

DIFFUSION IN THE WAKE
OF AN OUT-BOARD MOTOR BOAT

by

T. P. Halappa Gowda

Submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy

Department of Civil Engineering
School of Graduate Studies
University of Ottawa
Ottawa, Canada

April 1972

PREFACE

The wake of a watercraft may be used as a mixing device in some situations in the control of water quality. The dispersion in the wake may have a favourable or adverse effect on the water quality so that a study of the dispersion phenomenon in the wake would be desirable and it would help resolve the controversies involved. Wakes of watercraft may be used as mixing devices in the following situations:

1. To spread chemicals for the control of aquatic weed growth and algal blooms in natural bodies of water.
2. To disperse wastes and dredging spoil by discharging them into the wakes of vessels.
3. To spread a disinfectant for the control of pollution in beaches.
4. As artificial aeration devices.

This study was undertaken to investigate the diffusion in the wake of an out-board motor boat in a pond under quiescent conditions with the following objectives:

1. To examine the adequacy of wake models (cited in the literature) which are used to describe the diffusion phenomenon in a wake at a free surface and of which the wake of a boat is a typical example.
2. To determine the boundaries of the diffusion zone.
3. To study the variation of maximum concentration and to determine the diffusion coefficients.
4. To compare the results of this study with similar values in the literature.

5. To attempt to improve diffusion characteristics of the motor through simple modifications of the motor.

The last objective could not be attempted because of the limitations involved in conducting the tests.

Tests were conducted in a pond when the winds were calm as indicated by the undisturbed water surface. A fluorescent dye was used as a tracer which was injected into the wake at the centre of propeller. The dye was found to disperse mainly due to the masses of water set into motion by the action of the propeller. In some of the tests conducted, the dye was observed to move away from the test section even though the water surface was calm; this may be due to the persistence of currents due to winds prior to the test. In some other tests, winds started when the tests were in progress which resulted in the dye being blown out of the test section. (This was visible). In the analysis of data, the results of only those tests that were believed to be unaffected by these effects have been considered.

A simple, inexpensive sampling device was designed and used successfully to collect depth-integrated samples from an observation platform simultaneously at several points in a cross-section of the wake at regular time intervals. The samples were analyzed fluorometrically. A plot of observed fluorescence versus time at each sampling point resulted in zig-zag curves; a smooth line was drawn through

the points and these smoothed values were used in the analysis of data.

The concentration distribution at a cross-section in each test seemed to differ considerably from one test to another even though each test was conducted with the same initial and boundary conditions; this may have been due to the effects of bottom springs and variations in weather conditions. Hence an ensemble average could not be taken as a first step in the analysis of data. Thus, the data of each test were analyzed individually.

The concentration distribution in the wake showed that the dispersion phenomenon in the boat wake, which is typical of a wake at free surface, cannot be described by the classical wake models. Attempts have been made in this study to explain the formation and structure of these wakes. Based on this explanation, and a theoretical analysis of flows in the wake of a self-propelled body, a mathematical model to explain the diffusion in the wake has been developed. The lack of velocity and turbulence measurements in the wakes of boats and ships made it difficult to employ the most appropriate scales of flow, requiring suitable approximations instead. According to this model, the maximum concentration variation follows an exponential law, which is confirmed by the results of this study. The model also permits the computation of diffusion coefficients. Diffusion coefficients are also computed using the variance of the concentration distribution curves.

Tests conducted at different boat speeds indicate that the final diffusion is not influenced by the boat speed. Much of the diffusion is found to take place in a duration of about 20 minutes. Most of the tests were conducted in the mornings whereas a few tests were conducted in the afternoon. They indicate that the diffusion in the wake is affected by the diurnal variations in temperature. The zone of diffusion is found to have a trapezoidal or partial elliptic shape. Weather variations are observed to affect the diffusion phenomenon, which might have a favourable or adverse effect. This study shows that boat wakes under quiescent conditions are quite efficient as mixing devices in ponds and lakes. It is observed that the water in the wake gets aerated, and it would be of interest to investigate the possibility of using the wakes of watercraft as artificial aeration devices in natural bodies of water.

ACKNOWLEDGEMENTS

The author is deeply indebted to his thesis advisor, Dr. Richard G. Warnock, for suggesting this research topic, and for his advice, help, encouragement and personal understanding during the course of this study.

The author gratefully acknowledges the keen interest, valuable suggestions and help of Dr. Simon Ince in carrying out this study.

Special thanks are due to Mr. Smith and Mr. Gordon Priest, Technical Officers, N.R.C. Hydraulics Laboratory, for their willing assistance in setting up some of the experimental equipment. Further, the technical officers of the Department of Civil Engineering, University of Ottawa, are thanked for fabricating the sampling equipment.

The author wishes to thank Mr. Pierre Massonnie for his help in taking some of the photographs. The help of Mr. C. P. Khulbe in preparing the drawings is gratefully acknowledged. The author wishes to acknowledge the help of summer student employees in conducting the experiments.

This study was supported by research funds provided by the National Research Council, Canada.

TABLE OF CONTENTS

	<u>Page</u>
PREFACE	i
ACKNOWLEDGEMENTS	v
TABLE OF CONTENTS	vi
LIST OF FIGURES	ix
LIST OF TABLES	xi
LIST OF SYMBOLS	xii
CHAPTER I. INTRODUCTION	1
1.1 Use of Wakes of Watercraft for Dispersion	1
1.2 Objectives of this Study	5
1.3 Summary of this Study	6
CHAPTER II. LITERATURE REVIEW	8
2.1 Scope of Review	8
2.2 Eddy Diffusion	9
2.3 Ordinary Wake Flows	15
2.3.1 Physical Characteristics of Turbulent Flows	16
2.3.2 Self-preservation and Similarity Hypotheses	17
2.3.3 Velocity Distribution	18
2.3.4 Eddy Diffusion in Ordinary Wake Flows	18
2.4 Swirling Wake Flows	21
2.5 Flow in the Wake of Self-propelled Bodies	22
2.6 Previous Experimental Work	26

	<u>Page</u>
CHAPTER III. MATHEMATICAL MODEL OF WAKE	28
3.1 Structure of Out-board Motor Boat Wakes	28
3.1.1 Wake Formation	28
3.1.2 Wake Structure	30
3.2 Theoretical Considerations	35
3.2.1 Governing Differential Equation	35
3.2.2 Boundary Conditions	38
3.2.3 Solution of the Equation	38
CHAPTER IV. EXPERIMENTAL EQUIPMENT AND PROCEDURE	42
4.1 Experimental Set-up and Equipment	42
4.1.1 Experimental Site	42
4.1.2 Observation Platform	45
4.1.3 Out-board Motor Boat	48
4.1.4 Dye Injection Device	51
4.1.5 Samplers	51
4.1.6 Details of Fluorometry	58
4.1.7 Test Tubes	62
4.2 Experimental Procedure	63
4.3 Experimental Results	68
CHAPTER V. ANALYSIS OF DATA	70
5.1 Treatment of Experimental Data	70
5.2 Mass Balance Computations	72
5.3 Variation of Wake-width with Time	73
5.4 Analysis of Data by the Method of Variances	79

	<u>Page</u>
5.5 Data Analysis using the Proposed Mathematical Model	89
5.5.1 Variation of Maximum Concentration with Time	89
5.5.2 Computation of Diffusion Coefficient	94
CHAPTER VI. DISCUSSION OF RESULTS AND CONCLUSIONS	101
6.1 Variations in Experimental Data	101
6.2 Discussion of Experimental Results	105
6.3 Conclusions	113
LIST OF REFERENCES	116
APPENDIX A. GENERAL DETAILS OF EXPERIMENTS AND EXPERIMENTAL OBSERVATIONS	121
APPENDIX B. COMPUTER PROGRAM FOR DATA ANALYSIS	223
APPENDIX C. CONCENTRATION VERSUS LATERAL DISTANCE PLOTS AND COMPUTATIONAL RESULTS	229

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
3.1	Structure of Out-board Motor Boat Wake	31
3.2	Wake from Boat	33
3.3	Wake from Platform	34
4.1	Map of Pond showing Location of Test Site	43
4.2	View of Platform	46
4.3	View of Boat	49
4.4	Boat Speed vs RPM	50
4.5	Dye Injection Device	52
4.6	Details of Sampling Device	53
4.7	Details of Sampler	55
4.8	Fluorometer Calibration Curves	61
5.1	Wake Width vs Time for Series 3000	76
5.2	Wake Width vs Time for Series 2000	77
5.3	Wake Width vs Time for Series 2914	78
5.4	Wake Width vs Time for Series 2919	78
5.5	Variance at Depth 0-1 vs Time for Series 3000	82
5.6	Variance at Depth 1-2 vs Time for Series 3000	82
5.7	Variance at Depth 2-3 vs Time for Series 3000	83
5.8	Variance at Depth 3-4 vs Time for Series 3000	83
5.9	Variance at Depth 0-1 vs Time for Series 2000	84
5.10	Variance at Depth 1-2 vs Time for Series 2000	84
5.11	Variance at Depth 2-3 vs Time for Series 2000	85
5.12	Variance at Depth 3-4 vs Time for Series 2000	85

<u>Figure</u>		<u>Page</u>
5.13	Variance at Depth 0-1 vs Time for Series 2914	86
5.14	Variance at Depth 1-2 vs Time for Series 2914	86
5.15	Variance at Depth 0-1 vs Time for Series 2919	87
5.16	Variance at Depth 1-2 vs Time for Series 2919	87
5.17	f vs ξ for Series 3000	91
5.18	f vs ξ for Series 2000	92
5.19	f vs ξ for Series 2914	93
5.20	f vs ξ for Series 2919	93
5.21	g vs η for Series 3000	95
5.22	g vs η for Series 2000	97
5.23	g vs η for Series 2914	99
5.24	g vs η for Series 2919	99
A.1 to A.13	Fluorescence vs Time for Test Nos. 1 to 13	163
C.1 to C.13	Concentration vs Lateral Distance for Test Nos. 1 to 13	230

LIST OF TABLES

<u>Table</u>		<u>Page</u>
4-1	Results of Water Quality Tests	44
4-2	Tabular Form for Recording Experimental Data	67
5-1	Values of a and n	75
5-2	Diffusion Coefficients from Variance	88
5-3	Values of β	90
5-4	Diffusion Coefficients from Proposed Mathematical Model	100
6-1	Values of n	107
6-2	Values of $\frac{\epsilon}{U_0 D}$	112
A-1	General Details of Experiments	122
A-2 to A-14	Experimental Observations of Test Nos. 1 to 13	124
C-1 to C-13	Computational Results of Test Nos. 1 to 13	255
C-14 to C-26	Computations for Data Analysis of Test Nos. 1 to 13 by Proposed Mathematical Model	294

LIST OF SYMBOLS

A	- Cross-sectional area
A'	- Constant
a	- Constant
C ₁	- Constant of integration
c	- Mean concentration of diffusing substance
\bar{c}	- Cross-sectional average value of concentration
c _{max}	- Maximum concentration along wake centre-line
c _o	- Absolute maximum concentration
D	- Diameter of propeller
d	- Diameter of cylinder
E _T	- Dispersion coefficient
F	- Fluorescence
f	- $\frac{c_{max}}{c_o}$
g	- $\frac{c}{c_{max}}$
L	- Scale of turbulence characterising the size of those eddies that carry most of the turbulent energy
m	- Constant
n	- Constant
P	- Transferable property
R _τ	- Correlation between the velocity of a particle at any instant and that of the same particle after an interval τ
r	- Radial distance
r _{1/2}	- Wake width at the point where the axial turbulence intensity is one-half of maximum axial turbulence intensity

t	- Time
U	- Cross-sectional average value of velocity
U_d	- Maximum velocity defect
U_o	- Mean velocity of undisturbed stream
U_o	- Boat speed
u	- Local mean velocity component in the x-direction
u'	- Turbulence velocity
u^*	- Small scale part of u'
u^*	- Velocity scale characterizing those eddies that carry most of the turbulent energy
u_d	- Mean velocity deficit parallel to the undisturbed flow
u_i	- Local convective velocity in the ith direction
u'_{max}	- Maximum axial turbulence intensity
V	- Large scale part of u'
V_d	- Volume of stock solution of dye
V_e	- Volume of ethanol
v	- Mean velocity component in the y-direction
v'^2	- Mean square velocity of turbulence
W_D	- Total weight of dye per foot length of wake
w	- Weight of dye per foot length per foot depth
w	- Mean velocity component in the z-direction
x	- Axial direction
x_i	- ith co-ordinate direction
y	- Lateral direction
y	- Lateral distance

- y_0 - Wake width
- $\overline{y^2}$ - Mean square distance through which particles diffuse in time, t
- z - Vertical direction
-
- β - Constant
- l - Mixing length
- ϵ - Eddy diffusion coefficient
- ϵ_i - Turbulent mass transfer coefficient in the i th direction
- ϵ_m - Eddy diffusion coefficient from velocity distribution in wake of cylinder
- ϵ_t - Eddy diffusion coefficient from temperature distribution in wake of cylinder
- ϵ_x - Eddy diffusion coefficient in x -direction
- ϵ_y - Eddy diffusion coefficient in y -direction
- ϵ_z - Eddy diffusion coefficient in z -direction
- η - $\frac{r}{r_{1/2}}$, $\frac{y}{y_0}$
- γ - Weight density
- ϕ - Similarity function
- ρ_d - Density of stock solution of dye
- ρ_e - Density of ethanol
- ρ_w - Density of water
- σ_y^2 - Variance in y -direction
- τ_0 - Time at which R_τ becomes zero
- ξ - $\zeta/10^3$
- ζ - $\frac{x}{L} = \frac{U_0 t}{L}$

CHAPTER I

INTRODUCTION

1.1 Use of Wakes of Watercraft for Dispersion

In natural bodies of water, the wake of a watercraft such as a boat, barge or ship may be used in the control of water quality. The transport caused by the wake may have a favourable or adverse effect on the water quality. Some of these situations are described below.

Aquatic weed growth takes place in ponds, lakes, reservoirs and rivers under favourable environmental conditions. Algal blooms appear in water bodies rich in nutrients. While the discharge of nutrients into water bodies is being restricted, there are some uncontrollable sources such as wastes from unknown origins, decaying vegetation and minerals which are carried into water courses by snow-melt and storm run-off. These nutrients settle to the bottom of ponds, lakes and reservoirs. Seasonal variations in temperature induces circulation of water in these water bodies when the nutrients are mixed with the overlying water, thus stimulating the growth of weed and algae. The circulation characteristics of a lake depend on the geographical location of the lake; an excellent discussion of these characteristics can be found in a treatise on limnology by Hutchinson (23)¹.

While aquatic growths, upto a limit, help maintain a balanced aquatic environment, there are some situations

1. Numerals in parentheses refer to corresponding items in the List of References.

where they are undesirable. For example, excessive weed growth and algal bloom may create unaesthetic conditions and impair recreational uses of water; they may also become detrimental to other aquatic life such as fish. In such cases, their destruction becomes necessary. One of the simplest and most efficient methods of achieving this is by spreading a suitable chemical in such waters. Although in many instances the addition of any extraneous matter to a water body is undesirable, it is found that the controlled addition of chemicals helps to improve water quality which, otherwise, would further deteriorate due to the imbalance of nutrients. A common method of applying the chemical to water in shallow lakes is to add it in a regulated flow to the slipstream of an out-board motor boat (1,14). The chemical is dispersed immediately into the surrounding liquid by the turbulent movements created by the passage of a boat. The mixing is influenced by the currents set up in water by winds. The combined effect may be beneficial or detrimental depending on the velocity and direction of currents induced by the wind. For example, in strong winds, the chemical may be blown away from its place of application, thus becoming ineffective; it may also be blown to a shore, particularly in shallow lakes or ponds, where it may be trapped in a very high concentration that might be harmful to other aquatic life. A study of dispersion in a wake can help estimate the effectiveness and possible hazards in spreading chemicals in this way.

Barges and ships have been used to disperse treated wastes and dredging spoil by discharging them into the wakes of these vessels (25,34). Such methods of disposal are highly controversial; therefore, it is necessary that information on the dispersion of the material be available so that its effect upon the aquatic environment can be evaluated. Since the wake is usually used as a dispersion mechanism in this case, its efficiency and performance in this function should be evaluated.

Pollution from water craft due to ship board waste is increasing, causing concern in recent years (37). Reasonable controls on the disposal of the waste in this way require knowledge of the dispersing action of the wake.

Boat wakes may also be used to spread a disinfectant for the control of pollution in beaches where the currents are slow. It is observed that in most of the beaches, pollution due to human activity increases with increased usage of the beaches as indicated by the increase in the parameters of pollution such as coliform bacteria; it is of very much concern as the increase in pollution level is maximum during the mid-summer season when more and more people like to make use of beach facilities. In such cases, it may be possible to reduce the pollution level through the use of a disinfectant, which can be spread in the wake of a boat.

It is also of interest to note that the water in the wake is aerated when air bubbles are introduced into the wake

by the creation of vacuum pressure at the tip of the propeller blades; in addition, the turbulent movements in the wake cause more and more water masses to come in contact with the air. These facts make valuable the study of the possibility of using boats, barges and ships as artificial aeration devices. Dye diffusion studies in the coastal waters of Lake Huron and Lake Ontario have indicated that the effluents discharged from sewer outlets in lakes may form a stagnant pool around the outlet in low currents. This situation may become serious if on-shore currents are generated due to unfavourable meteorological conditions transporting effluents to the shore zone. Here they can be trapped for a considerable length of time, resulting in the deterioration of water quality (26). Because these situations are of a temporary nature, the water quality may be improved by artificial aeration devices. The use of wakes of boats, barges or ships would seem likely to be the best aeration method suitable in such situations, if they are found to be efficient enough.

Finally, a prototype study of dispersion in a wake at a free surface is of importance because it furnishes information on the structure and form of such a wake. The process of dispersion is intimately associated with the turbulence and mean flow of the wake. Thus, such a study can provide for the evaluation of the usefulness of the classical wake models for representing this flow.

1.2 Objectives of this Study

In the previous section, the practical importance of the wakes of boats, barges and ships was discussed. This study is confined to the case of wakes created by out-board motor boats in a pond or shallow lake only. When a substance is discharged into the wake, it is dispersed by the masses of water that are set into motion in the wake. Further dispersion may be affected by weather conditions. There may be bottom currents due to springs which would also affect the dispersion. This study is concerned mainly with the turbulent diffusion in the wake of an out-board motor boat in a pond under quiescent conditions. The effects of variations in weather conditions and bottom currents are neglected. The objectives of this study are as follows:

1. To examine the adequacy of wake models (cited in the literature) which are used to describe the diffusion phenomenon in a wake at a free surface and of which the wake of a boat is a typical example.
2. To determine the boundaries of the diffusion zone.
3. To study the variation of maximum concentration and to determine the diffusion coefficients in the wake.
4. To compare the results of this study with the values in the literature.
5. To attempt to improve the diffusion characteristics of the motor by simple modifications.

The last of these objectives could not be attempted because of the various limitations involved in conducting the tests.

1.3 Summary of this Study

Diffusion in the wake of a boat has been studied in a pond under quiescent conditions, using a fluorescent dye as a tracer. The diffusion is found to be mainly due to the masses of water set into motion by the action of the propeller. A relatively inexpensive, yet efficient sampling device, resembling a battery of pitot tubes, has been designed and used successfully to collect depth-integrated samples, from an observation platform, simultaneously at several points in a cross-section of the wake at regular time intervals (two minutes), which were analyzed fluorometrically.

The concentration distribution in the wake has shown that the dispersion in the boat wake, which is typical of a wake at a free surface, cannot be described by classical wake models. Attempts have been made to explain the mechanism of diffusion in these wakes. A mathematical model, which takes the flow characteristics into consideration, has been developed based on a theoretical analysis of flows in the wake of a self-propelled body. The model predicts that the maximum concentration variation follows an exponential law which has been confirmed by the experimental results. The model also permits the computation of diffusion coefficients. The diffusion coefficients have also been computed using the variance of the distribution curves. The boat speed has been observed to have very little effect on the final diffusion. Much of the diffusion is found to take place in a duration of

about 20 minutes. Most of the tests have been conducted during morning hours, with a few tests being conducted in the afternoon. These tests have indicated that the diffusion is affected by the diurnal variations in temperature. The zone of diffusion is found to have a trapezoidal or partial elliptic shape. The variations in weather conditions are found to affect the diffusion phenomenon in the wake, which might have favourable or adverse effects. It is suggested that the boat wakes under quiescent conditions are quite efficient as mixing devices. It is also observed that there is some amount of aeration taking place in the wake and it would be of interest to investigate the possibility of using wakes of watercraft as artificial aeration devices in natural bodies of water.

CHAPTER II

LITERATURE REVIEW

2.1 Scope of Review

A review of the literature on turbulent diffusion shows different theoretical developments for the study of diffusion in various types of turbulent flows. First, a simple case (such as diffusion in homogeneous, isotropic turbulence) may be considered wherein basic concepts of turbulent diffusion are developed. Some of the important theoretical approaches are the mixing length theory of Prandtl, statistical theory of Taylor and the analysis of relative diffusion of particles in turbulent flow put forward by Batchelor. The object of all these theories is the same - to predict the distribution of some transferable property of the flow (mass of dye, for example) with the aid of a suitably chosen coefficient of eddy diffusion.

In extending these theories to the complex case of diffusion in wake flows, the use of additional hypotheses (self-preservation and similarity of flows) has been found necessary. These hypotheses have been developed and verified in ordinary wake flows and extended to swirling wakes and wakes of self-propelled bodies. Ordinary wakes are discussed from this point of view before discussing the swirling wakes and wakes of self-propelled bodies.

The transport of a scalar quantity such as heat or mass in ordinary wakes has been investigated. Such studies for the wakes of self-propelled bodies seem to be lacking. In the case of the wakes of boats and ships, studies on the velocity and turbulence characteristics in the wakes could not be found in the literature; a few studies of limited nature on mass diffusion in these wakes have been reported. These are discussed in a subsequent section.

The literature on ordinary wake flows is very vast and only those works that are thought to be pertinent to this study are discussed here. Swirling wakes are briefly discussed since they might be of importance if the swirl velocities in the wakes of boats and ships are significant. Studies on flow in the wakes of self-propelled bodies are of theoretical importance and are discussed at some length. Finally, the experimental studies on diffusion in wakes of boats and ships are discussed.

2.2 Eddy Diffusion

Holley (22) has presented an excellent discussion of the basic concepts of diffusion. In any flow field where there is an interchange of fluid between two neighbouring zones, be it due to molecular or turbulent effects, there will be simultaneous interchange of every fluid characteristic involved. For example, if a fluid mass marked with a dye, is transported to a neighbouring zone across an imaginary

boundary that is free from dye-contamination, the marked fluid must be replaced by a fluid mass free from dye-contamination in order to satisfy the continuity relationship. This results in increased dye concentration on one side of the boundary and a reduction on the other side. This process, if allowed to proceed indefinitely, would bring about a uniform concentration of dye as each region goes on acquiring the properties of the other.

In a turbulent flow field, the fluid masses involved in the exchange process are termed "eddies" and the process is termed "eddy diffusion" because of its similarity to molecular diffusion.

The transport by the eddies, or the eddy diffusion, is expressed by a relation analogous to Fick's first law of molecular diffusion which states that the transport of a property such as the mass of a substance in any direction is proportional to the gradient of the property in that direction. When dealing with turbulent diffusion, it is usual to neglect the molecular diffusion effects, since the turbulent diffusion coefficients are generally 1000 times greater than the molecular diffusion coefficients (10). The general equation for turbulent diffusion termed "convective-diffusion equation", in rectangular coordinates, is given by

$$\frac{\partial c}{\partial t} + u \frac{\partial c}{\partial x} + v \frac{\partial c}{\partial y} + w \frac{\partial c}{\partial z} = \frac{\partial}{\partial x} \left(\epsilon_x \frac{\partial c}{\partial x} \right) + \frac{\partial}{\partial y} \left(\epsilon_y \frac{\partial c}{\partial y} \right) + \frac{\partial}{\partial z} \left(\epsilon_z \frac{\partial c}{\partial z} \right) \quad (2.1)$$

where c is the temporal mean concentration of diffusing substance,

t is the time of diffusion,

u, v, w are the temporal mean velocity components in the x -, y - and z -direction respectively,

and $\epsilon_x, \epsilon_y, \epsilon_z$ are the turbulent diffusion coefficients in the x -, y - and z -directions respectively.

A derivation of Eq. 2.1 can be found elsewhere (10,11). The first term on the left hand side indicates the change in concentration with time, and the remaining terms on the left represent the convective effect in the three directions, while the three terms on the right represent the diffusive effects in the three directions. Eq. 2.1 has to be solved with appropriate boundary conditions. Carslaw and Jaeger (6) have presented solutions of Eq. 2.1 for various initial and boundary conditions. Diachishin (11) has discussed different methods of evaluating the diffusion coefficients from dye dispersion studies. It has to be noted that the diffusion coefficients are to be considered constants to use the methods discussed by Diachishin. The solution for the one-dimensional case is the simplest, while it becomes more complicated for the 2-, and 3-dimensional cases. The basic requirement for these solutions to be applicable is that the concentration distribution should be close to the normal distribution, which is satisfied in most of the cases. This analysis does not consider the turbulent flow characteristics, nor give any insight into the flow characteristics which bring about the diffusion.

For diffusion in shear flows, such as pipe and open channel flows, Eq. 2.1 can be modified to take into account the spatial variation of the mean velocity. For flow through a conduit or channel of constant cross-sectional area, where the dispersing material fills the cross-section, Eq. 2.1 reduces to

$$\frac{\partial \bar{c}}{\partial t} + U \frac{\partial \bar{c}}{\partial x} = \frac{\partial}{\partial x} \left(E_T \frac{\partial \bar{c}}{\partial x} \right) \quad (2.2)$$

where \bar{c} represents the cross-sectional average value of concentration,

U represents the cross-sectional average value of velocity,

and E_T represents the dispersion coefficient.

The difference in longitudinal convective transfer which is associated with the actual velocity distribution and that which is accounted for by the mean velocity is incorporated into the diffusion term, the combined effect being termed the "longitudinal dispersion", and the symbol E_T represents the longitudinal dispersion coefficient. Taylor (41) first developed this analysis for the case of the flow of liquid through a pipe. Elder (13) and Fischer (16) have given similar treatments for turbulent flow in an open channel. Bowden (5) has considered some velocity profiles of interest that give rise to "shear effects" and presented expressions for the longitudinal dispersion coefficients.

In the case of shear flows discussed above, the mean velocity in the longitudinal direction has a constant

magnitude. But, in case of free-turbulent shear flows such as jets and wakes, the mean velocity is no longer constant, but varies with distance. The solutions for these cases are much more difficult.

The eddy diffusion coefficient of the turbulent flow field has been useful for the prediction of the concentration distributions. Several theories have been put forward to relate the diffusion coefficient to the parameters of the flow such as the scale and intensity of turbulence. Of these, Prandtl's mixing length theory, and the theories presented by Taylor (39) and Batchelor (2) are of importance and are discussed briefly.

Prandtl introduced the concept of "mixing length" in analogy to the "mean free path" of the kinetic theory of gases. Considering a fluid lump which is involved in the exchange process as an entity, Prandtl assumed that the lump will retain its distinct characteristics while it moves through a distance, l termed "mixing length". Then considering the momentum per unit mass of fluid as the property transported, Prandtl has derived an expression for the coefficient of eddy diffusion, ϵ which is given by

$$\epsilon = l^2 \frac{\partial u}{\partial y} \quad (2.3)$$

where $\frac{\partial u}{\partial y}$ represents the gradient of the temporal mean velocity in the y-direction.

In spite of the various objections to this theory (4), Eq. 2.3 has been very popular, especially among engineers, because of its simplicity. Hinze (21) has discussed the use of Eq. 2.3 to predict transport in ordinary wake flows.

Taylor (39), in his theory of diffusion by continuous movements, presented a new approach wherein the coefficient of eddy diffusion is related to the statistical parameters of turbulence. The variance of a particle undergoing diffusion by turbulent motion is related to the turbulence parameters by

$$\frac{1}{2} \frac{d}{dt} (\overline{y_2^2}) = \overline{v'^2} \int_0^t R_\tau d\tau, \quad (2.4)$$

where $\overline{y_2^2}$ is the mean square of the distance through which the particles have diffused in time t , $\overline{v'^2}$ is the mean square velocity of turbulence

fluctuations,

$R_\tau = \frac{\overline{v'(t_0) v'(t_0 + \tau)}}{\overline{v'^2}}$, is the correlation between the fluctuating velocities, $v'(t_0)$ and $v'(t_0 + \tau)$ of a particle at time t_0 and $(t_0 + \tau)$, respectively.

For long diffusion times, the coefficient of eddy diffusion is given by

$$\begin{aligned} \epsilon &= \frac{1}{2} \frac{d}{dt} (\overline{y_2^2}), \\ &= \overline{v'^2} \int_0^\infty R_\tau d\tau \end{aligned} \quad (2.5)$$

Kalinske and Pien (24), and Orlob (30) have used Eq. 2.5 to evaluate diffusion coefficient and turbulence parameters from variance measurements in homogeneous turbulent flows. For homogeneous turbulent flows where turbulence is decaying, Taylor (40) has presented suitable modifications to Eq. 2.4 to take into account the change in v' and R_T with time. As Batchelor (3) points out, Taylor's method for decaying turbulent flows takes into account only the changes in velocity scale, but ignores the possibility of an independent change in the time scale of motion.

Batchelor (2) presented a theory for the relative diffusion of particles in homogeneous turbulence. He has extended this analysis to diffusion in free turbulent shear flows such as jets and wakes (3), by taking into account the change in velocity and time scales. This analysis is valid for ordinary wake flows, for which the form of velocity profile is well-known.

2.3 Ordinary Wake Flows

The extensive investigation of ordinary wakes such as cylindrical and circular wakes, has led to the verification of the basic hypotheses for wake flows and to explain the mechanism of transport in these flows. Since these basic hypotheses are extended to wakes of self-propelled bodies with suitable modifications, flow in ordinary wakes is briefly discussed here. The discussions by Birkhoff and Zarantonello (4),

Hinze (21) and Townsend (42) are the most important studies of the many that have been given of ordinary wake flows.

2.3.1 Physical Characteristics

Turbulent wake flows form one of the groups of elementary shear flows with which is associated inhomogeneous, non-isotropic turbulence. The general characteristics of these turbulent wake flows have been discussed by Hinze (21) and Townsend (42). These characteristics are:

1. There exists a region of retarded flow immediately behind the body, creating a region of turbulence. The width of the region increases with distance away from the body in the downstream direction.
2. The turbulent region is separated from the non-turbulent region by an irregularly distorted boundary surface.
3. The mean velocity in the direction of flow is much larger than the mean velocity in the transverse direction.
4. The free turbulent flow region is long and narrow in the main flow direction compared to that in the transverse direction.
5. The mean pressure variation in the flow region is small.

As pointed out by Naudascher (27), it is the essential lack of disturbance of the mean flow which distinguishes the wake of a self-propelled body from an ordinary

wake. A towed body strains the flow as it produces turbulence energy representing the application of an external force, whereas a self-propelled body (such as an out-board motor boat) represents an essentially direct and strainless input of turbulence energy. The physical characteristics of wakes, discussed above, are valid for both types of the wakes.

2.3.2 Self-preservation and Similarity Hypotheses

Townsend (42) has discussed these hypotheses in detail. These hypotheses are:

1. There exists a similarity of flow structure at all high Reynolds numbers.
2. At any one Reynolds number, the structure of flow at all distances is similar. This hypothesis, unlike that of Reynolds number similarity, depends on the notion that the flow approaches a state of moving equilibrium which is determined by the broad features of the initial conditions.
3. If a flow is self-preserving through the action of a moving equilibrium, it must be expected that the final self-preserving form will not depend on the details of the boundary conditions of the flow, and that flows whose boundary conditions have similar properties of symmetry and homogeneity will have similar self-preserving flows.

2.3.3 Velocity Distribution

Based on the similarity and self-preservation hypotheses, the velocity distribution is expressed in the form

$$u_d = U_o x^{-n} \phi\left(\frac{y}{x^m}\right), \quad (2.6)$$

where u_d is the mean velocity deficit parallel to the undisturbed flow,

U_o is the mean velocity of the undisturbed stream,

x is the distance downstream of the body parallel to the undisturbed stream,

y is the distance from the centre line measured perpendicular to the undisturbed flow,

ϕ is a similarity function,

m, n are constants.

For cylindrical wakes $m = \frac{1}{2}$ and $n = \frac{1}{2}$, whereas for circular wakes $m = \frac{1}{3}$ and $n = \frac{2}{3}$.

Townsend (42) has investigated cylindrical wakes (which are formed behind a cylinder, circular or otherwise), while Swain (38), Goldstein (18,19), and Hall and Hislop (20) have discussed circular wakes (which occur behind a body of revolution). The similarity and self-preservation hypotheses have been verified in these studies.

2.3.4 Eddy Diffusion in Ordinary Wake Flows

Townsend (42) has presented an excellent discussion of the transport by eddies in wake flows. There exist small

scale, high intensity turbulent motions together with large scale slow motions in the wake, and this flow structure is termed the double structure of turbulence. It is the convective action of the large eddies and the diffusive action of the small eddies which bring about the transport of a property such as heat or mass of a tracer in the wake. The transport rate by the slow-moving large eddies whose size is comparable to the width of distribution of the diffusing property, depends more on the general distribution of the property than on its local intensity gradient, while transport by small eddies depends on the scale of the turbulence diffusing movements, being small compared with the scale of variation of intensity gradients. The total transport of a transferable property, P based on this double structure of turbulence, can then be expressed in the form

$$\begin{aligned}\overline{u'P} &= \overline{u^*P} + \overline{VP} \\ &= -\epsilon_P \frac{\partial P}{\partial x} + \overline{VP}\end{aligned}\quad (2.7)$$

where u^* and V represent the small scale and large scale parts of the turbulence velocity u' . The main difficulty in the application of Eq. 2.7 lies in the estimation of the component V .

Hinze (21) has discussed the transport of a scalar quantity in the wake of a cylinder according to the various phenomenological theories. The value of the coefficient of eddy diffusion, according to the mixing length theory, is

found to be too small near the axis and near the edges of the wake, whereas in the central part the agreement between measured and computed values is reasonably good. From the velocity distribution curve, the eddy diffusion coefficient, ϵ_m which has more or less a constant value in the central part of the curve, is found to be

$$\epsilon_m = 0.016 U_o d , \quad (2.8)$$

where U_o is the undisturbed freestream velocity, and d is the diameter of cylinder.

The experimental results of Fage and Falkner, and Townsend in the warm wake of a heated cylinder indicate a similarity in temperature profiles beyond 500 diameters (21). A comparison between the velocity and temperature profiles shows that the width of the temperature wake is much greater. The coefficient of eddy diffusion, ϵ_t , computed from the measured temperature distributions, is found to be nearly constant across the wake with an average value given by

$$\epsilon_t = 0.03 U_o d . \quad (2.9)$$

Swain (38), Goldstein (18) and Chevray (8) have discussed circular wakes. Goldstein has deduced expressions for velocity and temperature distributions according to various phenomenological theories. The agreement between the theory and the experimental results reported by Hall and Hislop (20) is not satisfactory as shown by Goldstein (19).

However, all these studies confirm the similarity of velocity and temperature profiles in the circular wake.

2.4 Swirling Wake Flows

Swirling wake flows have been discussed by Reynolds (35), and Chervinsky and Lorenz (7). Reynolds considered that both the net linear momentum and the net angular momentum of a developing swirling flow play important parts in determining its ultimate form. Considering a turbulent wake having both axial and swirl components of mean velocity, it is shown that the mean swirl component decreases more rapidly downstream than does the mean axial velocity defect. For a wake in which linear momentum predominates (axisymmetric wake), wake width varies as $x^{1/3}$ and velocity defect varies as $x^{-2/3}$, whereas for a wake in which angular momentum predominates (wake of a self-propelled body), wake width varies as $x^{1/4}$ and swirl velocity scale varies as $x^{-3/4}$.

Chervinsky and Lorenz (7) have discussed decay of turbulent axisymmetric free flows with rotation in which expressions have been derived for the velocity variations in a wake behind an axisymmetrical rotating body. No verification of the theory is made because of the lack of experimental results.

Chigier and Chervinsky (10) studied swirling vortex motion in jets. They have reported that the mean velocity and pressure profiles are similar from an axial distance of

four diameters for weak and moderate swirl, whereas for a strong swirl, a vortex is generated in a region close to the orifice resulting in a displacement of the axial velocity maximum from the jet axis; however, after a distance of ten diameters, the influence of the vortex becomes small, and similarity of the profiles is obtained farther downstream. The jet width and the mass flow rates of entrained fluid are found to increase with the degree of swirl.

2.5 Flow in the Wake of Self-propelled Bodies

Birkhoff and Zarantonello (4) and Naudascher (27) have discussed the flow in the wake of self-propelled bodies. On the assumption that the velocity distribution can be represented by a function similar to Eq. 2.6, Birkhoff and Zarantonello have deduced the values for the exponents m and n ; for two-dimensional wake behind a self-propelled body $m = \frac{1}{4}$ and $n = \frac{3}{4}$, whereas for hydrodynamical self-propulsion in space $m = \frac{1}{5}$ and $n = \frac{4}{5}$. No experimental verification of this analysis could be found in the literature.

Naudascher (27) has investigated the flow in the wake behind a totally immersed, axisymmetric self-propelled body, simulated in an air tunnel by a concentric nozzle and disc arrangement. A study of the production, convection, diffusion and dissipation of turbulence, and the continuous and systematic change of mean flow and turbulence patterns and their respective characteristics has revealed the following:

1. For any point in the wake cross-section, the local rate of production of turbulence is substantially smaller than the corresponding change in convection rate, contrary to the conditions in elementary shear flows.
2. The cumulative rate of turbulence production at any point in the wake cross-section approaches a constant value almost within ten disc diameters.
3. The entire turbulence energy is produced over an extremely limited shear zone, at the beginning of which the turbulence energy transfer by convection and diffusion is almost equal to the rate of production with dissipation setting in gradually.
4. As the diffusion becomes negligible past the shear zone, the axial rate of change of the cumulative rate of dissipation approaches that of the rate of convection. This fact, in particular, distinguishes the wake of self-propelled bodies from elementary flows in which equilibrium is approached between the rates of change of cumulative dissipation and production.

The hypotheses of self-preservation and similarity of flows, similar in principle to those used in elementary shear flows yet significantly different in form, provide the basis for the analysis of flow characteristics. The two hypotheses are as follows:

First, the eddy motion is generated by the inertial instabilities in the mean flow and governed by the inertial interaction of the eddies, so that viscosity affects only the dissipative components of the motion (for large Reynolds numbers). Secondly, as the eddies are carried along by the mean flow within a relatively narrow region, their structure is likely to approach a state of moving equilibrium as it has been continuously developing from earlier ones. Even though turbulence continues to be produced by the mean motion within an initial shear regime, the interrelation between turbulence and mean flow patterns is so great that both flow patterns may be expected to attain asymptotically self-preserving forms that are independent of Reynolds numbers and the particular initial conditions of flow generation. Experimental observations have confirmed the existence of self-preserved profiles (for mean velocity, turbulence shear, and turbulence intensities).

The notable difference between the self-preserved profiles for simple jets and wakes, and those for the self-propelled bodies lies in the number of scales necessary to normalize these profiles or describe them analytically. While one pair (U_d and $r_{1/2}$) proved sufficient for simple jets and wakes, two pairs are required for the wake of self-propelled bodies - one characterizing inhomogeneity (U_d and $r_{1/2}$), and another characterizing the structure of turbulence (u'_{max} and L), where U_d is the maximum velocity defect value,

$r_{1/2}$ is the width of wake at the point where the axial turbulence intensity is one-half of its maximum value, u'_{\max} is the maximum turbulence velocity, and L represents the scale of turbulence defined by

$$L = U_o \int_0^{\tau_o} R_\tau d\tau, \quad (2.10)$$

where U_o is the undisturbed free stream velocity, and τ_o is the time at which R_τ becomes zero.

The scale L is considered to represent the size of those eddies that carry most of the turbulence energy.

For the shear regime, based on the hypotheses of similarity and self-preservation described earlier for self-propelled bodies, the cross-sectional variation of all flow characteristics are expressed nondimensionally as universal functions of a relative radial position ($\eta = \frac{r}{r_{1/2}}$) through suitable kinematic and dynamic scales. These universal functions are subject to the restrictions imposed by the momentum and mean energy equations, through the use of which conditions for self-preservation of flow are derived. One of the results of this analysis is that (ϵ/Lu^*) should be a constant throughout the diffusion zone, and

$$\frac{r_{1/2} U_o}{\epsilon} \frac{dr_{1/2}}{dx} = \text{const.}, \quad (2.11)$$

The result (ϵ/Lu^*) is constant, is verified to be valid (Fig. 4 of (27)). Here u^* represents a velocity scale characterizing the turbulence movements which is assumed equal to u'_{\max} .

Based on the power-law approximations, Naudascher has derived the exponent of x for the power law development of L , $r_{1/2}$, etc., for various zones in case of point, line and plane sources of turbulence (Table 4 of (27)).

Naudascher has presented a new approach for the analysis of flow characteristics, pointing out the limitations of the power-law approximations. The most important result of this new approach is that the wake width approaches a constant value asymptotically, which seems to be confirmed by the visual observations of condensation trails past jet-propelled aircraft.

2.6 Previous Experimental Work

Ketchum and Ford (25) have investigated the dispersion of a chemical waste in the wake of a barge at sea. In their study, a waste material consisting of 10% iron and 8.5% sulphuric acid was discharged into the wake of a barge, and samples were collected at the estimated centre of the wake at different times which were later analysed for the concentration of iron. A coefficient of dispersion was computed assuming one-dimensional Gaussian distribution of the waste in the cross-section of wake and using the weight of waste material injected. However, the spatial distribution of the concentration of waste material and the rate of widening of wake were not investigated.

Schooley and Stewart (36) conducted experiments to study the diffusion in the wake of a self-propelled body submerged in a fluid with a vertical density gradient. In this study, the plastic propeller of a toy boat was used as the self-propelled body to create a wake in an experimental tank. A mixture of glycerin and water of different proportions was placed in the tank in a number of layers in order to obtain a substantially uniform density gradient. It was observed that, in the case of uniform density, the turbulent mixed fluid behind the body expanded into an irregular conical shape, whereas in the case of a density gradient, the initial expansion of the mixed fluid is quickly followed by a collapse in the vertical direction, accompanied by a further spreading in the horizontal direction. The volume of fluid behind the self-propelled body attains a more or less uniform density which is the average density of the fluid from which it is mixed. Due to the effect of gravity, this fluid tends to seek its own density level in the surrounding fluid when it flattens in the vertical direction and extends horizontally. In an infinite fluid with a vertical density gradient, the initial mixed fluid would ultimately become infinitesimally thin vertically and infinitely wide horizontally. These results would seem to be of considerable importance in the study of diffusion in boat wakes.

CHAPTER III

MATHEMATICAL MODEL OF WAKE

3.1 Structure of Out-board Motor Boat Wakes

3.1.1 Wake Formation

As an out-board motor boat passes through a quiescent body of water, a streak of foamy, churned water appears behind the boat which is known as the wake. The eddying motion of water in the wake, which is mainly responsible for the transport mechanism, can be attributed to the following: (1) the action of the propeller; (2) the straining action at the surface of contact of water and boat; and (3) the exhaust water of motor.

It is the action of the propeller that is mainly responsible for the formation of eddies (due to the rotation of the blades). The propeller blades are completely submerged in water; as the propeller rotates at a very high speed, there is a vacuum creation, which is responsible for the introduction of air bubbles below the water surface. These air bubbles have a motion which is away from the boat and upwards towards the water surface as they try to escape to the atmosphere. In this process, they are, to some extent, responsible for turbulence creation. This action would be greater at higher boat speeds. However, it would be very difficult to determine the relative importance of the air

bubbles in the mechanism of transport. The propeller blades also set the surrounding water into motion, creating eddies. The nature of this motion is mainly vortical. These sources cause a complicated fluid motion which can not be fully described because of the lack of velocity measurements in the wakes of boats and ships. The main result of the propeller action seems to be the creation of a dense core with masses of water similar to smoke puffs emitting from a chimney, being set into motion. These masses can be observed in the core of the wake for some distance behind the boat, after which the core fades out gradually.

A depression of the water surface just behind the boat is created due to the vacuum pressure. The depth of the depression would increase with speed. Water from the surrounding zones rushes into this area creating eddies in the process. The width of the depression is nearly equal to the stern width of the boat itself. The depression gradually fades out in a short length, the water surface having a wavy profile in this length. Relatively, the effect of depression seems to be second to the direct action of the propeller as a factor causing transport.

The effect of straining action seems to be very small. As Naudascher (27) has pointed out, the straining action is predominant in a towed body while it is negligible in the wake of a self-propelled body.

The exhaust water of the motor (used in the cooling system) is a very small quantity and its effect appears to be relatively negligible.

3.1.2 Wake Structure

Fig. 3.1 shows the structure of an out-board motor boat wake, which is based on the visual observation and photographs of the wakes. Fig. 3.1(a) shows the dense, narrow core, created by the propeller and the profile of the wake edge behind the boat. Fig. 3.1(b) shows the cross-sectional structure of the wake at different distances behind the boat. Fig. 3.1(c) indicates the depression in the water surface immediately behind the boat and the wavy surface profile for a short distance as well as the mixing effect in the vertical direction. Immediately behind the boat, the wake diverges with an included angle of 120° (approximately); at a certain distance astern (approximately equal to one boat-length), the wide divergence ceases rather rapidly beyond which the wake spreads with a very small included angle (approximately 2°). It is important to note that this observed edge of the wake is confined to a shallow layer very near to the water surface. There exists a sharp distinction between this superficial edge and the dense core edge. The dense, narrow core itself widens with a small included angle (about 10°) which persists for a relatively longer length (about five boat lengths or more) before it fades out. The transport

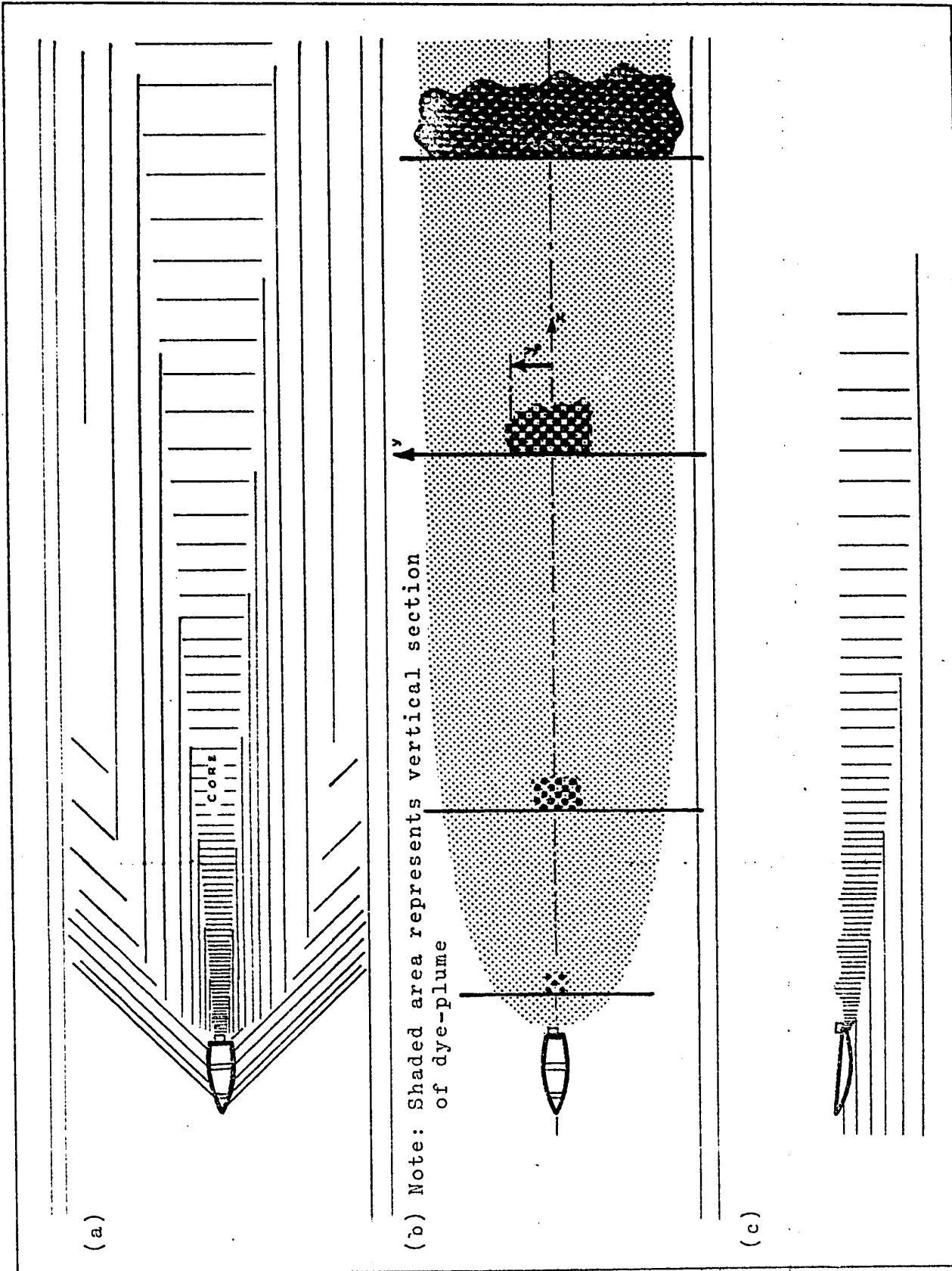


FIG. 3.1.1.--STRUCTURE OF OUT-BOARD MOTOR BOAT WAKE

in the wake is mainly due to the masses of water in the core, which move outward mostly in a lateral direction. Why they tend to move laterally rather than moving radially is not known; velocity and turbulence measurements in the wake might give further information on the phenomenon. However, the wake width, from the point of view of transport, is dependent on how the core widens out.

Figs. 3.2 and 3.3 show photographs of the wake behind an out-board motor boat. Fig. 3.2 shows a photograph of the wake taken from the boat itself, while Fig. 3.3 shows a photograph of the wake taken from an observation platform. In both these photographs, the core can be clearly distinguished.

The transport in the vertical direction seems to be confined to a finite depth. From experimental observations, it seems that most of the mixing in the vertical direction takes place within a short time. The depth of vertical mixing is observed to be much smaller than the lateral spread.

In this section, an attempt is made to explain the formation and structure of the wake of an out-board motor boat. Some of these features will be used in the next section in developing a mathematical model to explain the transport in the wake.



FIG. 3.2.--WAKE FROM BOAT

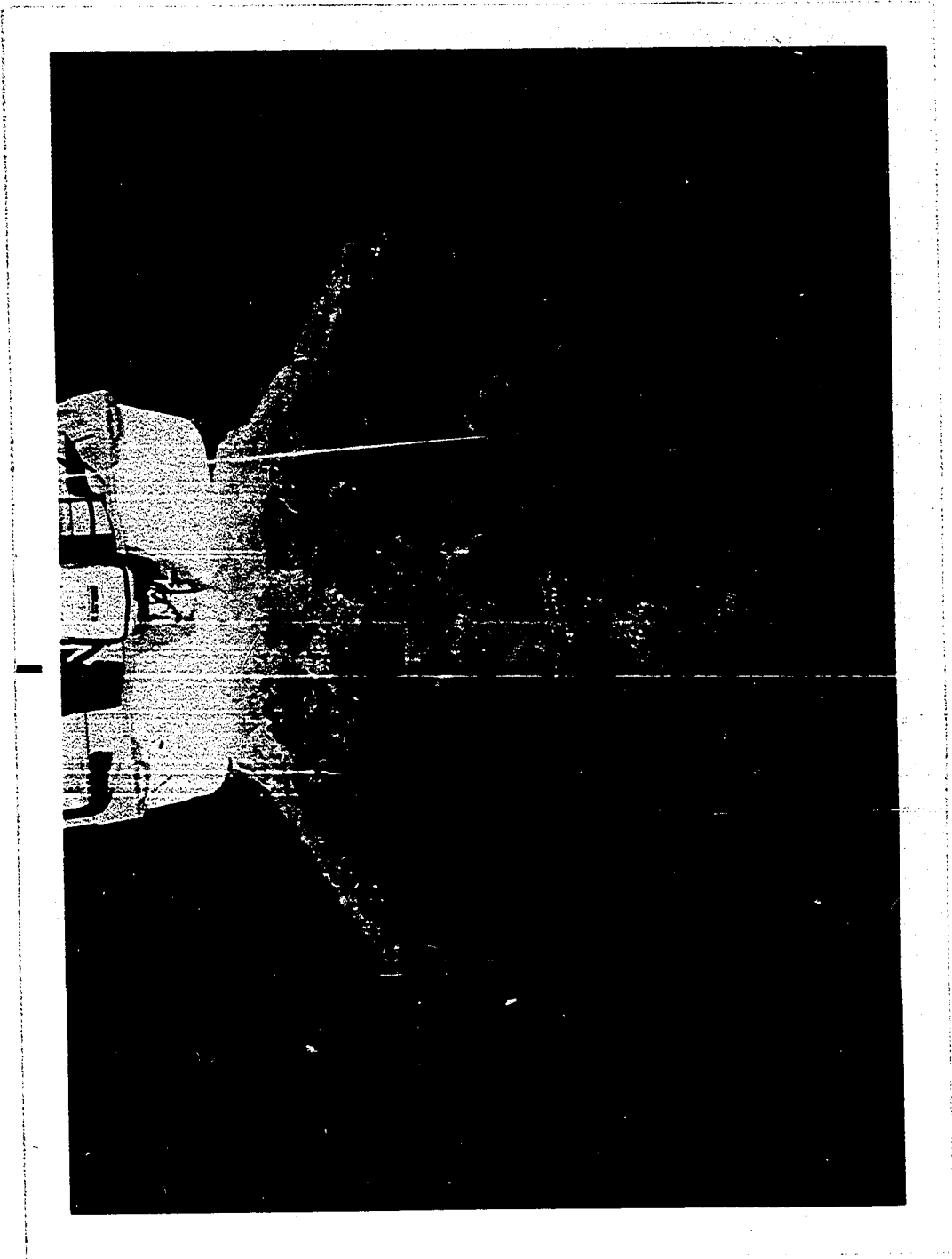


FIG. 3.3.--WAKE FROM PLATFORM

3.2 Theoretical Considerations

3.2.1 Governing Differential Equation

The basic equation for the transport of a scalar quantity in a turbulent flow can be derived by applying the principle of conservation of mass to an incremental volume of the flow (10,11). This equation, neglecting molecular diffusion effects is

$$\frac{\partial c}{\partial t} + u_i \frac{\partial c}{\partial x_i} = \frac{\partial}{\partial x_i} (\epsilon_i \frac{\partial c}{\partial x_i}) , \quad (3.1)$$

where c represents the concentration of the scalar quantity,
 t represents the time,
 u_i represents the local convective velocity in the i th direction,
 x_i represents the i th coordinate direction,
and ϵ_i represents the turbulent mass transfer coefficient in the i th direction.

For the wake of an out-board motor boat, Eq. 3.1 can be simplified with the following assumptions:

1. There is no average velocity in the lateral and vertical directions so that the corresponding convective transport terms can be omitted in Eq. 3.1.
2. The turbulent transport in the longitudinal direction is negligible. This is justified by

considering the fact that each unit length of the wake receives the same amount of dye along the centre line of wake, so that the source can be looked upon as a line source parallel to the x-axis through the principle of relative motion. Further, the wake is very narrow and long so that the change in any property in the x-direction is much smaller than that in the other directions.

3. The turbulent transport in the vertical (or z-) direction is much smaller than that in the lateral (or y-) direction. The justification for this has to come from experimental evidence (see p.32, para.3). Making use of the principle of relative motion and assuming steady state conditions, Eq. 3.1 simplifies to

$$u \frac{\partial c}{\partial x} = \frac{\partial}{\partial y} \left(\epsilon_y \frac{\partial c}{\partial y} \right), \quad (3.2)$$

where u represents the local mean velocity in the wake in x-direction. The form of velocity distribution in the wake of an out-board motor boat is not known. Naudascher (27) has pointed out that in the wake of a self-propelled body, the decay of the velocity defect in x-direction is much faster than in ordinary wakes; visual observations seem to confirm this in the wake of a boat, so that except close to the body, it is reasonable to assume $u \approx U_0$, where U_0 represents the undisturbed free stream velocity (which is equal in magnitude, but opposite in direction to the boat speed). Then $x \approx U_0 t$.

It is convenient to express Eq. 3.2 in non-dimensional form, before we seek its solution subject to appropriate initial and boundary conditions. This can be achieved through the use of the following hypotheses for the wake of self-propelled bodies suggested by Naudascher (27):

1. Reynolds number similarity, according to which the cross-sectional variation of all flow characteristics should be independent of the Reynolds number (which is valid for sufficiently high Reynolds numbers).
2. Self-preservation hypothesis. According to the definition of self-preservation of a flow in its more general form, the flow characteristics should be expressible, non-dimensionally, as universal functions of a relative lateral position $\eta = \frac{y}{y_0}$ (where y_0 is the width of wake at a known x or t), as follows:

$$\frac{c_{\max}}{c_0} = f(\zeta) , \quad \frac{c}{c_{\max}} = g(\eta) , \quad (3.3)$$

$$\zeta = \frac{x}{L} , \quad \eta = \frac{y}{y_0}$$

where c is the mean concentration at any point in the wake,

c_{\max} represents the maximum concentration (along the centre line) at any x or t ,

c_o represents the absolute maximum concentration (initial concentration at $x = 0, y = 0$),

and L represents a characteristic length scale of flow.

Using these substitutions, Eq. 3.2 can be written

$$\frac{1}{f} \frac{\partial f}{\partial \zeta} = \frac{1}{g} \frac{\partial}{\partial \eta} \left(\frac{L \epsilon_y}{U_o y_o^2} \frac{\partial g}{\partial \eta} \right) \quad (3.4)$$

3.2.2 Boundary Conditions

At $x = 0, y = 0$, we have $c_{\max} = c_o$; this corresponds to the condition $f(\zeta) = 1$ at $\zeta = 0$.

At any value of x (or t), $c = c_{\max}$ at $y = 0$ (i.e., on the centre line); this corresponds to the condition $g(\eta) = 1$ at $\eta = 0$.

At the wake edge ($y = y_o$), $c = 0$ which corresponds to the condition $g(\eta) = 0$ at $\eta = 1$.

3.2.3 Solution of the Equation

Eq. 3.4 must be solved subject to the above conditions. However, it is necessary to make some assumption about the dependence of the transport coefficient, ϵ_y , on η . It is usual to assume that it has a constant value across a cross-section. Townsend (42) points out that the assumption of a constant eddy viscosity within a turbulent fluid leads to remarkably accurate descriptions of the velocity distribution in self-preserving flows, and is undoubtedly a very

useful hypothesis to use when the nature of the turbulent motion is not concerned. Naudascher (27) has justified, through theory and experiments, the assumption of a constant eddy viscosity in the wake of self-propelled bodies. In view of these findings, it is assumed that the eddy diffusion coefficient, ϵ_y is constant in the wake cross-section.

Eq. 3.4 can now be rewritten in the form

$$\frac{1}{f} \frac{\partial f}{\partial \zeta} = \left(\frac{L\epsilon_y}{U_o y_o^2} \right) \frac{1}{g} \frac{\partial^2 g}{\partial \eta^2} \quad (3.5)$$

In Eq. 3.5, the terms on the left depend on ζ , while those on the right depend on η . Hence, each side can be equated to a constant, β . Then, we get the following equations:

$$\frac{1}{f} \frac{df}{d\zeta} = \beta \quad (3.6)$$

$$\frac{L\epsilon_y}{U_o y_o^2} \frac{1}{g} \frac{d^2 g}{d\eta^2} = \beta \quad (3.7)$$

Let us consider Eq. 3.6, which can be rewritten in the form

$$\frac{df}{f} = \beta \cdot d\zeta \quad , \quad (3.8)$$

Integrating Eq. 3.8, we get

$$\ln f = \beta \cdot \zeta + C_1 \quad , \quad (3.9)$$

where C_1 is a constant of integration.

Substituting the initial condition that $f = 1$ at $\zeta = 0$ in Eq. 3.9, we get $C_1 = 0$. Therefore, the solution of Eq. 3.6 is

$$\ln f = \beta \zeta ,$$

$$\text{or } f(\zeta) = \exp(\beta \zeta) \quad (3.10)$$

The constant β in Eq. 3.10 must be evaluated from the experimental results.

Eq. 3.10 expresses the variation of maximum concentration along the centre line of the wake. It is interesting to note that Pritchard (33) proposed a similar expression to express the decay of peak concentration in an estuary flow.

Let us now proceed to consider Eq. 3.7 which can be rewritten in the form

$$\frac{d^2 g}{d\eta^2} - k \cdot g = 0 , \quad (3.11)$$

where $k = \frac{U_o y_o^2}{L \epsilon_y} \beta$, is a constant.

A solution of Eq. 3.11 is of the form

$$g(\eta) = \exp(\lambda \eta) \quad (3.12)$$

Substitution of Eq. 3.12 in Eq. 3.11 yields

$$\lambda^2 - k = 0 ,$$

$$\text{or } \lambda = \pm k^{1/2} \quad (3.13)$$

From Eqs. 3.12 and 3.13, the solution of Eq. 3.11 is

$$g(\eta) = \exp(\pm k^{1/2} \eta) ,$$
$$\text{or } g(\eta) = \exp \left\{ \pm \left[\frac{U_o y_o^2}{L \epsilon_y} \beta \right]^{1/2} \eta \right\} \quad (3.14)$$

Eq. 3.14 satisfies the condition $g(\eta) = 1$, at $\eta = 0$. Let us now try to analyze the implications of the boundary condition $g(\eta) = 0$, at $\eta = 1$. Direct substitution of these in Eq. 3.14 will not give a meaningful result. However, we may examine the condition as follows. If $g(\eta)$ must be zero at $\eta = 1$ (i.e., on the wake edge), then

$$\exp \left\{ \pm \left[\frac{U_o y_o^2}{L \epsilon_y} \beta \right]^{1/2} \eta \right\} \rightarrow \exp(-\infty) \quad , \quad (3.15)$$

or

$$\left\{ \left[\frac{U_o y_o^2}{L \epsilon_y} \beta \right]^{1/2} \eta \right\} \rightarrow \infty$$

Each quantity in the numerator has a finite value; thus, the denominator should tend to zero. Since L is finite, ϵ_y must be zero on the edge of the wake, which indeed is the case. Also, the term inside the braces in Eq. 3.15 must have a negative sign so that the solution of Eq. 3.11 is given by

$$g(\eta) = \exp \left\{ - \left[\frac{U_o y_o^2}{L \epsilon_y} \beta \right]^{1/2} \eta \right\} \quad (3.16)$$

Eqs. 3.10 and 3.16 are used to analyze the data as described in Chapter V.

CHAPTER IV

EXPERIMENTAL EQUIPMENT AND PROCEDURE

4.1 Experimental Set-up and Equipment

4.1.1 Experimental Site

Permission was obtained to use a pond located inside the National Research Council grounds near the International Airport, Ottawa for conducting full-scale field experiments. Fig. 4.1 shows a map of the pond. At the test section, the pond is nearly 480 feet long, 80 feet wide and 7 to 10 feet deep. This site was ideal because of its restricted access to the public; there was no interference by other craft while the tests were being conducted.

Water quality tests were conducted to ascertain the suitability of the water for carrying out the experiments using a fluorescent dye as tracer. The results of the water quality tests conducted on May 27, 1969 are given in Table 4-1, which show that the water was suitable to carry out the experiments.

It was noticed that there was growth of a pond weed in late spring and early summer. The weeds were removed by dragging operation; in addition, a mild weed-killer was spread. No more growth of weeds was noticed afterwards.

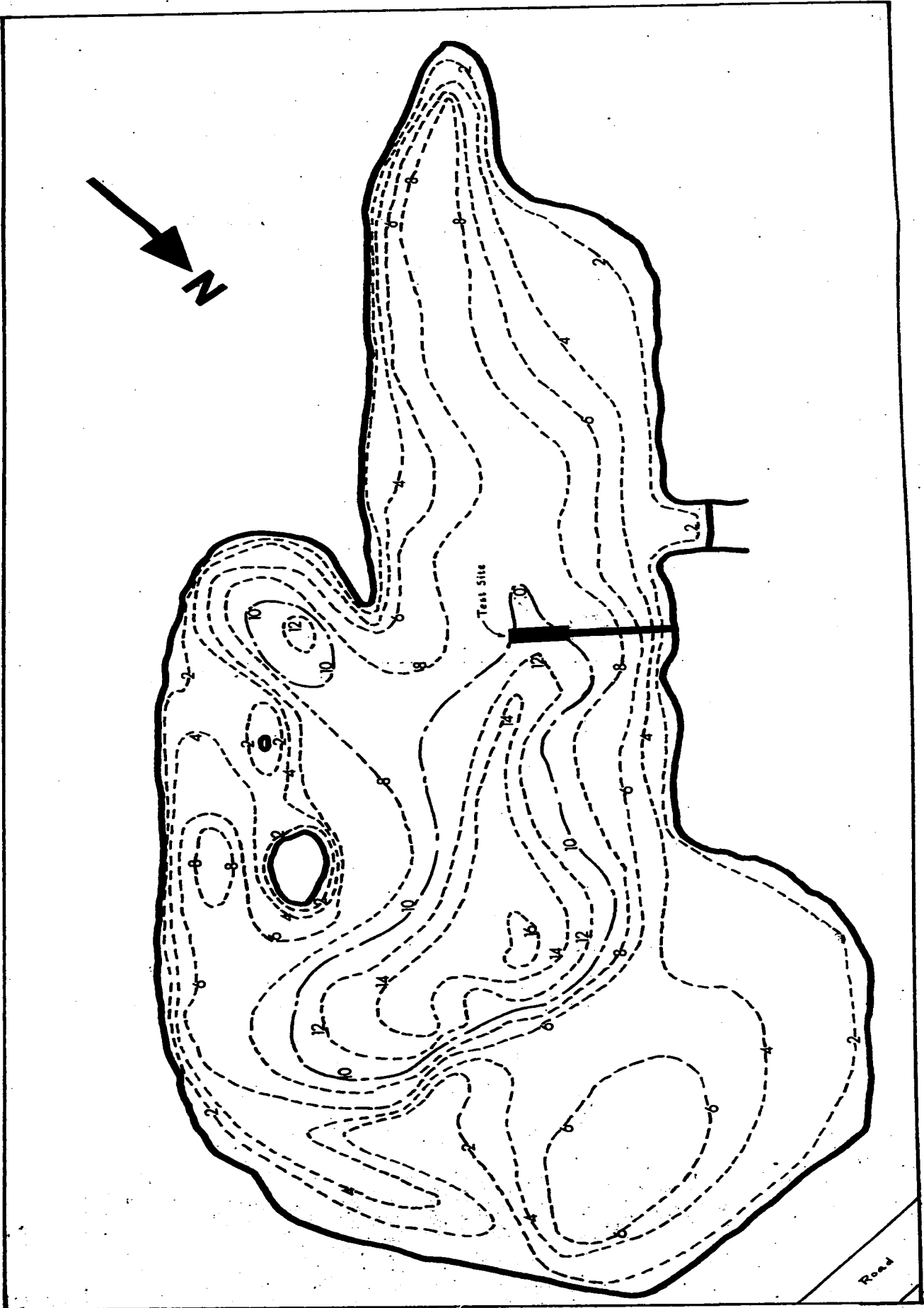


FIG. 4.1.1.--MAP OF POND SHOWING LOCATION OF TEST SITE

Scale: 1 inch = 40 feet

TABLE 4-1.--RESULTS OF WATER QUALITY TESTS

Sl.No.	Name of Test	Result
1	Alkalinity	Total alkalinity 150 ppm as CaCO ₃ Hydroxide alkalinity 0 Carbonate alkalinity 0 Bicarbonate alkalinity 150 ppm as CaCO ₃
2	Carbon dioxide	8 ppm as CaCO ₃
3	Chloride	5 ppm as Cl
4	Copper	0.25 ppm
5	Fluoride	0.30 ppm
6	Hardness (Calcium)	90. ppm as CaCO ₃
	Hardness (Total)	170. ppm as CaCO ₃
7	Iron	0.05 ppm
8	Nitrate Nitrogen	Nil
9	Nitrite Nitrogen	Nil
10	pH Value	8.5
11	Ortho-phosphate	0.12 ppm
	Meta- or Poly-phosphate	0.18 ppm
	Total phosphate	0.30 ppm
12	Silica	1.30 ppm
13	Sulfate	40. ppm
14	Turbidity	Nil
15	E. Coli Test	20 Coliforms per 100 ml (max. value of two samples)
16	5-day, 20°C BOD	2.2 mg./l

4.1.2 Observation Platform

Fig. 4.2 shows a view of the platform. Light-duty scaffolding material was used to build the two towers. For the tower on the left three ladder frames, two of 5 feet length each and one of 3 feet length, were used, while for the tower on the right two ladder frames of 5 feet length only were used. Each tower was assembled on the shore. An adjustable screw which had a bearing plate of six inch diameter, was tied to each leg of the tower to prevent it from falling down while lowering the tower.

The platform site is shown in Fig. 4.1. A steel cable line was run from shore to shore across the pond at the proposed site; the approximate position for installing the towers was marked on the cable. The tower positions were selected after taking soundings along the cable to know the approximate depths as well as to determine the bottom conditions for stability. The tower on the left was about 30 feet from the shore; the clear distance between the towers was 18 feet, which was determined by the length of beams (20 feet).

One of the towers was loaded onto an 18-foot boat, which was rowed to the intended location of the tower; the boat was tied firmly with ropes to pegs on the shore. The tower was now lowered slowly to the intended location; when it rested on the bed of the pond, its level was adjusted to be nearly horizontal through the ropes that were tied to the

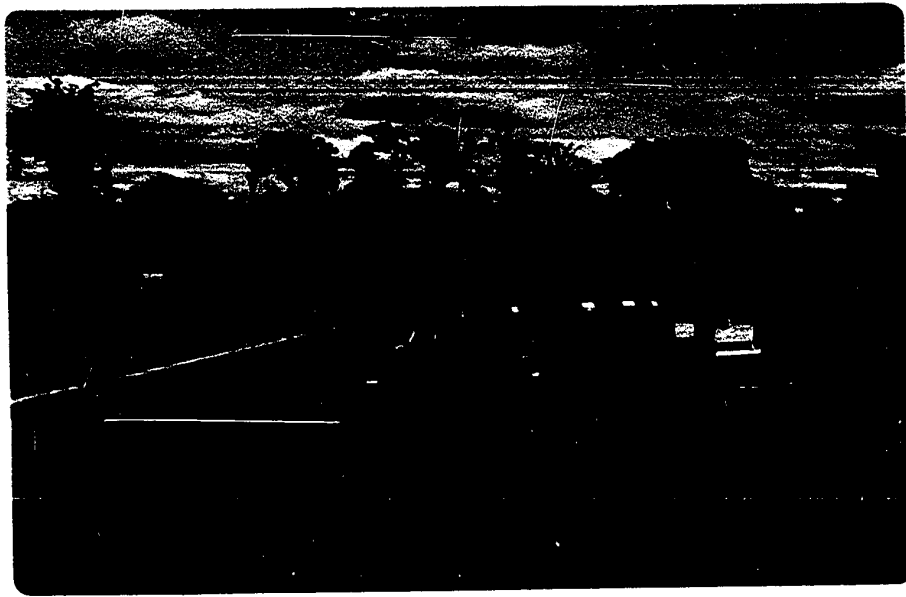


FIG. 4.2.--VIEW OF PLATFORM

posts of the tower. As the bed on which the tower was resting was not horizontal, the tower was firmly tied by the ropes to pegs on the shore. The boat was moved away. It was necessary to adjust the height of the legs so that they rested firmly on the bed. This was achieved by diving to the bed of the pond, locating and cutting the wire holding the adjustable screw of each leg, and adjusting the height of the base plate so that it was resting on firm bed. Now, the ropes used to tie the tower were removed. The top of the tower was made horizontal by suitable adjustment of the height of the legs. The other tower was also installed into its intended location in the same manner. The towers were allowed to settle for a few days after which the height of the legs was again checked and adjusted as necessary.

The difference in height between the two towers was made up by building a wooden frame work of sufficient height on the shorter one. On top of both the towers, two layers of 4" x 4" wooden frames were fixed; these were meant to secure the I-beams. The height of the towers was adjusted so that the clearance between the water surface and bottom of the beams was 3 feet to facilitate the passage of a boat under the platform.

Two steel I-beams, each 20 feet long, were then carried on the boat, one at a time, and placed 3 feet apart on the wooden frame work. The beams were firmly secured to the wooden beams.

Plywood sheets, 4 feet wide and 1 inch thick, were laid on the entire 20 feet length of beams. The sheets were secured to the beams with the help of nails. A walkway, from the shore to the platform was constructed using two 30 feet long beams, which were placed side by side, so that one end rested on the edge of the left tower while the other end rested on the ground close to the shore. The beams were covered with three expanded metal sheets, each about 1 foot wide and 10 feet long.

Hand rails, 3 feet high on one side and 2 feet high on the other side of the platform, were built using slotted steel angle sections, 2" x 2". These hand rails served as a resting place for samplers during experimental runs in addition to serving as guard rails.

4.1.3 Out-board Motor Boat

A 14-foot boat, driven by an out-board motor was used to conduct the tests. The motor used was a 5 H.P. Johnson motor with a propeller diameter of six inches. The boat width at the stern was 4 feet. The motor was equipped so that a tachometer could be attached so that the motor rpm could be read directly. Fig. 4.3 shows a view of the boat with the tachometer and dye injection device. A relation between the rpm and the boat speed was established by determining the average time required to pass a known distance at any one rpm under stipulated field conditions. Fig. 4.4 shows the relationship between the rpm and the boat speed.

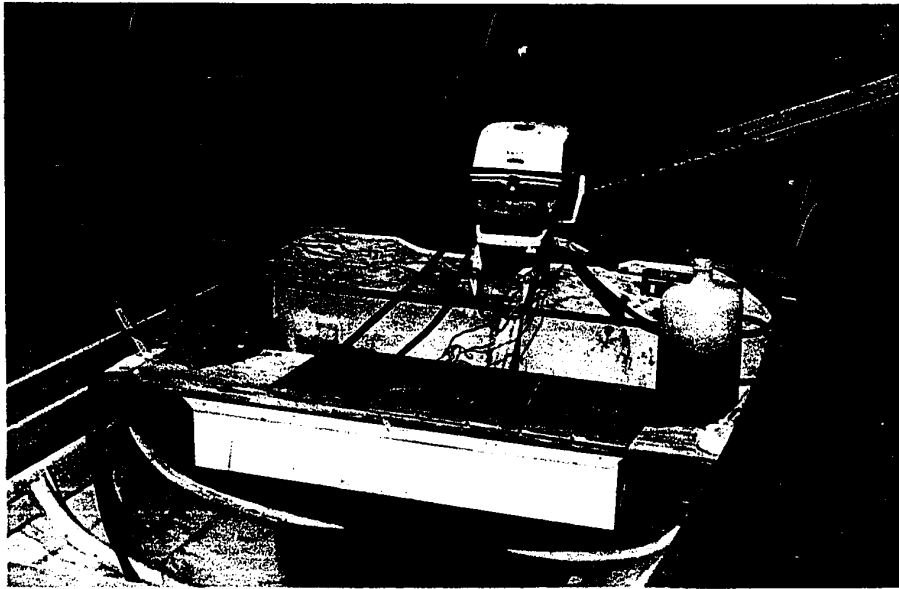


FIG. 4.3.--VIEW OF BOAT

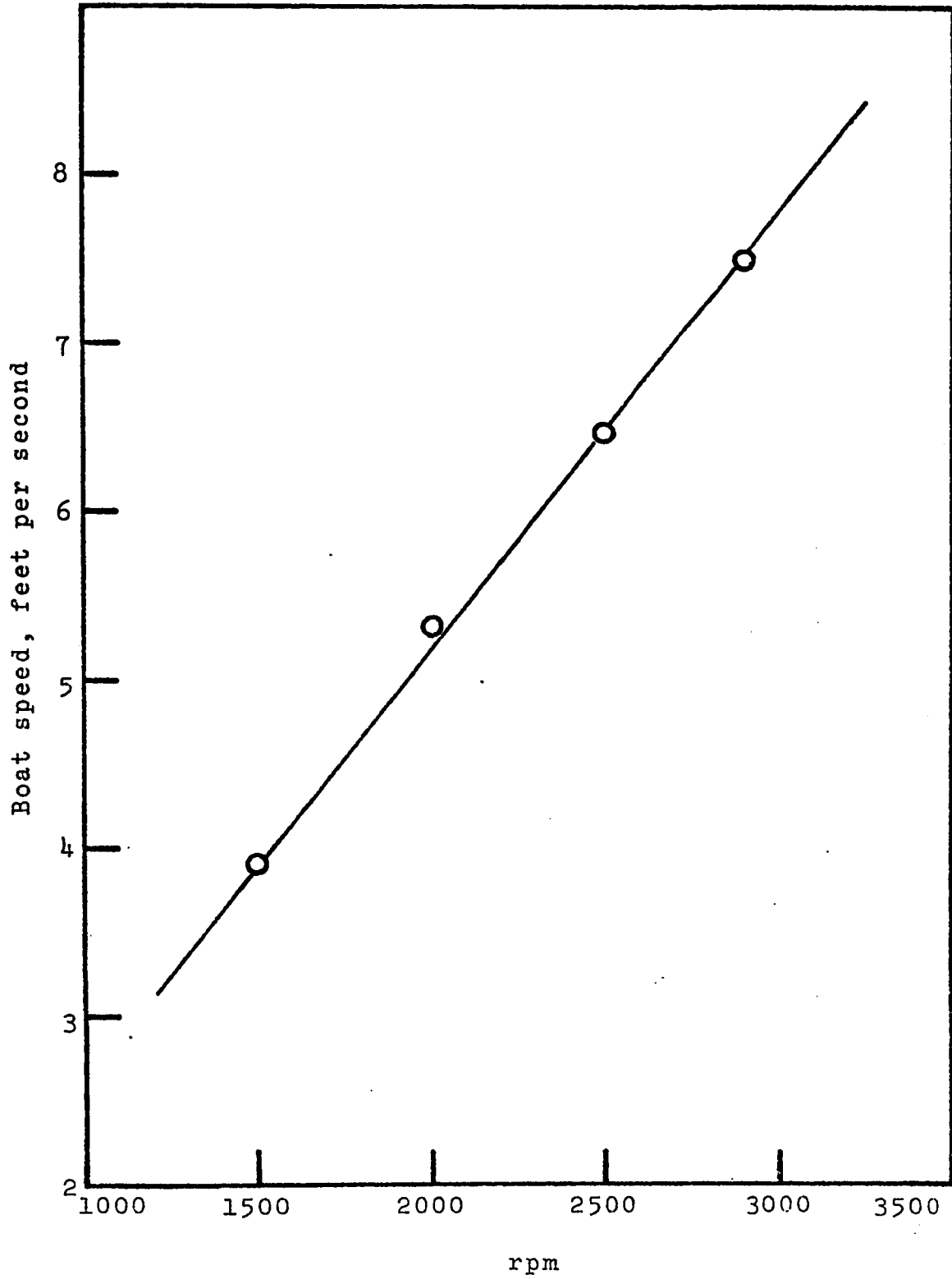


FIG. 4.4.--BOAT SPEED vs RPM

Two nylon ropes, 1/4 inch diameter, spaced 4 feet apart, were installed from shore to shore at right angles to the platform. Each rope was about 500 feet long. The ropes were placed so that they were just above the water surface and as close to the right tower as possible leaving enough margin for the boat to pass; they were tied to pegs driven on the shores. These ropes were used to guide the boat as explained in the experimental procedure.

4.1.4 Dye Injection Device

A syphon type of arrangement was used as a dye-injection device. Fig. 4.5 shows the arrangement. It consists of a Nalgene container, 1/2 gallon capacity, provided with a stopper with two holes into which two glass pipes were fitted as shown in the figure. The glass pipe, bent to an L-shape, served as a dye discharge hose while the other one served as an air vent. Both pipes were fitted with plastic hoses of suitable length.

