The Stagnant Turbid Layers Developed in the Thermocline of Lake Aoki and Lake Noziri

By
Masayuki MUKAI

In 1948, the author found out a conspicuous turbid layer developed in the thermocline of Lake Aoki in stagnant state in the period from the late summer to the early autumn.

He, therefire continued the observations on this kind of layer of the lake in 1950 and in 1951, and extended the observation to Lake Noziri in 1951 to make sure of its development and stagnancy, with the measurements of the electrical conductivity, the hydrogen ion concentration etc. in addition to the observation of the turbid layer to find out the qualitative or quantitative correlations, if any, among these factors.

Though the observations are not yet finished, the author desires to report the results obtained by the observations hitherto made.

Introduction

Lake Aoki and Lake Noziri are situated in central Japan, the surface area and the depth at the deepest point of the former amount to 1.86 square kilometre and 60. metres respectively, and those of the latter amount to 3.98 square kilometres and 38 metres respectively

Figures 1 and 2 are the sketch-maps of Lake Aoki and Lake Noziri.

The English and the Greek alphabet in them indicate the places where the water to be measured was drawn.

There is no conspicuous stream from which the water flows into these lakes.

The transparency of Lake Aoki is in the range from 8.0 to 12.5 metres. and that of Lake Noziri is in the range from 5.0 to 10.0 metres.

The water reserved in the epilimnion of Lake Aoki is neutral, and that of Lake Noziri is slightly alkaline.

To recognize the turbid layer the author measured the vertical distribution of the absorption coefficient which is defined by the Lambert's exponential law, viz. the fraction of intensity of the incident light absorbed and scattered per unit thickness of the medium.

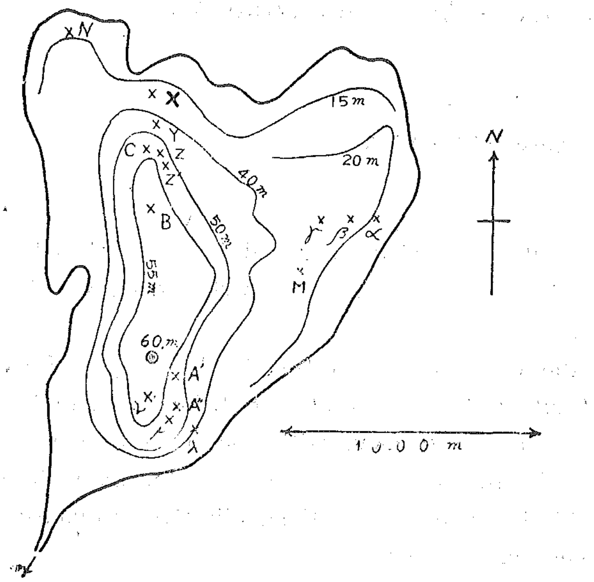


Fig. 1. Sketch-map of Lake Aoki.

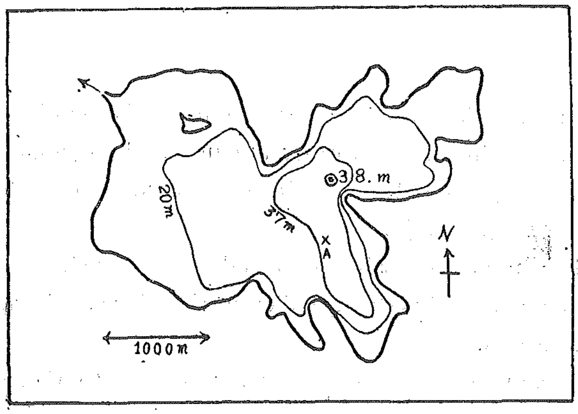


Fig. 2. Sketch-map of Lake Noziri.

The turbid layer is the layer where the absorption coefficient is larger than that of the other layer.

The actual measurements were performed with the unit $cm.^{-1}$

The value of the absorption coefficient of the lake water, when it is left in rest state after drawing, gradually decreases; however the time rate of its change is, roughly considering, nearly equal for any water drawn from any place whether it is deep or shallow.

Therefore, simply to find out the turbid layer, it is not absolutely necessary to perform the measurements immediately after the drawing of water.

The measurements of the electrical conductivity of water were performed by the Kohlrausch's method, the alternating current used in the measurements were generated by a valve oscillator, which was constructed by Tadamoto Nimura.(1)

The measurements of the absorption coefficient and conductivity were performed at room temperature, from 8 to 12 hours after the water to be measured was drawn out of the lake.

The measurements of pH were performed by the method of comparing colors, immediately after the drawing of water. To draw the water out of the lake, the author used a drawing instrument of Kitahara type when the intervals of one drawing depth and its adjacent one were more than 1 metre, and an air pump and gum tubes when the intervals were less than 1 metre. To draw water by a gum tube, one end of it is hanged at desired depth and the other end of it is connected with a glass bottle, and by an air pump the air is slowly drawn out of the bottle, then the water at desired depth slowly flows into the bottle.

The author often used two or more gum tubes and the same number of bottles, to draw water from several depths at the same time. The water for the purpose of measuring the amount of the dissolved oxygen and that of nitrogen in it were drawn as not to come in contact with the air.

Observations performed in 1948 in lake Aoki.

The observation to find out the turbid layer developed in 1948 was commenced on the 29th of August; and a conspicuous turbid layer was found on this day at the middle layer of the thermocline. The author continued the observation on this layer to the 24th of October to make sure of its stagnancy. During this period the observations were performed twelve times at five places of the lake.

The results obtained from these observations are shown in figures 3, 4, 5, 6, and 7, taking the absorption coefficient as abscissae and the drawing depth as ordinates.

The numerals appended to the right sides of all graphs of this paper, show the temperature of the water at that depth, dates and alphabet (English and Greek) in all figures of this paper show the dates of the observations and the places where the water to be measured was drawn.

The numerals noted with cm. in bracket show the level of the surface of this lake on the days of observations.

Figure 3 shows the results of observations performed on the 29th of August and on the 1st of September in graphs.

Table I. Measured on the 29th of Aug. 1948.

drawing depth (m)	0	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0	37.5
absorption coef.	1.8	2.1	1.3	1.9	4.5	3.1	2.8	3.0	2.0	1.3	1.8	1.2	1.4	1.5	1.8	1.0

The result of observation made on 29th of August is also shown in the table I, for the purpose of showing the order of the magnitude of the absorption coefficient, measured with the unit cm.$^{-1}$ In the table, the numerical values of it is shown multiplied by a factor 10^3.

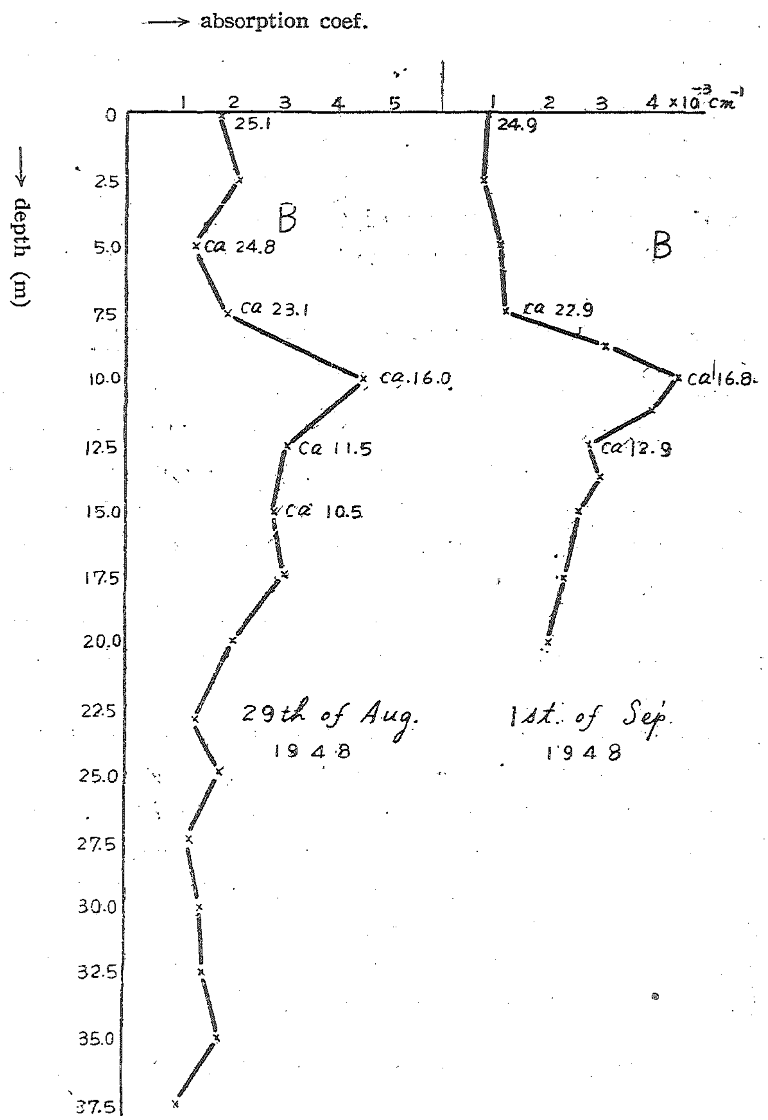


Fig. 3.

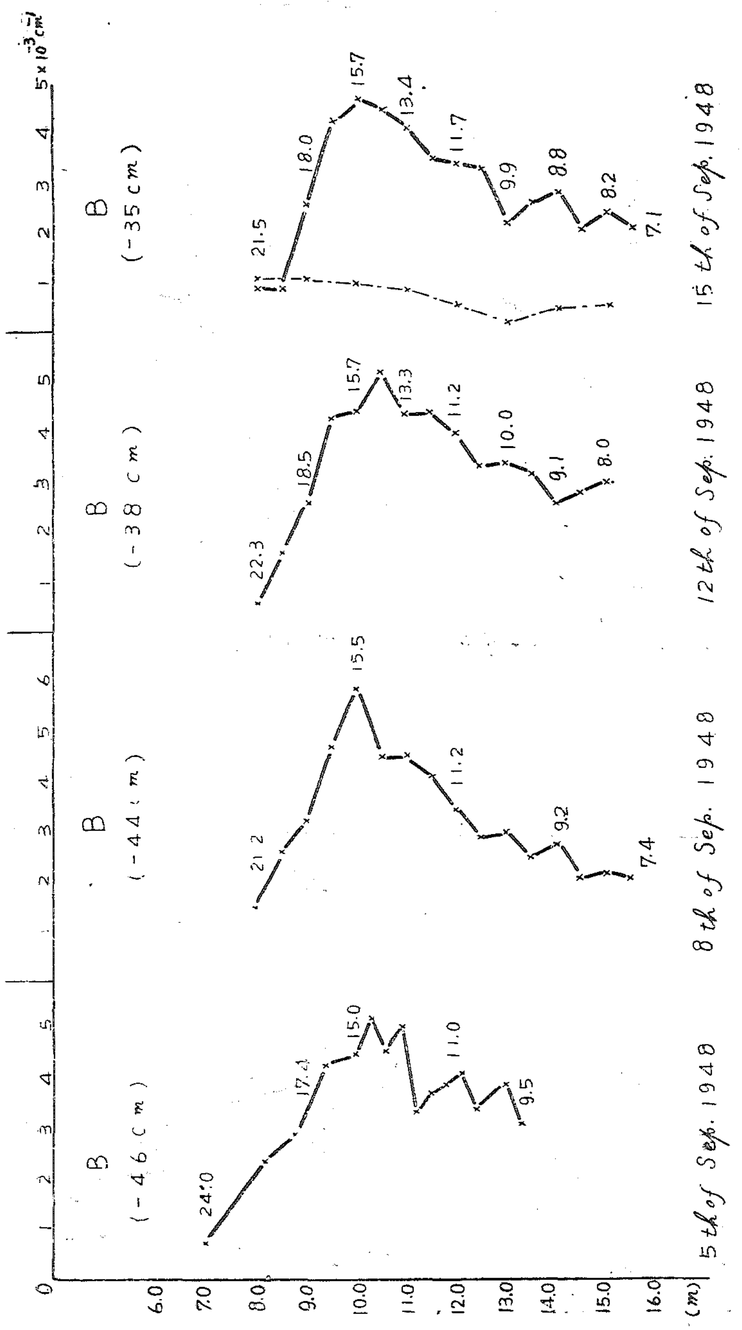

B
(-46 cm)
5th of Sep. 1948
B
(-44 m)
8th of Sep. 1948
B
(-38 cm)
12th of Sep. 1948
B
(-35 cm)
15th of Sep. 1948
(m)

Fig. 4.

