.

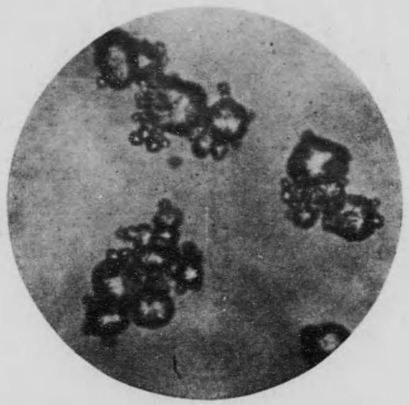


Fig. 51. N. T_o. + 2 months. × 750.

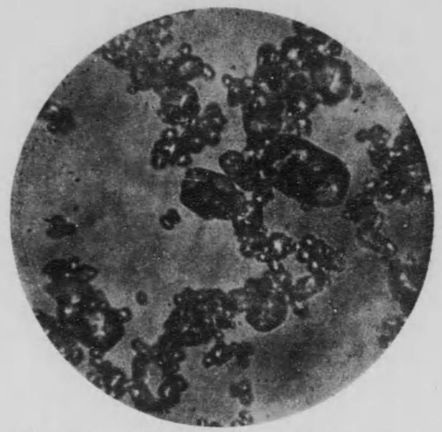


Fig. 52. N. T_o. + 6 months. × 750.

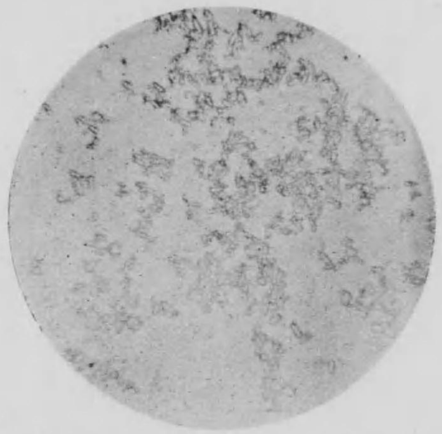


Fig. 53. 0.8 N. T_o. + 1 hour. × 750.

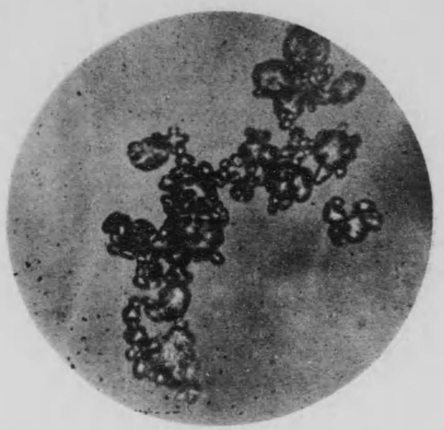


Fig. 54. .08 N. T_o. + 2 months. × 750.

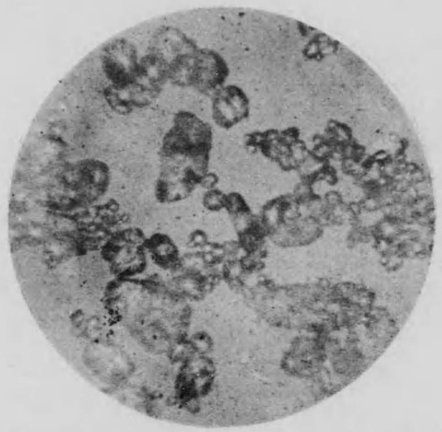


Fig. 55. .08 N. T_o. + 6 months. × 750.

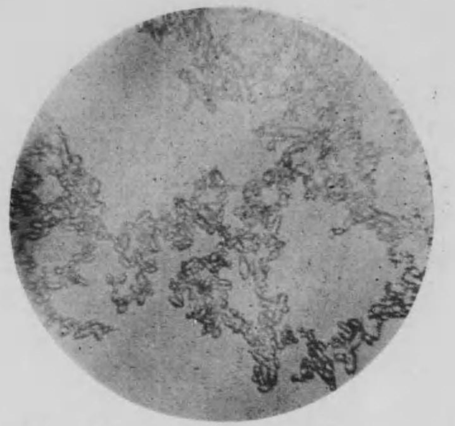


Fig. 56. 0.4 N. T_o. + 1 hour. × 750.

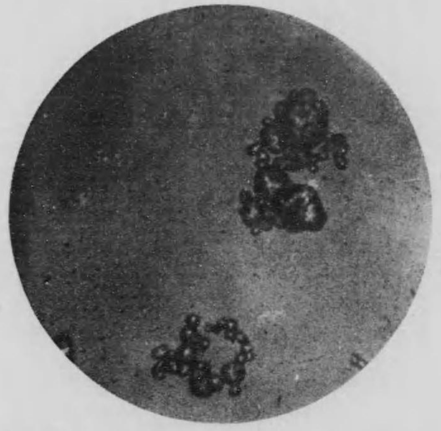


Fig. 57. 0.4 N. T_o. + 2 months. × 750.

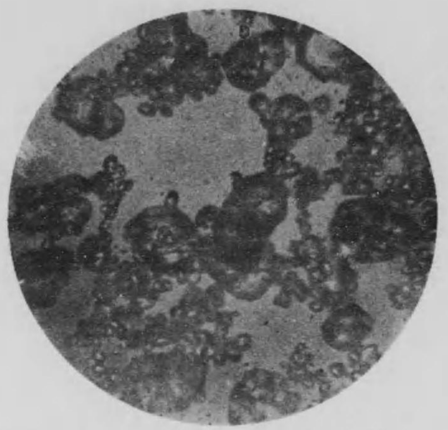


Fig. 58. 0.4 N. T_o. + 6 months. × 750.

Fig. 59. 0.2 N. T_o. + 1 hour. × 750.

Fig. 60. 0.2 N. T_o. + 2 months. × 750.

Fig. 61. 0.2 N. T_o. + 6 months. × 750.

Fig. 62. $\frac{1}{7}$ N. T_o. + 1 hour. × 750.

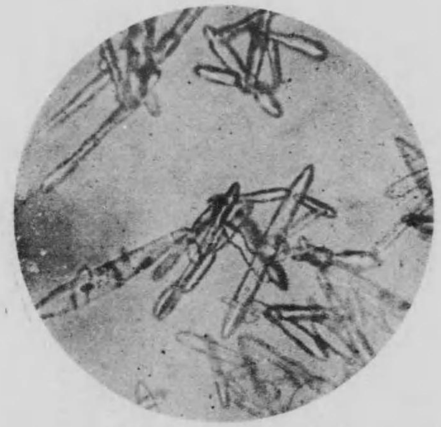


Fig. 63. $\frac{1}{7}$ N. T_o. + 6 months. × 750.

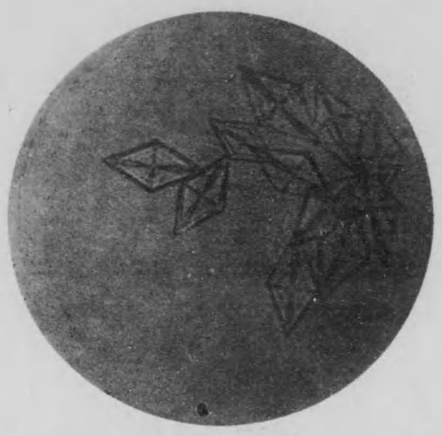


Fig. 64. $\frac{1}{10}$ N. T_o. + 5 min. × 750.