4.1.5 Samplers

4.1.5.1 Details of Sampling Device

Figs. 4.6(a), (b) and (c) show details of the sampling device used to collect samples. It resembles a battery of pitot tubes. Each sampler was built as follows: Four galvanized iron pipes, 1/4 inch external diameter and 3/16 inch internal diameter, ranging in length from 3 to 6 feet, were bent through 90° at one end. They were placed

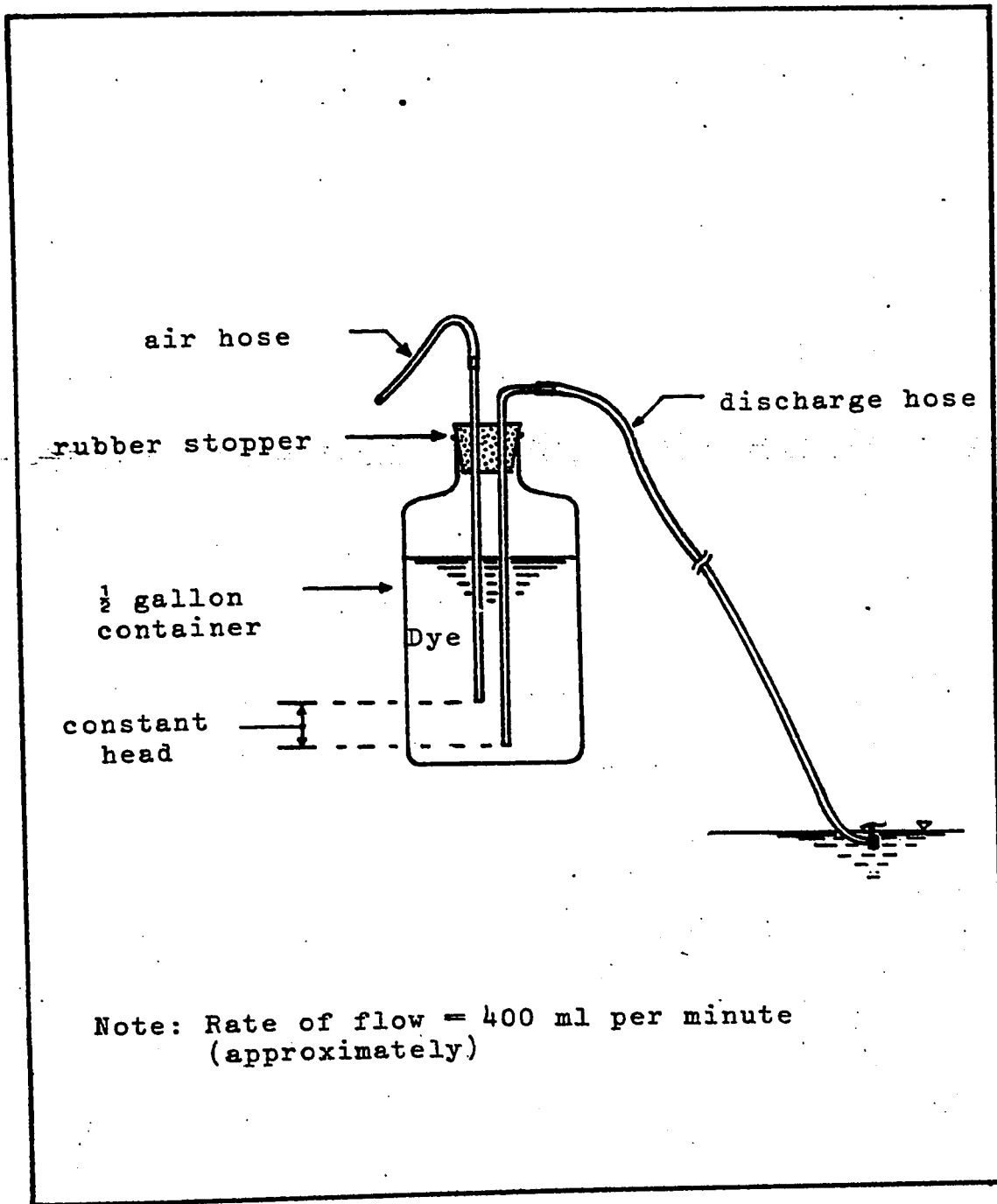


FIG. 4.5.--DYE INJECTION DEVICE

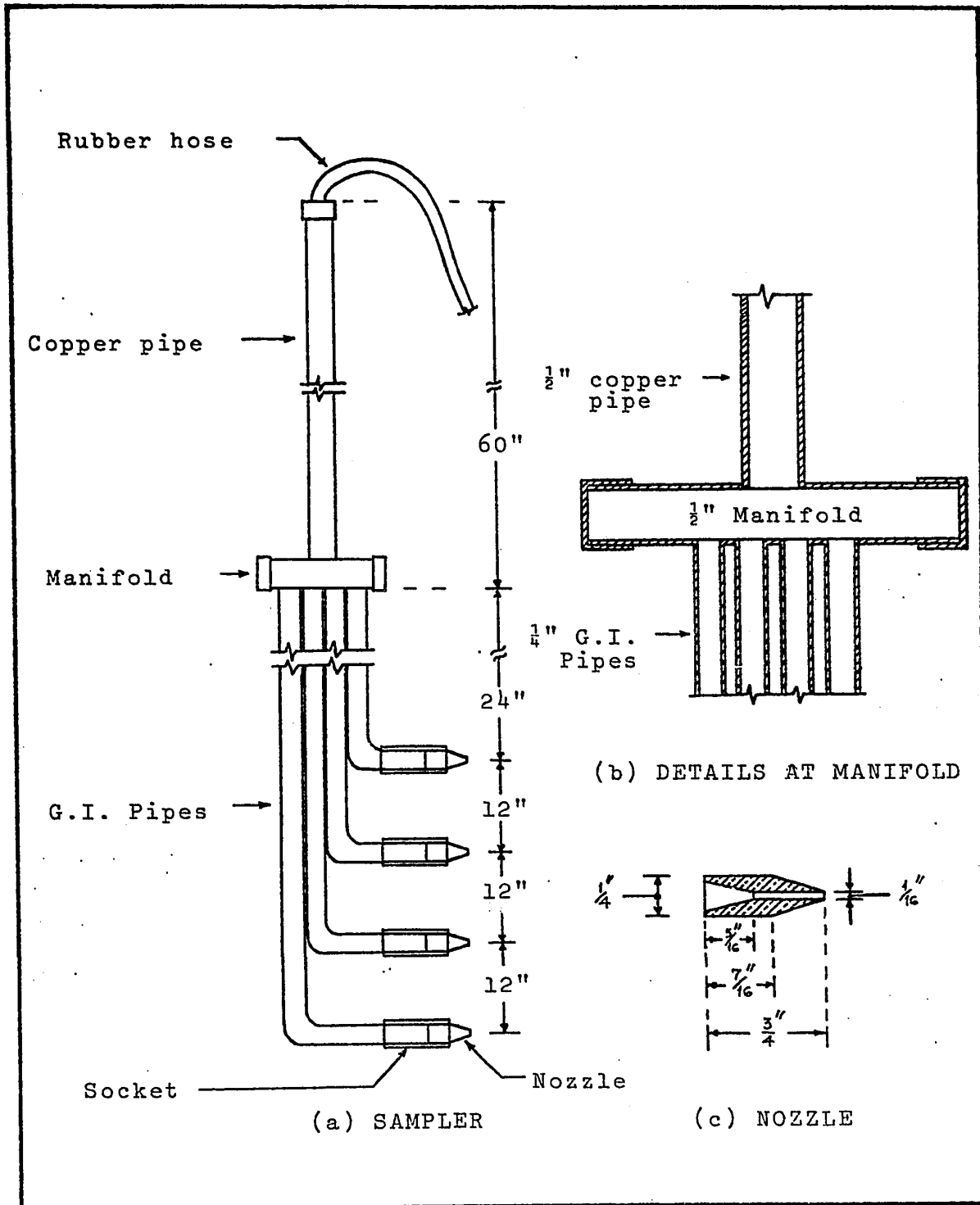


FIG. 4.6.--DETAILS OF SAMPLING DEVICE

(Not to scale)

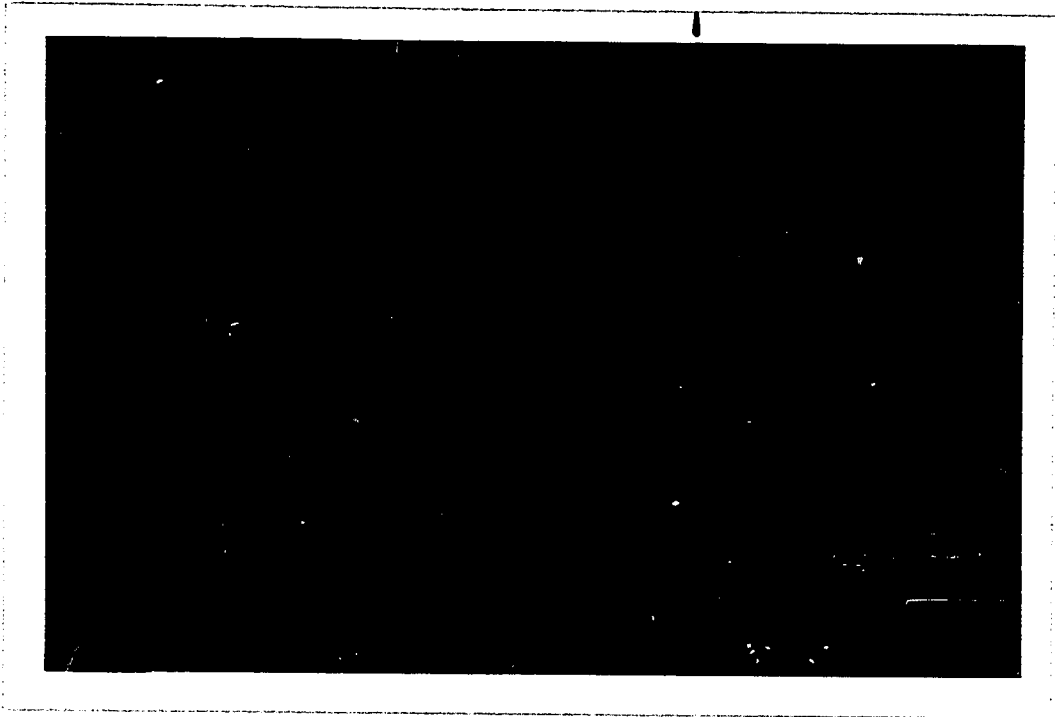
side by side such that the bent ends were exactly one foot apart and point-welded to hold them together in this position. The other end of the pipes was welded to a short copper manifold tube, 1/2 inch diameter and 3 inches long. A copper pipe, 1/2 inch diameter and 5 feet long, was welded over a hole on the upper side of the manifold. The open end of the copper tube was fitted with a pipe plug to which a short 1/4 inch diameter and 6-foot length, was fitted to this short tube. The bent ends were trimmed such that the ends were on the same vertical line when held upright.

The ends of the bent pipes were fitted with brass nozzles (the details of which are shown in Fig. 4.6(c)) using short lengths of 1/4-inch plastic hose as sockets. A ball bearing, 1/8-inch diameter, was inserted into each of the pipes before fitting the nozzles. Each pipe was slightly pinched just above the bend in the vertical portion in order to prevent the ball bearings from entering the manifold when the sampler was tilted.

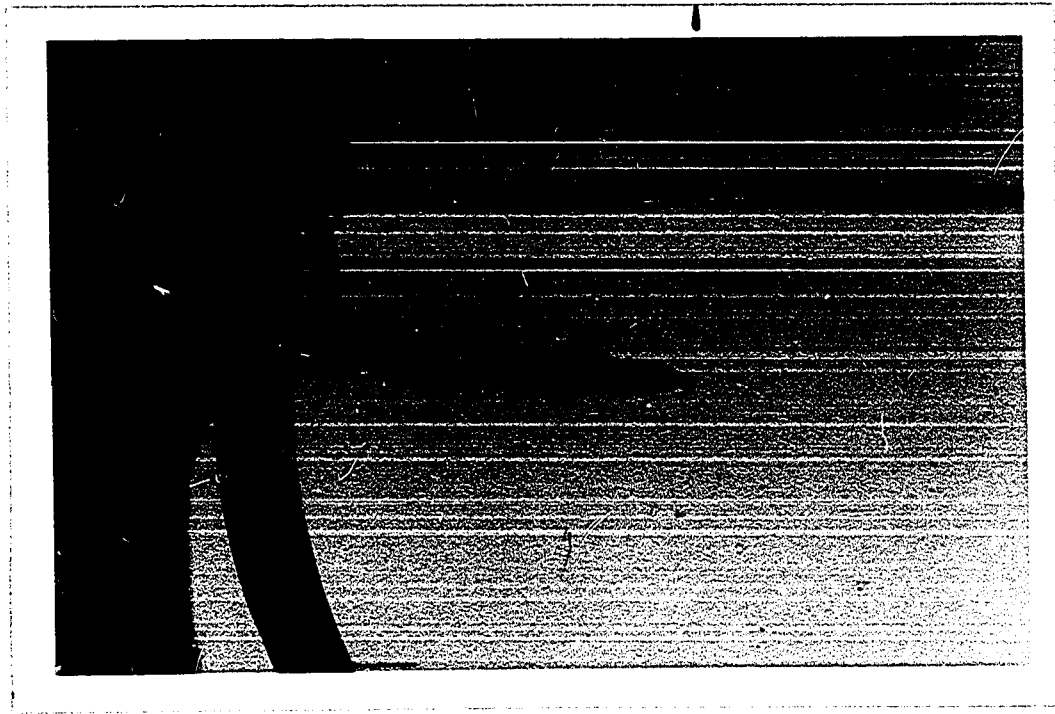
Figs. 4.7(a) and (b) are photographs of a sampler showing the socket, ball bearing and nozzle.

4.1.5.2 Operation of the Sampling Device

The operation of the sampler, which may be used to get instantaneous point samples or depth-averaged samples, was as follows: The sampler was held in the vertical position such that the lowest pitot tube-like pipe was just above



(a)



(b)

FIG. 4.7.--DETAILS OF SAMPLER

the water surface. At this position, the sampler was pressurized by blowing air through the rubber hose. This resulted in the ball bearings in each pipe moving to the bell-mouth portion of the nozzles, thus blocking the orifice and preventing the entry of sample inside the pipes. The sampler was now lowered (still holding the pressure) to the desired depth and air pressure released upon which a sample of water entered the pipe due to the hydrostatic pressure. Instantaneous point samples could be collected by holding the sampler at any desired depth for a few seconds. In order to collect depth-averaged samples, the pressurized sampler has to be lowered to a predetermined depth, the air pressure released, and the sampler slowly lowered through the depth over which depth-averaging was desired. In this study, samples averaged over one-foot depth were collected. After the sample was collected, the sampler was tilted slightly from the vertical so that the nozzles faced downwards; the ball bearings would then move to the bell-mouth portion (by gravity), thus preventing the escape of sample. The sampler was then taken out slowly (to prevent disturbance of surrounding water) and placed on the guard rails. By inserting an unfolded paper clip through the nozzle orifice, the ball bearing is pushed back from the bell-mouth portion of the nozzle whereupon the sample would start to flow through the orifice of the nozzle. This water sample was collected in a test tube. The entire operation of collecting

a sample required about 90 seconds. Any excess sample, after filling the test tube, was wasted. Any sample that may have remained in the pipes was drained by the alternate blowing and sucking of air through the plastic hose a few times. Then, the sampler was ready to collect another sample.

Before being used to collect samples in the experiments, the performance of the sampler was carefully evaluated by collecting samples in a laboratory sump. A few difficulties arose during this evaluation for which suitable remedial measures were taken. They are briefly described below:

1. The pipes were found to rust due to water retained in the pipes after use. This was prevented by drying the sampler immediately after the experiment was over.
2. Ball bearings were found to become rusty which was prevented by cleaning after each use and storing them separately.
3. Sometimes, the ball bearings would get stuck in the pipe during sampling. They were replaced with spare ones.

It was noticed that the top-most pipe was not collecting enough sample, probably due to insufficient hydrostatic pressure. A slight suction was applied (immediately after releasing the air pressure) by sucking in air through the plastic hose for a short time, which was found to be a satisfactory remedy.

4.1.6 Details of Fluorometry

Fluorescent tracers have been used extensively to study the mixing characteristics in rivers, lakes and oceans because of their detectability even in very low concentrations. Several researchers have investigated the fluorescent characteristics of various dyes available in the market. One such study has been conducted by Feuerstein and Selleck (15); they have investigated the effect of environmental factors such as temperature, salinity, pH, background level and turbidity characteristics of the sample on the analytical determination of three fluorescent tracers namely, Rhodamine B, Pontacyl Brilliant Pink B and fluorescein. They have also investigated the photochemical decay rates and physical adsorption isotherms for suspended sediments and algae. After carefully evaluating their findings in relation to this study, it was decided that fluorescein dye would be best suited for this work because of the following reasons:

1. Fluorescein is least affected by the temperature.
2. The pH of pond water is 8.5 (see Table 4-1), at which the fluorescence intensity of fluorescein dye remains fairly constant.
3. The chloride content of pond water is only 5 ppm as Cl, so that the salinity effects are negligible.
4. The background level of fluorescein in pond water is about 2 ppb. Since the samples were analyzed

on 1x and 10x ranges of the fluorometer, the effect of background level is not a critical factor.

5. Fluorescein did not exhibit any measurable adsorption of suspended sediments. Also, the turbidity of pond water was zero units.
6. Photochemical decay rate of fluorescein dye is very high, especially in bright sunlight. However, this has been minimized by conducting most of the experiments early in the morning; also, the length of sampling time is less than one hour after injecting the dye. Precautions were taken to prevent exposure of samples to sunlight through proper storage before they were analyzed.
7. Fluorescein costs much less than the other dyes.

Fluorescein dye, manufactured by Matheson, Coleman and Bell, was used in this study. This dye is available in water-soluble, powder form in glass bottles with a net weight of one pound and is designated as suitable for water pollution work.

The analysis of samples for fluorescence intensity was done with a Turner Model 111 Fluorometer which is an automatic servo-balancing instrument. The light source used was the general purpose ultraviolet lamp, normally supplied with the fluorometer. The instrument has a means of manually controlling the available sensitivity which can be accomplished

by a range selector between the lamp and the primary filter. There are four positions designated 1x, 3x, 10x and 30x, indicating their approximate relative sensitivity; the 1x position is the least sensitive. The standard, or discrete sample door, was used to analyze the samples. The cuvettes used were 12 by 75 mm culture tubes, the details of which are furnished in the next section.

According to Feuerstein and Selleck (15), the maximum absorbance of fluorescein occurs at a wavelength of 480 m μ , and the maximum fluorescence intensity of fluorescein occurs at 510 m μ . The primary filter system consisted of a combination of one each of a sharp-cut filter of colour specification #2A and a narrow pass filter of colour specification #47B. The secondary filter consisted of one sharp-cut filter of colour specification #2A-12. This filter system is the same as that suggested in Reference (17).

The fluorometer was calibrated by preparing solutions of known dye concentration and noting the corresponding fluorescence intensity (or dial reading in units) at each range selection position of the fluorometer. At any one range position, the relation between the concentration of dye and its fluorescence intensity is found to be linear. Fig. 4.8 shows the relationship between the fluorescence intensity in units and the concentration of dye in parts per billion (corresponding to each range position) for the particular filter combinations and light source used.

August 24, 1969
Fluorescein dye
Distilled water
diluent
Samples at 20°C

Turner Model 111 Fluoro-
meter; standard door;
general purpose UV lamp;
filters (2A+47B)/2A-12

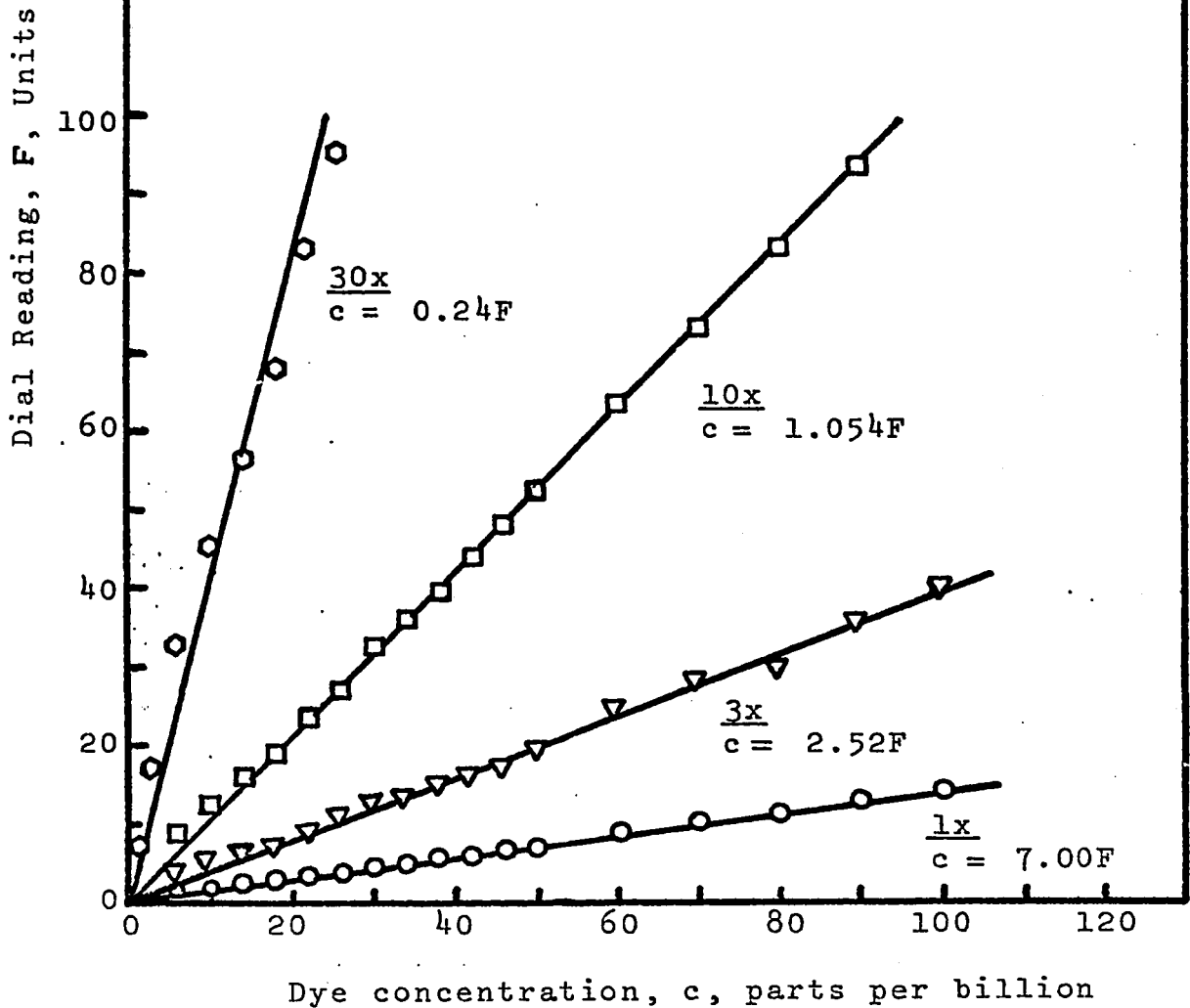


FIG. 4.8.--FLUOROMETER CALIBRATION CURVES

4.1.7 Test Tubes

An estimate of the number of samples that would be collected in each experiment indicated the number to be up to 800. A suggested procedure in the fluorometric analysis of samples using standard door is that each sample be held in a standard cuvette. If this procedure were to be followed, the cuvette would have to be cleaned before another sample is taken in it. This procedure would have been laborious and time-consuming for the analysis of a large of samples. An alternate way would have been to collect each sample directly into a standard cuvette; however, the high cost of standard cuvettes was a drawback.

The operating instructions for the 110-005 door, standard cuvette, supplied by G. K. Turner Associates (29), indicates that the optical requirements of the cuvettes are not stringent since the fluorometer utilizes a diffuse light source with slits so arranged that the lens effects in the cuvettes cancel out. It is only necessary to discard those test tubes with defects such as air bubbles, visible scratches, etc.

About 300 Pyrex brand bacteriological culture test tubes, 12 by 75 mm size, were purchased and tested in the laboratory. First, they were visually examined for air bubbles and scratches, discarding the defective ones. Then a dye solution of a known concentration was filled in about 25% of the test tubes randomly picked from the lot, and they

were analyzed for fluorescence intensity. The readings indicated that the variation of fluorescence intensity did not exceed more than 3%. So, it was decided to use this type of culture test tube for collection and analysis of samples. These test tubes cost much less than the standard cuvettes. Suitable test-tube racks were used to keep the test tubes.

4.2 Experimental Procedure

Most of the experiments were conducted during mornings (between 7 a.m. and 9 a.m.) when the winds were calm. The weather conditions were recorded before each experiment. The temperature of pond water was determined at various depths by collecting water samples at known depths and reading the temperature using a thermometer. The experimental procedure consisted of preparing the dye solution, equipping the samplers and boat, and collecting and analyzing the samples. The details of these steps are given below:

1. Preparation of dye solution: A stock solution of dye of concentration 1 in 10 was prepared in the laboratory (usually once a week), using distilled water as diluent and adding sufficient ethanol (sp.gr. \approx 0.8) to adjust the density to 1.03. Using this stock solution, about one litre dye solution of 1 in 12 or 1 in 15 concentration, whose density was adjusted to that of pond water, was prepared just before the experiment as follows: From the law of conservation of mass, assuming constant volume,

$$V_d \rho_d + V_e \rho_e = (V_d + V_e) \rho_w, \quad (4.1)$$

in which

V_d = Volume of stock solution of dye, ml

V_e = Volume of ethanol, ml

ρ_d = density of stock solution of dye,

ρ_e = density of ethanol,

ρ_w = density of pond water.

From Eq. 4.1, the volume of ethanol, V_e , required to be added to a known volume, V_d , of stock solution of dye is given by

$$V_e = \frac{\rho_d - \rho_w}{\rho_w - \rho_e} V_d \quad (4.2)$$

The values of ρ_d , ρ_e and ρ_w were determined using hydrometers.

After adding ethanol in an amount determined by Eq. 4.2, the concentration of dye was adjusted to the desired value (1 in 12 in the tests at 3000 rpm and 1 in 15 in the tests at 2000 rpm) by the addition of sufficient amount of pond water. The bottle containing this solution was kept in the pond water in order to prevent any possible temperature variations.

2. While the dye solution was being prepared by one or two persons, the other members of the group (which consisted of three to five persons) were preparing the samples for use. This consisted of fitting the bronze nozzles to the sampler pipes after inserting ball bearings and testing the samples for proper operation and no leakage.

3. The boat was fitted with the out-board motor. The tachometer was connected to the motor. The dye bottle was fitted with the syphon device and kept in the boat close to

the motor. The discharge hose of the syphon was tied to the centre of the propeller. The boat was now rowed to a position in between the nylon ropes, about 200 feet from the platform. The boat was tied to the nylon ropes at four places using hooks, so that the boat was guided by the ropes when the motor was started.

4. The location of the sampling stations were as follows: Each person on the platform, holding a sampler, would position himself at a marked station which were located 3 feet or 4 feet apart. The person at the far-end of the platform would position himself in line with the centre of proposed path of boat; he would also serve as time-keeper.

5. After signalling the group on the platform, the person in the boat would start the motor and adjust the engine rpm to the desired value. Next, the syphon device would be started by blowing air through the air hose, upon which the dye would start flowing; it was found necessary to hold the air-pressure even after the start of the syphon action in order to maintain uninterrupted flow of dye. Usually, the total length of dye injection was about 300 feet, - 150 feet on either side of the platform. The motor would be stopped at the end of run, untied from the nylon ropes and rowed to the shore. The person driving the boat would now join the sampling group.

6. The time-keeper would start a stop-watch at the instant the stern of the boat passed the sampling section,

and signal to collect samples immediately. Thereafter, samples were collected at two minute intervals up to about 48 minutes. Each sample would be kept in test tube racks in a predetermined order. Each rack was labelled indicating to the station location.

The samples were collected at 2-minute intervals at any one station regularly or at alternate stations depending on the number of persons.

7. When the sampling was over, the test tube racks containing the samples were moved to a shelter; they were later taken to the laboratory and kept under a dark cover until they were analyzed.

8. The samplers were cleaned and dried after removing the nozzles and ball bearings, and then stored. The nozzles and ball bearings were also dried of water and stored.

9. Analysis of samples: The fluorometer was turned on and allowed to warm up for about an hour. The background fluorescence level of pond water was determined using distilled water as a blank. Next, using the pond water as a blank, the dial reading was adjusted to zero. Most of the samples were analyzed on 10x (range position); however, some of the highly concentrated samples had to be analyzed on 1x (range position). The temperature of the sample at the time of analysis was noted. The dial readings were recorded in a tabular form shown in Table 4-2.

TABLE 4-2.--TABULAR FORM FOR RECORDING EXPERIMENTAL DATA

Date:

Weather:

Background fluorescence:
of pond water, units

Distance (sampling station):

RPM:

Air Temperature:

Temperature of sample:
during analysis

Depth	Dial Reading, Units			Depth	Dial Reading, Units		
	1X	3X	30X		1X	3X	30X
0-1							
1-2							
2-3							
3-4							

4.3 Experimental Results

Experiments were conducted in the summer and early fall of 1969, and in the summer of 1970. Two series of experiments were conducted - one series at 2000 engine rpm and the other at 3000 rpm. A number of experiments were conducted at each rpm when the winds were calm with a view to obtain an ensemble average concentration distribution in the wake. However, in some of the experiments it was observed that the dye moved away from the test section. Hence, only those experimental results which have not shown this tendency have been considered for the analysis. The general details of the tests are provided in Table A-1 in Appendix A. The observed fluorescence values are reported in Tables A-2 to A-14 in Appendix A. For convenience, Tests 1 to 6, which were conducted at 2900 or 3000 rpm as indicated, have been grouped together and termed "Series 3000"; Tests 7 to 11, which were conducted at 2000 rpm have been grouped and termed "Series 2000". While Tests 1 to 11 were conducted during the morning hours, the Tests 12 and 13 were conducted at 2900 rpm, late in the afternoon. They could not be grouped together for the purpose of analysis, and hence are designated individually as "Series 2914" and "Series 2919" respectively.

For convenience, the dial readings read on the range 1X are reported in equivalent units on the range 10X. All the fluorescence values reported in Appendix A correspond to the range position 10X, and represent the dial readings (or fluorescence intensity) in units.

The depths 0-1, 1-2, 2-3 and 3-4 refer to the depth in feet below the water surface. This designation is adopted to represent appropriately the depth-averaged sample locations.

CHAPTER V

ANALYSIS OF DATA

5.1 Treatment of Experimental Data

The first step in the analysis of data involving turbulent diffusion is some type of averaging process. Hinze (21) has discussed various methods of averaging and where each method is best suited. In a quasi-steady field of turbulence, averaging with respect to time is useful, whereas in a homogeneous turbulence flow field, averaging with respect to space is useful. When the flow field is neither steady nor homogeneous, averages may be taken over a large number of experiments that have the same initial and boundary conditions; this is referred to as an ensemble mean value.

The wake flow under consideration belongs to the latter category so that an ensemble mean is desirable. A number of tests, with the same initial and boundary conditions, were conducted at a known boat speed with a view to obtaining ensemble mean values of the concentration of dye. However, the observed data seemed to differ considerably from one test to another. It is interesting to note an observation that attempts to reproduce wakes of ships were unsuccessful even though conditions seemed to be ideal (32). Hence, an ensemble average has not been taken as a first step in the analysis of

data. However, as we shall see later, the analysis shows that the data of some tests could have been used to obtain ensemble mean values.

It has been stated in the experimental procedure that the samples have been averaged over one-foot depths. While this procedure cannot be fully justified, it amounts to assuming homogeneous conditions at intervals of one foot in the vertical direction. It was felt, at the time of collection of data, that such a procedure would provide a satisfactory approximation.

The fluorescence values for each test must be referred to a standard temperature of 20°C, in order to take into account the differences in temperature during the analysis of samples. Investigations by Feuerstein and Selleck (15) reveal that fluorescein dye is affected little by differences in the temperature range normally encountered. Hence, the temperature correction was found not necessary.

Plots of fluorescence versus time at each sampling point resulted in curves with zig-zag patterns. A smooth curve was drawn through the points and these values of the fluorescence were used in the analysis. Figs. A.1 to A.13 in Appendix A show plots of fluorescence versus time. Each curve is identified by three numbers, the first one representing the distance to sampling station from the centre line of wake while the other two represent the depth over which sample is collected; for example, 6:1-2 identifies the curve at the

station 6 feet from centre line and at depth 1-2. The smoothed values of fluorescence are given in Tables A-2 to A-14 in Appendix A.

A computer program was written to carry out the various computations involved in the analysis of data. The program is given in Appendix B. The computations involved are for mass balance, calculation of variance from one-dimensional normal distribution equation and from the second moment method, and analysis of data by the proposed mathematical model. The details of these computations are given in the following sections.

5.2 Mass Balance Computations

The amount of dye in the cross-section per unit length of wake at any time must remain constant, assuming no movement of dye in the longitudinal direction (see assumptions in §5.4). The total weight of dye per foot length of wake, W_D , at any time, assuming no longitudinal diffusion, is given by

$$W_D = \gamma \int_A c \cdot dA \quad (5.1)$$

where c is the concentration of dye,

γ is the weight density,

and dA is the elemental cross-sectional area.

In the computations, the weight of dye, w , per foot length per foot depth has been determined using

$$w = \gamma \int c \cdot dy \quad (5.2)$$

This computation is done for the four one-foot depth intervals in which the samples are collected. The total weight, W_D , is then obtained by the sum of these weights. Tables in Appendix C show the values of W_D in grams.

An examination of the values of W_D at different times in a test indicates that the mass of dye in the cross-section remains fairly constant. During the initial time period (from 0 to 6 minutes approximately), the value of W_D is seen to fluctuate somewhat. This is probably due to the fact that the dye is not well mixed in the initial stages, but is concentrated in discrete masses of water. Again, after the diffusion has progressed for some time (about 20 minutes), there is a gradual decrease in the value of W_D . This is mostly due to the diffusion of dye beyond the sampling region. Photochemical decay of the dye may also cause this. However, it is reasonable to assume that the photochemical effect is negligible since most of the tests were conducted during the morning hours when the effect of sun-light was minimum; also, the total duration of sampling was less than one hour.

5.3 Variation of Wake-width with Time

The wake width and time are assumed to be related by an expression of the form

$$y_o = a t^n , \quad (5.3)$$

in which y_o is the wake width at time, t (measured from the centre line to the wake-edge), and a and n are constants.

These constants are evaluated from the experimental data as follows: Curves of concentration, c , versus lateral distance, y , are plotted for a specified depth at various values of time and a smooth curve is drawn through the points. The wake width, y_0 , at any time, t , is taken to be the value of y measured from the centre line to a point on the edge of the wake where the concentration, c , is zero. It is assumed that the concentration distribution curves at various times have similar patterns. It was observed in the plots of c versus y that this assumption is valid upto some value of time in each test, beyond which the distribution became too irregular, making it unfeasible to obtain the values of y_0 . Hence, in each test, the values of y_0 upto some value of time only are given. Further, in Tests 1 to 11, plots of c versus y at depth 3-4 were very irregular and have been left out. In Tests 12 and 13, concentration values at depths 2-3 and 3-4 are very small or zero and hence they are not considered. Figs. C.1 to C.13 in Appendix C show plots of c versus y . The values of y_0 are given in the tables in Appendix C.

Taking logarithms on both sides of Eq. 5.3,

$$\log y_0 = \log a + n \log t \quad (5.4)$$

Therefore, a plot of y_0 versus $\log t$ gives a straight line of slope n and intercept $\log a$ from which n and a can be evaluated.

The values of y_0 from each test in any one series are plotted on the same graph in order to obtain average

values of a and n at a known rpm or boat speed. Figs. 5.1 to 5.4 show plots of $\log y_0$ versus $\log t$. Table 5-1 shows the values of a and n at various depths for each series. The standard deviations of a and n are also given in the table for series 3000 and series 2000.

TABLE 5-1. - VALUES OF a AND n

Series	Depth	a	Standard Deviation of a	n	Standard Deviation of n
3000	0-1	5.7	0.59	0.37	0.05
	1-2	3.1	1.14	0.61	0.08
	2-3	2.6	0.89	0.61	0.17
	3-4	-	-	-	-
2000	0-1	7.5	0.78	0.39	0.04
	1-2	4.8	0.42	0.68	0.06
	2-3	3.4	0.77	0.55	0.17
	3-4	-	-	-	-
2914	0-1	3.8	-	0.58	-
	1-2	3.9	-	0.61	-
	2-3	-	-	-	-
	3-4	-	-	-	-
2919	0-1	2.2	-	0.57	-
	1-2	2.6	-	0.50	-
	2-3	-	-	-	-
	3-4	-	-	-	-

An examination of Figs. 5.1, 5.2 and 5.4 indicates that after some value of time (about 20 minutes), the increase in wake-width with time diminishes, tending towards a constant value. In Series 2914, wake-width values could not be obtained beyond some time (about 10 minutes), making it difficult to find the trend of the curve in Fig. 5.3.

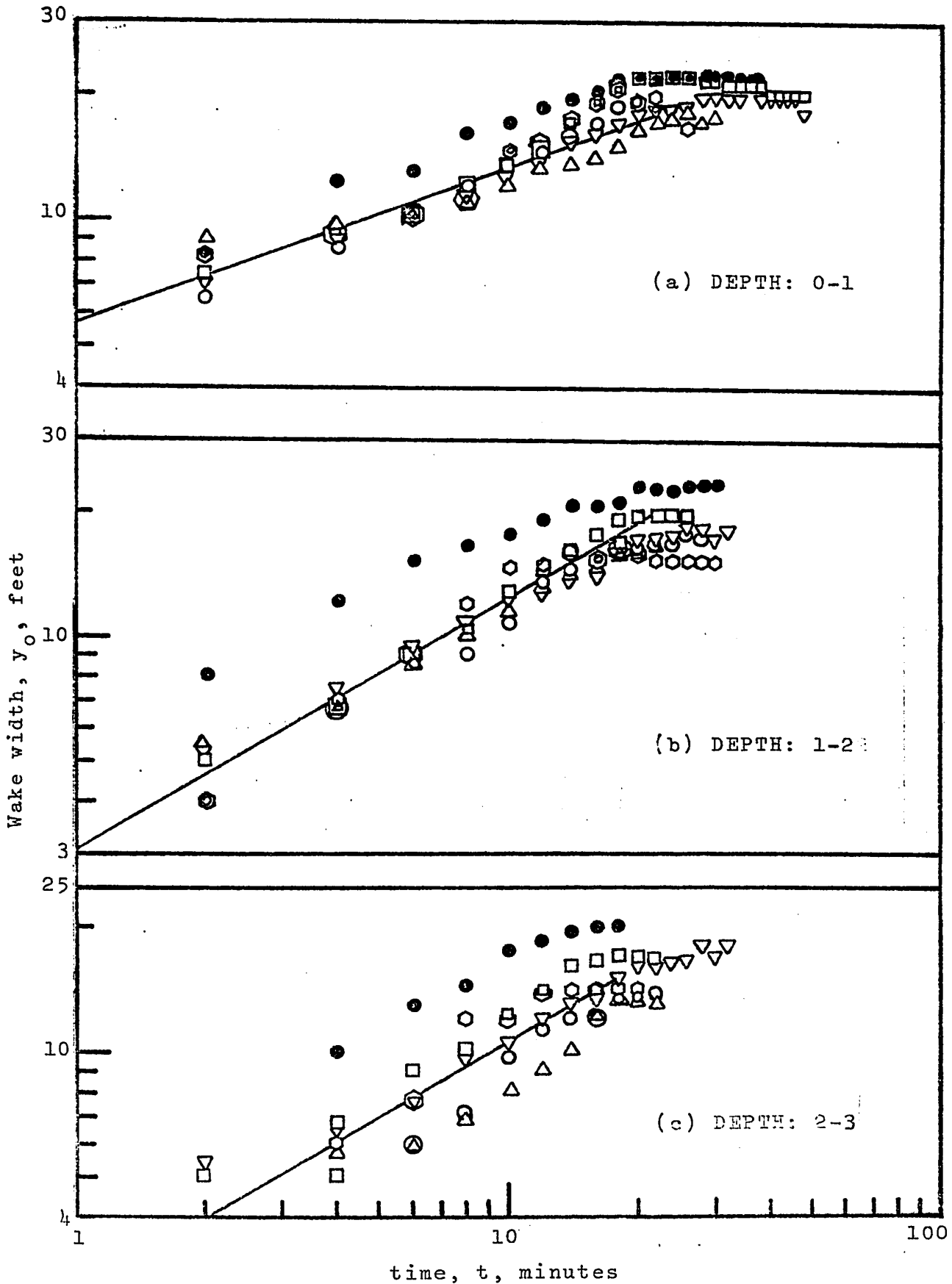


FIG. 5.1.--WAKE WIDTH vs TIME FOR SERIES 3000

Symbols ∇ , \square , \circ , \circ , \triangle , \bullet represent in order Test Nos. 1,2,3,4,5,6

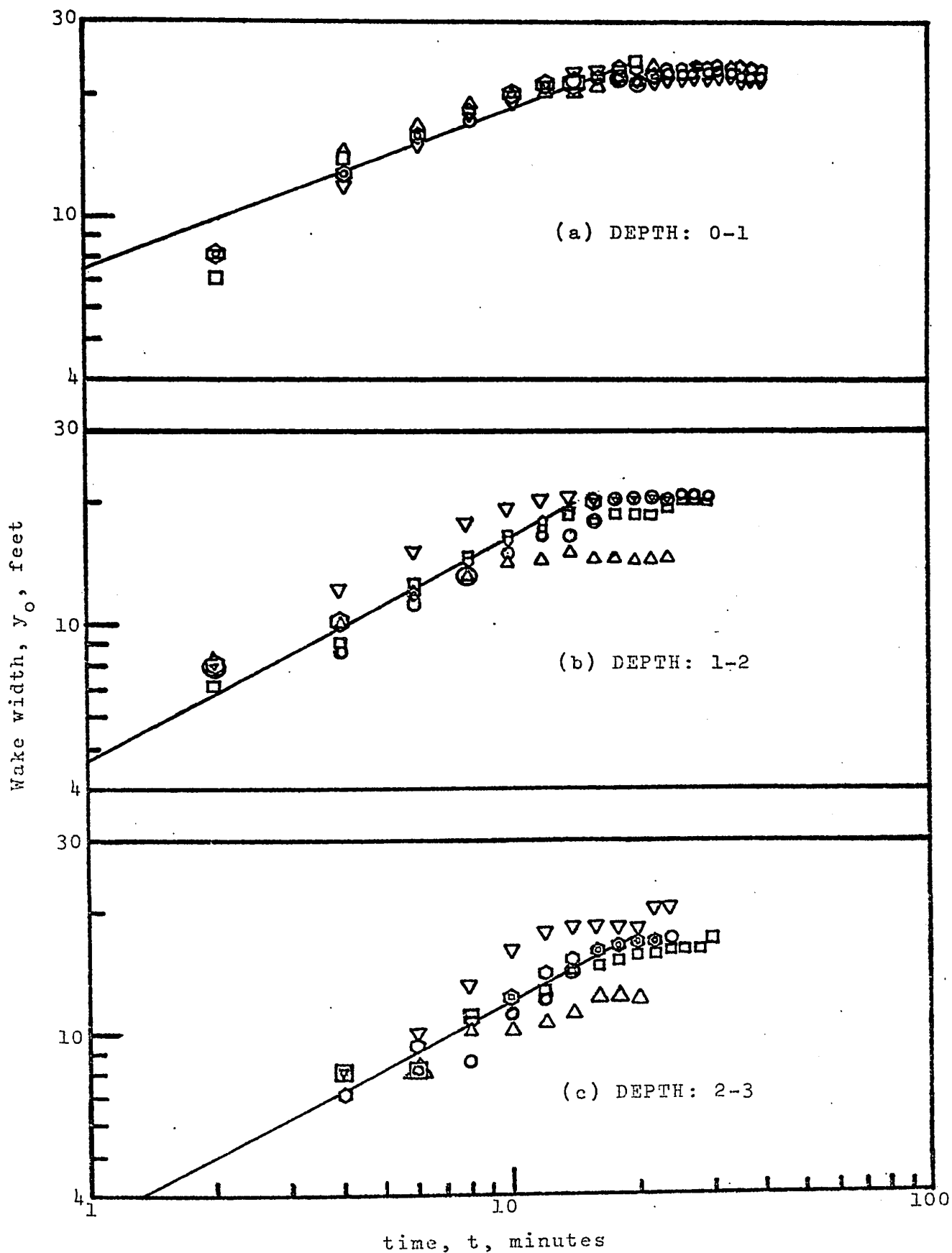


FIG. 5.2.--WAKE WIDTH vs TIME FOR SERIES 2000

Symbols $\circ, \circ, \nabla, \square, \triangle$ represent in order Test Nos. 7,8,9,10,11

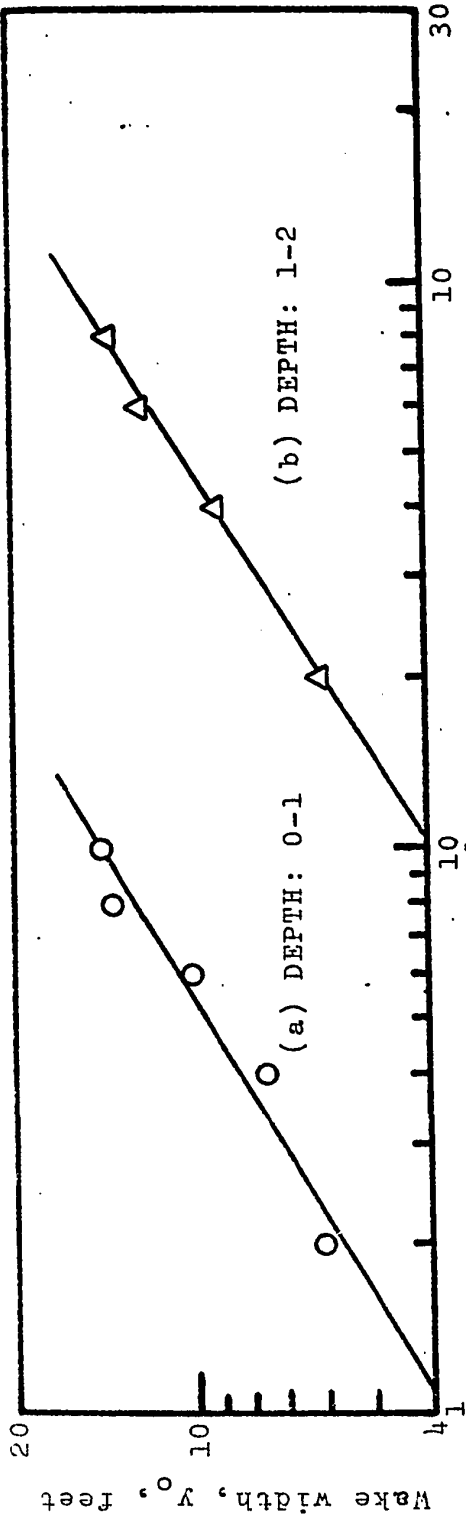


FIG. 5.3.--WAKE WIDTH vs TIME FOR SERIES 2914

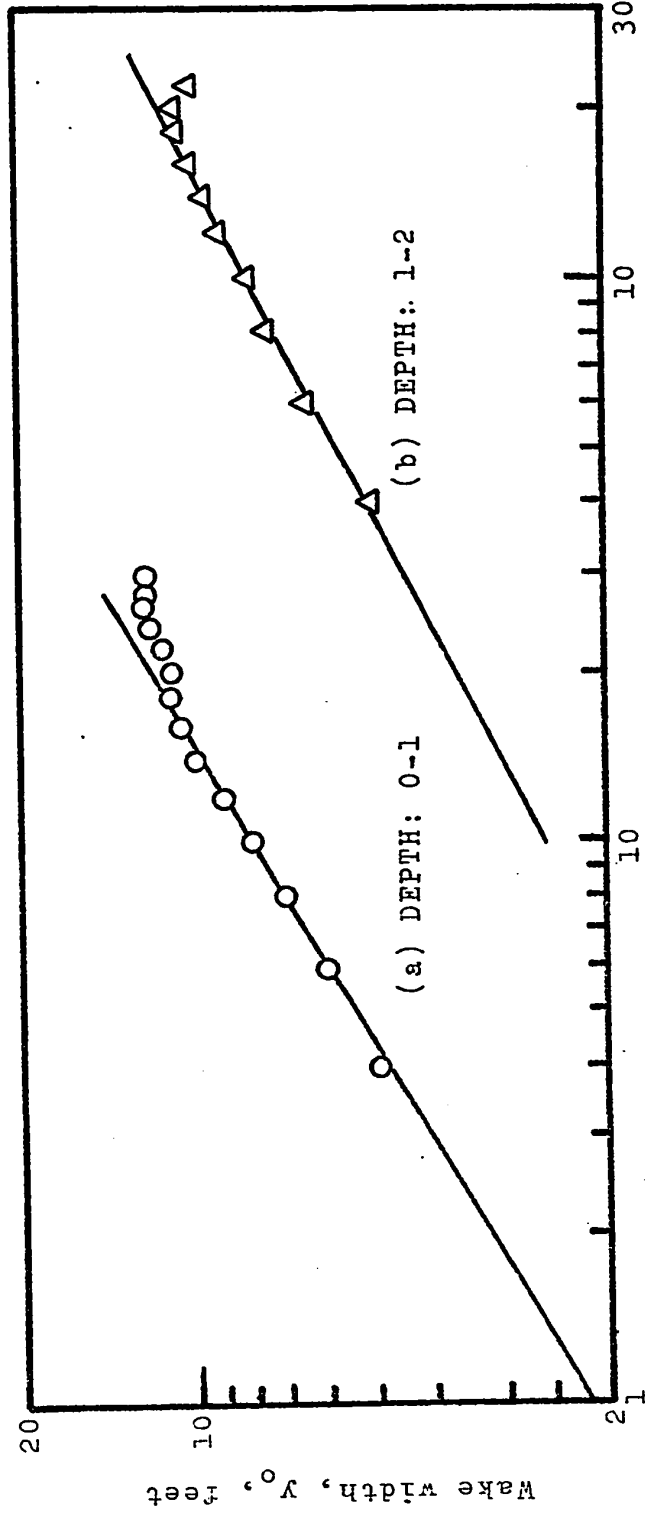


FIG. 5.4.--WAKE WIDTH vs TIME FOR SERIES 2919

5.4 Analysis of Data by the Method of Variance

The variance of a distribution curve can be computed either by fitting the normal distribution equation to the data or, directly, by determining the second moment of the curve.

The following assumptions are made:

1. The vertical mixing over the region of sampling is instantaneous. In most of the tests, dye was detected upto 4 feet depth soon after the injection of dye (usually less than 4 minutes).
2. Longitudinal diffusion is negligible. Each point of the wake receives the same amount of dye along the centre line; the wake is long and narrow, and the longitudinal gradients become much smaller than the transverse gradients in a short time (usually less than 4 minutes). These experimental facts justify this assumption.
3. The concentration distribution in the transverse direction follows the normal curve.

With these assumptions, the diffusion becomes one-dimensional, with diffusion taking place in transverse direction only. The one-dimensional normal equation can be written in the form

$$c = \frac{A'}{\sigma_y} \exp \left[- \frac{y^2}{\sigma_y^2} \right], \quad (5.5)$$

in which c is the concentration at time t ,

σ_y^2 is the variance of the curve in y -direction

and A' is a constant.

At $y = 0$, $c = c_{\max} = (A/\sigma_y)$, so that Eq. 5.5 can be rewritten as

$$c = c_{\max} \cdot \exp \left[- \frac{y^2}{\sigma_y^2} \right] \quad (5.6)$$

Taking logarithms on both sides of Eq. 5.6, we get

$$\log c = \log c_{\max} - \frac{y^2}{\sigma_y^2} \log e \quad (5.7)$$

Hence, a plot of $\log c$ versus y^2 results in a straight line with slope $(\log e/\sigma_y^2)$ and intercept $\log c_{\max}$. The variance σ_y^2 can now be computed from the slope. The variance, σ_y^2 can also be obtained from the second moment of the curve as follows

$$\sigma_y^2 = \frac{\int c \cdot dy \cdot y^2}{\int c \cdot dy} \quad (5.8)$$

in which the numerator represents the second moment of the area under the curve about its centroid and the denominator represents the area under the curve. This method may give incorrect variance values due to insufficient data to define the tail of the curve completely, particularly after the dye has diffused beyond the sampling region. The variance computations have been done using both methods. The values of the variance are given in the tables in Appendix C. An examination of these values reveals that both methods give nearly the same values upto some value of time beyond which Eq. 5.7 seems to give values that are too high, whereas Eq. 5.8 seems to give values of the variance that are too low. The

latter result is due to insufficient data in order to define the tail portion of the curve. The variance, σ_y^2 at any time t , and the diffusion coefficient, ϵ_y , are related (for use in conjunction with Eqs. 5.5 to 5.8) by the expression (26)

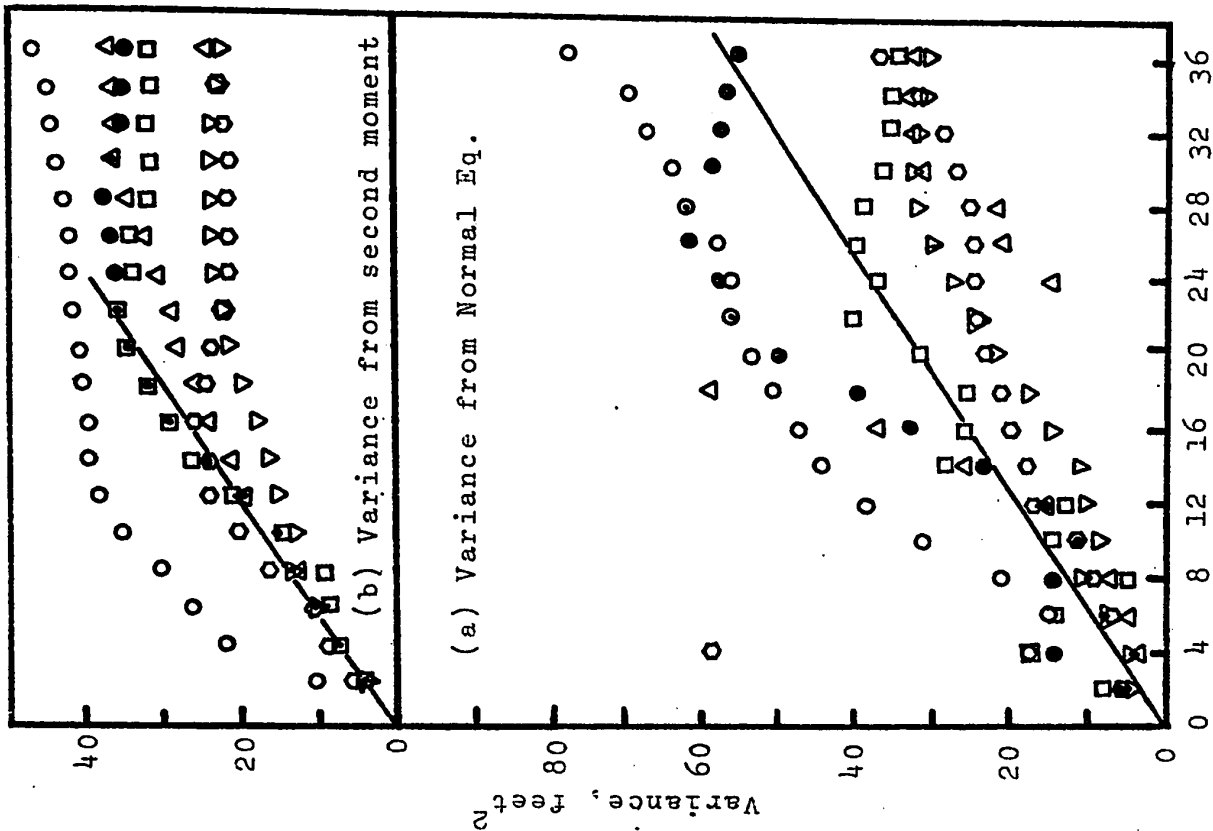
$$\sigma_y^2 = 4\epsilon_y t \quad (5.9)$$

so that a plot of σ_y^2 versus t would result in a straight line of slope $4\epsilon_y$ from which ϵ_y can be computed.

Figs. 5.5 to 5.16 show plots of variance (at a specified depth) versus time for each series. In these plots, variance values up to 36 minutes only have been used for convenience. It can be observed from these plots that both methods give more or less the same results up to some value of time (approximately 20 minutes); after this, the variance values computed from fitting the normal distribution equation to the data, increase or fluctuate very much whereas those computed from the second moment tend towards a constant value with very little fluctuation, if any.

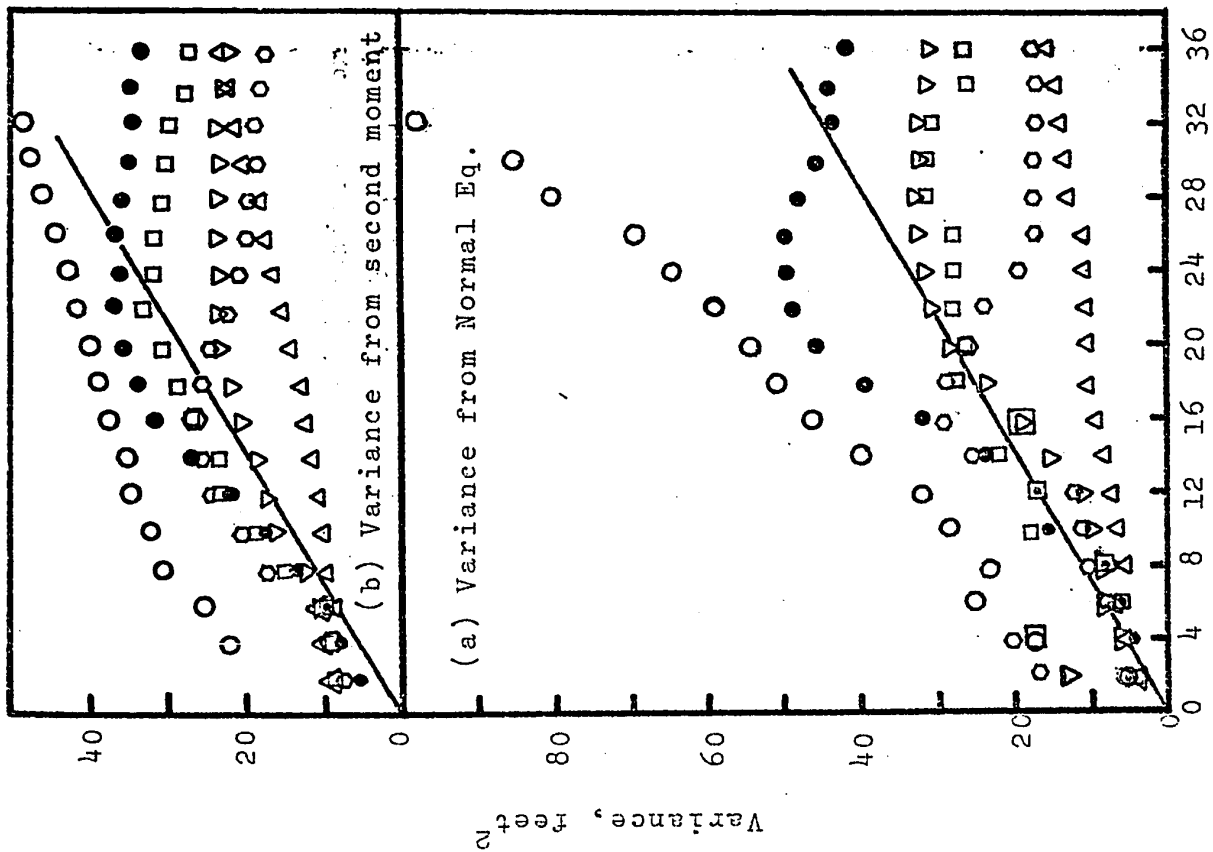
When the normal equation was fitted to the data, the correlation coefficients were found to vary from 0.70 to 0.98 except at depth 3-4 where the values varied from 0.5 to 0.8.

The values of the diffusion coefficients computed from the variances are given in Table 5-2, together with the standard deviation values.



time, minutes

FIG. 5.6.--DEPTH: 1-2



time, minutes

FIG. 5.5.--DEPTH: 0-1

FIGS. 5.5 and 5.6.--VARIANCE vs TIME FOR SERIES 3000

Symbols ∇ , \bullet , \circ , \square , Δ , \circ represent in order Test Nos. 1, 2, 3, 4, 5, 6

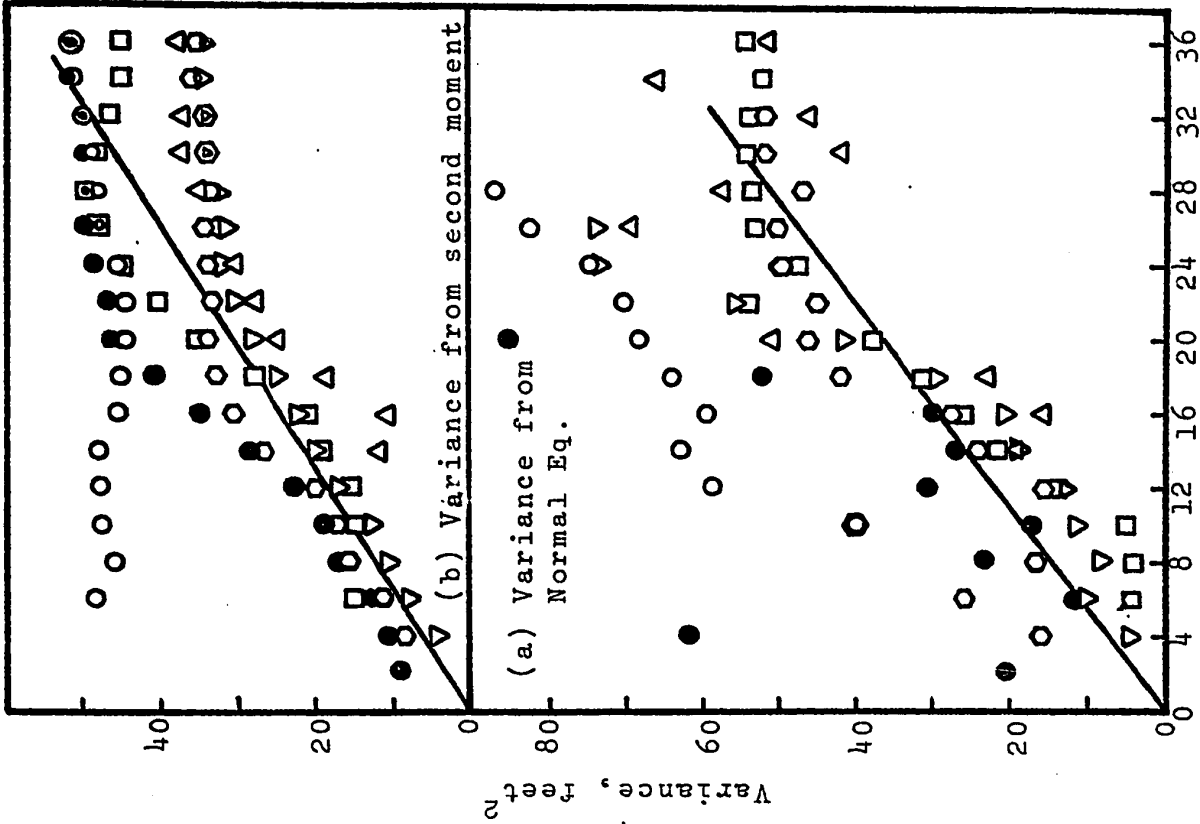


FIG. 5.8.--DEPTH: 3-4

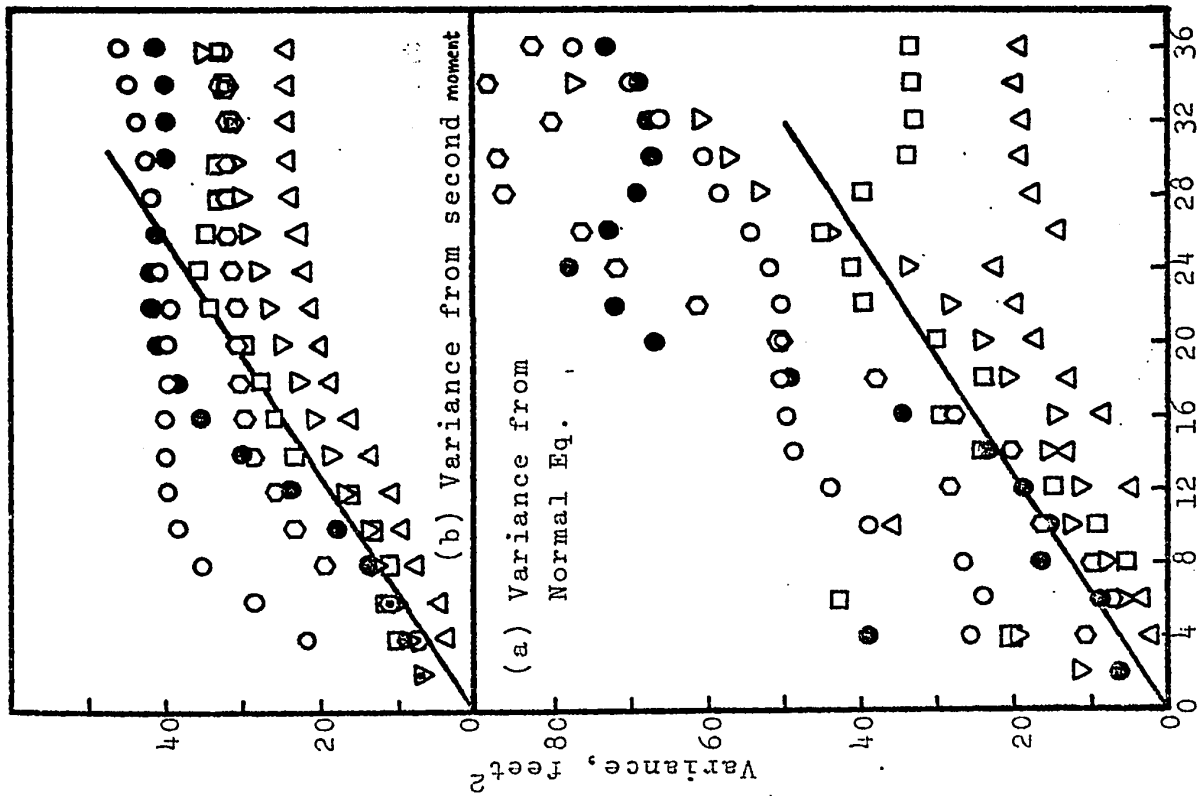


FIG. 5.7.--DEPTH: 2-3

FIGS. 5.7 and 5.8.--VARIANCE vs TIME FOR SERIES 3000
Symbols ∇ , \bullet , \circ , \square , Δ , \circ represent in order Test Nos. 1, 2, 3, 4, 5, 6

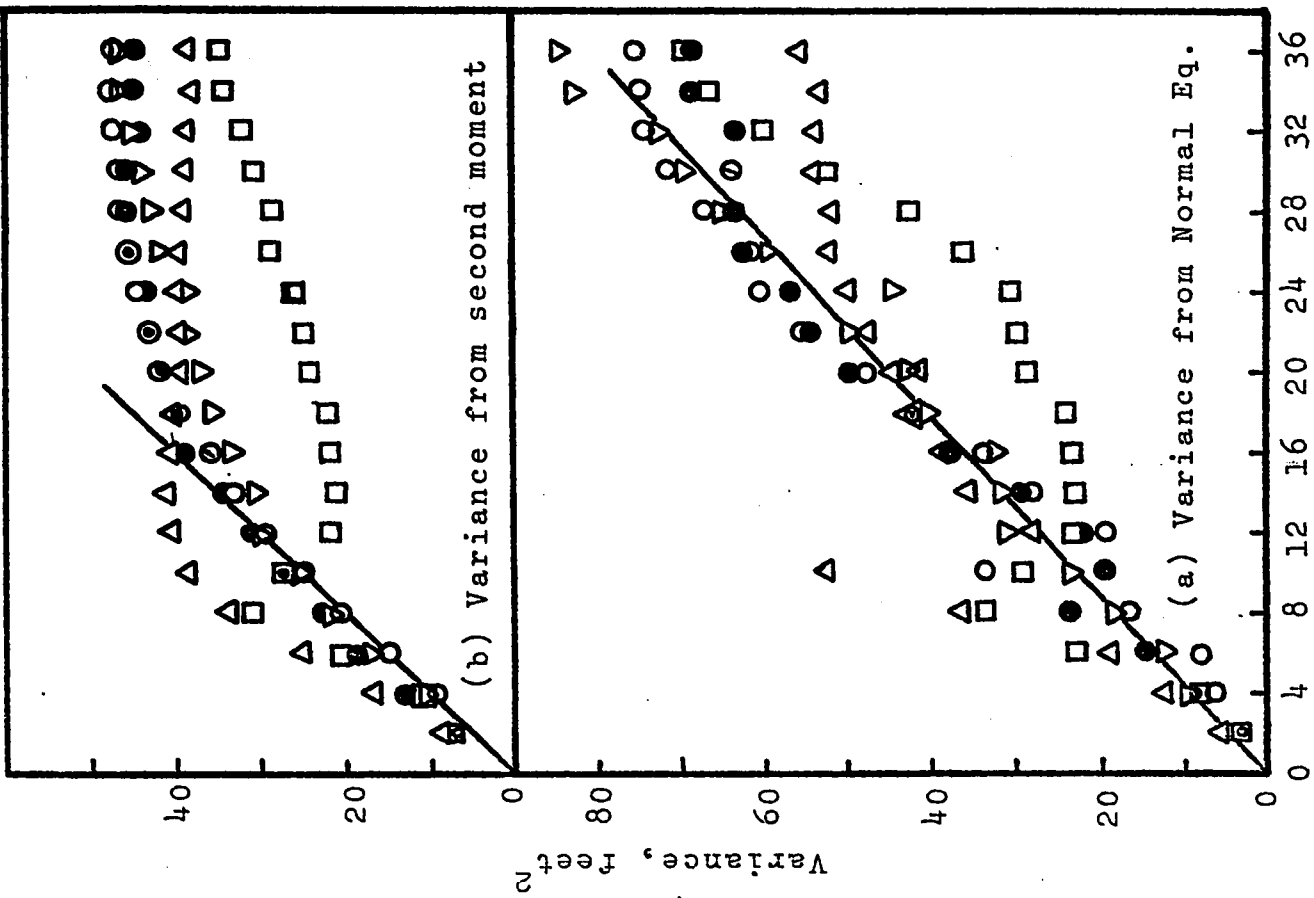


FIG. 5.10.--DEPTH: 1-2

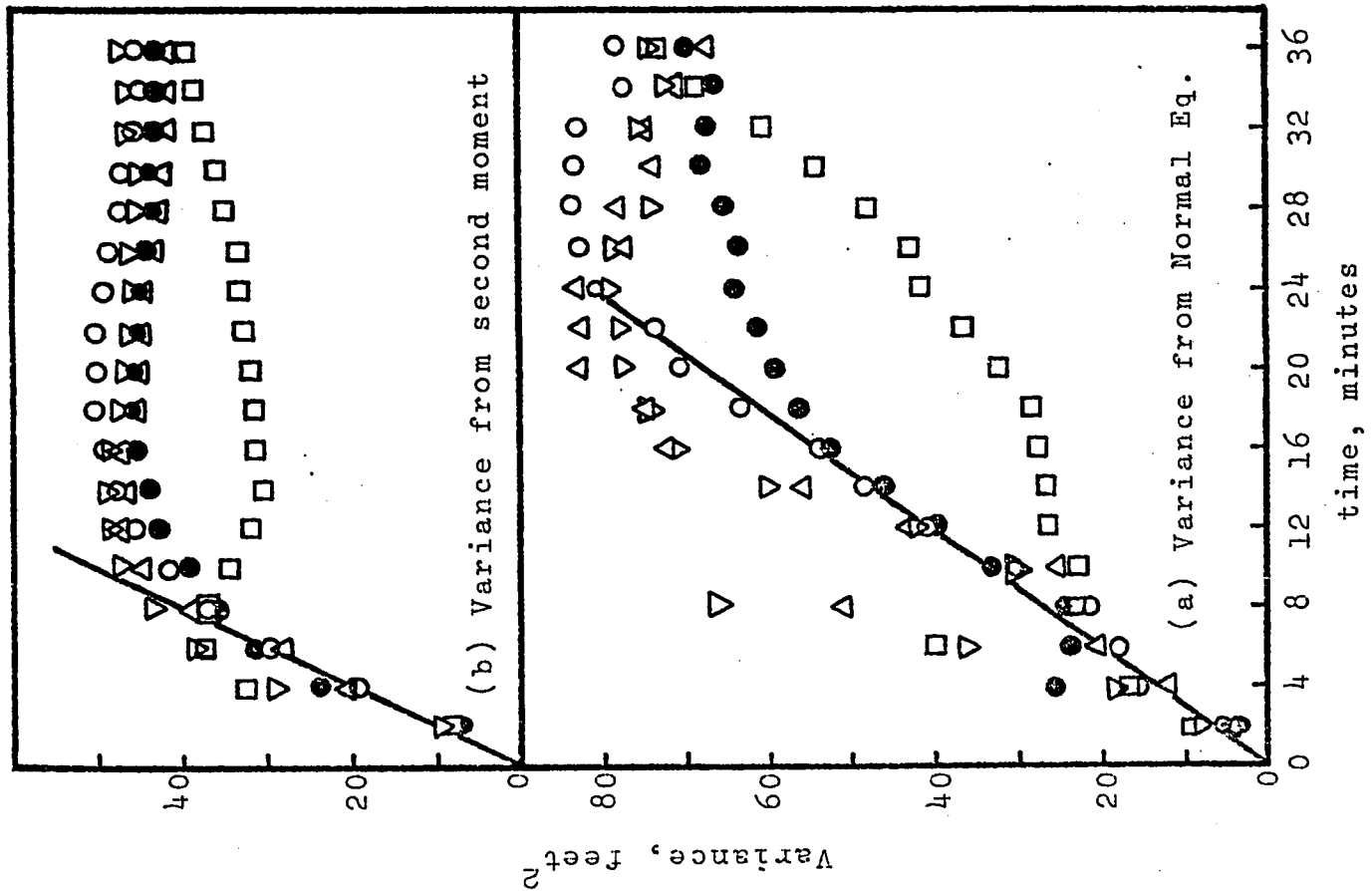


FIG. 5.9.--DEPTH: 0-1

FIGS. 5.9 and 5.10.--VARIANCE vs TIME FOR SERIES 2000

Symbols O, ●, Δ, ∇, □ represent in order Test Nos. 7, 8, 9, 10, 11

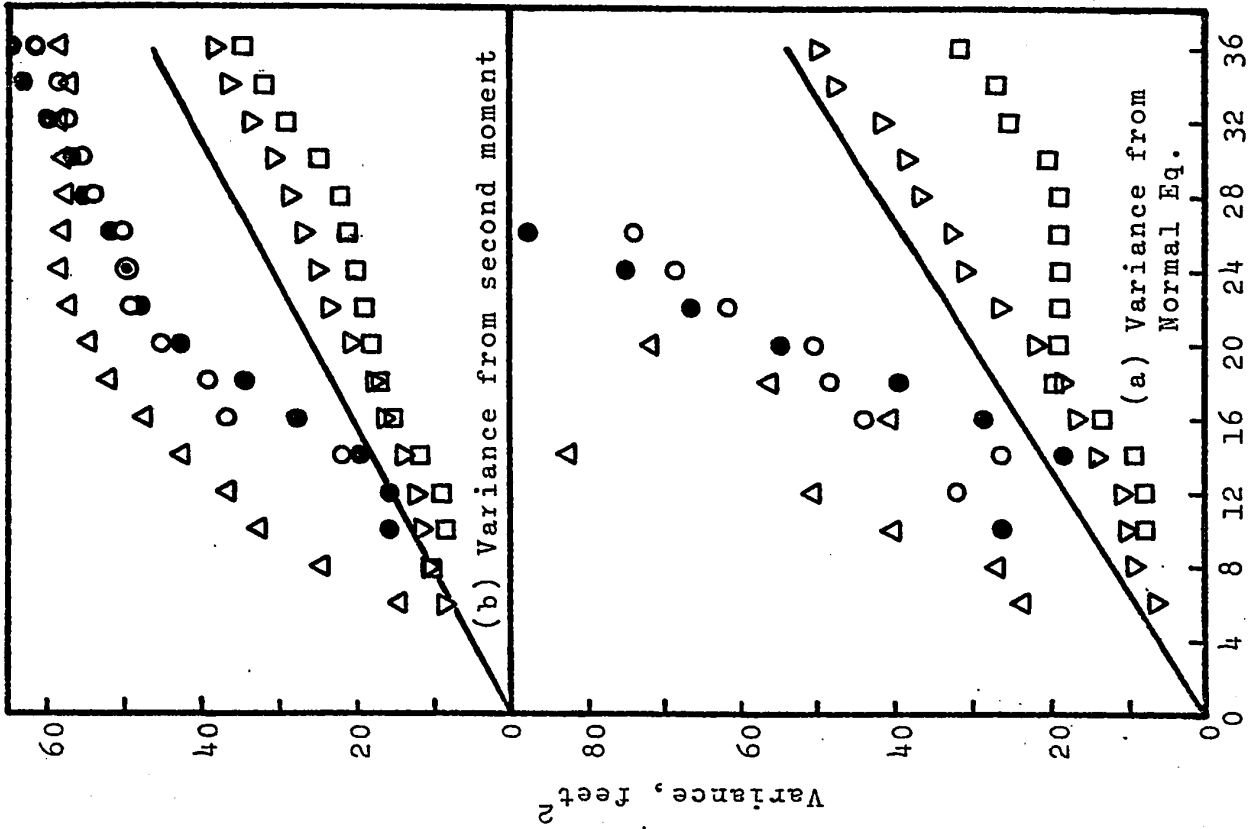


FIG. 5.12.--DEPTH: 3-4

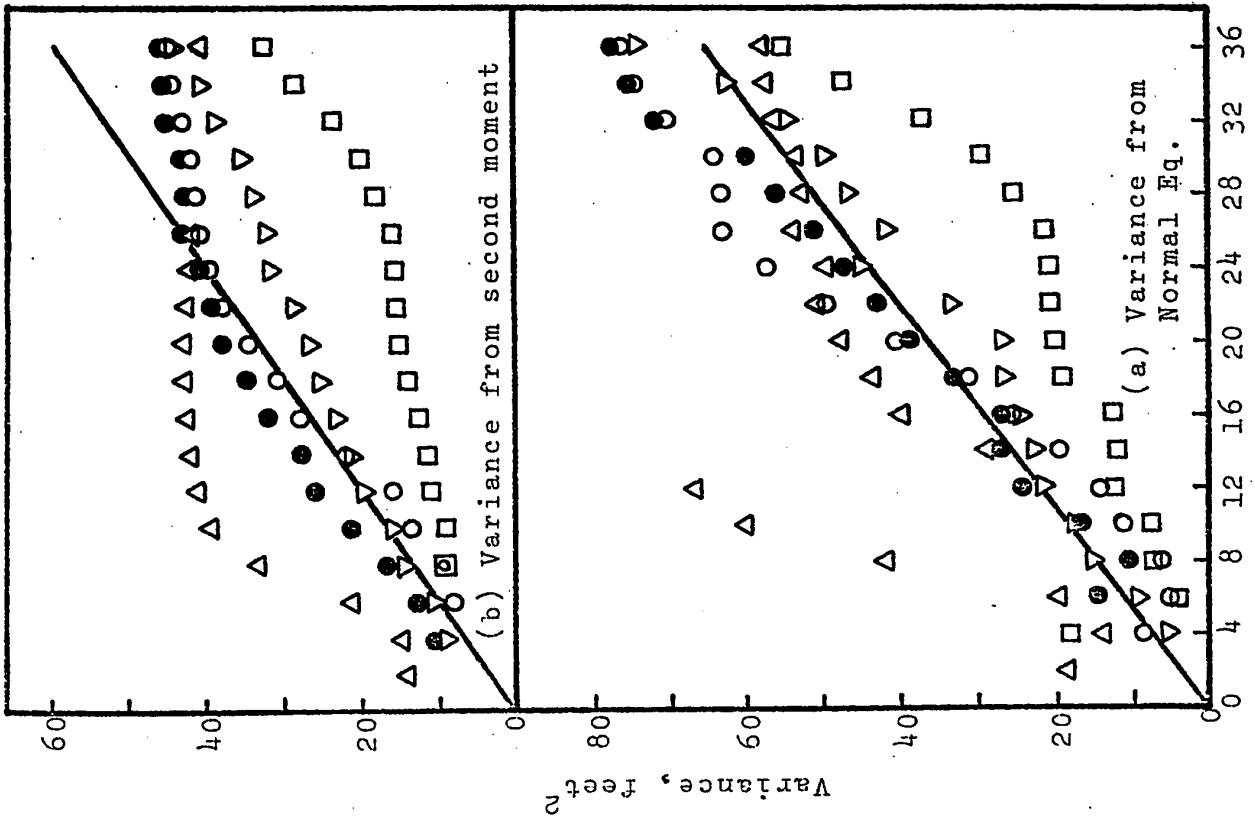


FIG. 5.11.--DEPTH: 2-3

FIGS. 5.11 and 5.12.--VARIANCE vs TIME FOR SERIES 2000
Symbols O, ●, Δ, ▽, □ represent in order Test Nos. 7, 8, 9, 10, 11

UNIVERSITY OF MICHIGAN LIBRARY

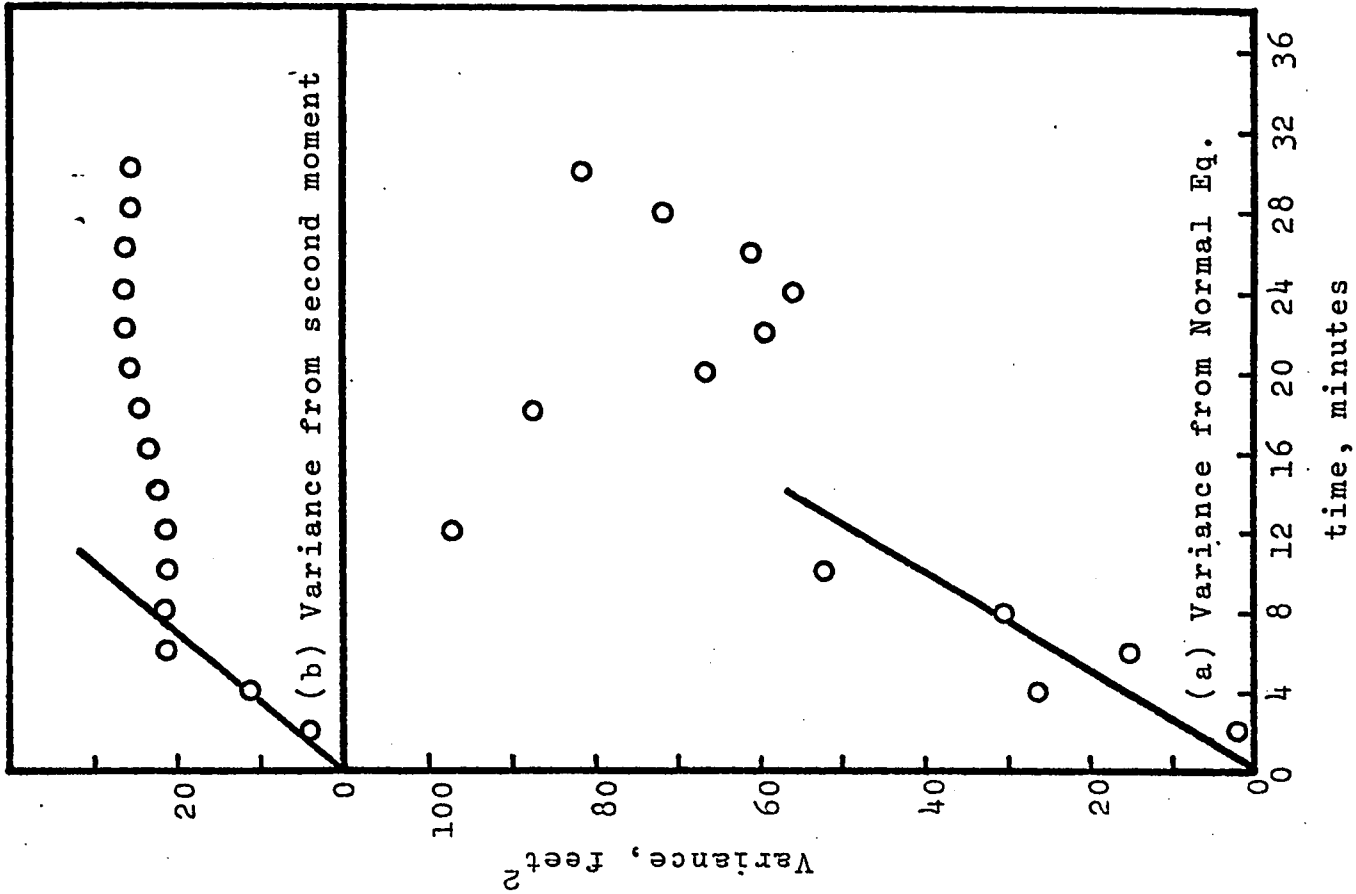
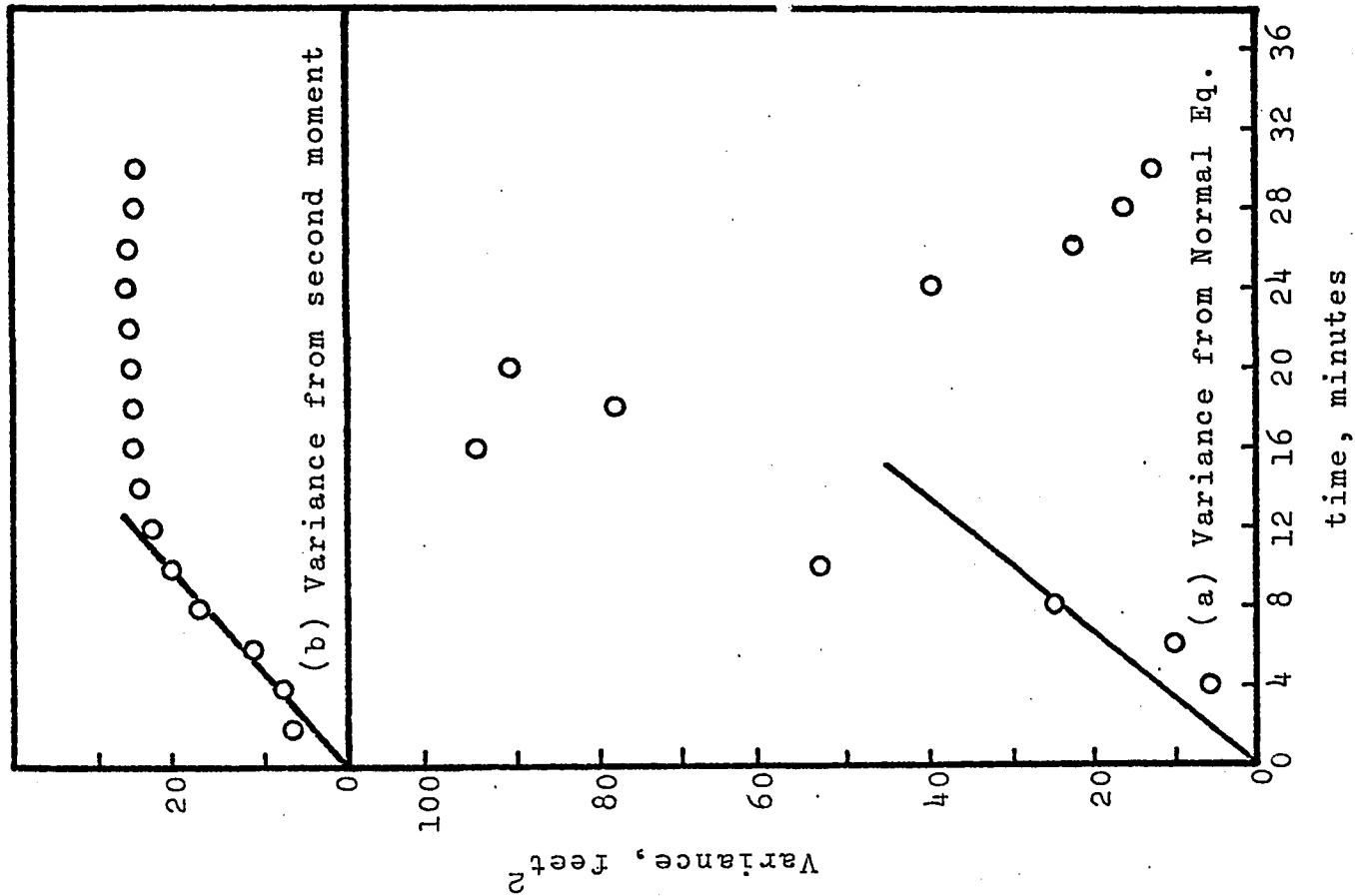


FIG. 5.13.--DEPTH: 0-1

FIG. 5.14.--DEPTH: 1-2

FIGS. 5.13 and 5.14.--VARIANCE vs TIME FOR SERIES 2914

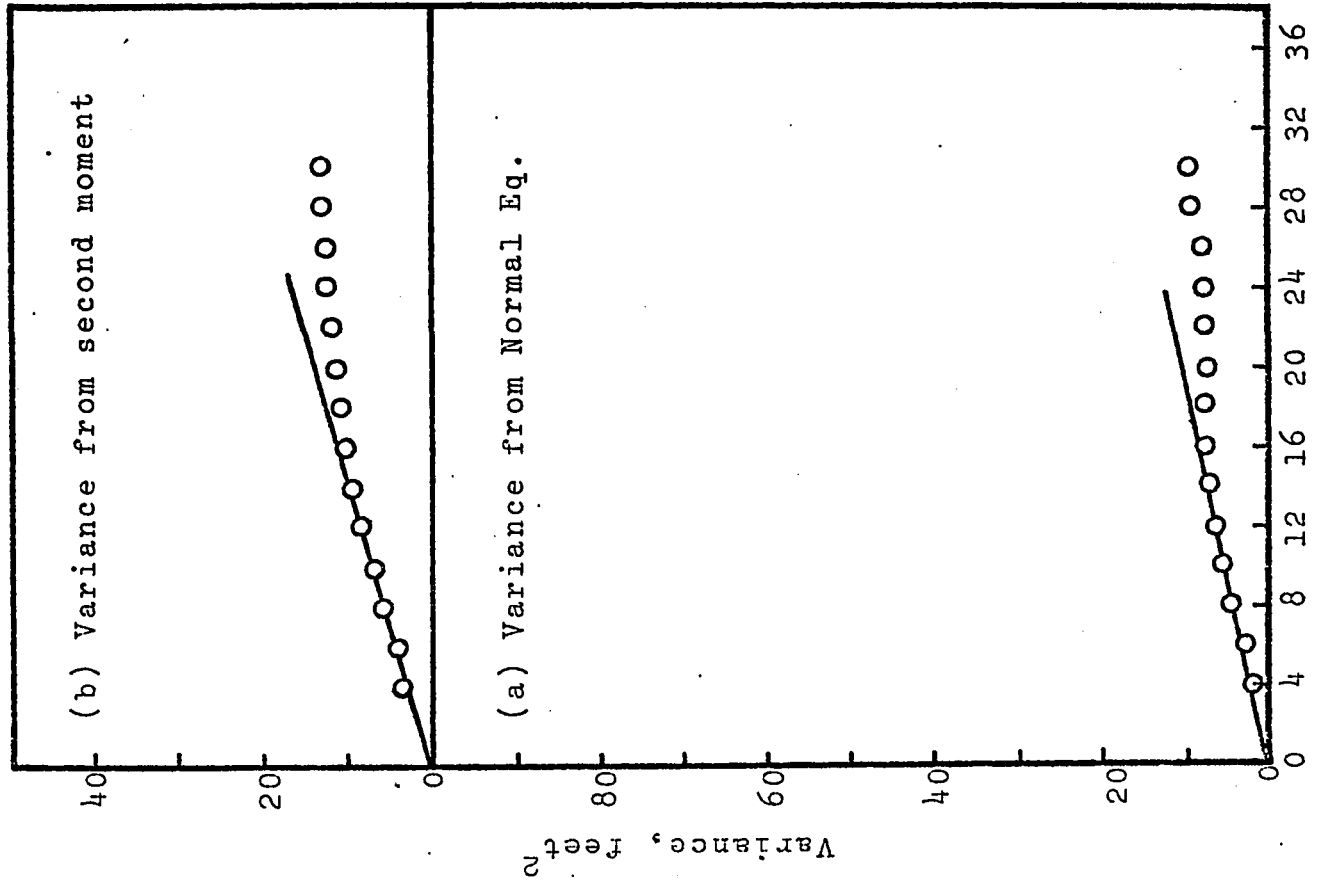
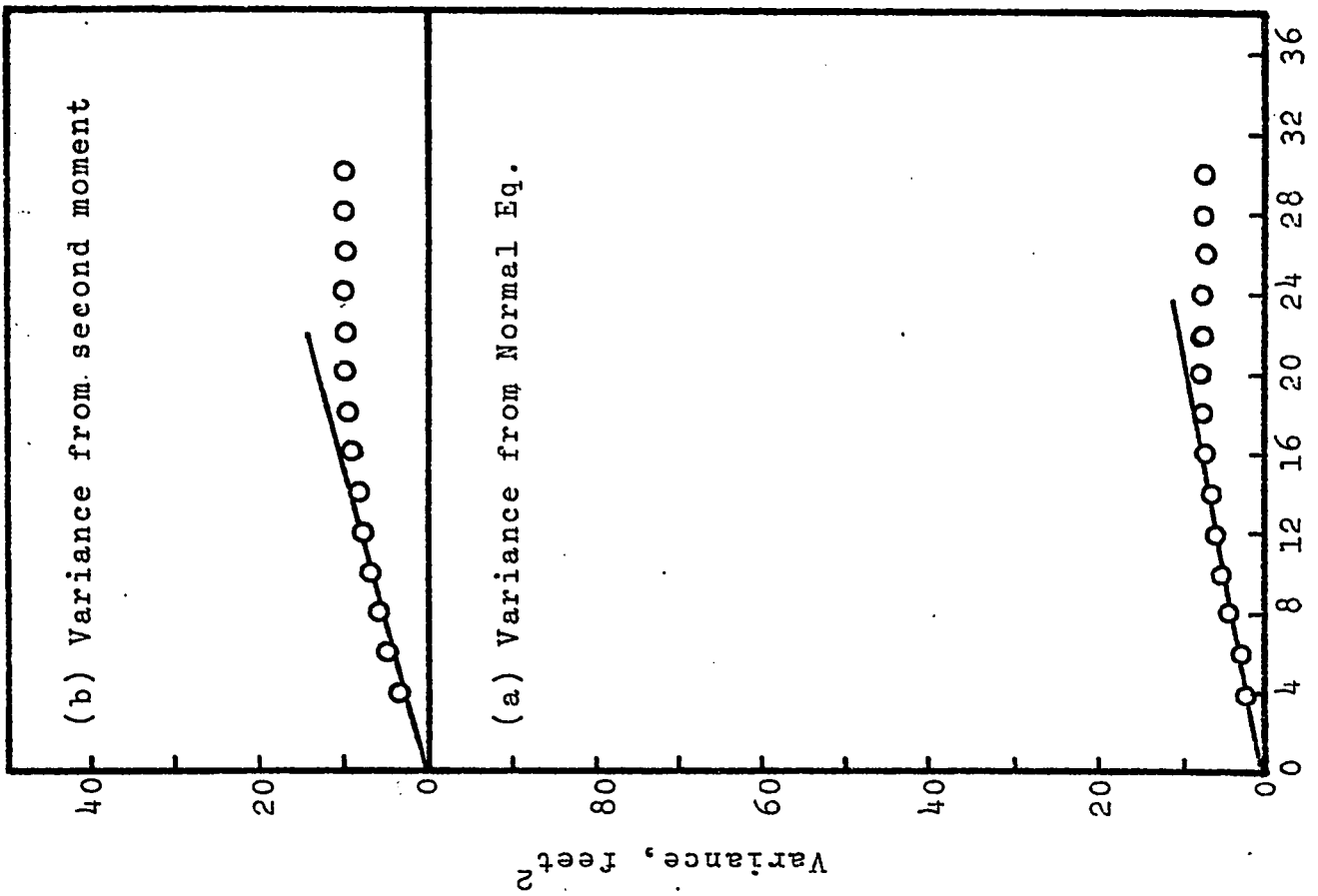


FIG. 5.16.--DEPTH: 1-2

FIG. 5.15.--DEPTH: 0-1

FIGS. 5.15 and 5.16.--VARIANCE vs TIME FOR SERIES 2919

TABLE 5-2. - DIFFUSION COEFFICIENTS FROM VARIANCE

Series	Depth	ϵ_y , feet ² per minute			
		from Normal Equation		from Second Moment	
		Mean	Standard deviation	Mean	Standard deviation
3000	0-1	0.35	0.19	0.35	0.19
	1-2	0.38	0.18	0.42	0.19
	2-3	0.39	0.26	0.39	0.27
	3-4	0.45	0.23	0.39	0.28
2000	0-1	0.85	0.12	1.25	0.19
	1-2	0.56	0.05	0.63	0.18
	2-3	0.45	0.14	0.41	0.19
	3-4	0.38	0.28	0.32	0.22
2914	0-1	0.75	-	0.53	-
	1-2	1.02	-	0.36	-
	2-3	-	-	-	-
	3-4	-	-	-	-
2919	0-1	0.13	-	0.18	-
	1-2	0.13	-	0.17	-
	2-3	-	-	-	-
	3-4	-	-	-	-

5.5 Data Analysis using the Proposed Mathematical Model

The use of the mathematical model (developed in Chapter III) to analyse the data is described in this section. Eqs. 3.10 and 3.16 are used here to determine the variation of maximum concentration with time and to compute the diffusion coefficients in the wake. The following computations have been done using the data at the depth 0-1 only, since the concentration at other depths is not necessarily a maximum at time of zero.