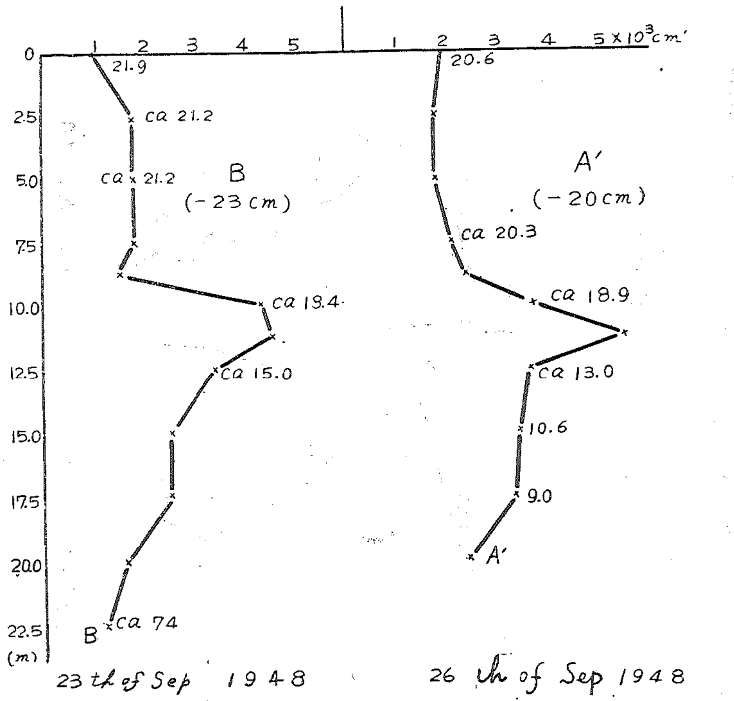

1 2 3 4 5
1 2 3 4 5 x 10³ cm'
0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
(m)
21.9
ca 21.2
ca 21.2
B
(−23 cm)
ca 13.4
ca 15.0
ca 74
B
20.6
A'
(−20 cm)
ca 20.3
ca 18.9
ca 13.0
10.6
9.0
A'
23 th of Sep 1948
26 th of Sep 1948

Fig. 5.

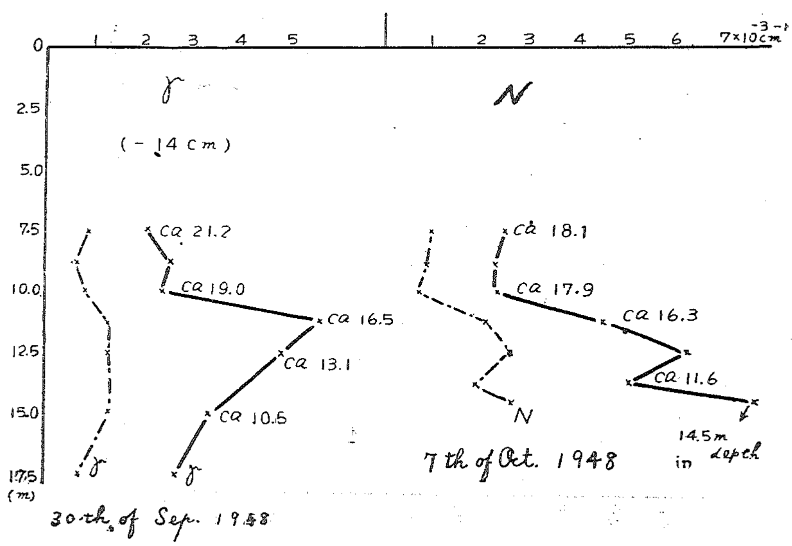

1 2 3 4 5
1 2 3 4 5 6 7 x 10⁻³ cm⁻¹
0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
(m)
γ
(−14 cm)
ca 21.2
ca 19.0
ca 16.5
ca 13.1
ca 10.5
γ
γ
N
ca 18.1
ca 17.9
ca 16.3
ca 11.6
N
14.5 m in depth
7 th of Oct. 1948
30 th of Sep. 1948

Fig. 6.

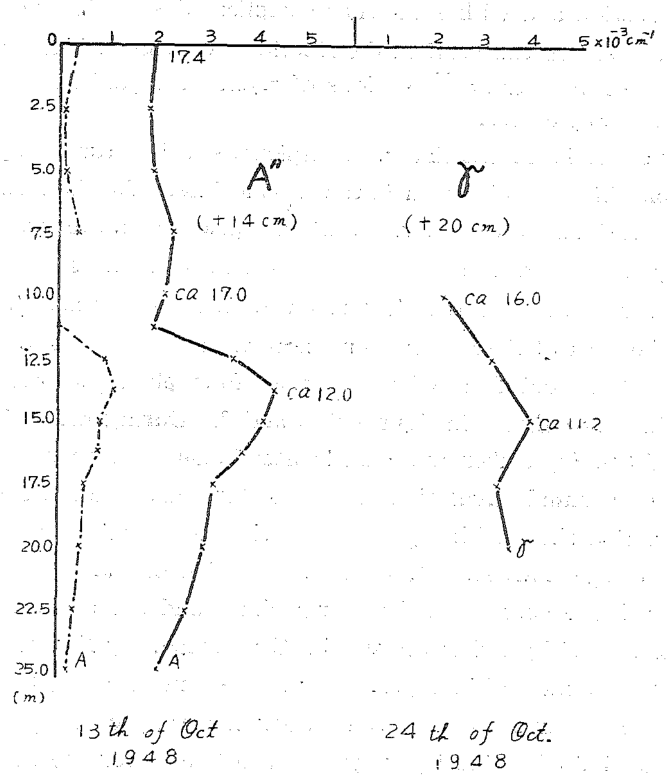


Fig. 7.

From the observation performed on the 29th of August, it is known that the turbid layer existed between 7.5 and 12.5 metres in depth, and also that the position of this turbid layer is included in the thermocline of the lake. The author, therefore, decreased the intervals of the drawing depths to 125 cm. between 7.5 and 15.0 metres in depth, and performed the observation on the 1st of September. From this, it was more accurately known the position of the most turbid part of the layer, viz. it was situated about 10 metres in depth. The author decreased the intervals of the drawing depths to 60 cm. and 30 cm. on the observation of the 5th of September, and decreased to 50 cm. on the observations of the 8th, 12th, and 15th of the same month. (figure 4) From these more minutely performed observations, he has come to think that the state of turbidity of this kind of layer is clarified to some extent, viz. the most turbid part of it falls nearly on the middle layer of the thermocline, the position of it is about 10 metres in depth, the temperature of water at that part is about 15.°5C, and that from this most turbid part the turbidity decreases in both directions, smoothly and somewhat rapidly in the upper direction and with somewhat complicated state in the lower direction. Figure 5 shows the vertical distributions of the turbidity extended to somewhat wide range, the observations of them were performed on the 23rd and the 26th of September.

From them, it is known that no conspicuous thick turbid layer appears except the one hitherto observed in the thermocline. Till the 23rd of September the observations were performed at the place B, however, the author altered the places where the water to be drawn, to make sure whether the turbid layer spread all over the thermocline of the lake or not. The observations after the 26th of September were performed on the 30th of September, and the 7th, 13th, and 24th of October at four places of the lake. The results obtained are shown in figures 5, 6 and 7. During the period after the latter part of the September the cooled water began to descend to the turbid layer by the autumnal circulation of lake water. However, the observations during this period show without exception, that the turbid layer still existed in the fairly conspicuous state, though the position of the layer descended in accordance with the descent of the thermocline; and the temperature of the layer also descended by a few degrees in Centigrade, by the mixing of the cooled water with the turbid layer. From these results together with the results shown in figures 3 and 4, the author naturally comes to the conclusion that this kind of turbid layer spreads nearly all over the thermocline of the lake with the stagnant state covering the deep parts as well as the shallow parts, and gradually descends after the circulation of lake water extends to this layer.

The turbidity which was observed on the 7th of October at the depth of 14.5 metres (figure 6) perhaps belongs to the bottom turbidity.

The chain lines in figures 4, 6 and 7 show the vertical distribution of turbidity of water filtrated by filter papers for qualitative analysis. The filtrations were performed more than 20 hours after the water was drawn out of the lake, and immediately after the filtration the absorption coefficients were measured. These results show that the filtrated water is fairly transparent.

The author has concluded from these results that the most part of the turbidity, at least at the time of its measurements, is caused by the particles which can not pass through the filter paper, and therefore, the sizes of them are larger than the colloid particles. If the turbidity results from the presence of suspended particles, it is also concluded that, at least, the part of the turbidity of the layer above mentioned is caused by the particles, the rate of settling of which was diminished by the abrupt increase of density and of viscosity of water in the thermocline.

Observations performed in 1950 in Lake Aoki.