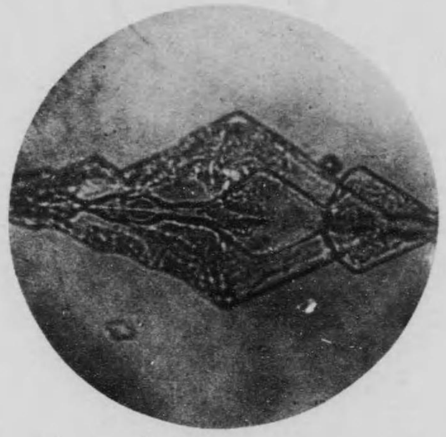


Fig. 65. $\frac{1}{10}$ N. T_o. + 10 min. × 750.

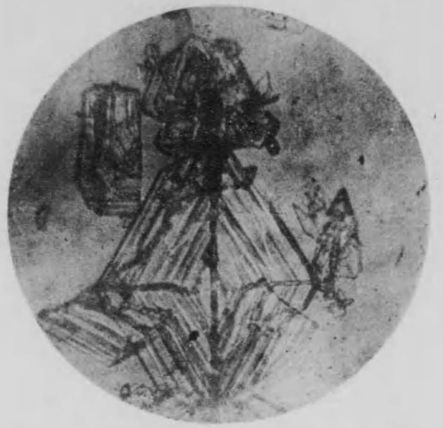


Fig. 66. $\frac{1}{10}$ N. $T_{o'}$ + 20 min. × 750.

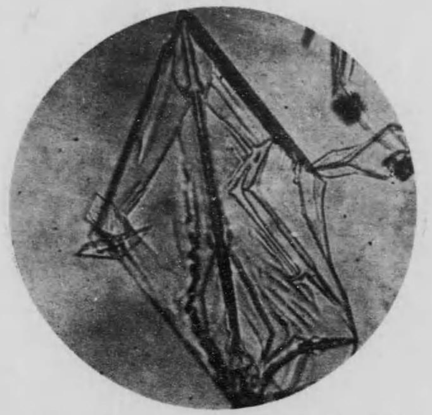


Fig. 67. $\frac{1}{10}$ N. $T_{o'}$ + 40 min. × 750.

Fig. 68. $\frac{1}{10}$ N. $T_{o'}$ + 1 hour. × 750.

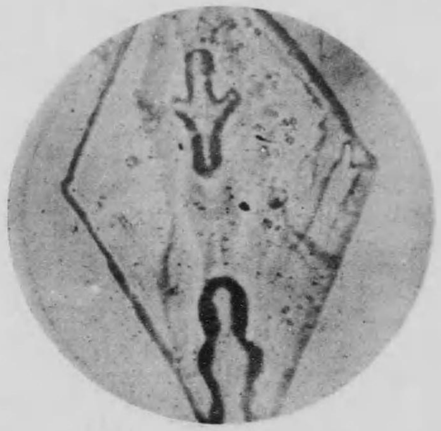


Fig. 69. $\frac{1}{10}$ N. $T_{o'}$ + 2 months. × 750.

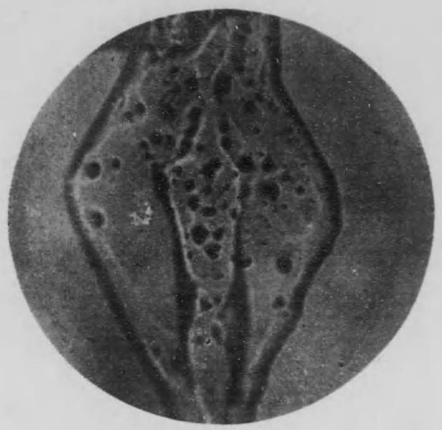


Fig. 70. $\frac{1}{10}$ N. T_o + 6 months. × 625.

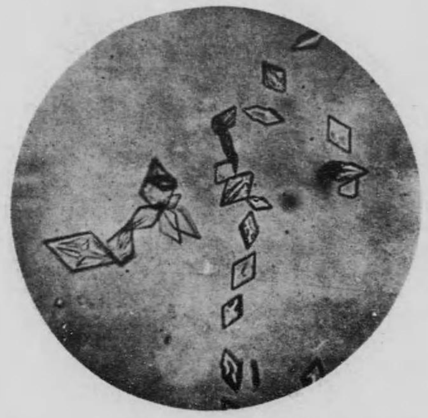


Fig. 71. $\frac{1}{15}$ N. T_o + 5 min. × 750.

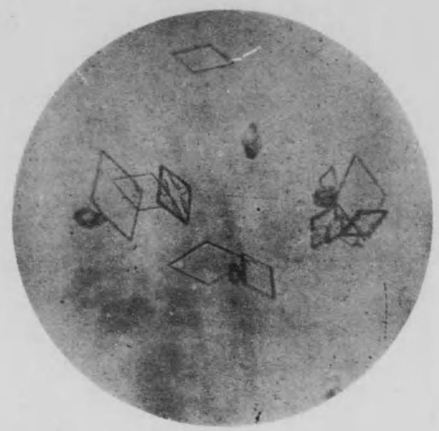


Fig. 72. $\frac{1}{15}$ N. T_o + 10 min. × 750.

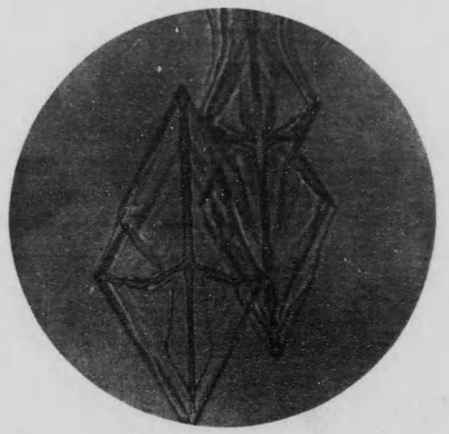


Fig. 73. $\frac{1}{15}$ N. T_o + 20 min. × 750.

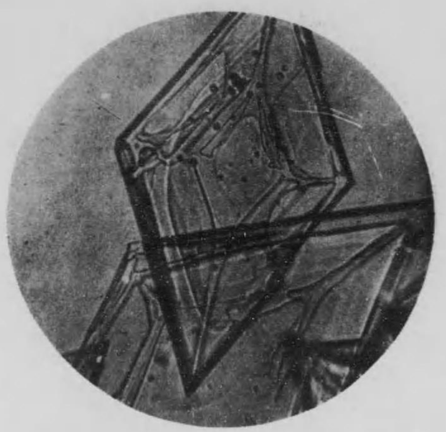


Fig. 74. $\frac{1}{15}$ N. T_o + 40 min. × 750.

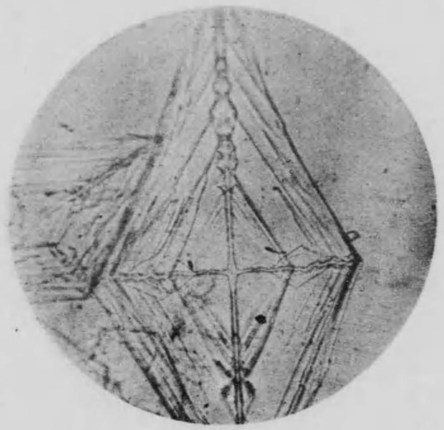


Fig. 75. $\frac{1}{15}$ N. T_o + 1 hour. × 750.