5.5.1 Variation of Maximum Concentration with Time

Taking logarithms on both sides of Eq. 3.10, we get

$$\log f = \beta \cdot \zeta \cdot \log e \quad , \quad (5.12)$$

so that a plot of f versus ζ should result in a straight line with slope $(\beta \log e)$, from which the constant, β can be evaluated.

By definition, ζ equals (x/L) , where L is a characteristic length scale of flow. It would have been appropriate to use the value of L obtained from Eq. 2.10. This is not possible, because of the lack of velocity and turbulence measurements in boat wakes. The predominant part of the turbulent movements in the wake are created by the propeller as pointed out earlier. It is reasonable to assume that the length scale, L , characterizing the turbulent movements is related to the size of the propeller. Therefore, the length scale, L , is taken to be equal to the diameter of the propeller, D .

The values of f and ξ , where ξ equals $(z/1000)$, are given for each test in the tables in Appendix C. Figs. 5.17 to 5.20 show plots of f versus ξ for the various series. The plots show two straight line portions having different slopes, with a transition in between. Line (1) indicates a steep change in maximum concentration in a short time (from 2 to 4 minutes), whereas line (2) has a much smaller slope (from about 8 minutes to about 20 minutes); in between, there appears to be a transition zone.

The values of β for the lines (1) and (2) are given in Table 5-3.

TABLE 5-3. - VALUES OF β

Series	Constant, β	
	Line (1)	Line (2)
3000	-0.0005620	-0.0000537
2000	-0.0008040	-0.0000568
2914	-0.0002285	-0.0000732
2919	-0.0003170	-0.0000835

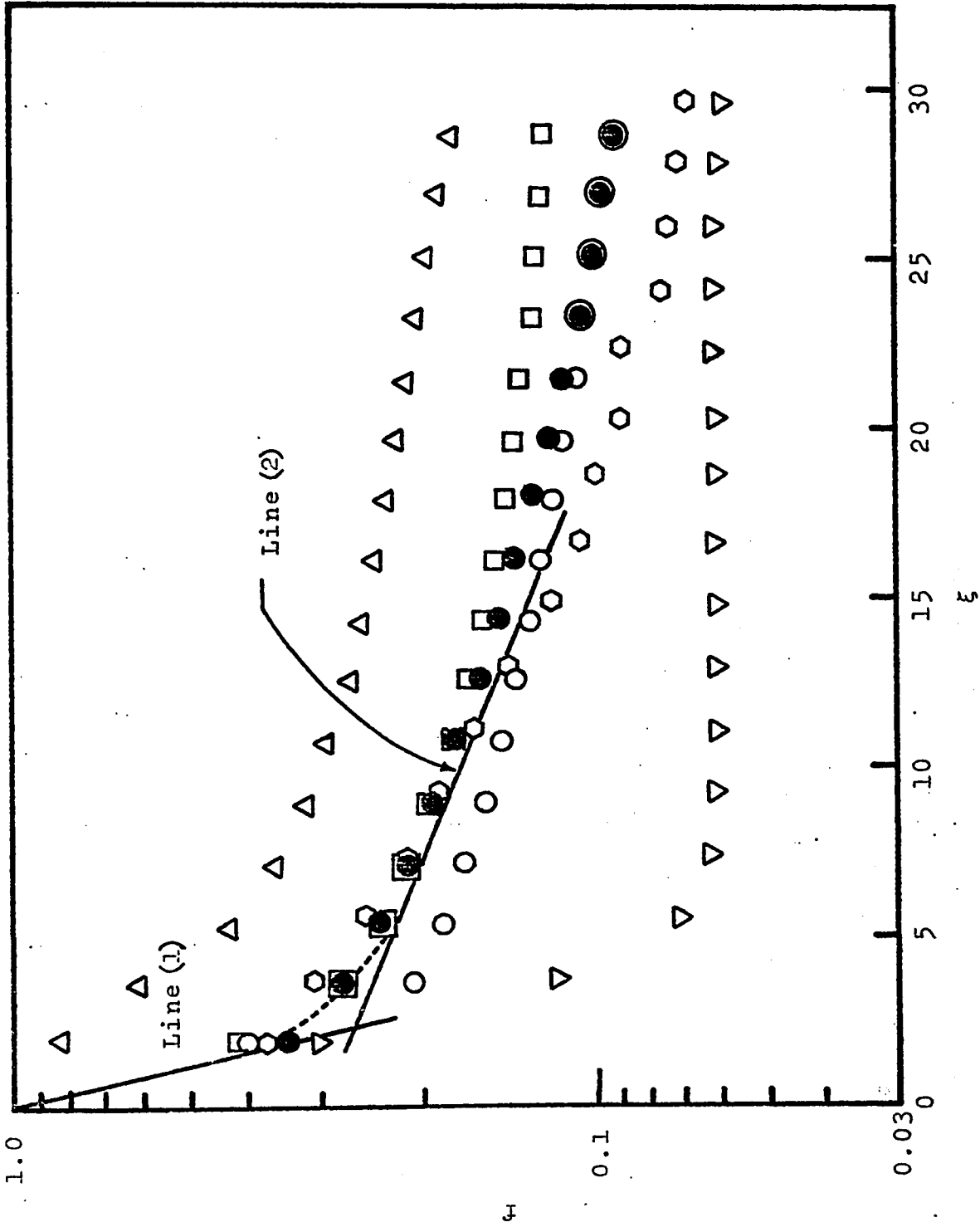


FIG. 5.17.--f vs ξ FOR SERIES 3000

Symbols \bullet , \square , \circ , Δ , ∇ represent in order Tests Nos. 1, 2, 3, 4, 5, 6.

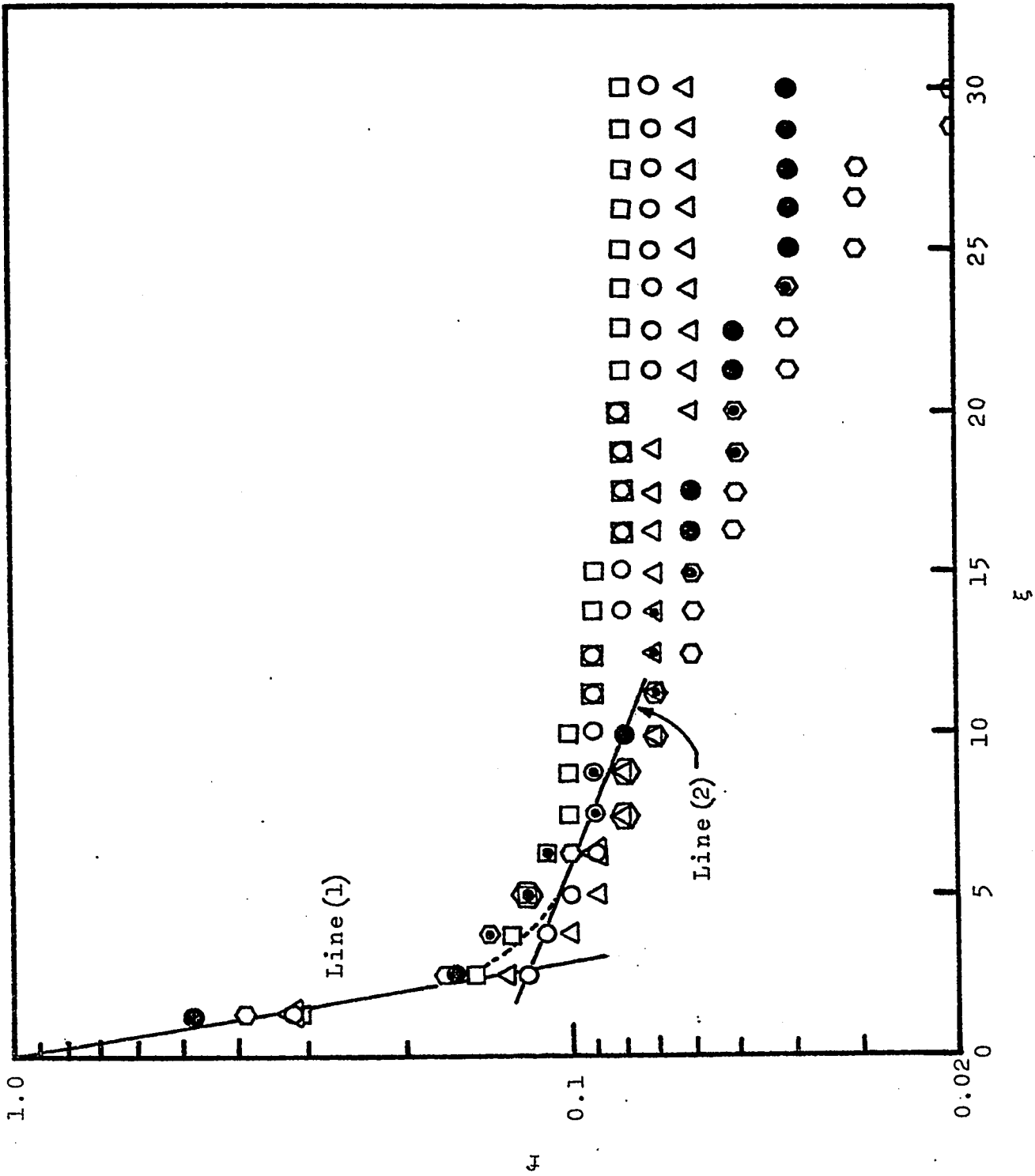
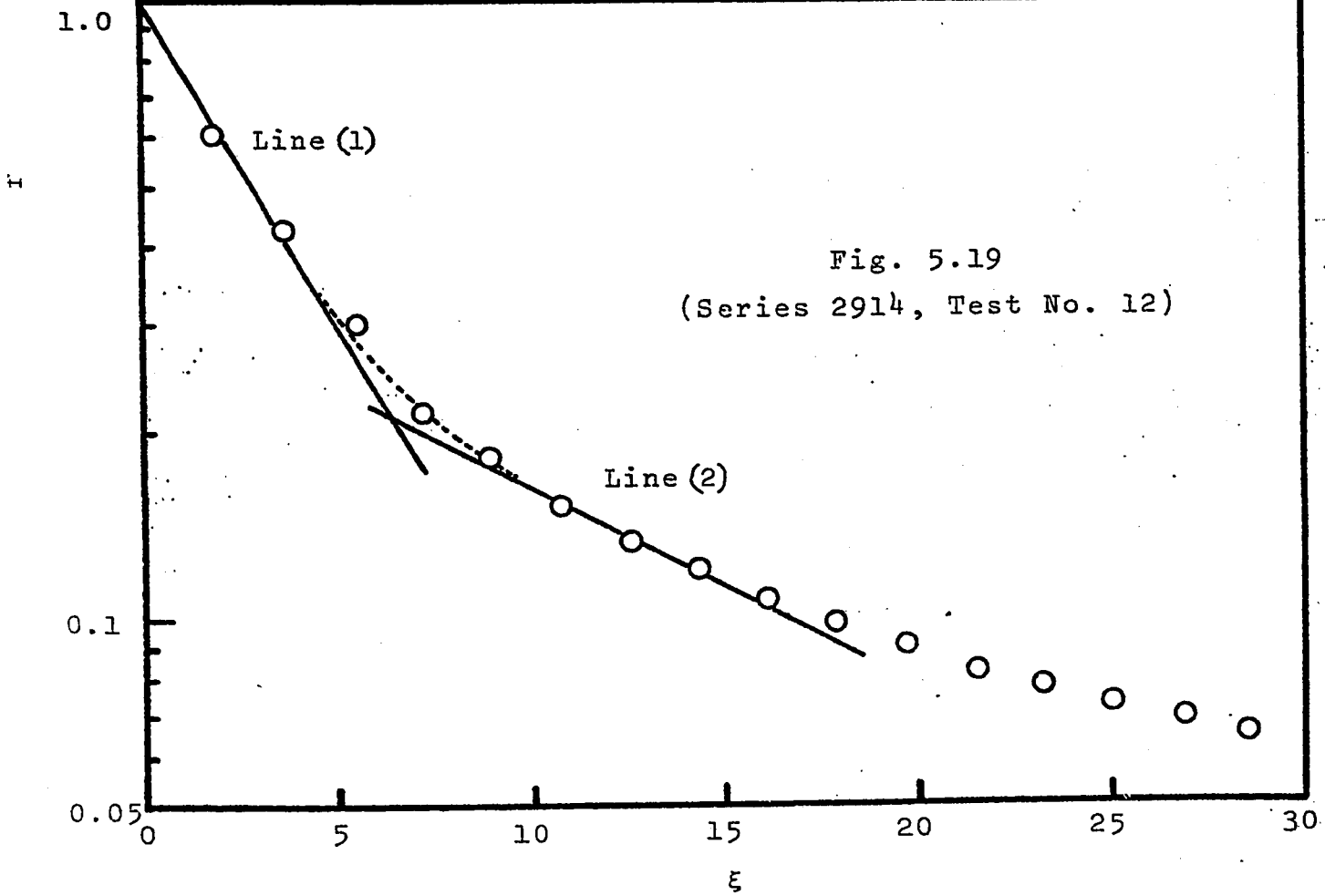
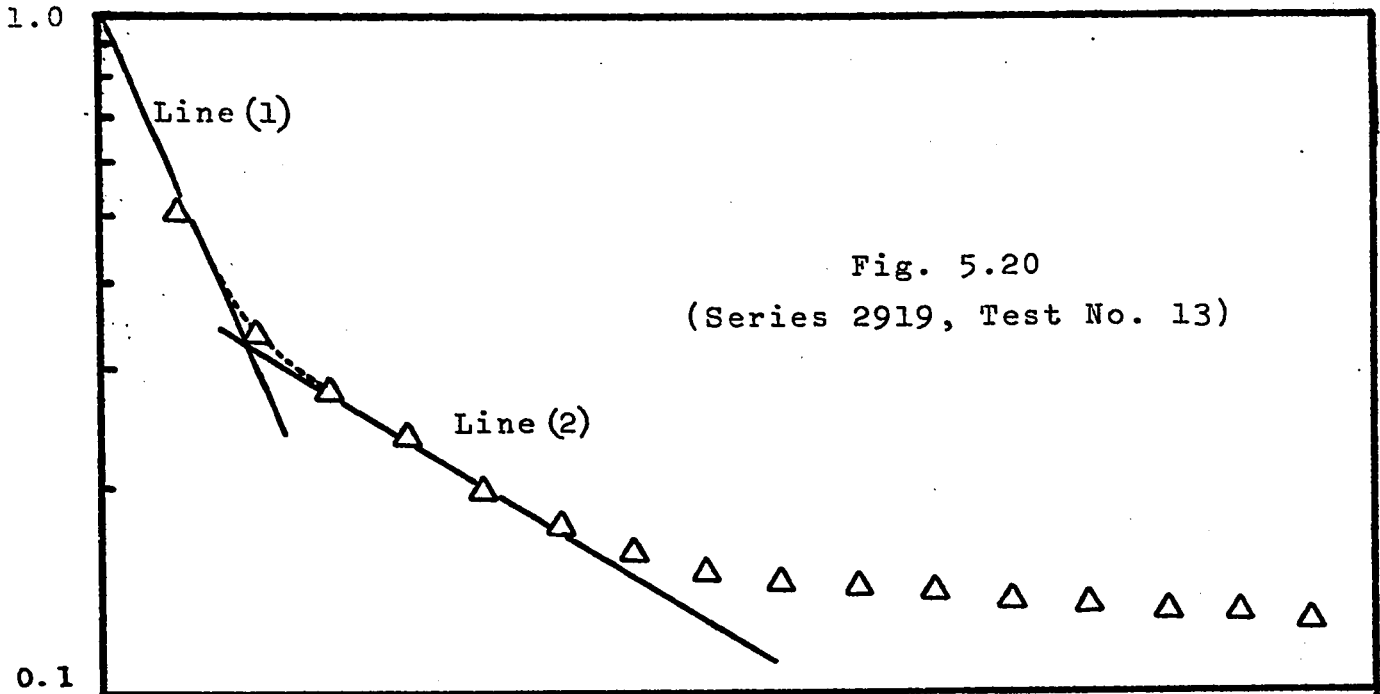


FIG. 5.18.--f vs ξ FOR SERIES 2000

Symbols : O, \square , \triangle , \bullet , \circ represent in order Test Nos. 7, 8, 9, 10, 11.



FIGS. 5.19 and 5.20.--f vs ξ FOR SERIES 2914 and 2919

5.5.2 Computation of Diffusion Coefficient

Taking logarithms on both sides of Eq. 3.16, we get

$$\log g = - \left[\left(\frac{\beta U_o y_o^2}{L \epsilon_y} \right)^{1/2} \log e \right] \eta \quad (5.13)$$

A plot of $\log g$ versus η at any time would result in a straight line with a slope, s , equal to the term inside the square brackets in Eq. 5.13; since β is known, ϵ_y can be computed.

The values of g and η have been computed for each test and are given in tables in Appendix C. In the computation of η , the values of y_o given by the Eq. 5.3 are used.

Figs. 5.21 to 5.24 show plots of g versus η . The values of the slope, s , and diffusion coefficient, ϵ_y , are given in Table 5-4. In the computation of ϵ_y , the following values of velocity, U_o , are used: for Series 3000, $U_o = 447$ feet per minute; for Series 2000, $U_o = 312$ feet per minute; for Series 2914 and 2919, $U_o = 447$ feet per minute.

The correlation coefficients obtained by fitting Eq. 5.13 to the experimental data varied from 0.6 to 0.9 after a time of about 6 minutes in Series 3000 and 2000, indicating a reasonably good agreement between theory and experiments; however, in the initial period, the values were too low. (In the computation of the correlation coefficients, data values near the wake edge were excluded, as they are subject to intermittency effects.).

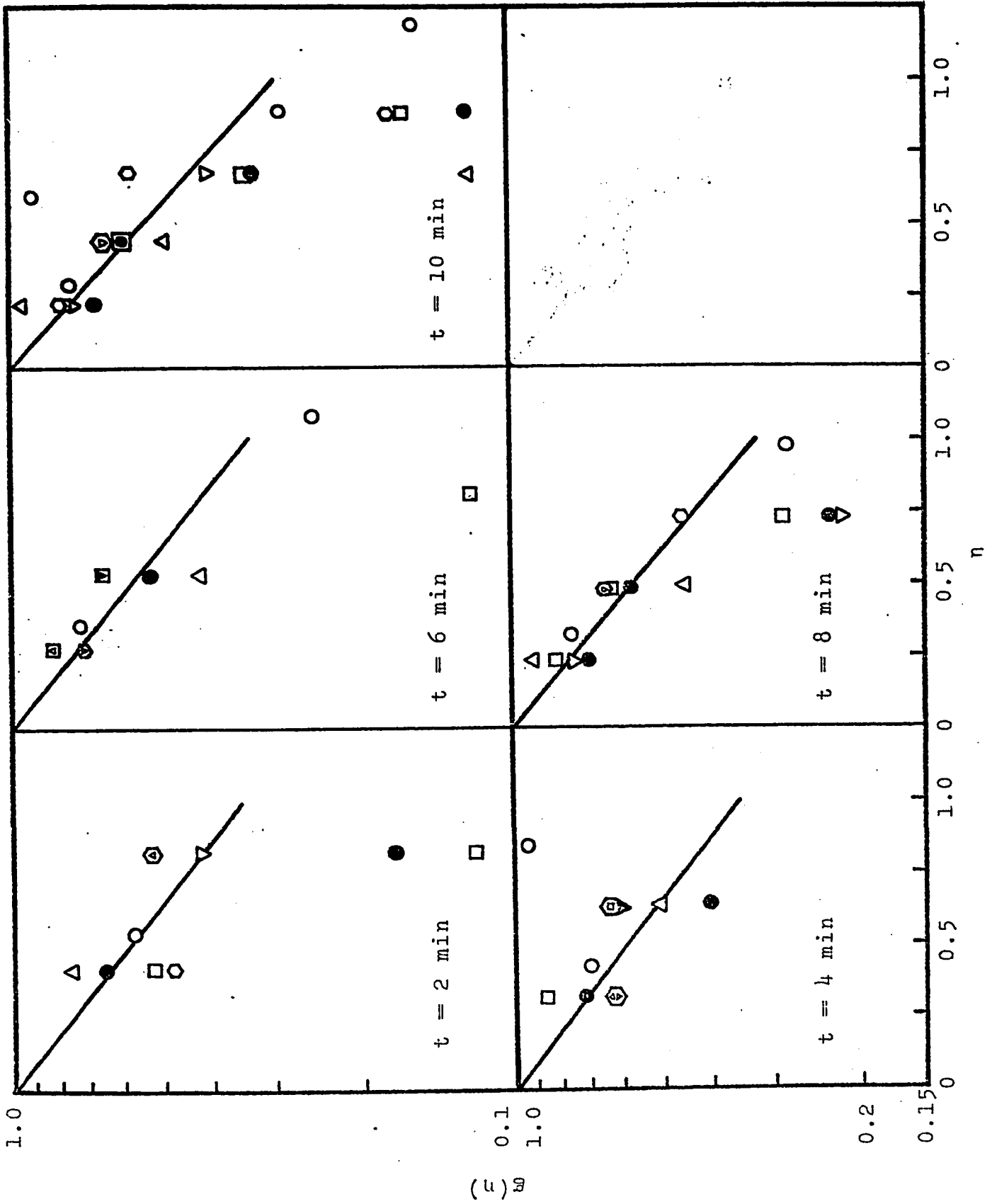


FIG. 5.21. $g(\eta)$ vs η FOR SERIES 3000
Symbols ∇ , \bullet , \square , Δ , \circ represent in order Test Nos. 1, 2, 3, 4, 5, 6.

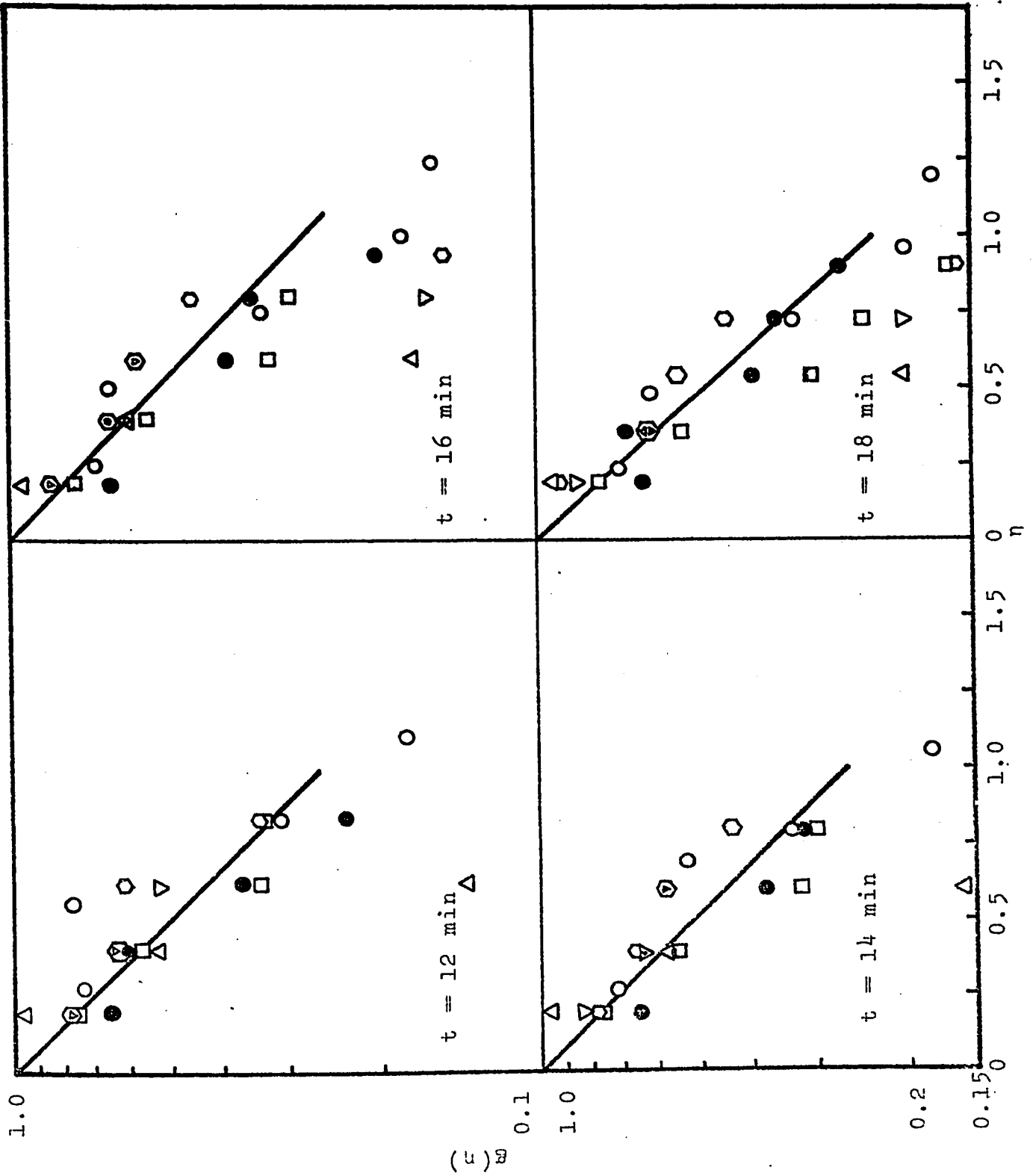


FIG. 5.21. ---CONTINUED

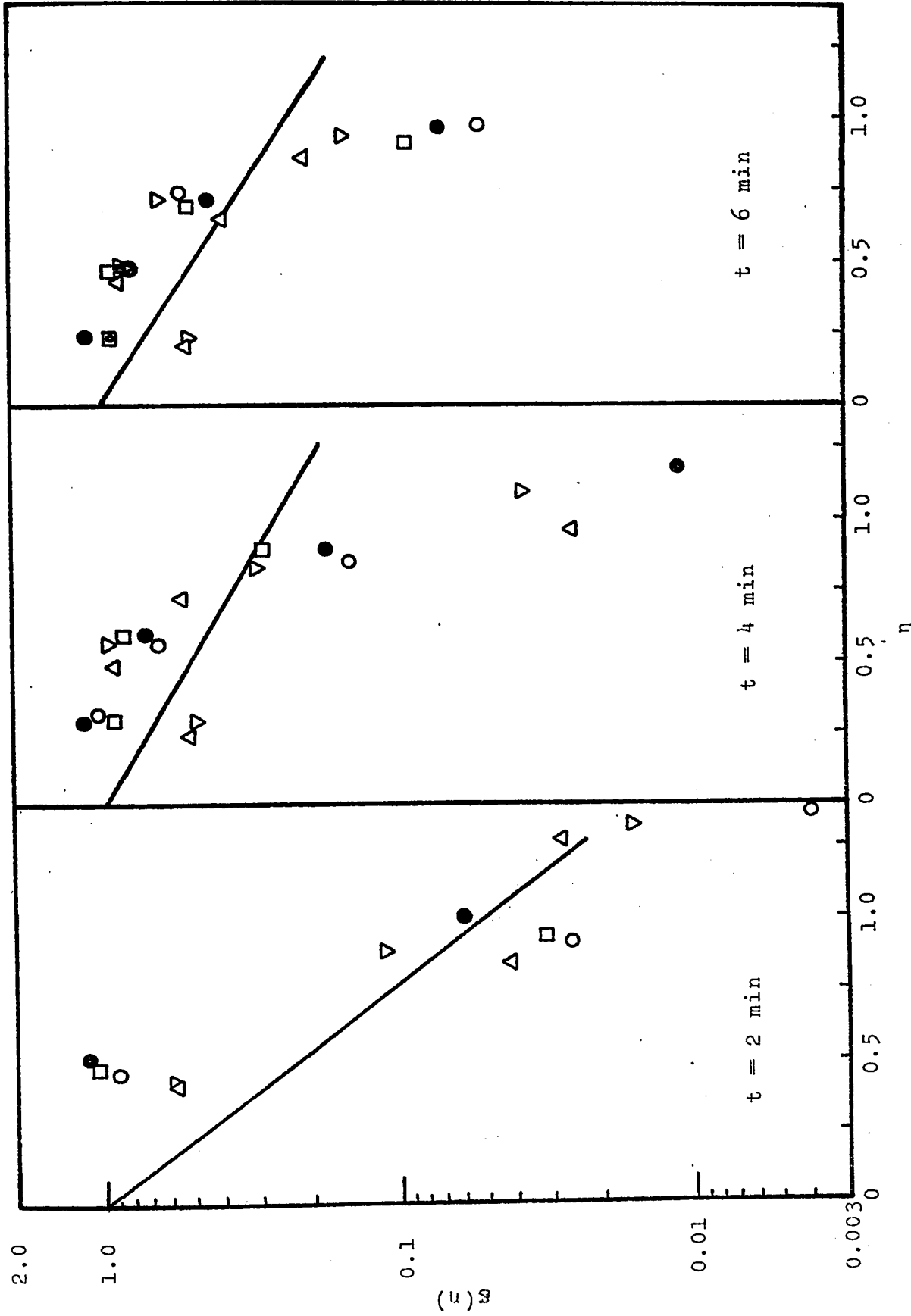


FIG. 5.22.-- $g(\eta)$ vs η FOR SERIES 2000
Symbols O, □, ●, ▽, △ represent in order Test Nos. 7, 8, 9, 10, 11.

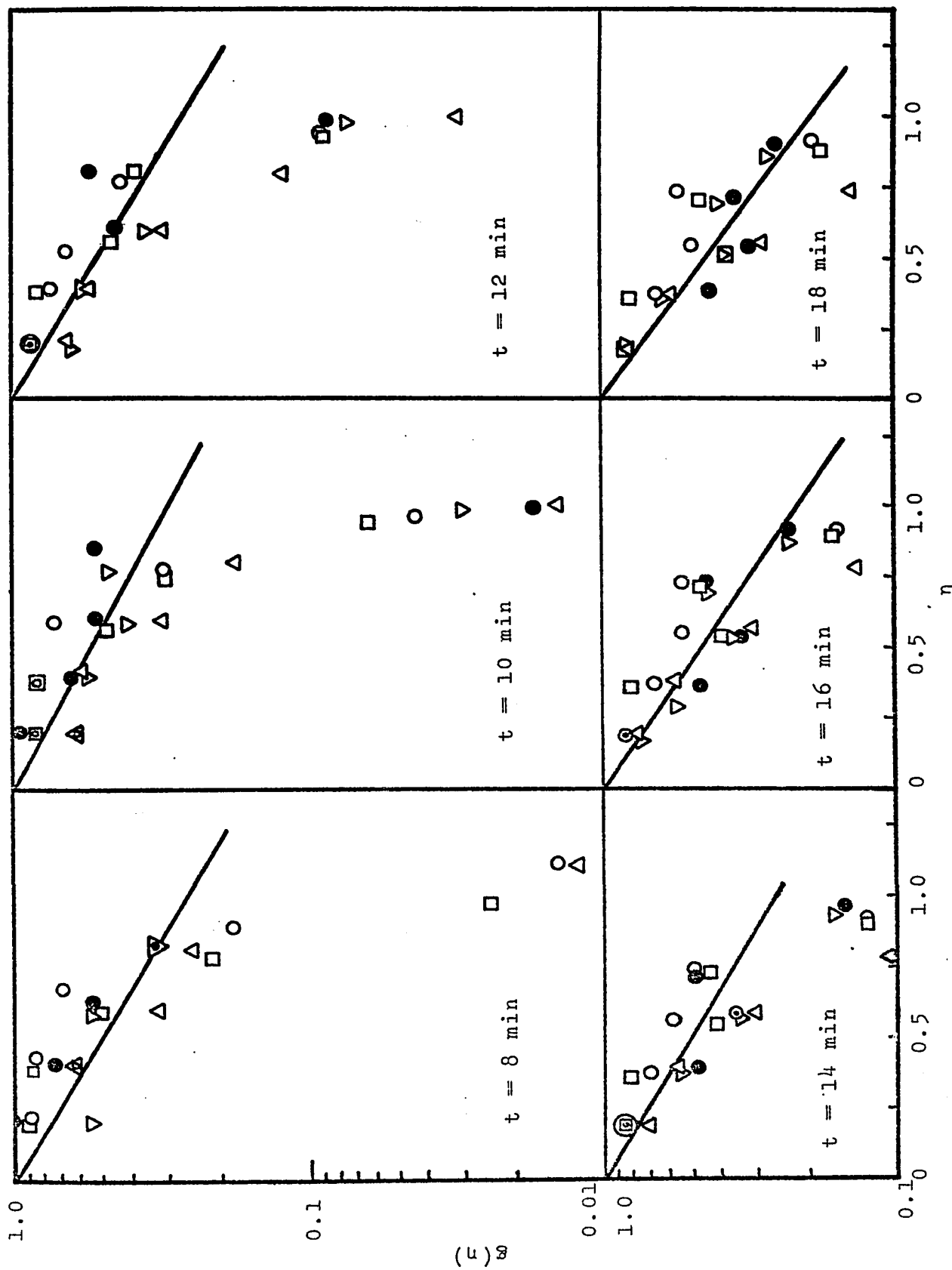


FIG. 5.22.---CONTINUED

YAMAWAKI, KANEKO, AND YAMAMOTO

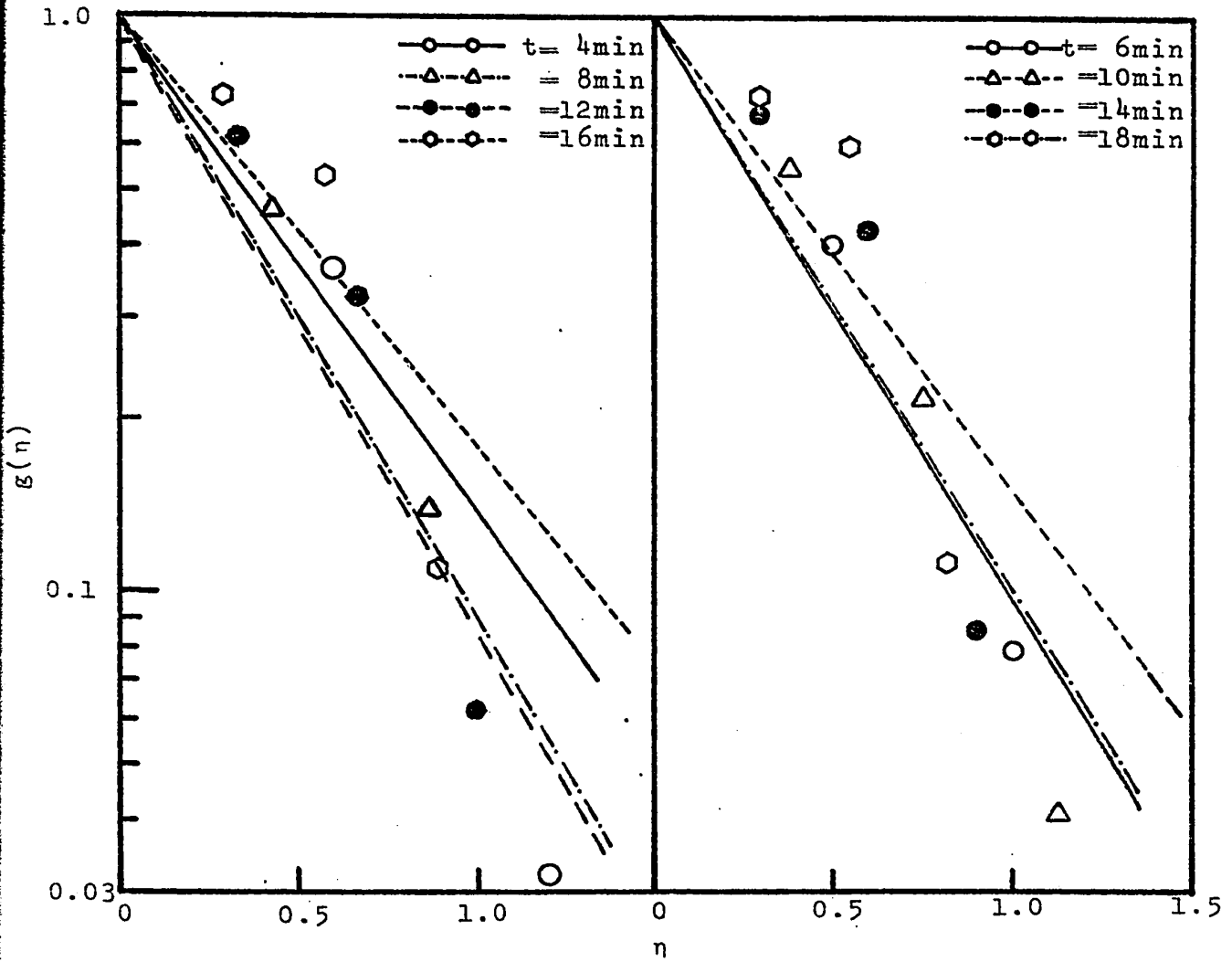


FIG. 5.24.-- $g(\eta)$ vs η FOR SERIES 2919

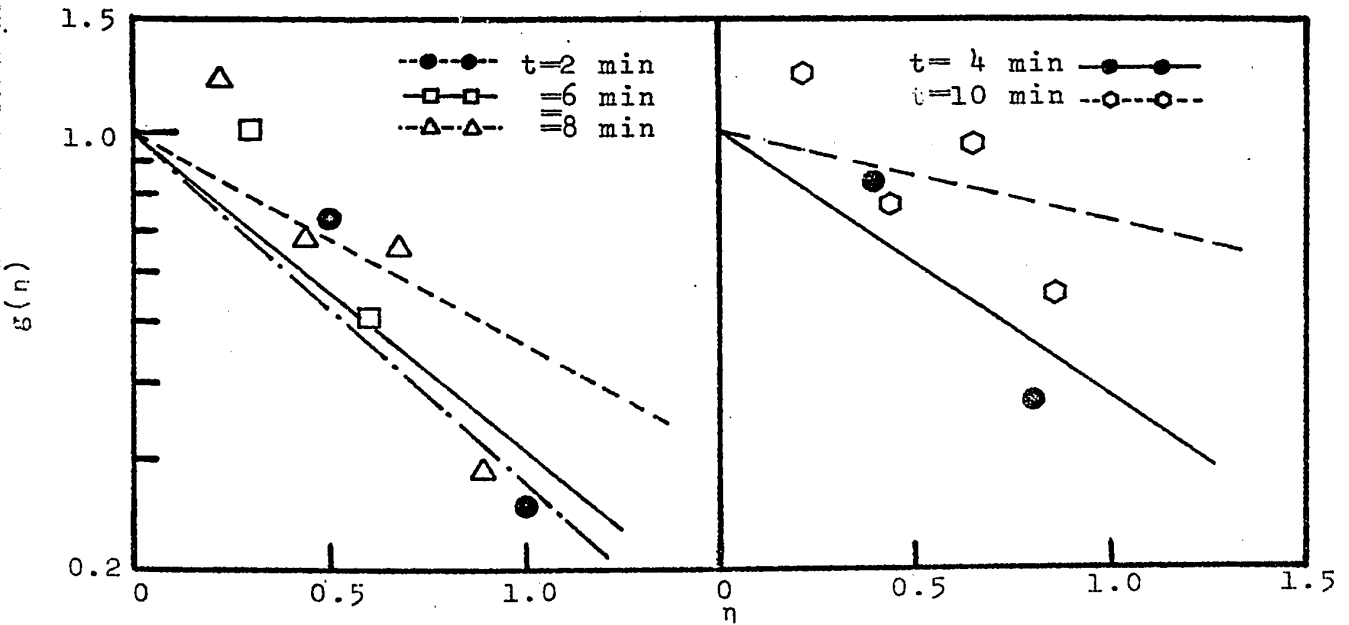


FIG. 5.23.-- $g(\eta)$ vs η FOR SERIES 2914

TABLE 5-4. - DIFFUSION COEFFICIENTS FROM
PROPOSED MATHEMATICAL MODEL

Series	Time minutes	β	y_0 , feet	slope, s	ϵ_y , feet ² per minute
3000	2	-0.000562	7.3	-0.4400	25.75
	4	Transition	9.5	-	-
	6	"	11.1	-	-
	8	-0.0000537	12.3	-0.4950	5.58
	10	"	13.5	-0.5314	5.84
	12	"	14.4	-0.5925	5.35
	14	"	15.2	-0.5867	6.08
	16	"	16.0	-0.5616	7.35
	18	"	16.7	-0.6380	6.20
2000	2	-0.0008040	9.9	-1.1650	6.83
	4	"	13.0	-0.5780	48.0
	6	Transition	15.3	-	-
	8	-0.0000568	17.0	-0.6360	4.67
	10	"	18.7	-0.5250	8.48
	12	"	20.0	-0.5900	7.68
	14	"	21.3	-0.5850	8.88
	16	"	22.5	-0.7500	6.02
	18	"	23.6	-0.7140	7.32
2914	2	-0.0002285	5.6	-0.5030	4.76
	4	-0.0002285	8.3	-0.4180	15.15
	6	Transition	10.5	-	-
	8	Transition	12.4	-	-
	10	-0.0000732	14.0	-0.1300	142.50
2919	2	-0.000317	3.20	-	-
	4	Transition	4.75	-	-
	6	-0.0000835	6.0	-1.0080	0.50
	8	"	7.0	-1.0420	0.63
	10	"	8.0	-0.9950	0.91
	12	"	8.9	-0.8580	1.51
	14	"	9.7	-0.8100	2.02

CHAPTER VI

DISCUSSION OF RESULTS AND CONCLUSIONS

6.1 Variations in Experimental Data

An examination of Tables A-1 to A-14 and Figs. A.1 to A.13 reveals the following: In the series 3000 which consists of the tests conducted at 2900 and 3000 rpm, Tests 1 to 5 can be considered to have been conducted in homogeneous pond as indicated by the temperature movements given in Table A-1; Test No. 6 seems to be in a stratified condition. This may be the reason for the general deviation of the results of Test No. 6 from those of other tests in the series as observed in various plots. It is surprising to note that the concentrations at all the depths approached uniform values in Test No. 6, whereas in other tests, concentrations at depth 3-4 are generally much less than those at other depths. Further, in Tests 1 to 5, the average temperature of water varied from one test to another; it seems from this study, that the overall diffusion is not affected by the temperature differences normally encountered in the pond.

In the series 2000 which consists of the tests conducted at 2000 rpm; Tests 7 and 8 show a high surface temperature of water, with an almost uniform value at other depths; Tests 9, 10 and 11 can be considered to be at homogeneous condition. In Tests 7, 8 and 9, the concentration

values at depth 3-4 are much less than those at other depths, whereas in Tests 10 and 11, the concentrations reached higher values at depth 3-4 and lower values at depth 0-1. No explanation is possible for such an observation. However, as pointed out before, the overall diffusion seems to be unaffected by the temperature variations.

It is interesting to note that when the concentration at depth 3-4 was very high, an appreciable amount of dye had not moved to greater depths which can be clearly seen by the very small decrease in the value of W_D .

In Tests 12 and 13 which were conducted late in the afternoon, the dye remained within the top two feet depth only. Complete temperature measurements for Test No. 12 are not available; but the surface temperature of water was quite high. In Test No. 13, there is some variation in temperature, which may be comparable to the variation in some of the tests in series 3000 and 2000. Here again it is very difficult to give a satisfactory explanation for this type of diffusion phenomenon.

In some tests, there exist negative concentration gradients and regions of discontinuity. These can be particularly observed in Tests 12 and 13.

There are three possible reasons for the observed variation in data from one test to another: (1) the diffusion process is purely random, with a higher degree of randomness compared to the sampling scheme adopted particularly in the

vertical direction; (2) variations in weather conditions; and (3) possible existence of bottom springs. It is very difficult to estimate the effect of randomness; however, from a large number of realizations under the same conditions (about 25 realizations), an average value can be obtained for each depth; a comparison of these averages would give an insight into the degree of randomness. For example, if the averages at all depths have more or less the same values, then the process is completely random over the entire depth. Such a study could best be done in the laboratory. Under field conditions, it is very difficult to get the same initial and boundary conditions due to variations in weather and other unknown effects such as bottom springs, etc. Winds and temperature variations appear to have an important effect on the diffusion process.

In a shallow lake, the flow seems to become turbulent at very small velocities of currents. Experimental observations in a shallow channel indicate that the flow becomes turbulent when the Reynolds number is 310 (23). Applying this result to the pond and taking an average depth of six feet, the critical velocity is found to be 0.000335 feet per second, indicating the flow may become turbulent even by small currents due to wind. This, perhaps, explains the reason for the movement of dye away from the test section in a number of tests. Even though the winds were calm at the time of test (as indicated by the undisturbed water surface), the circulation induced by the winds prior to the testing

period may persist for some length of time; the velocity of these currents may be too small to notice, but they may still be turbulent. Such a circulation was noticed at the test section in a few tests, which was indicated by the movement of floating matter even though the water surface was calm.

The diurnal variations in temperature also seem to affect the diffusion process as indicated by a comparison between the tests conducted in the morning and those conducted late in the afternoon. It was possible to use the data of only two experiments conducted late in the afternoon, both of which differed from one another. Hence, all the comments on these two tests are considered subject to these limitations.

Bottom springs are found to be quite common in ponds and shallow lakes. Their existence affects the diffusion process, which is very difficult to estimate.

The sampling device may also have affected the diffusion. Careful precautions were taken to minimize this effect. A visual test was conducted in the laboratory to evaluate the effect of an external disturbance, similar to the disturbance caused by the sampler on a dye cloud. A drop of dye was placed into a container of water under quiet conditions. A disturbance was created at the dye cloud. It was observed that the disturbance did not move the dye cloud appreciably. Based on this observation, it is believed that during the period of appreciable diffusion (upto about 20 minutes), the diffusion due to disturbance by the samplers is

negligibly small in relation to the diffusion caused by the turbulent movements.

6.2 Discussion of Experimental Results

The plots of observed fluorescence values versus time at each sampling point show irregular fluctuations (see Figs. A.1 to A.13 in Appendix A). It was extremely difficult, in some cases, to draw a smooth curve through the points. In such cases, the curves at the neighbouring sampling points were taken as a guide to draw the smooth curves. In many cases, the smoothed lines were drawn to coincide with the observed maximum values, because there is no way of estimating the fluctuations. This is particularly true at the depth 0-1 on the centre line at time of zero. As this value is used in the computations for variation of maximum concentration with time, its magnitude is of importance. In each series, it can be seen that the maximum value at zero time on the centre line differs from one test to another. An ensemble average value (of all the tests in a series) would have been a better parameter. As each test was considered individually in the analysis of data, an average was not taken.

Plots of concentration versus lateral distance (Figs. C.1 to C.13 in Appendix C) show that after some time, the concentration distribution in the cross-section becomes more and more irregular, with an increase in the fluctuation

of concentration values near the edge of the wake. This is due to the effect of the intermittent nature of flow near the wake boundary. It may be recalled that the concentration values at the depth 3-4 were also irregular in many of the tests, suggesting intermittency affects the results near that depth. Townsend (42) states that the data near the boundary must be corrected by using an intermittency factor, and has discussed in detail the method of obtaining the factor and correcting the data in the wake of a cylinder. In the absence of such a factor for the type of wakes studied here, the average wake width was obtained as described in Chapter V.

From Figs. 5.1 to 5.4, it is quite clear that the wake width increases upto some time after which it tends towards a constant value. This agrees with the findings of Naudascher in wakes of self-propelled bodies (27). Generally, the increase takes place upto about 20 minutes in the series 3000, 2000 and 2919; in series 2914, the wake width up to 10 minutes only could be obtained from which it is not possible to know the time upto which the width increases.

The wake width y_0 was assumed to be proportional to t^n . The values of the exponent n , given in Table 5-1 show that in the series 3000 and 2000, the value at depth 0-1 is much smaller than those at the depths 1-2 and 2-3; in series 2914, they are nearly the same at depths 0-1 and 1-2, while in the series 2919, the value at depth 0-1 is slightly higher than that at depth 1-2. The values of n vary from about 0.37

to about 0.61. Table 6-1 shows the values of n for different wakes of interest cited in the literature. A comparison between the values of n in Tables 5-1 and 6-1 shows that the values observed for boat wakes are generally much higher.

TABLE 6-1.--VALUES OF n

Serial No.	Name of Wake	n	Ref.
1	Cylindrical wake	0.500	(21)
2	Circular wake	0.330	(21)
3	Wake of self-propelled body		
	a) 2-dimensional wake	0.250	(4)
	b) 3-dimensional wake	0.200	(4)
	c) swirling wakes	0.250	(35)
	d) 2-dimensional wake	0.305 (initial zone) 0.125 (semi-final zone)	(27)
	e) axisymmetric wake	0.270 (initial zone) 0.125 (semi-final zone)	(27)

The boundary of diffusion appears to have a trapezoidal or partial-elliptic shape in the series 3000 and 2000; the final width seems to vary from about 40 feet at the top to about 25 or 30 feet at an average depth of 4 to 5 feet. For small craft, the depth of wake is reported to be nearly four times the draft of the vessel (32); the results of series 3000 and 2000 appear to agree with this since the draft of the boat was about one foot. In series 2914 and 2919, the depth is only two feet, while the width is almost the same as in others,

indicating the effect of diurnal variations in temperature. This fact can be advantageously utilized to spread chemicals depending on the type of weeds present; for example, emergent plants can be treated in the afternoon (on calm days) to take advantage of the shallow nature of diffusion, whereas submerged rooted aquatics can be treated in the morning.

According to the one-dimensional normal distribution equation, the maximum concentration varies as $t^{-1/2}$, whereas according to Eq. 3.10 the variation follows an exponential law. In Figs. 5.17 to 5.20, which show plots of $f(\zeta)$ versus ξ , the exponential variation seems to be confirmed. The exponential variation prediction has these significant features:

First, the maximum concentration in a wake flow decays much faster than that predicted by the normal equation.

Secondly, the maximum concentration varies with time according to different exponential laws between some time intervals as indicated by lines (1) and (2) in Figs. 5.17 to 5.20, suggesting the existence of different zones of flow. The normal equation would not give any such insight into the structure of the flow.

Both these features are completely in agreement with the findings of Naudascher in wakes of self-propelled bodies (27). From Figs. 5.17 to 5.20, the following zones may be suggested (based on an analogy with Naudascher's findings):

1. Initial zone, in which the transport is mainly convective in nature; the change in concentration

is very fast; this is a region of very high shear. This zone appears to last for a relatively short time, from 0 to about 2 or 4 minutes. The concentration decay is very rapid as indicated by the steepness of line (1).

2. Transition zone, in which transport is due to both convective and diffusive eddies; the concentration in this zone changes constantly. This zone seems to last from about 2 or 4 minutes to about 6 or 8 minutes, and is indicated by the dotted lines between the lines (1) and (2) in the figures.
 3. Diffusive zone, in which the transport is mainly due to the diffusive eddies; the change in concentration is much less compared to that in the zones mentioned above; this appears to be a region of negligible shear. This zone lasts for a relatively longer duration, from about 4 minutes to about 20 minutes. Most of the diffusion takes place in this zone, and the diffusion appears to be fairly constant.
 4. Final zone, in which the transport is negligible; the concentration changes very very slowly, gradually tending towards a constant value. This zone seems to exist soon after the diffusive zone.
- It should be noted that there is an overlap of

adjacent zones. This classification is made purely for convenience to explain the mechanism of diffusion in the wake.

The existence of these zones is not fully noticeable in plots of wake width versus time due to lack of sufficient data in the initial period; however, the distinction between diffusive and final zones is clearly noticeable at about 20 minutes, which is in agreement with that found from plots of maximum concentration versus time.

The limitations of the computation of variances using the normal equation and the second moment method were pointed out in Chapter V. The diffusion coefficients computed from both these methods are given in Table 5-2 which shows that in the series 3000, both methods gave almost the same value up to depth 2-3, with some discrepancy at depth 3-4; in all other series, there exists discrepancy in results at all depths. A common assumption of this method is that the concentration distribution approaches the normal distribution after the diffusion has progressed for a sufficiently long time. For wake flows, it is very difficult to justify this assumption since the diffusion takes place only up to some finite time.

From plots of variance versus time (Figs. 5.5 to 5.16), it can be observed that the variance values increase with time steadily up to about 20 minutes, indicating that the diffusion takes place up to this time, after which it diminishes. This confirms the previous observations.

The diffusion coefficients obtained by the proposed method are tabulated in Table 5-4. In the initial period, the values fluctuate considerably. However, after some time, they seem to attain more or less a constant value in series 3000 and 2000. The small variation in values probably resulted from the determination of the slope, s , from plots of $g(\eta)$ versus η (Figs. 5.21 to 5.24); towards the wake edge, the scatter in the data becomes more due to intermittency effects as already explained. In series 2914 and 2919, the values of ϵ_y vary considerably, because they are the values computed from a single realization only.

For comparison purposes, an average from the values of ϵ_y from 8 to 18 minutes (after the transition) is obtained in the series 3000 and 2000 separately; the values are 6.070 and 7.175 feet² per minute respectively. Table 6-2 shows the values of $(\epsilon/U_o D)$ for some of the wakes for which data are available in the literature and those computed from this study (at depth 0-1 only).

Ketchum and Ford (25) report that the average mixing coefficients in the wake of a barge at sea are 2000 cm² per second (129 feet² per minute) in April and 7000 cm² per second (452 feet² per minute) in January. The data were analyzed using one dimensional normal distribution equation. Unfortunately, a suitable length parameter is not available to express this result in non dimensional form for comparison purposes. The mixing was due to the wake effect as well as turbulence of sea water as pointed out in the study.

TABLE 6-2.--VALUES OF $\frac{\epsilon}{U_0 D}$

Serial No.	Type of Wake	$\frac{\epsilon}{U_0 D}$	Reference
1	Wake of cylinder (a) Velocity Distribution	0.016	(21)
	(b) Temperature Distribution	0.030	(21)
2	Wake of self-propelled body	0.008	(27)
3	Boat wake (a) Series 3000 (i) from Normal Equation	0.0016	This study
	(ii) from second moment	0.0016	
	(iii) from proposed method	0.0271	
(b) Series 2000	(i) from Normal Equation	0.0022	
	(ii) from second moment	0.0040	
	(iii) from proposed method	0.0460	

Parker studied diffusion in a shallow reservoir under quiescent conditions and reports that the diffusion coefficients (computed from the normal distribution equation) varied from 78 feet² per minute to 8640 feet² per minute (31). A comparison of these values with those in the wake of boat should have indicated the effectiveness of wakes; however, such a comparison seems to be not possible because of the very high values of diffusion coefficients reported by Parker which suggests that the two test conditions are not comparable.

6.3 Conclusions

Diffusion of a substance in the wake of an out-board motor boat was studied in a pond under quiescent conditions, using a fluorescent dye as a tracer. The diffusion was mainly due to the masses of water set into motion by the action of the propeller. Samples were collected from an observation platform, simultaneously at several points in a cross-section of the wake at regular time intervals using inexpensive samplers of a very simple design. The cross-sectional distribution of concentration showed that the diffusion in the wake of a boat differs considerably from the diffusion in classic wake flows cited in the literature. A mathematical model for the diffusion process in the wake was suggested, which takes into consideration the flow characteristics. The model permits the study of variation of maximum concentration with time, and the computation of diffusion

coefficients. Diffusion coefficients were also computed from the variance of the distribution curves. Tests were conducted at different boat speeds in order to determine the effect of boat speed on the diffusion process. Tests were conducted in the morning hours as well as during late afternoons.

The following conclusions can be made from this study:

1. Boat wakes can be used as efficient mixing devices in ponds or shallow lakes under quiescent conditions.
2. The variations in boat speed do not influence the final diffusion appreciably, although the absolute concentration values may differ with the speed.
3. The diurnal variation in temperature has a marked influence on the diffusion process.
4. The diffusion zone has a trapezoidal or partial-elliptic shape with an average width of about 40 feet at the top and about 30 feet at a depth of about 4 feet. (In the afternoon tests, the depth was 2 feet only).
5. Most of the diffusion takes place in about 20 minutes from the instant the dye is injected into the wake.
6. The maximum concentration on the centre line of the wake decreases rapidly following an exponential law, so that there need be no fear of creation of high concentration regions which may be harmful to some aquatic life when chemicals are spread.

7. The various wake models cited in the literature cannot be used to describe adequately the diffusion process in a wake at a free surface of which the boat wake is a typical example.
8. Diffusion coefficients were computed from the variance method and by the proposed model. These are given in Tables 5-2 and 5-4.

In view of the fact that the wake models cited in literature cannot be used to describe the diffusion phenomenon in the wake at a free surface, it is suggested that the flow characteristics of a wake at a free surface should be investigated. Such a study may help explain the diffusion process more precisely; also, it might help verify some of the assumptions made in the development of the mathematical model and to improve the model.

During this investigation, it was observed that air bubbles are introduced into the wake; it would be of interest to investigate the use of wakes of watercraft as artificial aeration devices in natural bodies of water.

The use of boat wakes to spread a disinfectant for the control of pollution at beaches where currents or circulation are minimal would seem to be worthy of investigations.

LIST OF REFERENCES

1. Aquatic Plant and Algae Control, Published by the Ontario Water Resources Commission, Toronto.
2. Batchelor, G. K., "Diffusion in a Field of Homogeneous Turbulence, I - Eulerian Analysis," Australian Journal of Scientific Research, Vol. 2, 1949.
3. Batchelor, G. K., "Diffusion in Free Turbulent Shear Flows," Journal of Fluid Mechanics, Vol. 3, 1957-58.
4. Birkhoff, G. and Zarantonello, E. H., Applied Mathematics and Mechanics, Vol. 2, - Jets, Wakes and Cavities, Academic Press Inc., New York, 1957.
5. Bowden, K. F., "Horizontal Mixing in the Sea due to a Shearing Current," Journal of Fluid Mechanics, Vol. 21, part 2, 1965.
6. Carslaw, H. S. and Jaeger, J. C., Conduction of Heat in Solids, Oxford University Press, 1956.
7. Chervinsky, A. and Lorenz, D., "Decay of Turbulent Axisymmetrical Free Flows with Rotation," Journal of Applied Mechanics, Vol. 34, Transactions, American Society of Mechanical Engineers, Vol. 89, Series E, December 1967.
8. Chevray, R., "The Turbulent Wake of a Body of Revolution," Journal of Basic Engineering, Transactions, American Society of Mechanical Engineers, Vol. 90, Series D, 1968.

9. Chigier, N. A. and Chervinsky, A., "Experimental Investigation of Swirling Vortex Motion in Jets," Journal of Applied Mechanics, Vol. 34, Transactions, American Society of Mechanical Engineers, Vol. 89, Series E, June 1967.
10. Daily, J. W. and Harleman, D. R. F., Fluid Dynamics, Addison Wesley Ltd., 1966.
11. Diachishin, A. N., "Dye Dispersion Studies," Journal of the Sanitary Engineering Division, American Society of Civil Engineers, Vol. 89, 1963.
12. Dobbins, W. E., "Diffusion and Mixing," Boston Society of Civil Engineers, Vol. 52, April 1965.
13. Elder, J. W., "The Dispersion of Marked Fluid in Turbulent Shear Flow," Journal of Fluid Mechanics, Vol. 5, 1959.
14. Fair, G. M. and Geyer, J. C., Water Supply and Waste-Water Disposal, John Wiley & Sons, Inc., New York, August 1961, pp.815-820.
15. Feuerstein, D. L. and Selleck, R. E., "Fluorescent Tracers for Dispersion Measurements," Journal of the Sanitary Engineering Division, American Society of Civil Engineers, Vol. 89, August 1963.
16. Fischer, H. B., "Longitudinal Dispersion in Natural Streams," Journal of the Hydraulics Division, American Society of Civil Engineers, Vol. 93, 1967.

17. Fluorometry in Studies of Pollution and Movement of Fluids, Fluorometry Reviews, G. K. Turner Associates, Palo Alto, California, Acc. No. 9941, February 1968.
18. Goldstein, S., "On the Velocity and Temperature Distributions in the Turbulent Wake behind a Heated Body of Revolution," Proceedings, Cambridge Philosophical Society, Vol. 34, 1938.
19. Goldstein, S., "Note on the Velocity and Temperature Distributions behind a Heated Body of Revolution," Proceedings, Cambridge Philosophical Society, Vol. 34, 1938.
20. Hall, A. A. and Hislop, G. S., "Velocity and Temperature Distributions in the Turbulent Wake behind a Heated Body of Revolution," Proceedings, Cambridge Philosophical Society, Vol. 34, 1938.
21. Hinze, J. O., Turbulence, McGraw-Hill Book Co., 1959.
22. Holley, E. R., "Unified View of Diffusion and Dispersion," Journal of the Hydraulics Division, American Society of Civil Engineers, Vol. 95, 1969.
23. Hutchinson, G. E., A Treatise on Limnology, Vol. I, John Wiley & Sons, Inc., New York, 1957.
24. Kalinske, A. A. and Pien, C. L. "Eddy Diffusion," Industrial and Engineering Chemistry, Vol. 36, 1944.
25. Ketchum, B. H. and Ford, W. L., "Rate of Dispersion in the Wake of a Barge at Sea," Transactions, American Geophysical Union, Vol. 33, 1952.

26. Murthy, C. R., "Complex Diffusion Processes in Coastal Currents of a Lake," *Journal of Physical Oceanography*, Vol. 2, January 1972.
27. Naudascher, E., "Flow in the Wake of Self-propelled Bodies and Related Sources of Turbulence," *Journal of Fluid Mechanics*, Vol. 22, 1965.
28. Naudascher, E., "On a General Similarity Analysis for Turbulent Jet and Wake Flows," IIHR Report No. 106, Iowa Institute of Hydraulic Research, University of Iowa, Iowa, December 1967.
29. Operating Instructions-110-005 Door, Standard Cuvette, G. K. Turner Associates, Palo Alto, California, May 1966.
30. Orlob, G. T., "Eddy Diffusion in Homogeneous Turbulence," Transactions, American Society of Civil Engineers, Vol. 127, Part I, 1961.
31. Parker, F. L., "Eddy Diffusion in Reservoirs and Pipe Lines," *Journal of Hydraulic Division, American Society of Civil Engineers*, Vol. 87, May 1961.
32. Physics of Sound in the Sea, Department of the Navy Headquarters Naval Material Command, Washington, D. C., 1969.
33. Pritchard, D. W., "A Study of Flushing in the Delaware Model," Technical Report VII, The Chesapeake Bay Institute of the Johns Hopkins University, Baltimore, Maryland, 1954.

34. Redfield, A. C. and Walford, L. A., "A Study of Chemical Waste Disposal at Sea," National Research Council Publication 201, Washington, D. C., 1959.
35. Reynolds, A. J., "Similarity in Swirling Wakes and Jets," Journal of Fluid Mechanics, Vol. 14, October 1962.
36. Schooley, A. H. and Stewart, R. W., "Experiments with a Self-propelled Body Submerged in a Fluid with a Vertical Density Gradient," Journal of Fluid Mechanics, Vol. 15, 1963.
37. Sittig, M., Water Pollution Control and Solid Wastes Disposal, Chemical Process Review No. 32, 1969, pp.11 Noyes Development Corporation, Park Ridge, New Jersey, U. S. A.
38. Swain, L. M., "On the Turbulent Wake Behind a Body of Revolution," Proceedings, Royal Society of London, Series A, Vol. 125, 1929.
39. Taylor, G. I., "Diffusion by Continuous Movements," Proceedings, London Mathematical Society, Vol. 20, 1921.
40. Taylor, G. I., "Statistical Theory of Turbulence-Part I," Proceedings, Royal Society of London, Series A, Vol. 151, 1935.
41. Taylor, G. I., "Dispersion of Matter in Turbulent Flow through a Pipe," Proceedings, Royal Society of London, Series A, Vol. 223, 1954.
42. Townsend, A. A., The Structure of Turbulent Shear Flow, Cambridge University Press, Cambridge, Great Britain, 1956.