The observations on the turbid layer in the thermocline in the year 1950 was commenced on the 1st of August and continued to the 26th of October. During this period the observations were performed sixteen times at twelve places of the lake with the measurements of the vertical distribution of the electrical conductivity in addition to the observation of the vertical distribution of the turbidity and of the temperature of the water. The results obtained are graphically shown in figures 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, and 23. The conductivity was relatively measured at constant temperature. The dotted lines in all figures of this paper show the vertical distribution of the conductivity, taking it as abscissae. Numerals noted

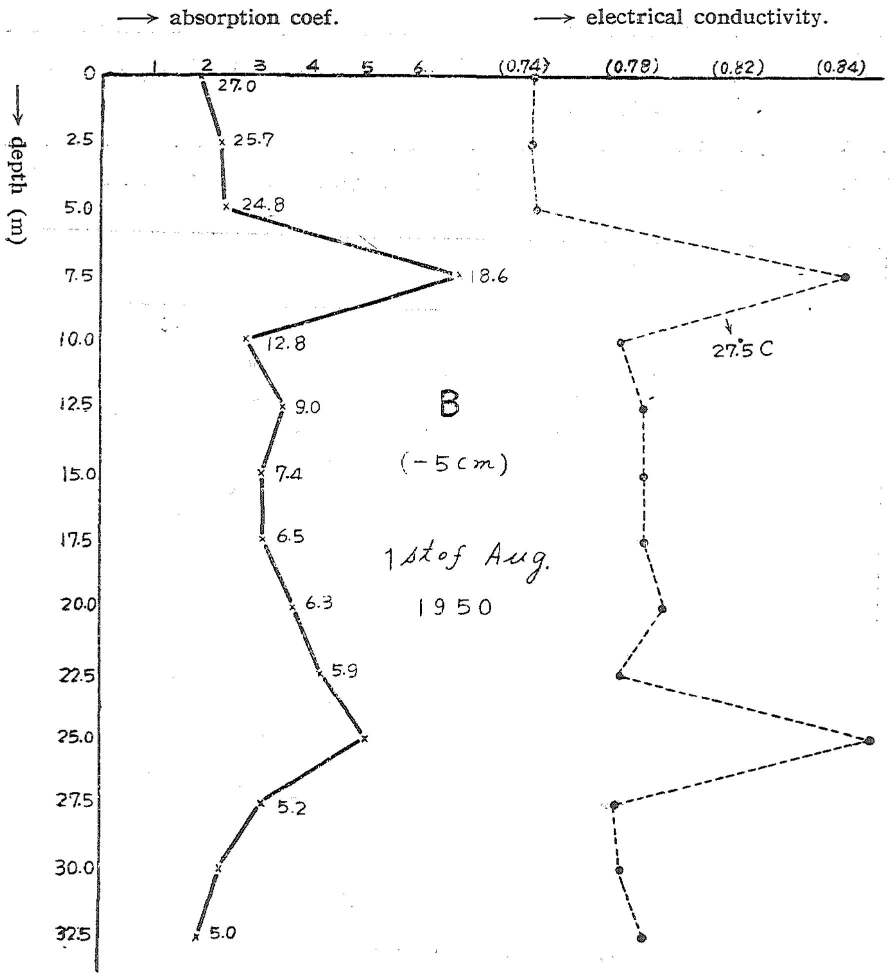


Fig. 8.

with C and appended to the dotted lines show the temperature of water at the time of measurements of its conductivity. The conductivity of the water fairly varies with the temperature, therefore, the actual value of the conductivity of the water when it was in the thermocline or hypolimnion before drawing must be fairly less than that shown in the figures.

Figure 8 show the result of observation performed on the 1st of August. It is evident that two conspicuous turbid layers existed on this day, the upper one between 5.0 and 10.0 metres in depth which belongs to the thermocline, and the lower one about 25 metres in depth, which belongs to the hypolimnion, and at these turbid layers the electrical conductivity show the maximum values. Moreover the conductivity in the epilimnion is somewhat smaller than that of in the thermocline and in the hypolimnion. The author continued the observation on the 3rd of August (figure 9) decreasing the intervals of the drawing depths to 125 cm. to make sure of the result obtained on the 1st of August.

On this day he added the place C as a new place to draw the water to B where the water was drawn on the 1st of August. At B the most turbid

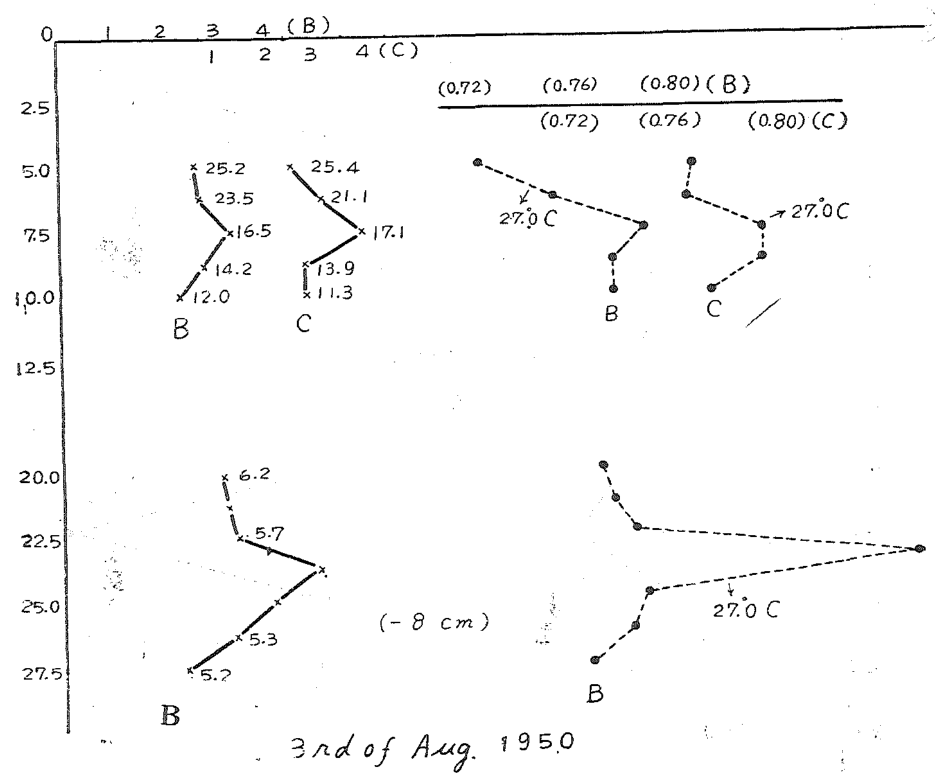


Fig. 9.

parts were found about 7.5 metres in depth, and 23.5 metres in depth, and at C also about 7.5 metres in depth; the maximum values of the conductivity coincide with the turbid layer at both B and C as was observed on the 1st of August. The water temperature of any depth at B differs from that of the same depth at C. It is perhaps due to the internal seiches of the lake. The same phenomenon always appeared when the water to be measured was drawn from more than two places in a day. Figure 10 shows the result of observation performed on the 17th of August to see the state of the vertical distribution of the turbidity and of the conductivity to somewhat wider range. In this observation, the intervals of the drawing depths were all 250 cm.

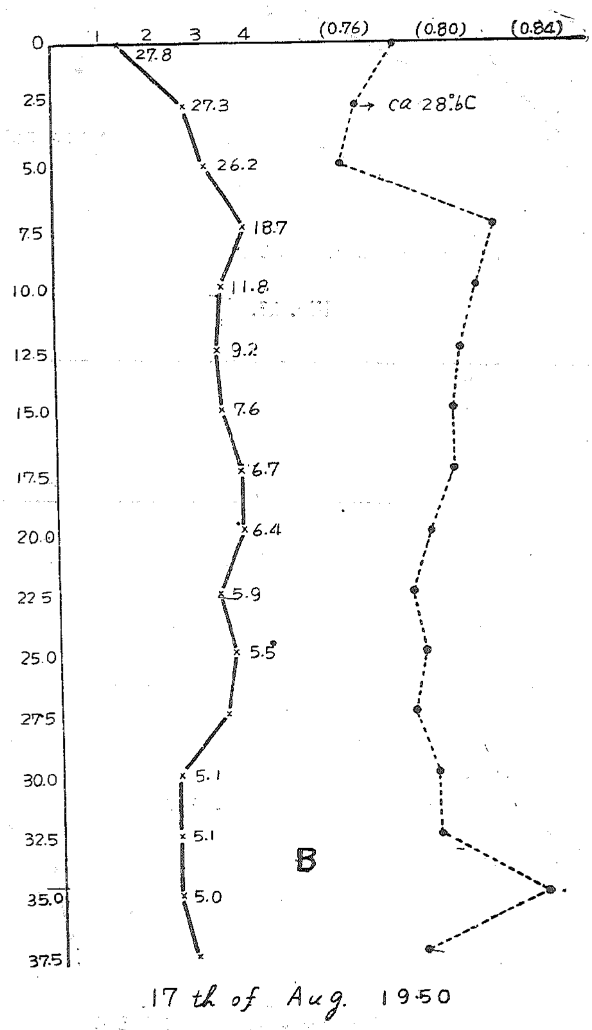
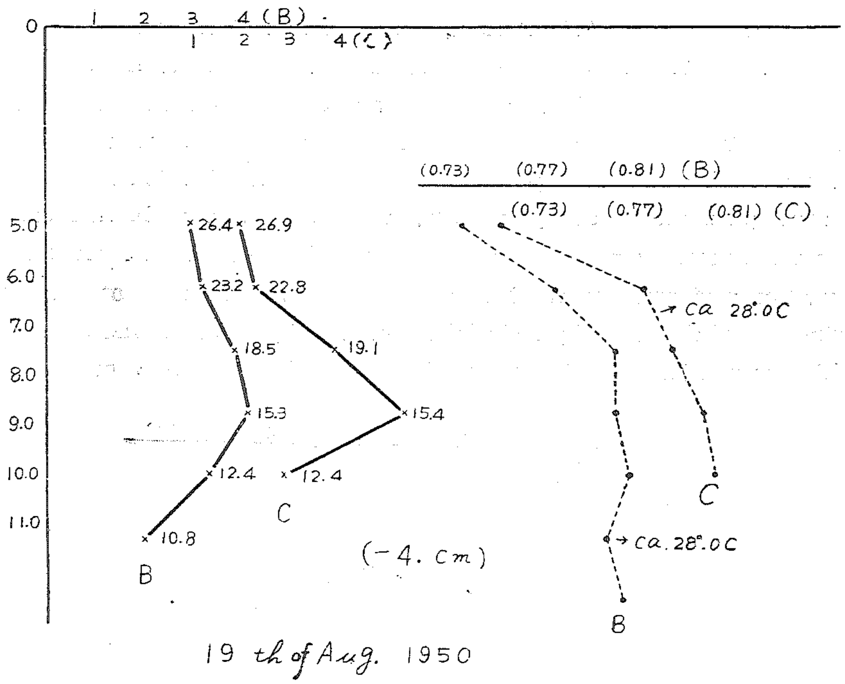
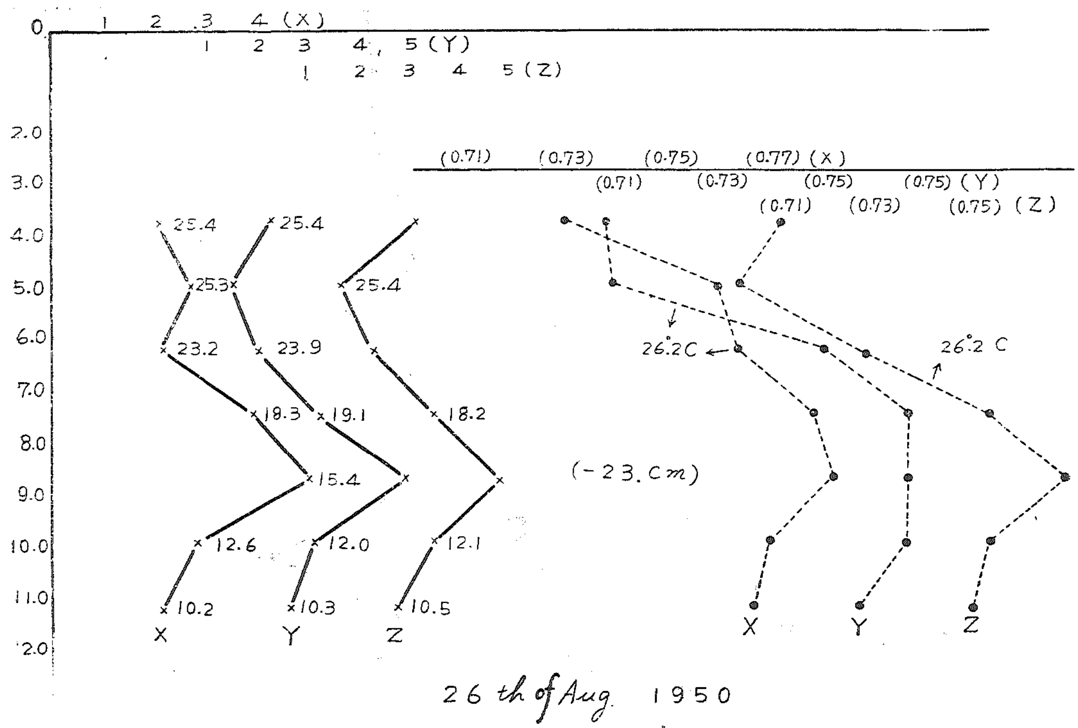