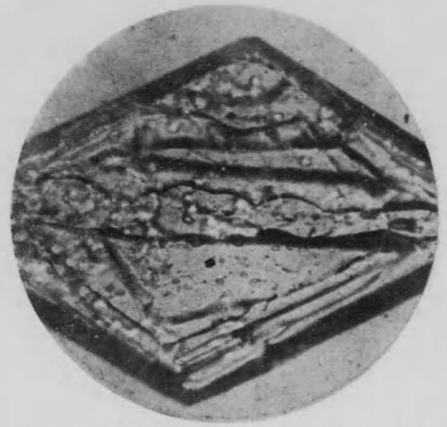


Fig. 76. $\frac{1}{15}$ N. T_o + 2 months. × 500.

Fig. 77. $\frac{1}{15}$ N. T_o + 6 months. × 500.

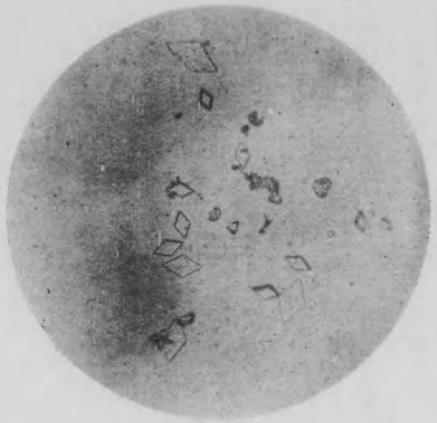


Fig. 78. $\frac{1}{20}$ N. T_o + 5 min. × 750.

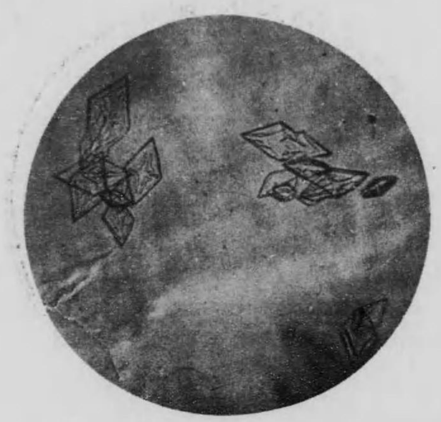


Fig. 79. $\frac{1}{20}$ N. T_o + 10 min. × 750.

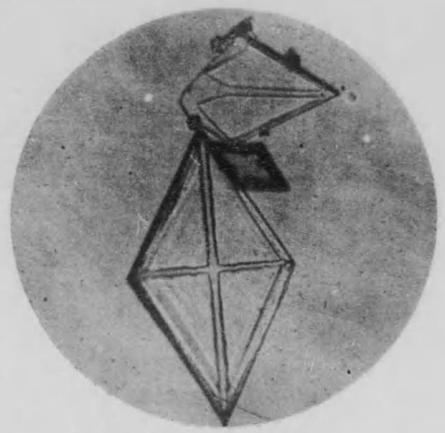


Fig. 80. $\frac{1}{20}$ N. T_o + 20 min. × 750.

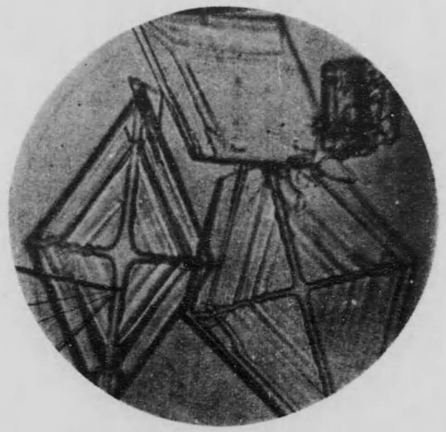


Fig. 81. $\frac{1}{20}$ N. T_o + 40 min. × 750.

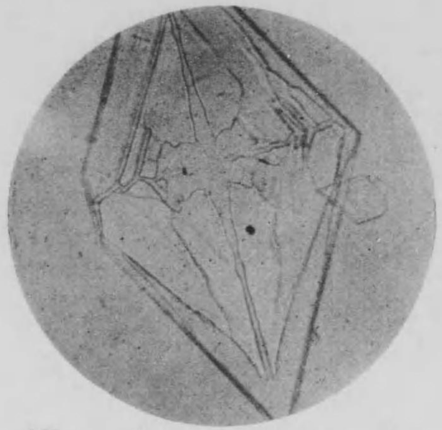


Fig. 82. $\frac{1}{20}$ N. T_{0° + 1 hour. × 750.

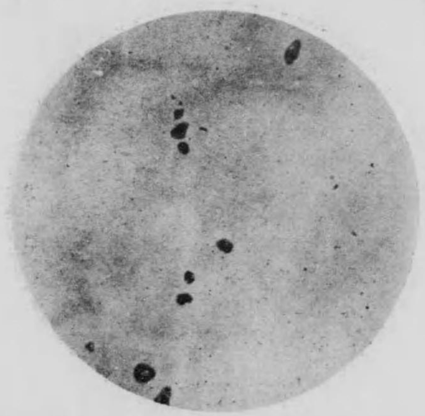


Fig. 83. $\frac{1}{25}$ N. T_{0° + 1 hour. × 750.

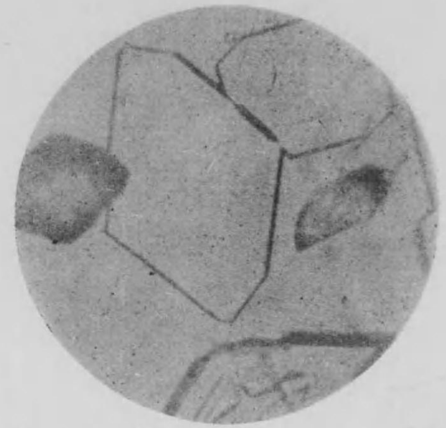


Fig. 84. $\frac{1}{25}$ N. T_{0° + 3 hours. × 750.

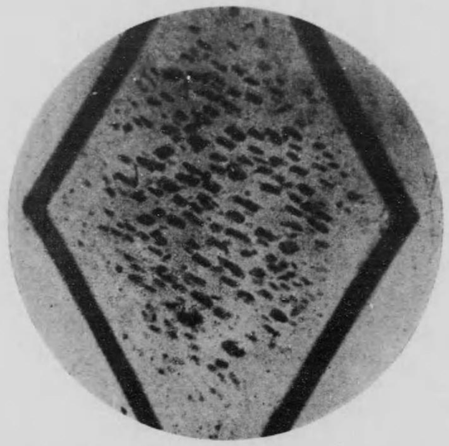


Fig. 85. $\frac{1}{25}$ N. T_{0° + 1 day. × 625.

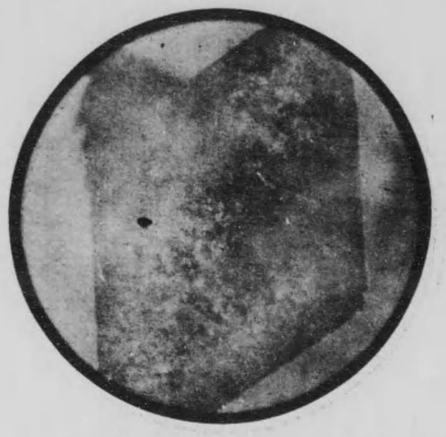


Fig. 86. $\frac{1}{25}$ N. T_o. + 6 months. × 300.