APPENDIX A

GENERAL DETAILS OF EXPERIMENTS

AND

EXPERIMENTAL OBSERVATIONS

TABLE A-1. - GENERAL DETAILS OF EXPERIMENTS

Test No.	RPM	Date of Tests	Weather	Air Temp., in degrees centigrade	Temperature of pond water, in degrees centigrade at stated depth, in feet						Remarks	
					0	1	2	3	4	5		6
1	2900	Sept. 16 1969	clear, calm (no winds)	16.8	18.5	18.4	18.0	18.0	18.0	18.0	17.6	Tests 1 to 6 are grouped and designated "Series 3000"
2	2900	Sept. 22 1969	Foggy calm	5.0	11.9	12.8	13.0	13.0	12.9	12.4	12.0	
3	3000	Sept. 24 1969	Cloudy calm	15.5	16.0	16.7	16.9	16.9	17.0	17.0	16.5	
4	2900	Sept. 28 1969	Clear calm	10.5	13.9	13.8	13.9	13.3	13.3	13.4	13.3	
5	2900	Oct. 3 1969	Foggy calm	7.0	15.0	14.8	14.8	14.8	14.3	14.3	14.5	
6	3000	Sept. 3 1970	Cloudy calm	14.0	19.0	15.5	15.0	14.5	13.5	13.5	13.5	
7	2000	Aug. 12 1970	Clear	18.5	26.5	22.0	22.5	23.0	22.0	21.8	22.0	Tests 7 to 11 grouped together and designated "Series 2000"
8	2000	Aug. 14 1970	Clear calm	19.0	26.5	22.5	23.5	23.0	22.8	23.0	23.0	

Table A-1. - Continued

Test No.	RPM	Date of Tests	Weather	Air Temp., in degrees centigrade	Temperature of pond water, in degrees centigrade at stated depth, in feet							Remarks
					0	1	2	3	4	5	6	
9	2000	Aug.25 1970	Clear calm	19.0	21.0	20.0	18.5	18.5	19.5	19.5	19.0	
10	2000	Aug.27 1970	Clear calm	18.0	18.0	17.0	17.0	17.0	18.0	17.5	17.5	
11	2000	Aug.28 1970	Light clouds calm	15.0	18.0	17.5	17.0	17.0	17.0	16.5	16.5	
12	2900	Sept.14 1969	Clear occasional light winds	26.0	23.5	Temperature at depths 1 to 6 feet were not recorded						Experiment conducted late in the afternoon. "Series 2914"
13	2900	Sept.19 1969	Clear calm	15.0	17.0	16.0	14.8	14.5	15.5	15.0	14.0	Experiment conducted late in the afternoon. "Series 2919"

TABLE A-2--EXPERIMENTAL OBSERVATIONS OF TEST NO. 1

TEMPERATURE OF SAMPLES DURING ANALYSIS=25.0 DEGREES CENTIGRADE

FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET

TIME MIN	DEPTH FT	0.0		3.0		6.0		9.0		12.0		15.0	
		OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
0.0	1-1	626.5	626.0	7.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	60.5	60.0	0.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-1	6.5	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-2	5.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	1-1	214.0	214.0	74.5	74.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	199.0	174.0	13.0	12.0	14.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-1	15.0	17.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-2	5.5	7.0	0.0	0.0	105.0	103.0	4.0	4.0	0.0	0.0	0.0	0.0
4.0	1-1	157.0	165.0	109.5	108.0	42.5	42.0	1.0	1.0	0.0	0.0	0.0	0.0
	1-2	137.0	188.0	27.0	49.0	10.0	11.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-1	2.0	25.0	0.5	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-2	9.0	14.0	0.0	106.0	0.0	0.0	12.5	13.0	0.0	0.0	0.0	0.0
6.0	1-1	146.5	149.0	109.5	106.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	112.5	100.0	178.5	174.0	0.0	0.0	4.0	4.0	0.0	0.0	0.0	0.0
	2-1	15.0	34.0	13.5	11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-2	154.0	133.0	12.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0	1-1	120.0	134.0	85.0	100.0	78.0	85.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	137.0	34.0	18.0	19.0	23.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-1	14.0	11.0	17.0	16.0	6.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-2	131.0	120.0	96.0	93.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.0	1-1	196.5	103.0	26.5	25.0	36.0	36.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	27.0	119.0	28.0	28.0	10.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-1	99.0	109.0	91.0	87.0	72.5	68.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-2	105.0	101.0	80.0	83.0	68.5	80.0	0.0	0.0	0.0	0.0	0.0	0.0
12.0	1-1	126.0	131.0	28.0	28.0	15.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	94.0	109.0	75.0	82.0	64.5	57.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-1	93.0	96.0	34.0	31.0	35.0	41.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-2	110.0	110.0	11.0	10.0	13.0	13.0	0.0	0.0	0.0	0.0	0.0	0.0

SMT: SMOOTHED VALUE

OBS: OBSERVED VALUE

TABLE A- 2. --CONTINUED

TIME DEPTH	FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET												
	1.0	3.0	6.0	9.0	12.0	15.0	1.0	3.0	6.0	9.0			
MIN	FT	OBS	SMT	OPS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
16.0	0-1	96.5	93.0	75.5	77.0	58.0	56.0	53.0	53.0	15.0	15.0	6.5	7.0
	1-2	91.0	91.0	78.0	73.0	73.0	67.0	43.0	42.0	16.0	16.0	3.0	3.0
	2-3	105.5	106.0	31.0	32.0	38.5	42.0	26.0	26.0	3.0	3.0	1.5	1.5
18.0	3-4	104.5	106.0	67.0	72.0	14.0	15.0	47.0	47.0	17.0	17.0	1.0	1.0
	4-5	88.5	87.0	31.0	31.0	27.0	39.0	25.0	25.0	14.0	14.0		
	5-6	27.0	27.0	37.5	31.0	44.5	48.0	42.0	42.0	18.0	18.0	0.5	0.5
20.0	6-7	82.0	80.0	67.0	68.0	61.0	58.0	42.0	42.0	17.0	17.0	0.5	0.5
	7-8	21.0	22.0	61.5	64.0	37.5	38.0	27.0	27.0	11.0	11.0	0.5	0.5
	8-9	17.5	22.0	5.5	3.0	11.0	11.0	34.0	39.0	19.0	19.0	0.5	0.5
22.0	9-10	77.5	75.0	70.0	68.0	62.0	54.0	39.0	39.0	11.0	11.0	0.5	0.5
	10-11	13.0	73.0	65.0	61.0	45.0	46.0	28.0	28.0	16.0	16.0	0.5	0.5
	11-12	81.0	76.0	64.0	61.0	41.0	42.0	36.0	36.0	17.0	17.0	0.5	0.5
24.0	12-13	81.0	76.0	58.0	59.0	46.5	50.0	32.0	32.0	19.0	19.0	0.5	0.5
	13-14	21.0	21.0	27.0	26.0	38.0	34.0	30.0	33.0	16.0	16.0	0.5	0.5
	14-15	18.0	66.0	61.0	59.0	47.0	39.0	33.0	33.0	18.0	18.0	0.5	0.5
26.0	15-16	71.5	70.0	51.0	52.0	44.0	47.0	32.0	32.0	16.0	16.0	0.5	0.5
	16-17	17.0	16.0	19.5	23.0	39.0	37.0	29.0	31.0	17.0	17.0	0.5	0.5
	17-18	56.0	63.0	56.0	56.0	44.0	44.0	30.0	30.0	16.0	16.0	0.5	0.5
28.0	18-19	62.5	78.0	50.0	52.0	41.0	40.0	28.0	28.0	17.0	17.0	0.5	0.5
	19-20	27.5	68.0	10.0	9.0	12.0	9.0	30.0	29.0	15.0	15.0	0.5	0.5
30.0	20-21	58.5	68.0	52.0	54.0	35.0	36.0	24.0	24.0	16.0	16.0	0.5	0.5
	21-22	15.0	17.0	19.0	28.0	41.0	41.0	27.0	27.0	17.0	17.0	0.5	0.5
	22-23	56.0	57.0	50.0	49.0	36.0	35.0	23.0	23.0	14.0	14.0	0.5	0.5
32.0	23-24	13.0	17.0	22.0	18.0	26.0	25.0	19.0	19.0	15.0	15.0	0.5	0.5
	24-25	66.0	66.0	57.0	57.0	49.0	49.0	27.0	27.0	14.0	14.0	0.5	0.5
	25-26	13.0	17.0	22.0	18.0	26.0	25.0	19.0	19.0	15.0	15.0	0.5	0.5

TABLE A- 3.--EXPERIMENTAL OBSERVATIONS OF TEST NO. 2

TEMPERATURE OF SAMPLES DURING ANALYSIS=19.5 DEGREES CENTIGRADE

FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET

TIME	DEPTH	0.0	3.0	6.0	9.0	12.0	15.0	18.0
MIN	FT	OBS	OBS	OBS	OBS	OBS	OBS	OBS
		SMT	SMT	SMT	SMT	SMT	SMT	SMT
0.0	0-1	482.0	234.0	0.0	0.0	0.0	0.0	0.0
	1-2	203.0	5.0	0.0	0.0	0.0	0.0	0.0
	2-3	5.5	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	4.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	0-1	171.0	132.0	35.5	0.0	0.0	0.0	0.0
	1-2	130.5	27.0	24.0	0.0	0.5	0.0	0.0
	2-3	26.0	1.0	5.0	0.0	0.0	0.0	0.0
	3-4	7.0	1.5	4.0	0.0	0.0	0.0	0.0
4.0	0-1	97.5	99.5	55.0	2.5	0.0	0.0	0.0
	1-2	55.0	47.5	45.0	0.5	0.0	0.0	0.0
	2-3	49.0	22.0	27.0	0.0	0.0	0.0	0.0
	3-4	11.5	8.0	9.0	0.0	0.0	0.0	0.0
6.0	0-1	191.0	80.0	58.5	0.0	0.0	0.0	0.0
	1-2	130.0	55.0	51.0	1.7	0.0	0.0	0.0
	2-3	45.0	27.0	21.0	5.0	0.0	0.0	0.0
	3-4	8.5	11.0	17.0	0.0	0.0	0.0	0.0
8.0	0-1	119.0	79.0	57.0	23.5	0.0	0.0	0.0
	1-2	89.5	63.0	52.0	20.5	0.0	0.0	0.0
	2-3	57.0	28.5	13.0	13.5	0.0	0.0	0.0
	3-4	8.0	9.0	12.0	5.5	0.0	0.0	0.0
10.0	0-1	72.0	62.0	55.0	57.0	11.0	0.0	0.0
	1-2	71.0	60.0	52.0	51.5	3.5	0.0	0.0
	2-3	40.5	30.0	21.0	20.5	4.0	0.0	0.0
	3-4	4.0	13.0	11.0	18.0	2.0	0.0	0.0
12.0	0-1	37.0	52.0	52.0	32.0	11.0	0.0	0.0
	1-2	66.5	57.0	52.0	26.0	4.0	0.0	0.0
	2-3	33.5	33.5	21.0	18.0	2.0	0.0	0.0
	3-4	18.5	17.5	10.0	11.0	0.0	0.0	0.0
14.0	0-1	61.0	52.0	51.0	46.5	25.5	5.0	0.0
	1-2	55.0	59.0	51.0	54.0	16.0	3.0	0.0
	2-3	38.0	28.0	20.0	17.0	18.0	1.0	0.0
	3-4	18.5	14.0	10.0	12.5	5.5	0.0	0.0

OBS: OBSERVED VALUE SMT: SMOOTHED VALUE

TABLE A- 30--CONTINUED

TIME MIN	DEPTH FT	FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET													
		0.0		3.0		6.0		9.0		12.0		15.0		18.0	
		OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
16.0	1	84.0	75.0	50.5	48.0	49.0	49.0	27.0	29.0	26.0	26.0	15.0	15.0	5.0	5.0
	2	65.0	59.0	54.5	58.0	50.0	50.0	25.5	24.0	27.0	27.0	14.5	13.0	7.0	7.0
	3	37.0	37.0	27.0	26.0	19.0	19.0	15.5	18.0	18.0	18.0	9.5	10.0	3.0	3.0
18.0	3	16.0	17.0	15.0	15.0	48.0	48.0	11.0	28.0	23.0	23.0	5.0	5.0	9.0	9.0
	4	59.0	57.0	45.0	47.0	49.0	49.0	21.0	23.0	19.0	19.0	6.5	6.0	9.0	9.0
	5	13.0	17.0	17.0	17.0	19.0	19.0	11.0	19.0	19.0	19.0	5.0	5.0	5.0	5.0
20.0	1	70.0	69.0	40.0	43.0	46.0	46.0	27.0	27.0	25.0	25.0	21.0	21.0	11.0	11.0
	2	53.0	54.0	57.0	56.0	48.0	48.0	18.0	22.0	22.0	22.0	11.0	10.0	13.0	13.0
	3	38.0	35.0	21.0	24.0	17.0	17.0	17.0	15.0	16.0	16.0	9.0	9.0	13.0	13.0
	4	19.0	19.0	10.0	13.0	47.0	47.0	5.0	21.0	21.0	21.0	5.0	5.0	12.0	12.0
22.0	1	33.0	33.0	10.0	15.0	44.0	46.0	17.0	21.0	21.0	21.0	18.0	18.0	9.0	9.0
	2	34.0	34.0	44.0	45.0	44.0	45.0	16.0	19.0	19.0	19.0	17.0	17.0	11.0	11.0
	3	17.0	19.0	56.0	54.0	45.0	45.0	16.0	15.0	16.0	16.0	14.0	14.0	12.0	12.0
24.0	1	53.0	52.0	24.0	22.0	45.0	46.0	17.0	25.0	25.0	25.0	16.0	16.0	11.0	11.0
	2	32.0	33.0	10.0	11.0	18.0	18.0	17.0	19.0	19.0	19.0	14.0	14.0	11.0	11.0
	3	16.0	15.0	44.0	44.0	38.0	44.0	20.0	21.0	21.0	21.0	23.0	23.0	17.0	17.0
26.0	1	54.0	51.0	36.0	38.0	44.0	45.0	14.0	18.0	18.0	18.0	15.0	15.0	13.0	13.0
	2	34.0	33.0	32.0	33.0	45.0	45.0	14.0	14.0	14.0	14.0	14.0	14.0	17.0	17.0
	3	15.0	15.0	36.0	35.0	40.0	40.0	21.0	25.0	25.0	25.0	23.0	23.0	17.0	17.0
28.0	1	49.0	49.0	32.0	32.0	44.0	44.0	12.0	13.0	13.0	13.0	12.0	12.0	11.0	11.0
	2	34.0	32.0	35.0	32.0	45.0	45.0	12.0	11.0	11.0	11.0	9.0	9.0	11.0	11.0
	3	15.0	15.0	35.0	35.0	44.0	44.0	12.0	13.0	13.0	13.0	12.0	12.0	11.0	11.0
30.0	1	47.0	47.0	30.0	37.0	40.0	44.0	16.0	18.0	18.0	18.0	15.0	15.0	15.0	15.0
	2	37.0	34.0	35.0	35.0	44.0	44.0	16.0	13.0	13.0	13.0	13.0	13.0	18.0	18.0
	3	17.0	17.0	35.0	35.0	41.0	41.0	15.0	13.0	13.0	13.0	13.0	13.0	18.0	18.0
32.0	1	49.0	49.0	35.0	35.0	44.0	44.0	15.0	17.0	17.0	17.0	18.0	18.0	14.0	14.0
	2	30.0	31.0	19.0	19.0	41.0	41.0	15.0	11.0	11.0	11.0	13.0	13.0	14.0	14.0
	3	16.0	14.0	19.0	19.0	41.0	41.0	15.0	11.0	11.0	11.0	13.0	13.0	14.0	14.0

TABLE A-3--CONTINUED

TIME	DEPTH	FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET													
		0.0		2.0		6.0		9.0		12.0		15.0		18.0	
MIN	FT	OBS	SAT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
34.0	0-1	59.0	58.0		36.0	41.5	40.0	23.0	19.0	21.0	19.0	16.0	16.0	9.0	9.0
	1-2	50.0	49.0		50.0	28.0	43.0	17.0	16.0	11.0	13.0	20.0	20.0	13.5	14.0
	2-3	51.0	51.0		18.0	18.0	14.0	17.0	13.0	13.0	13.0	9.0	9.0	19.5	18.0
	3-4	15.0	15.0		36.0	16.5	40.0	22.0	19.0	16.5	18.0	15.0	15.0	7.0	8.0
36.0	0-1	56.0	56.0	41.0	50.0		42.0	16.0	16.0	15.0	16.0	18.0	18.0	13.0	13.0
	1-2	47.0	48.0	15.5	17.0		12.0	17.0	13.0	11.0	13.0	11.0	11.0	13.0	13.0
	2-3	11.0	15.0		16.0		39.0	22.0	18.0	20.0	18.0	14.0	14.0	6.0	7.0
38.0	0-1	14.0	15.0		30.0	41.0	41.0	17.0	16.0	17.5	16.0	19.0	19.0	17.0	13.0
	1-2	43.0	46.0		17.0	15.0	13.0	17.0	13.0	12.5	13.0	17.0	17.0	17.0	13.0
	2-3	34.0	32.0		17.0	19.0	12.0	16.0	15.0	15.0	15.0	13.0	13.0	18.5	13.0
40.0	0-1	12.0	14.0	5.0	35.0		38.0	21.0	18.0	17.0	18.0	13.0	13.0	6.0	6.0
	1-2	48.0	48.0	16.0	50.0		41.0	15.0	15.0	18.5	15.0	19.0	19.0	17.0	13.0
	2-3	30.0	29.0	9.0	16.0		12.0	16.0	11.0	10.0	11.0	9.0	9.0	13.5	8.0
42.0	0-1	15.0	13.0		30.0	30.0	37.0	20.0	17.0	15.5	17.0	13.0	13.0	6.0	6.0
	1-2	45.0	47.0		30.0	44.0	40.0	15.0	15.0	18.5	15.0	19.0	19.0	17.0	13.0
	2-3	22.0	28.0		15.0	10.0	17.0	16.0	11.0	10.0	12.0	7.0	7.0	9.0	8.0
44.0	0-1	12.0	14.0	34.0	34.0		37.0	19.0	19.0	11.0	17.0	11.0	12.0	6.0	6.0
	1-2	47.0	46.0	48.0	50.0		39.0	14.0	14.0	19.0	14.0	18.0	18.0	17.0	13.0
	2-3	24.0	27.0	15.0	14.0		17.0	16.0	11.0	15.0	12.0	7.0	7.0	9.0	8.0
46.0	0-1	47.0	51.0		34.0	36.0	36.0	19.0	19.0	17.5	17.0	12.0	12.0	6.0	5.0
	1-2	45.0	45.0		50.0	37.0	38.0	14.0	14.0	11.0	14.0	11.0	11.0	10.0	13.0
	2-3	12.0	11.0		17.0	10.0	17.0	16.0	11.0	17.0	12.0	6.0	6.0	10.0	8.0
48.0	0-1	49.0	45.0	29.0	34.0		36.0	18.0	18.0	13.0	16.0	13.0	12.0	6.0	6.0
	1-2	42.0	45.0	46.0	50.0		38.0	13.0	13.0	19.0	14.0	13.0	13.0	10.0	13.0
	2-3	22.0	25.0	4.0	14.0		17.0	13.0	13.0	14.0	11.0	9.0	9.0	16.0	8.0
50.0	0-1	11.0	20.0		39.0	39.0	17.0	16.0	16.0	18.0	14.0	13.0	12.0	5.0	5.0
	1-2	23.0	23.0	14.0	23.0	23.0	23.0	14.0	14.0	16.5	14.0	13.0	13.0	18.0	13.0
	2-3	11.0	11.0	11.0	17.0	11.0	17.0	16.0	11.0	13.0	11.0	9.0	9.0	18.0	13.0

TABLE A-4.--EXPERIMENTAL OBSERVATIONS OF TEST NO. 3
 TEMPERATURE OF SAMPLES DURING ANALYSIS=20.5 DEGREES CENTIGRADE

TIME	DEPTH	FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET											
		1.0		3.0		6.0		9.0		12.0		15.0	
MIN	FT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
0.0	1-1	550.0	555.0	38.0	38.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	47.5	47.0	7.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	45.5	45.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	42.5	42.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	1-1	175.0	207.0	109.0	101.0	139.0	108.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	8.5	8.0	14.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	2.5	2.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	4.5	4.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	1-1	105.0	170.0	131.0	107.0	97.5	104.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	153.5	103.0	140.5	41.0	82.5	65.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	68.0	42.0	3.0	4.0	11.0	11.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	11.5	10.0	2.0	2.0	4.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	1-1	64.0	140.0	63.0	98.0	89.0	91.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	58.5	107.0	42.0	65.0	53.0	95.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	18.0	140.0	0.0	11.0	30.0	26.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	15.0	11.0	1.0	2.0	0.0	9.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0	1-1	105.0	119.0	101.0	89.0	81.0	77.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	125.0	136.0	124.0	75.0	105.0	86.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	130.0	36.0	34.0	21.0	18.0	17.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	112.5	11.0	2.0	21.0	19.0	17.0	0.0	0.0	0.0	0.0	0.0	0.0
10.0	1-1	116.0	103.0	108.0	77.0	71.0	63.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	117.0	138.0	124.0	20.0	79.0	46.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	176.0	110.0	5.0	4.0	27.0	19.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	127.0	97.0	81.0	70.0	54.0	57.0	0.0	0.0	0.0	0.0	0.0	0.0
12.0	1-1	176.0	97.0	60.0	74.0	70.0	76.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	61.0	37.0	43.0	35.0	63.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	13.0	17.0	3.0	5.0	22.0	19.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	90.0	78.0	53.0	61.0	64.0	49.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0	1-1	72.0	92.0	38.0	70.0	63.0	68.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	39.0	27.0	44.0	34.0	59.0	51.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	8.0	9.0	20.0	5.0	14.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0

OBS: OBSERVED VALUE SMT: SMOOTHED VALUE

TABLE A- 4.--CONTINUED

TIME DEPTH MIN	FT	1.0		3.0		6.0		9.0		12.0		15.0	
		OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
16.0	1-1	57.5	67.0	39.5	42.0	62.5	39.0	62.5	39.0	30.0	14.5	10.0	10.0
	1-2	68.0	87.0	37.5	60.0	64.5	63.0	64.5	63.0	34.0	20.5	15.0	15.0
	2-3	17.0	26.0	17.0	17.0	71.0	64.0	71.0	64.0	16.0	6.0	6.0	6.0
	2-4	65.0	59.0	54.0	36.0	13.0	31.0	13.0	31.0	26.0	4.0	4.0	4.0
18.0	1-1	1.0	35.0	24.0	52.0	49.5	48.0	49.5	48.0	28.0	12.0	12.0	12.0
	1-2	4.5	35.0	3.0	15.0	21.5	61.0	21.5	61.0	17.0	5.0	5.0	5.0
	2-3	2.5	53.0	5.5	45.0	49.5	37.0	49.5	37.0	24.0	3.0	3.0	3.0
20.0	0-1	52.5	77.0	35.5	52.0	66.5	58.0	66.5	58.0	24.0	16.0	16.0	16.0
	1-2	68.5	32.0	46.5	14.0	17.0	31.0	17.0	31.0	17.0	3.0	3.0	3.0
	2-3	55.5	73.0	44.5	47.0	21.0	38.0	21.0	38.0	19.5	19.5	19.5	19.5
22.0	0-1	60.5	69.0	34.5	52.0	30.5	35.0	30.5	35.0	19.0	13.0	13.0	13.0
	1-2	80.5	72.0	37.5	28.0	26.5	19.0	26.5	19.0	13.0	18.0	18.0	18.0
	2-3	2.0	33.0	34.0	47.0	27.0	19.0	27.0	19.0	11.0	11.0	11.0	11.0
24.0	0-1	47.5	47.0	28.5	24.0	14.0	34.0	14.0	34.0	13.0	13.0	13.0	13.0
	1-2	63.5	67.0	14.5	21.0	42.0	25.0	42.0	25.0	12.0	16.0	16.0	16.0
	2-3	14.5	32.0	54.5	46.0	23.0	12.0	23.0	12.0	9.5	9.5	9.5	9.5
26.0	0-1	37.5	42.0	56.5	46.0	15.5	31.0	15.5	31.0	18.0	13.0	13.0	13.0
	1-2	43.5	63.0	12.5	24.0	25.0	18.0	25.0	18.0	7.0	7.0	7.0	7.0
	2-3	34.5	41.0	32.5	51.0	15.0	18.0	15.0	18.0	14.0	14.0	14.0	14.0
28.0	0-1	34.0	41.0	20.5	23.0	19.0	16.0	19.0	16.0	13.0	6.0	6.0	6.0
	1-2	52.0	57.0	54.5	45.0	27.0	43.0	27.0	43.0	19.0	37.0	37.0	37.0
	2-3	21.0	39.0	46.5	19.0	9.0	15.0	9.0	15.0	5.0	5.0	5.0	5.0
30.0	0-1	28.0	39.0	47.5	45.0	17.0	30.0	17.0	30.0	12.0	12.0	12.0	12.0
	1-2	53.0	52.0	16.5	14.0	61.0	26.0	61.0	26.0	9.0	9.0	9.0	9.0
	2-3	33.0	29.0	16.5	49.0	10.0	12.0	10.0	12.0	3.5	3.5	3.5	3.5
32.0	0-1	44.0	28.0	50.5	30.0	18.0	14.0	18.0	14.0	12.0	15.0	15.0	15.0
	1-2	56.0	24.0	33.0	14.0	57.5	18.0	57.5	18.0	9.0	9.0	9.0	9.0
	2-3	31.0	26.0	14.0	49.0	18.0	17.0	18.0	17.0	1.75	1.75	1.75	1.75

TABLE A-4.--CONTINUED

TIME DEPTH		FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET											
MIN	FT	3.0		6.0		9.0		12.0		15.0		SMT	SMT
		OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT		
34.0	0-1	35.5	37.0	43.0	24.0	38.0	24.0	13.0	13.0	12.5	8.0	2.0	2.0
	1-2	51.0	34.0	47.0	30.0	45.0	30.0	25.0	25.0	13.0	17.0	12.5	12.5
	2-3	23.0	28.0	18.0	48.0	46.0	10.0	12.0	12.0	7.0	5.0	2.0	2.0
	3-4	33.0	25.0	41.0	24.0	10.0	20.0	15.0	15.0	3.0	8.0	3.0	3.0
36.0	1-2	38.0	37.0	45.0	20.0	27.0	20.0	27.0	27.0	11.0	16.0	11.0	11.0
	2-3	31.0	27.0	19.0	48.0	48.0	10.0	46.0	46.0	2.0	5.0	2.0	2.0
	3-4	33.0	25.0	40.0	14.0	28.0	14.0	11.0	11.0	6.0	8.0	6.0	6.0
38.0	1-2	30.0	37.0	42.0	28.0	50.0	28.0	24.0	24.0	10.0	16.0	10.0	10.0
	2-3	36.0	36.0	13.0	40.0	50.0	40.0	11.0	11.0	7.0	5.0	7.0	7.0
	3-4	33.0	34.0	38.0	14.0	14.0	14.0	11.0	11.0	3.0	7.0	3.0	3.0
40.0	1-2	33.0	37.0	40.0	28.0	33.0	28.0	25.0	25.0	10.0	16.0	10.0	10.0
	2-3	37.0	26.0	12.0	45.0	46.0	45.0	46.0	46.0	5.0	5.0	5.0	5.0
	3-4	34.0	24.0	36.0	10.0	10.0	10.0	11.0	11.0	4.0	7.0	4.0	4.0
42.0	1-2	35.0	36.0	37.0	27.0	17.0	27.0	25.0	25.0	6.0	9.0	6.0	6.0
	2-3	37.0	23.0	13.0	40.0	44.0	40.0	41.0	41.0	7.0	5.0	7.0	7.0
	3-4	35.0	23.0	38.0	24.0	44.0	24.0	46.0	46.0	4.0	5.0	4.0	4.0
44.0	1-2	37.0	36.0	35.0	13.0	15.0	13.0	19.0	19.0	5.0	7.0	5.0	5.0
	2-3	31.0	35.0	13.0	40.0	45.0	40.0	41.0	41.0	7.0	9.0	7.0	7.0
	3-4	37.0	36.0	35.0	13.0	15.0	13.0	19.0	19.0	5.0	7.0	5.0	5.0
46.0	1-2	33.0	36.0	35.0	13.0	15.0	13.0	19.0	19.0	5.0	7.0	5.0	5.0
	2-3	31.0	36.0	13.0	40.0	45.0	40.0	41.0	41.0	7.0	9.0	7.0	7.0
	3-4	37.0	36.0	35.0	13.0	15.0	13.0	19.0	19.0	5.0	7.0	5.0	5.0
48.0	1-2	34.0	36.0	33.0	13.0	17.0	13.0	23.0	23.0	8.0	9.0	8.0	8.0
	2-3	42.0	36.0	13.0	40.0	45.0	40.0	41.0	41.0	14.0	14.0	14.0	14.0
	3-4	36.0	36.0	33.0	13.0	17.0	13.0	23.0	23.0	8.0	9.0	8.0	8.0
50.0	1-2	38.0	36.0	32.0	13.0	17.0	13.0	23.0	23.0	9.0	9.0	9.0	9.0
	2-3	35.0	32.0	13.0	40.0	44.0	40.0	41.0	41.0	18.0	18.0	18.0	18.0
	3-4	32.0	32.0	13.0	40.0	44.0	40.0	41.0	41.0	9.0	9.0	9.0	9.0

TABLE A- 5.--EXPERIMENTAL OBSERVATIONS OF TEST NO. 4

TEMPERATURE OF SAMPLES DURING ANALYSIS=22.5 DEGREES CENTIGRADE

FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET

TIME	DEPTH	WTN	FT	1.0'	2.0'	3.0'	6.0'	9.0'	12.0'	15.0'	18.0'	21.0'
0.0	0-1	54.0	54.0	221.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	1-2	176.0	176.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	2-2	23.0	23.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	3-1	11.0	11.0	105.5	26.5	26.0	26.0	0.0	0.0	0.0	0.0	0.0
4.0	4-1	100.0	100.0	5.5	17.0	15.0	15.0	0.0	0.0	0.0	0.0	0.0
5.0	5-1	31.0	31.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	6-1	70.5	70.5	116.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	7-1	69.0	69.0	121.0	38.0	38.0	38.0	0.0	0.0	0.0	0.0	0.0
8.0	8-1	58.5	58.5	20.5	21.0	21.0	21.0	0.0	0.0	0.0	0.0	0.0
9.0	9-1	4.0	4.0	0.0	0.0	0.0	0.0	12.0	0.0	0.0	0.0	0.0
10.0	10-1	83.0	83.0	72.5	55.0	48.5	48.5	11.0	0.0	0.0	0.0	0.0
11.0	11-2	84.0	84.0	58.0	75.0	39.0	39.0	0.0	0.0	0.0	0.0	0.0
12.0	12-2	35.0	35.0	16.0	7.0	7.0	7.0	0.0	0.0	0.0	0.0	0.0
13.0	13-1	2.0	2.0	78.0	2.0	64.5	57.0	33.0	1.0	0.0	0.0	0.0
14.0	14-1	105.0	105.0	72.0	74.0	51.0	51.0	1.0	0.0	0.0	0.0	0.0
15.0	15-2	172.5	172.5	62.5	72.0	27.0	27.0	0.0	0.0	0.0	0.0	0.0
16.0	16-2	34.0	34.0	12.5	17.0	14.0	14.0	0.0	0.0	0.0	0.0	0.0
17.0	17-1	1.0	1.0	65.0	65.0	50.0	50.0	29.0	14.0	0.0	0.0	0.0
18.0	18-1	86.0	86.0	64.0	64.0	52.0	52.0	15.0	11.0	0.0	0.0	0.0
19.0	19-2	30.0	30.0	22.0	40.0	16.0	16.0	5.0	0.0	0.0	0.0	0.0
20.0	20-1	32.0	32.0	4.0	59.0	44.0	44.0	1.0	0.0	0.0	0.0	0.0
21.0	21-1	71.0	71.0	59.0	63.0	55.0	55.0	28.0	27.0	5.0	0.0	0.0
22.0	22-1	73.0	73.0	67.0	24.0	27.0	27.0	14.0	24.0	0.0	0.0	0.0
23.0	23-1	40.0	40.0	5.0	6.0	9.0	9.0	25.0	23.0	0.0	0.0	0.0
24.0	24-1	9.0	9.0	52.0	56.0	36.0	36.0	1.0	0.0	0.0	0.0	0.0
25.0	25-1	67.0	67.0	52.0	62.0	49.0	49.0	27.0	27.0	1.0	0.0	0.0
26.0	26-1	74.0	74.0	27.0	27.0	19.0	19.0	29.0	27.0	0.0	0.0	0.0
27.0	27-1	38.0	38.0	27.0	27.0	13.0	13.0	3.0	2.0	0.0	0.0	0.0

SMT: SMOOTHED VALUE

OBS: OBSERVED VALUE

TABLE A-6--EXPERIMENTAL OBSERVATIONS OF TEST NO. 5

TEMPERATURE OF SAMPLES DURING ANALYSIS=24.0 DEGREES CENTIGRADE

FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET

TIME	DEPTH	0.0		3.0		6.0		9.0		12.0		15.0		18.0		
		U.S.	S.M.T.	OBS.	S.M.T.	OBS.	S.M.T.	OBS.	S.M.T.	OBS.	S.M.T.	OBS.	S.M.T.	OBS.	S.M.T.	OBS.
0.0	0-1	525.0	525.0	382.5	382.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	491.0	491.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	19.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	0-1	392.5	435.0	235.0	334.0	235.0	334.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	202.5	220.0	60.0	112.0	60.0	112.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	12.0	22.0	0.0	4.2	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	0.0	0.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	0-1	322.0	322.0	191.5	210.0	164.0	164.0	9.5	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	205.5	187.0	150.0	152.0	85.0	85.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	217.5	193.0	97.5	152.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	0.0	0.0	5.5	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	0-1	245.0	224.0	86.5	186.0	94.0	94.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	77.5	170.0	86.5	139.0	121.0	121.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	126.0	189.0	7.5	51.0	9.0	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0	0-1	127.5	188.0	168.5	170.0	84.0	84.0	39.0	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	105.0	159.0	176.5	139.0	129.0	129.0	12.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	0.0	177.0	29.0	149.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	0.0	0.0	1.5	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.0	0-1	161.5	166.0	82.5	157.0	82.5	82.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	170.5	151.0	165.0	137.0	136.0	136.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	45.0	64.0	60.0	48.0	60.0	48.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.0	0-1	165.0	153.0	142.5	147.0	82.0	82.0	18.0	21.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	180.0	145.0	179.5	134.0	140.0	140.0	102.0	77.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	10.0	53.0	8.0	46.0	0.0	0.0	5.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0	0-1	120.0	142.0	60.0	137.0	81.0	81.0	40.0	22.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	161.0	139.0	116.5	129.0	116.5	141.0	50.5	92.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	22.0	44.0	15.0	45.0	0.0	49.0	0.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	0.0	2.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OBS: OBSERVED VALUE

SMT: SMOOTHED VALUE

TABLE A- 6.--CONTINUED

TIME DEPTH MIN FT	FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET													
	0.0		3.0		6.0		9.0		12.0		15.0		18.0	
	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
34.0	0-1	97.5	69.0	0	82.5	79.0	39.0	0	28.0	24.0	0	23.0	1.0	0
	1-2	71.0	79.0	0	97.5	108.0	92.0	0	80.0	106.0	0	13.0	1.0	0
	2-3	20.0	29.0	0	26.5	32.0	23.0	0	4.0	7.0	0	2.0	1.0	0
	3-4	1.5	4.0	0	4.0	4.0	6.0	0	7.0	5.0	0	3.0	1.0	0
36.0	0-1	79.5	54.0	0	101.5	79.0	39.5	0	39.5	26.0	0	3.0	1.0	0
	1-2	46.5	76.0	0	35.0	105.0	90.0	0	100.0	107.0	0	9.0	1.0	0
	2-3	41.5	27.0	0	21.5	31.0	21.5	0	11.5	26.0	0	3.0	1.0	0
	3-4	6.5	3.0	0	0.0	3.0	5.0	0	5.0	5.0	0	1.0	1.0	0
38.0	0-1	77.5	46.0	0	67.5	78.0	42.0	0	24.0	28.0	0	3.0	1.0	0
	1-2	37.5	74.0	0	64.0	101.0	88.0	0	105.0	97.0	0	13.0	1.0	0
	2-3	15.5	24.0	0	34.0	29.0	15.0	0	1.0	4.0	0	3.0	1.0	0
	3-4	0.5	3.0	0	0.0	3.0	4.0	0	1.0	7.0	0	3.0	1.0	0
40.0	0-1	75.5	72.0	0	85.5	78.0	47.0	0	43.0	31.0	0	3.0	1.0	0
	1-2	63.5	72.0	0	54.0	97.0	87.0	0	71.0	93.0	0	2.0	1.0	0
	2-3	2.5	2.0	0	2.0	27.0	1.0	0	1.0	3.0	0	3.0	1.0	0
	3-4	2.5	3.0	0	2.0	3.0	3.0	0	3.0	3.0	0	3.0	1.0	0
42.0	0-1	93.0	36.0	0	94.0	77.0	47.0	0	38.0	38.0	0	3.0	1.0	0
	1-2	32.0	70.0	0	112.5	94.0	86.0	0	84.0	89.0	0	7.0	1.0	0
	2-3	2.0	2.0	0	130.0	23.0	19.0	0	6.0	3.0	0	3.0	1.0	0
	3-4	0.5	3.0	0	4.0	3.0	3.0	0	2.0	6.0	0	3.0	1.0	0
44.0	0-1	38.5	30.0	0	29.0	75.0	49.0	0	50.0	37.0	0	3.0	1.0	0
	1-2	18.0	68.0	0	95.0	89.0	86.0	0	93.0	86.0	0	7.0	1.0	0
	2-3	0.0	2.0	0	2.0	3.0	1.0	0	1.0	3.0	0	3.0	1.0	0
	3-4	0.5	3.0	0	3.0	3.0	3.0	0	3.0	3.0	0	3.0	1.0	0
46.0	0-1	52.0	24.0	0	71.0	74.0	52.0	0	45.5	47.0	0	3.0	1.0	0
	1-2	45.0	66.0	0	75.0	86.0	85.0	0	83.5	77.0	0	7.0	1.0	0
	2-3	10.0	21.0	0	15.0	21.0	16.0	0	5.0	2.0	0	3.0	1.0	0
	3-4	0.0	3.0	0	0.0	3.0	3.0	0	2.0	6.0	0	3.0	1.0	0
48.0	0-1	49.0	19.0	0	18.5	73.0	54.0	0	59.0	43.0	0	4.0	1.0	0
	1-2	21.0	65.0	0	99.0	84.0	85.0	0	86.0	71.0	0	6.0	1.0	0
	2-3	21.0	20.0	0	20.0	19.0	16.0	0	20.0	16.0	0	4.0	1.0	0
	3-4	0.0	2.0	0	1.0	2.0	1.5	0	2.0	2.0	0	4.0	1.0	0
50.0	0-1	68.0	68.0	0	68.0	19.0	42.0	0	42.0	48.5	0	2.0	0.5	0
	1-2	79.0	79.0	0	79.0	79.0	79.0	0	79.0	79.0	0	79.0	0.5	0
	2-3	15.0	15.0	0	15.0	15.0	15.0	0	15.0	15.0	0	15.0	0.5	0
	3-4	4.0	4.0	0	4.0	4.0	4.0	0	4.0	4.0	0	4.0	0.5	0

TABLE A- 7.--EXPERIMENTAL OBSERVATIONS OF TEST NO. 6

TEMPERATURE OF SAMPLES DURING ANALYSIS=21.0 DEGREES CENTIGRADE

FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET

TIME MIN	DEPTH FT	0.0		4.0		8.0		12.0		16.0		20.0	
		OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
0.0	1-1	732.0	732.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	1-2	103.0	102.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	2-2	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	1-1	22.0	22.0	128.0	128.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
2.0	1-2	1.5	1.5	0.5	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2.0	2-4	1.0	1.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
4.0	1-1	85.0	85.0	62.0	62.0	81.0	81.0	81.0	81.0	81.0	81.0	81.0	81.0
4.0	1-2	56.0	56.0	18.0	18.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0
4.0	2-2	37.0	37.0	22.0	22.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0
6.0	1-1	17.0	17.0	30.0	30.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0
6.0	1-2	44.0	44.0	22.0	22.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
6.0	2-2	1.0	1.0	16.0	16.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
8.0	1-1	46.0	46.0	41.0	41.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
8.0	1-2	47.0	47.0	13.0	13.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
8.0	2-2	33.0	33.0	3.0	3.0	49.0	49.0	49.0	49.0	49.0	49.0	49.0	49.0
10.0	1-1	45.0	45.0	14.0	14.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
10.0	1-2	45.0	45.0	32.0	32.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0
10.0	2-2	42.0	42.0	4.0	4.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
12.0	1-1	42.0	42.0	37.0	37.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
12.0	1-2	43.0	43.0	19.0	19.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0
12.0	2-2	43.0	43.0	25.0	25.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0
14.0	1-1	41.0	41.0	28.0	28.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
14.0	1-2	41.0	41.0	30.0	30.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
14.0	2-2	44.0	44.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0

OBS: OBSERVED VALUE SMT: SMOOTHED VALUE

TABLE A-7.--CONTINUED

TIME DEPTH MIN FT	1.0		4.0		8.0		12.0		16.0		20.0	
	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
16.0 0-1	47.0	45.0	35.0	31.0	26.0	29.0	7.5	15.0	7.0	8.0	7.0	7.0
17.0 1-2	41.0	43.0	43.0	39.0	25.0	23.0	4.5	27.0	18.5	7.0	18.5	8.0
18.0 2-3	47.0	42.0	40.0	38.0	18.0	24.0	2.0	23.0	22.5	12.0	19.0	7.0
19.0 3-4	45.0	42.0	38.0	33.0	19.0	35.0	5.0	26.0	19.0	7.0	9.0	9.0
20.0 4-5	47.0	44.0	35.0	33.0	24.0	26.0	5.0	24.0	14.5	12.0	13.5	9.0
21.0 5-6	46.0	42.0	11.0	33.0	9.0	27.0	5.0	23.0	13.5	7.0	11.0	10.0
22.0 6-7	41.0	44.0	15.0	40.0	17.0	28.0	5.0	26.0	11.5	10.0	11.0	11.0
23.0 7-8	45.0	41.0	38.0	38.0	27.0	31.0	5.0	22.0	11.5	10.0	11.0	11.0
24.0 8-9	47.0	45.0	17.0	31.0	29.0	29.0	5.0	25.0	9.0	12.0	11.0	10.0
25.0 9-10	47.0	43.0	46.0	40.0	14.0	30.0	5.0	27.0	8.0	11.0	10.0	10.0
26.0 10-11	42.0	41.0	27.0	32.0	21.0	32.0	5.0	25.0	8.0	12.0	10.0	10.0
27.0 11-12	45.0	42.0	48.0	37.0	30.0	32.0	5.0	27.0	9.5	13.0	10.0	10.0
28.0 12-13	44.0	41.0	36.0	33.0	20.0	28.0	5.0	25.0	6.5	13.0	11.0	11.0
29.0 13-14	41.0	42.0	40.0	39.0	22.0	32.0	5.0	28.0	11.0	13.0	11.0	11.0
30.0 14-15	41.0	40.0	35.0	32.0	20.0	32.0	5.0	27.0	16.5	13.0	11.0	11.0
31.0 15-16	36.0	40.0	30.0	37.0	22.0	35.0	5.0	27.0	10.5	13.0	11.0	11.0
32.0 16-17	37.0	39.0	34.0	36.0	24.0	32.0	5.0	29.0	17.5	13.0	11.0	11.0
33.0 17-18	38.0	40.0	30.0	33.0	23.0	35.0	5.0	27.0	22.5	13.0	11.0	11.0
34.0 18-19	37.0	44.0	36.0	32.0	21.0	34.0	5.0	27.0	13.0	11.0	11.0	11.0
35.0 19-20	37.0	42.0	36.0	33.0	23.0	34.0	5.0	27.0	13.0	11.0	11.0	11.0

TABLE A- 7.--CONTINUED

TIME MIN	DEPTH FT	FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET											
		0.0		4.0		8.0		12.0		16.0		20.0	
		OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
24.0	0-1	42.0	43.0	38.0	30.0	25.0	24.0	14.0	19.0	15.0	4.0	18.0	0.0
	1-2	44.0	38.0	30.0	32.0	22.0	27.0	24.0	21.0	10.0	11.0	11.0	0.0
	2-4	36.0	36.0	31.0	37.0	31.0	34.0	28.0	29.0	9.0	14.0	14.0	0.0
36.0	0-1	46.0	42.0	34.0	31.0	35.0	26.0	39.0	21.0	31.0	11.0	12.0	0.0
	1-2	46.0	37.0	34.0	35.0	22.0	30.0	37.0	23.0	19.0	11.0	11.0	0.0
	2-4	31.0	34.0	30.0	37.0	27.0	32.0	19.0	21.0	15.0	14.0	14.0	0.0
38.0	0-1	47.0	34.0	37.0	31.0	27.0	26.0	35.0	23.0	19.0	11.0	13.0	0.0
	1-2	37.0	37.0	34.0	36.0	24.0	32.0	34.0	22.0	17.0	11.0	11.0	0.0
	2-4	32.0	34.0	37.0	36.0	23.0	33.0	32.0	21.0	15.0	11.0	11.0	0.0
40.0	0-1	40.0	37.0	39.0	35.0	29.0	25.0	47.0	21.0	14.0	11.0	11.0	0.0
	1-2	40.0	37.0	38.0	35.0	23.0	32.0	34.0	22.0	16.0	11.0	11.0	0.0
	2-4	40.0	37.0	37.0	35.0	21.0	33.0	32.0	21.0	14.0	11.0	11.0	0.0
42.0	0-1	40.0	37.0	35.0	39.0	28.0	23.0	38.0	21.0	18.0	11.0	11.0	0.0
	1-2	40.0	37.0	35.0	35.0	24.0	32.0	32.0	22.0	18.0	11.0	11.0	0.0
	2-4	40.0	37.0	35.0	35.0	20.0	32.0	32.0	22.0	18.0	11.0	11.0	0.0
44.0	0-1	46.0	37.0	36.0	36.0	22.0	23.0	32.0	21.0	19.0	11.0	11.0	0.0
	1-2	46.0	37.0	36.0	36.0	22.0	23.0	32.0	21.0	19.0	11.0	11.0	0.0
	2-4	41.0	37.0	36.0	36.0	22.0	23.0	32.0	21.0	19.0	11.0	11.0	0.0
46.0	0-1	39.0	37.0	36.0	35.0	23.0	23.0	34.0	21.0	16.0	11.0	11.0	0.0
	1-2	38.0	37.0	36.0	35.0	22.0	23.0	34.0	21.0	16.0	11.0	11.0	0.0
	2-4	38.0	37.0	36.0	35.0	22.0	23.0	34.0	21.0	16.0	11.0	11.0	0.0
48.0	0-1	38.0	37.0	36.0	35.0	24.0	23.0	34.0	21.0	16.0	11.0	11.0	0.0
	1-2	38.0	37.0	36.0	35.0	24.0	23.0	34.0	21.0	16.0	11.0	11.0	0.0
	2-4	38.0	37.0	36.0	35.0	24.0	23.0	34.0	21.0	16.0	11.0	11.0	0.0

TABLE A-8--EXPERIMENTAL OBSERVATIONS OF TEST NO. 7

TEMPERATURE OF SAMPLES DURING ANALYSIS=28.0 DEGREES CENTIGRADE

FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET

TIME DEPTH MIN	FT	0.0		4.0		8.0		12.0		16.0		20.0	
		OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
1	1	722.0	722.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	2	240.0	240.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	1	232.0	232.0	214.0	214.0	4.5	6.0	2.0	1.0	1.0	0.0	0.0	0.0
3	2	58.0	58.0	97.0	97.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
3	3	1.0	2.0	2.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	4	1.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	1	64.0	85.0	82.0	92.0	57.5	58.0	7.5	13.0	13.0	0.0	0.0	0.0
4	2	65.0	81.0	62.0	77.0	9.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0
4	3	14.0	5.0	10.0	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	4	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	1	70.0	78.0	86.0	72.0	67.0	65.0	48.5	42.0	42.0	1.0	3.0	3.0
5	2	80.0	70.0	73.0	62.0	36.0	34.0	1.0	1.0	1.0	0.0	0.0	0.0
5	3	16.0	18.0	17.0	14.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
5	4	1.0	1.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	1	82.0	72.0	80.0	64.0	62.0	62.0	46.0	46.0	50.0	0.0	0.0	0.0
6	2	56.0	63.0	53.0	50.0	46.0	45.0	0.0	0.0	0.0	0.0	0.0	0.0
6	3	24.0	26.0	1.0	1.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
6	4	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	1	69.0	68.0	52.0	58.0	48.0	55.0	53.0	49.0	49.0	26.0	21.0	21.0
7	2	54.0	59.0	34.0	40.0	44.0	44.0	15.0	22.0	22.0	0.0	0.0	0.0
7	3	2.0	2.0	2.0	2.0	7.0	7.0	1.0	2.0	2.0	0.0	0.0	0.0
7	4	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	1	66.0	65.0	58.0	55.0	46.0	49.0	48.0	43.0	43.0	0.0	0.0	0.0
8	2	36.0	33.0	33.0	34.0	42.0	42.0	2.0	25.0	25.0	0.0	0.0	0.0
8	3	30.0	32.0	23.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	4	61.0	64.0	45.0	52.0	45.0	45.0	31.0	38.0	38.0	28.0	28.0	28.0
9	1	57.0	54.0	38.0	44.0	39.0	41.0	10.0	27.0	27.0	5.0	5.0	5.0
9	2	40.0	42.0	22.0	27.0	13.0	11.0	1.0	2.0	2.0	0.0	0.0	0.0
9	3	13.0	16.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OBS: OBSERVED VALUE

SMT: SMOOTHED VALUE

TABLE A- 8.--CONTINUED

TIME MIN	DEPTH FT	FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET											
		0.0		4.0		8.0		12.0		16.0		20.0	
		OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
16.0	0-1	57.0	62.0	50.5	51.0	43.0	42.0	35.5	34.0	34.0	34.0	9.5	10.0
	1-2	56.5	52.5	31.0	31.0	37.5	40.0	29.5	24.0	24.0	24.0	4.5	14.0
	2-4	27.0	48.0	29.0	27.0	15.5	14.0	9.5	9.0	4.0	5.0	0.5	1.0
18.0	0-1	49.0	62.0	50.5	30.0	40.0	39.0	31.0	31.0	31.0	31.0	17.0	16.0
	1-2	46.5	41.0	21.0	30.0	15.5	15.0	9.5	10.0	6.0	5.0	0.0	2.0
	2-4	13.0	12.0	13.0	9.0	37.5	40.0	26.0	27.0	20.0	20.0	15.5	17.0
20.0	0-1	44.5	49.0	35.0	30.0	33.0	35.0	24.0	18.0	18.0	18.0	3.5	4.0
	1-2	44.5	49.0	35.0	30.0	33.0	35.0	24.0	18.0	18.0	18.0	3.5	4.0
	2-4	14.5	11.0	17.0	18.0	40.0	39.0	28.0	25.0	25.0	25.0	17.0	16.0
22.0	0-1	45.0	50.0	31.0	33.0	37.5	37.0	28.0	23.0	23.0	23.0	11.0	11.0
	1-2	46.0	50.0	31.0	33.0	37.5	37.0	28.0	23.0	23.0	23.0	11.0	11.0
	2-4	15.0	15.0	15.0	17.0	37.5	39.0	28.0	23.0	23.0	23.0	11.0	11.0
24.0	0-1	50.0	51.0	44.0	47.0	37.5	36.0	33.0	31.0	31.0	31.0	18.0	18.0
	1-2	50.0	51.0	44.0	47.0	37.5	36.0	33.0	31.0	31.0	31.0	18.0	18.0
	2-4	15.0	18.0	17.0	18.0	37.5	36.0	33.0	31.0	31.0	31.0	18.0	18.0
26.0	0-1	59.0	64.0	47.0	50.0	40.0	38.0	36.0	33.0	33.0	33.0	26.0	26.0
	1-2	59.0	64.0	47.0	50.0	40.0	38.0	36.0	33.0	33.0	33.0	26.0	26.0
	2-4	11.0	18.0	17.0	18.0	40.0	38.0	36.0	33.0	33.0	33.0	26.0	26.0
28.0	0-1	41.0	52.0	33.0	35.0	33.0	35.0	28.0	27.0	27.0	27.0	20.5	19.0
	1-2	42.0	52.0	33.0	35.0	33.0	35.0	28.0	27.0	27.0	27.0	20.5	19.0
	2-4	11.0	17.0	15.0	16.0	33.0	35.0	28.0	27.0	27.0	27.0	20.5	19.0
30.0	0-1	55.0	57.0	47.0	47.0	34.0	37.0	31.0	30.0	30.0	30.0	28.5	27.0
	1-2	55.0	57.0	47.0	47.0	34.0	37.0	31.0	30.0	30.0	30.0	28.5	27.0
	2-4	11.0	17.0	15.0	16.0	34.0	37.0	31.0	30.0	30.0	30.0	28.5	27.0
32.0	0-1	33.0	44.0	25.0	25.0	34.0	33.0	28.0	28.0	28.0	28.0	17.0	19.0
	1-2	33.0	44.0	25.0	25.0	34.0	33.0	28.0	28.0	28.0	28.0	17.0	19.0
	2-4	11.0	17.0	15.0	16.0	34.0	33.0	28.0	28.0	28.0	28.0	17.0	19.0

TABLE A-8---CONTINUED

TIME DEPTH MIN FT	FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET											
	0.0	4.0	8.0	12.0	16.0	20.0	0.0	4.0	8.0	12.0	16.0	20.0
34.0	57.0	45.0	35.0	19.0	18.0	18.0	42.0	45.0	37.0	19.0	16.5	18.0
34.0	44.0	30.0	33.0	15.0	13.5	13.0	33.0	31.0	32.0	15.0	16.0	12.0
34.0	49.0	32.0	14.0	14.0	11.5	11.0	44.0	30.0	11.0	12.0	14.0	14.0
36.0	43.0	25.0	36.0	15.0	13.0	13.0	27.0	32.0	14.0	14.0	10.5	18.0
36.0	48.0	25.0	18.0	13.0	11.0	11.0	26.0	11.0	11.0	13.0	10.5	10.5
38.0	43.0	25.0	41.0	22.0	18.0	17.0	32.0	31.0	10.0	14.0	17.0	10.5
38.0	47.0	25.0	29.0	18.0	16.0	16.0	37.0	36.0	10.0	14.0	14.0	10.5
40.0	47.0	25.0	39.0	16.0	14.0	14.0	32.0	33.0	10.0	16.0	17.0	10.5
40.0	47.0	25.0	10.0	10.0	10.0	10.0	39.0	39.0	10.0	16.0	17.0	10.5
42.0	49.0	25.0	10.0	10.0	10.0	10.0	34.0	36.0	10.0	16.0	17.0	10.5
42.0	43.0	25.0	39.0	12.0	11.0	11.0	33.0	30.0	10.0	16.0	17.0	10.5
44.0	46.0	25.0	43.0	10.0	9.0	9.0	42.0	38.0	10.0	16.0	17.0	10.5
44.0	41.0	25.0	22.0	10.0	9.0	9.0	42.0	35.0	10.0	16.0	17.0	10.5
46.0	43.0	25.0	45.0	10.0	9.0	9.0	42.0	38.0	10.0	16.0	17.0	10.5
46.0	47.0	25.0	31.0	10.0	9.0	9.0	43.0	35.0	10.0	16.0	17.0	10.5
48.0	40.0	25.0	47.0	10.0	9.0	9.0	42.0	32.0	10.0	16.0	17.0	10.5
48.0	48.0	25.0	41.0	10.0	9.0	9.0	42.0	35.0	10.0	16.0	17.0	10.5
48.0	42.0	25.0	42.0	10.0	9.0	9.0	42.0	32.0	10.0	16.0	17.0	10.5
48.0	41.0	25.0	42.0	10.0	9.0	9.0	42.0	32.0	10.0	16.0	17.0	10.5

TABLE A- 9.---EXPERIMENTAL OBSERVATIONS OF TEST NO. 8

TEMPERATURE OF SAMPLES DURING ANALYSIS=22.0 DEGREES CENTIGRADE

FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET

TIME DEPTH	0.0		4.0		8.0		12.0		16.0		20.0	
	MIN	FT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
0.0	0-1	712.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	251.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	0-1	221.5	234.0	234.0	6.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	67.0	83.5	83.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	1.0	4.0	3.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	0-1	740.0	106.0	98.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	99.0	79.0	78.0	17.5	24.0	30.5	31.0	0.0	0.0	0.0	0.0
	2-3	14.5	10.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	0-1	112.5	79.0	82.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	166.5	66.5	69.0	4.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	18.0	18.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0	0-1	57.0	81.0	75.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	84.5	62.5	61.0	4.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	34.0	14.0	13.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.0	0-1	85.0	61.0	65.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	24.5	50.0	54.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	2.5	12.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.0	0-1	69.0	61.0	67.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	47.0	38.0	37.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0	0-1	75.0	55.0	55.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	53.0	44.0	36.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	34.0	11.0	19.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	6.0	0.0	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OBS: OBSERVED VALUE SMT: SMOOTHED VALUE

TABLE A- 9. ---CONTINUED

TIME	DEPTH		0.0		4.0		8.0		12.0		16.0		20.0	
	MIN	FT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
16.0	0-1	66.0	68.0	57.0	54.0	55.0	57.0	54.0	55.0	27.0	32.0	12.0	11.0	11.0
	1-2	62.0	56.0	40.0	27.0	16.0	40.0	16.0	32.0	27.8	16.0	13.0	10.5	15.0
18.0	1-2	62.0	48.0	12.0	1.0	0.0	9.0	1.0	0.0	25.0	1.0	1.0	0.0	1.0
	1-2	68.0	64.0	45.0	38.0	21.0	58.0	21.0	45.0	25.6	31.2	12.0	11.0	12.0
	1-2	64.0	64.0	32.0	19.0	6.0	31.0	6.0	19.0	33.0	28.0	13.0	10.0	13.0
20.0	1-2	62.0	64.0	21.0	16.0	5.0	37.0	5.0	16.0	34.0	29.0	13.0	11.0	13.0
	1-2	63.0	63.0	15.0	12.0	0.0	33.0	0.0	12.0	31.5	26.0	10.0	9.0	10.0
	1-2	65.0	65.0	9.0	7.0	0.0	29.0	0.0	7.0	22.0	17.0	10.0	9.0	10.0
22.0	1-2	64.0	62.0	5.0	3.0	0.0	25.0	0.0	3.0	21.5	15.0	10.0	9.0	10.0
	1-2	65.0	65.0	0.0	0.0	0.0	23.0	0.0	0.0	22.0	14.0	10.0	9.0	10.0
	1-2	64.0	64.0	0.0	0.0	0.0	21.0	0.0	0.0	21.7	11.0	10.0	9.0	10.0
24.0	1-2	63.0	63.0	1.0	1.0	0.0	23.0	0.0	1.0	22.0	11.0	10.0	9.0	10.0
	1-2	63.0	63.0	1.0	1.0	0.0	21.0	0.0	1.0	21.9	10.0	10.0	9.0	10.0
	1-2	65.0	65.0	1.0	1.0	0.0	19.0	0.0	1.0	21.0	9.0	10.0	9.0	10.0
26.0	1-2	65.0	65.0	1.0	1.0	0.0	17.0	0.0	1.0	21.0	8.0	10.0	9.0	10.0
	1-2	65.0	65.0	1.0	1.0	0.0	15.0	0.0	1.0	21.0	7.0	10.0	9.0	10.0
	1-2	65.0	65.0	1.0	1.0	0.0	13.0	0.0	1.0	21.0	6.0	10.0	9.0	10.0
28.0	1-2	66.0	66.0	1.0	1.0	0.0	11.0	0.0	1.0	21.0	5.0	10.0	9.0	10.0
	1-2	66.0	66.0	1.0	1.0	0.0	9.0	0.0	1.0	21.0	4.0	10.0	9.0	10.0
	1-2	66.0	66.0	1.0	1.0	0.0	7.0	0.0	1.0	21.0	3.0	10.0	9.0	10.0
30.0	1-2	67.0	67.0	1.0	1.0	0.0	5.0	0.0	1.0	21.0	2.0	10.0	9.0	10.0
	1-2	67.0	67.0	1.0	1.0	0.0	3.0	0.0	1.0	21.0	1.0	10.0	9.0	10.0
	1-2	67.0	67.0	1.0	1.0	0.0	1.0	0.0	1.0	21.0	0.0	10.0	9.0	10.0
32.0	1-2	67.0	67.0	1.0	1.0	0.0	0.0	0.0	1.0	21.0	0.0	10.0	9.0	10.0
	1-2	67.0	67.0	1.0	1.0	0.0	0.0	0.0	1.0	21.0	0.0	10.0	9.0	10.0
	1-2	67.0	67.0	1.0	1.0	0.0	0.0	0.0	1.0	21.0	0.0	10.0	9.0	10.0

TABLE A-9.--CONTINUED

TIME	DEPTH	FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET											
		0.0		4.0		8.0		12.0		16.0		20.0	
MIN	FT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
34.0	0-1	60.0	58.0	49.0	49.0	40.0	43.0	50.0	43.0	18.5	20.0	18.5	17.0
	1-2	50.0	44.0	44.0	30.0	29.0	28.0	23.0	18.0	15.0	13.0	12.0	11.0
	2-3	46.0	44.0	44.0	40.0	30.0	28.0	23.0	18.0	15.0	13.0	12.0	11.0
36.0	0-1	51.0	49.0	44.0	40.0	30.0	28.0	23.0	18.0	15.0	13.0	12.0	11.0
	1-2	46.0	44.0	44.0	40.0	30.0	28.0	23.0	18.0	15.0	13.0	12.0	11.0
	2-3	47.0	43.0	43.0	30.0	29.0	27.0	22.0	17.0	14.0	13.0	12.0	11.0
38.0	0-1	58.0	47.0	43.0	40.0	30.0	28.0	23.0	18.0	15.0	13.0	12.0	11.0
	1-2	44.0	43.0	43.0	30.0	29.0	27.0	22.0	17.0	14.0	13.0	12.0	11.0
	2-3	44.0	43.0	43.0	30.0	29.0	27.0	22.0	17.0	14.0	13.0	12.0	11.0
40.0	0-1	49.0	43.0	43.0	30.0	29.0	27.0	22.0	17.0	14.0	13.0	12.0	11.0
	1-2	55.0	43.0	43.0	30.0	29.0	27.0	22.0	17.0	14.0	13.0	12.0	11.0
	2-3	50.0	43.0	43.0	30.0	29.0	27.0	22.0	17.0	14.0	13.0	12.0	11.0
42.0	0-1	48.0	43.0	43.0	30.0	29.0	27.0	22.0	17.0	14.0	13.0	12.0	11.0
	1-2	55.0	43.0	43.0	30.0	29.0	27.0	22.0	17.0	14.0	13.0	12.0	11.0
	2-3	48.0	43.0	43.0	30.0	29.0	27.0	22.0	17.0	14.0	13.0	12.0	11.0
44.0	0-1	41.0	43.0	43.0	30.0	29.0	27.0	22.0	17.0	14.0	13.0	12.0	11.0
	1-2	54.0	43.0	43.0	30.0	29.0	27.0	22.0	17.0	14.0	13.0	12.0	11.0
	2-3	41.0	43.0	43.0	30.0	29.0	27.0	22.0	17.0	14.0	13.0	12.0	11.0
46.0	0-1	67.0	43.0	43.0	30.0	29.0	27.0	22.0	17.0	14.0	13.0	12.0	11.0
	1-2	62.0	43.0	43.0	30.0	29.0	27.0	22.0	17.0	14.0	13.0	12.0	11.0
	2-3	64.0	43.0	43.0	30.0	29.0	27.0	22.0	17.0	14.0	13.0	12.0	11.0
48.0	0-1	66.0	43.0	43.0	30.0	29.0	27.0	22.0	17.0	14.0	13.0	12.0	11.0
	1-2	43.0	43.0	43.0	30.0	29.0	27.0	22.0	17.0	14.0	13.0	12.0	11.0
	2-3	47.0	43.0	43.0	30.0	29.0	27.0	22.0	17.0	14.0	13.0	12.0	11.0

TABLE A-10. -- EXPERIMENTAL OBSERVATIONS OF TEST NO. 9

TEMPERATURE OF SAMPLES DURING ANALYSIS=25.0 DEGREES CENTIGRADE		FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET											
TIME MIN	DEPTH FT	0.0		4.0		8.0		12.0		16.0		20.0	
		OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
0.0	0-1	686.0	686.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	228.0	228.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	0-1	217.0	247.0	247.0	13.0	12.5	13.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	57.0	109.0	109.0	13.0	10.5	11.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	1.0	2.0	7.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	0-1	56.0	90.0	0.5	66.0	66.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
	1-2	131.0	114.0	83.0	55.0	55.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0
	2-3	1.0	2.0	4.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-4	1.0	2.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	0-1	69.0	72.0	93.0	81.0	56.0	62.0	30.0	31.0	5.0	5.0	5.0	5.0
	1-2	105.0	100.0	83.0	77.0	59.0	57.0	27.0	27.0	5.0	5.0	5.0	5.0
	2-3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	3-4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
8.0	0-1	75.0	64.0	84.0	65.0	40.0	46.0	38.0	35.0	22.0	22.0	22.0	22.0
	1-2	69.0	89.0	72.0	69.0	46.0	50.0	34.0	34.0	1.0	1.0	1.0	1.0
	2-3	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	3-4	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
10.0	0-1	65.0	59.0	47.0	37.0	37.0	47.0	29.0	31.0	30.0	30.0	30.0	30.0
	1-2	76.0	82.0	52.0	41.0	41.0	41.0	31.0	33.0	1.0	1.0	1.0	1.0
	2-3	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	3-4	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
12.0	0-1	56.0	56.0	55.0	56.0	45.0	39.0	22.0	22.0	25.0	25.0	25.0	25.0
	1-2	73.0	77.0	35.0	32.0	32.0	31.0	16.0	16.0	16.0	16.0	16.0	16.0
	2-3	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	3-4	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
14.0	0-1	56.0	53.0	48.0	44.0	28.0	26.0	14.0	14.0	29.0	29.0	29.0	29.0
	1-2	76.0	73.0	51.0	41.0	37.0	35.0	22.0	22.0	17.0	17.0	17.0	17.0
	2-3	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	3-4	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0

OBS: OBSERVED VALUE

SMT: SMOOTHED VALUE

TABLE A-10. --CONTINUED

TIME DEPTH MIN FT	FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET											
	0.0	4.0	8.0	12.0	16.0	20.0	0.0	4.0	8.0	12.0	16.0	20.0
16.0	48.0	51.0	41.0	15.0	17.0	22.0	28.5	49.0	27.0	15.0	17.0	22.0
17.0	72.0	69.0	50.0	14.0	17.0	23.0	31.0	49.0	36.0	14.0	19.0	27.0
18.0	75.0	49.0	49.0	13.0	16.0	23.0	15.0	49.0	13.0	18.0	18.0	30.0
19.0	51.0	50.0	49.0	29.0	16.0	17.0	52.0	49.0	29.0	15.0	17.0	18.0
20.0	65.0	67.0	34.0	11.0	19.0	17.0	35.0	49.0	11.0	15.0	15.0	16.0
21.0	52.0	49.0	34.0	19.0	18.0	17.0	41.0	49.0	19.0	15.0	15.0	16.0
22.0	41.0	49.0	33.0	11.0	17.0	17.0	31.0	49.0	11.0	15.0	15.0	16.0
23.0	44.0	49.0	33.0	11.0	17.0	17.0	41.0	49.0	11.0	15.0	15.0	16.0
24.0	64.0	49.0	47.0	13.0	19.0	17.0	30.0	49.0	13.0	15.0	15.0	16.0
25.0	64.0	51.0	43.0	13.0	19.0	17.0	36.0	49.0	13.0	15.0	15.0	16.0
26.0	45.0	47.0	42.0	13.0	19.0	17.0	33.0	49.0	13.0	15.0	15.0	16.0
27.0	65.0	43.0	42.0	13.0	19.0	17.0	33.0	49.0	13.0	15.0	15.0	16.0
28.0	48.0	46.0	41.0	13.0	19.0	17.0	30.0	49.0	13.0	15.0	15.0	16.0
29.0	62.0	46.0	40.0	13.0	19.0	17.0	30.0	49.0	13.0	15.0	15.0	16.0
30.0	62.0	46.0	40.0	13.0	19.0	17.0	30.0	49.0	13.0	15.0	15.0	16.0
31.0	48.0	46.0	40.0	13.0	19.0	17.0	30.0	49.0	13.0	15.0	15.0	16.0
32.0	55.0	48.0	40.0	13.0	19.0	17.0	30.0	49.0	13.0	15.0	15.0	16.0
33.0	48.0	48.0	40.0	13.0	19.0	17.0	30.0	49.0	13.0	15.0	15.0	16.0
34.0	67.0	48.0	40.0	13.0	19.0	17.0	30.0	49.0	13.0	15.0	15.0	16.0

TABLE A-10.--CONTINUED

TIME MIN	DEPTH FT	FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET													
		0.0	4.0	8.0	12.0	16.0	20.0	OBS	SMT	OBS	SMT	OBS	SMT		
34.0	0-1	46.0	39.0	37.0	18.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	12.0	12.0
	1-2	54.0	47.0	47.0	16.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	11.8	11.8
	2-3	11.0	11.0	11.0	15.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	11.6	11.6
36.0	1-1	42.0	38.0	37.0	16.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	11.5	11.5
	2-3	56.0	49.0	47.0	17.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	12.8	12.8
	3-4	17.0	17.0	17.0	13.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	11.7	11.7
38.0	1-2	55.0	48.0	46.0	18.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	12.9	12.9
	2-3	45.0	42.0	41.0	14.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	12.3	12.3
	3-4	8.0	8.0	8.0	11.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	11.8	11.8
40.0	0-1	55.0	43.0	42.0	18.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	12.5	12.5
	1-2	53.0	43.0	42.0	16.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	11.8	11.8
	2-3	37.0	32.0	31.0	13.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	11.2	11.2
42.0	0-1	54.0	44.0	43.0	18.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	12.2	12.2
	1-2	57.0	47.0	46.0	16.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	11.7	11.7
	2-3	40.0	37.0	36.0	13.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	11.2	11.2
44.0	0-1	41.0	37.0	36.0	18.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	12.0	12.0
	1-2	50.0	42.0	41.0	16.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	11.7	11.7
	2-3	43.0	38.0	37.0	15.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	11.2	11.2
46.0	0-1	48.0	43.0	42.0	18.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	12.0	12.0
	1-2	53.0	46.0	45.0	16.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	11.6	11.6
	2-3	48.0	41.0	40.0	15.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	11.2	11.2
48.0	0-1	46.0	43.0	42.0	18.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	12.0	12.0
	1-2	53.0	46.0	45.0	16.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	11.6	11.6
	2-3	45.0	43.0	42.0	15.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	11.2	11.2

TABLE A-11.---EXPERIMENTAL OBSERVATIONS OF TEST NO.10
 TEMPERATURE OF SAMPLES DURING ANALYSIS=23.0 DEGREES CENTIGRADE

TIME DEPTH MIN	FT	FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET											
		0.0		4.0		8.0		12.0		16.0		20.0	
		OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
0.0	1-1	686.0	686.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	244.0	244.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	1-1	304.0	304.0	176.0	176.0	34.0	34.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-2	127.0	127.0	103.0	103.0	2.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-3	3.0	3.0	17.0	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-4	7.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	1-1	80.0	80.0	54.0	54.0	105.0	105.0	3.0	3.0	3.0	3.0	3.0	3.0
	1-2	30.0	30.0	77.0	77.0	12.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-3	7.0	7.0	18.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-4	9.0	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	1-1	86.0	86.0	39.0	39.0	91.0	91.0	5.0	5.0	5.0	5.0	5.0	5.0
	1-2	58.0	58.0	35.0	35.0	38.0	38.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-3	15.0	15.0	5.0	5.0	2.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-4	78.0	78.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0	1-1	69.0	69.0	5.0	5.0	20.0	20.0	4.0	4.0	4.0	4.0	4.0	4.0
	1-2	32.0	32.0	3.0	3.0	4.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-3	24.0	24.0	14.0	14.0	2.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-4	65.0	65.0	4.0	4.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
10.0	1-1	74.0	74.0	6.0	6.0	4.0	4.0	2.0	2.0	2.0	2.0	2.0	2.0
	1-2	24.0	24.0	5.0	5.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-3	65.0	65.0	3.0	3.0	7.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-4	47.0	47.0	2.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.0	1-1	77.0	77.0	5.0	5.0	4.0	4.0	2.0	2.0	2.0	2.0	2.0	2.0
	1-2	74.0	74.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-3	67.0	67.0	5.0	5.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-4	57.0	57.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0	1-1	64.0	64.0	4.0	4.0	4.0	4.0	1.0	1.0	1.0	1.0	1.0	1.0
	1-2	65.0	65.0	4.0	4.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-3	6.0	6.0	4.0	4.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-4	6.0	6.0	4.0	4.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0

OBS: OBSERVED VALUE SMT: SMOOTHED VALUE

TABLE A-11.--CONTINUED

TIME DEPTH MIN FT	FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET											
	0.0		4.0		8.0		12.0		16.0		20.0	
	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
16.0	51.0	56.0	41.0	42.0	30.0	32.0	21.0	20.0	25.0	14.5	13.0	0.0
17.0	56.0	57.0	35.0	45.0	17.0	14.0	14.0	12.0	16.0	4.0	0.0	0.0
18.0	66.0	65.0	38.0	41.0	19.0	12.0	21.0	20.0	21.0	0.0	0.0	0.0
19.0	46.0	51.0	32.0	42.0	37.0	19.0	18.0	17.0	17.0	7.0	15.0	0.0
20.0	75.0	54.0	38.0	42.0	19.0	16.0	21.0	20.0	18.0	3.0	2.0	0.0
21.0	69.0	57.0	43.0	43.0	25.0	17.0	11.0	14.0	11.0	1.0	0.0	0.0
22.0	67.0	54.0	46.0	43.0	16.0	13.0	11.0	11.0	12.0	5.0	15.0	0.0
23.0	43.0	48.0	66.0	53.0	22.0	19.0	11.0	11.0	15.0	9.0	4.0	0.0
24.0	66.0	47.0	75.0	39.0	27.0	18.0	11.0	11.0	15.0	5.0	4.0	0.0
25.0	45.0	45.0	37.0	37.0	19.0	12.0	11.0	11.0	12.0	3.0	18.0	0.0
26.0	68.0	45.0	60.0	35.0	15.0	11.0	11.0	11.0	11.0	6.0	4.0	0.0
27.0	31.0	46.0	42.0	38.0	30.0	17.0	11.0	11.0	11.0	1.0	3.0	0.0
28.0	66.0	33.0	44.0	35.0	14.0	11.0	11.0	11.0	11.0	5.0	10.0	0.0
29.0	36.0	39.0	35.0	47.0	12.0	11.0	11.0	11.0	11.0	8.0	3.0	0.0
30.0	51.0	33.0	35.0	44.0	27.0	11.0	11.0	11.0	11.0	5.0	5.0	0.0
31.0	38.0	36.0	32.0	34.0	17.0	11.0	11.0	11.0	11.0	8.0	0.0	0.0
32.0	45.0	34.0	43.0	31.0	11.0	11.0	11.0	11.0	11.0	5.0	0.0	0.0
33.0	42.0	33.0	24.0	33.0	11.0	11.0	11.0	11.0	11.0	8.0	0.0	0.0

TABLE A-11.--CONTINUED

TIME MIN	DEPTH FT	FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET											
		0.0		4.0		8.0		12.0		16.0		20.0	
		OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
34.0	0-1	28.5	32.0	30.0	35.0	0.0	9.0	5.5	9.0	11.0	13.0	12.0	14.0
	1-2	32.0	32.0	26.0	33.0	0.0	13.0	11.0	13.0	11.0	12.0	11.0	12.0
	2-3	29.0	44.0	36.0	34.0	0.0	9.0	7.5	11.0	11.0	13.0	11.0	12.0
36.0	0-1	34.0	41.0	33.0	34.0	0.0	12.0	10.0	13.0	11.0	12.0	11.0	12.0
	1-2	36.0	32.0	31.0	32.0	0.0	19.0	13.0	13.0	11.0	12.0	11.0	12.0
	2-3	37.0	34.0	28.0	31.0	0.0	16.0	12.0	13.0	11.0	12.0	11.0	12.0
38.0	0-1	31.0	35.0	30.0	33.0	0.0	20.0	15.0	18.0	15.0	12.0	11.0	12.0
	1-2	28.0	33.0	30.0	32.0	0.0	18.0	12.0	13.0	11.0	12.0	11.0	12.0
	2-3	36.0	33.0	31.0	32.0	0.0	27.0	21.0	21.0	18.0	13.0	11.0	12.0
40.0	0-1	29.0	33.0	28.0	32.0	0.0	21.0	17.0	21.0	18.0	13.0	11.0	12.0
	1-2	27.0	33.0	22.0	32.0	0.0	19.0	15.0	21.0	18.0	13.0	11.0	12.0
	2-3	31.0	36.0	22.0	32.0	0.0	26.0	21.0	21.0	18.0	13.0	11.0	12.0
42.0	0-1	18.0	29.0	16.0	29.0	0.0	12.0	10.0	18.0	15.0	12.0	11.0	12.0
	1-2	38.0	29.0	21.0	29.0	0.0	17.0	14.0	21.0	18.0	13.0	11.0	12.0
	2-3	27.0	24.0	21.0	29.0	0.0	16.0	14.0	21.0	18.0	13.0	11.0	12.0
44.0	0-1	11.0	22.0	9.0	22.0	0.0	18.0	16.0	22.0	19.0	14.0	11.0	12.0
	1-2	38.0	22.0	14.0	22.0	0.0	17.0	15.0	22.0	19.0	14.0	11.0	12.0
	2-3	27.0	22.0	17.0	22.0	0.0	15.0	13.0	22.0	19.0	14.0	11.0	12.0
46.0	0-1	11.0	22.0	9.0	22.0	0.0	18.0	16.0	22.0	19.0	14.0	11.0	12.0
	1-2	38.0	22.0	14.0	22.0	0.0	17.0	15.0	22.0	19.0	14.0	11.0	12.0
	2-3	27.0	22.0	17.0	22.0	0.0	15.0	13.0	22.0	19.0	14.0	11.0	12.0
48.0	0-1	11.0	22.0	9.0	22.0	0.0	18.0	16.0	22.0	19.0	14.0	11.0	12.0
	1-2	38.0	22.0	14.0	22.0	0.0	17.0	15.0	22.0	19.0	14.0	11.0	12.0
	2-3	27.0	22.0	17.0	22.0	0.0	15.0	13.0	22.0	19.0	14.0	11.0	12.0

TABLE A-12.--EXPERIMENTAL OBSERVATIONS OF TEST NO.11

TEMPERATURE OF SAMPLES DURING ANALYSIS=24.0 DEGREES CENTIGRADE

FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET

TIME MIN	DEPTH FT	0.0		4.0		8.0		12.0		16.0		20.0	
		OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
0.0	1-1	722.0	722.0	0.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	1-2	225.0	225.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	2-3	7.0	7.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0
0.0	2-4	0.5	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0
2.0	1-1	285.0	285.0	165.0	165.0	3.5	12.0	1.5	8.0	0.0	0.0	0.0	0.0
2.0	1-2	135.0	135.0	38.0	23.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	1-3	4.5	1.0	0.0	0.0	0.5	11.0	1.0	0.0	0.0	0.0	0.0	0.0
2.0	2-4	74.5	120.0	7.5	62.0	11.5	11.0	6.5	65.0	3.5	3.0	0.0	0.0
4.0	1-1	26.5	18.0	16.0	63.0	0.0	0.0	0.5	1.0	0.0	0.0	0.0	0.0
4.0	1-2	6.5	2.0	1.8	31.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
4.0	1-3	6.0	2.0	4.0	57.0	0.0	86.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	2-4	98.5	98.0	21.0	41.0	1.5	1.0	2.4	37.0	2.9	2.9	0.0	0.0
6.0	1-1	55.5	77.0	21.0	36.0	0.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	1-2	2.0	22.0	0.5	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
6.0	1-3	7.5	7.0	0.5	0.0	0.0	52.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	2-4	70.5	94.0	50.0	46.0	0.0	1.0	3.8	28.0	21.0	22.0	0.0	0.0
8.0	1-1	72.5	71.0	49.0	54.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
8.0	1-2	48.5	48.0	32.0	42.0	0.0	42.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0	1-3	26.0	26.0	14.0	44.0	0.0	1.0	2.0	1.0	0.0	0.0	0.0	0.0
8.0	2-4	65.5	68.0	71.0	51.0	0.0	1.0	1.0	2.4	1.0	1.0	0.0	0.0
10.0	1-1	73.5	68.0	66.0	44.0	0.0	26.0	0.5	6.0	0.5	0.0	0.0	0.0
10.0	1-2	51.0	52.0	25.0	22.0	0.0	1.0	2.0	1.0	0.0	0.0	0.0	0.0
10.0	1-3	91.0	65.0	50.0	49.0	0.0	3.0	0.5	2.0	0.0	0.0	0.0	0.0
10.0	2-4	73.0	64.0	37.0	47.0	0.0	19.0	0.0	1.0	0.0	0.0	0.0	0.0
12.0	1-1	59.5	58.0	41.0	30.0	0.0	3.0	0.5	1.0	0.0	0.0	0.0	0.0
12.0	1-2	60.5	58.0	42.0	41.0	0.0	3.0	0.5	1.0	0.0	0.0	0.0	0.0
12.0	1-3	74.0	61.0	52.0	49.0	0.0	17.0	0.5	1.0	0.0	0.0	0.0	0.0
12.0	2-4	95.0	91.0	41.0	36.0	0.0	25.0	0.0	1.2	0.0	0.0	0.0	0.0

OBS: OBSERVED VALUE SMT: SMOOTHED VALUE

TABLE A-12.--CONTINUED

TIME DEPTH MIN FT	0.0		4.0		8.0		12.0		16.0		20.0	
	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
16.0	42.0	52.0	41.5	40.0	28.5	30.0	11.0	16.0	0.0	7.5	2.0	0.0
17.0	47.0	57.0	36.0	44.0	14.5	18.0	1.0	4.0	0.0	1.0	0.0	0.0
18.0	44.0	66.0	49.0	51.0	13.5	17.0	1.0	3.0	0.0	1.0	0.0	0.0
19.0	45.0	68.0	28.0	40.0	13.0	27.0	1.0	3.5	0.0	1.0	0.0	0.0
20.0	44.0	74.0	35.0	39.0	15.0	16.0	1.0	4.0	0.0	1.0	0.0	0.0
21.0	66.0	54.0	36.0	41.0	18.0	22.0	1.0	3.0	0.0	1.0	0.0	0.0
22.0	57.0	64.0	15.0	37.0	22.0	17.0	1.0	5.0	0.0	1.0	0.0	0.0
23.0	68.0	50.0	8.0	33.0	17.0	16.0	1.0	5.0	0.0	1.0	0.0	0.0
24.0	70.0	63.0	3.0	45.0	11.0	23.0	1.0	4.0	0.0	1.0	0.0	0.0
25.0	49.0	47.0	2.0	35.0	11.0	15.0	1.0	5.0	0.0	1.0	0.0	0.0
26.0	62.0	70.0	3.0	45.0	17.0	17.0	1.0	4.0	0.0	1.0	0.0	0.0
27.0	41.0	43.0	2.0	33.0	12.0	13.0	1.0	5.0	0.0	1.0	0.0	0.0
28.0	46.0	69.0	4.0	44.0	17.0	13.0	1.0	5.0	0.0	1.0	0.0	0.0
29.0	37.0	40.0	3.0	32.0	11.0	15.0	1.0	5.0	0.0	1.0	0.0	0.0
30.0	36.0	42.0	3.0	34.0	18.0	18.0	1.0	5.0	0.0	1.0	0.0	0.0
31.0	35.0	66.0	2.0	33.0	15.0	16.0	1.0	5.0	0.0	1.0	0.0	0.0
32.0	34.0	36.0	2.0	36.0	14.0	17.0	1.0	5.0	0.0	1.0	0.0	0.0
33.0	33.0	35.0	2.0	32.0	11.0	13.0	1.0	5.0	0.0	1.0	0.0	0.0
34.0	33.0	33.0	2.0	33.0	14.0	13.0	1.0	5.0	0.0	1.0	0.0	0.0
35.0	37.0	49.0	3.0	36.0	19.0	13.0	1.0	5.0	0.0	1.0	0.0	0.0
36.0	41.0	34.0	3.0	37.0	14.0	16.0	1.0	5.0	0.0	1.0	0.0	0.0
37.0	39.0	31.0	3.0	33.0	19.0	12.0	1.0	5.0	0.0	1.0	0.0	0.0
38.0	35.0	33.0	3.0	33.0	18.0	12.0	1.0	5.0	0.0	1.0	0.0	0.0
39.0	33.0	33.0	3.0	33.0	14.0	12.0	1.0	5.0	0.0	1.0	0.0	0.0
40.0	33.0	33.0	3.0	33.0	14.0	12.0	1.0	5.0	0.0	1.0	0.0	0.0

TABLE A-12.--CONTINUED

TIME DEPTH MIN FT	FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET												
	0.0	4.0	8.0	12.0	16.0	20.0	0.0	4.0	8.0	12.0	16.0	20.0	
34.0	31.0	32.0	4.5	10.0	9.0	12.0	6.0	16.0	6.5	12.0	12.0	7.0	9.0
35.0	37.0	29.0	11.0	16.0	3.0	3.5	3.5	3.0	3.5	4.5	4.5	5.0	6.0
36.0	34.0	36.0	17.0	39.0	25.0	28.0	28.0	19.0	16.0	14.5	14.5	4.0	2.9
37.0	26.0	37.0	7.0	9.0	6.0	5.0	5.0	6.0	6.0	11.0	11.0	7.0	8.0
38.0	23.0	32.0	6.0	10.0	2.0	2.0	2.0	18.0	18.0	6.0	6.0	5.0	7.0
39.0	35.0	32.0	4.0	38.0	21.0	21.0	21.0	7.0	7.0	5.0	5.0	3.0	3.0
40.0	27.0	33.0	21.0	6.0	19.0	13.0	13.0	5.0	5.0	13.0	13.0	7.0	6.0
41.0	22.0	33.0	13.0	17.0	26.0	26.0	26.0	20.0	20.0	2.0	2.0	5.0	4.0
42.0	33.0	32.0	49.0	8.0	7.0	8.0	8.0	27.0	27.0	11.0	11.0	5.0	5.0
43.0	38.0	32.0	7.0	9.0	6.0	6.0	6.0	35.0	35.0	14.0	14.0	6.0	6.0
44.0	34.0	32.0	24.0	6.0	9.0	15.0	15.0	8.0	8.0	10.0	10.0	7.0	7.0
45.0	31.0	32.0	27.0	35.0	38.0	38.0	38.0	38.0	38.0	18.0	18.0	5.0	5.0
46.0	36.0	33.0	14.0	38.0	39.0	39.0	39.0	38.0	38.0	9.0	9.0	8.0	7.0
47.0	38.0	34.0	8.0	5.0	8.0	8.0	8.0	5.0	5.0	7.0	7.0	4.0	4.0
48.0	31.0	32.0	29.0	38.0	28.0	28.0	28.0	28.0	28.0	10.0	10.0	5.0	5.0
49.0	24.0	32.0	17.0	26.0	28.0	28.0	28.0	28.0	28.0	5.0	5.0	7.0	6.0
50.0	17.0	34.0	16.0	5.0	8.0	8.0	8.0	8.0	8.0	12.0	12.0	4.0	4.0

TABLE A-13.--EXPERIMENTAL OBSERVATIONS OF TEST NO.12

TEMPERATURE OF SAMPLES DURING ANALYSIS=25.5 DEGREES CENTIGRADE

TIME DEPTH FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET

MIN	FT	0.0	3.0	6.0	9.0	12.0
		OBS	SMT	OBS	SMT	OBS
0.0	0-1	600.0	600.0	394.0	394.0	0.0
	0-2	4.0	4.0	6.0	6.0	0.0
	0-3	0.0	0.0	0.0	0.0	0.0
	0-4	5.0	15.0	15.0	15.0	0.0
2.0	1-1	264.0	264.0	91.5	92.0	0.0
	1-2	176.0	176.0	6.0	5.0	0.0
	1-3	0.0	0.0	0.0	0.0	0.0
	1-4	247.0	256.0	21.0	94.0	0.0
4.0	2-1	80.0	280.0	138.5	104.0	0.0
	2-2	0.0	0.0	0.0	2.0	0.0
	2-3	1.0	0.0	7.0	6.0	0.0
	2-4	210.0	180.0	146.0	91.0	34.0
6.0	3-1	53.0	153.0	188.0	112.0	68.0
	3-2	2.0	0.0	16.0	10.0	0.0
	3-3	116.0	130.0	71.0	88.0	0.0
	3-4	145.0	145.0	123.5	113.0	85.0
8.0	4-1	0.0	0.0	0.0	9.0	0.0
	4-2	0.0	0.0	12.0	10.0	0.0
	4-3	123.0	110.0	183.0	84.0	104.0
	4-4	33.0	140.0	98.0	108.0	32.0
10.0	5-1	0.0	0.0	1.0	9.0	0.0
	5-2	0.0	0.0	0.0	0.0	0.0
	5-3	78.0	92.0	55.0	80.0	0.0
	5-4	30.0	37.0	11.5	100.0	0.0
12.0	6-1	0.0	0.0	0.0	9.0	0.0
	6-2	0.0	0.0	11.0	5.0	0.0
	6-3	108.0	80.0	85.0	76.0	0.0
	6-4	54.0	34.0	101.0	90.0	0.0
14.0	7-1	0.0	0.0	16.0	8.0	0.0
	7-2	0.0	0.0	0.0	0.0	0.0
	7-3	0.0	0.0	0.0	0.0	0.0
	7-4	0.0	0.0	0.0	0.0	0.0

OBS: OBSERVED VALUE SMT: SMOOTHED VALUE

TABLE A-13.--CONTINUED

TIME MIN	DEPTH FT	FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET											
		0.0		3.0		6.0		9.0		12.0			
		OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
16.0	0-1	75.5	72.0	101.5	92.0	43.0	71.0	71.0	92.0	128.0	108.0	128.0	108.0
	1-3	32.0	32.0	19.0	33.0	78.5	74.0	74.0	25.0	53.0	52.0	53.0	52.0
	2-4	0.5	0.0	7.0	3.0	1.5	8.0	8.0	0.0	0.0	0.0	0.0	0.0
18.0	0-1	55.5	64.0	101.0	83.0	60.5	63.0	63.0	85.0	86.5	86.0	86.5	86.0
	1-3	22.5	31.0	40.0	33.0	50.5	44.0	44.0	25.0	20.5	20.0	20.5	20.0
	2-4	0.5	0.0	1.0	1.0	1.0	7.0	7.0	0.0	3.0	0.0	0.0	0.0
20.0	0-1	40.5	59.0	43.0	75.0	10.0	64.0	64.0	64.0	96.0	96.0	96.0	96.0
	1-3	0.5	30.0	20.5	32.0	60.5	52.0	52.0	20.0	87.0	61.0	87.0	61.0
	2-4	0.5	0.0	3.0	3.0	7.0	4.0	4.0	0.0	1.5	0.0	1.5	0.0
22.0	0-1	40.5	54.0	28.0	18.0	10.5	60.0	60.0	49.0	75.5	56.0	75.5	56.0
	1-3	0.5	20.0	15.0	32.0	15.5	42.0	42.0	25.0	27.0	61.0	27.0	61.0
	2-4	0.5	0.0	0.5	1.0	7.0	7.0	7.0	0.0	1.5	0.0	1.5	0.0
24.0	0-1	35.0	49.0	32.0	61.0	98.5	58.0	58.0	32.0	0.5	27.0	0.5	27.0
	1-3	14.0	28.0	18.0	33.0	27.5	34.0	34.0	25.0	14.0	50.0	14.0	50.0
	2-4	0.0	0.0	1.5	1.0	4.0	6.0	6.0	0.0	1.0	15.0	1.0	15.0
26.0	0-1	38.0	46.0	45.0	56.0	91.5	57.0	57.0	18.5	18.5	15.0	18.5	15.0
	1-3	29.0	42.0	25.0	33.0	12.5	27.0	27.0	25.0	21.0	50.0	21.0	50.0
	2-4	0.5	0.0	1.0	1.0	6.0	6.0	6.0	0.0	0.5	10.0	0.5	10.0
28.0	0-1	58.0	43.0	64.0	51.0	23.0	53.0	53.0	24.0	0.5	47.0	0.5	47.0
	1-3	31.0	27.0	33.0	33.0	35.0	24.0	24.0	24.0	0.5	0.0	0.5	0.0
	2-4	0.0	0.0	1.0	1.0	2.0	3.0	3.0	0.0	0.5	7.0	0.5	7.0
30.0	0-1	58.0	42.0	71.0	40.0	14.0	51.0	51.0	29.0	29.0	43.0	29.0	43.0
	1-3	40.0	47.0	22.0	33.0	38.0	23.0	23.0	24.0	0.0	0.0	0.0	0.0
	2-4	0.5	0.0	0.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32.0	0-1	62.0	39.0	63.0	42.0	27.0	49.0	49.0	24.0	11.5	39.0	11.5	39.0
	1-3	0.0	20.0	23.0	33.0	11.0	21.0	21.0	24.0	0.0	0.0	0.0	0.0
	2-4	0.0	0.0	0.5	1.0	1.0	3.5	3.5	0.0	0.0	0.0	0.0	0.0