Fig. 10.



0
1 2 3 4 (B)
1 2 3 4 (C)
5.0
6.0
7.0
8.0
9.0
10.0
11.0
26.4 26.9
23.2 22.8
18.5 19.1
15.3 15.4
12.4 12.4
10.8
B
C
(0.73) (0.77) (0.81) (B)
(0.73) (0.77) (0.81) (C)
Ca 28°.0C
Ca. 28°.0C
(−4. cm)
B
C
19 th of Aug. 1950

Fig. 11.



0
1 2 3 4 (X)
1 2 3 4 5 (Y)
1 2 3 4 5 (Z)
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
2.0
25.4 25.4
25.3 25.4
23.2 23.9
18.3 19.1 18.2
15.4
12.6 12.0 12.1
10.2 10.3 10.5
X Y Z
(0.71) (0.73) (0.75) (0.77) (X)
(0.71) (0.73) (0.75) (0.75) (Y)
(0.71) (0.73) (0.75) (Z)
26.2C
26.2 C
(−23. cm)
X Y Z
26 th of Aug. 1950

Fig. 12.

which seems to be too gross to determine the relation between the turbidity and the electrical conductivity, but it was still observed that the turbid layer was situated in the thermocline coinciding with the maximum part of the electrical conductivity as was observed on the 1st and the 3rd, of this month; the turbid layer observed on the 1st of August in the hypolimnion seems to have disappeared on the 17th of August. Further, the conductivity in the epilimnion is somewhat smaller than that in the thermocline and in the hypolimnion, and the change of it occurs somewhat abruptly at the turbid part. The author continued the observation to make sure of the result obtained

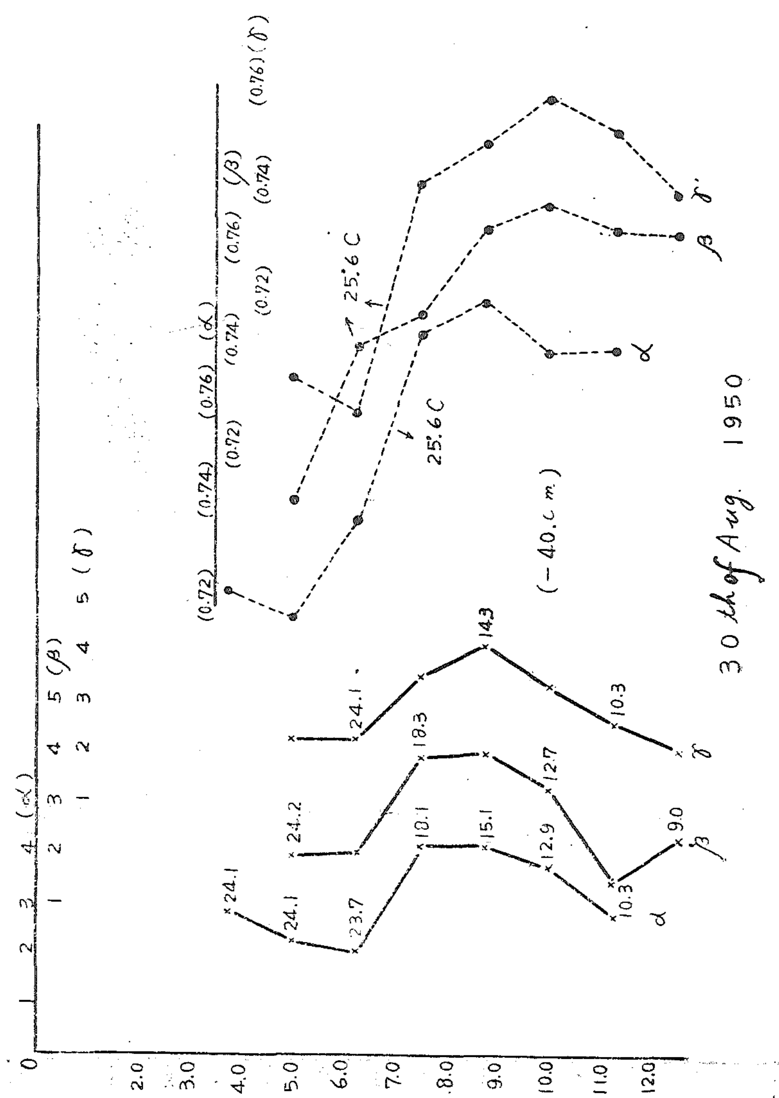


Fig. 13.

on the 17th of August by decreasing the intervals of the drawing depths to 125 cm. two days after at two places B and C (figure 11). At both places, the most turbid parts find themselves about 8.75 metres in depth which falls on the middle layer of the thermocline. At B the conductivity increases as the depth increases down to the most turbid part, and then the variation seems very slight; at C the measurements in deeper parts are wanting, but

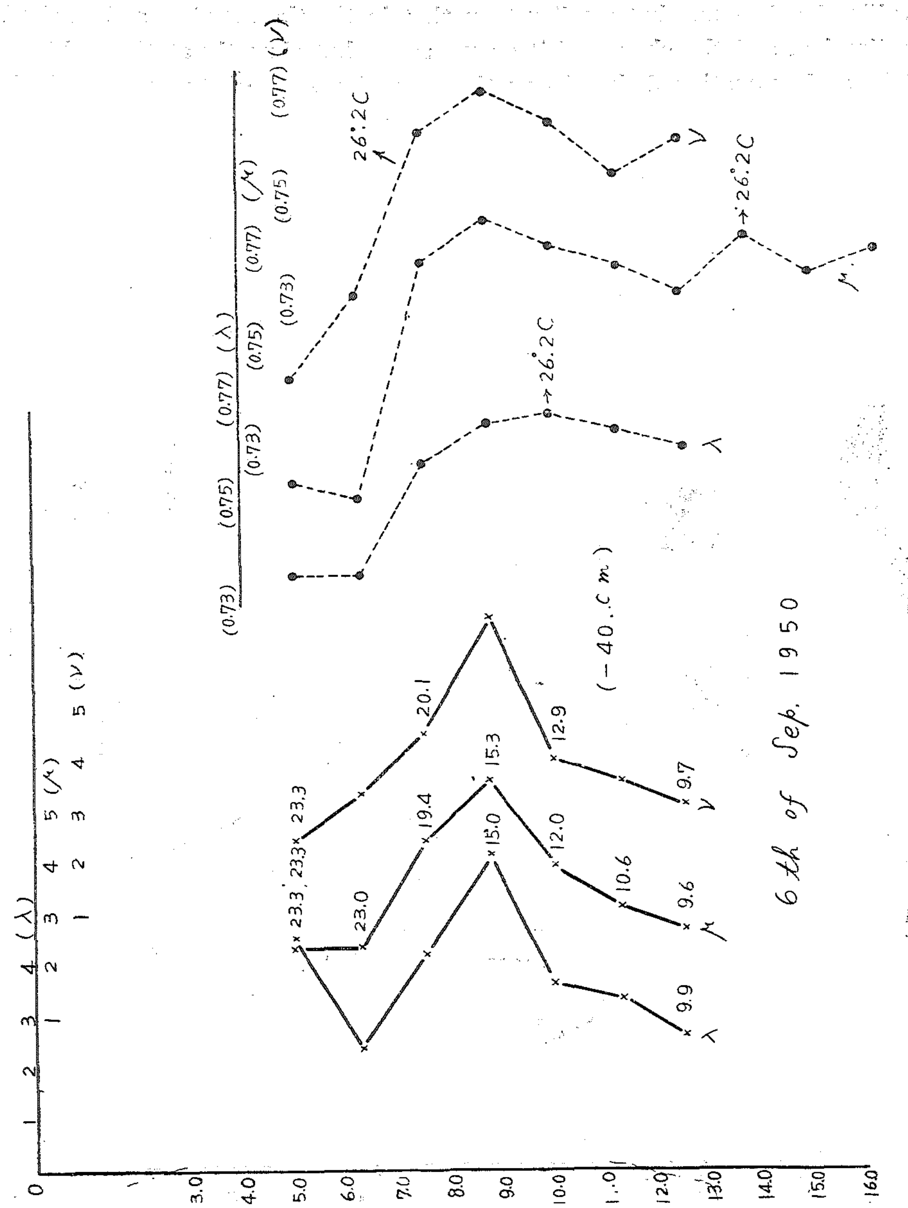


Fig. 14.