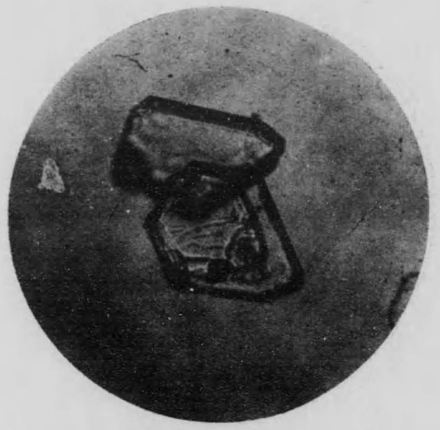


Fig. 87. $\frac{1}{30}$ N. T_o. + 3 hours. × 750.

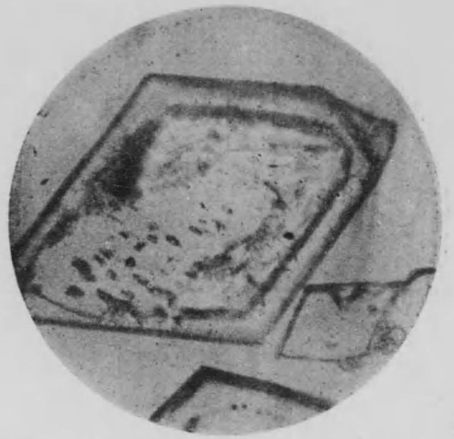


Fig. 88. $\frac{1}{30}$ N. T_o. + 1 day. × 625.

Fig. 89. $\frac{1}{30}$ N. T_o. + 2 months. × 500.

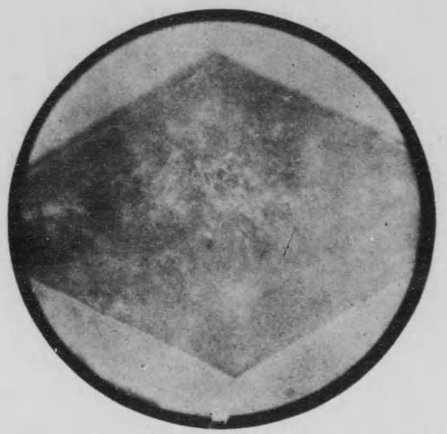


Fig. 90. $\frac{1}{30}$ N. T_o. + 6 months × 300.

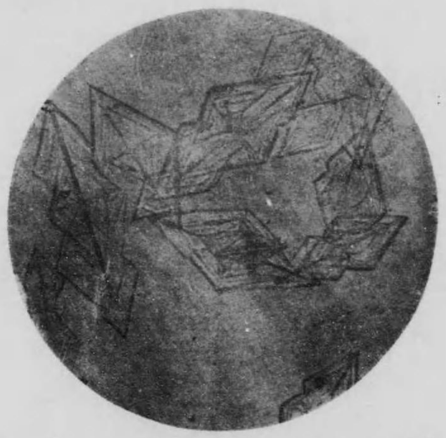


Fig. 91. $\frac{1}{15}$ N. T_o. + 1 hour. × 218.

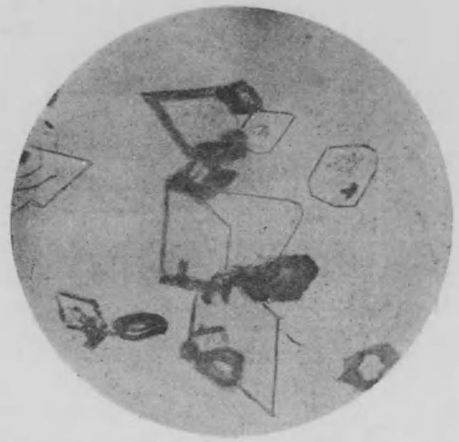


Fig. 92. $\frac{1}{25}$ N. T_o. + 3 hours. × 218.

Fig. 93. $\frac{1}{25}$ N. T_o. + 1 day. × 218.

PRECIPITATES IN 60% ALCOHOLIC AQUEOUS SOLUTIONS.

III. Silver Nitrate Solution ⟵ Manganous Sulphate Solution.

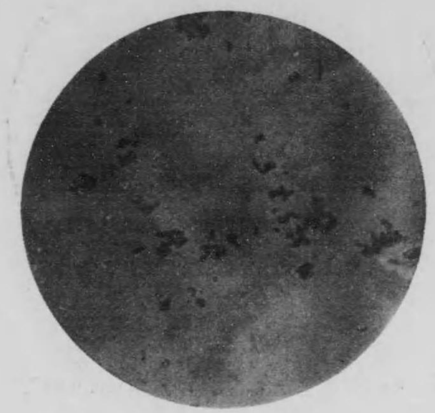


Fig. 94. $\frac{1}{10}$ N. $T_o \times 750$.

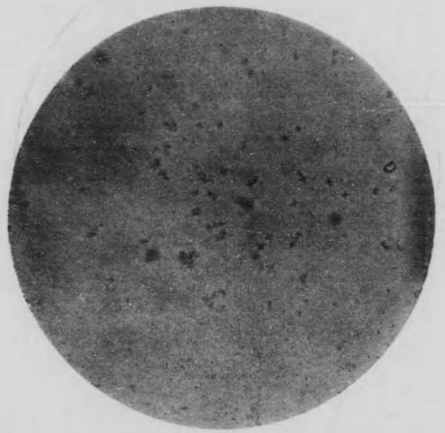


Fig. 95. $\frac{1}{20}$ N. $T_o \times 750$.

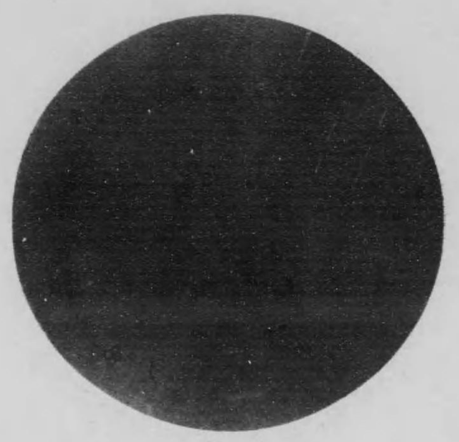


Fig. 96. $\frac{1}{35}$ N. $T_o \times 750$.

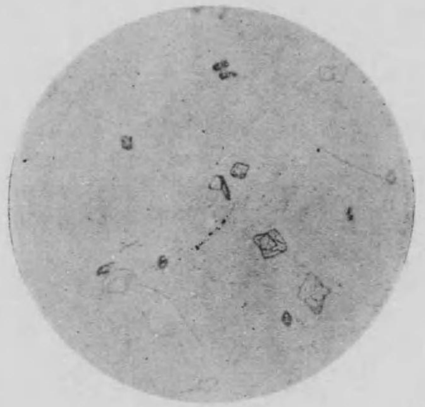


Fig. 97. $\frac{1}{50}$ N. $T_o \times 750$.

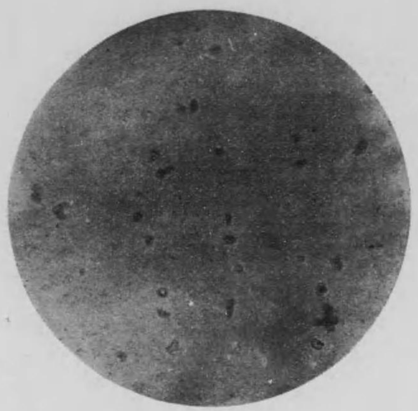


Fig. 98. $\frac{1}{80}$ N. T_o. × 750.