TABLE A-13.--CONTINUED

TIME MIN	DEPTH FT	FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET											
		0.0		3.0		6.0		9.0		12.0		SMT	
		OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
34.0	1-1	64.0	37.0	27.5	39.0	98.0	48.0	1.5	24.0	2.0	4.0	35.0	4.0
	1-2	1.0	25.0	46.0	30.0	28.0	21.0	36.5	24.0	24.0	30.0	30.0	35.0
	2-4	10.5	0.0	0.5	1.0	17.0	5.0	0.5	0.0	0.0	0.0	0.0	0.0
36.0	1-1	26.5	25.0	4.5	36.0	101.5	48.0	2.5	24.0	24.0	32.0	32.0	32.0
	1-2	0.5	0.0	5.5	3.0	42.5	3.0	0.5	0.0	0.0	0.0	0.0	0.0
	2-4	1.5	0.0	1.5	1.0	6.5	4.0	3.5	24.0	24.0	4.0	4.0	4.0
38.0	1-1	25.0	24.0	15.0	34.0	45.0	48.0	0.0	24.0	24.0	29.0	29.0	29.0
	1-2	30.0	20.0	1.5	30.0	41.0	23.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-4	8.5	0.0	5.5	3.0	0.5	4.0	0.0	24.0	24.0	4.0	4.0	4.0
40.0	1-1	27.5	22.0	5.0	31.0	29.0	48.0	0.0	24.0	24.0	26.0	26.0	26.0
	1-2	11.0	22.0	3.0	30.0	79.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-4	0.5	0.0	5.0	3.0	0.5	2.3	0.0	24.0	24.0	4.0	4.0	4.0
42.0	1-1	28.0	21.0	5.5	29.0	26.0	48.0	0.0	24.0	24.0	25.0	25.0	25.0
	1-2	0.5	0.0	5.0	3.0	4.0	2.3	0.0	24.0	24.0	4.0	4.0	4.0
	2-4	42.0	30.0	2.0	26.0	68.0	42.0	0.0	24.0	24.0	24.0	24.0	24.0
44.0	1-1	46.0	0.0	5.0	31.0	31.0	48.0	0.0	24.0	24.0	24.0	24.0	24.0
	1-2	2.0	24.0	2.0	23.0	32.0	2.3	0.0	24.0	24.0	5.5	5.5	5.5
	2-4	2.0	0.0	5.0	16.0	21.0	42.0	0.0	24.0	24.0	33.0	33.0	33.0
46.0	1-1	28.0	24.0	4.0	23.0	32.0	48.0	0.0	24.0	24.0	23.0	23.0	23.0
	1-2	68.0	24.0	5.0	24.0	22.0	2.3	0.0	24.0	24.0	11.0	11.0	11.0
	2-4	0.5	0.0	5.0	3.0	7.5	42.0	0.0	24.0	24.0	10.0	10.0	10.0
48.0	1-1	10.5	28.0	5.0	23.0	54.0	48.0	0.0	24.0	24.0	11.0	11.0	11.0
	1-2	10.5	28.0	5.0	23.0	20.0	2.3	0.0	24.0	24.0	10.0	10.0	10.0
	2-4	10.5	28.0	5.0	23.0	20.0	2.3	0.0	24.0	24.0	10.0	10.0	10.0
50.0	1-1	18.0	8.5	0.0	18.0	18.0	2.3	0.0	24.0	24.0	18.0	18.0	18.0
	1-2	13.0	3.0	0.5	13.0	13.0	2.3	0.0	24.0	24.0	13.0	13.0	13.0
	2-4	0.5	0.0	0.0	0.0	0.0	2.3	0.0	24.0	24.0	0.5	0.5	0.5

TABLE A-14. -- EXPERIMENTAL OBSERVATIONS OF TEST NO. 13

TEMPERATURE OF SAMPLES DURING ANALYSIS=22.5 DEGREES CENTIGRADE

TIME DEPTH FLUORESCENCE IN UNITS AT STATED LATERAL DISTANCE IN FEET

MIN	FT	0.0	3.0	6.0	9.0	12.0
		OBS	OBS	OBS	OBS	OBS
		SMT	SMT	SMT	SMT	SMT
0.0	1-1	367.0	54.0	0.0	0.0	0.0
	1-2	16.5	19.0	0.0	0.0	0.0
	2-3	4.0	0.0	0.0	0.0	0.0
	3-4	10.5	0.0	0.0	0.0	0.0
2.0	0-1	187.5	46.5	0.0	0.0	0.0
	1-2	198.5	50.0	0.0	0.0	0.0
	2-3	6.0	1.0	0.0	0.0	0.0
	3-4	150.0	0.0	0.0	0.0	0.0
4.0	0-1	36.0	0.0	0.0	0.0	0.0
	1-2	124.0	45.0	4.0	0.0	0.0
	2-3	131.5	47.0	0.0	0.0	0.0
	3-4	162.0	56.5	4.0	0.0	0.0
6.0	0-1	36.0	7.0	0.0	0.0	0.0
	1-2	103.0	39.5	0.0	0.0	0.0
	2-3	102.0	69.0	15.0	0.0	0.0
	3-4	66.0	2.0	0.0	0.0	0.0
8.0	0-1	60.0	1.0	0.0	0.0	0.0
	1-2	87.5	40.0	0.5	11.0	0.0
	2-3	39.5	67.0	1.0	0.0	0.0
	3-4	76.5	24.0	0.5	0.0	0.0
10.0	0-1	73.5	1.0	0.0	0.0	0.0
	1-2	83.5	40.0	0.5	0.0	0.0
	2-3	35.5	62.0	1.0	0.0	0.0
	3-4	57.0	40.0	0.5	0.0	0.0
12.0	0-1	65.5	31.0	0.5	0.0	0.0
	1-2	2.0	47.0	0.5	3.0	0.0
	2-3	42.0	0.5	0.5	0.0	0.0
	3-4	70.5	32.0	0.5	0.0	0.0
14.0	0-1	70.5	1.0	0.0	0.0	0.0
	1-2	2.0	57.0	0.0	0.0	0.0
	2-3	4.0	40.0	0.0	0.0	0.0
	3-4	2.0	52.0	0.0	0.0	0.0

OBS: OBSERVED VALUE SMT: SMOOTHED VALUE

TABLE A-14.--CONTINUED

TIME DEPTH MIN FT	0.0		3.0		6.0		9.0		12.0	
	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
16.0	56.0	55.0	40.0	40.0	15.0	29.0	4.5	6.0	0.0	0.0
1-2	64.0	64.0	60.0	54.0	14.0	21.0	9.5	6.0	0.0	0.0
2-4	13.0	5.0	0.0	2.0	0.0	0.0	3.5	2.0	0.0	0.0
18.0	49.5	54.0	40.5	39.0	22.0	32.0	0.5	6.0	0.0	1.0
1-2	18.0	6.0	47.0	50.0	16.0	33.0	0.0	2.0	0.0	0.0
2-4	48.0	4.0	4.0	1.0	0.0	0.0	0.0	7.0	0.0	1.0
20.0	68.0	60.0	53.0	39.0	42.0	34.0	4.0	6.0	0.0	0.0
1-2	6.0	6.0	52.0	47.0	22.0	32.0	4.0	2.0	0.0	0.0
2-4	1.0	4.0	1.0	2.0	1.0	0.0	0.5	8.0	0.0	1.0
22.0	48.0	52.0	44.0	39.0	26.0	35.0	0.0	5.0	2.0	0.0
1-2	62.0	5.0	4.0	3.0	2.0	0.0	0.0	1.0	0.0	0.0
2-4	1.0	4.0	1.0	2.0	1.0	0.0	0.0	9.0	0.0	1.0
24.0	71.0	56.0	38.0	39.0	47.0	36.0	8.5	1.0	0.0	0.0
1-2	17.0	4.0	3.0	4.0	3.0	0.0	0.5	9.5	0.0	0.0
2-4	51.0	5.0	3.0	2.0	2.0	0.0	0.0	1.0	0.0	0.0
26.0	55.0	50.0	36.0	33.0	58.0	36.0	0.0	10.0	0.0	0.0
1-2	11.0	6.0	1.0	2.0	4.0	1.0	0.0	4.0	0.0	0.0
2-4	48.0	48.0	37.0	34.0	38.0	35.0	7.0	11.0	0.0	2.0
28.0	54.0	52.0	31.0	32.0	36.0	32.0	0.0	0.0	0.0	0.0
1-2	4.0	6.0	1.0	2.0	5.0	1.0	0.0	0.0	0.0	0.0
2-4	46.0	46.0	39.0	38.0	19.0	35.0	1.0	12.0	0.0	0.0
30.0	49.0	50.0	33.0	32.0	12.0	22.0	0.0	14.0	0.0	0.0
1-2	11.0	6.0	1.0	2.0	1.0	0.0	0.0	0.0	0.0	0.0
2-4	50.0	47.0	41.0	38.0	28.0	34.0	22.0	13.0	0.0	2.0
32.0	51.0	48.0	24.0	31.0	21.0	22.0	0.5	14.0	0.0	0.0
1-2	1.0	4.0	1.0	2.0	1.0	1.0	0.0	0.0	0.0	0.0
2-4	1.0	4.0	1.0	2.0	1.0	1.0	0.0	0.0	0.0	0.0

TABLE A-14.--CONTINUED

TIME DEPTH MIN	DEPTH FT	0.0		3.0		6.0		9.0		12.0	
		OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT	OBS	SMT
34.0	1-1	47.5	46.0	37.0	38.0	36.5	34.0	14.0	14.0	1.0	2.0
	1-2	48.0	46.0	28.0	30.0	17.5	23.0	0.0	0.0	0.0	0.0
	2-3	18.5	3.0	1.5	2.0	0.0	1.0	0.0	0.0	0.0	0.0
36.0	2-4	30.5	45.0	41.5	38.0	40.0	32.0	18.0	15.0	0.0	3.0
	1-2	42.5	45.0	32.0	22.0	22.0	22.0	0.0	0.0	0.0	0.0
	2-3	46.5	36.0	1.5	2.0	1.0	1.0	0.0	0.0	0.0	0.0
38.0	3-4	37.0	44.0	39.0	38.0	38.0	32.0	0.0	0.0	0.0	3.0
	1-2	47.0	43.0	34.5	28.0	21.0	21.0	16.0	14.0	3.0	0.0
	2-3	5.5	3.0	5.0	2.0	0.5	1.0	0.0	0.0	0.0	0.0
40.0	3-4	34.5	41.0	35.5	37.0	37.5	32.0	16.5	16.0	0.0	3.0
	1-2	39.5	41.0	30.5	28.0	26.0	20.0	20.0	16.0	0.0	0.0
	2-3	5.5	4.0	4.0	2.0	3.0	2.0	0.0	0.0	0.0	0.0
42.0	3-4	43.0	40.0	40.0	37.0	37.5	31.0	0.0	0.0	0.0	4.0
	1-2	5.0	4.0	1.5	2.0	2.0	1.0	0.0	0.0	0.0	0.0
	2-3	47.0	46.0	34.0	37.0	32.0	31.0	16.0	16.0	5.0	0.0
44.0	3-4	47.0	40.0	1.5	2.0	2.0	1.0	0.0	0.0	0.0	0.0
	1-2	17.5	3.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
	2-3	46.5	38.0	14.5	36.0	13.0	30.0	18.0	14.0	5.0	0.0
46.0	3-4	41.5	36.0	2.0	2.0	1.0	1.0	0.0	0.0	0.0	0.0
	1-2	52.5	39.0	25.5	35.0	16.5	29.0	0.0	0.0	0.0	5.0
	2-3	2.0	3.0	2.5	2.0	0.5	1.0	0.0	0.0	0.0	0.0
48.0	3-4	41.0	38.0	1.0	2.0	0.5	1.0	0.0	0.0	0.0	0.0
	1-2	16.0	33.0	31.0	36.0	31.0	28.0	14.5	16.0	0.0	0.0
	2-3	11.0	33.0	2.5	2.0	1.0	1.0	0.0	0.0	0.0	0.0
50.0	3-4	11.0	34.0	1.0	2.0	1.0	1.0	0.0	0.0	0.0	0.0
	1-2	1.0	3.0	1.0	2.0	0.5	1.0	0.0	0.0	0.0	0.0
	2-3	1.0	3.0	1.0	2.0	0.5	1.0	0.0	0.0	0.0	0.0