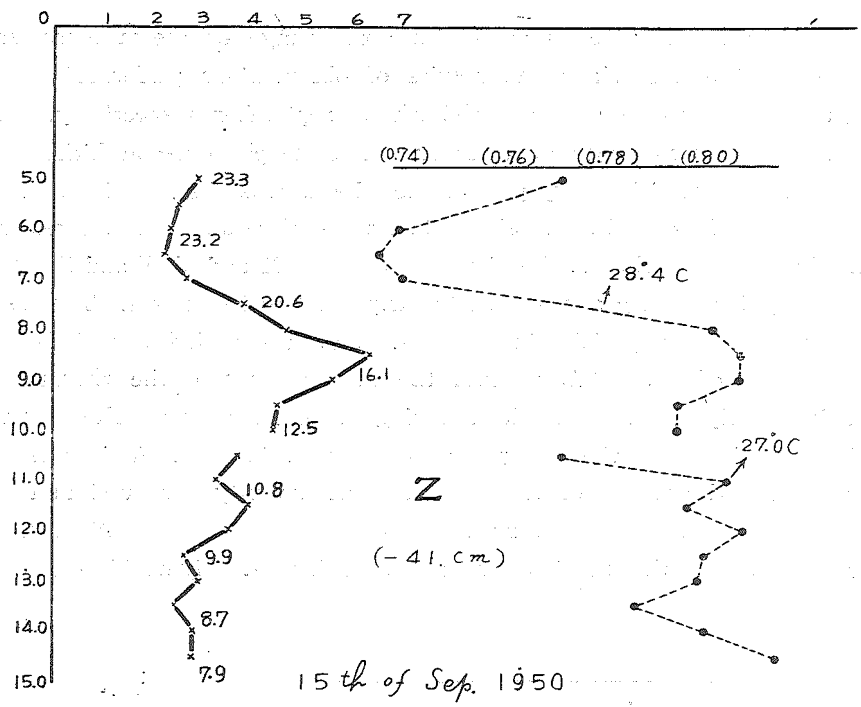

0
1
2
3
4
5
6
7
(0.74)
(0.76)
(0.78)
(0.80)
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
23.3
23.2
20.6
16.1
12.5
10.8
9.9
8.7
7.9
28.°4 C
27.°0C
Z
(−41. cm)
15 th of Sep. 1950

Fig. 15.

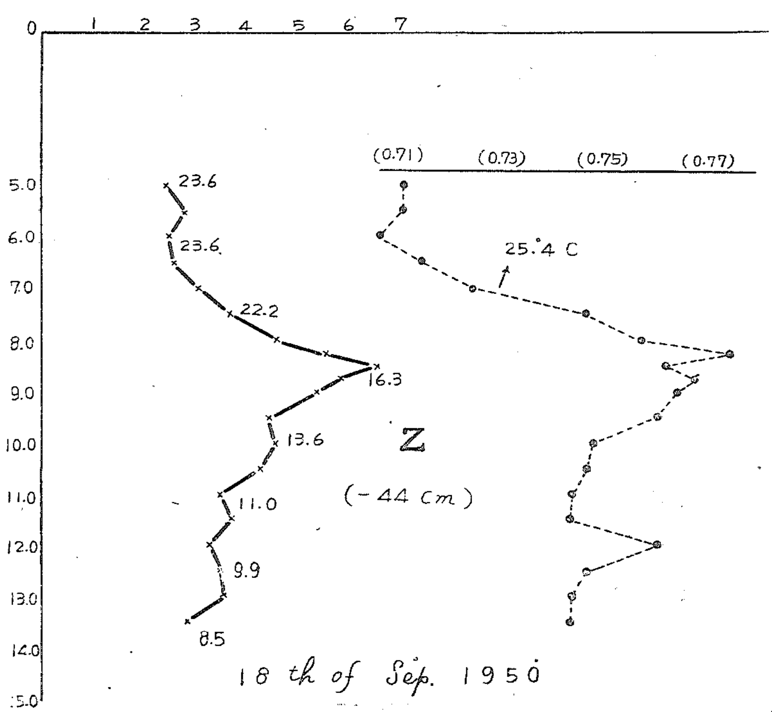

0
1
2
3
4
5
6
7
(0.71)
(0.73)
(0.75)
(0.77)
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
23.6
23.6
22.2
16.3
13.6
11.0
9.9
8.5
25.°4 C
Z
(−44 cm)
18 th of Sep. 1950

Fig. 16.

appears the same feature as at B within the range of the measurements. Figures 12, 13 and 14 show the results of observations performed on the 26th, and the 30th of August and the 6th of September respectively. They were intended for making sure whether or not the phenomenon hitherto observed also appeared in every part of the lake as was observed in 1948.

The places X, α and λ are situated on the surface about 100 metres from each of the nearest shores, the distances between X and Y, Y and Z, α and β, β and γ, λ and μ, μ and ν are all nearly equal to 100 metres. The results of observations were positive in all cases. The most turbid part finds itself at the depth of about 8.75 metres, the middle layer of the thermocline, spreading nearly all over the lake covering the places near the shore as well as the central part of the lake as was observed in 1948. And it is also observed that the values of the electrical conductivity are maximum near this 8.75 metres in depth at every part of the lake, without exception, though at certain places the maxima are not conspicuous. Figure 15 shows the

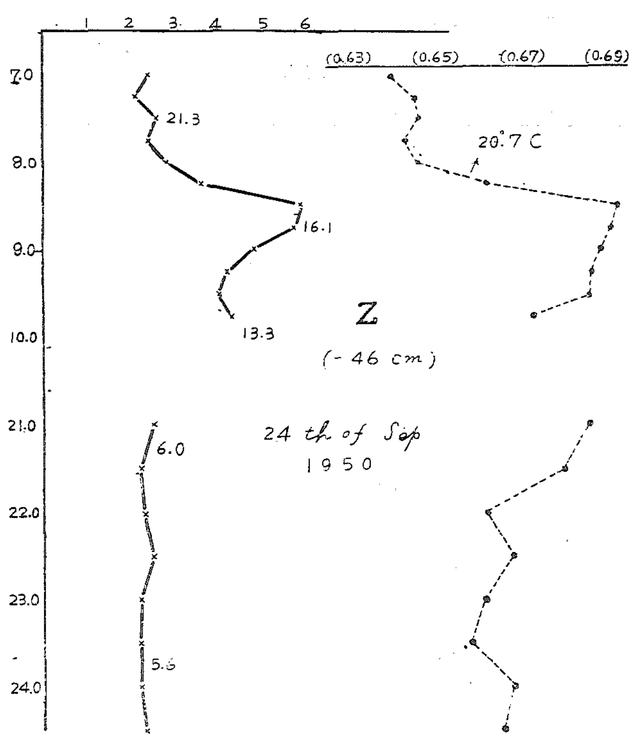


Fig. 17.

result of observation performed on the 15th of September. The intervals of the drawing depths were decreased to 50 cm. The measurements on the water drawn from the spot deeper than 10.5 metres were performed in the morning of the next day. This is one of two cases where the measurements were performed more than 20 hours after the water to be measured was drawn out of the lake. Another case is the measurements on the water drawn on the 7th of October. The most turbid part of the layer finds itself at the depth of about 8.5 metres which falls on the middle layer of the thermocline, and the turbidity decreases in both directions, smoothly in the upper direction, and with somewhat complicated feature in the lower direction as was observed in 1948.

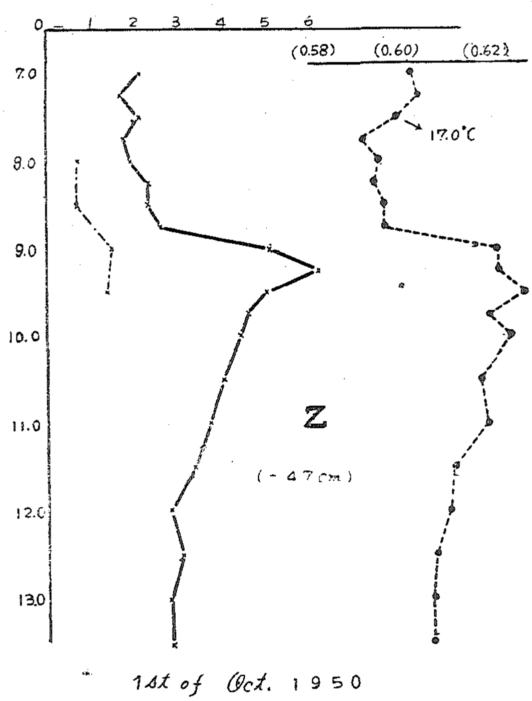


Fig. 18.

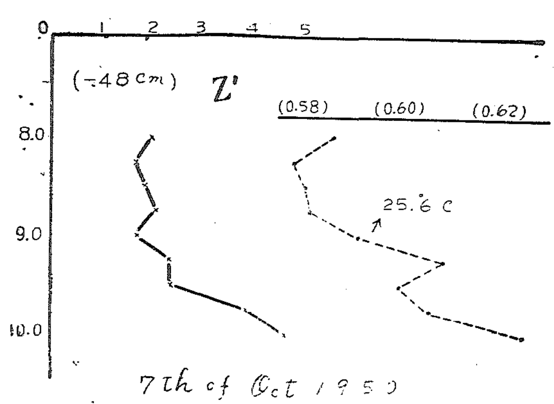


Fig. 19.

In the upper part of the graph, the larger value of the conductivity corresponds very distinctly to the larger value of the absorption coefficient, and the smaller value of the former to the smaller value of the latter respectively. The all observations after this day were performed at places Z and Z′, both are situated distant about 300 metres from the north shore of the lake. Figure 16 shows the result of observation performed on the 18th of September. On this day, the intervals of the drawing depths near the most turbid part were decreased to 25 cm.

On both turbidity and the conductivity almost the same tendencies were observed as in the observation on the 15th of September. Figure 17 shows the result of observation performed on the 24th of September. On this day, the observation was extended in the hypolimnion, viz. between 21 and 24.5 metres in depth. In the thermocline, the relation between turbidity and conductivity was the same as it had been before. The same tendency was observed to exist in the hypolimnion, but the phenomenon is not conspicuous. Figure 18 shows the result of observation performed on the 1st of October, which still shows the same tendency as is shown in figure 17. But the most turbid part descended by the amount from 50 cm. to 80 cm. during a week by the fair advancement of the circulation of the lake water. Figure 19 shows the result of observation performed on the 7th of October, which is only one case that the water for measurement was drawn at night. The water was drawn between about 10 o'clock P.M. and 11 P.M. and the measurements on the water was performed in the evening of the next day.

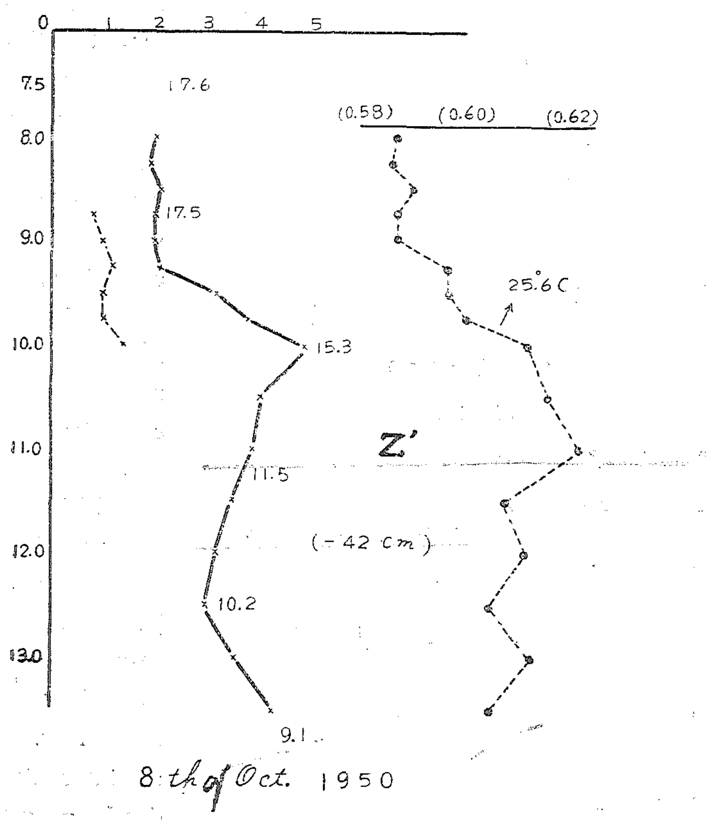


Fig. 20.