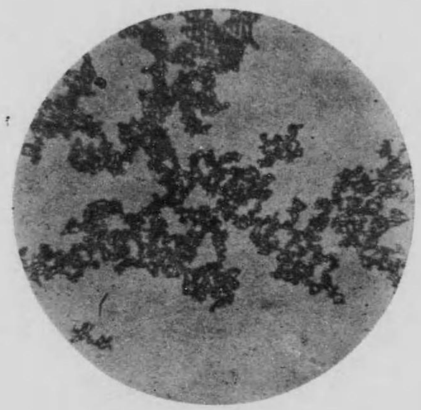


Fig. 99. $\frac{1}{10}$ N. T_o. + 1 hour. × 750.

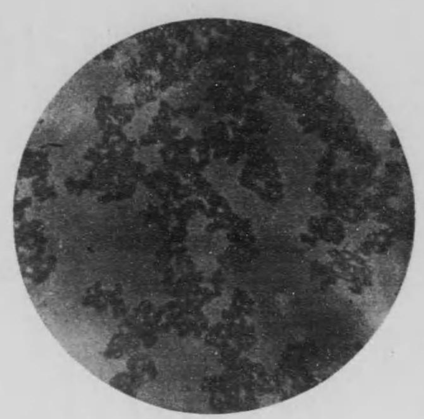


Fig. 100. $\frac{1}{20}$ N. T_o. + 1 hour. × 750.

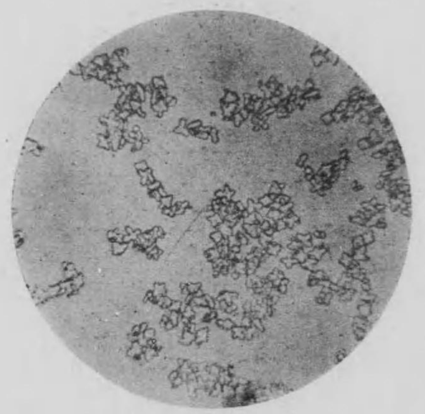


Fig. 101. $\frac{1}{35}$ N. T_o. + 1 hour. × 750.

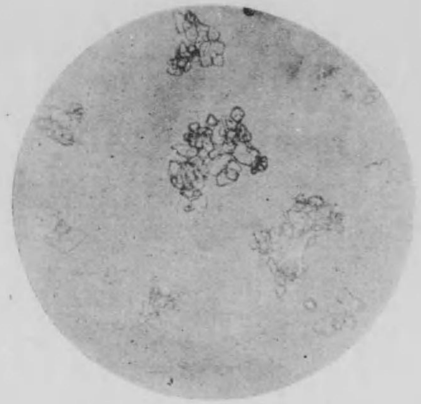


Fig. 102. $\frac{1}{50}$ N. T_0. + 1 hour. × 750.

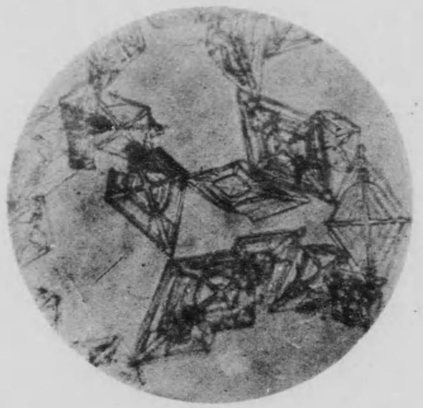


Fig. 103. $\frac{1}{80}$ N. T_0. + 1 hour. × 750.

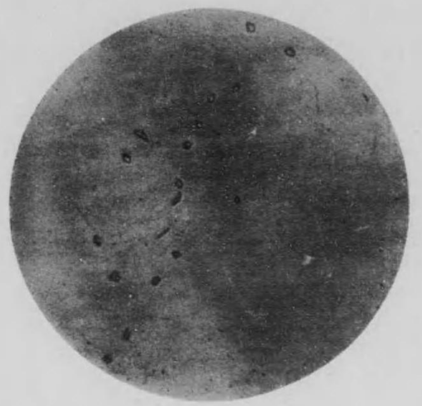


Fig. 104. $\frac{1}{100}$ N. T_0. + 1 hour. × 750.

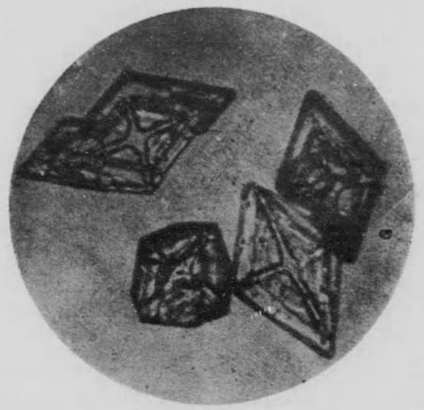


Fig. 105. $\frac{1}{100}$ N. T_0. + 1 day. × 750.

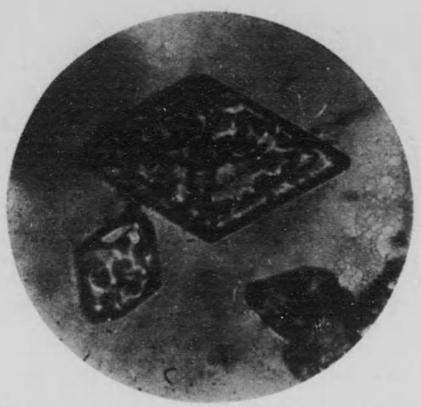


Fig. 106. $\frac{1}{100}$ N. T_o. + 1 week. × 750.

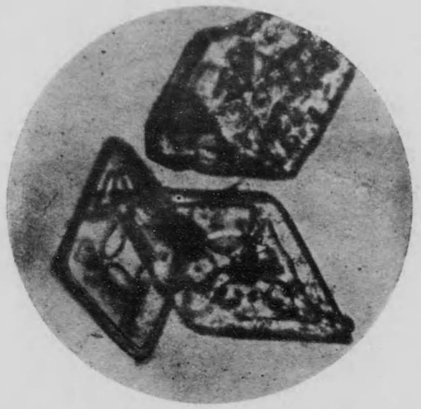


Fig. 107. $\frac{1}{100}$ N. T_o. + 1 month. × 750.

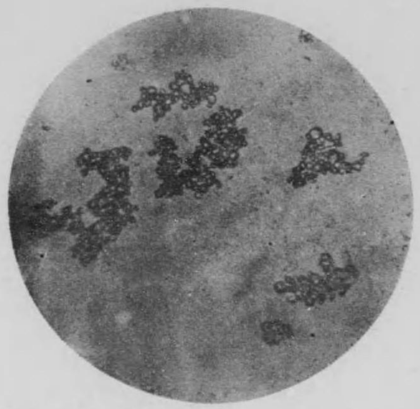


Fig. 108. $\frac{1}{10}$ N. T_o. + 1 week. × 750.

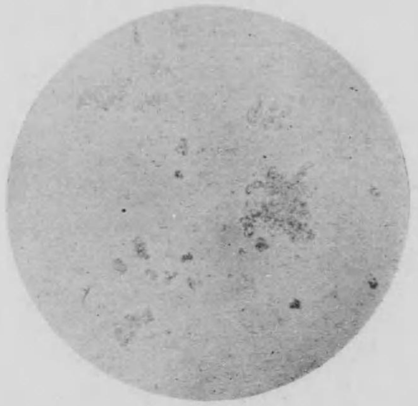


Fig. 109. $\frac{1}{20}$ N. T_o. + 1 week. × 750.

Fig. 110. $\frac{1}{80}$ N. T_o. + 1 week. × 750.

Fig. 111. $\frac{1}{35}$ N. T_o. + 1 month. × 750.