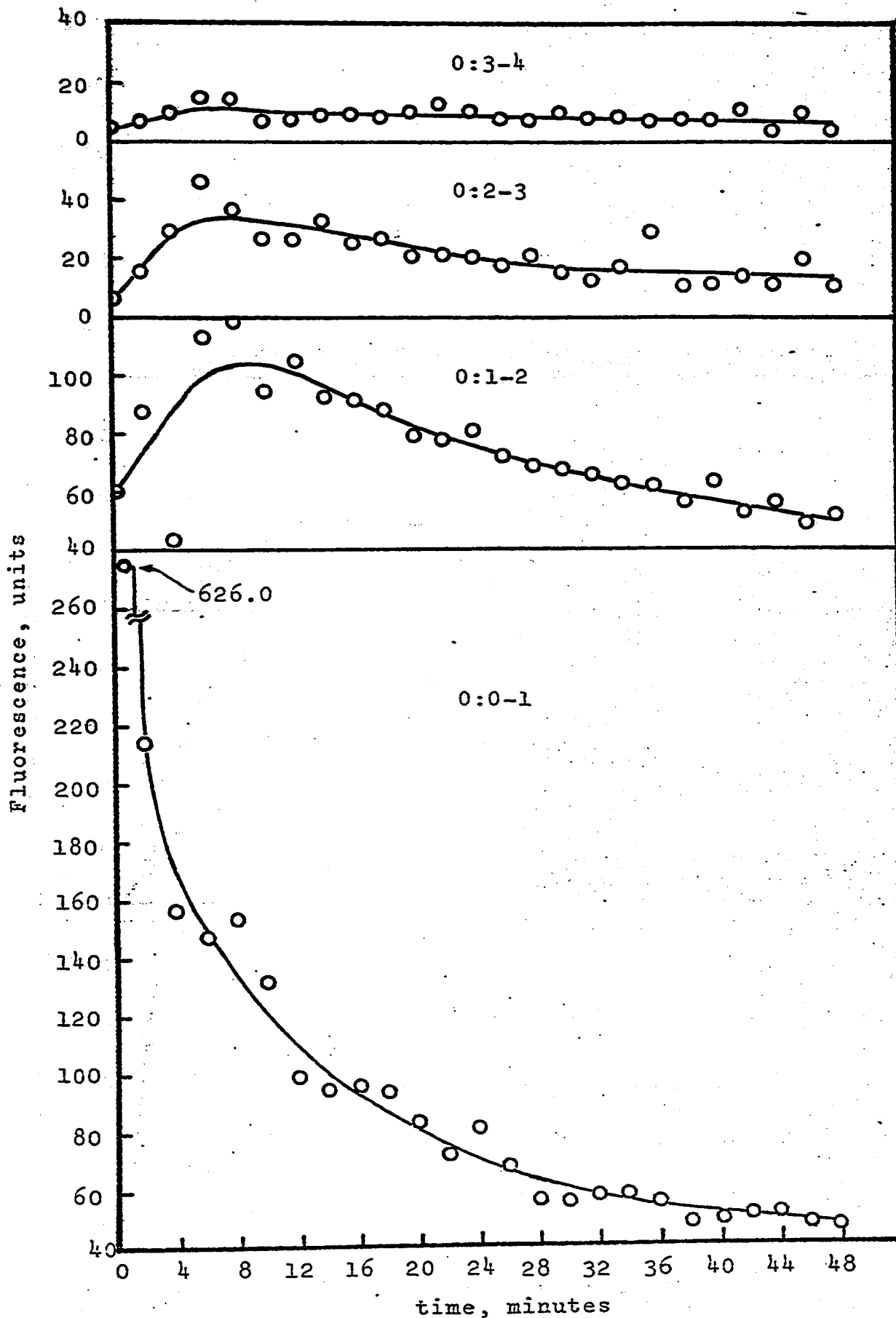


FIG. A.1.--FLUORESCENCE vs. TIME FOR TEST NO. 1

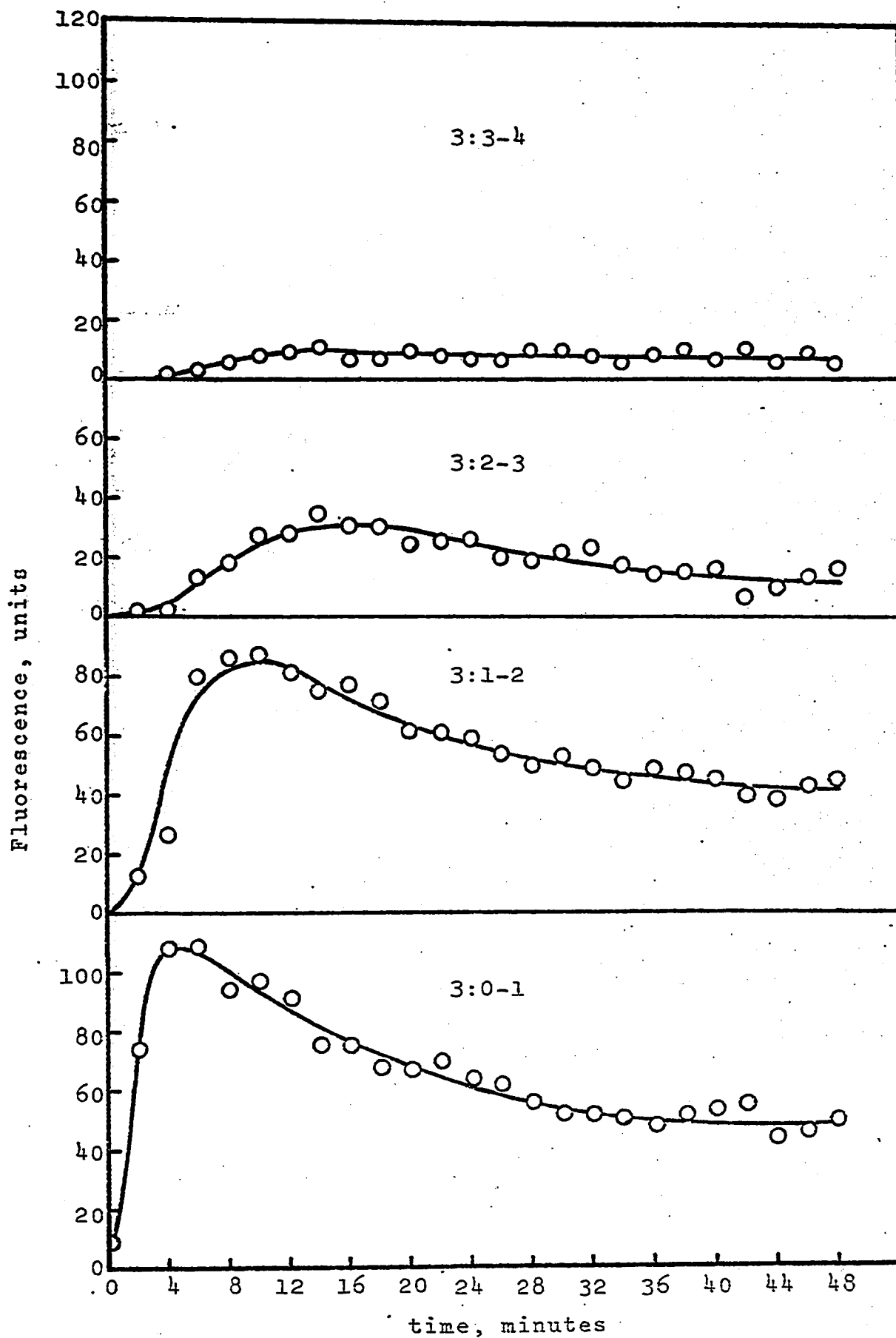


FIG. A.1.--CONTINUED

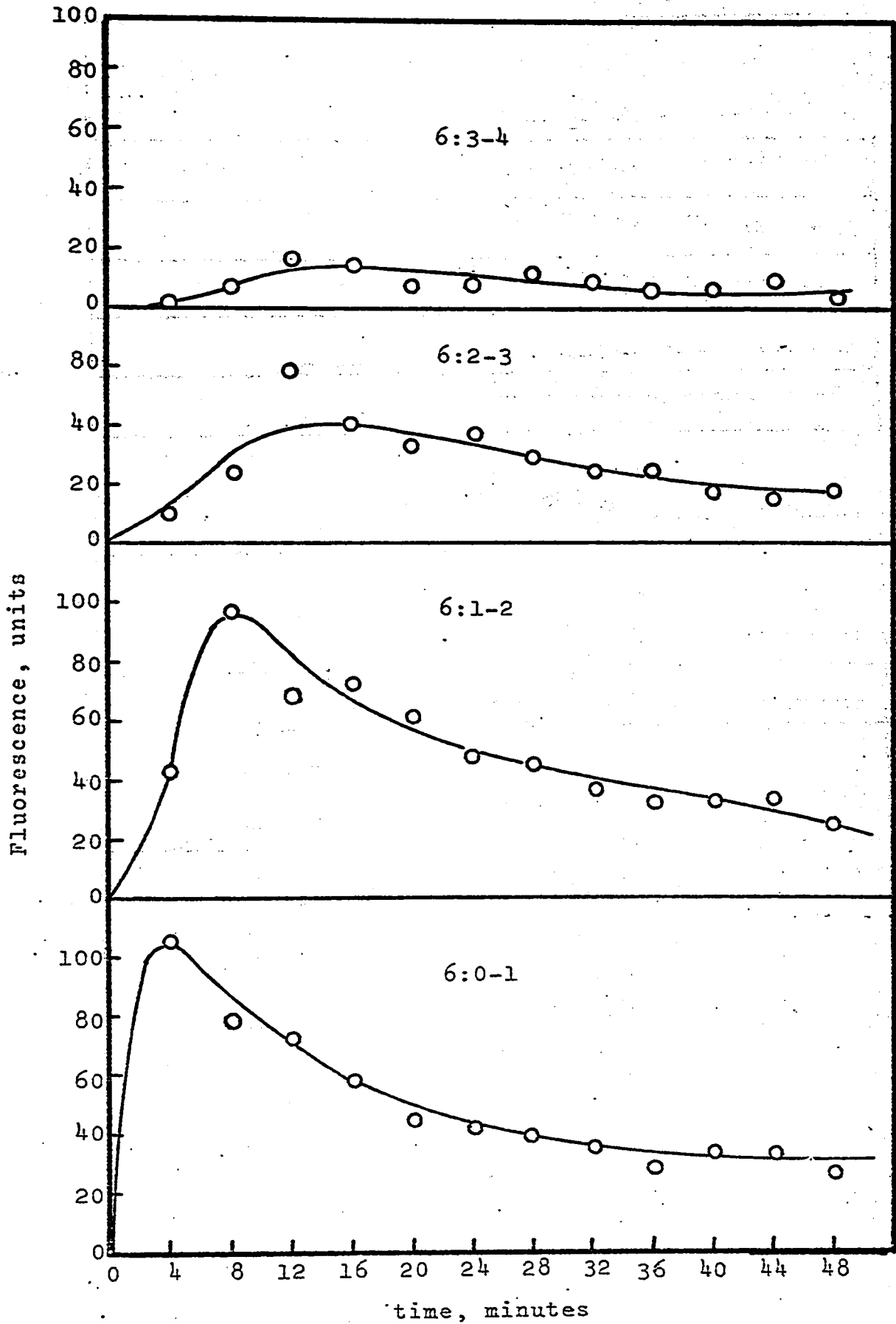


FIG. A.1.--CONTINUED

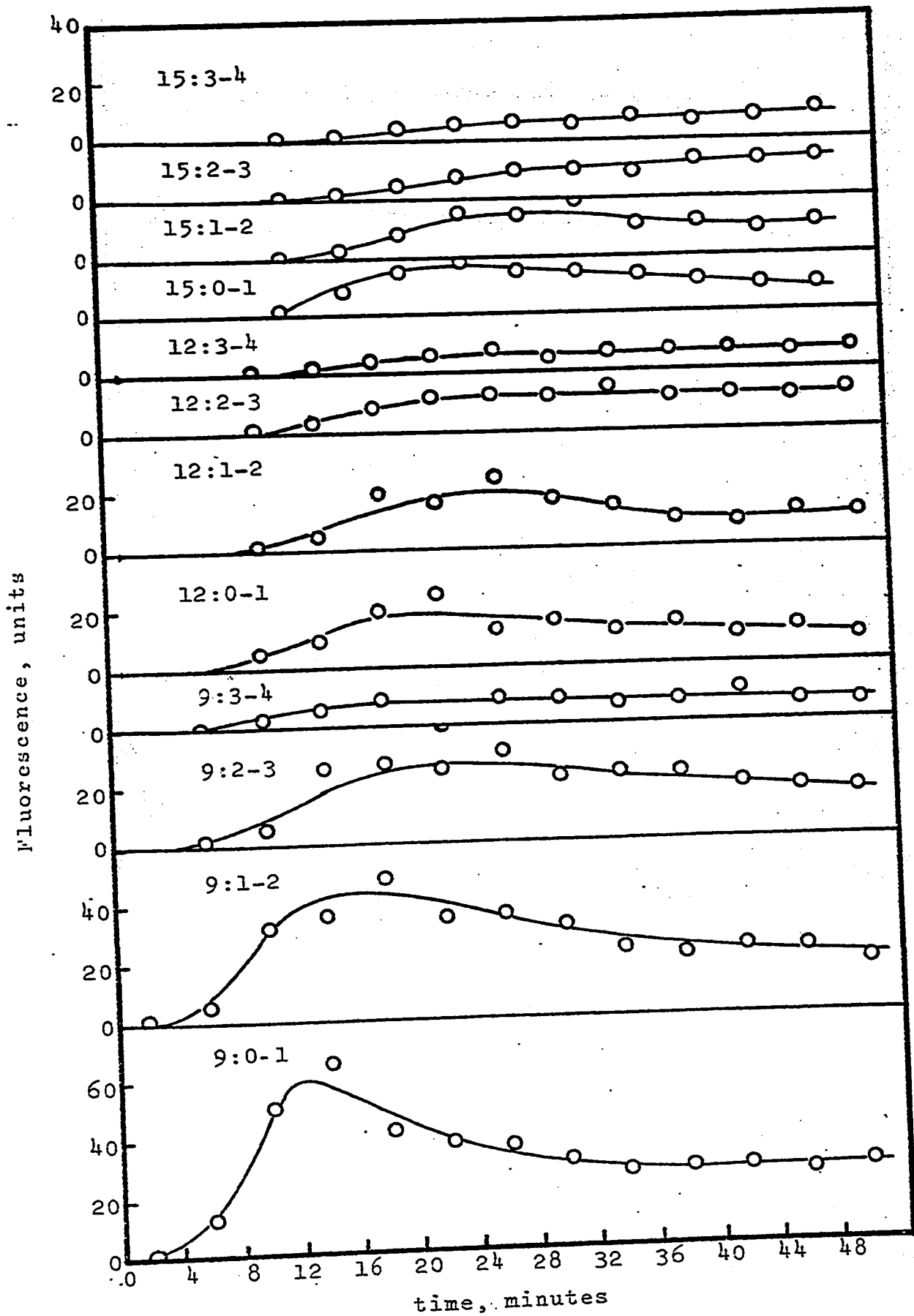


FIG. A.1.--CONTINUED

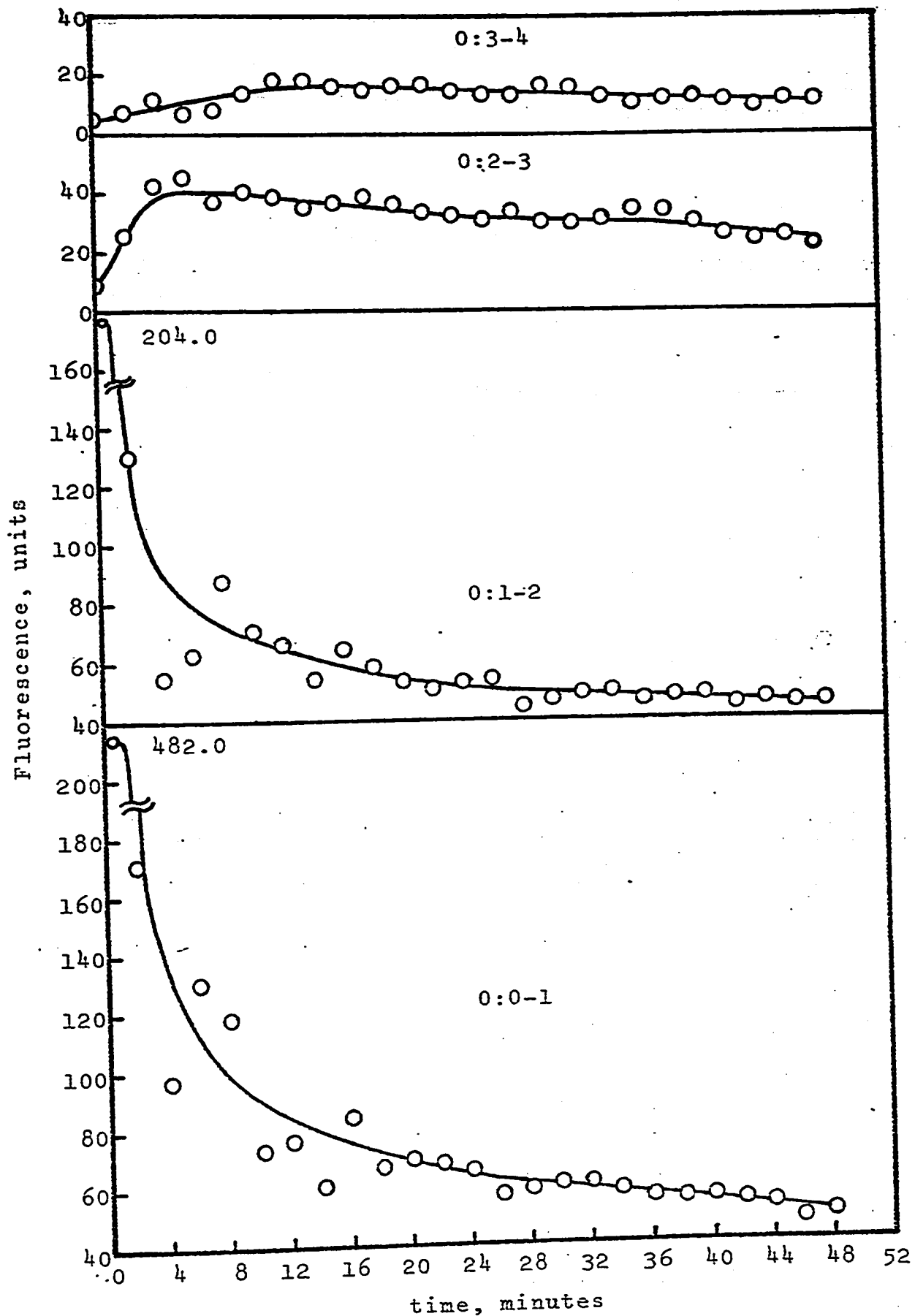


FIG. A.2.--FLUORESCENCE vs TIME FOR TEST NO. 2

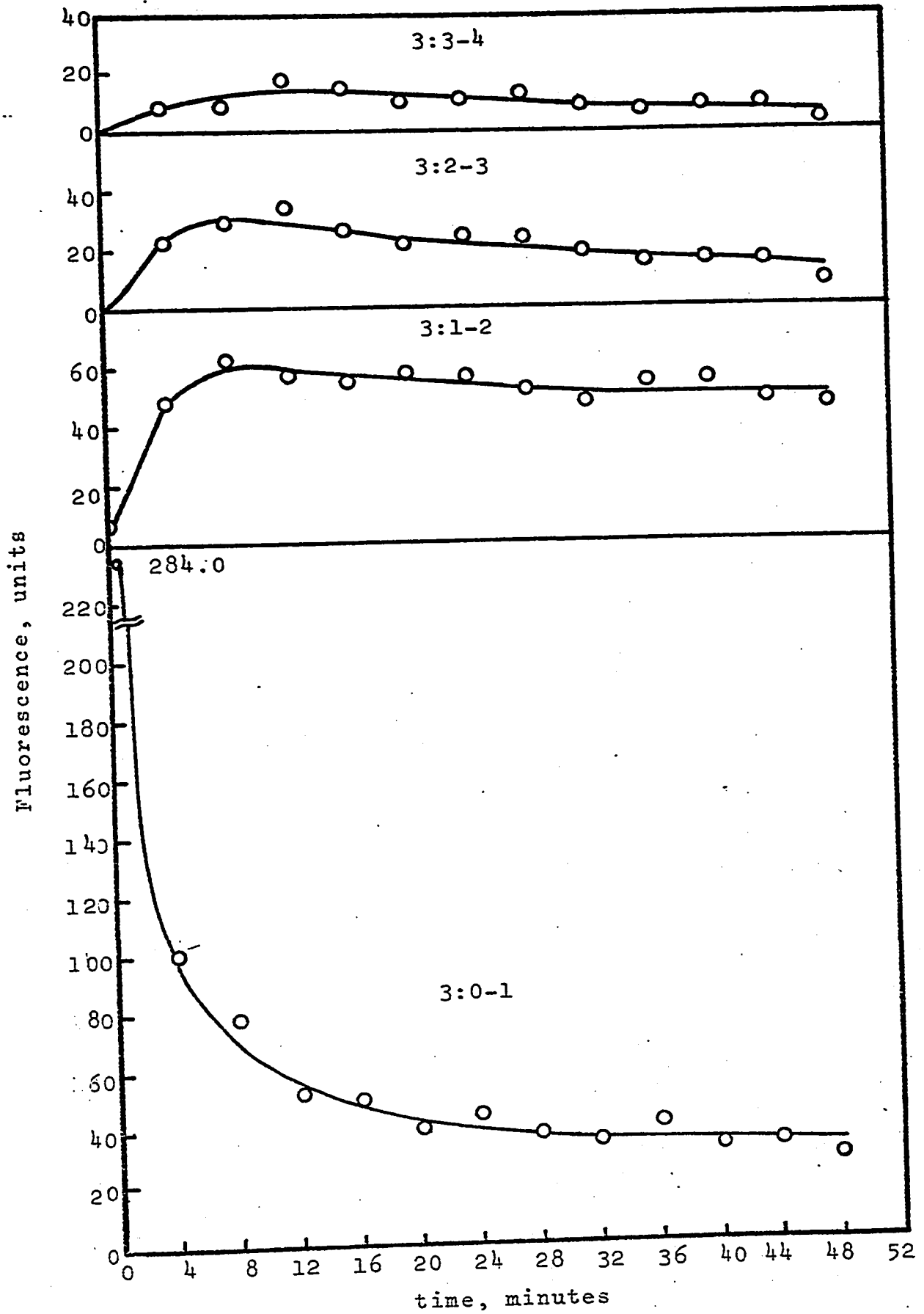


FIG. A.2.--CONTINUED

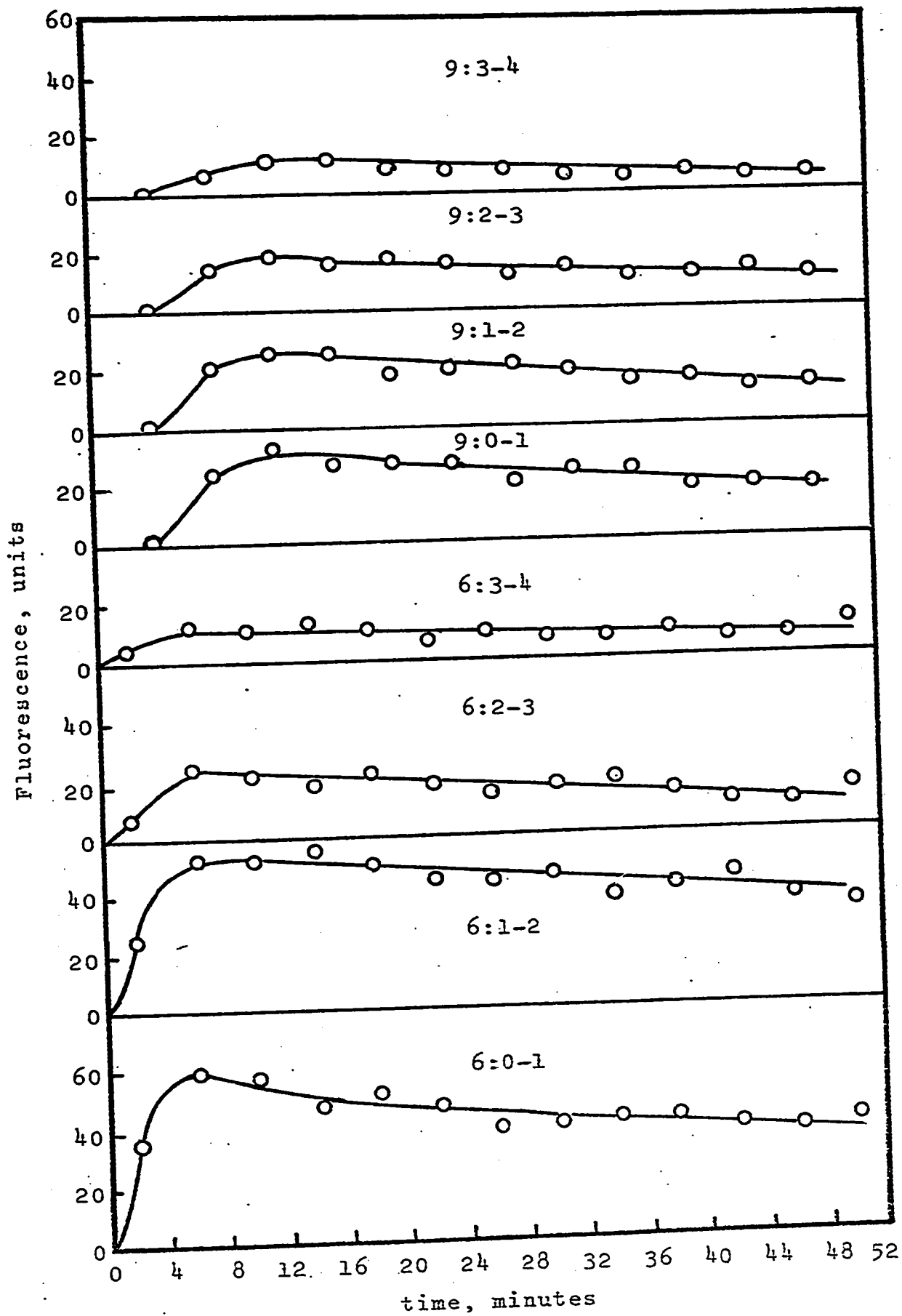


FIG. A.2.--CONTINUED

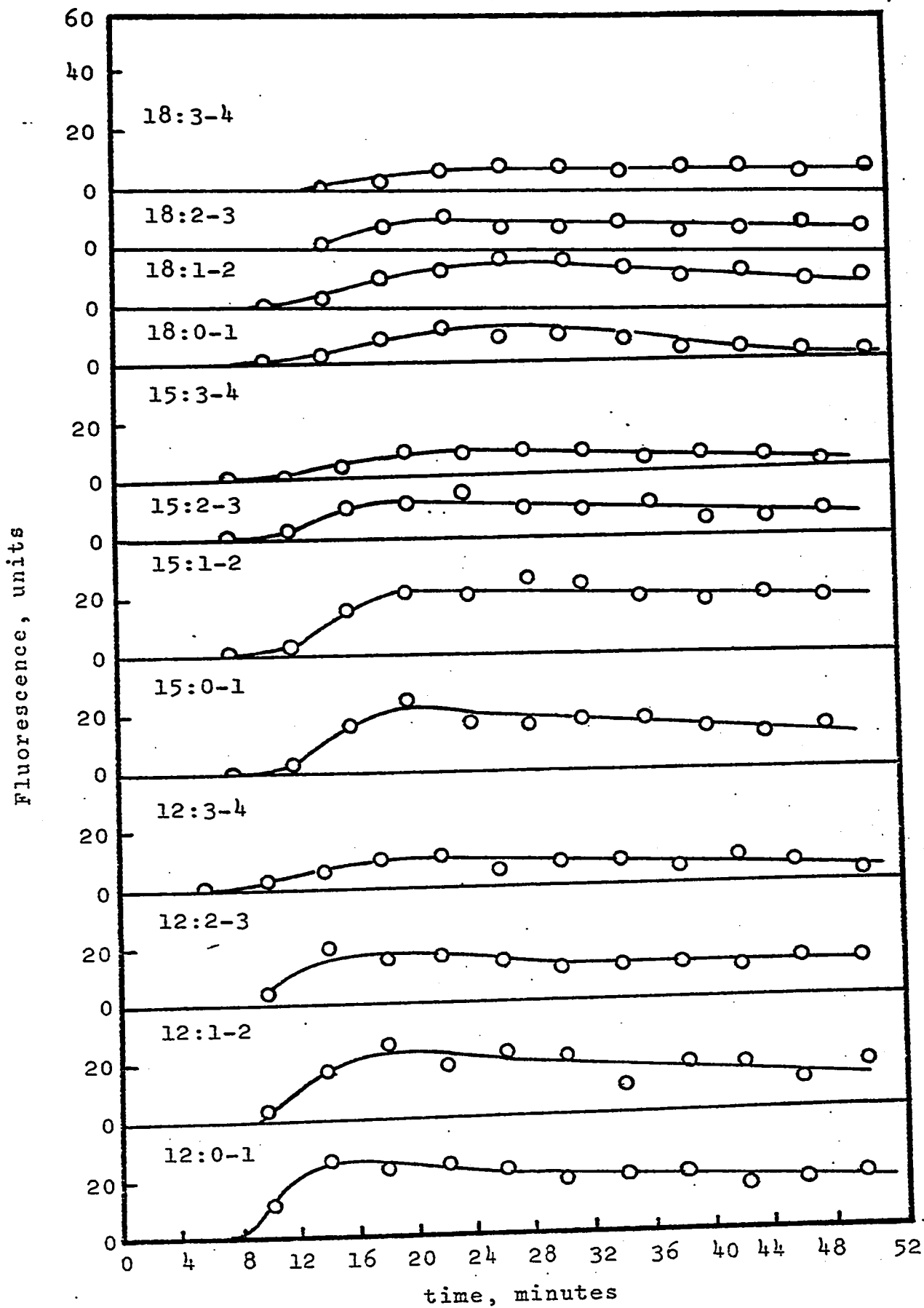


FIG. A.2.--CONTINUED

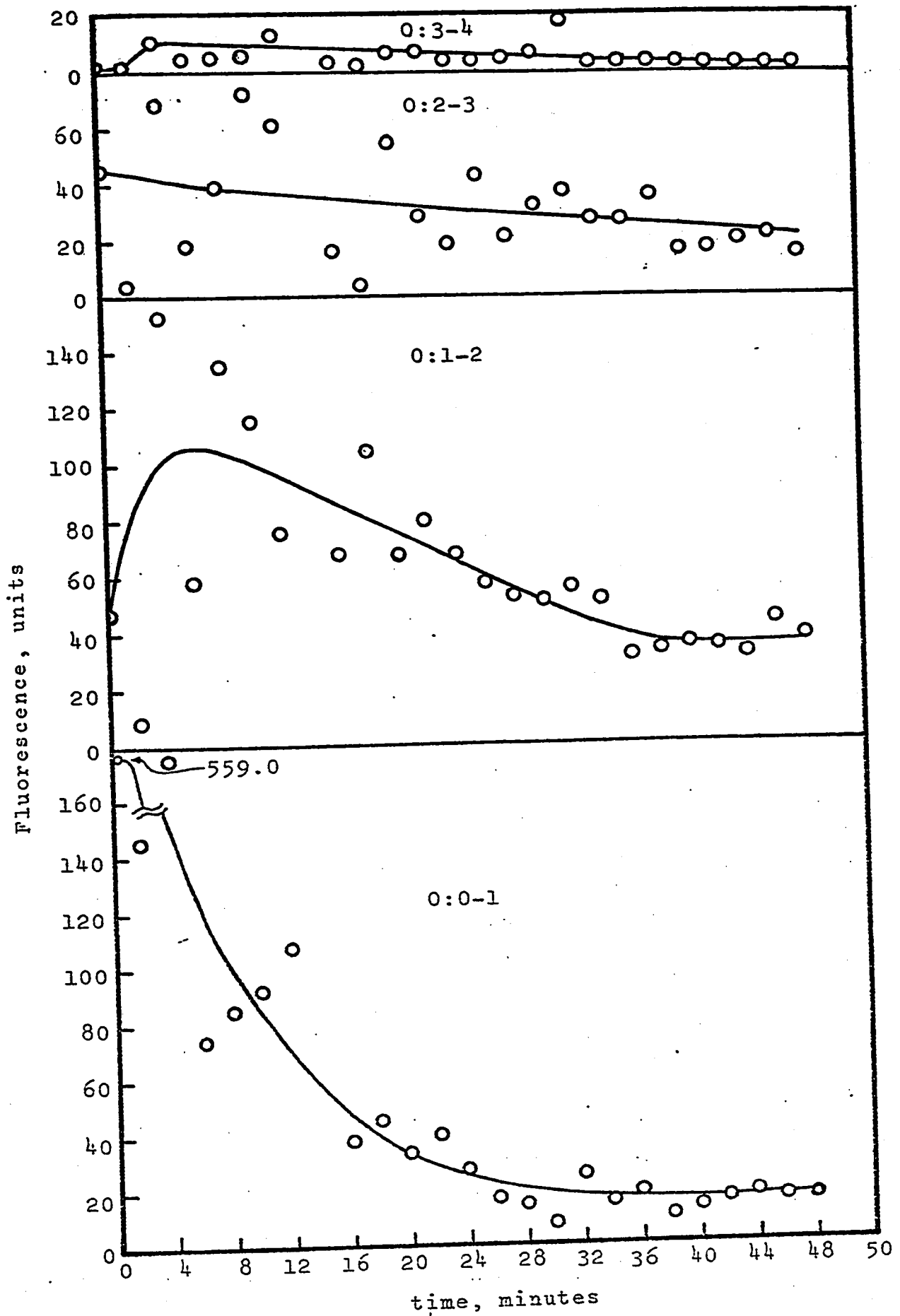


FIG. A.3--FLUORESCENCE vs TIME FOR TEST NO. 3

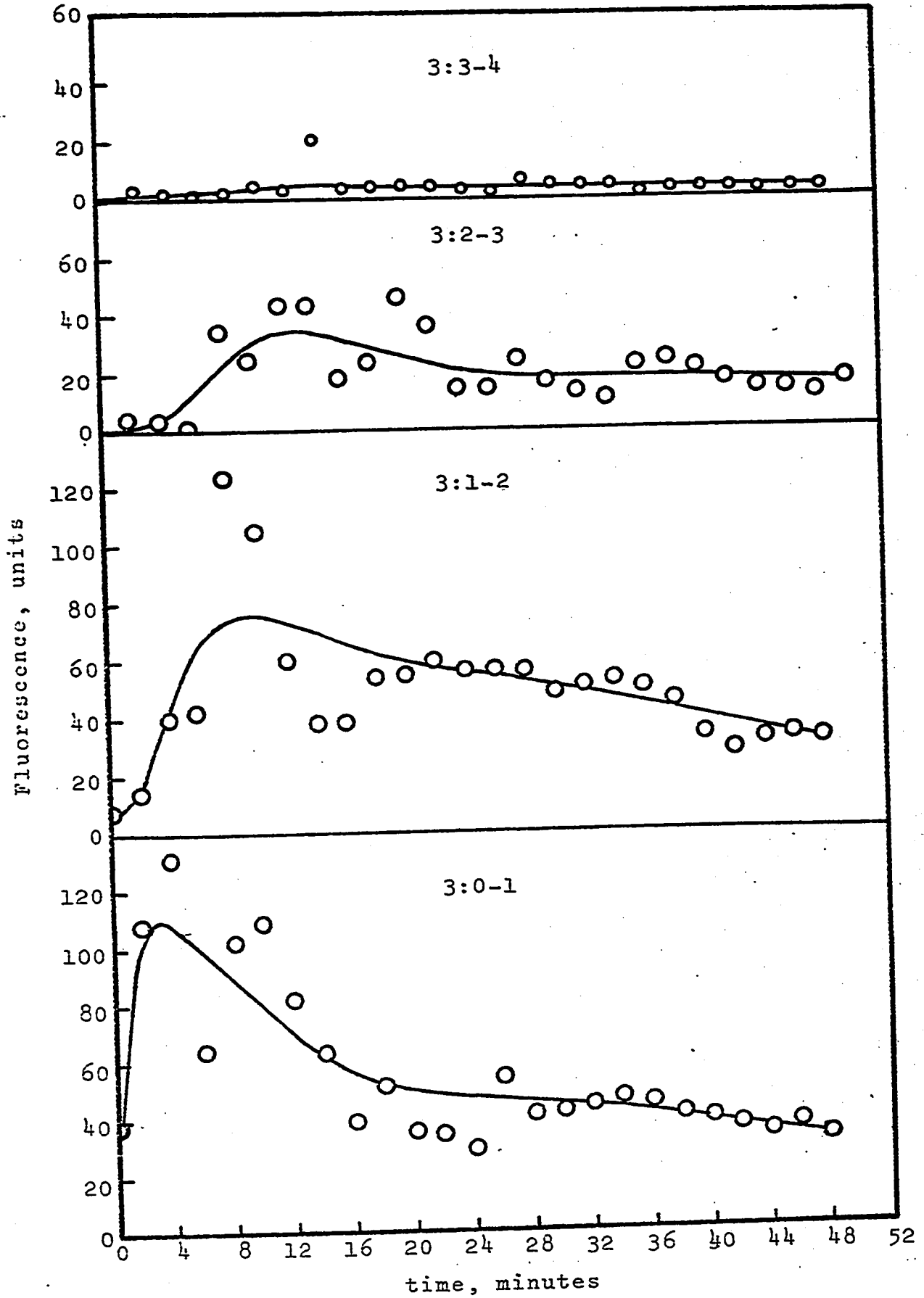


FIG. A.3.--CONTINUED

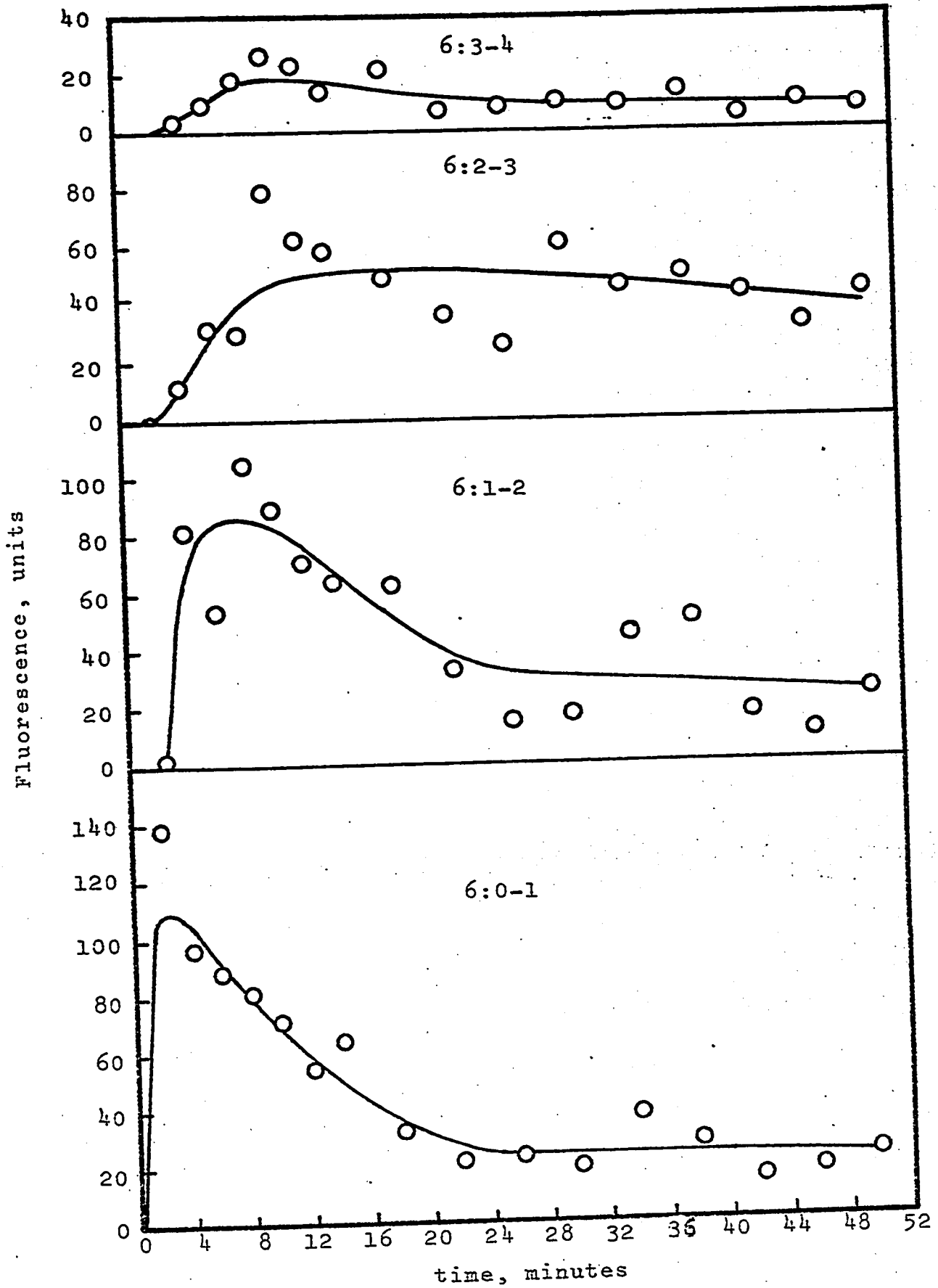


FIG. A.3.--CONTINUED

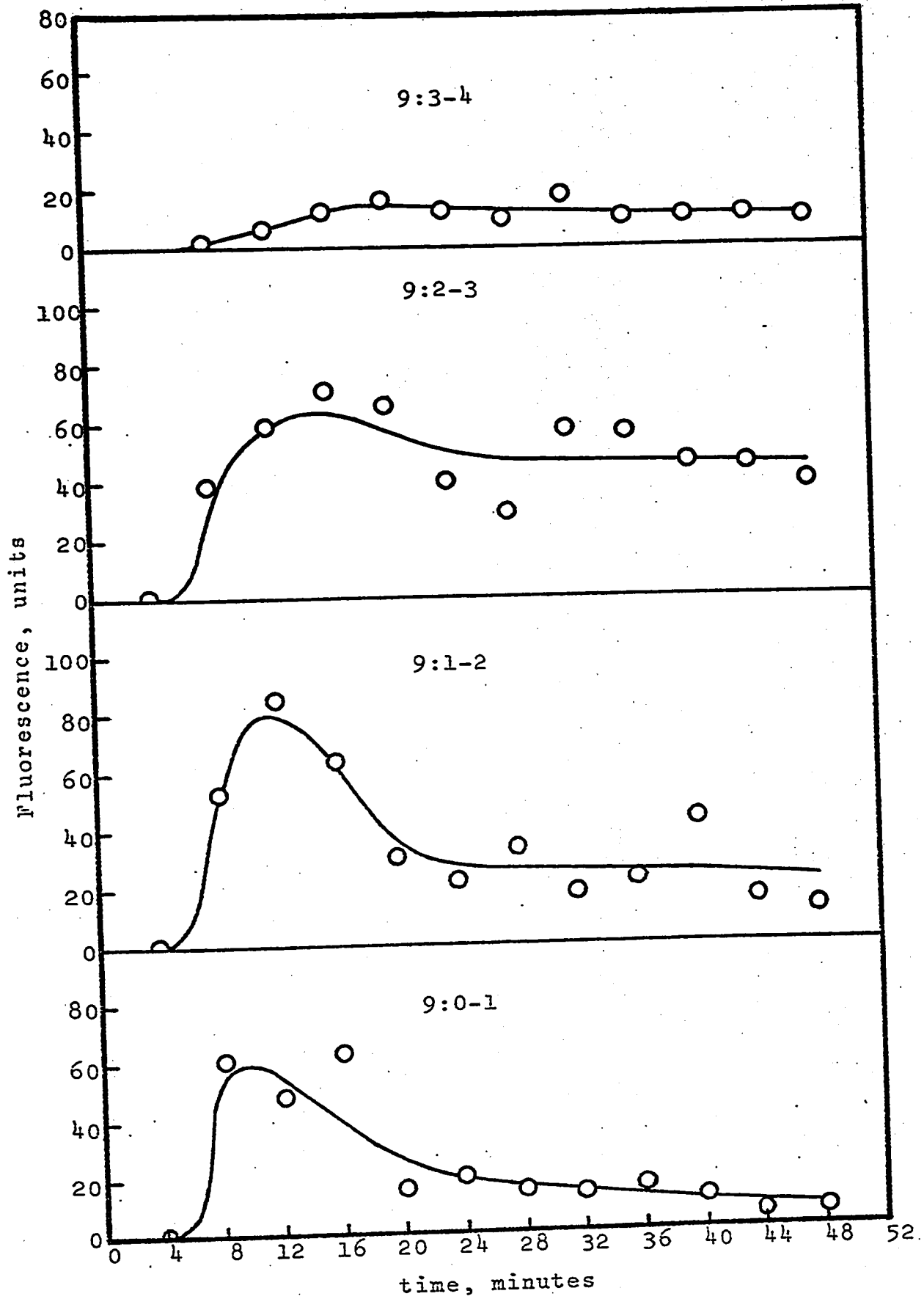


FIG. A.3.--CONTINUED

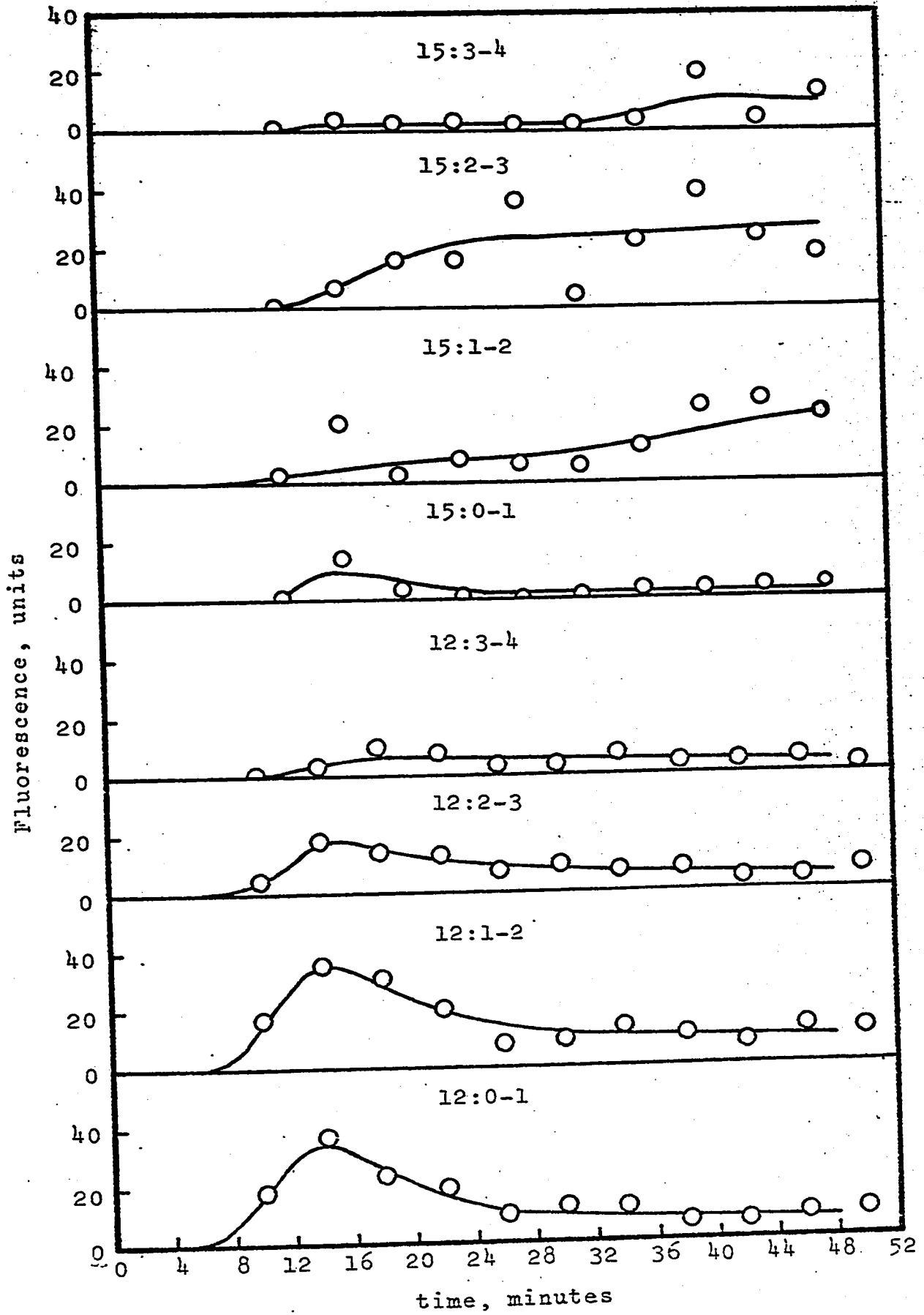


FIG. A.3.--CONTINUED

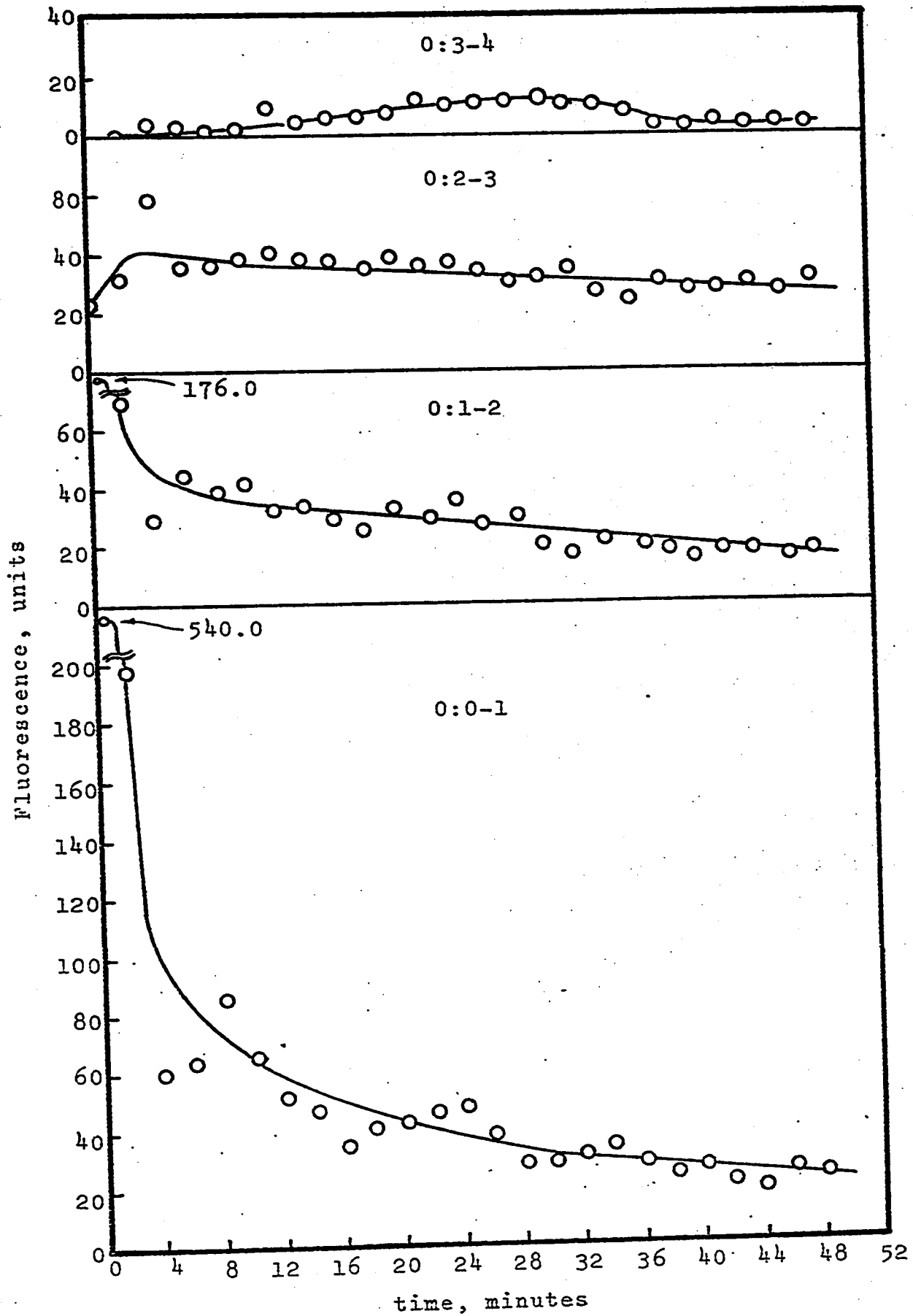


FIG. A.4.--FLUORESCENCE vs TIME FOR TEST NO. 4

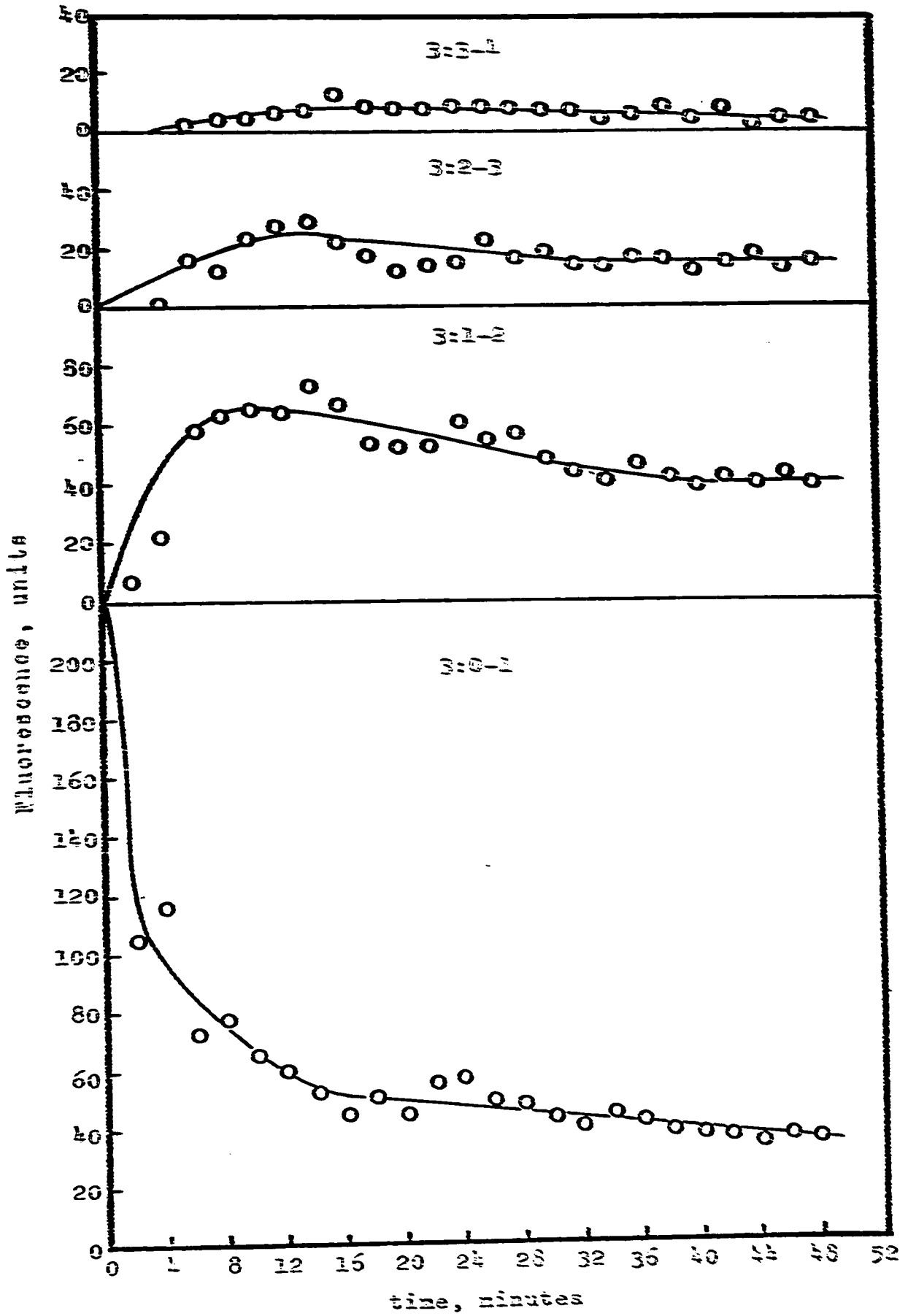


FIG. A.4.--CONTINUED

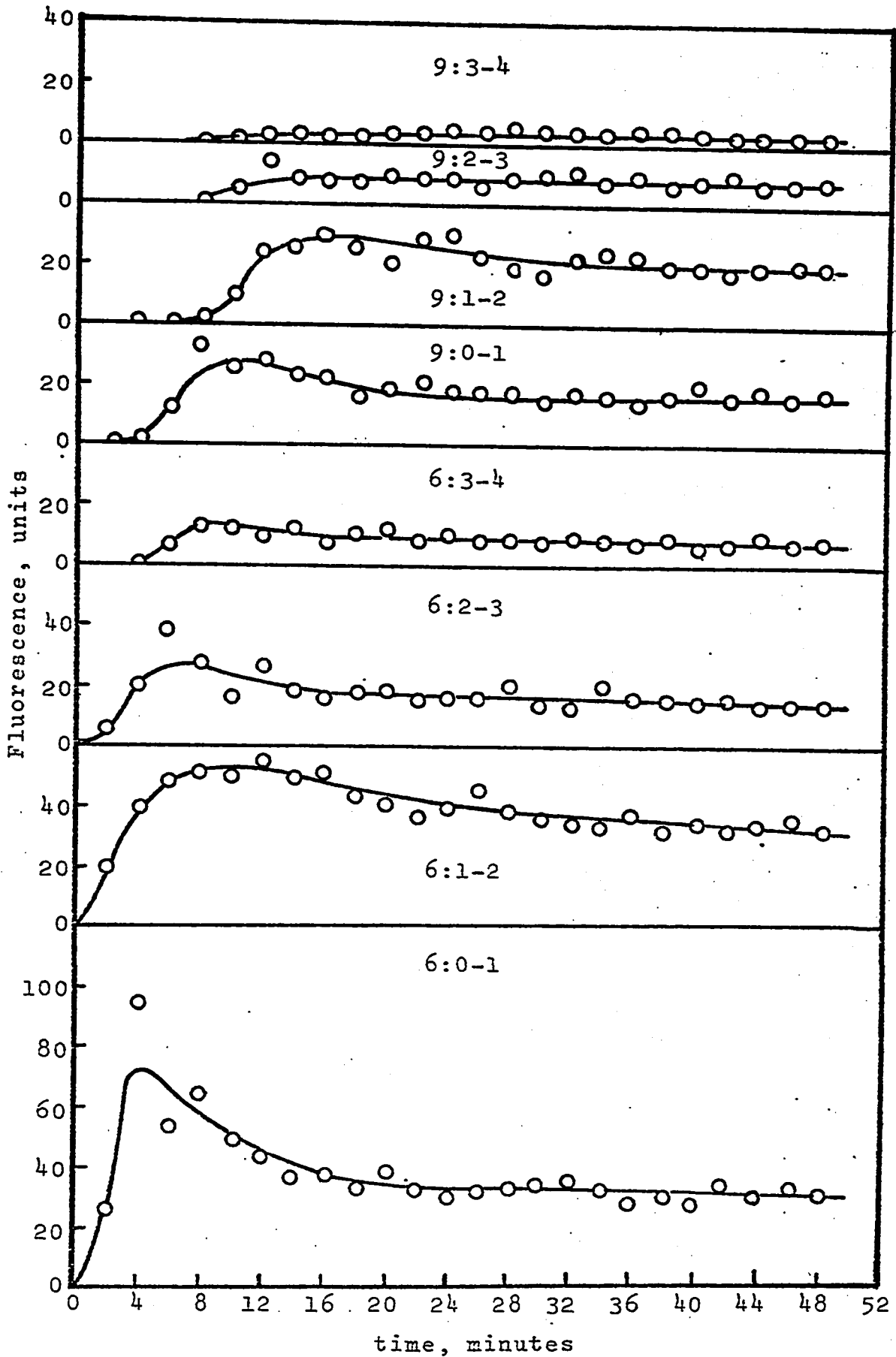


FIG. A.4.--CONTINUED

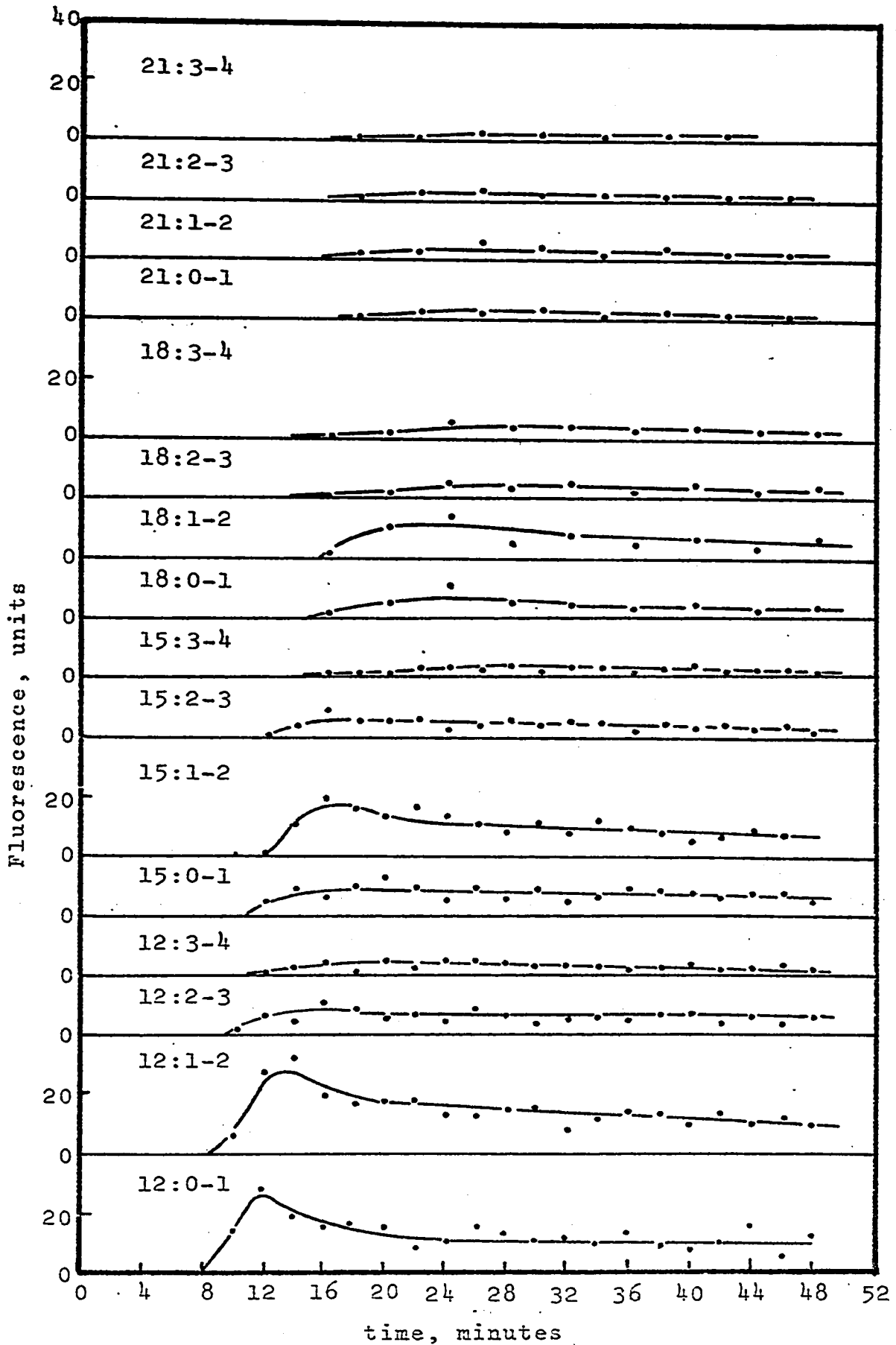


FIG. A.4.--CONTINUED

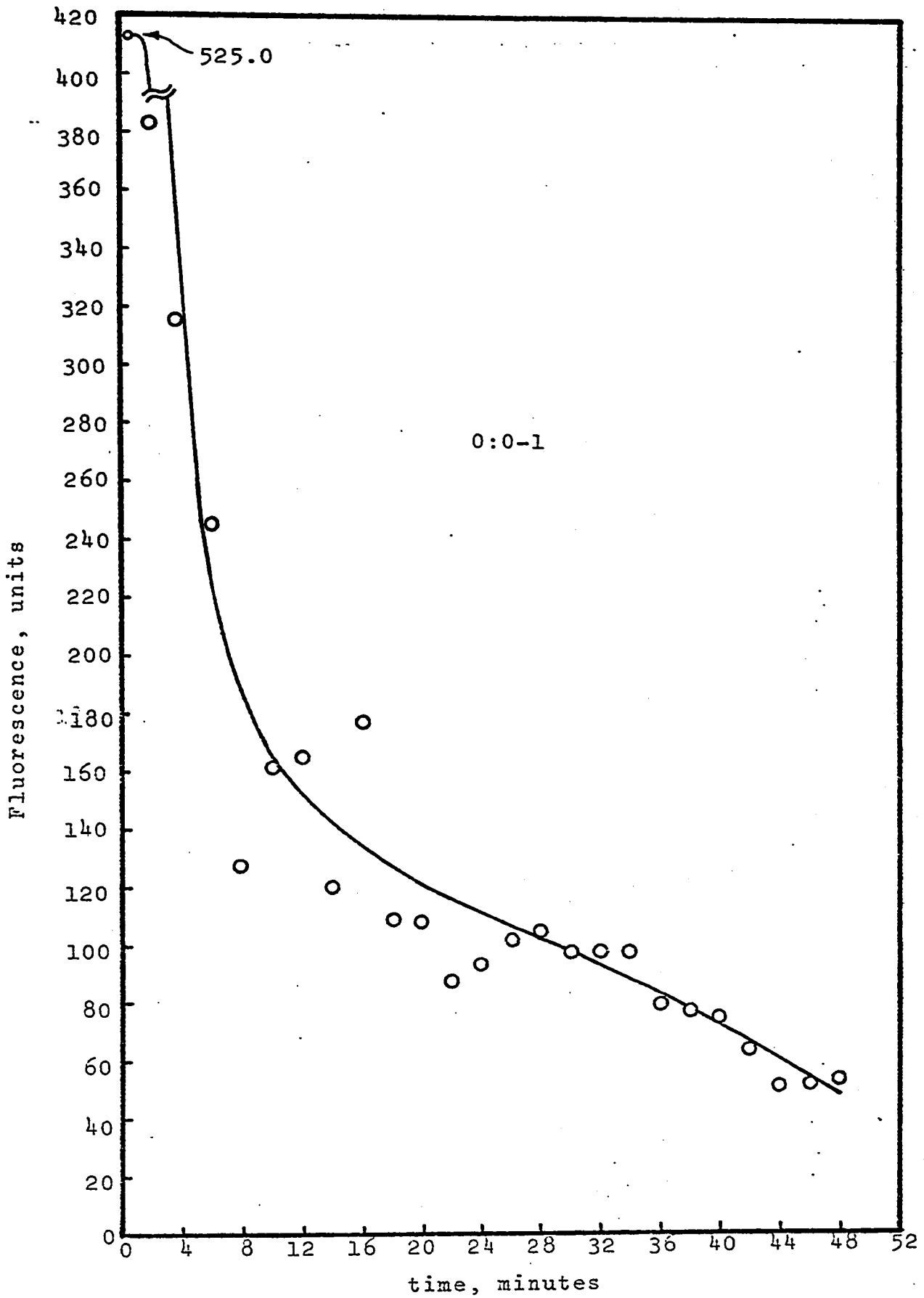


FIG. A.5.--FLUORESCENCE vs TIME FOR TEST NO. 5

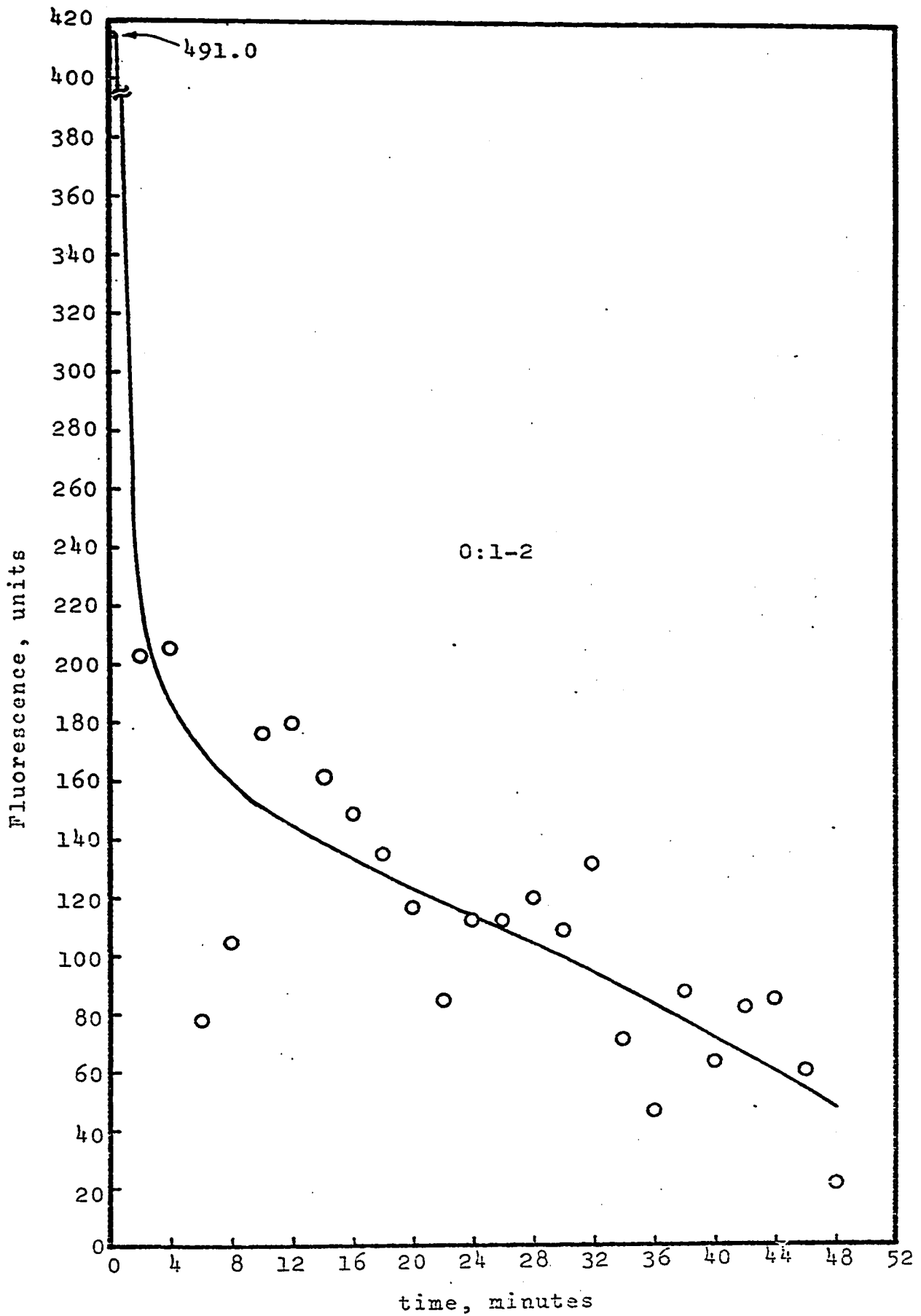


FIG. A.5.--CONTINUED

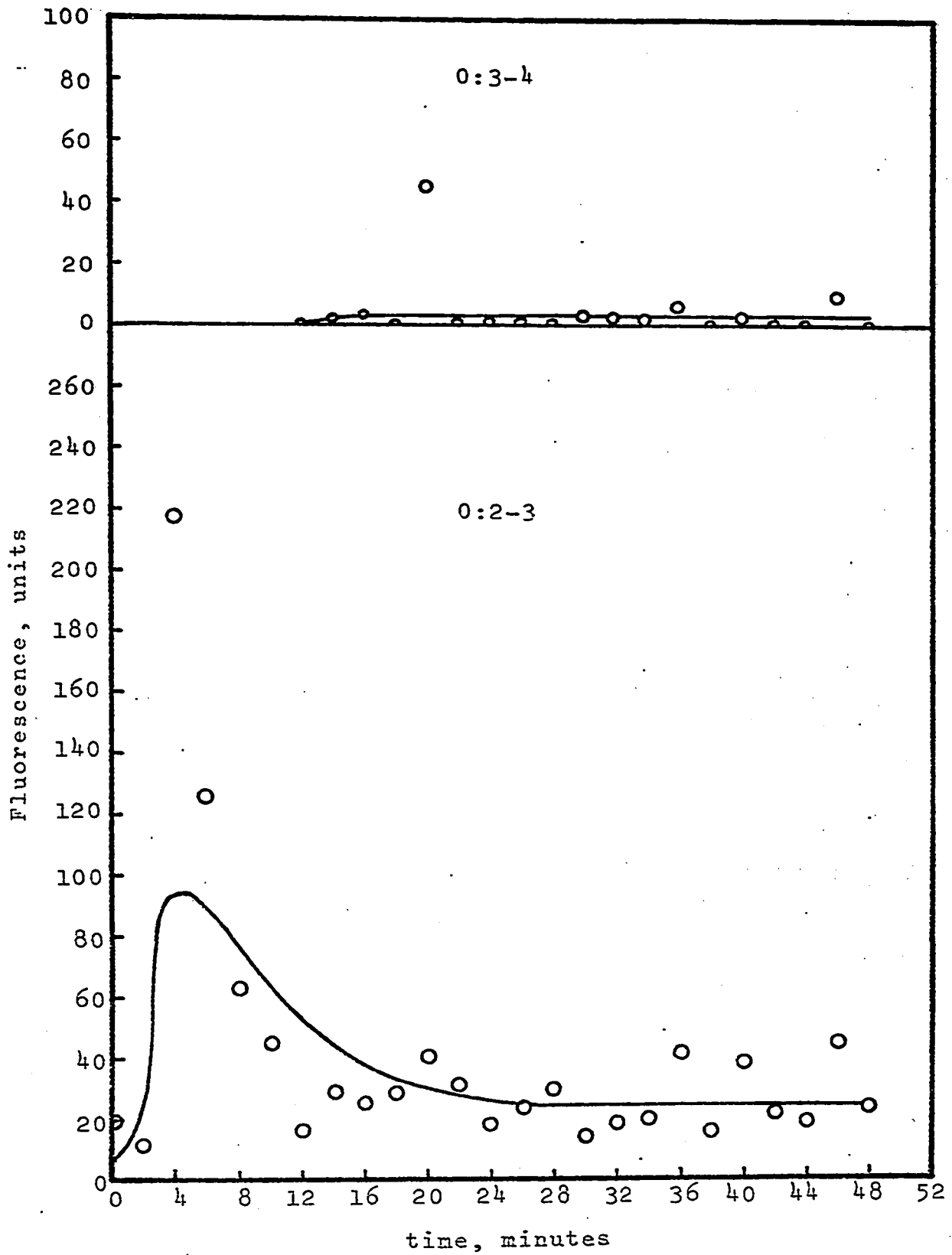


FIG. A.5.--CONTINUED

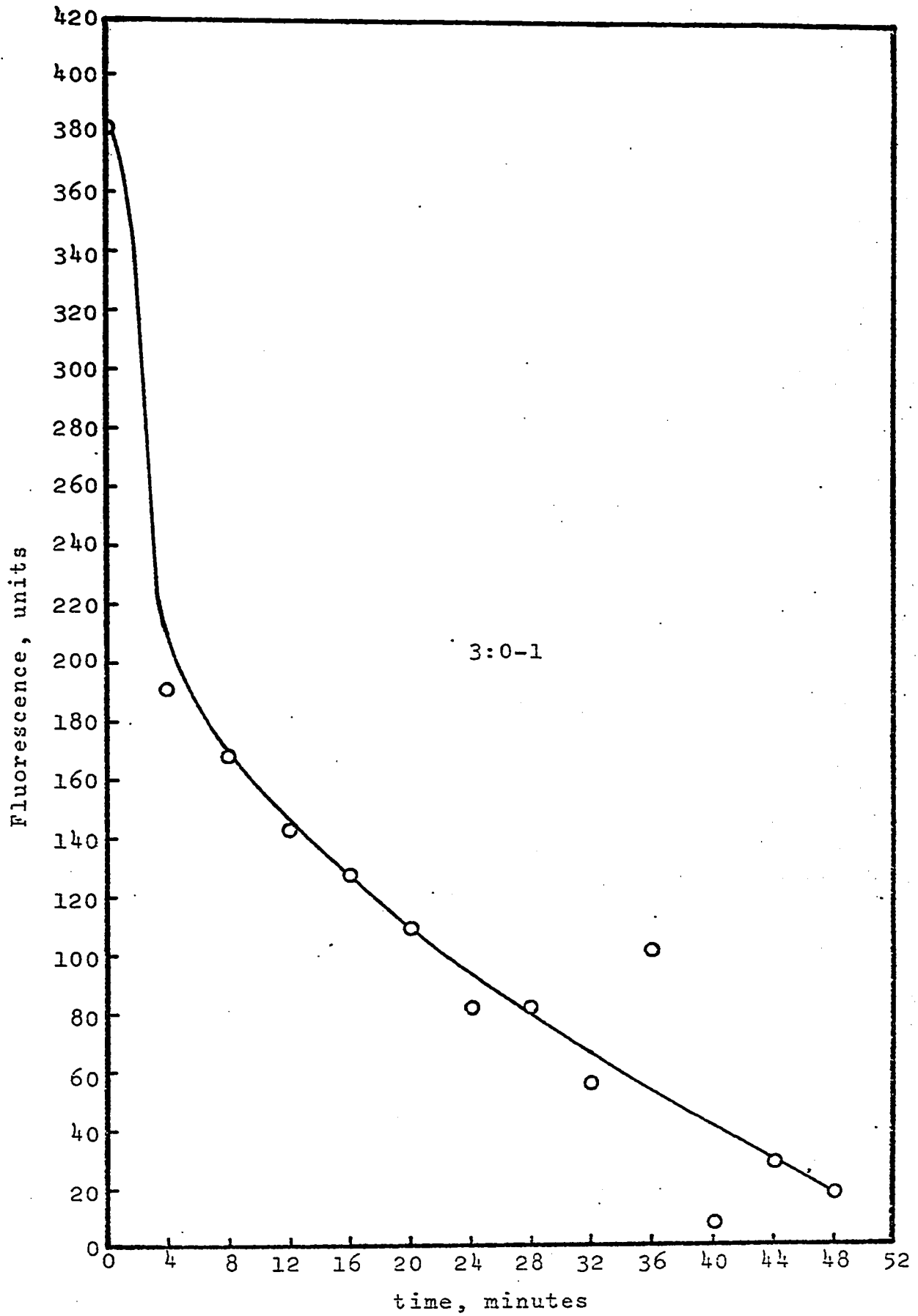


FIG. A.5.--CONTINUED

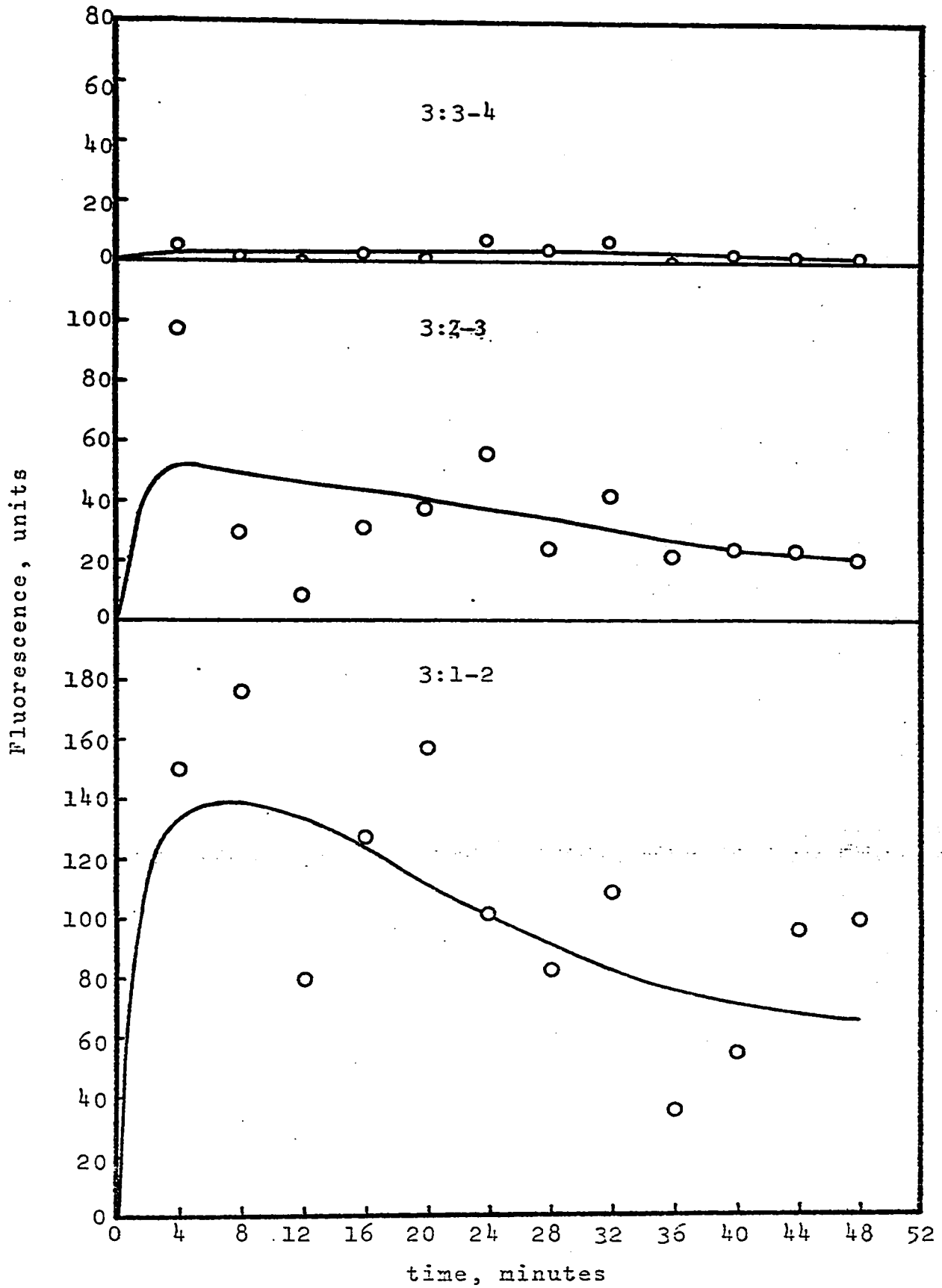


FIG. A.5.--CONTINUED

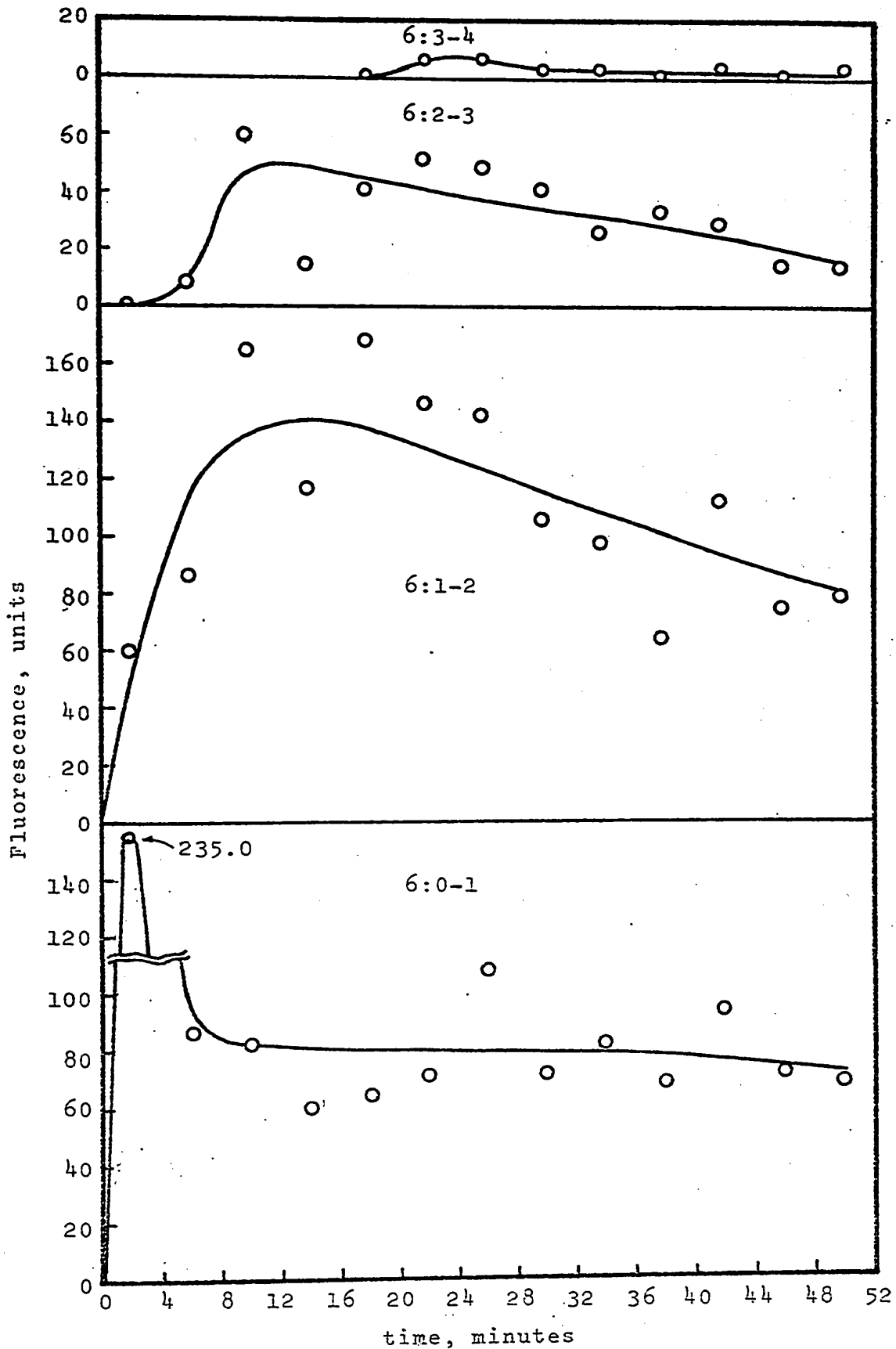


FIG. A.5.--CONTINUED

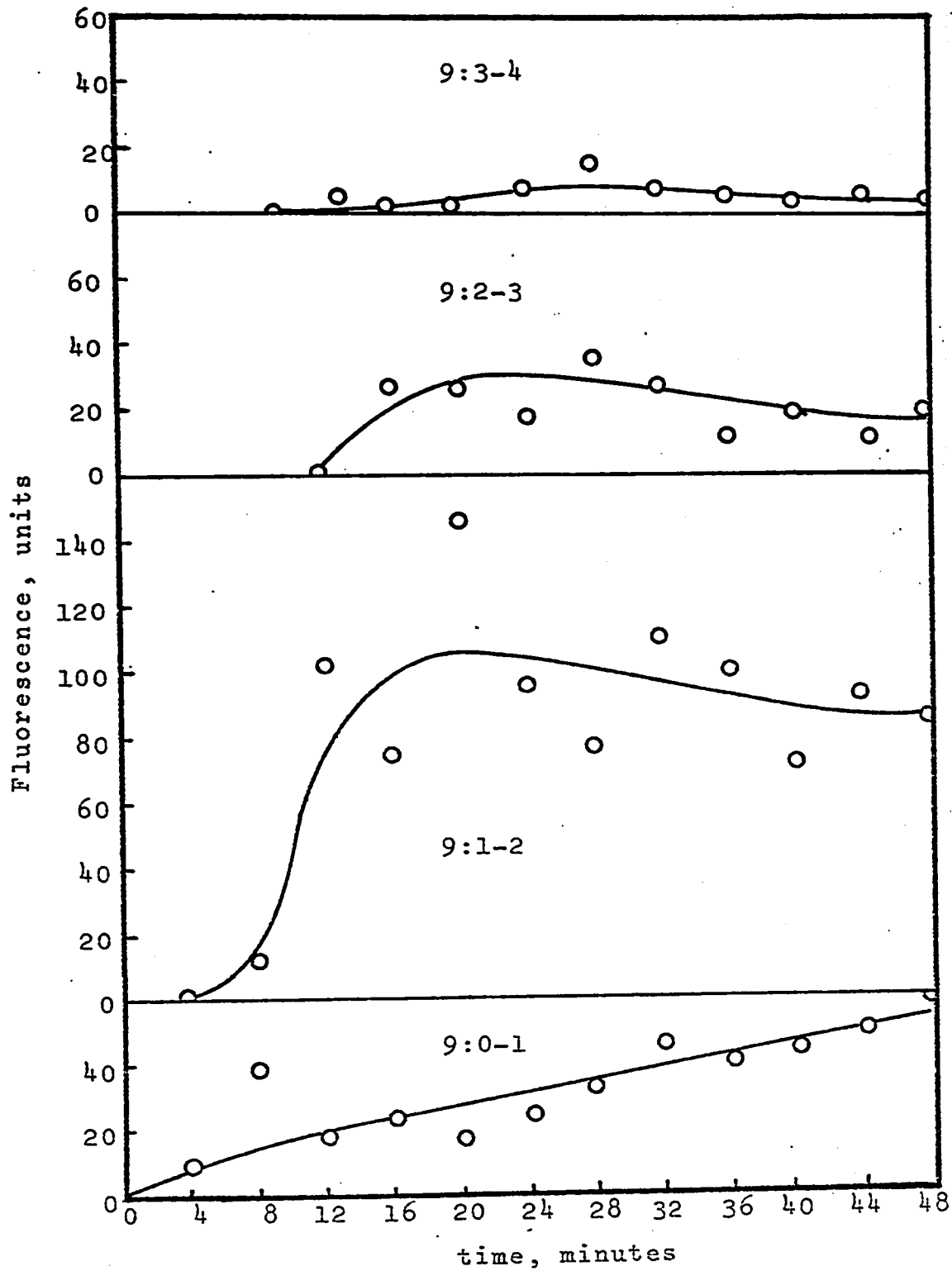


FIG. A.5.--CONTINUED

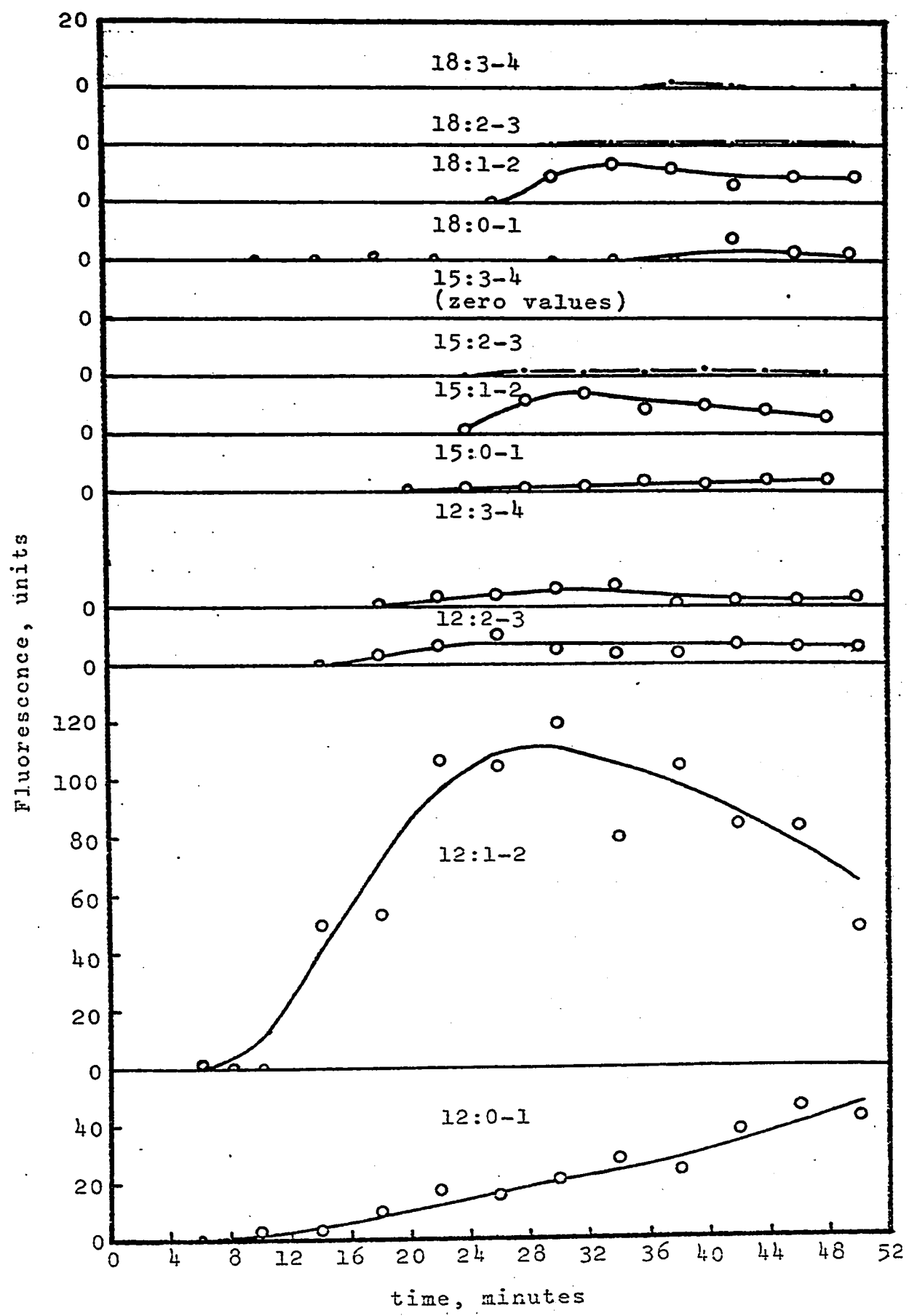


FIG. A.5.--CONTINUED

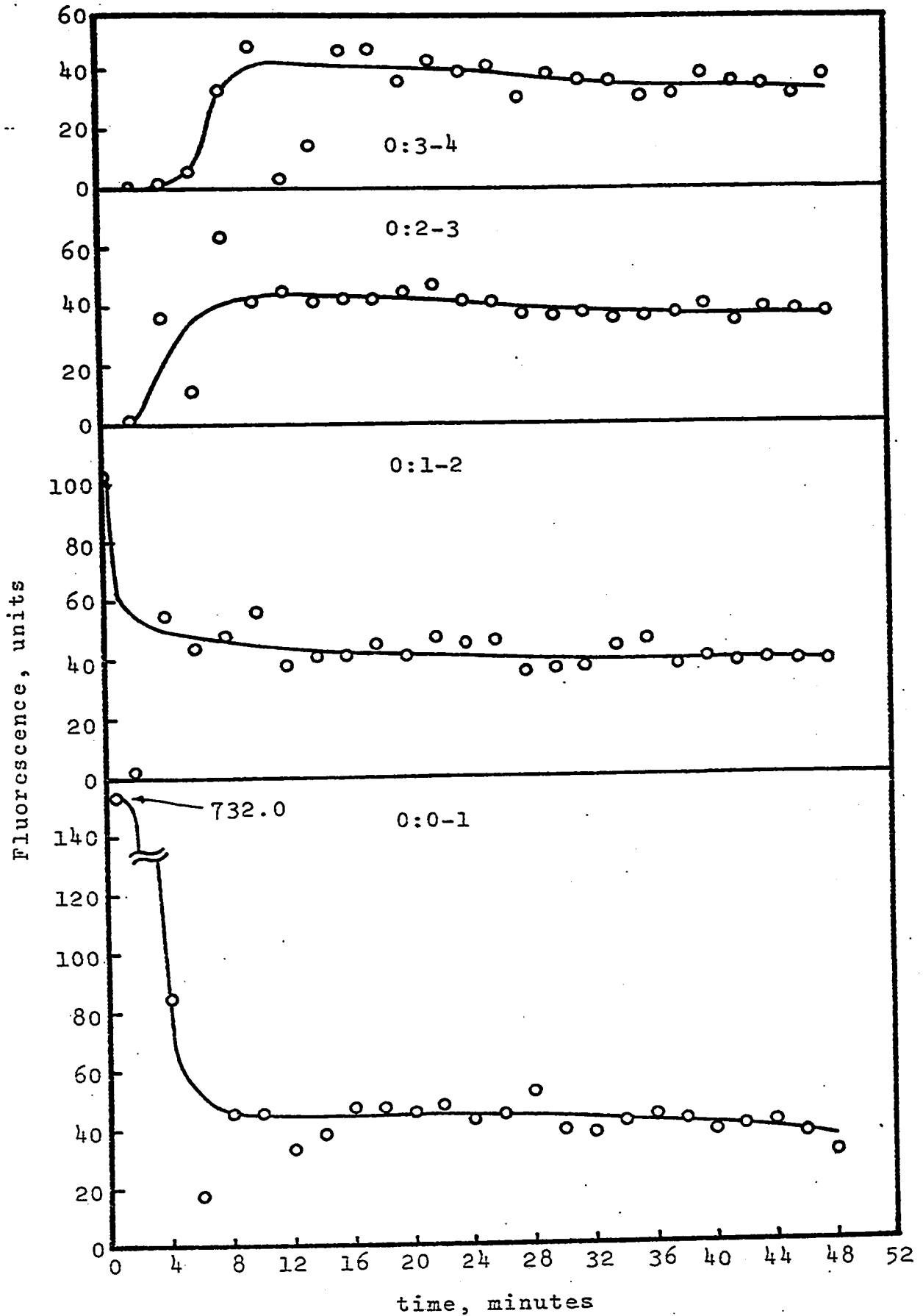


FIG. A.6.--FLUORESCENCE vs TIME FOR TEST NO. 6

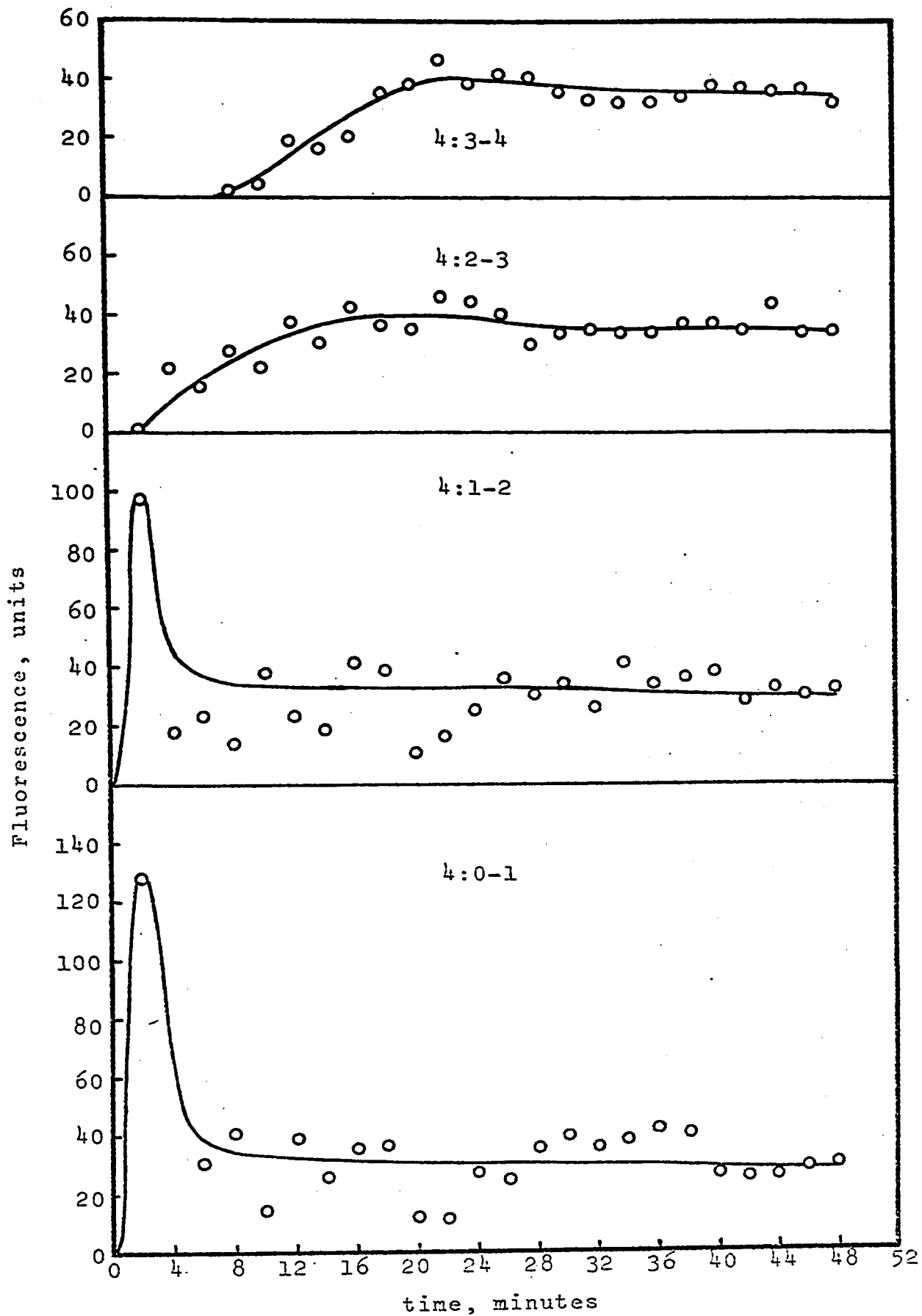


FIG. A.6.--CONTINUED

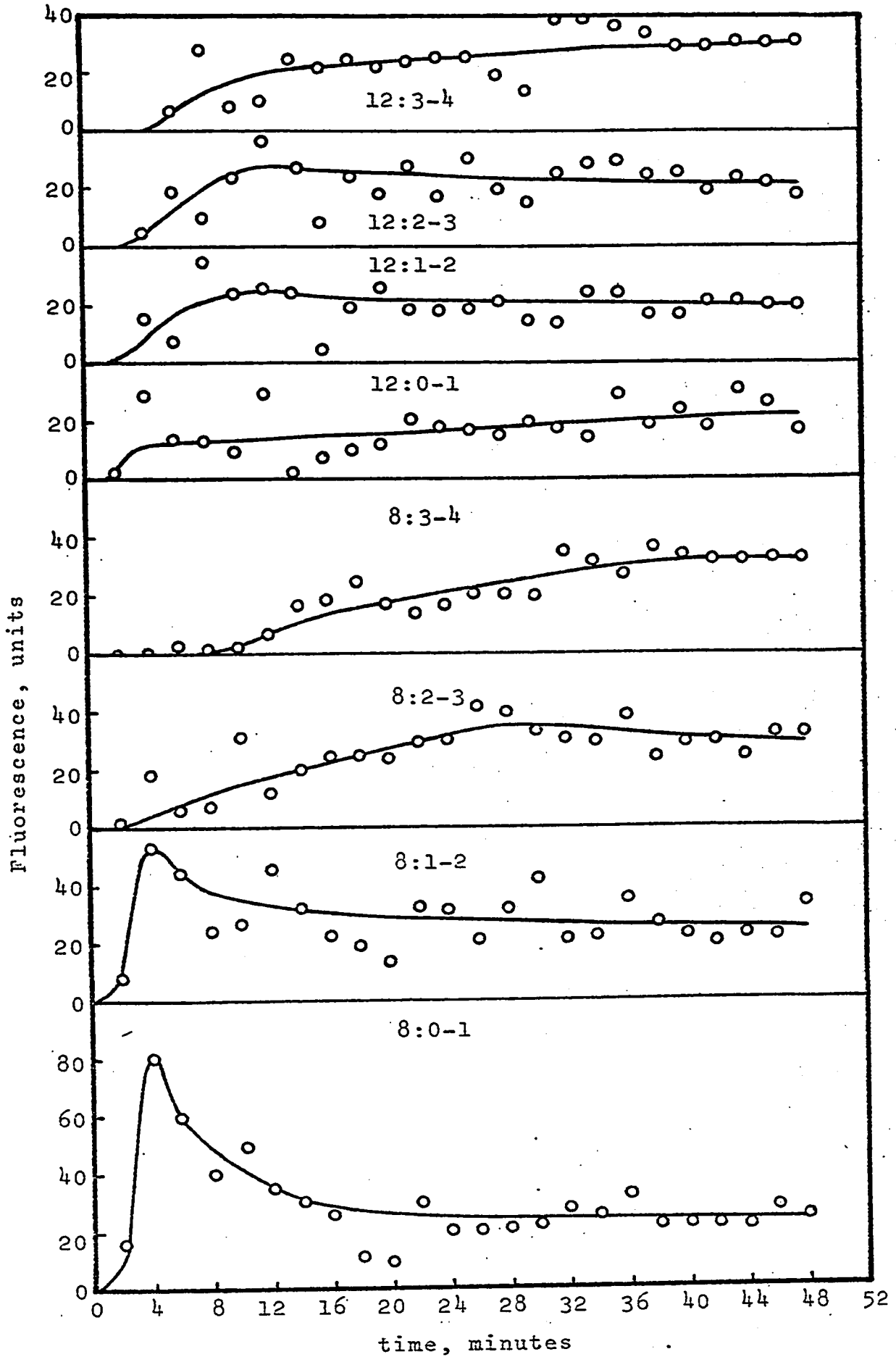


FIG. A.6.--CONTINUED

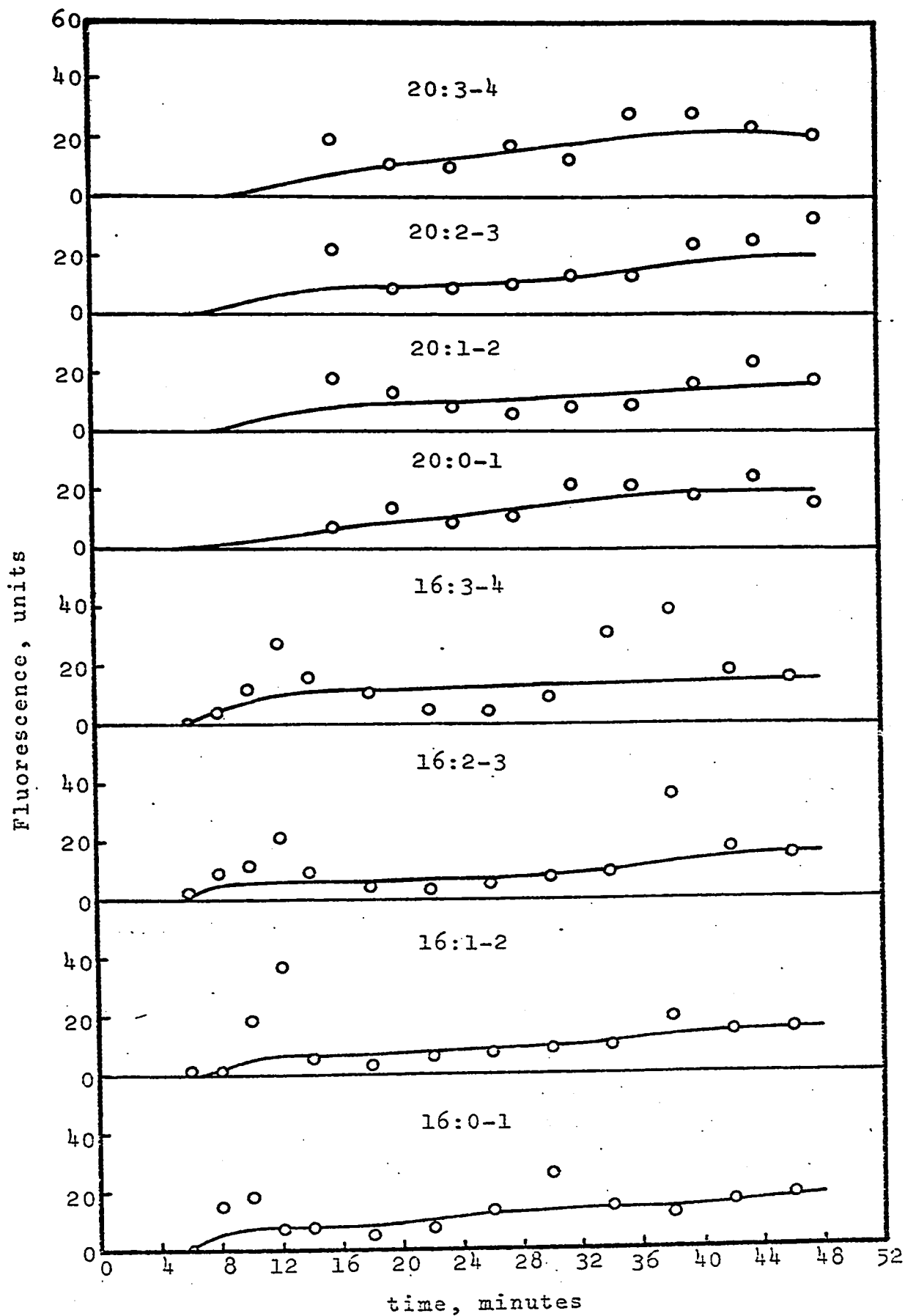


FIG. A.6.--CONTINUED

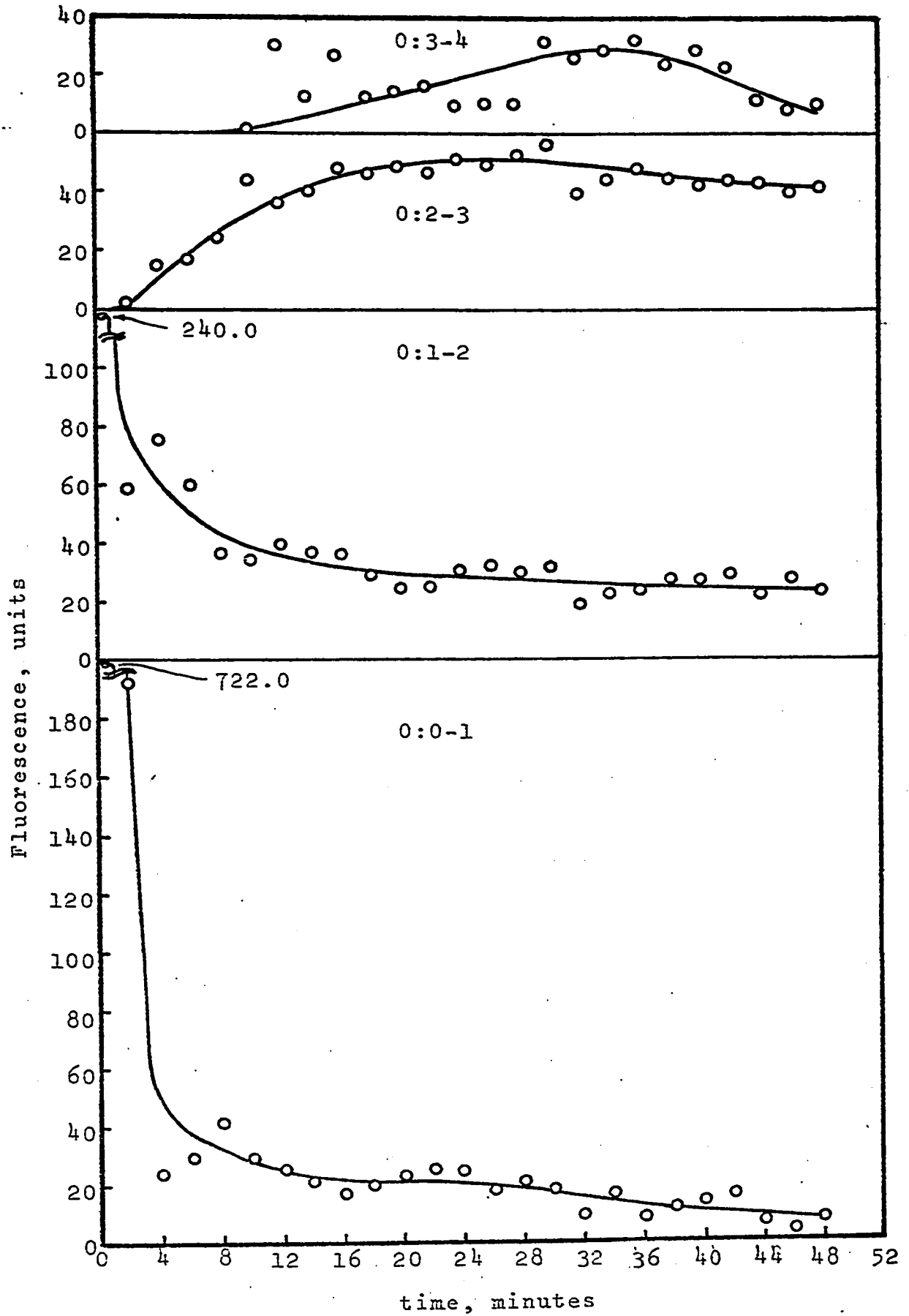


FIG. A.7.--FLUORESCENCE vs TIME FOR TEST NO. 7

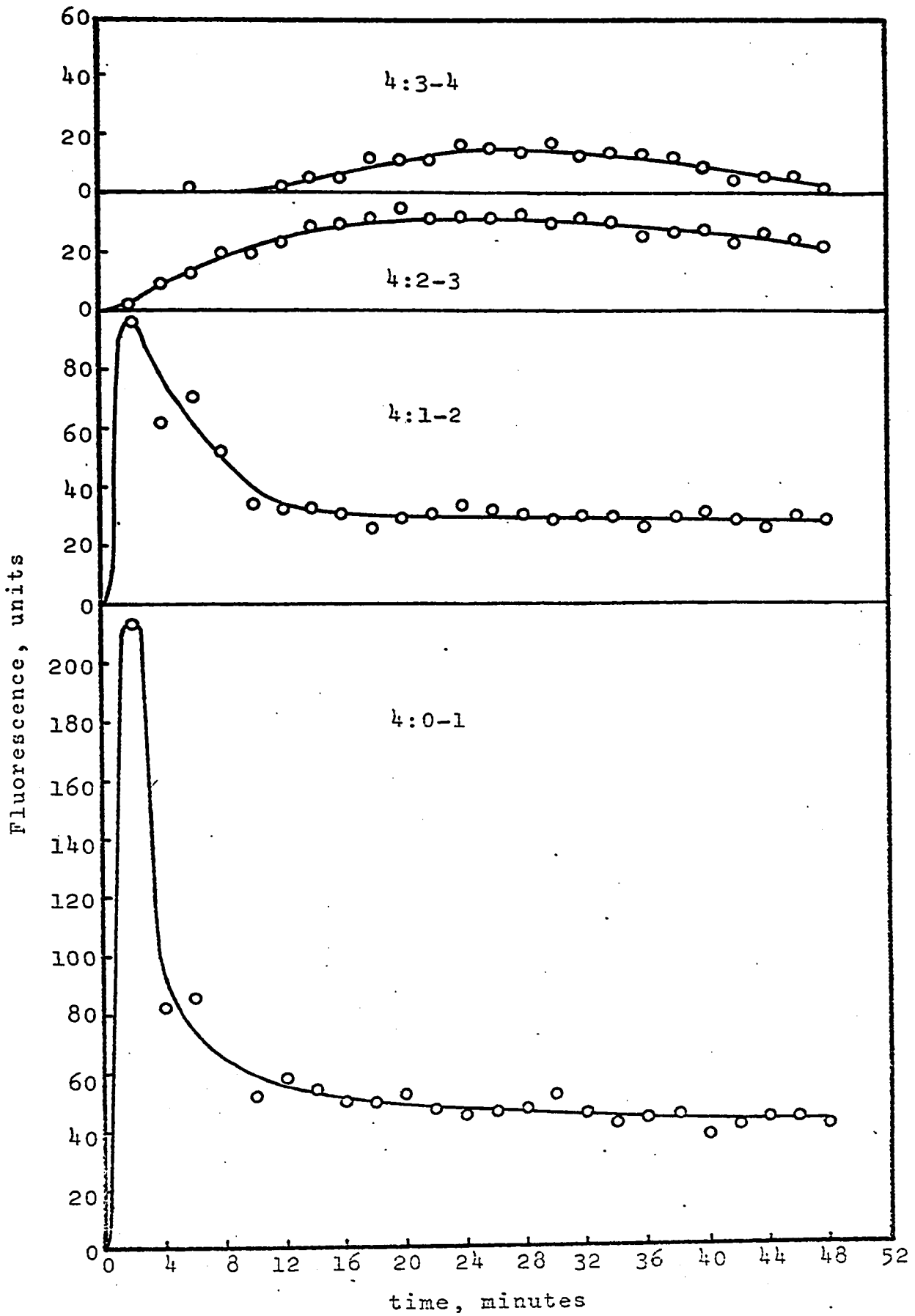


FIG. A.7.--CONTINUED

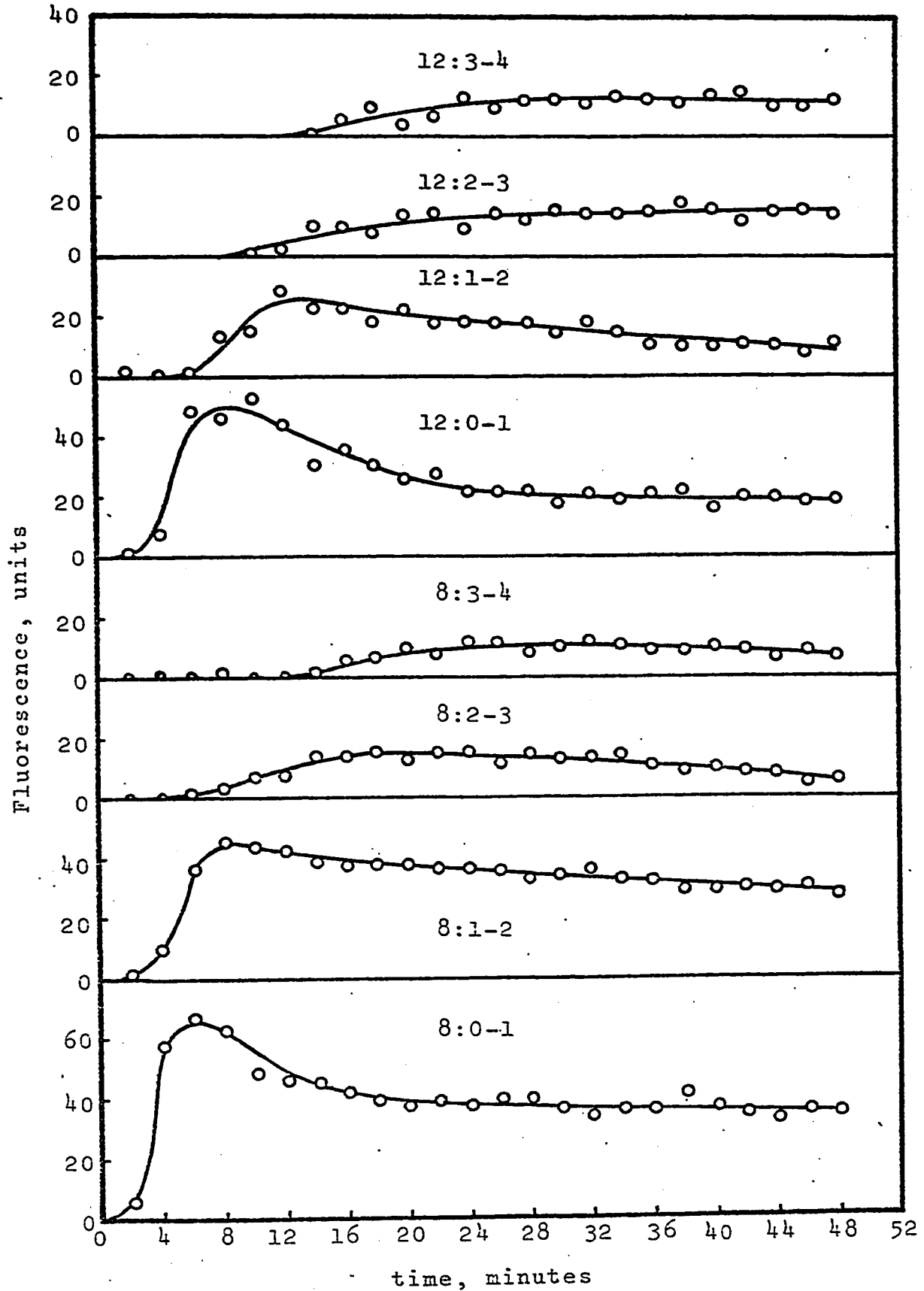


FIG. A.7.--CONTINUED

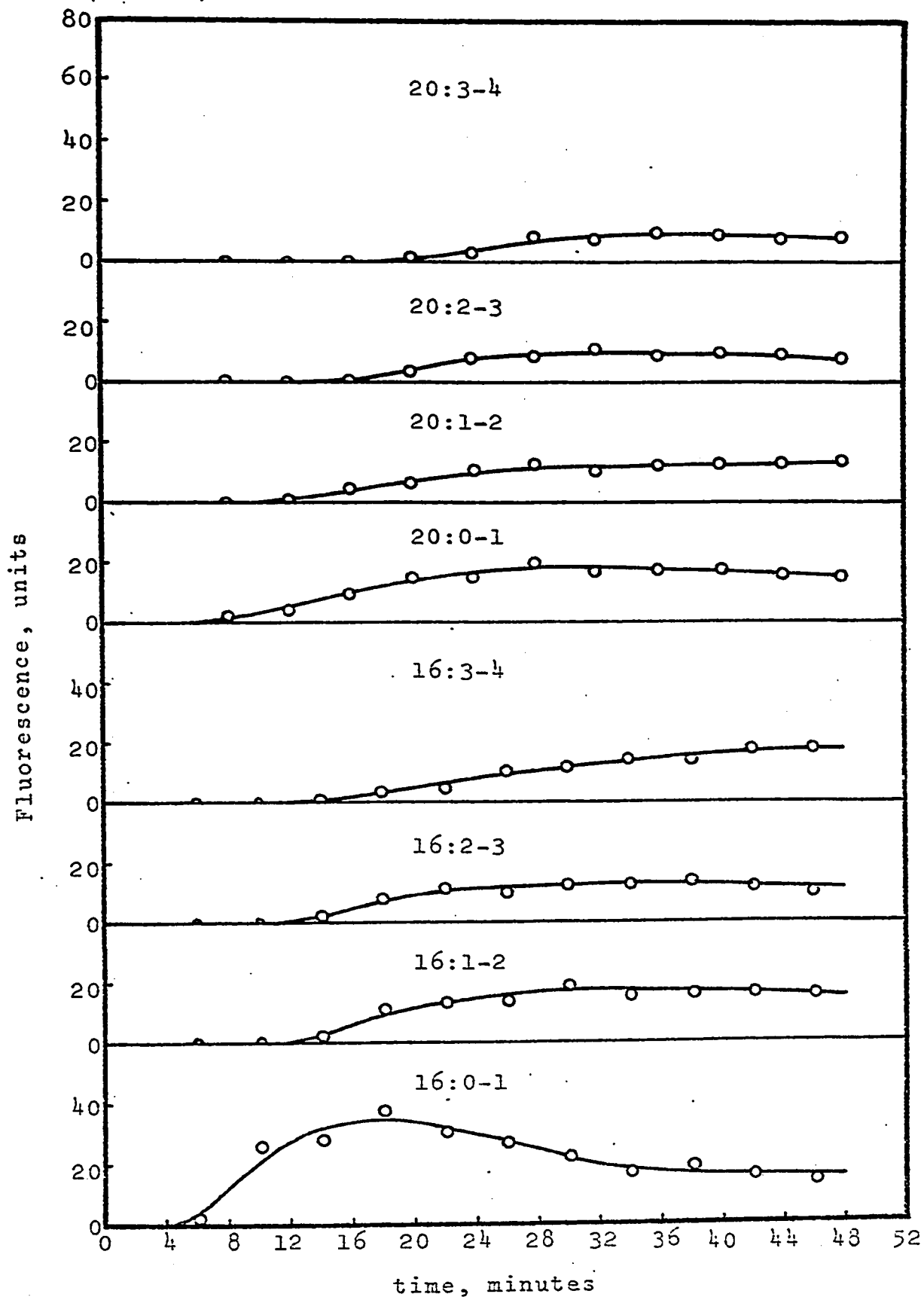


FIG. A.7.--CONTINUED

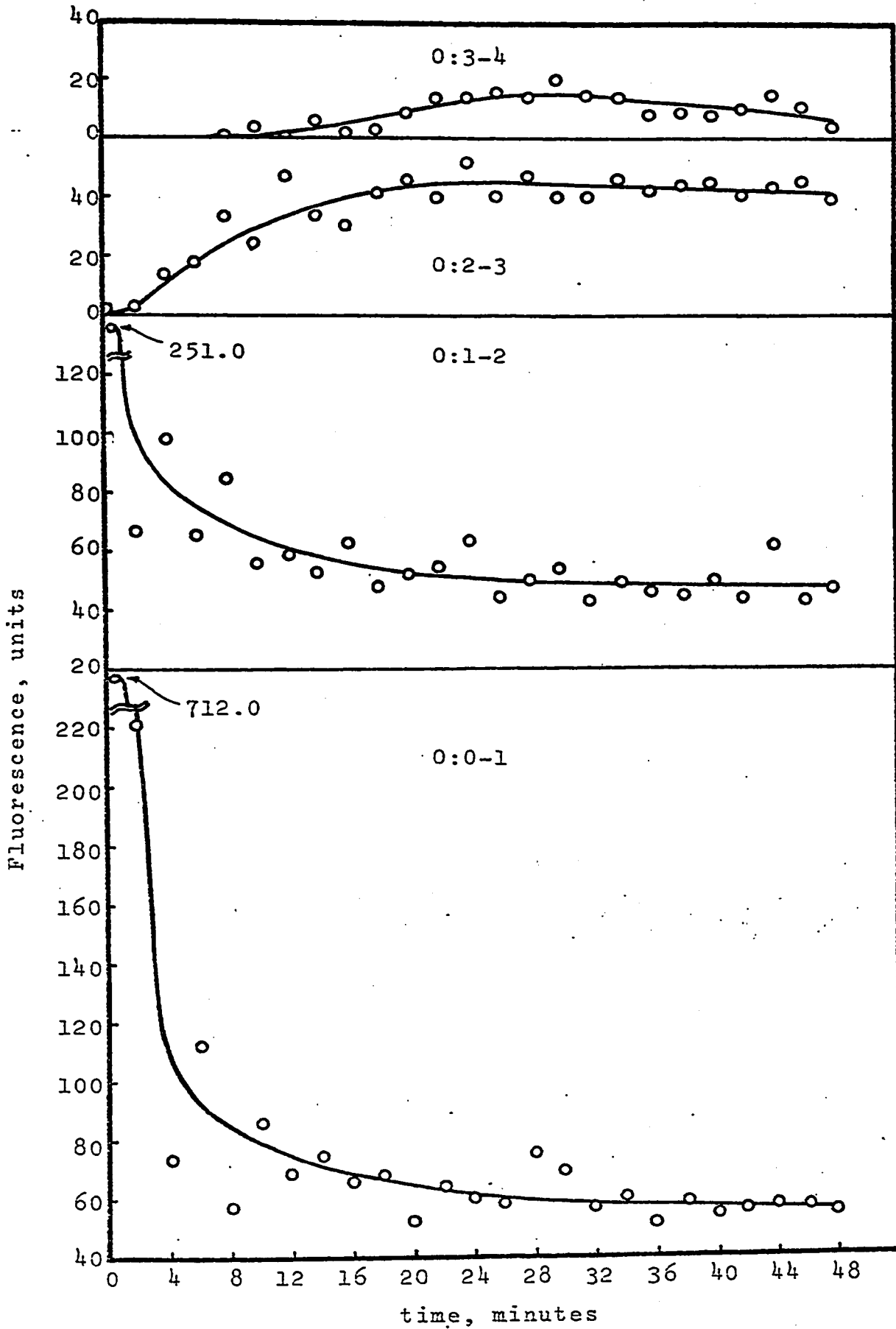


FIG. A.8.--FLUORESCENCE vs TIME FOR TEST NO. 8

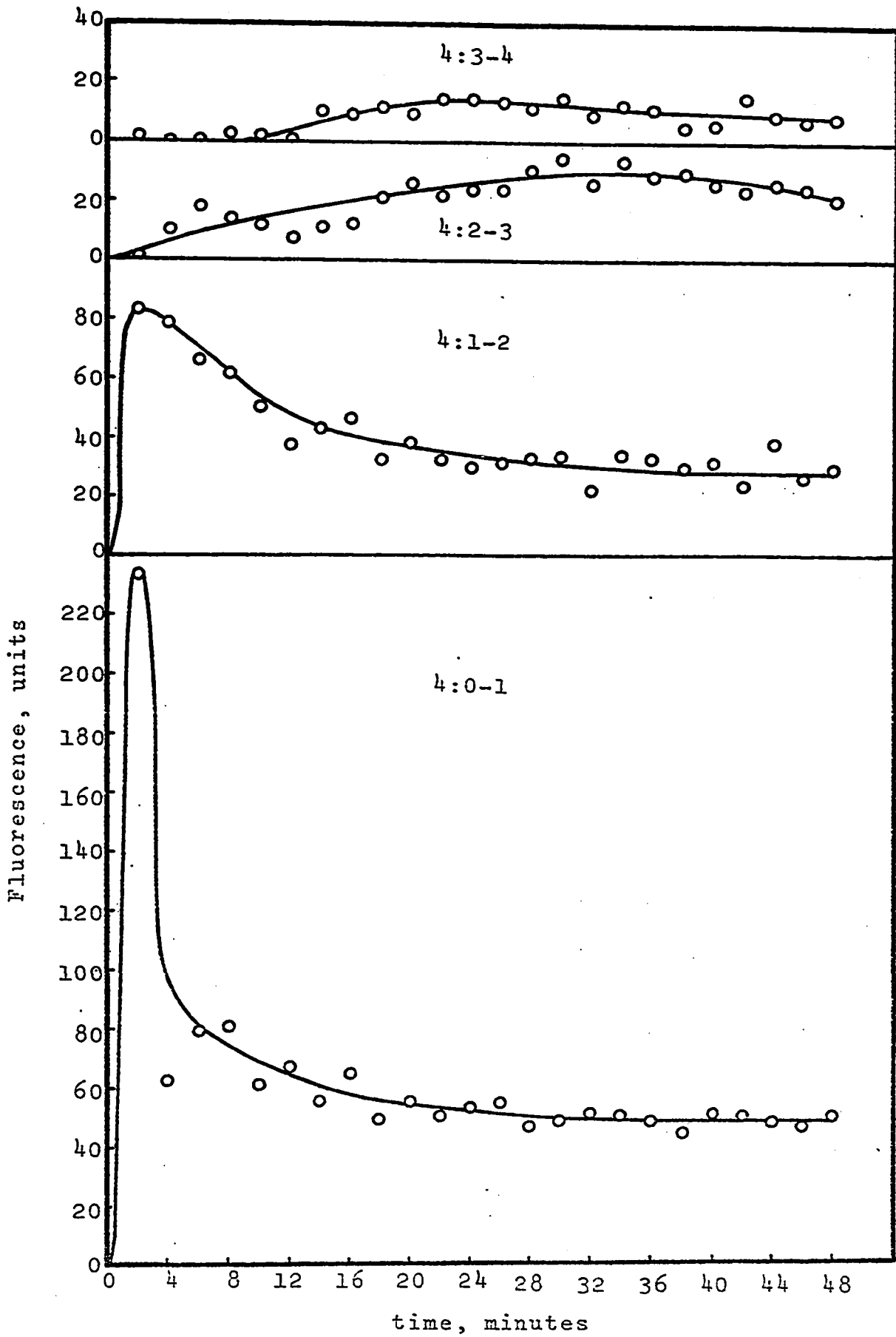


FIG. A.8.--CONTINUED

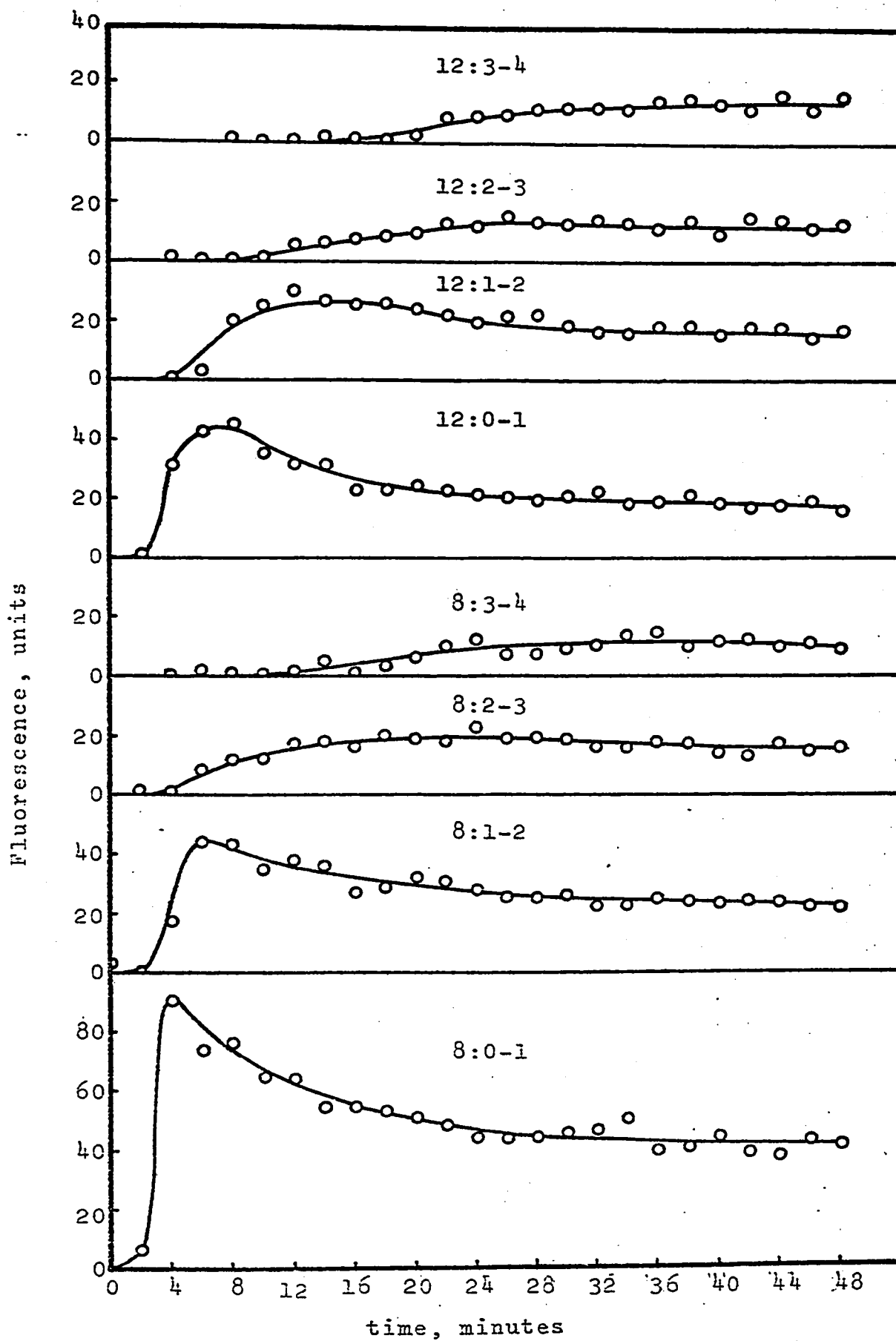


FIG. A.8.--CONTINUED

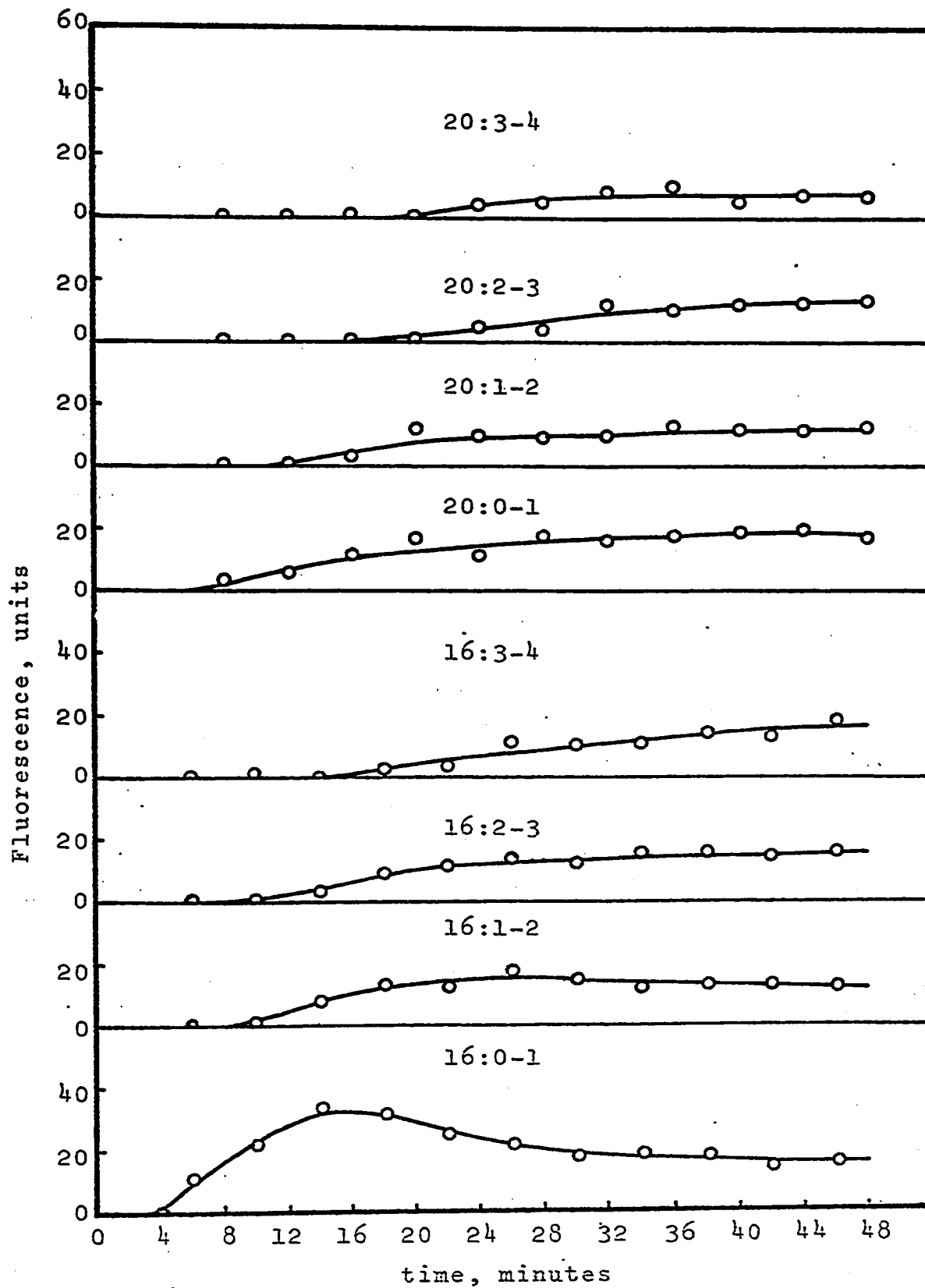


FIG. A.8.--CONTINUED

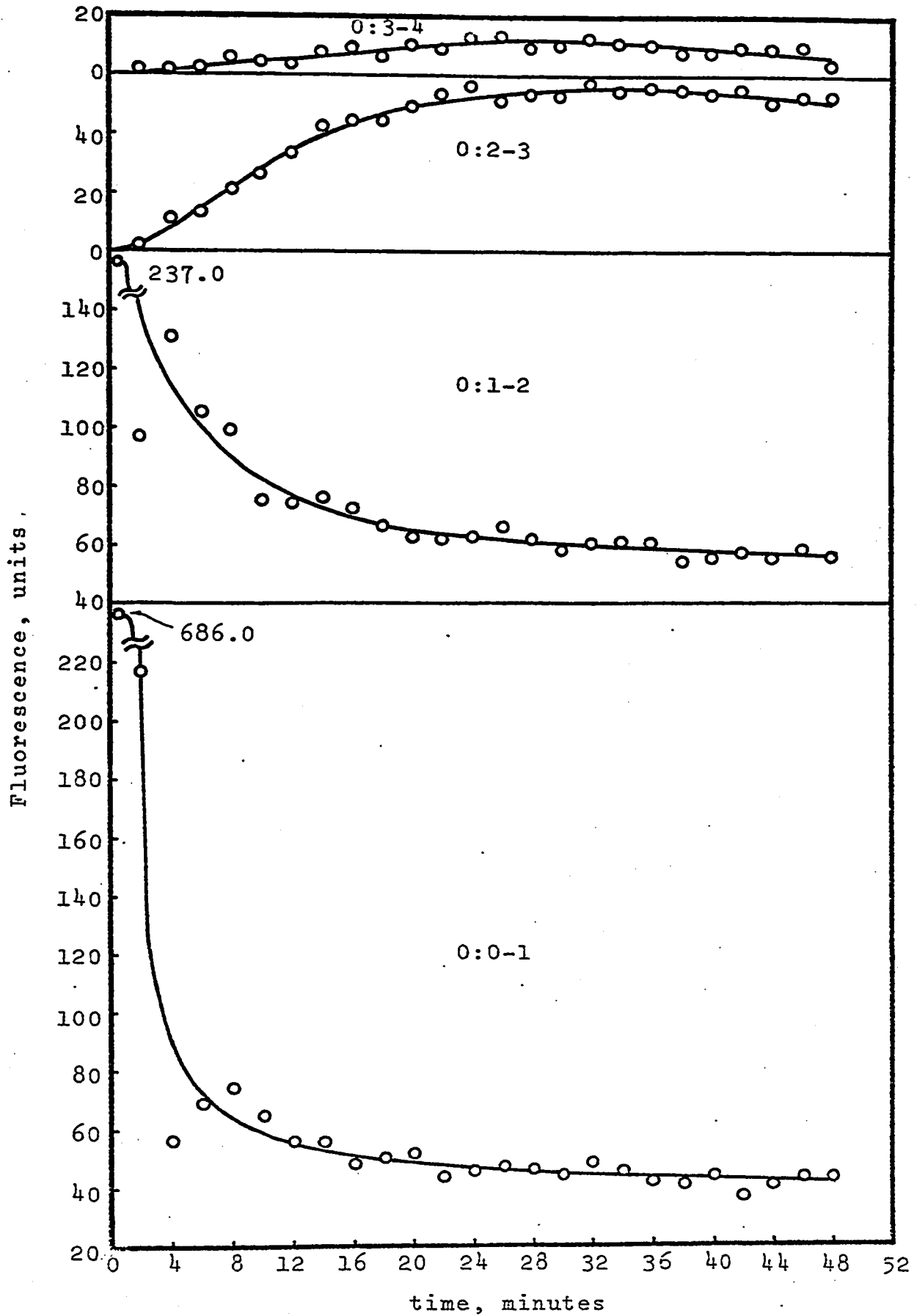


FIG. A.9.--FLUORESCENCE vs TIME FOR TEST NO. 9

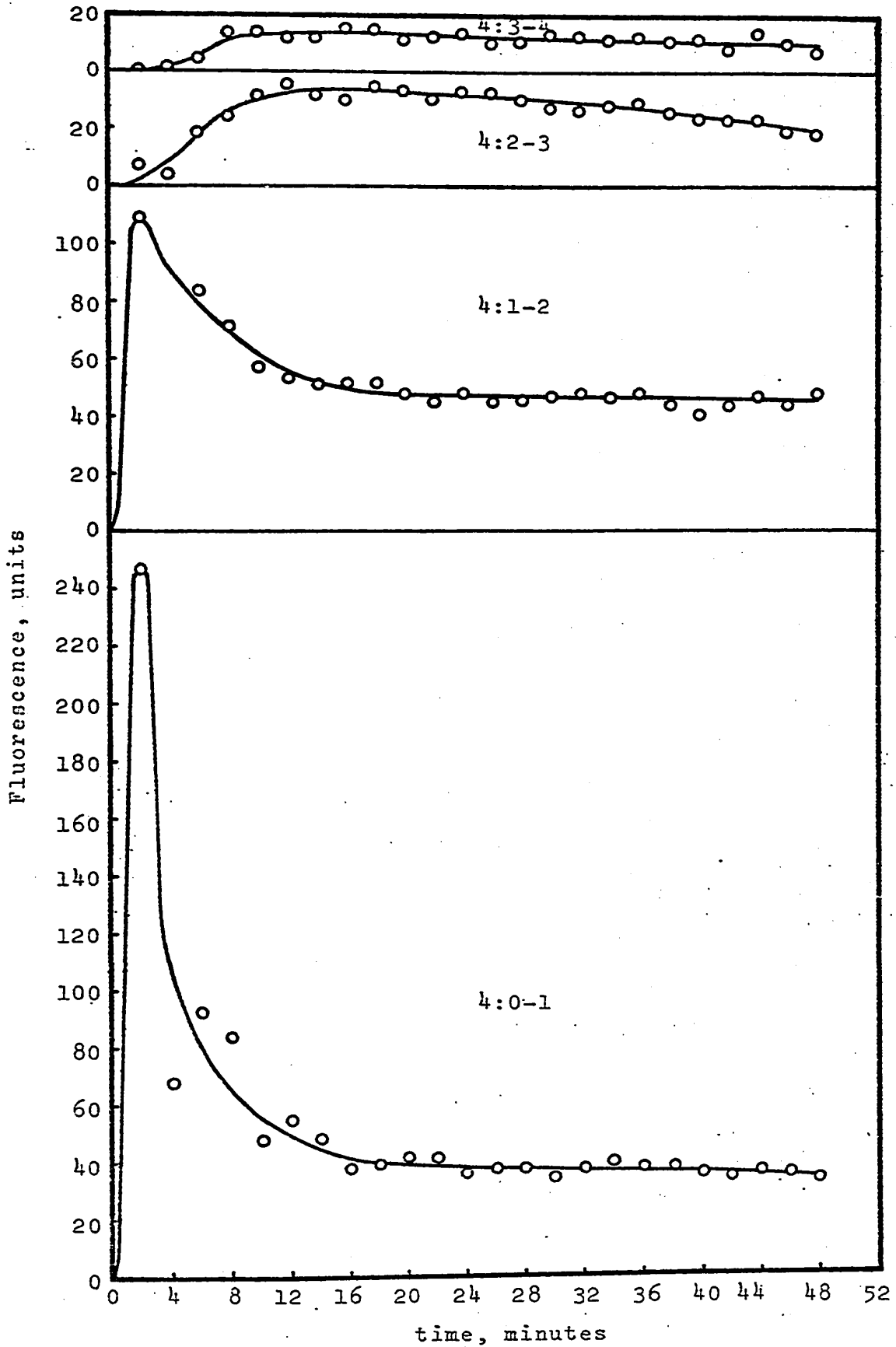


FIG. A.9.--CONTINUED

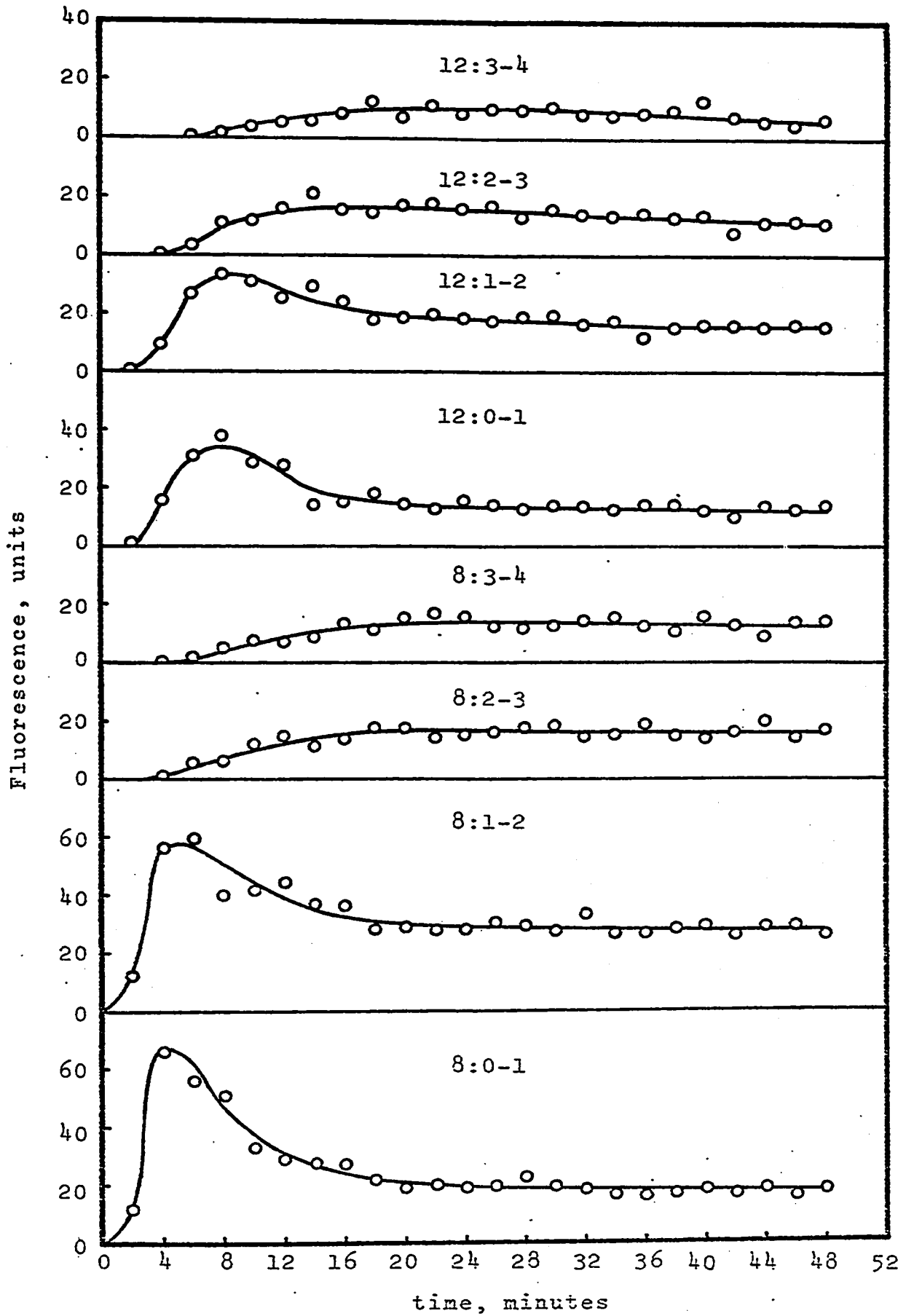


FIG. A.9.--CONTINUED

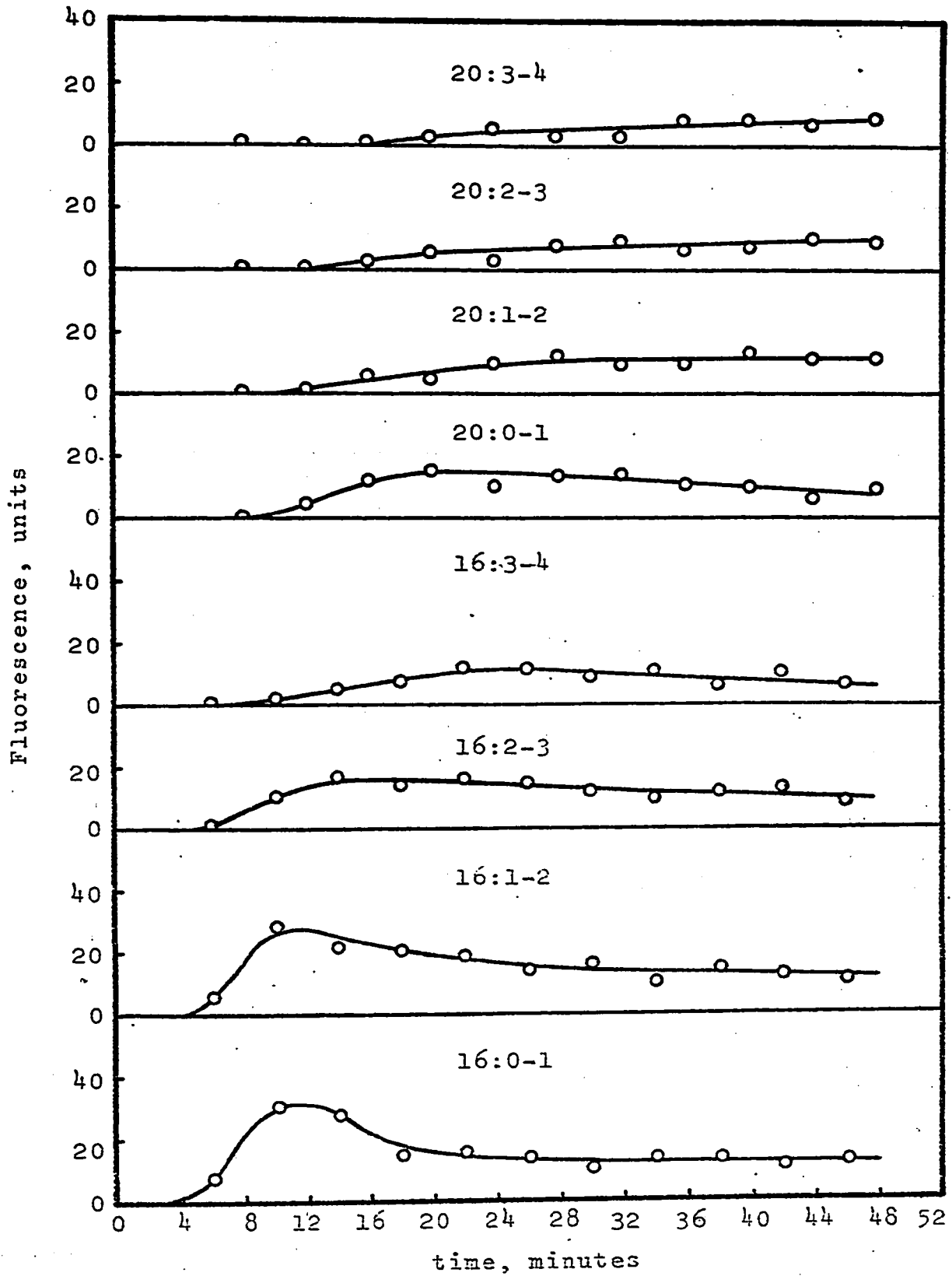


FIG. A.9.--CONTINUED

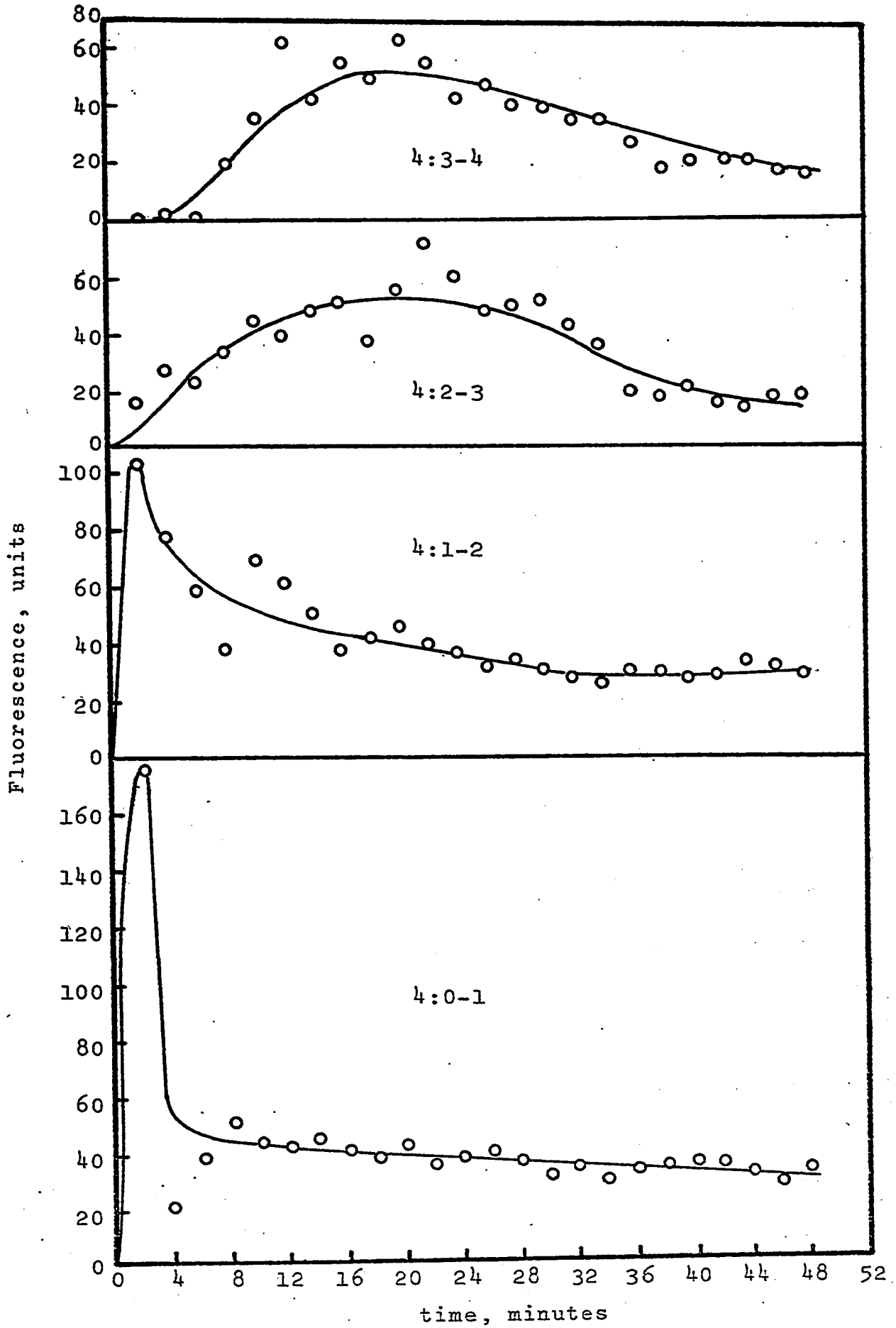


FIG. A.10.--CONTINUED

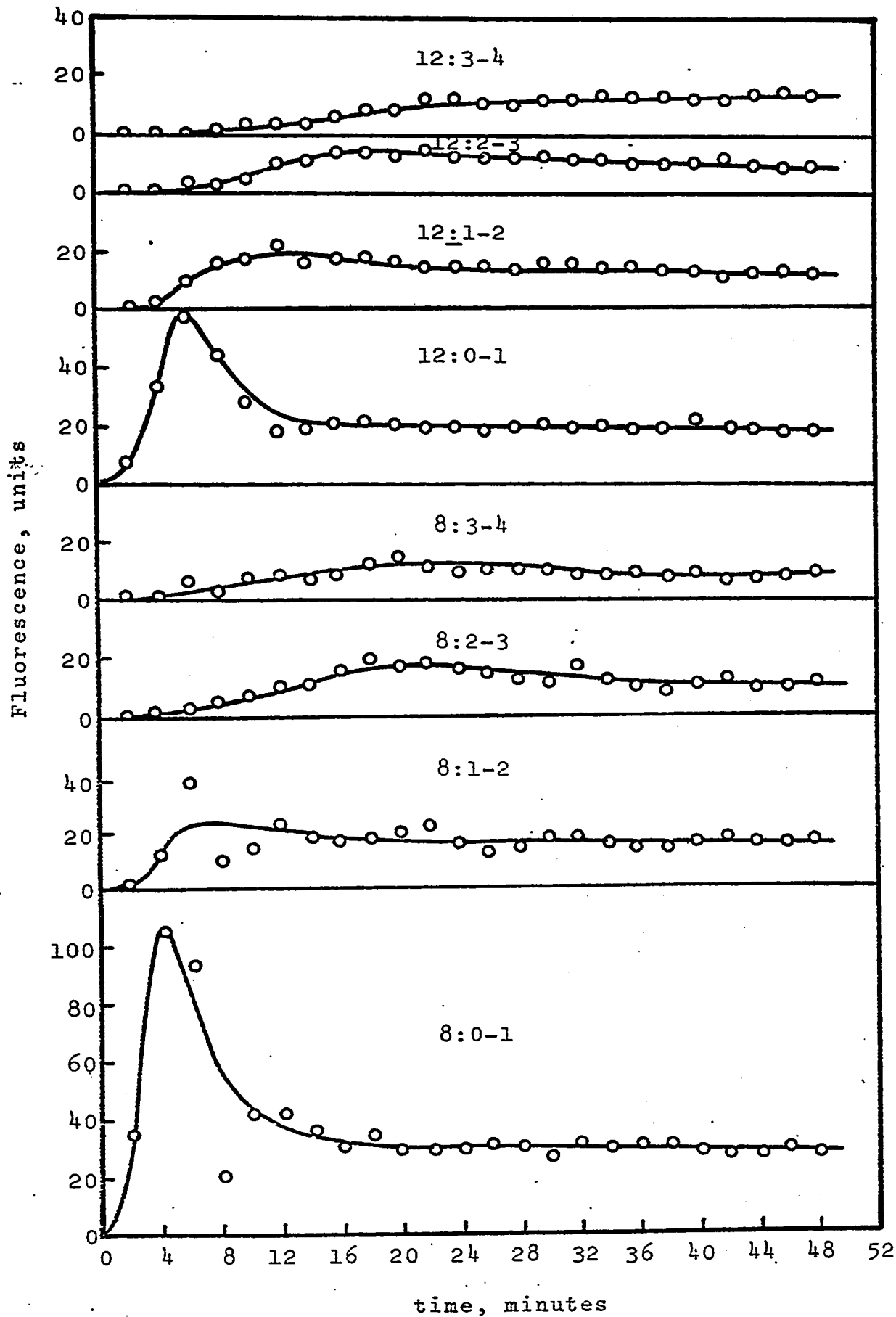


FIG. A:10.--CONTINUED

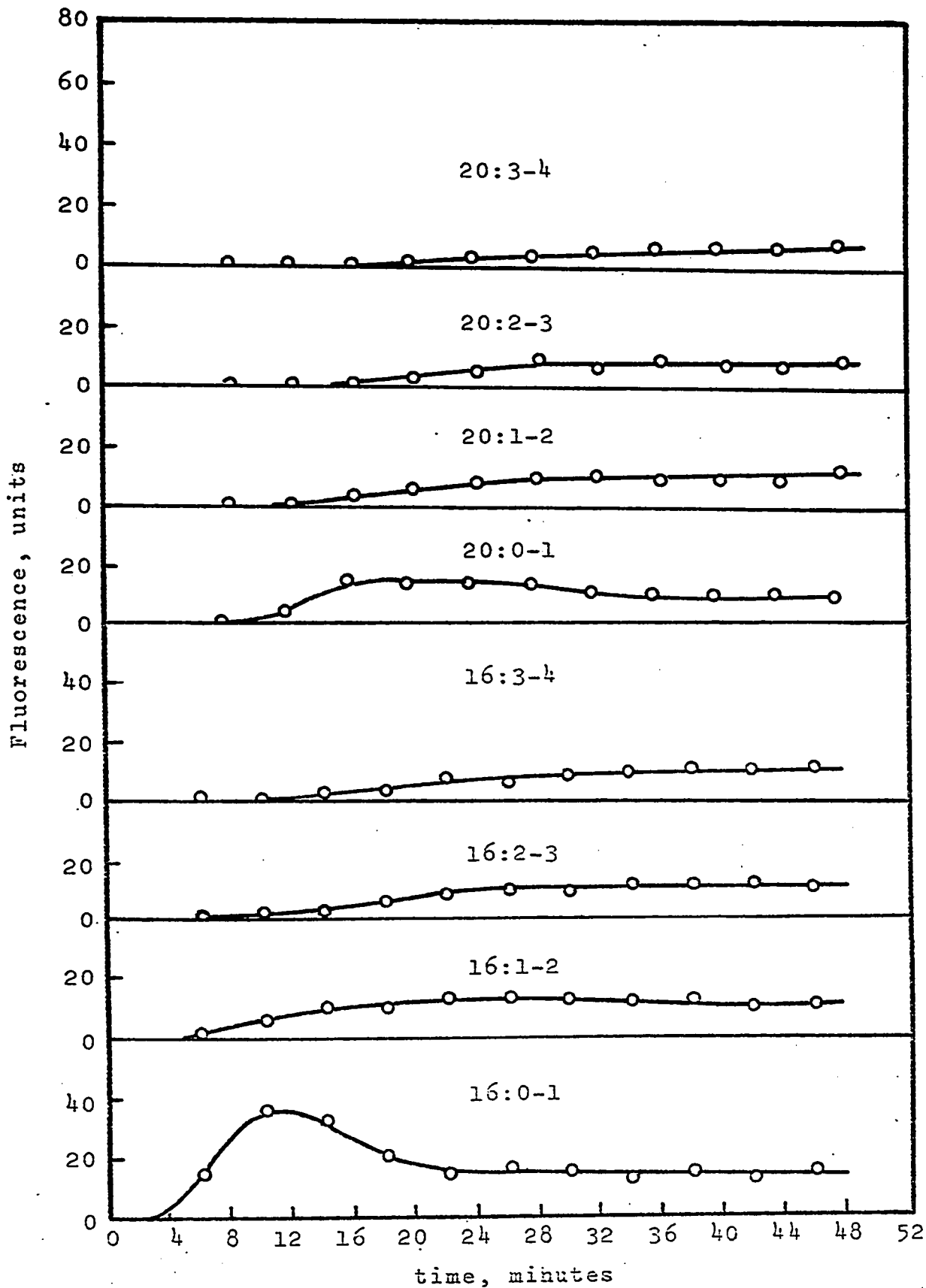


FIG. A.10.--CONTINUED

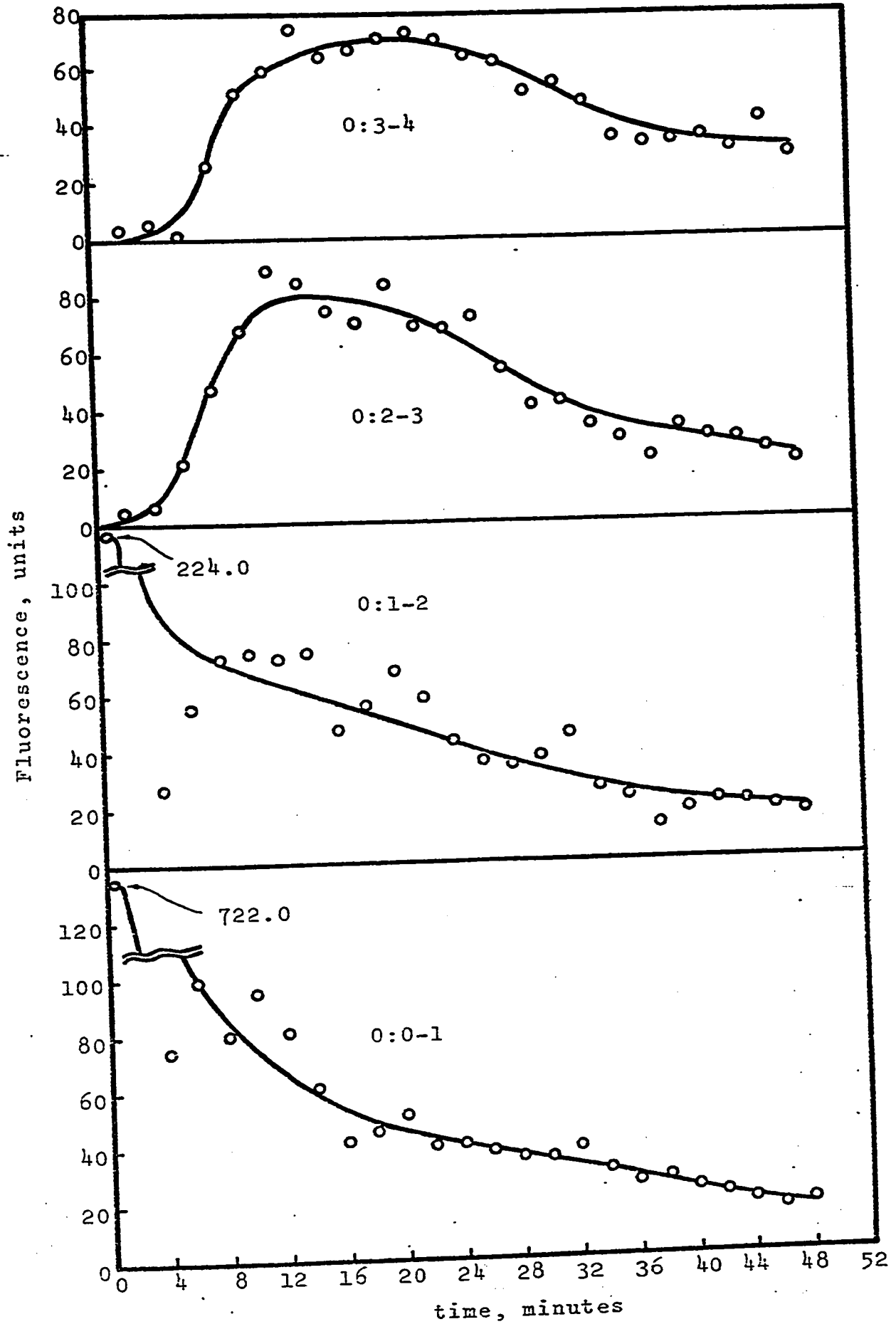


FIG. A.11.--FLUORESCENCE vs TIME FOR TEST NO. 11

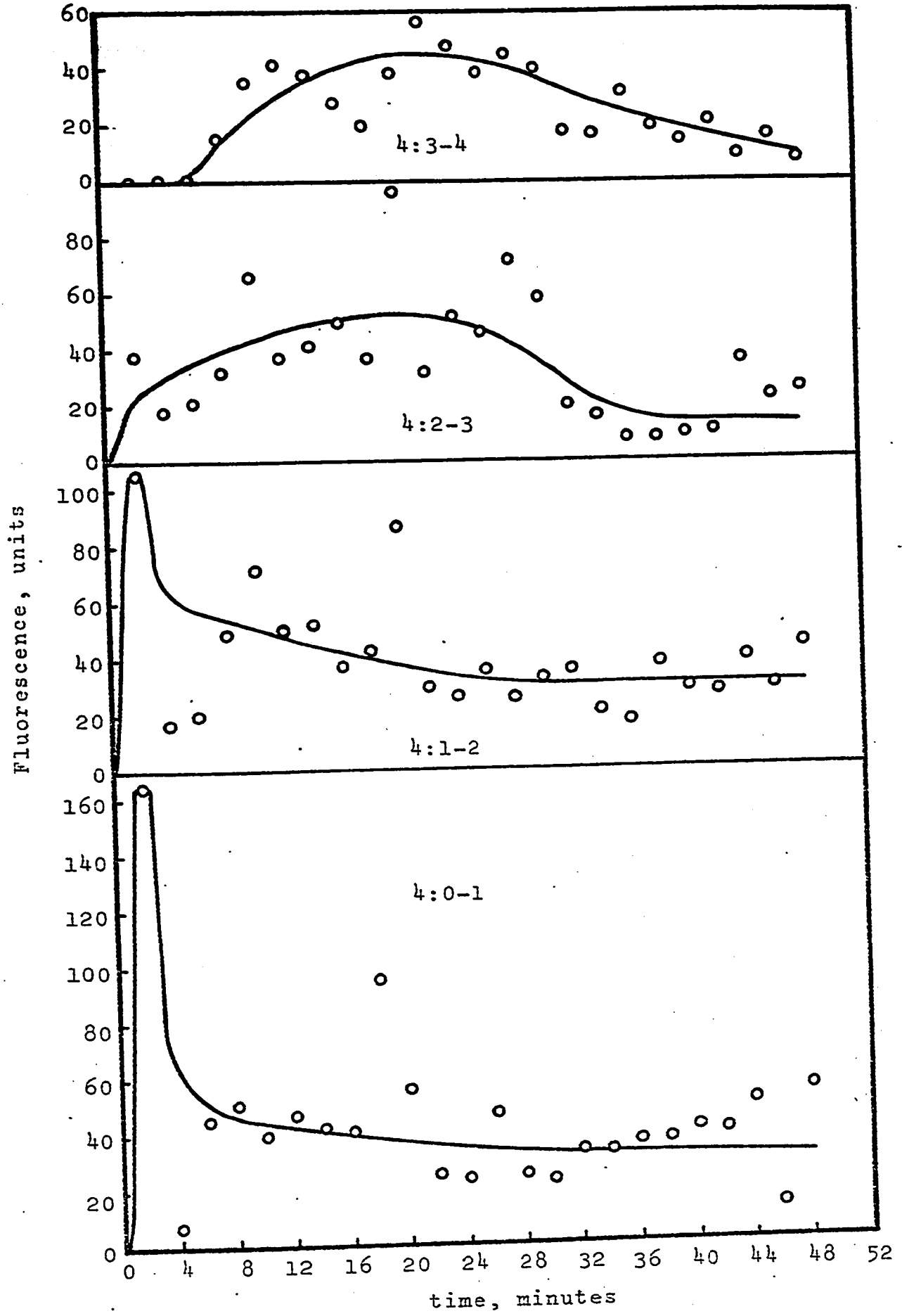


FIG. A.11--CONTINUED

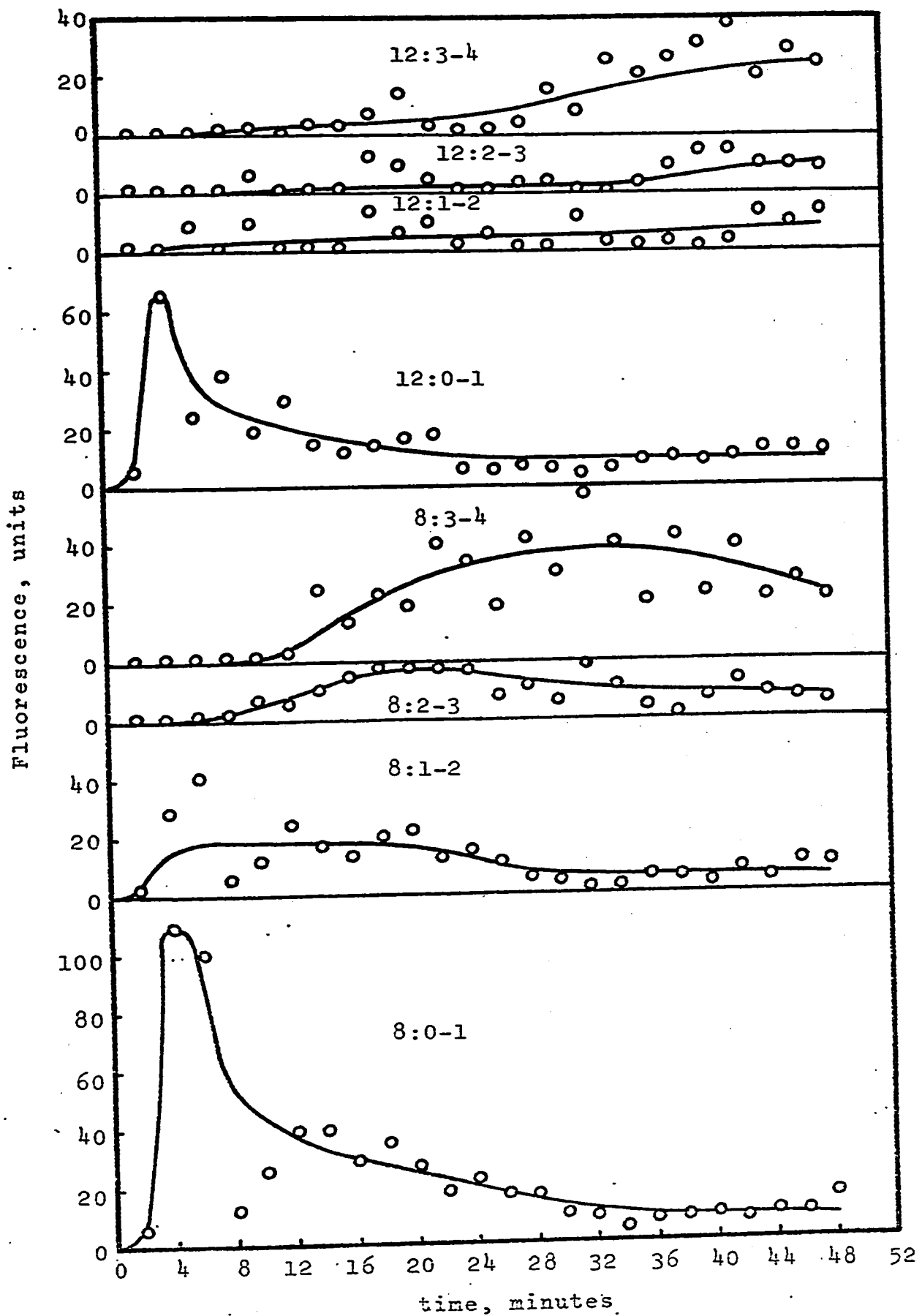


FIG. A.11.--CONTINUED

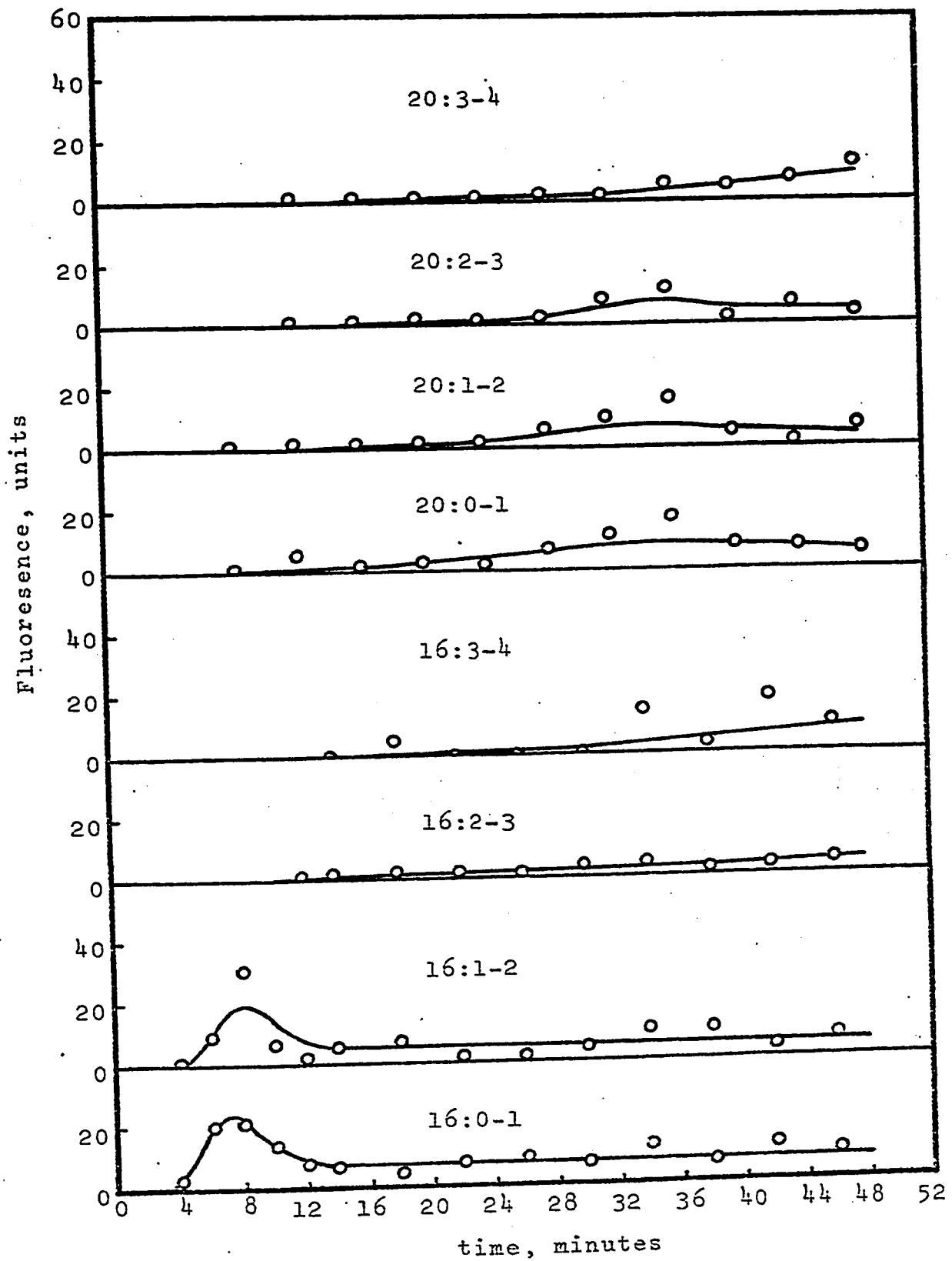


FIG. A.11.--CONTINUED

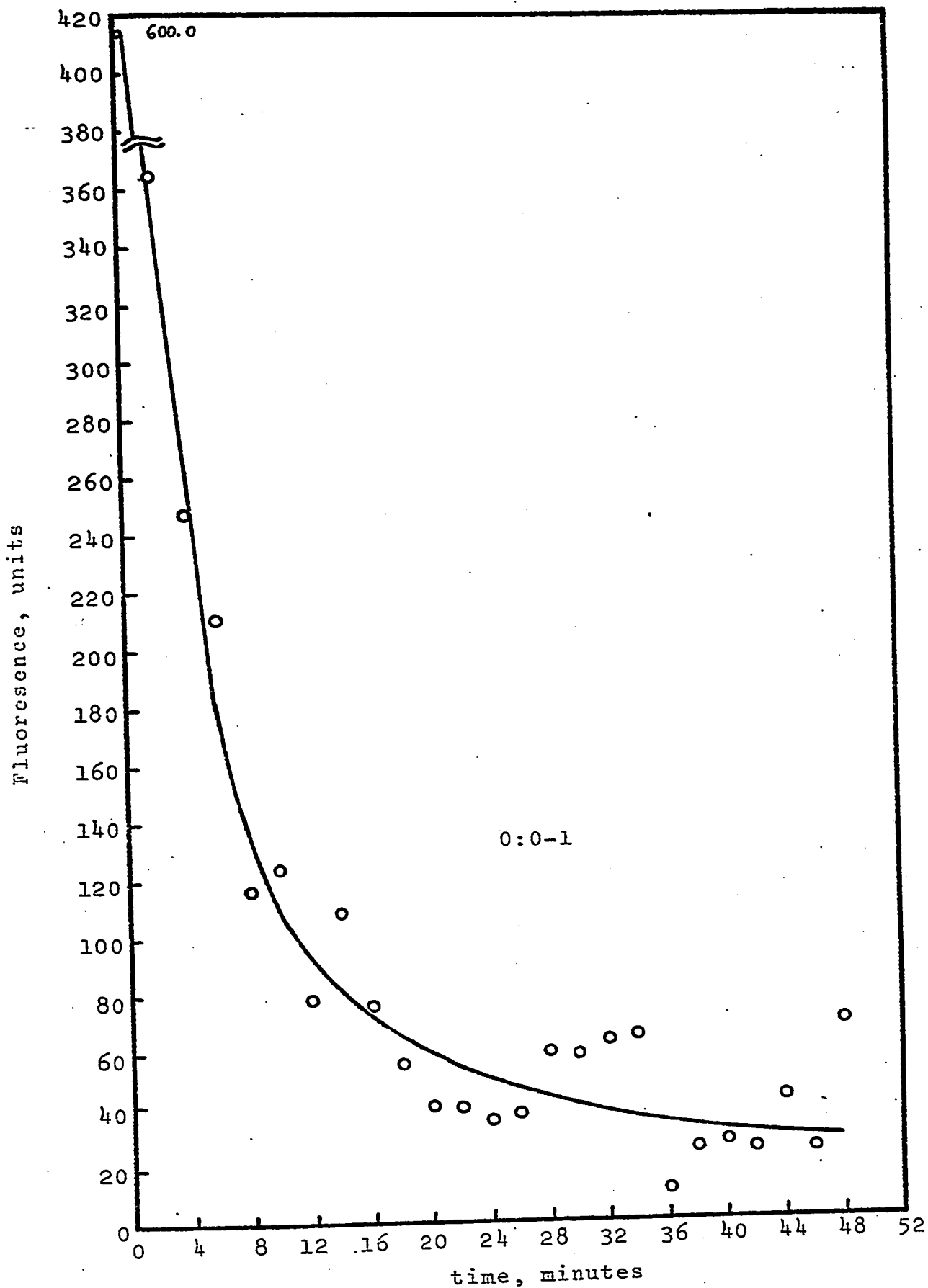


FIG. A.12.--FLUORESCENCE vs TIME FOR TEST NO. 12

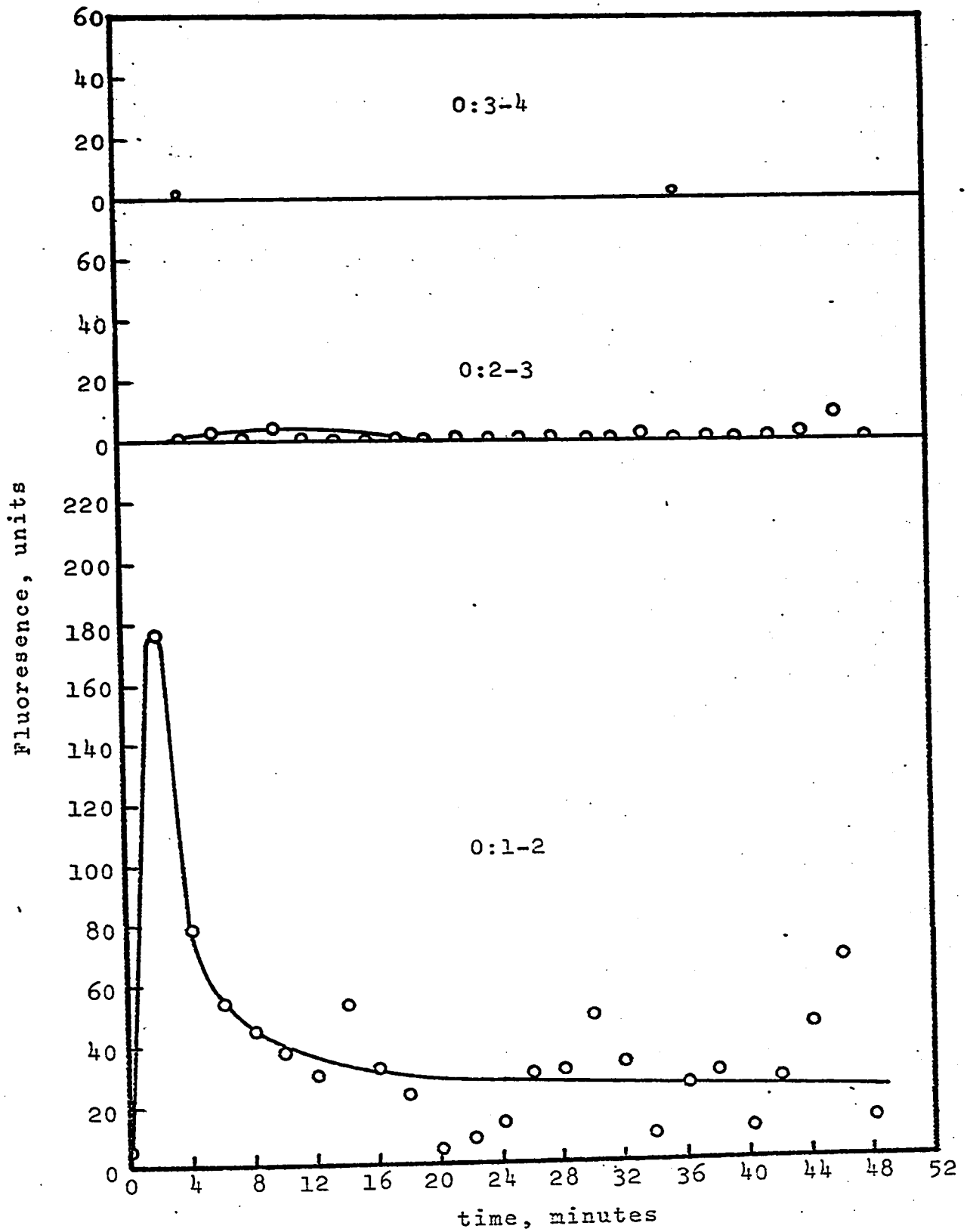


FIG. A.12.--CONTINUED

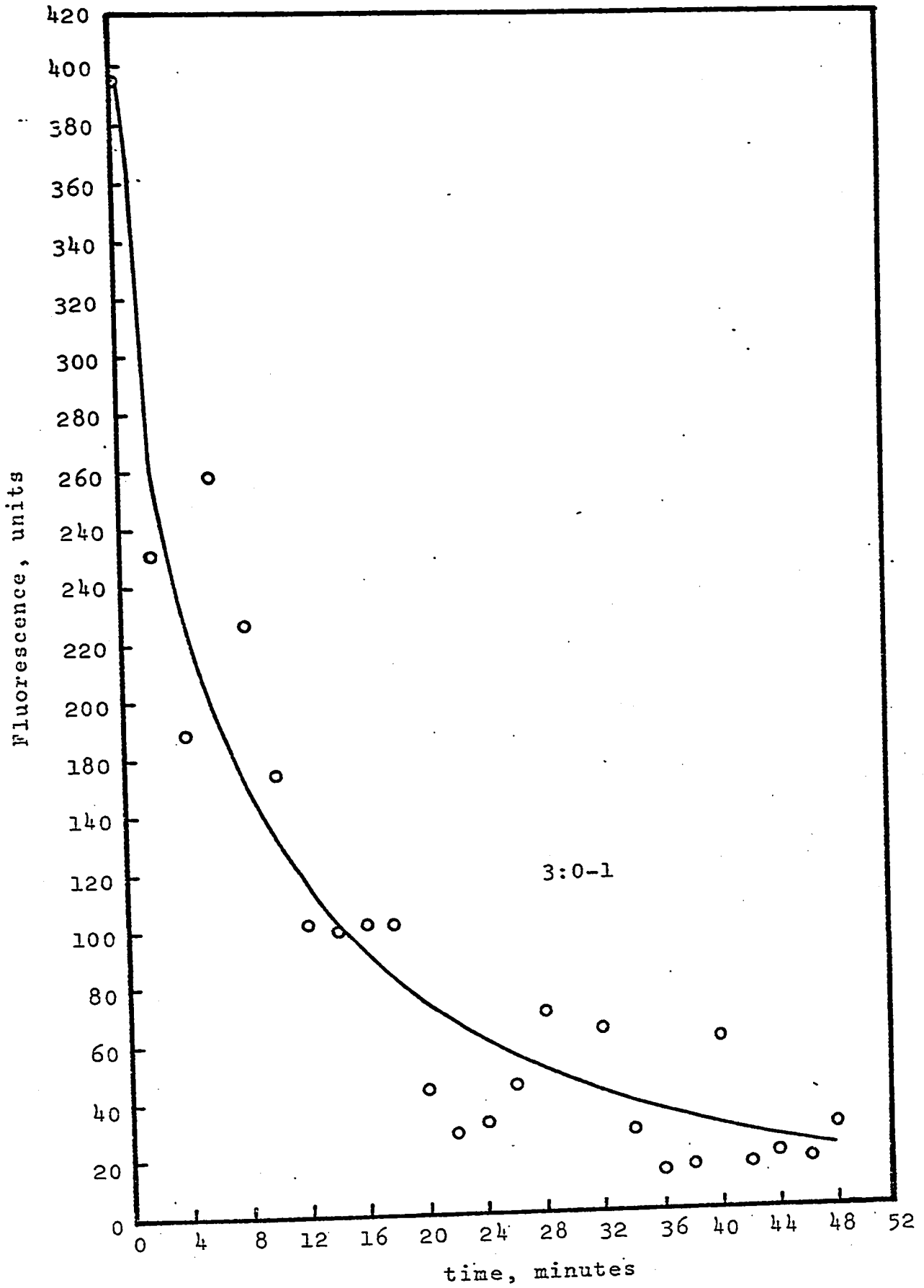


FIG. A.12.--CONTINUED

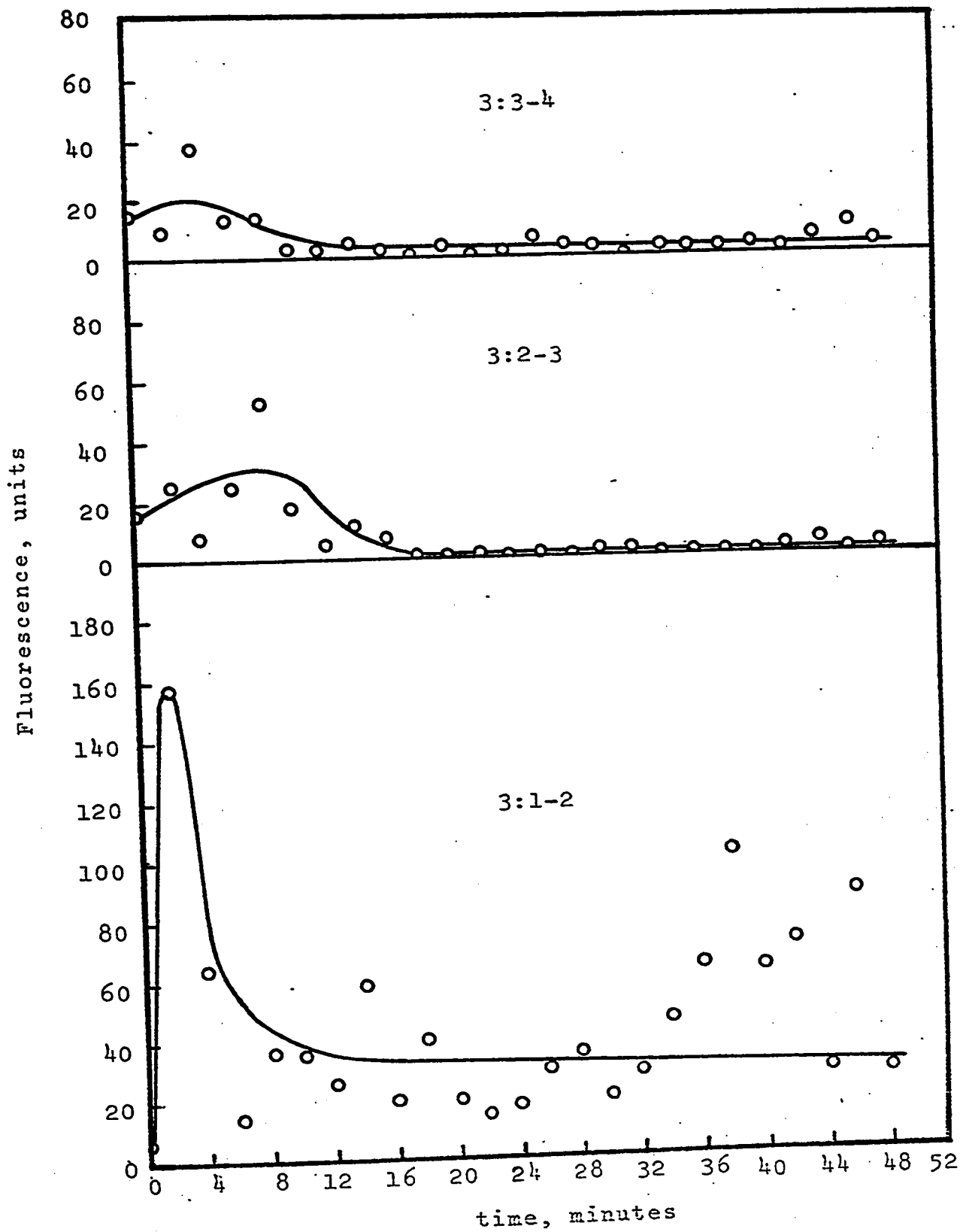


FIG. A.12.--CONTINUED

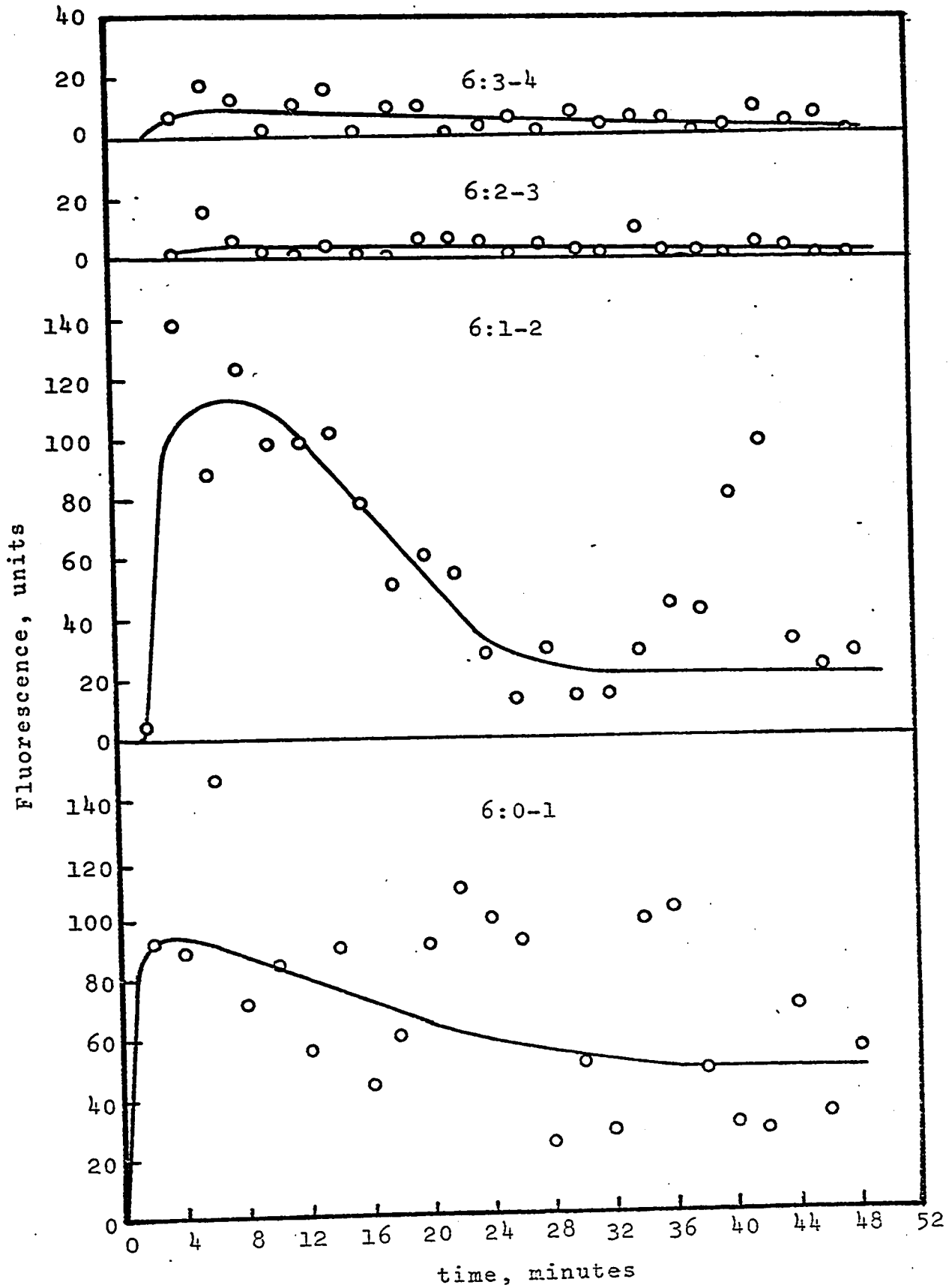


FIG. A.12.--CONTINUED

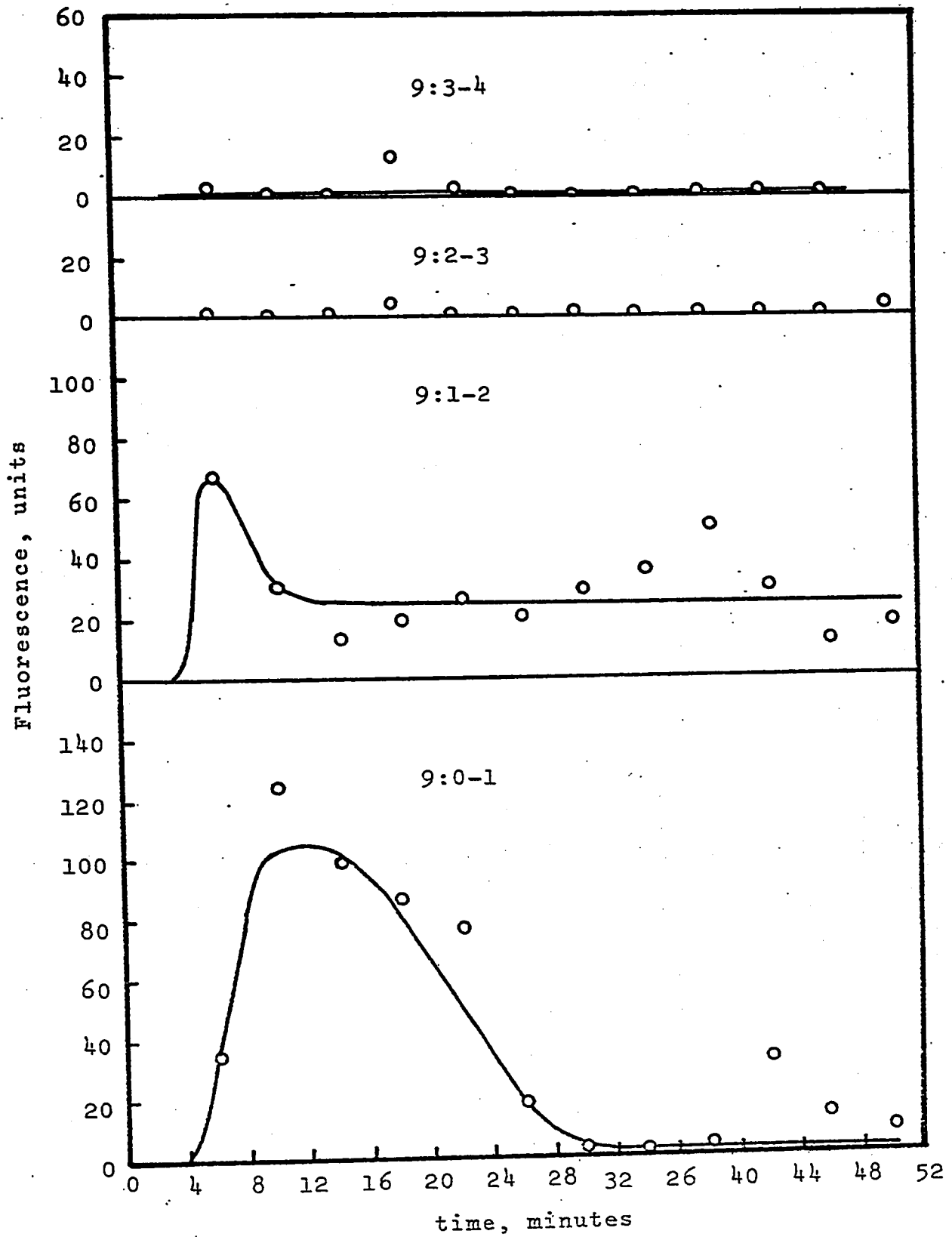


FIG. A.12.--CONTINUED

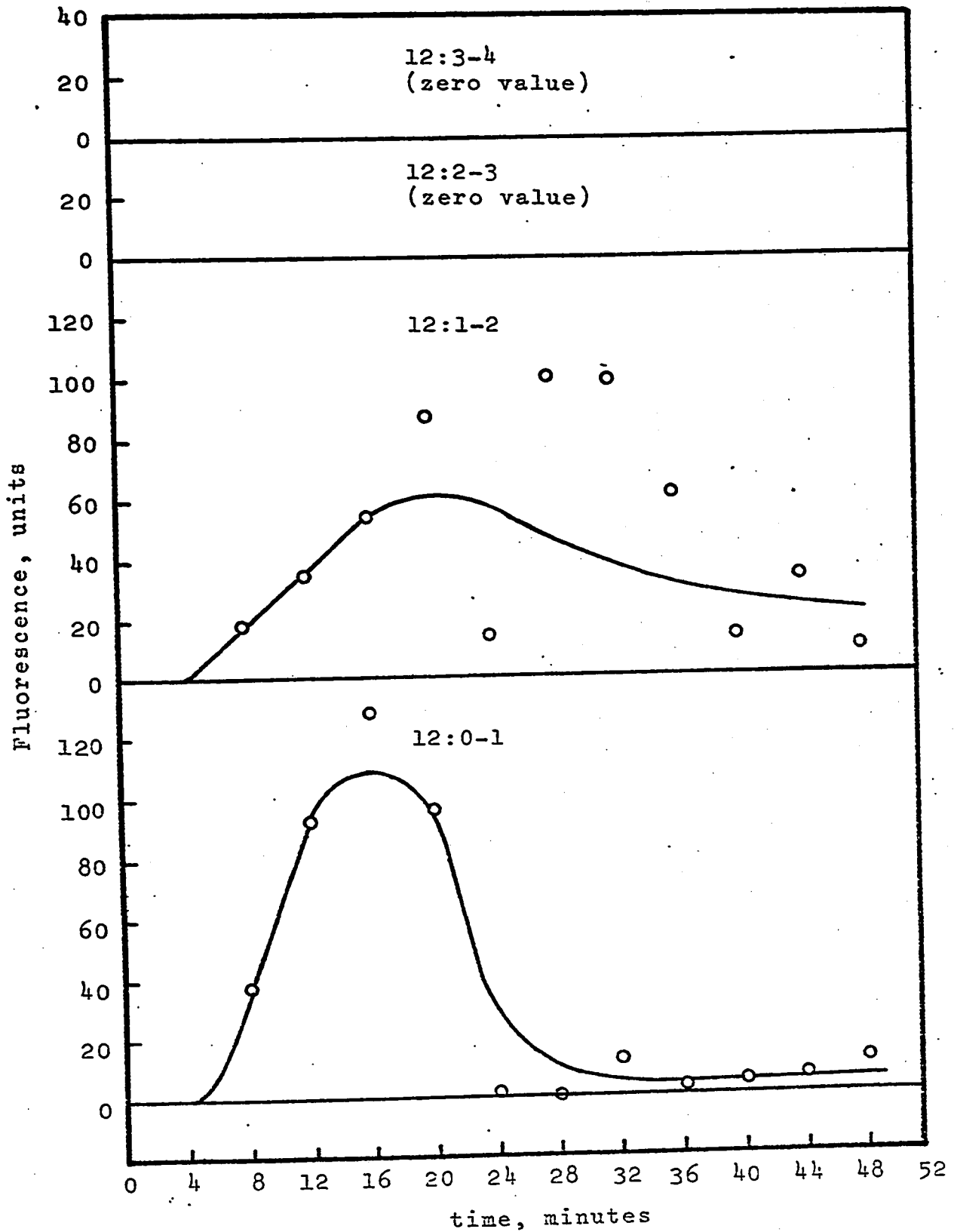


FIG. A.12.--CONTINUED

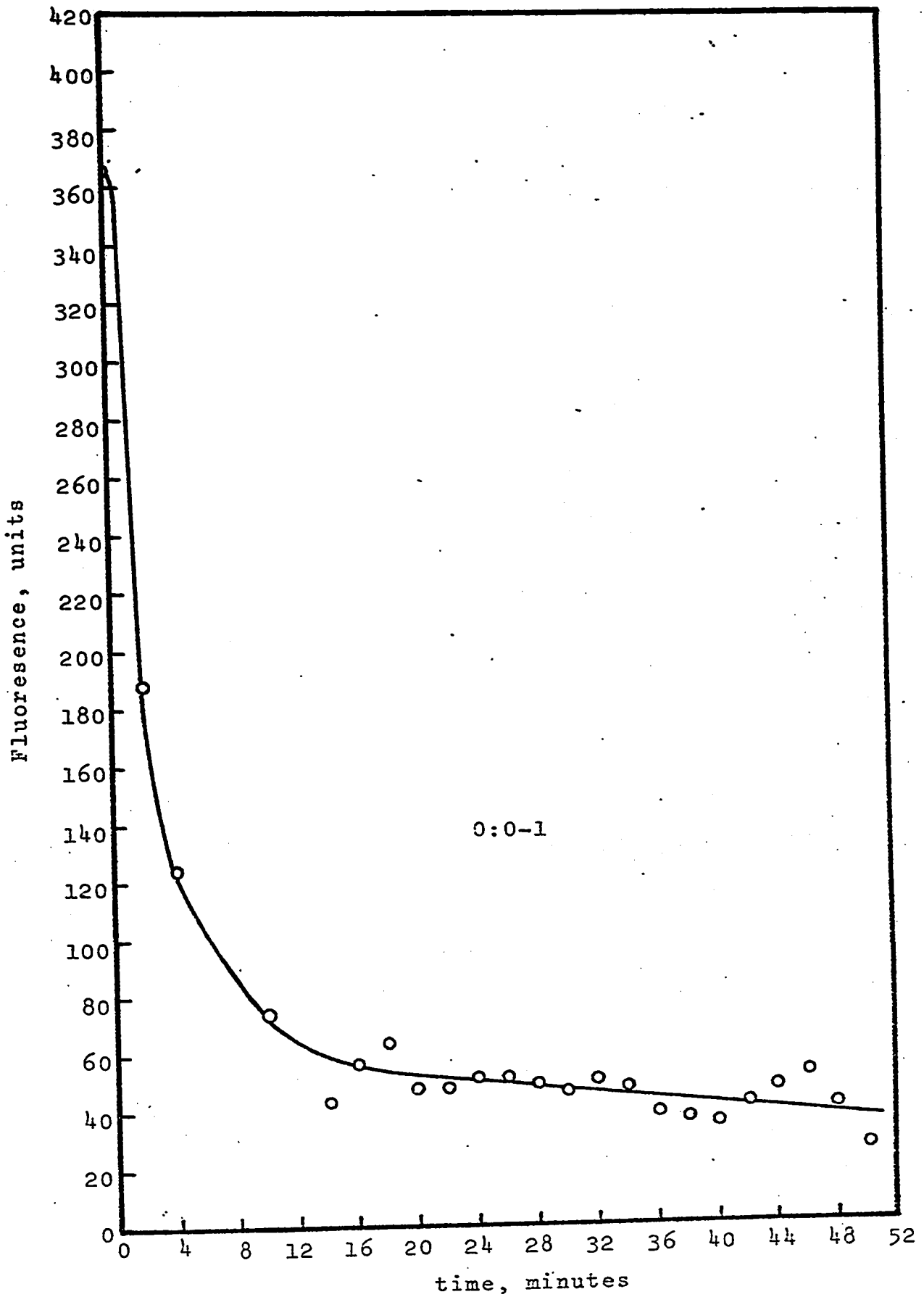


FIG. A.13.--FLUORESENCE vs TIME FOR TEST NO. 11

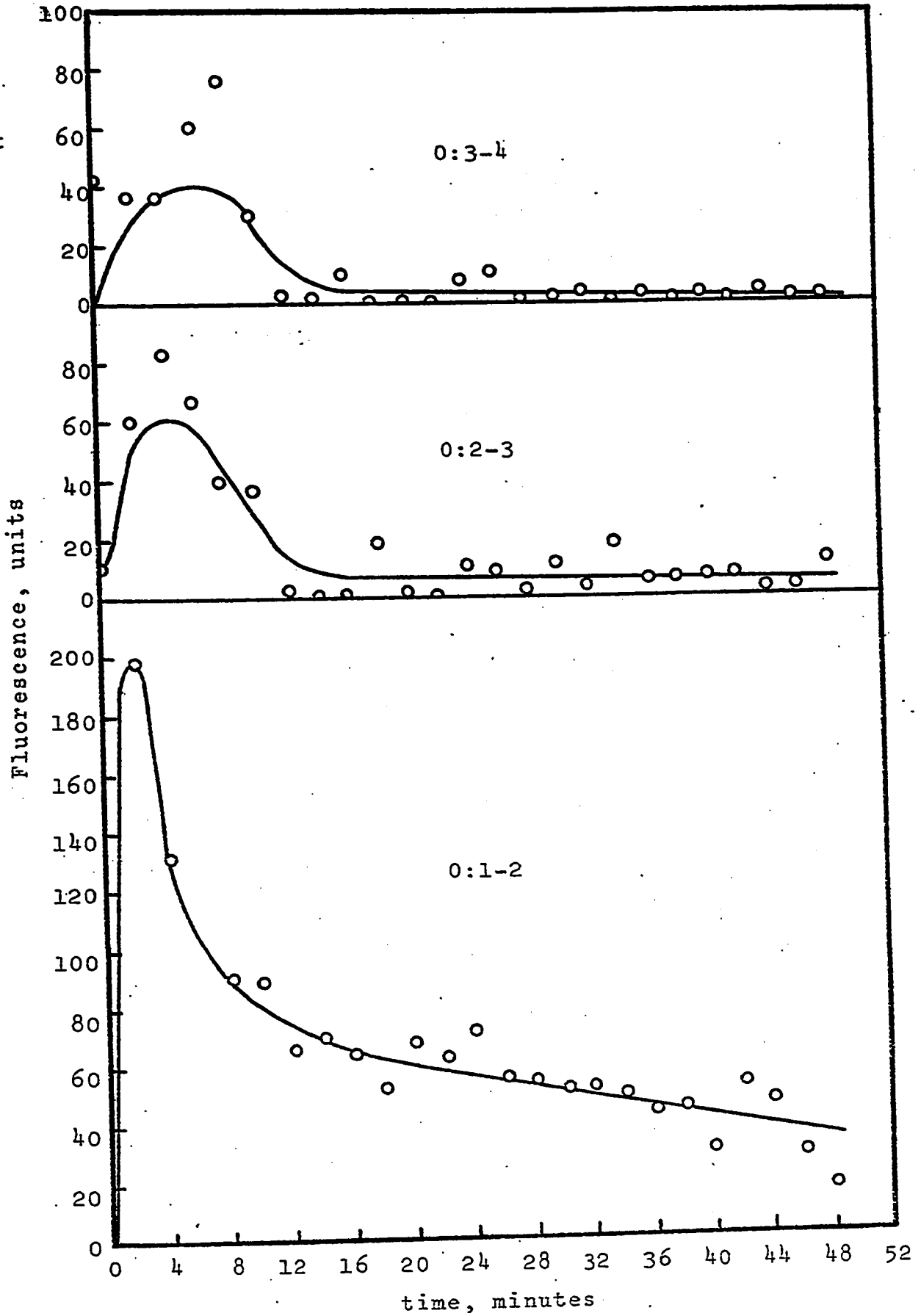


FIG. A.13.--CONTINUED

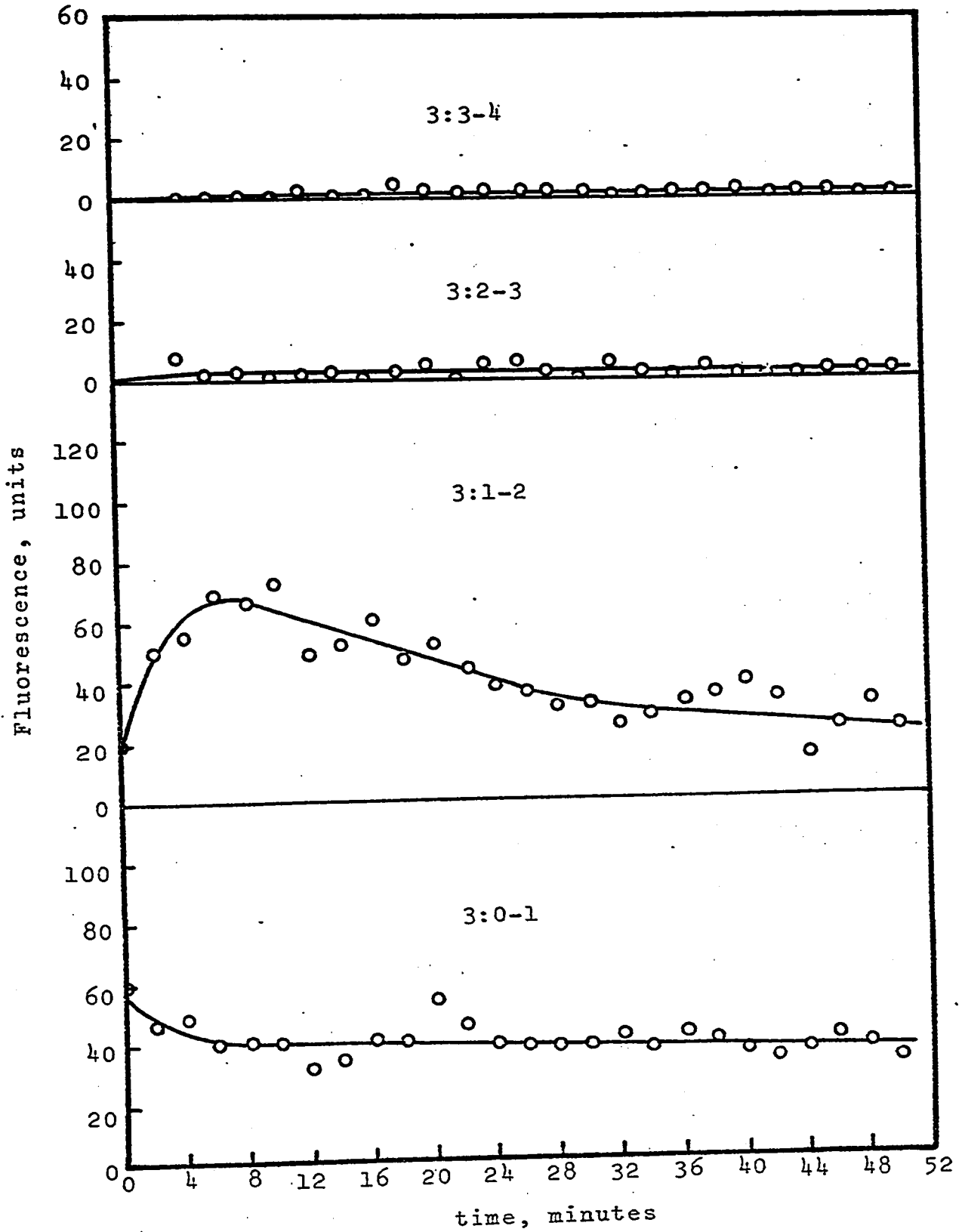


FIG. A.13.--CONTINUED

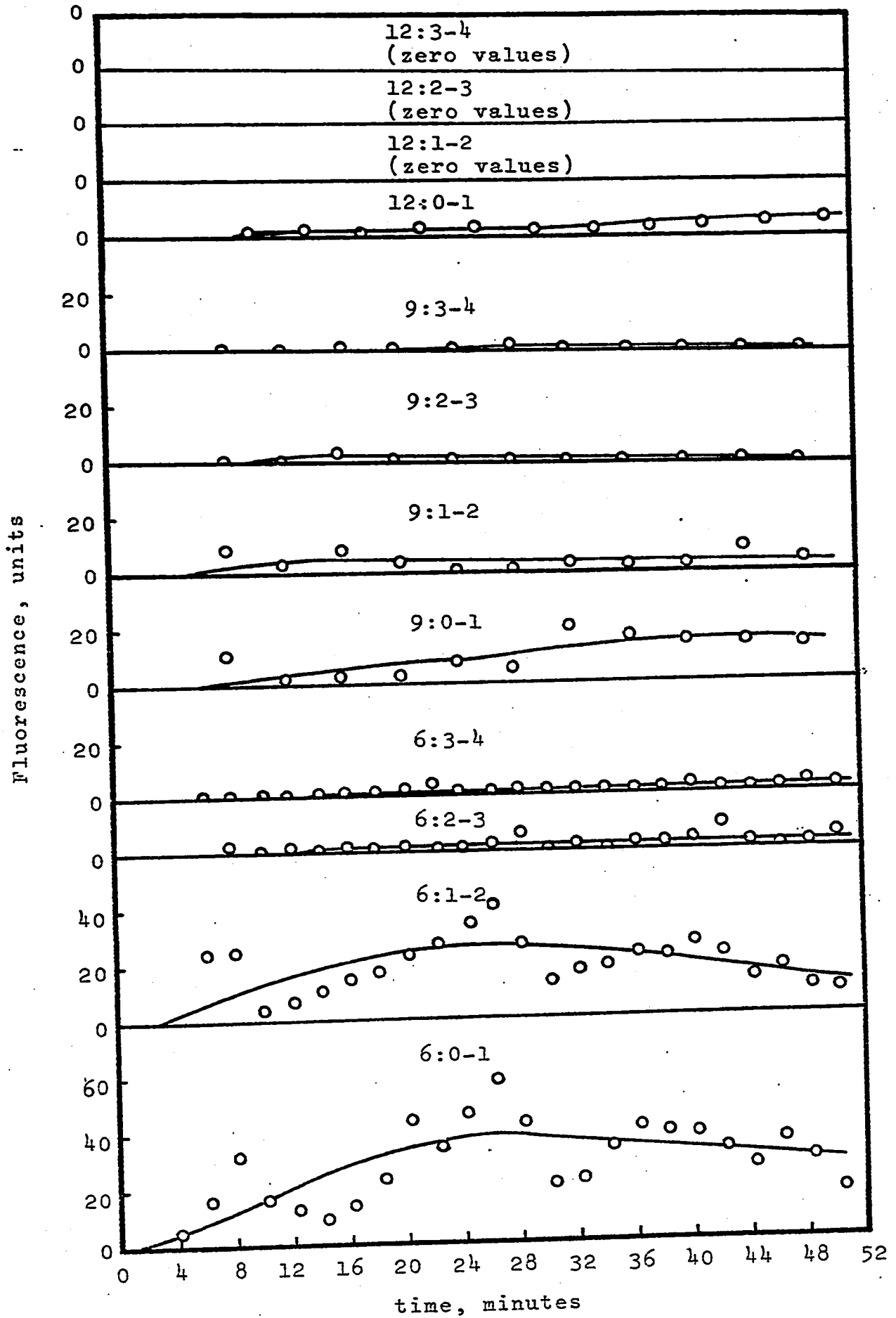


FIG. A.13.--CONTINUED

APPENDIX B

COMPUTER PROGRAM FOR DATA ANALYSIS

AC & AN : CONSTANTS A & N CONCENTRATION DISTRIBUTION CURVE
 AY : AREA UNDER CON. PPR.
 C : CONCENTRATION, PPR.
 CMAX : MAXIMUM CONCENTRATION
 CO : ABSOLUTE MAXIMUM CONCENTRATION
 D : PROPELLER DIAMETER, FT.
 DATEX : DATE OF EXPERIMENT, WEATHER, BOAT SPEED
 E : FLUORESCENCE, UNITS
 F : TEST NUMBER
 I : SURROUTINE FOR LEAST SQUARES ANALYSIS
 LFSOAN : RATIO CMAX/CO
 RCMAX : RATIO CF C TO CMAX