The measurements in the part deeper than 10.0 metres in depth are wanting, therefore, it is inadequate to determine the position of the maximum turbidity. However, within the range of measurements, the turbidity and conductivity show quite the same features as were observed on the 1st of October and on the days of September. Further, from the fact that both turbidity and conductivity show the largest values at 10.0 metres in depth, it is evident that the depth of the layer of the maximum turbidity of this day increased by an amount probably more than 60 cm. compared with that of the 1st of October. Figure 20 shows the result of observation performed on the 8th of October. The most turbid part finds itself about 10.0 metres in depth, at the temperature of 15.3 C, viz. in the middle layer of the thermocline; and the whole state approximates much to the general features shown in 18. Figure 21 shows the result of observation performed on the 12th of October. The most turbid part descended to the depth of about 10.5 metres. The results of observations performed in the period from the 15th of September to the 8th of October (figures from 15 to 20) show nearly the same feature, but the graph in figure 21 show slightly varied state. However, the relation between turbidity and conductivity is still fairly distinct, viz. the graphs showing the turbidity and conductivity are parallel in the upper part of the graph, as were observed on previous days. Figure 22 shows the result of observation performed on the 18th of October. The most turbid part descended to the depth of about 11 metres, the tendency concerning the turbidity and conductivity was just as observed as before. Figure 23 shows the result of observation performed on the 26th of October. The most turbid part descended

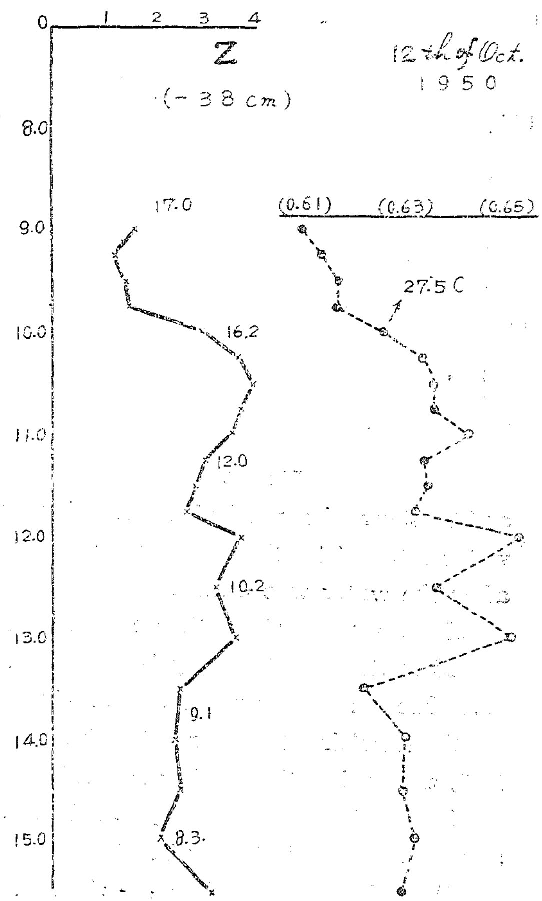


Fig. 21.

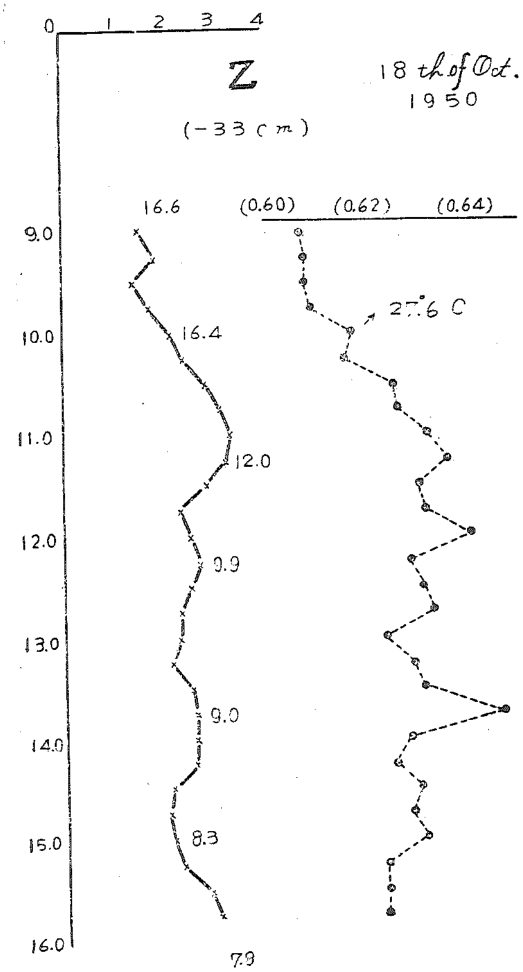


Fig. 22.

to the depth of about 12 metres perhaps due to the conspicuous progress of the circulation of the lake water. The relation between turbidity and conductivity was still fairly distinct as was observed on the 12th and the 18th of October. The water temperature at the most turbid part was about 16.0 C during the stagnant period, viz. from the commencement to the 24th of September, which is nearly the same value as was observed in 1948; and then it began to decrease by a small amount after the mixing of water reaches to this layer by the progress of the circulation of the lake water as was observed in 1948; and decreased to about 13°.0 C on the 26th of October, the day of the last observation for the purposes of making sure of the stagnancy of this kind of turbid layer and finding out the correlations between turbidity and conductivity in 1950.

The chain lines in figures 18 and 20 show the vertical distributions of the absorption coefficient of the water filtrated by the filter paper for qualitative analysis more than 10 hours after the water was drawn.

These results show that the filtrated water is fairly transparent, and therefore that the turbidity is caused almost by the particles which can not pass through a filter paper as was observed in 1948.

Summarizing the all results obtained by the observations performed in 1950, the author thinks that it can be concluded as follows:

Concerning the turbid layer, it has developed quite similar in every point as was observed in 1948, viz.

(1) It has developed in the thermocline spreading all over the lake, in stagnant state in the late in the summer.

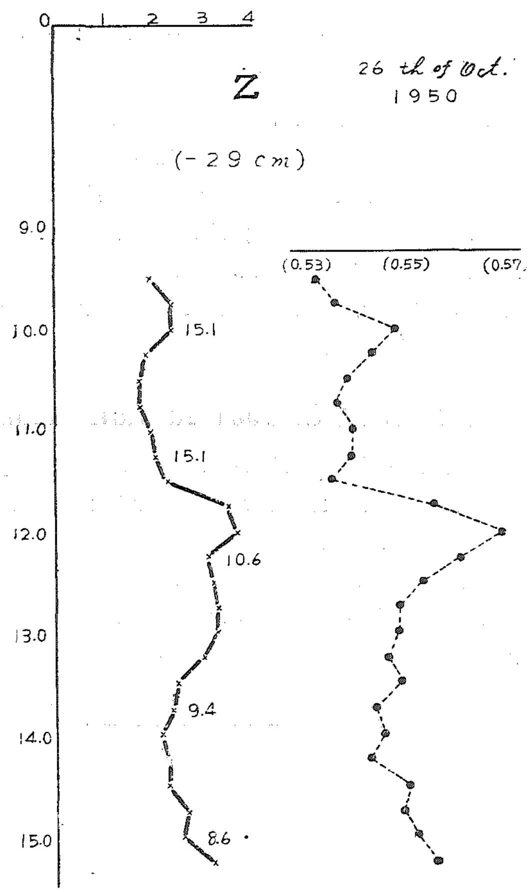


Fig. 23.

(2) The position of the maximum turbidity always falls on the middle layer of the thermocline, the depth of which was about 9 metres.

(3) From this most turbid part the turbidity decreases smoothly and somewhat rapidly in the upper direction, and decreases with somewhat complicated state in the lower direction, viz. there is a tendency that the micro-layers superpose on the lower part of the layer.

(4) The temperature of water at the most turbid part was maintained about 16°.0C during the period that the autumnal circulation of lake water is not yet conspicuous.

(5) After the mixing of water by the progress of the circulation extends to the turbid layer, the most turbid part gradually descends, and the temperature of this part also gradually decreases, the amount of descent of this year was a few degrees in Centigrade.

(6) It seems that the turbidity of the water drawn from the turbid layer

is caused, at least after more than 10 hours from drawing of the water, by the suspended particles somewhat larger than the colloid particles.

Concerning the electrical conductivity as follows:

(1) The value of it is conparatively small in the epilimnion.

(2) In the upper part of the turbid layer in the thermocline, the conductivity increases parallel to the increasing of the turbidity.

(3) Generally the conductivity attains to the largest value at the most turbid part of the turbid layer, and from this layer the variation in the lower direction is not conspicuous.

Observations performed in 1951 in Lake Aoki.

The author continued the observations on this kind of layer in 1951, with the simultaneous observations on the vertical distribution of pH etc. in addition to that of hitherto performed.

The results obtained are shown in figures 24, 25, 26, 27, 28, and 29. Figure 24 shows the result of observation performed on the 1st of August. On this day, the turbidity from the surface to the depth of about 13 metres

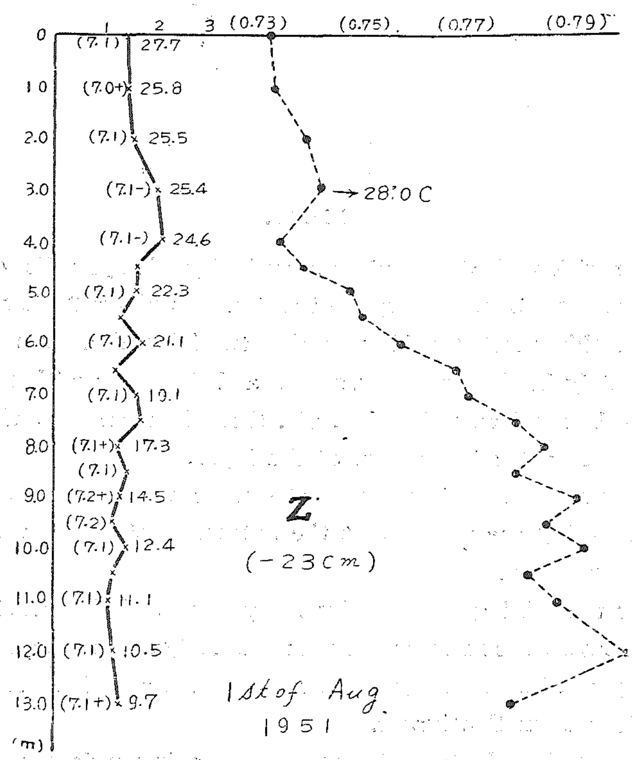


Fig. 24.

was measured. As is seen from the graph, the turbidity is faint within this range of measurements, and there not yet found a conspicuous turbid layer in the thermocline, though the electrical conductivity already shows the same feature as were observed in the previous year.