PRECIPITATES IN AQUEOUS SOLUTIONS.

IV. Manganous Sulphate Solution ← Silvernitrate Solution.

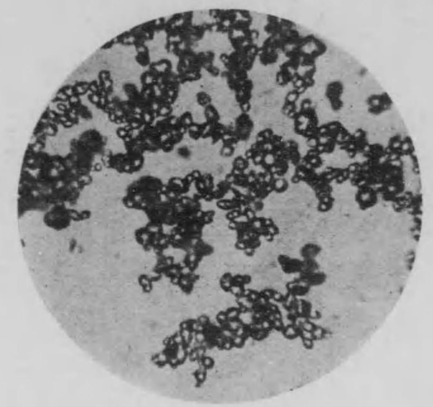


Fig. 112. 7 N. T_o. × 750.

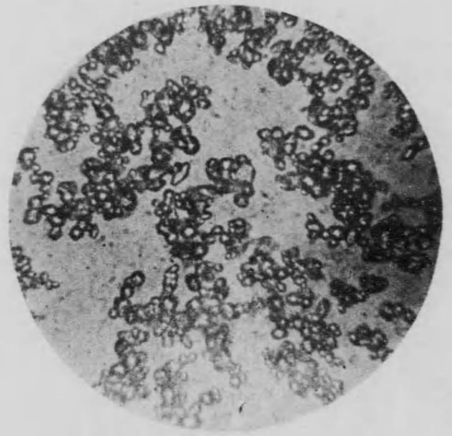


Fig. 113. 6 N. T_o. × 750.

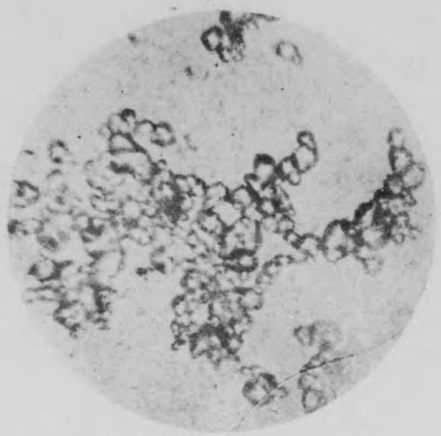


Fig. 114. 4 N. T_o. ×750.

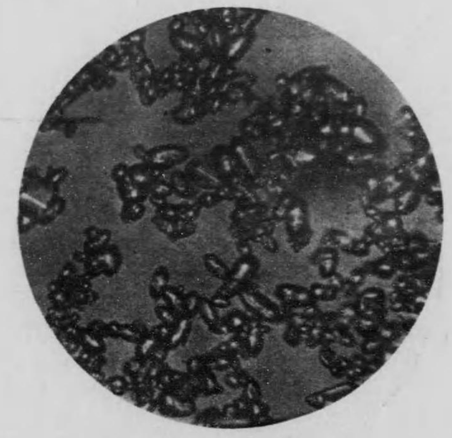


Fig. 115. 2 N. T_o. ×750.

Fig. 116. N. T_o. ×750.

Fig. 117. 0.8 N. T_o. ×750.

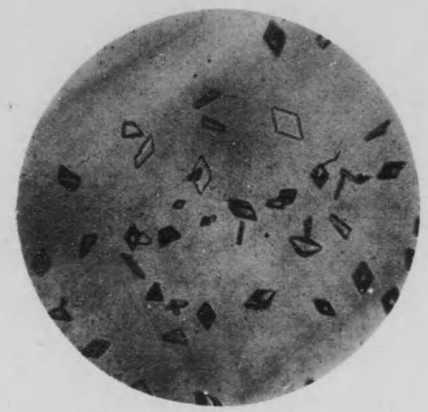


Fig. 118. 0.4 N. T_0. × 750.

Fig. 119. 0.2 N. T_0. × 750.

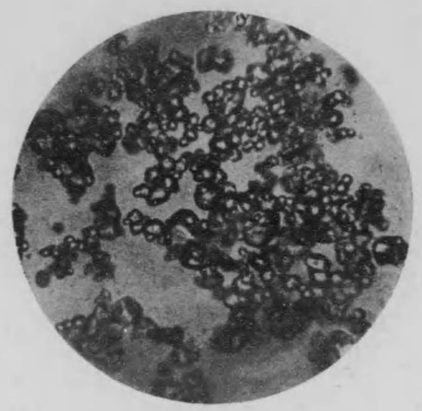


Fig. 120. 7 N. T_0. + 1 hour. × 750.

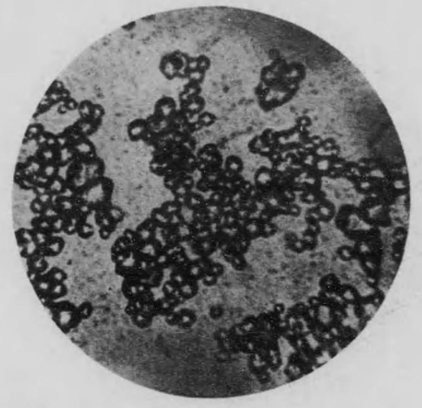


Fig. 121. 6 N. T_0. + 1 hour. × 750.

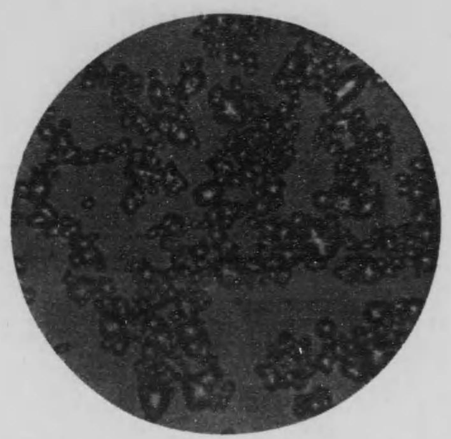


Fig. 122. 4 N. T_o. + 1 hour. × 750.

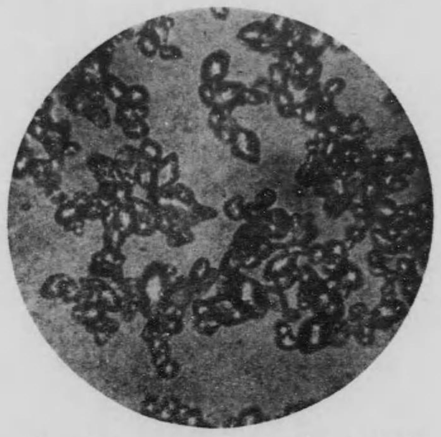


Fig. 123. 2 N. T_o. + 1 hour. × 750.

Fig. 124. N. T_o. + 1 hour. × 750.

Fig. 125. N. T_o. + 2 months. × 750.

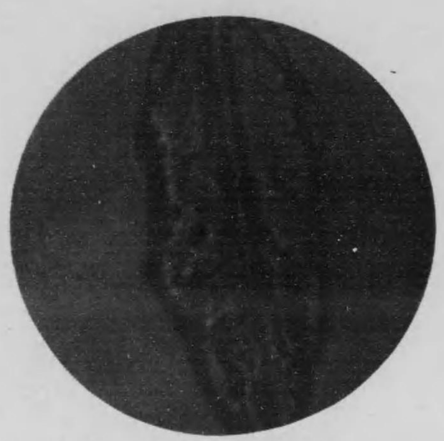


Fig. 126. 0.8 N. T_o. + 6 months. × 750.

Fig. 127. 0.2 N. T_o. + 1 hour. × 218.