 RCY : TIME, MINUTES, FEET PER MINUTE
 T : BOAT SPEED, DYE IN GRAMS IN WAKE CROSS SECTION
 U : WEIGHT OF DYE IN GRAMS PER FOOT DEPTH
 WPFD : WEIGHT/(1000*0#0)
 XI : LATERAL DISTANCE, FT., FEET
 Y : WAKE WIDTH AT ANY BY A T * N
 YC : WAKE WIDTH GIVEN BY COMPUTED FROM SECOND MOMENT
 YNC : VARIANCE OF Y COMPUTED FROM SECOND MOMENT
 YVAR : VARIANCE FROM NORMAL DIST. EQ.
 YVNOB : VERTICAL DISTANCE, FT.

DIMENSION AY(26,4), WPFD(26,4), WD(26), YVAR(26,4), YVNOB(26,4)
 DIMENSION RCMAX(26), RCY(26,8,4), YOC(26), XI(26), ETAL(26,8)
 DIMENSION T(26), Y(8), Z(4), F(26,8,4), DATEX(8)
 DIMENSION CL(8), YY(8), CRT(8), CTL(8), YL(26,4)
 DIMENSION FO(26,8,4), FATCH(8)
 READ(1,80,END=99) DATEX
 FORMAT(80A1)
 READ(1,28) NT, NY, YL, U, D
 FORMAT(215,3F10.0)
 DO 12 K=1, NT
 YOC(K)=0, F
 DO 12 M=1, NY
 DO 12 N=1, 4
 YC(K, M, N)=0.
 F(K, M, N)=0.
 READ(1,82) ITTEST
 FORMAT(15)
 ITAB1=ITTEST
 ITAB2=ITAB1+13
 READ(1,86)((YOC(K, N), N=1, 3), K=1, NT)
 FORMAT(15F5.0)

98
 80
 28
 12
 82
 86

CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

```

8P READ(1,99)AC,AN
FORMAT(2F10.0)
NYN=NY-1
DO 10 M=1, NYN
Y(M+1)=Y(M)+YL
Z(1)=0.5
DO 14 N=1, 3
Z(N+1)=Z(N)+1.0
DO 16 M=1, NY
DO 16 K=1, NT
READ(1,18) T(K), (F(K, M, N), N=1, 4)
FORMAT(5F10.0)
DO 11 M=1, NY
DO 11 K=1, NT
DO 11 N=1, 4
C(K, M, N)=1.054*F(K, M, N)
MASS BALANCE IN THE CROSS SECTION OF WAKE
DO 22 K=1, NT
WD(K)=0.
DO 23 N=1, 4
AY(K, N)=0.
DO 21 M=1, NYN
AY(K, N)=AY(K, N)+YL*(C(K, M, N)+C(K, M+1, N))
WPDF(K, N)=(AY(K, N)*28.4)/10.0**6
WD(K)=WD(K)+WPDF(K, N)
CONTINUE
LATERAL VARIANCE COMPUTATION BY ONE DIMENSIONAL EQUATION
DO 44 K=1, NT
DO 44 N=1, 4
LC=0
DO 42 M=1, NY
IF(C(K, M, N).LE.0.0) GO TO 42
LC=LC+1
CL(LC)=ALOG(C(K, M, N))
YY(LC)=Y(M)**2
CONTINUE
IF(LC.LE.2) GO TO 40
CALL FERGAN(YY, CL, LC, DCONST, DSLOPE, DCOFF, DERR)
DISPY=ABS(1.0/(4.6**6*DSLOPE))
VVAR(K, N)=DISPY
GO TO 44
VVAR(K, N)=0.0
CONTINUE
COMPUTATION OF LATERAL VARIANCE BY THE SECOND MOMENT METHOD
DO 30 K=1, NT
DO 30 N=1, 4

```

```

SMW=0.0
APFA=0.0
DO 32 M=1, NVN
SMW=SMW+0.25*YI*(C(K,M,N)+C(K,M+1,N))*(Y(M)+Y(M+1))*2
APFA=AREA+YI*(C(K,M,N)+C(K,M+1,N))
IF (AREA.GT.0.0) GO TO 34
YVAR(K,N)=0.0
GO TO 35
YVAR(K,N)=0.5*SMW/AREA
CONTINUE
COMPUTATIONS FOR ANALYSIS BY PROPOSED MODEL UPTO 20 MINUTES ONLY
NTT=1
DO 71 K=1, NTT
IF(K.LE.1) GO TO 76
YCC(K)=ACCT(K)*AN
DO 72 M=1, NV
IF(YCC(K).GT.0.0) GO TO 74
ETA(K,M)=0.0
GO TO 76
ETA(K,M)=Y(M)/YCC(K)
XT(K)=(U*XT(K))/(1000.0*AD)
RCMAX(K)=C(K,1,1)/C(1,1,1)
N=1
DO 72 M=1, NV
IF(C(K,1,N).LE.0.0) GO TO 73
PCY(K,M,N)=C(K,M,N)/C(K,1,N)
GO TO 72
PCY(K,M,N)=0.0
CONTINUE
WRITE(3,202)
FORMAT(1H1,//////)
FORMAT(20X, 'TABLE C-', I2, ' --- COMPUTATIONAL RESULTS OF TEST NO.', I2,
*, //)
FORMAT(1X, 'TIME', 1X, 'DEPTH', 10X, 'CONCENTRATION IN PPM AT', 16X,
1 'VADTANCE', 5X, 'YD', 5X, 'WD',
114 'FORMAT(19X, 'STATED LATERAL DISTANCE IN FEET', 13X, 'SQ. FT.', //)
FORMAT(1X, 'MIN', 4X, 'FT', 2X, 6F7.1, 5X, 'MORE Q', 1X, '2ND MOM', 2X, 'FT', 4X
3 'GRAM', //)
FORMAT(1X, 'F4.1, 2X, I1, '---', I1, 1X, 6F7.1)
FORMAT(1X, '56X, 2F7.2, F6.1)
FORMAT(1X, 'I1, '---', I1, 1X, 6F7.1)
FORMAT(1X, '176X, F8.4)
FORMAT(1X, '56X, 2F7.2)
FORMAT(13X, 'TABLE C-', I2, ' --- COMPUTATIONS FOR DATA ANALYSIS OF TES
CONTINUE
FORMAT(25X, 'BY PROPOSED MATHEMATICAL MODEL', //)

```

32

34

35

C

74

75

72

72

71

202

112

114

118

122

124

126

128

130

132

134


```

WRITE(3,130)ITAB2,ITEST
WRITE(3,131)
WRITE(3,132)
WRITE(3,134) (Y(M),M=1,NY)
DO 140 K=1,NTT
N=1
IF(K.GT.1)GO TO 133
WRITE(3,135)T(K),XI(K),PCMAX(K)
GO TO 140
WRITE(3,136) T(K), (STA(K,M), M=1, NY)
WRITE(3,138) X(K), PCMAX(K)
WRITE(3,139) (RCY(K,M,N),M=1,NY)
CONTINUE
GO TO 98
RETURN
END
SUBROUTINE LESQAN(X,Y,N,C,SL,COFF,SEST)
DIMENSION X(8),Y(8)
SUMX=0.0
SUMY=0.0
SUMXX=0.0
SUMYY=0.0
SUMXY=0.0
DO 10 I=1,N
SUMX=SUMX+X(I)
SUMY=SUMY+Y(I)
SUMXX=SUMXX+X(I)**2
SUMYY=SUMYY+Y(I)**2
SUMXY=SUMXY+X(I)*Y(I)
C=(SUMY*SUMXX-SUMXY)/(SUMX-SUMXY)/(N*SUMXX-SUMX**2)
SL=(SUMY-N*C)/SUMX
SSX=(SUMXX-SUMY**2/N)/(N-1)
SSY=(SUMYY-SUMXY**2/N)/(N-1)
IF(SSX.LE.0.0)CR=SSY.LE.0.0)COFF=0.0
IF(SSX.LE.0.0)CR=SSY.LE.0.0)GO TO 12
COFF=SL*SQRT(SSX)/SQRT(SSY)
CONTINUE
SSYX=(SSY-SL*SL*SSX)/(N-1)/(N-2)
IF(SSYX.LE.0.0)SEST=0
IF(SSYX.LE.0.0)GO TO 14
SEST=SQRT(SSYX)
CONTINUE
RETURN
END

```

133

141

98

10

12

14

APPENDIX C

CONCENTRATION vs LATERAL DISTANCE PLOTS

AND

COMPUTATIONAL RESULTS

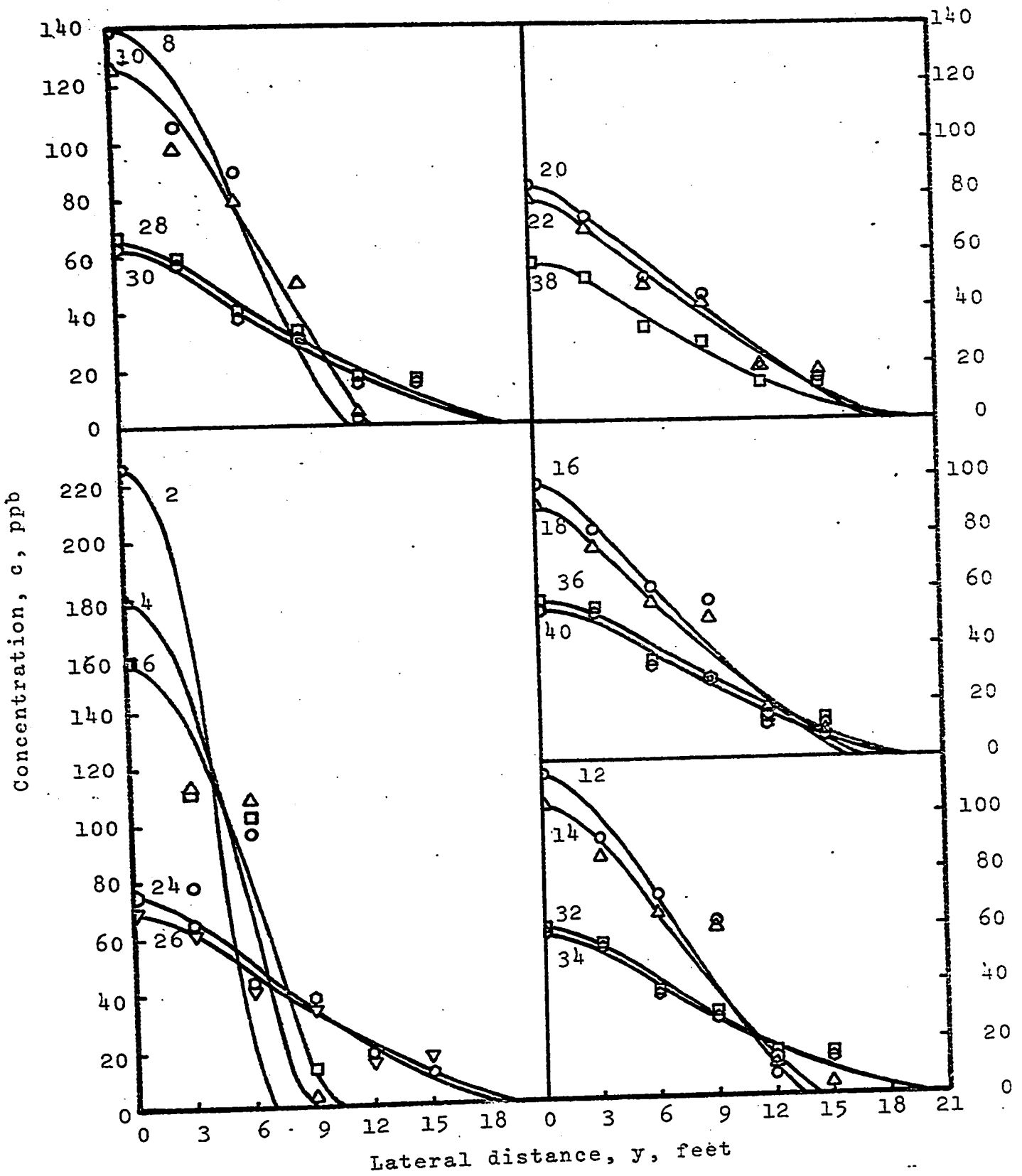
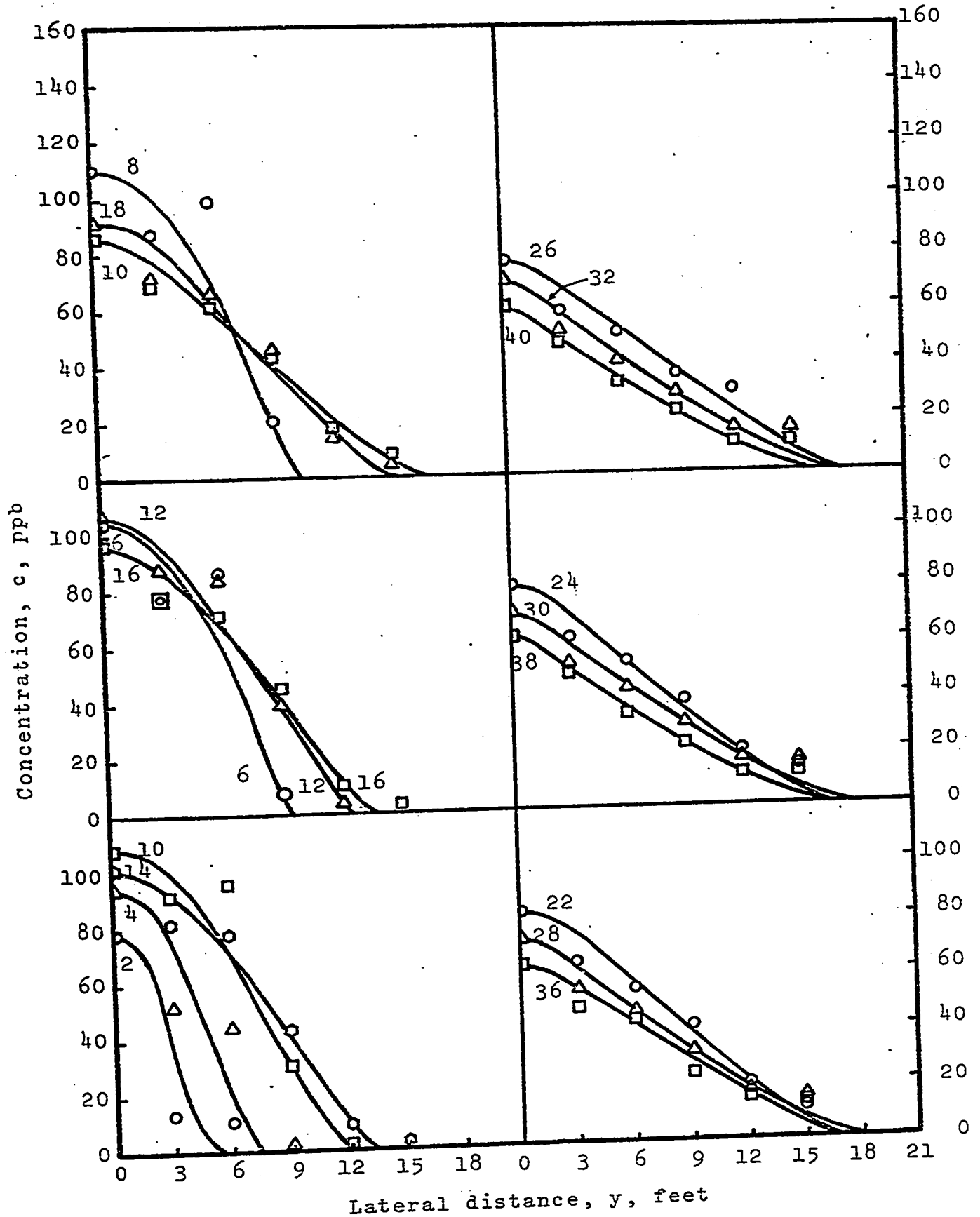
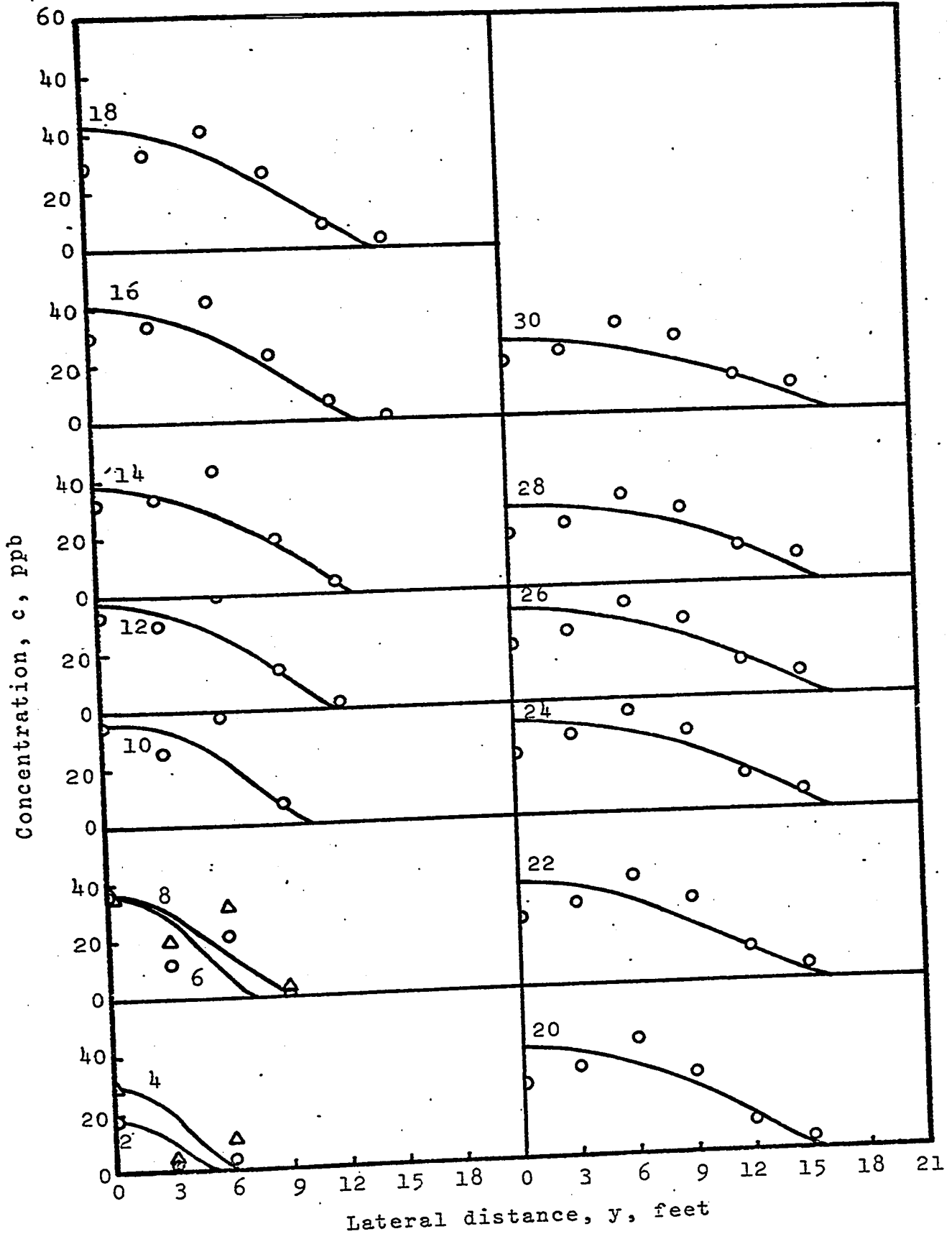


FIG. C.1.--CONCENTRATION vs LATERAL DISTANCE FOR TEST NO. 1
Numbers on curves indicate time in minutes. The symbols O, Δ, □, ○, ▽, ●. represent in order the concentration at stated lateral distance of increasing time values.