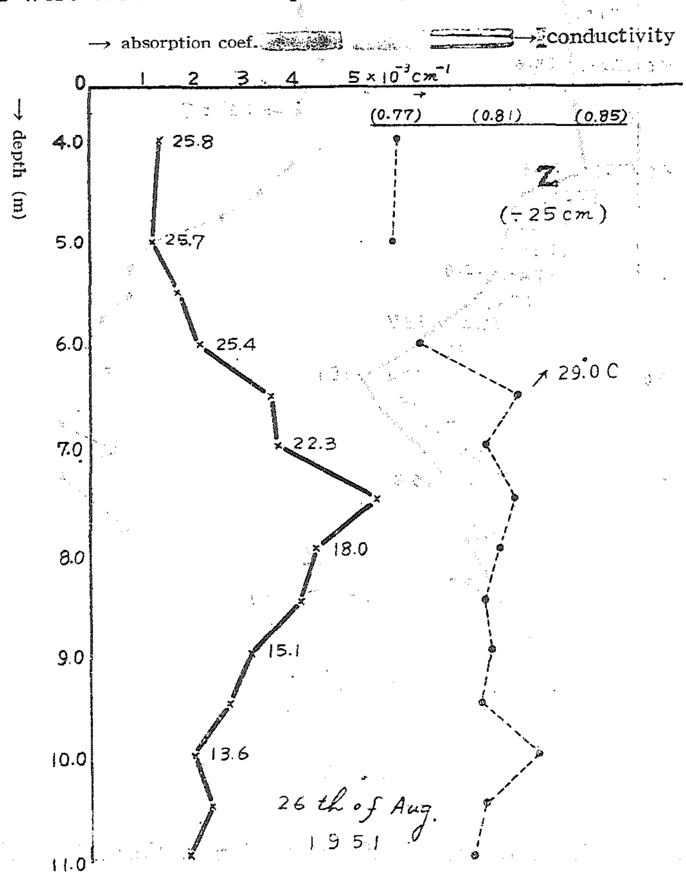


Fig. 25.

Numerals bracketed and appended to the left sides of the graphs representing the turbidity show pH at that depth, which also shows no conspicuous layer as in the turbidity. But on the 26th of August (figure 25) a conspicuous turbid layer was observed in the thermocline as was observed in the former years. The vertical distribution of electrical conductivity also shows the same feature as was observed in the previous year and on the 1st of August of this year. Figure 26 shows the result of observation performed on the 30th of August, which much resembles that of observed on the 26th of this month. Further, the vertical distribution of pH was measured on this day, which shows that at the turbid layer the water is alkaline in some

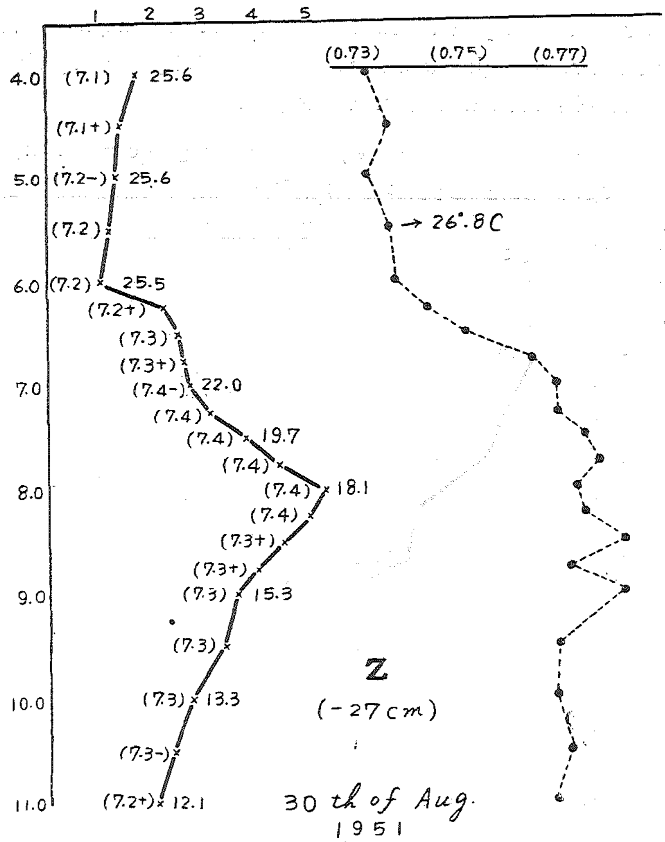


Fig. 26.

degree. Figure 27 shows the result of observation performed on the 2nd of September. On this day, the place of drawing water was altered, but the features of the graphs representing the turbidity and the conductivity much resembles that of observed on the 26th, and the 30th of August, and also with the same result in the case of pH. Figure 28 shows the result of observation performed on the 12th of September. On this day, the circulation of water advanced in some degree by the abortive descendance of the atmospheric temperature of this month, therefore the turbidity, the variation of the electrical conductivity and also the alkalinity of water in the turbid layer became faint, and further the most turbid part of the turbid layer somewhat descended as was observed in the previous years. But the vertical distribution of them still retain the same features as were observed in previous days.

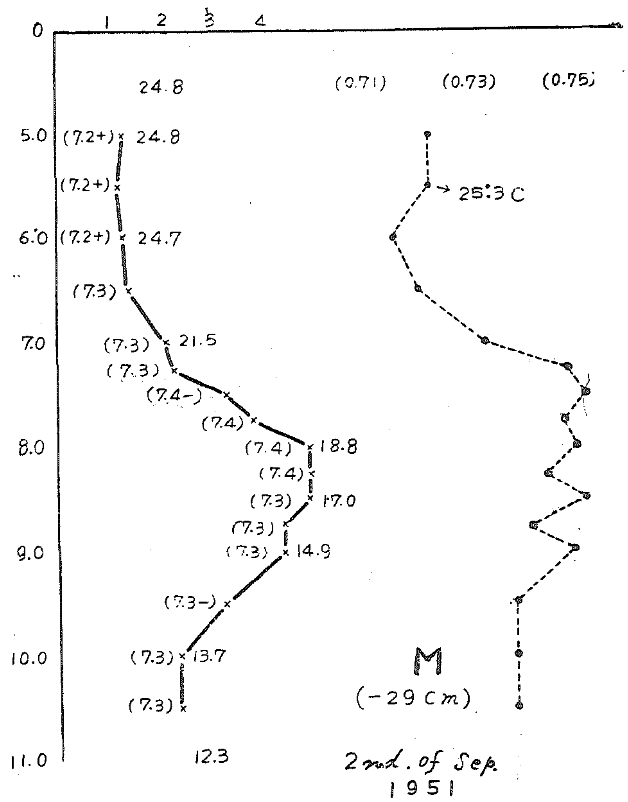


Fig. 27.

On this day, further, the amounts of dissolved oxygen and of nitrogen were measured by Ariyuki Aihara.(2)

Table II. Degree of saturation (%) measured on the 12th of Sep. 1951.

drawing depth (m)	0	6.0	8.25	11.0
N_2	105	105	118	115
O_2	106	104	138	126

Table II shows the results of his measurements. Numerals in the table represent the degree of saturation of oxygen and nitrogen at the water temperature before its drawing. Really, the nitrogen contains small amounts of another gases. Both oxygen and nitrogen are in the states of supersaturation in the thermocline.

Further, the degree of saturation of oxygen is more conspicuous than

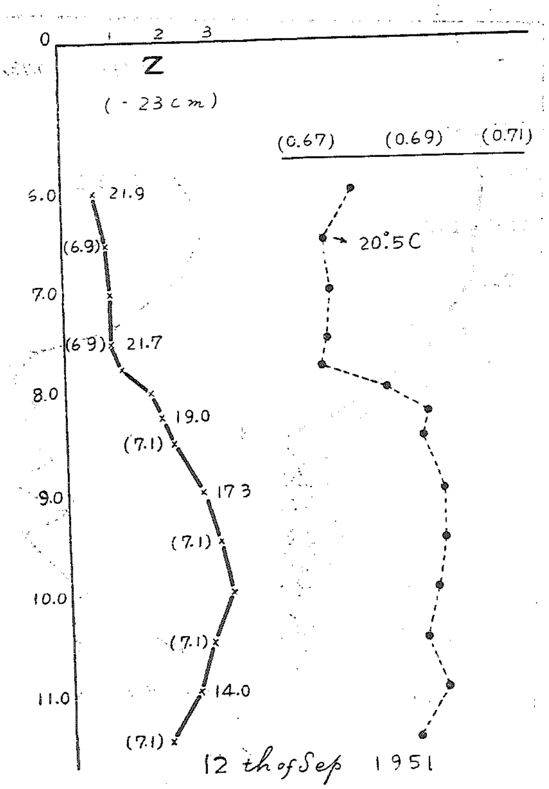


Fig. 28.

that of nitrogen, as was already observed by S. Yoshimura and other researchers. Figure 29 shows the result of observation performed on the 17th of October. On this day, the circulation of lake water already fairly advanced, and the stratifications are almost disappeared, retaining only a lingering trace. In summarizing the all results obtained from the observations performed in 1951, the author believes it can be concluded as follows, though the number of times of the observations were small, because of the abortive coolness of the atmosphere early in September.

(1) On the turbidity and the conductivity after the development of the turbid layer in the thermocline, the same phenomena were observed quite similar in every point to those observed in 1948 and in 1950, except a small fact that the water temperature at the most turbid part was higher, by the amount of order of 2°C than that observed in 1950.

(2) The water at the turbid layer is slightly alkaline compared with the water in other layers.

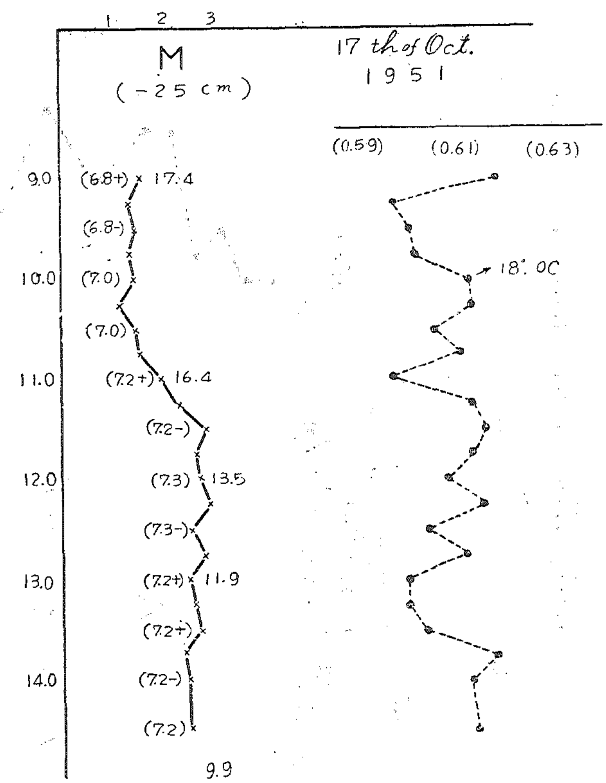


Fig. 29.