PRECIPITATES IN 30% ALCOHOLIC AQUEOUS SOLUTIONS.

V. Manganous Sulphate Solution ⟵ Silvernitrate Solution.

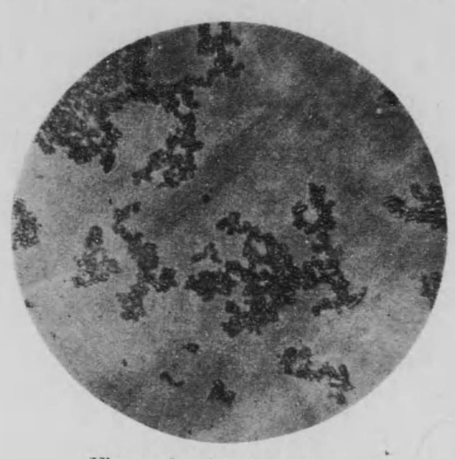


Fig. 128. N. T_o. × 750.

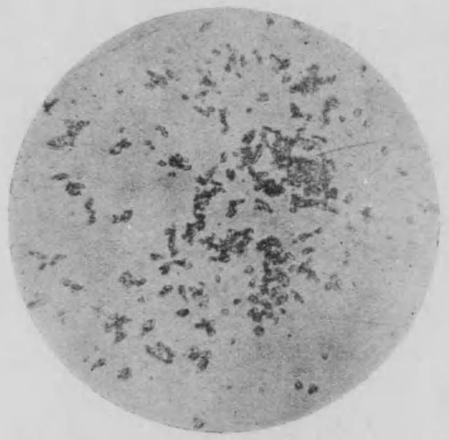


Fig. 129. 0.8 N. T_o. × 750.

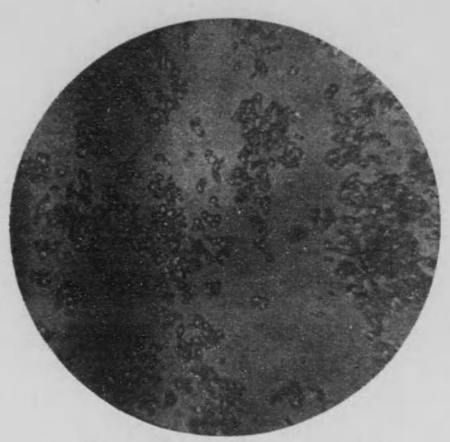


Fig. 130. 0.4 N. T_o. × 750.

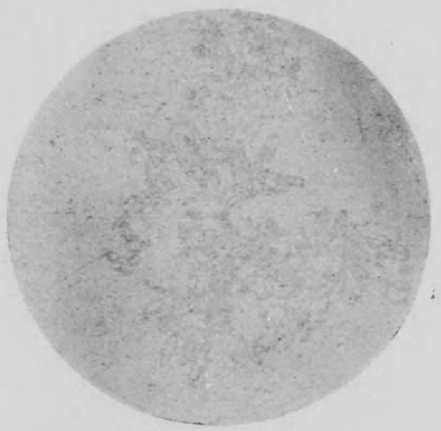


Fig. 131. 0.2 N. T_o. × 750.

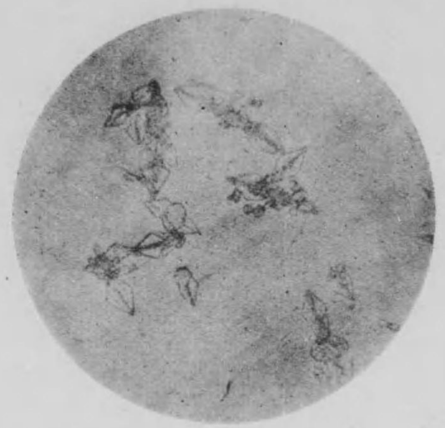


Fig. 132. $\frac{1}{7}$ N. T_o. × 750.

Fig. 133. $\frac{1}{10}$ N. T_o. × 750.

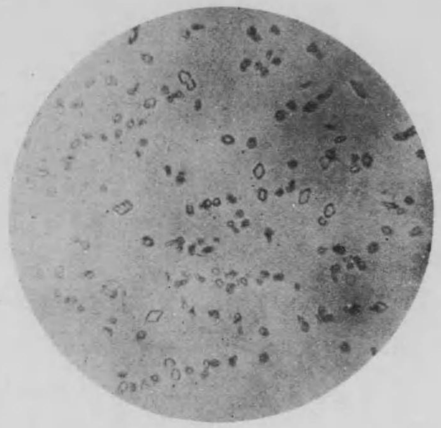


Fig. 134. $\frac{1}{15}$ N. T_o. ×750.

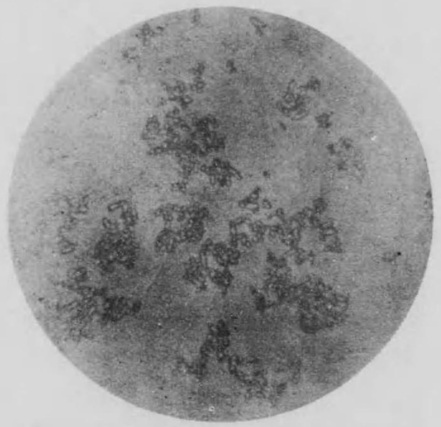


Fig. 135. N. T_o. + 1 hour. ×750.

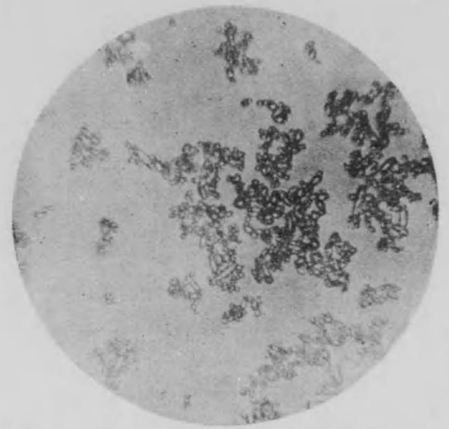


Fig. 136. 0.8 N. T_o. + 1 hour. × 750.

Fig. 137. 0.4 N. T_o. + 1 hour. × 750.

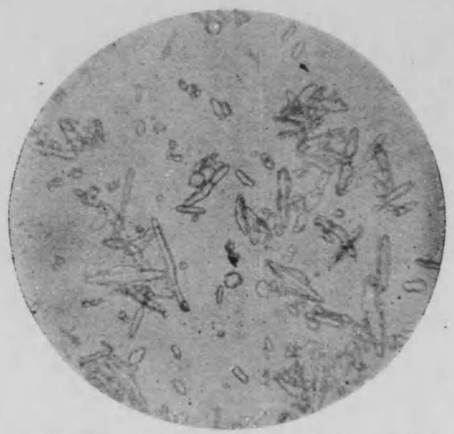


Fig. 138 0.2 N. T_o. + 1 hour. × 750.

Fig. 139. $\frac{1}{7}$ N. T_o. + 1 hour. × 750.

Fig. 140. $\frac{1}{7}$ N. T_o. + 2 months. × 750.

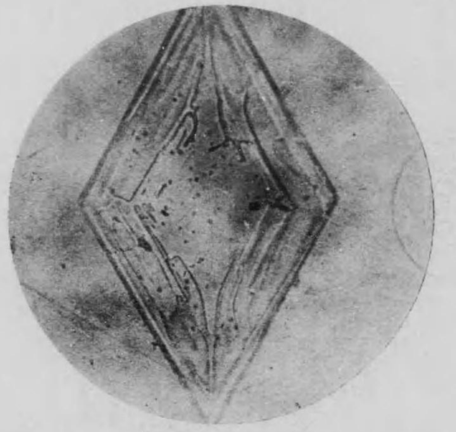


Fig. 141. $\frac{1}{15}$ N, T_o. + 1 hour. × 625.