(3) The degree of saturation of dissolved oxygen and nitrogen is largest in the thermocline.

Between these gases the degree of the saturation of the former is higher than that of the latter.

Observations on this kind of layer before 1948.

Throughout the year 1940 and 1941, the author measured the vertical distribution of the turbidity of Lake Aoki to observe the seasonal variation of the turbid layer.

The results obtained were reported in the Journal of the Meteorological Society of Japan.(3)

The observations performed on the 23rd of August, the 27th of August, the 29th of September of the year 1940, and on the 17th of August, the 5th of October of the year 1941 fall on the period during which the stagnant turbid layer develops in the thermocline.

On the 17th of August 1941 a turbid layer was found at the depth of

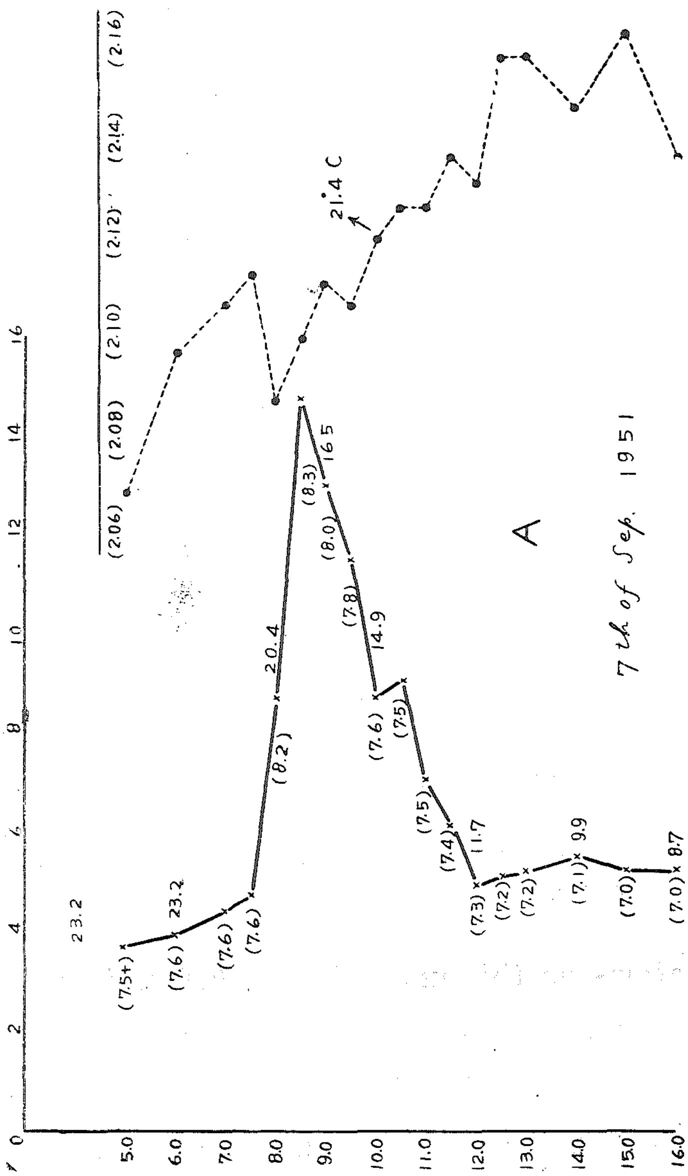


Fig. 30.

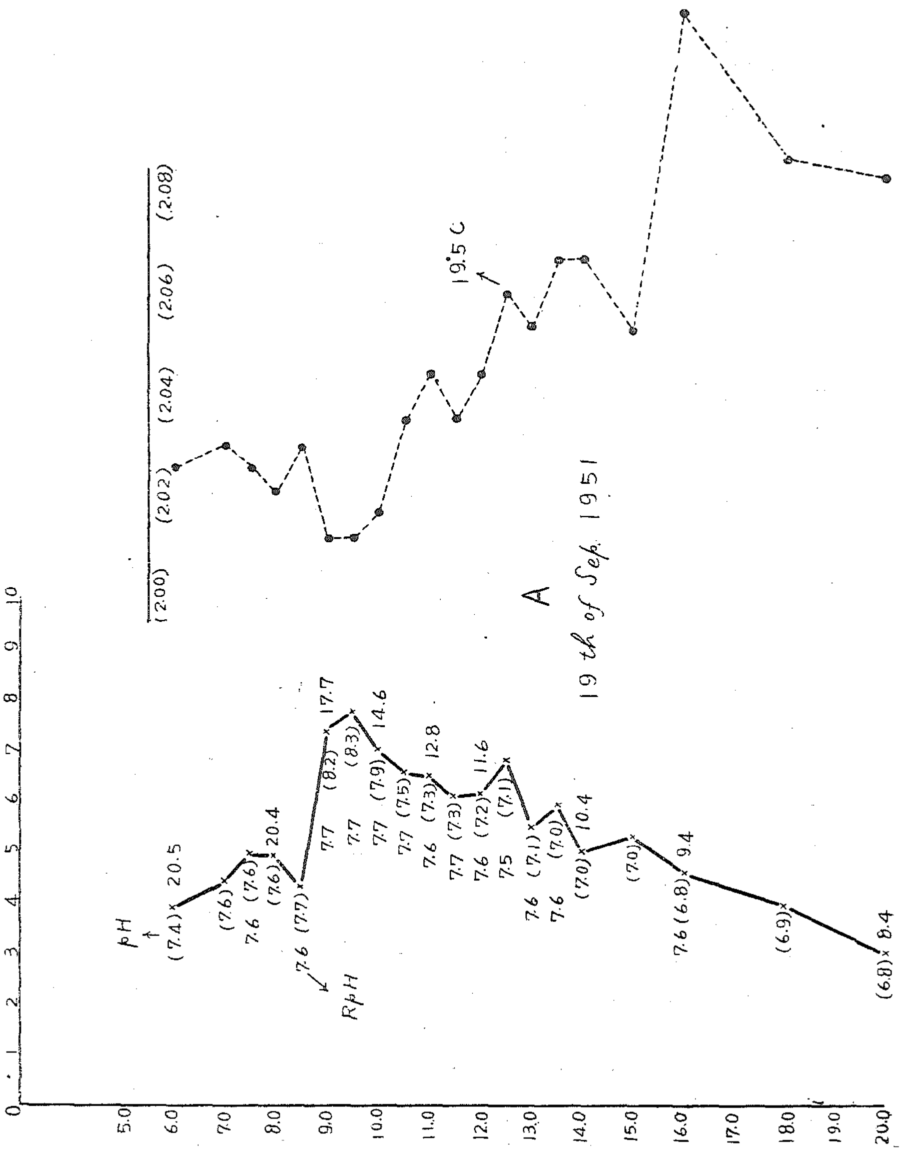


Fig. 31.

about 8 metres; and on the 5th of October of the same year it was found at the depth of about 10 metres, both corresponding to the middle layer of the thermocline.

In the observations performed in 1940 the intervals of the drawing depths were 5 metres, which is too gross surely to detect the turbid layer of this kind, and therefore, it will be probable that the turbid layer escaped from the observation, though it had been in existence.

Observation performed in Lake Noziri.

The author extended the observations to Lake Noziri in 1951. The observations were performed on the 7th, and the 19th of September. Figure 30 shows the result of observation performed on the 7th of September.

The turbidity and the alkalinity of the turbid layer are very conspicuous.

The most turbid part and the most alkaline part fall well on the middle layer of the thermocline, where the water temperature is about 18.0°C.

From this middle layer, both turbidity and alkalinity decease abruptly in the upper direction, while in the lower direction with slightly complicated state, as was always observed in Lake Aoki.

The vertical distribution of the electrical conductivity is somewhat different from that of Lake Aoki.

The conductivity increases, roughly considering, straightly toward the bottom within this range of measurements, while in lake Aoki the conductivity also increases toward the bottom, but somewhat abruptly in the upper part of the turbid layer and then the variation is slight toward the bottom.

Moreover, the numerical values of the conductivity of the water of this lake is, roughly considering, three times as large as that of Lake Aoki.

Figure 31 shows the result of observation performed on the 19th of September.

The numerals without bracket on the left side of the turbidity graph show the Reserve pH, which is constant within the range of measurements.

On this day, the circulation of lake water somewhat advanced and the most turbid part of the turbid layer descended approximately 1 metre more in the case of the previous observation, as was always observed in Lake Aoki in this season of the year.

From the feature of the graph, it seems that the self-collapsing action of the layer fairly advanced.

However, the phenomena observed on the 7th of September still remarkably remain, viz., the alkalinity and the turbidity at the most turbid part of the layer are still conspicuous, and the distribution of the conductivity also shows nearly the same feature.

On this day, the amounts of dissolved oxygen and of nitrogen in the water of the turbid layer were measured by A. Aihara.

Table III shows the results of his measurements. Numerals in the table show the degree of saturation of dissolved oxygen and nitrogen at the water temperature before its drawing, as in the case of Lake Aoki.

Table III. Degree of saturation (%) measured on the 19th of Sep. 1951.

drawing depth (m)	8.0	9.0	10.0	11.0
N_2	101	119	121	119
O_2	106	138	131	118

The nitrogen contains small amounts of another gases. Both oxygen and nitrogen are in the state of supersaturation in the turbid layer, the degree of saturation is most conspicuous where the turbidity is remarkable. Further, the degree of saturation of oxygen is more remarkable than that of nitrogen as was observed in Lake Aoki.

Summary.

(1) This kind of turbid layer appeared in every year, without exception, when the days of the author's observations, making the intervals of the drawing depths less than 250 cm., were included in the period from the late summer to the early autumn.

(2) In every case in every year, when the minute observations were performed, the states concerning the turbidity, electrical conductivity, hydrogen ion concentration, with the correlations among these factors, presented themselves with the same feature as are mentioned in the ends of sections "Observations performed in 1950 in Lake Aoki" "ditto in 1951".

The author thinks the facts are considered to be important to conclude the stagnancy of the layer, that all observations in detail, show nearly the same results, without exception.

(3) The amount of dissolved oxygen and of nitrogen are in the states of supersaturation in the thermocline.

Further, the degree of the saturation of the former is more conspicuous than that of the latter.

(4) In Lake Noziri, nearly the same phenomena were also observed, as were observed in Lake Aoki, besides the phenomenon concerning the electrical conductivity.

Moreover, Toshiji Takemura[(4)] has measured the vertical distributions of the density of lake water reduced to the same temperature, and of the amount of consumption of potassium permanganate, in Lake Aoki and Lake Noziri, and obtained the results that the maxima of them fall on the turbid layer in the thermocline.

Of course, these are the important factors to clarify the nature of the turbid layer.

In conclusion, the author wishes to thank the Ministry of Education for the Grant in Aid for Fundamental Scientific Research with which he has been able to make such observations as he liked.

Masayuki MUKAI.
Department of Physics,
Faculty of Liberal Arts
of Shinshu University.

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(4) Tutor of Shinshu-Univ.