Fig. 142. $\frac{1}{20}$ N. T_0. + 1 hour. × 218.

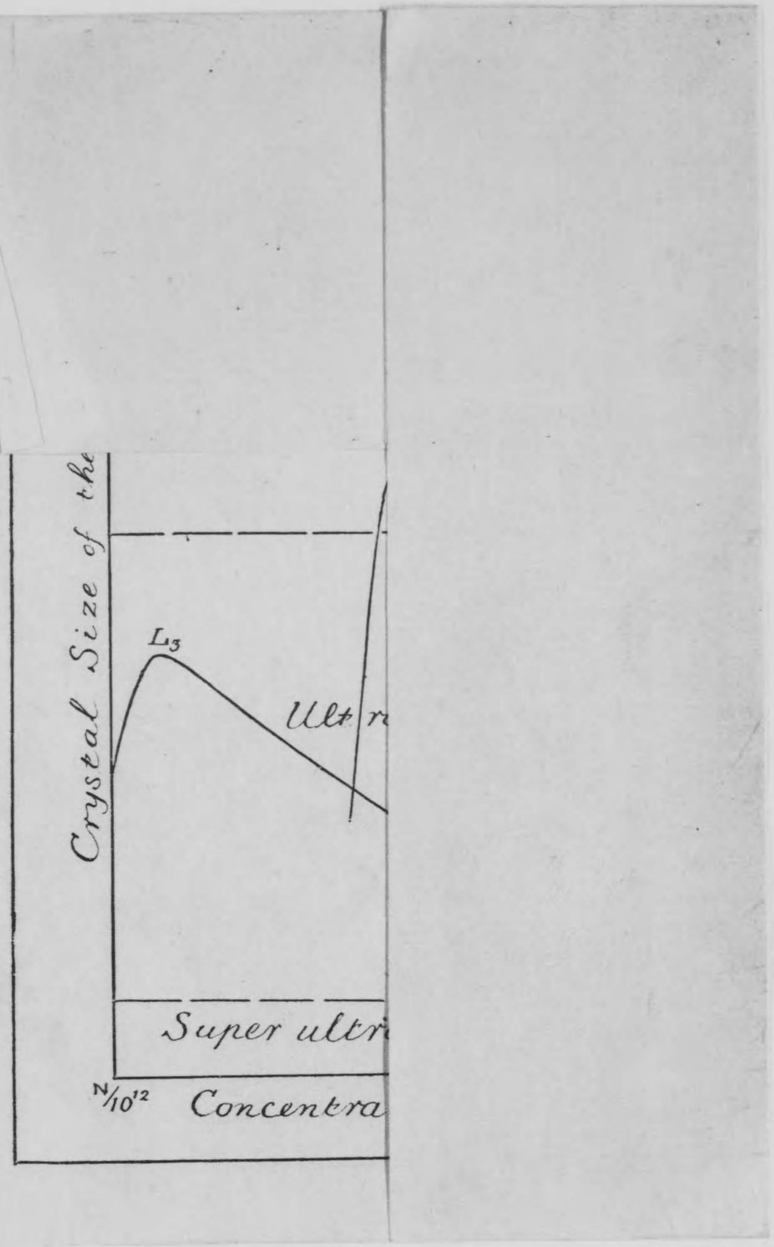
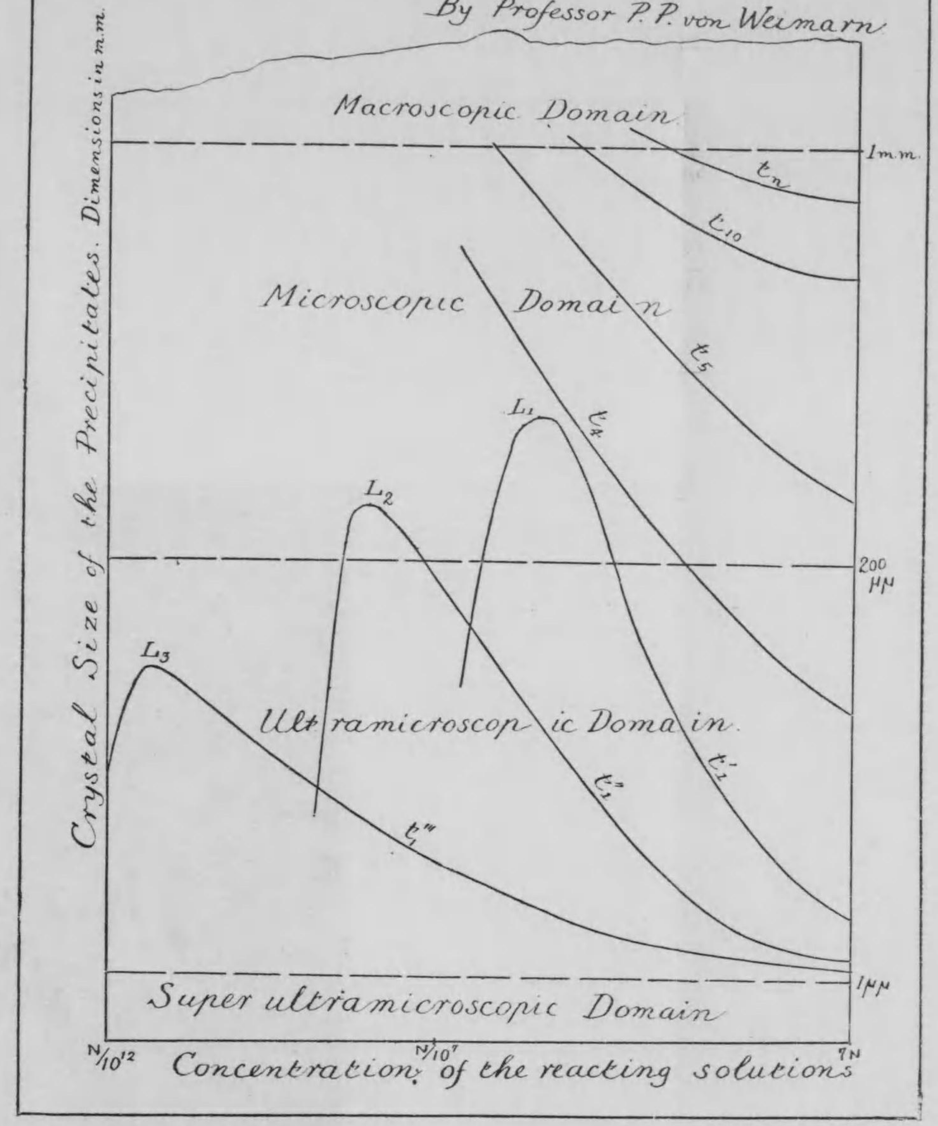


Fig. 142. $\frac{1}{20}$ N. T_0. + 1 hour. × 218.

Plate 1.

Diagram of the Transition of any Substance from the "World of the Crystalloids" into the "World of the Colloids" and vice versa.

By Professor P. P. von Weimarn



大正十二年十月二十五日印刷
大正十二年十月二十七日發行

農商務省

大阪工業試驗所

印刷人 大阪市北區玉江町一丁目 石西豐藏

大阪工業試驗所報告第四回　目　次

終