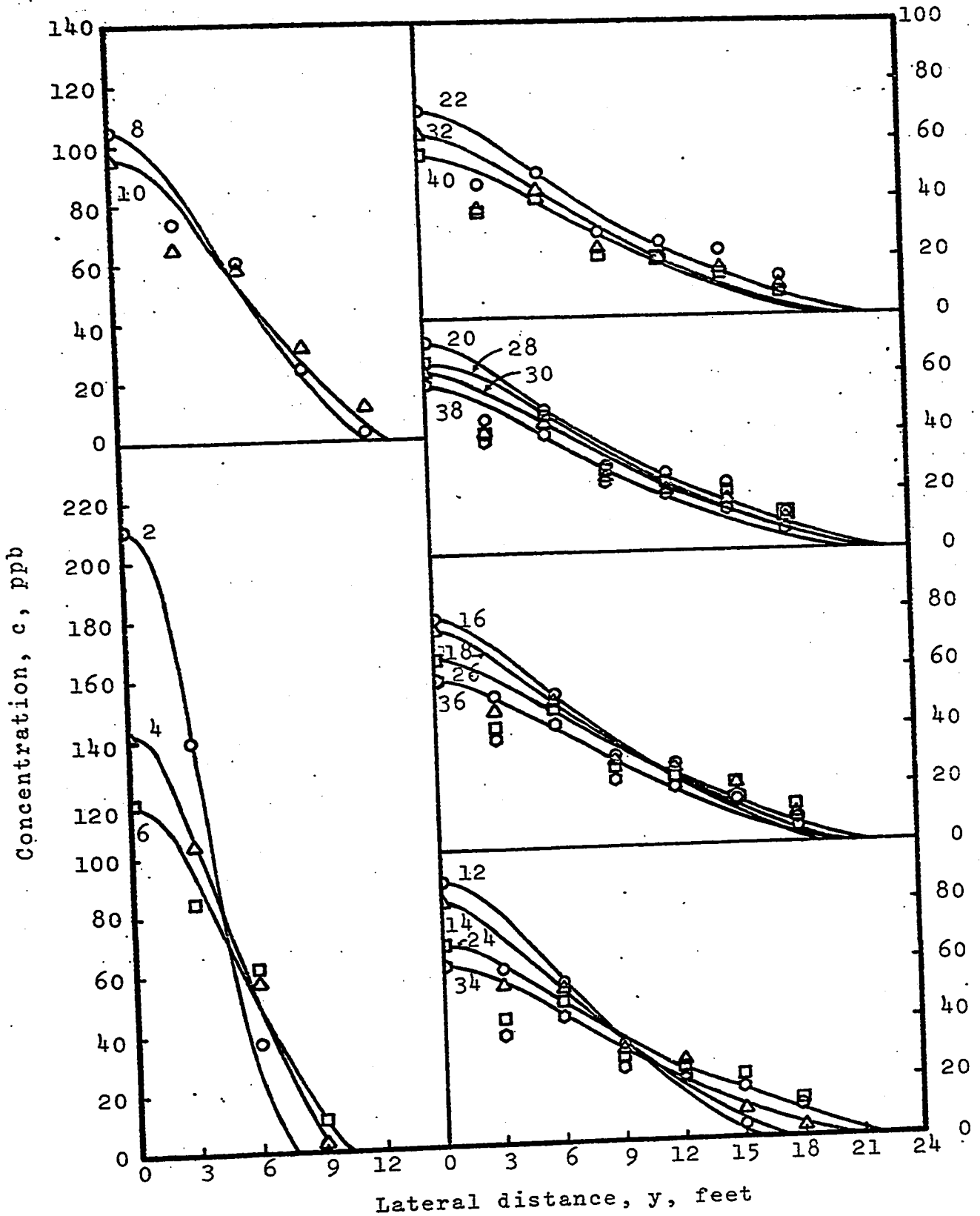
(b) DEPTH: 1-2

FIG. C.1.--CONTINUED



(c) DEPTH: 2-3

FIG. C.1.--CONTINUED



(a) DEPTH: 0-1

FIG. C.2.--CONCENTRATION vs LATERAL DISTANCE FOR TEST NO. 2
Number on curves and symbols as explained in Fig. C.1.

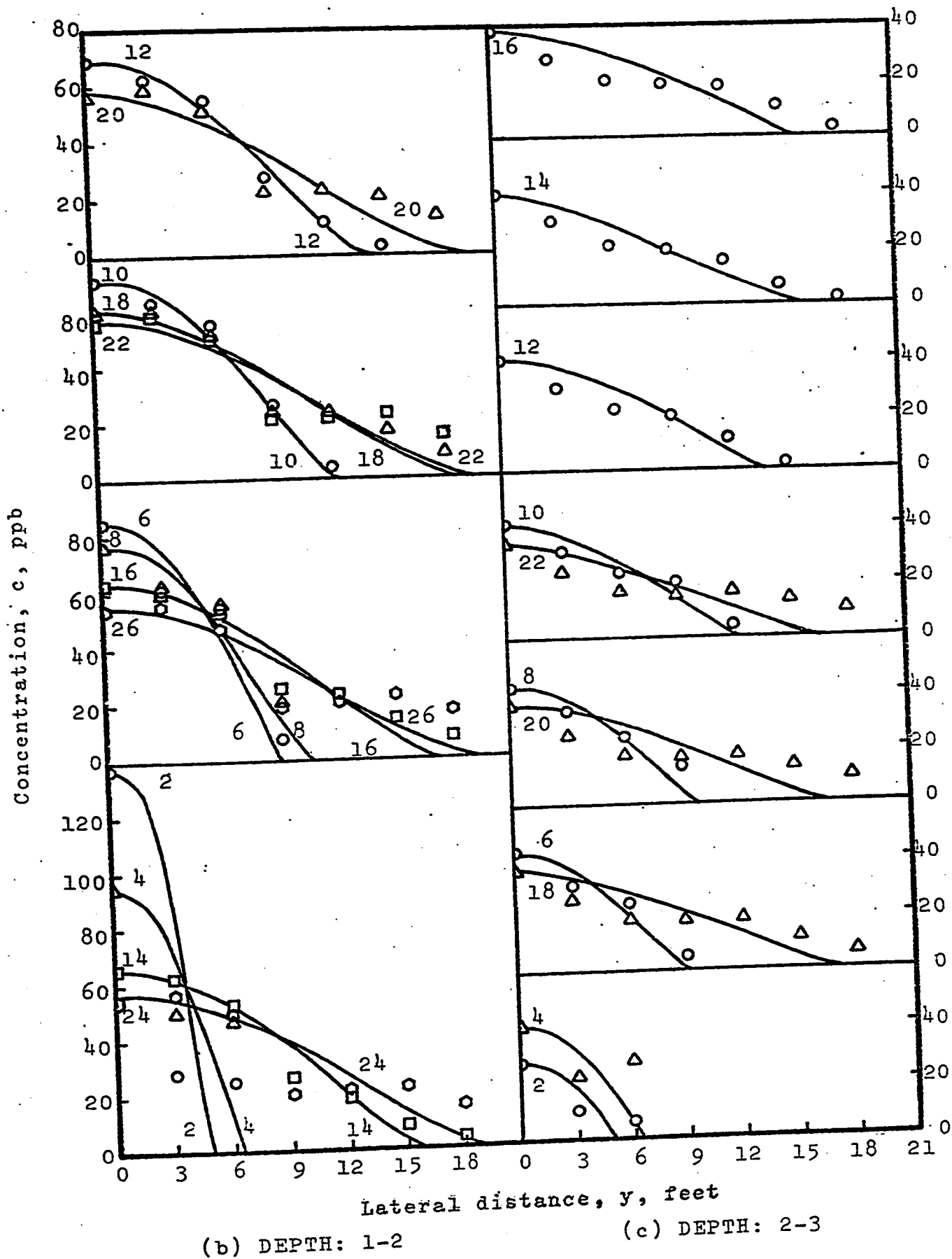


FIG. C.2.--CONTINUED

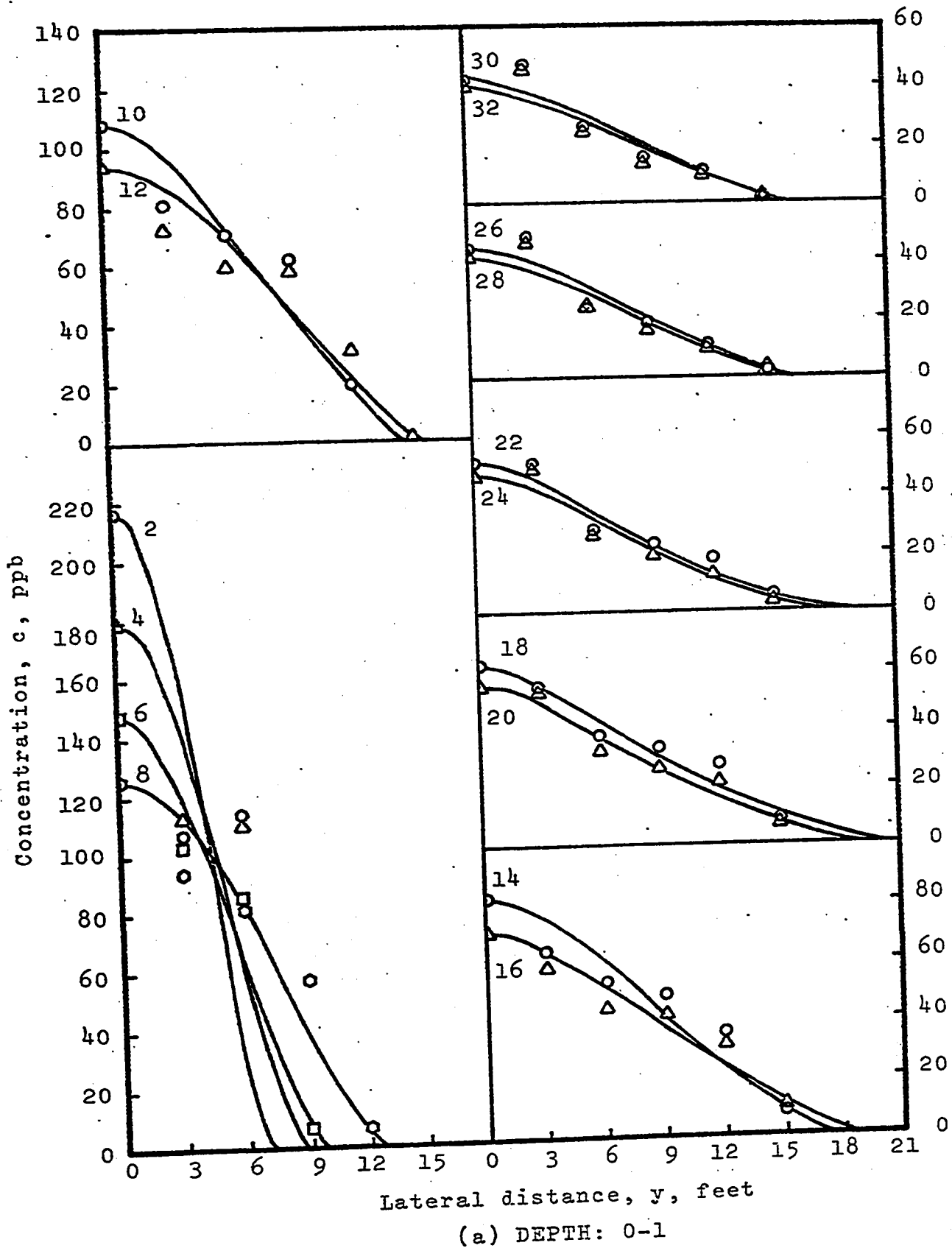


FIG. C.3.--CONCENTRATION vs LATERAL DISTANCE FOR TEST NO. 3
Number on curves and symbols as explained in Fig. C.1

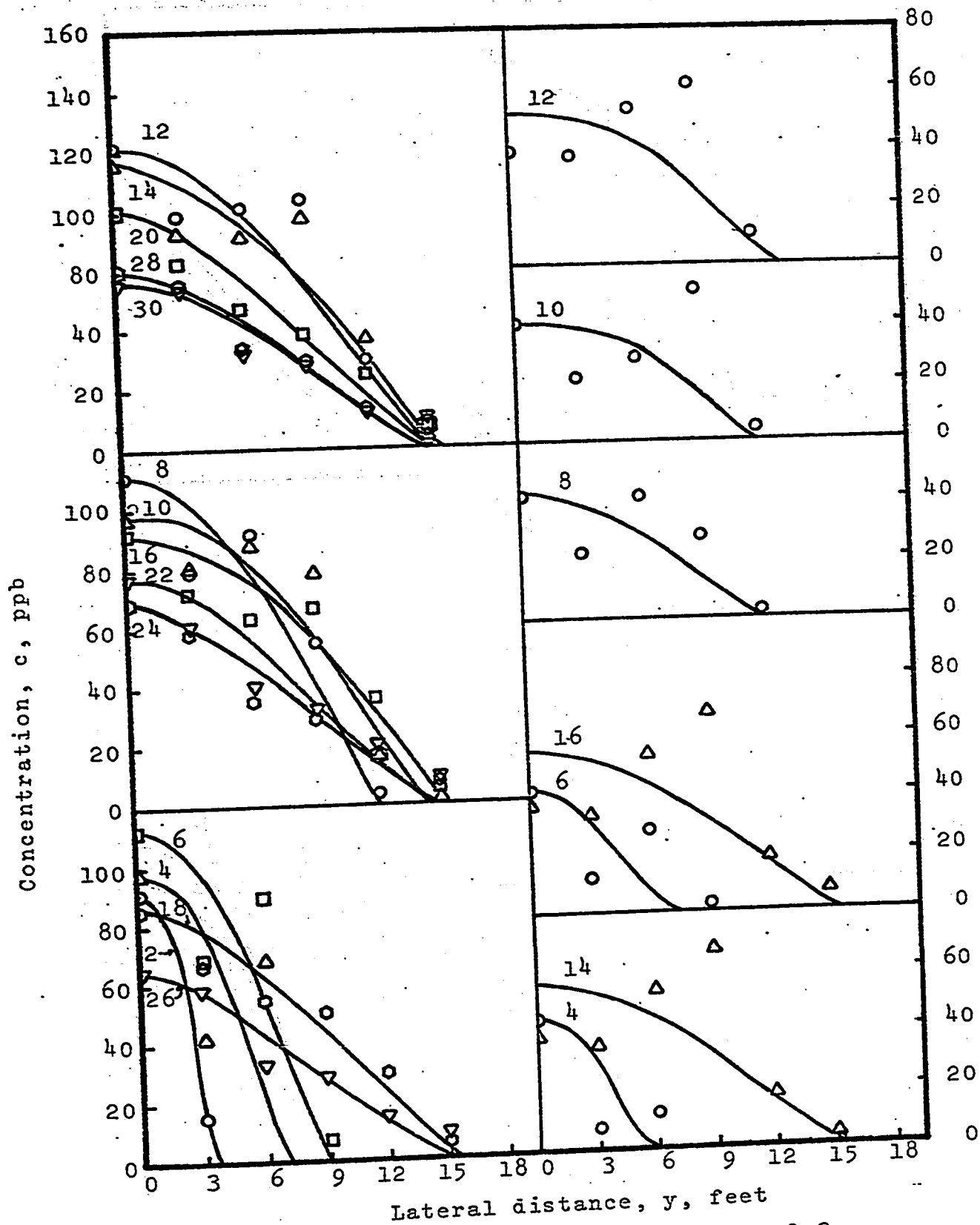


FIG. C.3.--CONTINUED

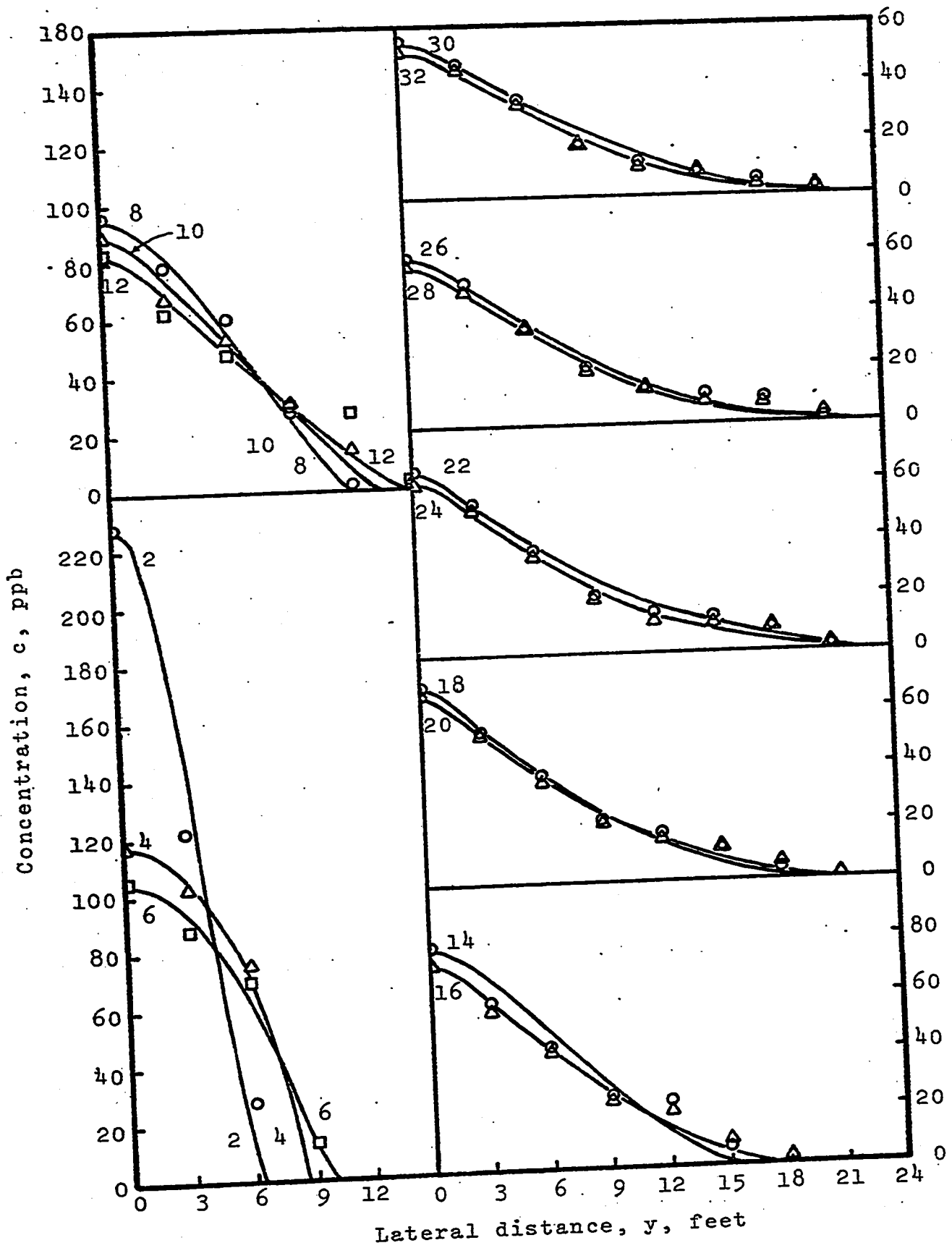
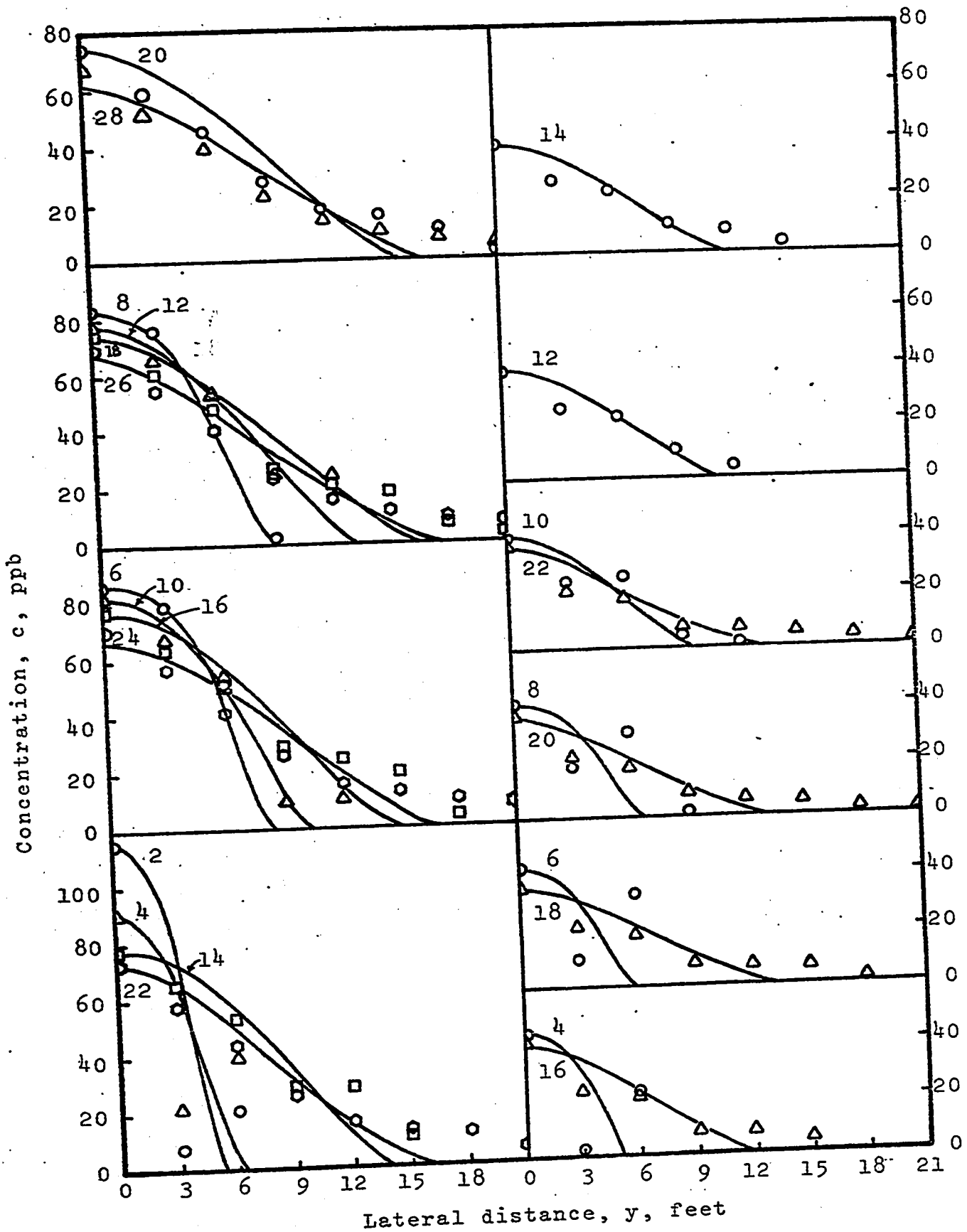


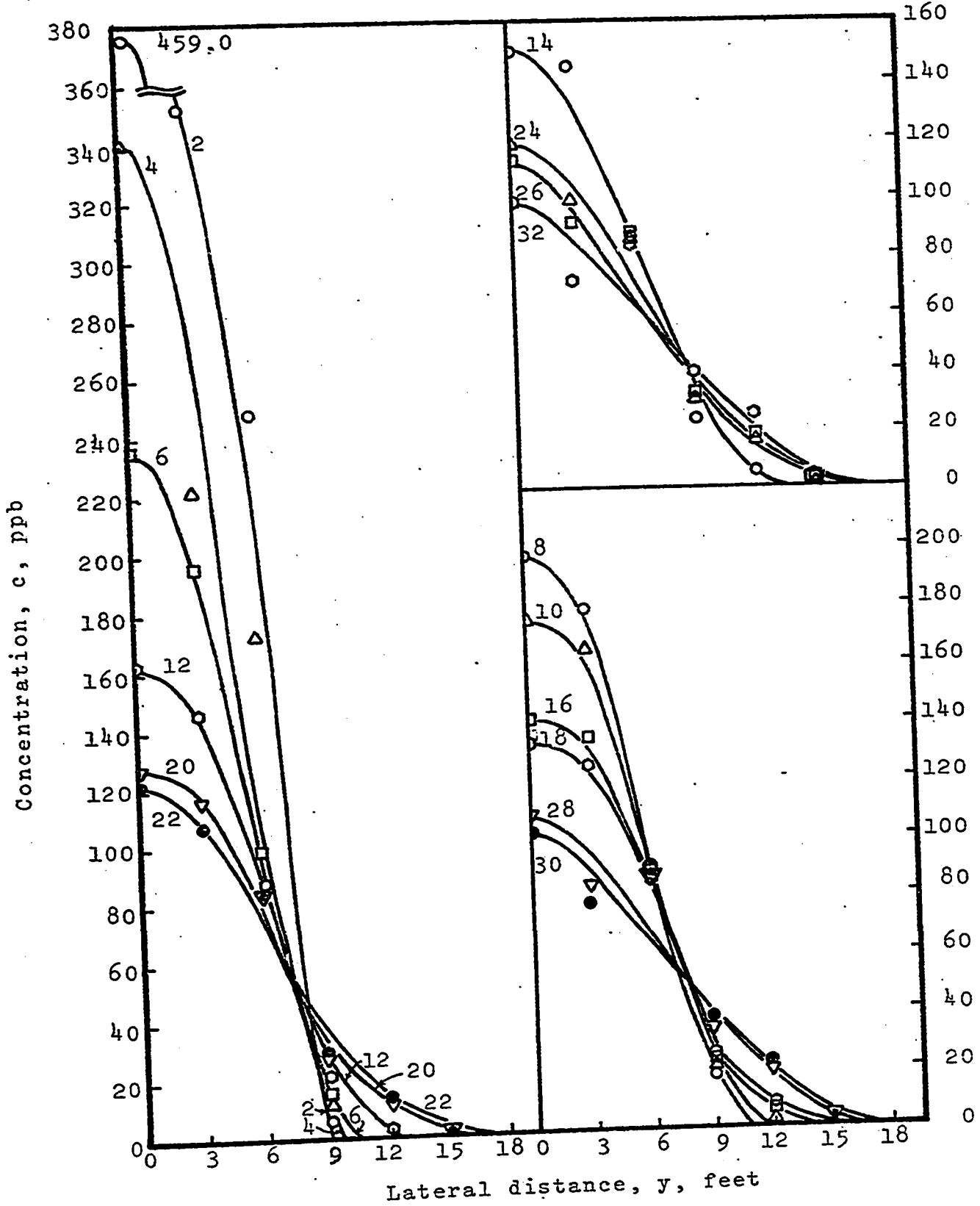
FIG. C.4.--CONCENTRATION vs LATERAL DISTANCE FOR TEST NO. 4
Number on curves and symbols as explained in Fig. C.1



(b) DEPTH: 1-2

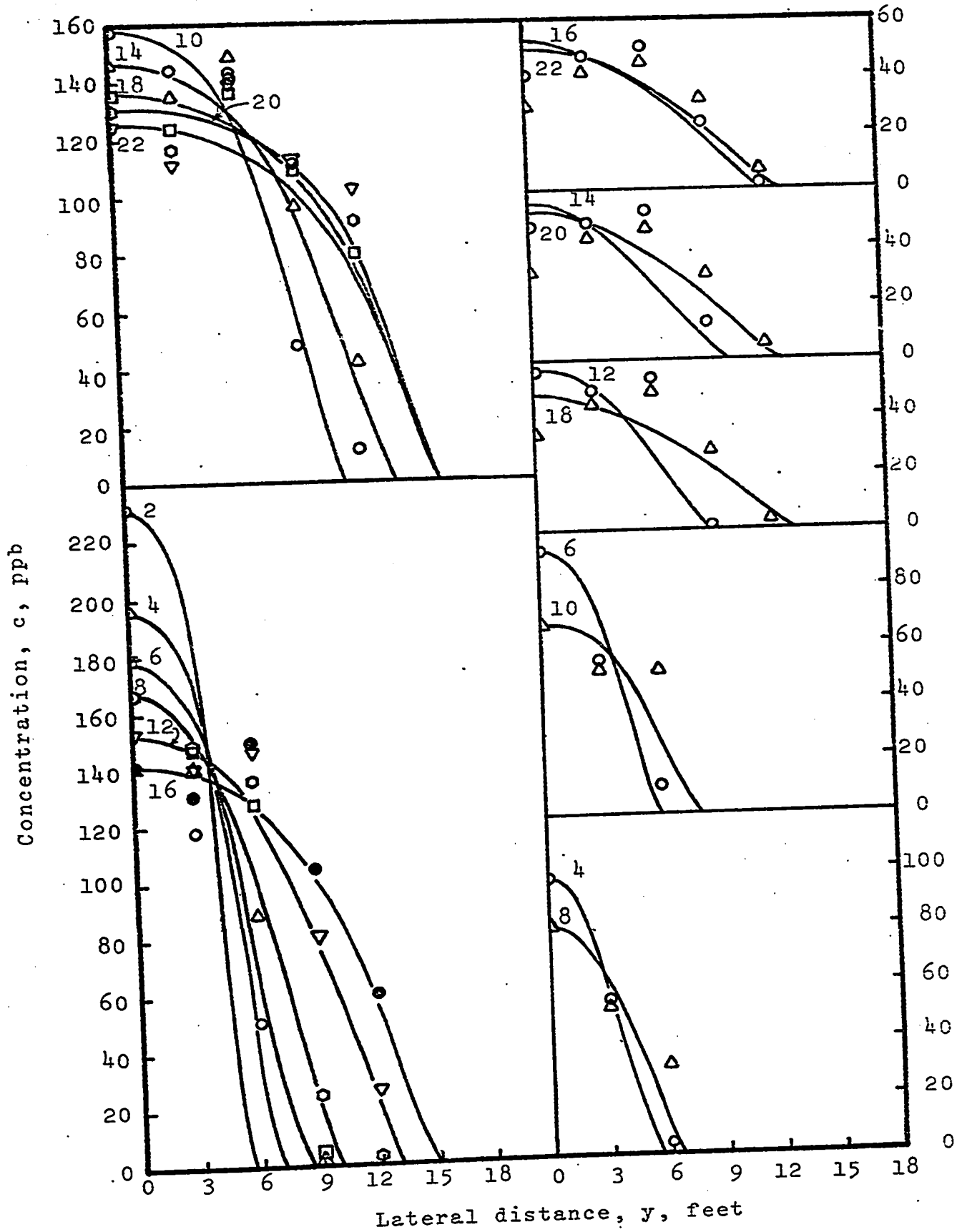
(c) DEPTH: 2-3

FIG. C.4.--CONTINUED



(a) DEPTH: 0-1

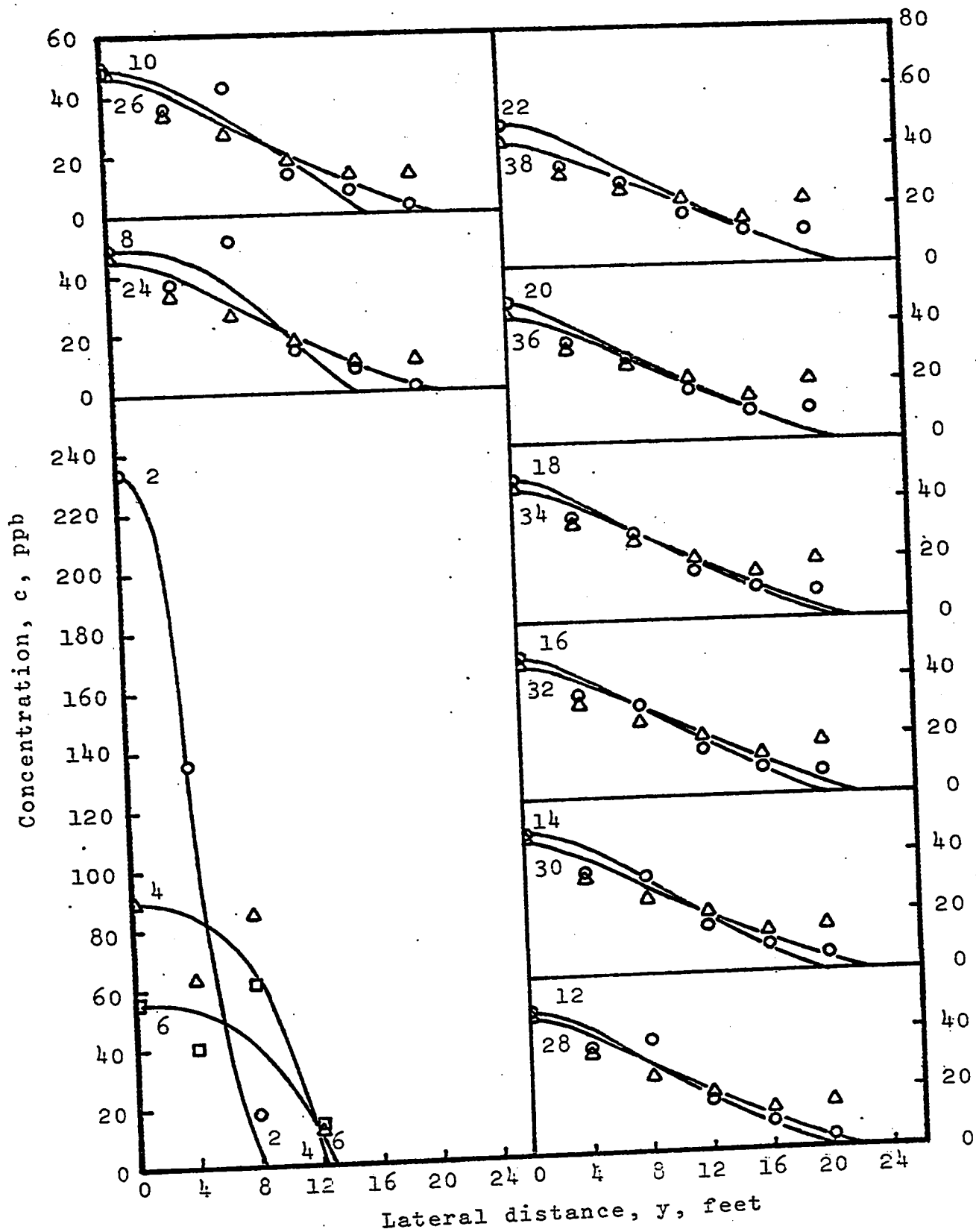
FIG. C.5.--CONCENTRATION vs LATERAL DISTANCE FOR TEST NO. 5
Number on curves and symbols as explained in Fig. C.1



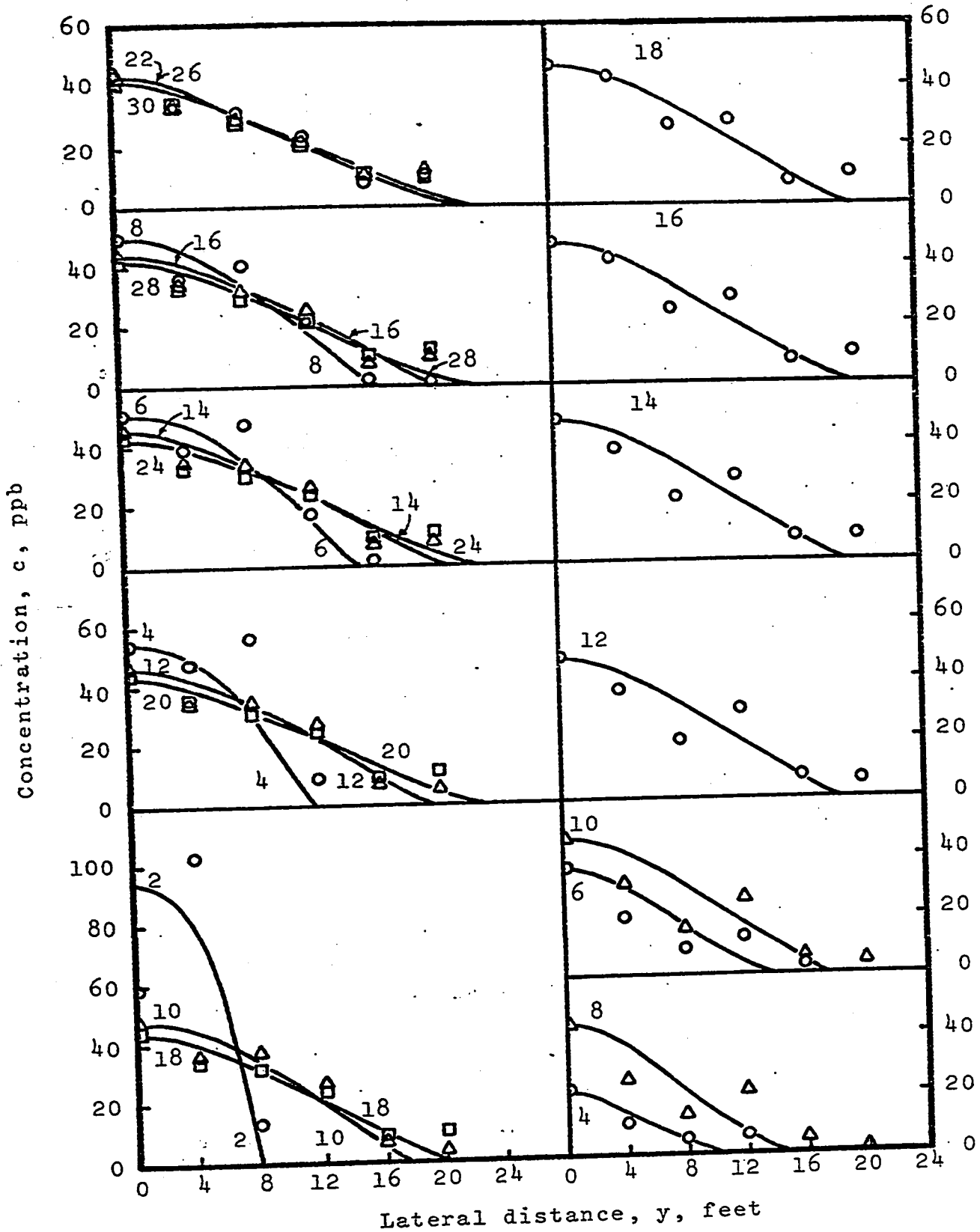
(b) DEPTH: 1-2

(c) DEPTH: 2-3

FIG. C.5.--CONTINUED



(a) DEPTH: 0-1
FIG. C.6.--CONCENTRATION vs LATERAL DISTANCE FOR TEST NO. 6
Number on curves and symbols as explained in Fig. C.1



(b) DEPTH: 1-2

(c) DEPTH: 2-3

FIG. C.6.--CONTINUED

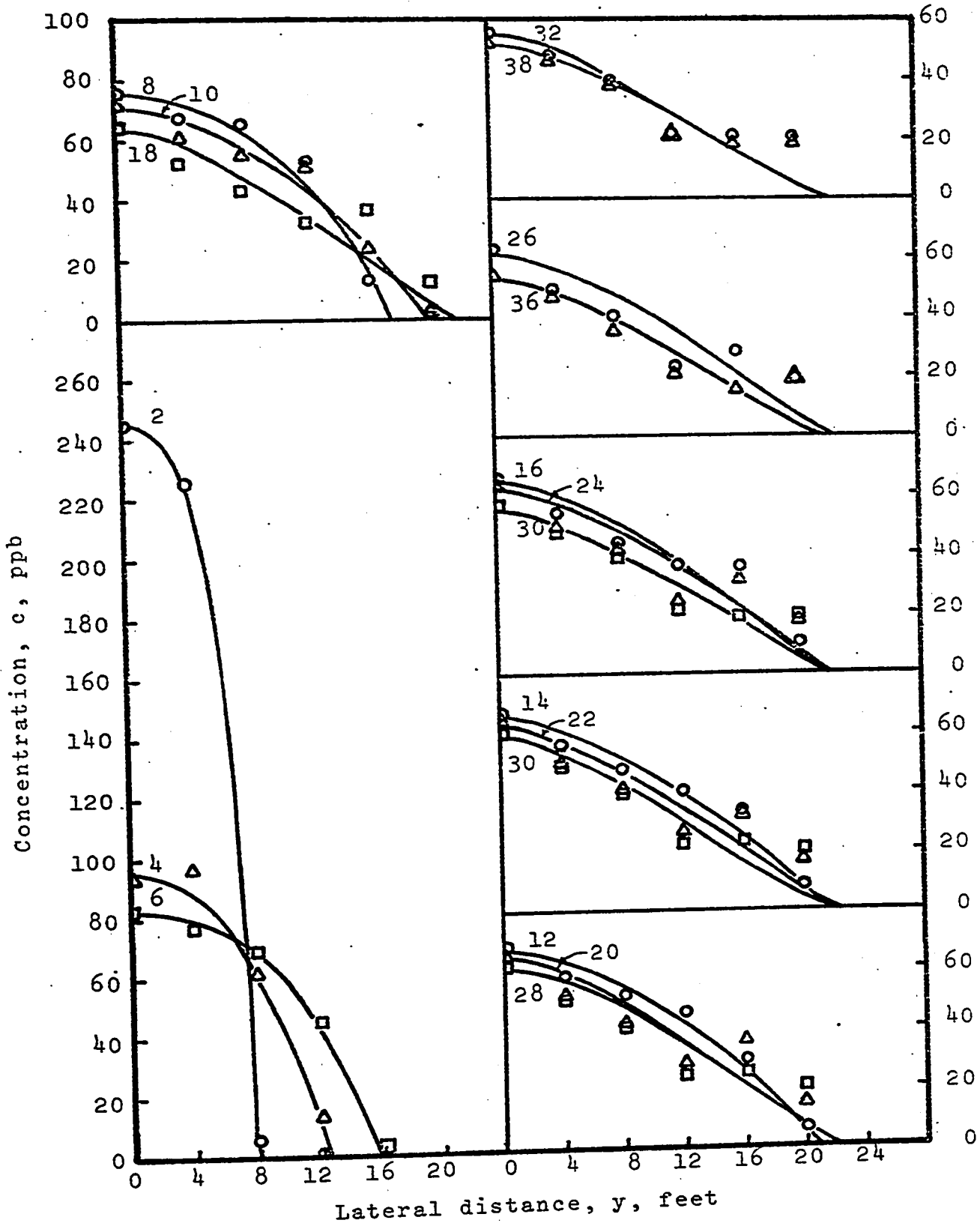


FIG. C.7.--CONCENTRATION vs LATERAL DISTANCE FOR TEST NO. 7
Number on curves and symbols as explained in Fig. C.1

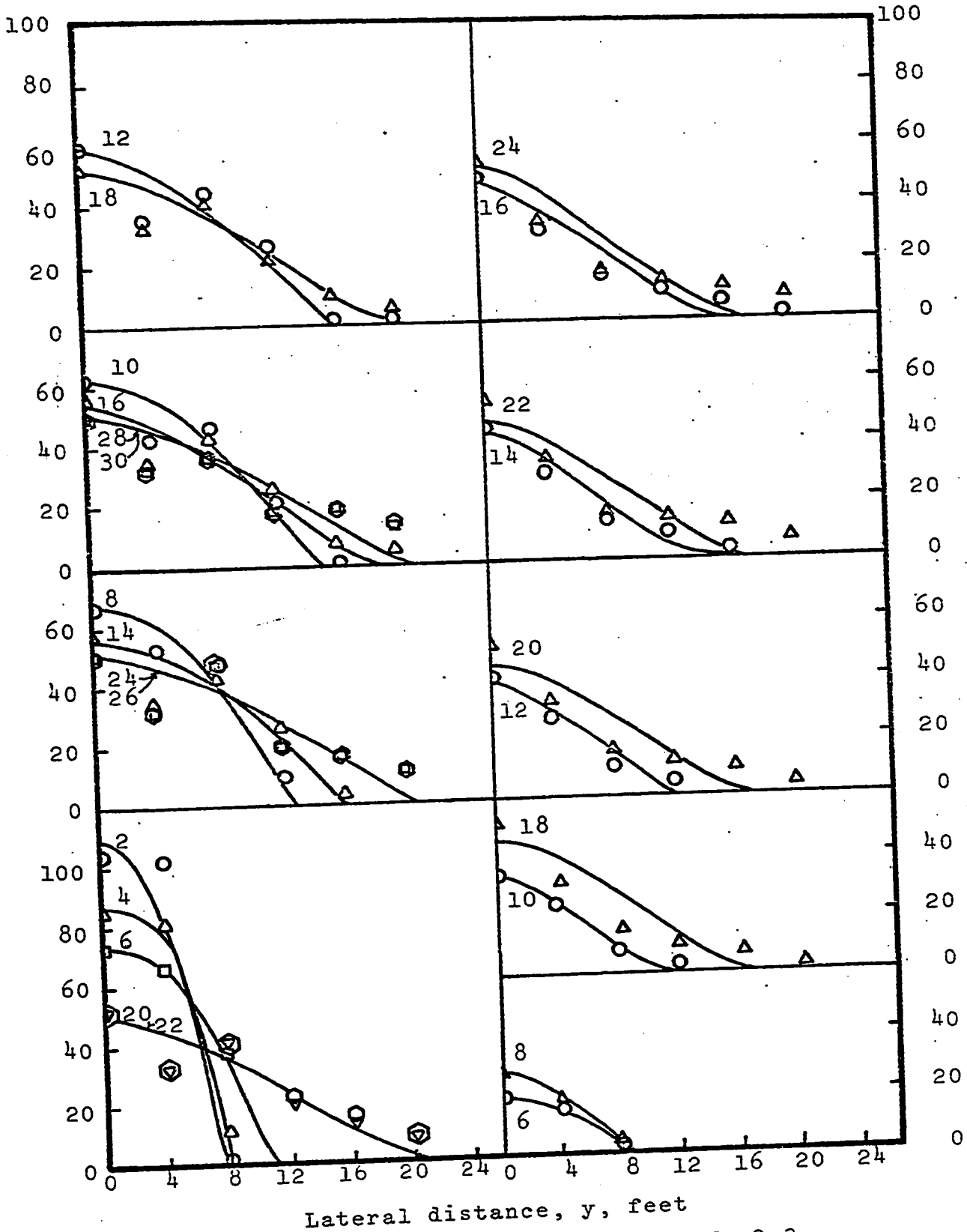


FIG. C.7.---CONTINUED

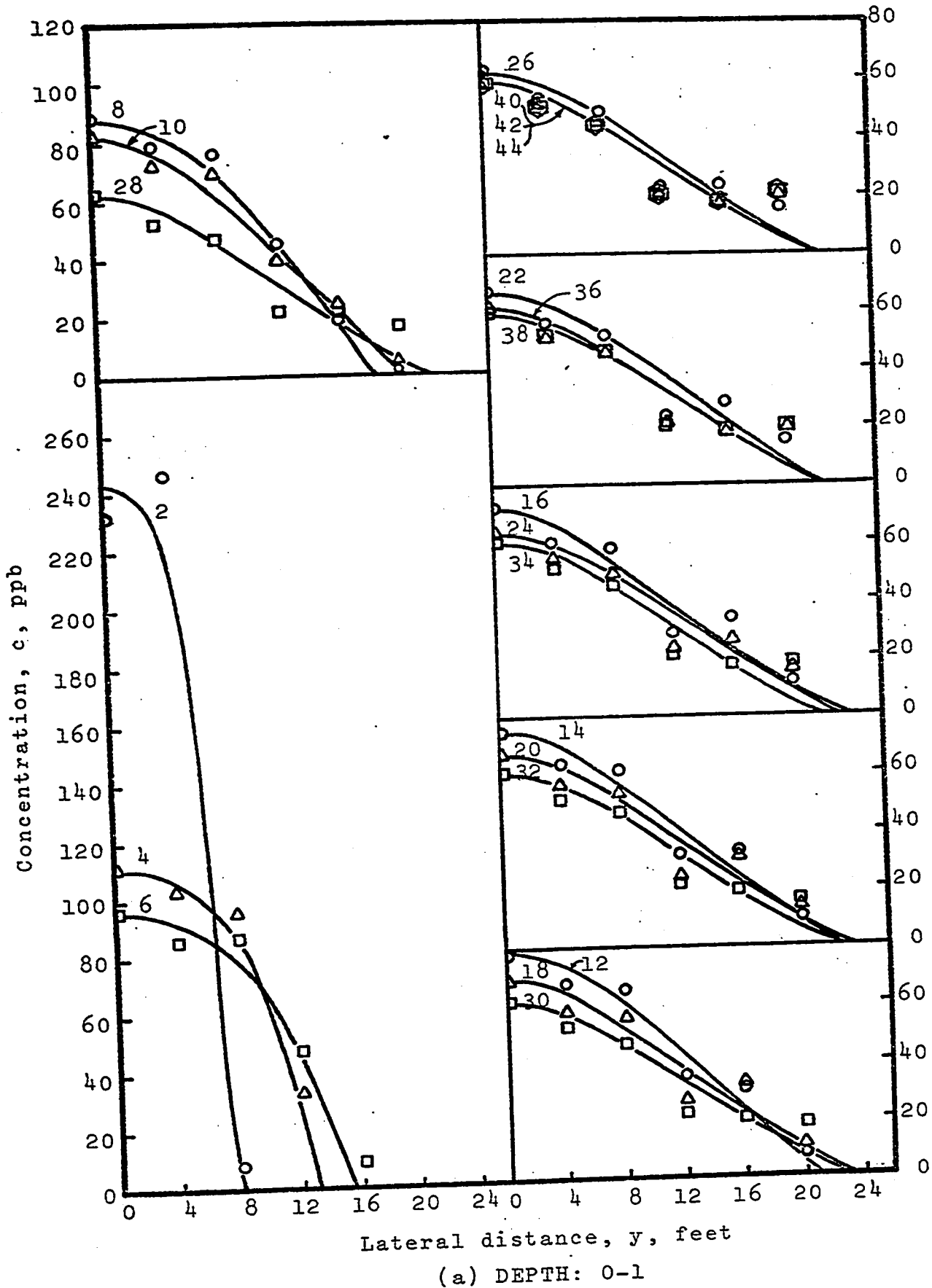
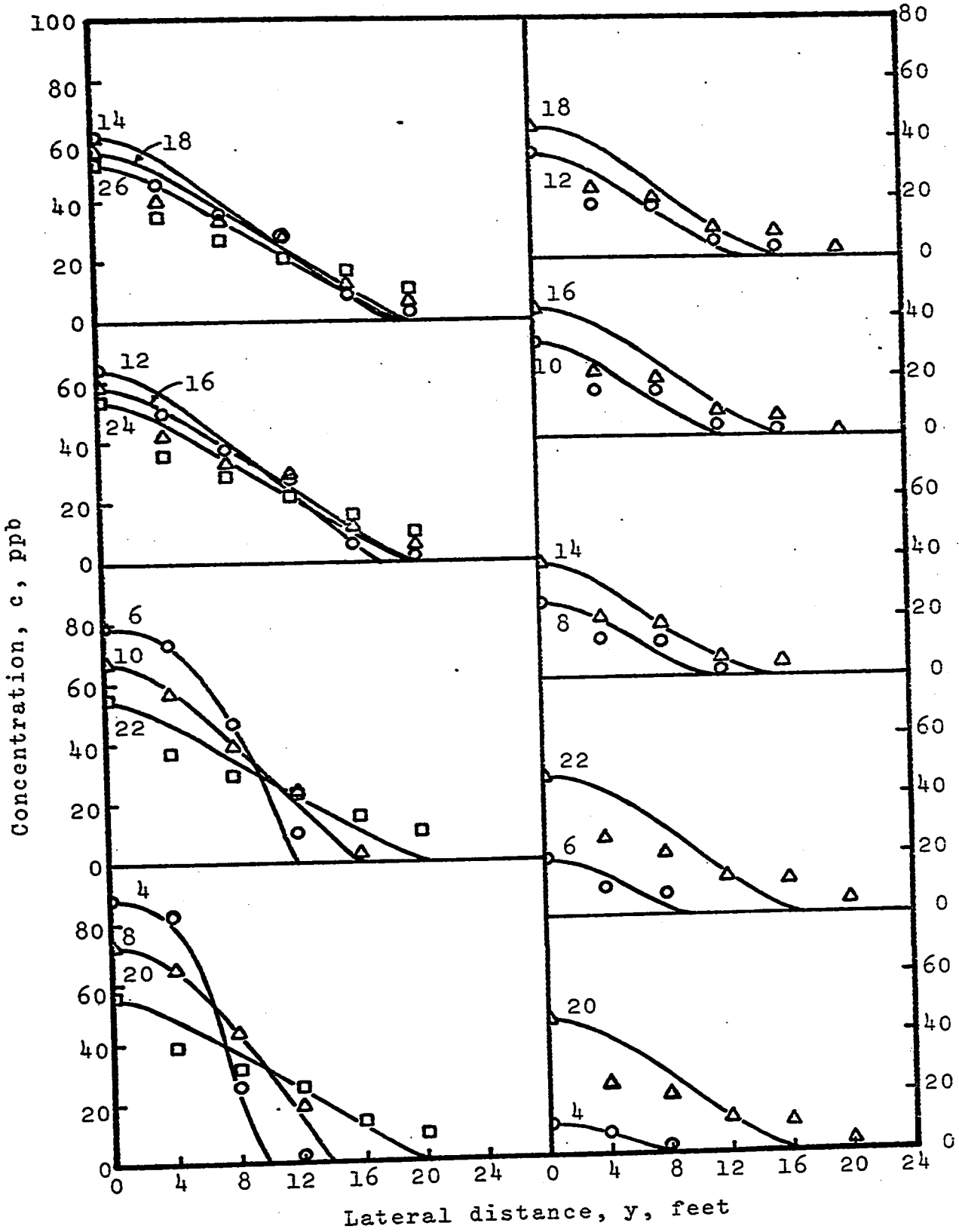


FIG. C.8.--CONCENTRATION vs LATERAL DISTANCE FOR TEST NO. C.8
Number on curves and symbols as explained in Fig. C.1



(b) DEPTH: 1-2

(c) DEPTH: 2-3

FIG. C.8.--CONTINUED

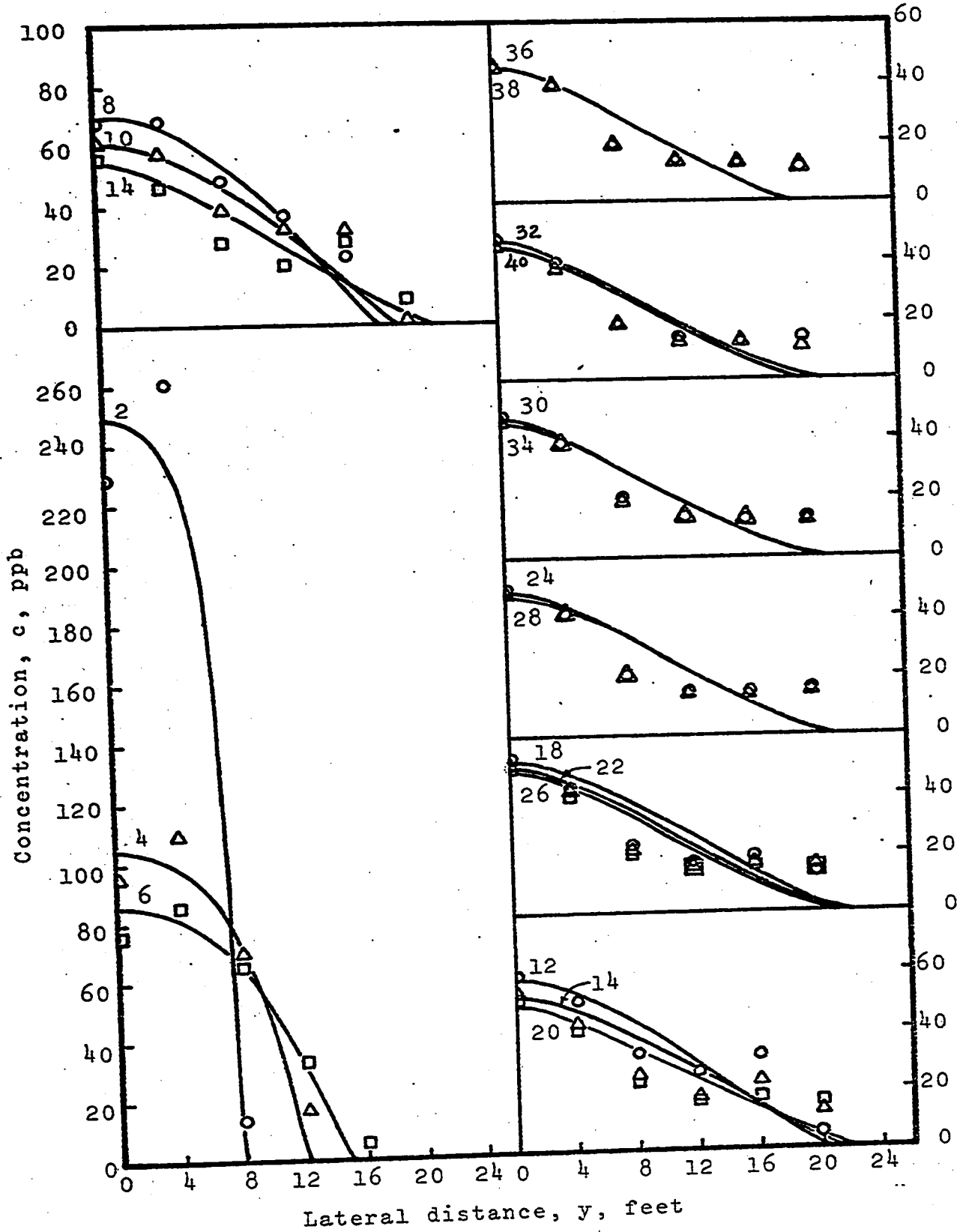
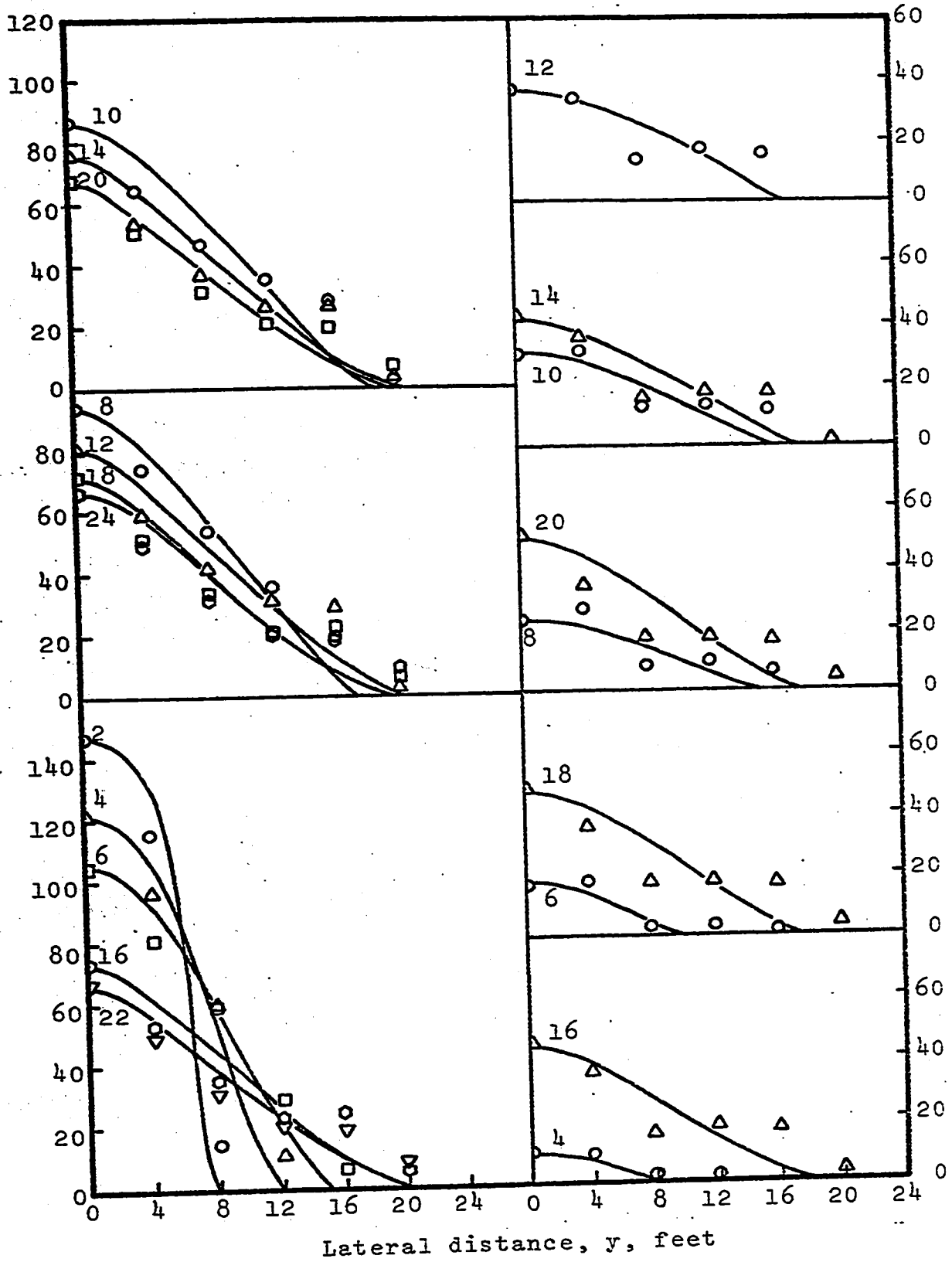


FIG. C.9.--CONCENTRATION vs LATERAL DISTANCE FOR TEST NO. 9
Number on curves and symbols as explained in Fig. C.1



(b) DEPTH: 1-2

(c) DEPTH: 2-3

FIG. C.9.--CONTINUED

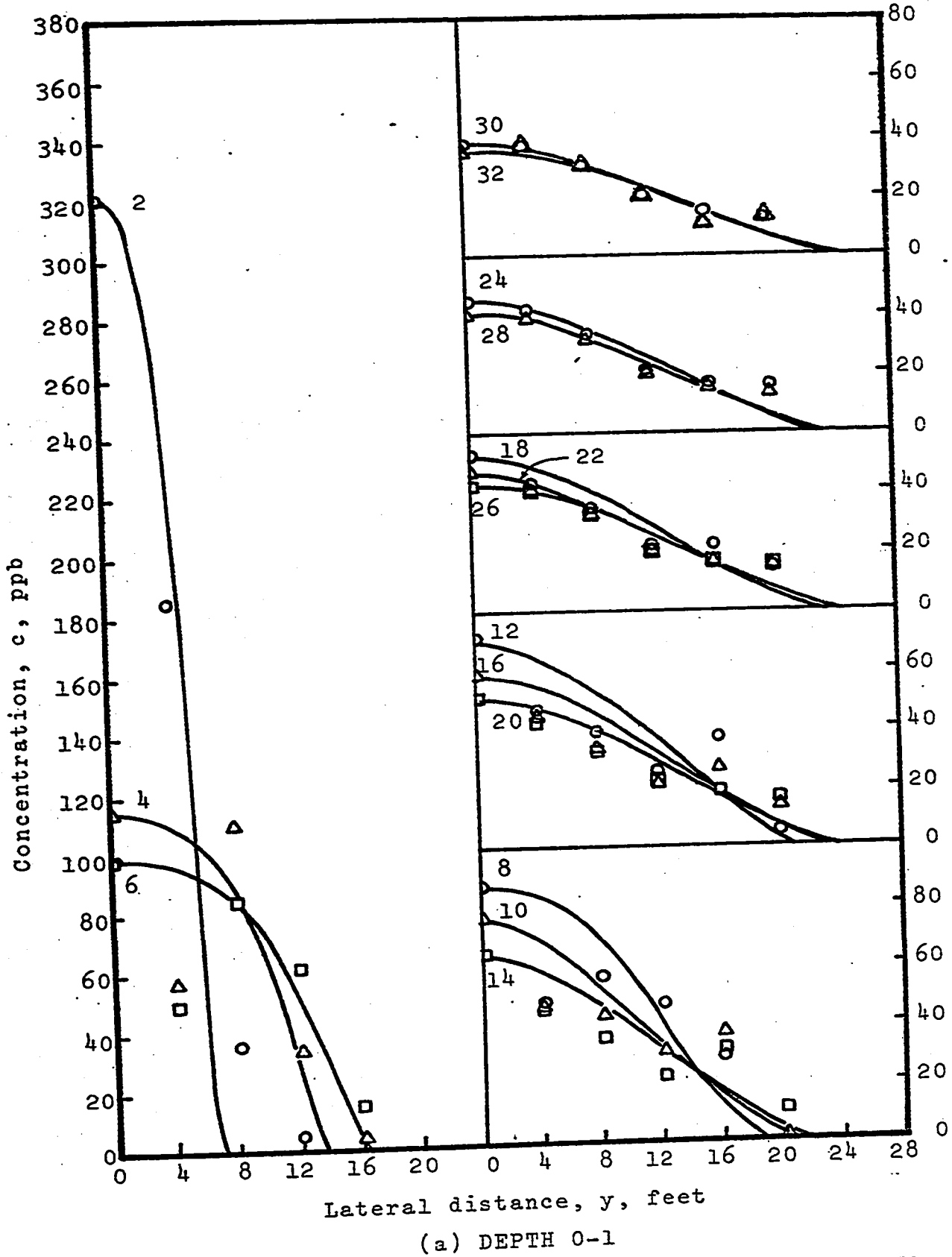


FIG. C.10.--CONCENTRATION vs LATERAL DISTANCE FOR TEST NO. 10
Numbers on curves and symbols as explained in Fig. C.1.

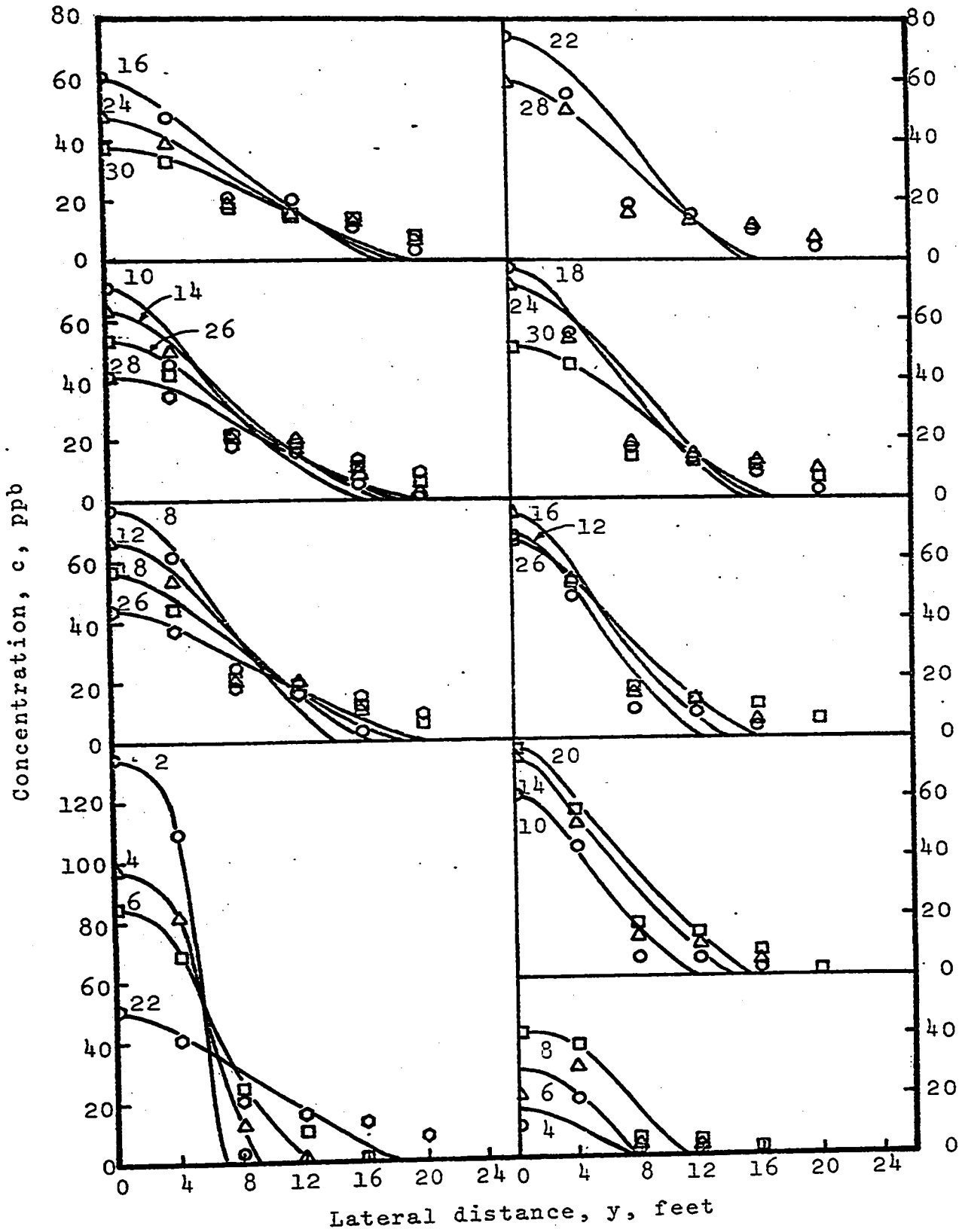


FIG. C.10.--CONTINUED

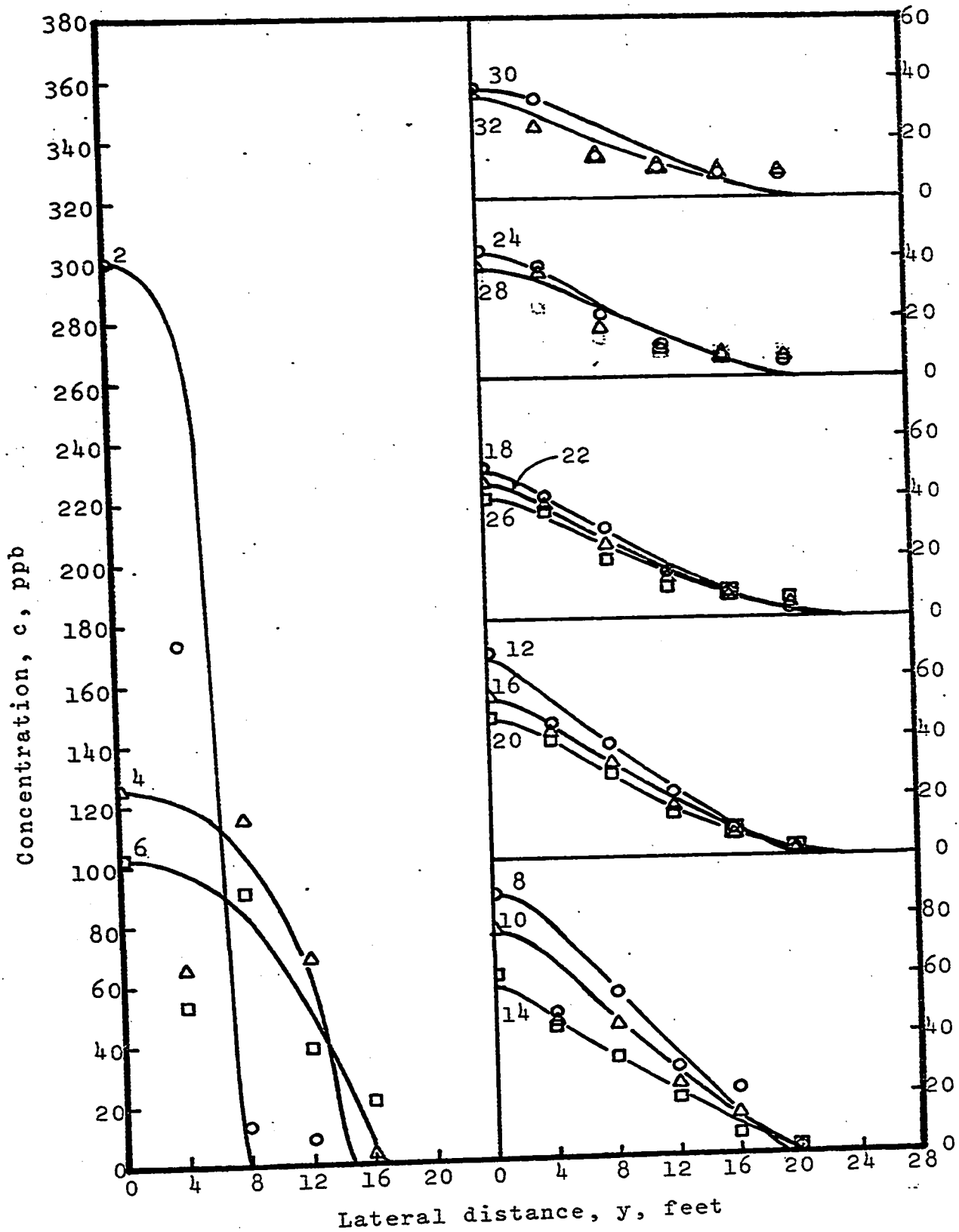


FIG. C.11.--CONCENTRATION vs LATERAL DISTANCE FOR TEST NO. 11
Numbers on curves and symbols as explained in Fig. C.1

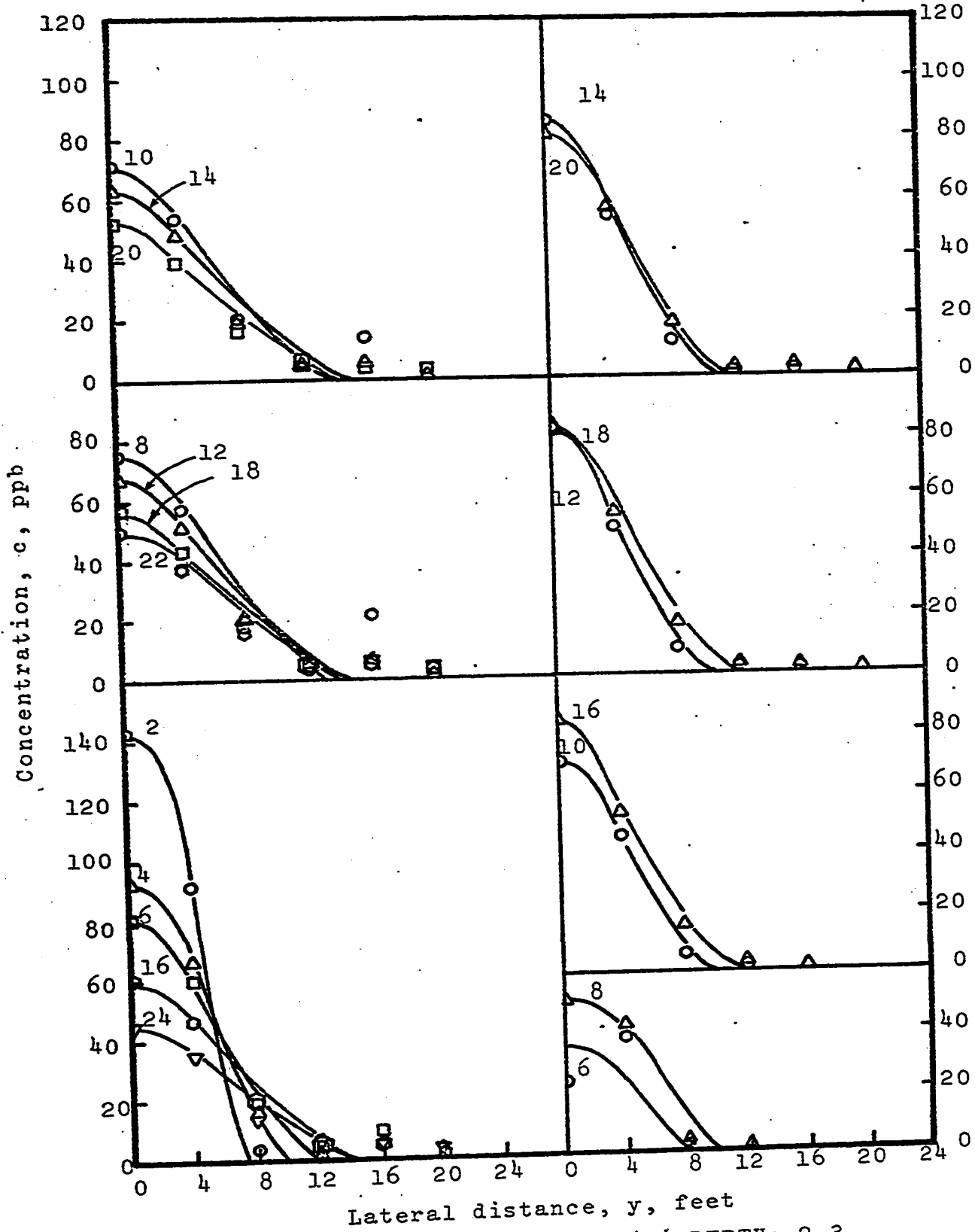


FIG. C.11.--CONTINUED

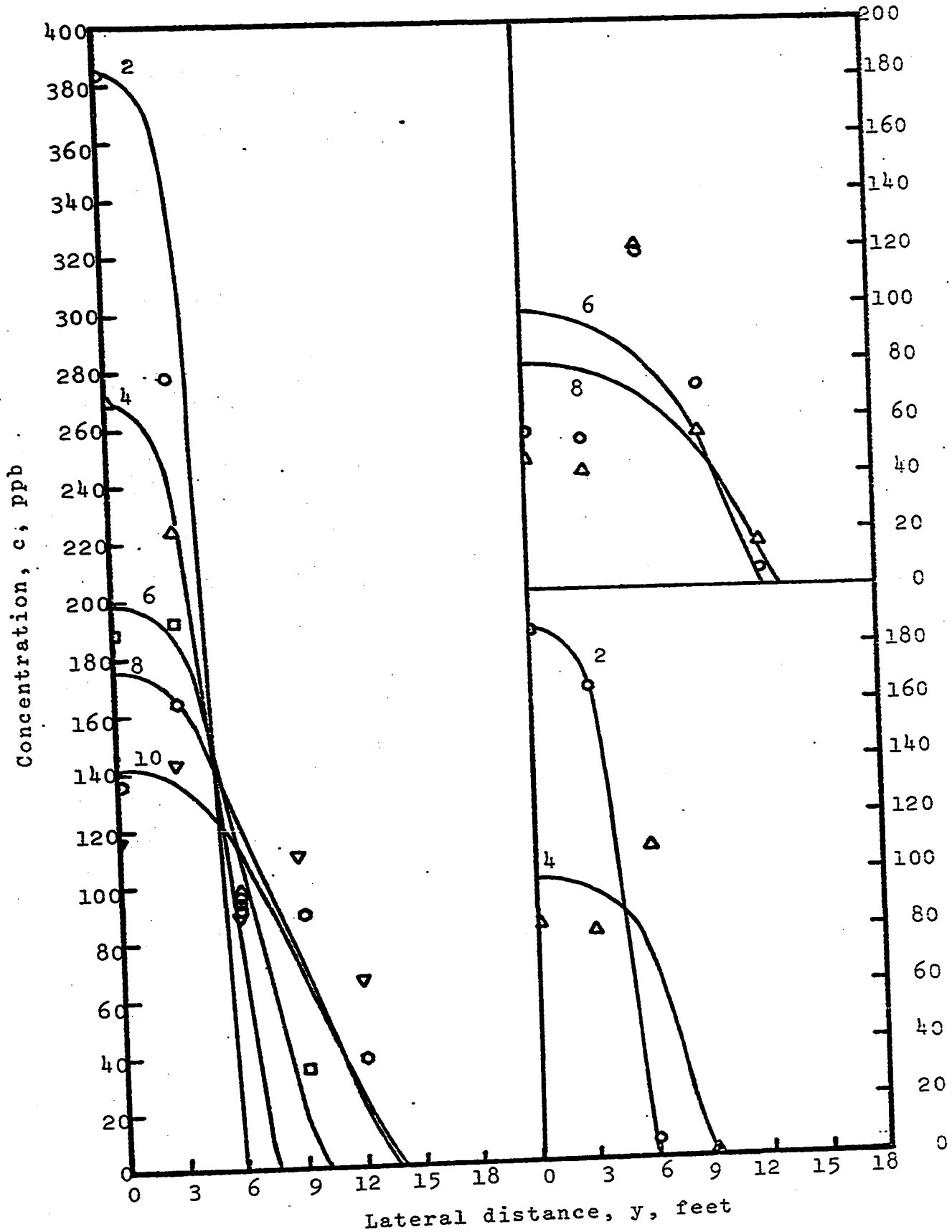
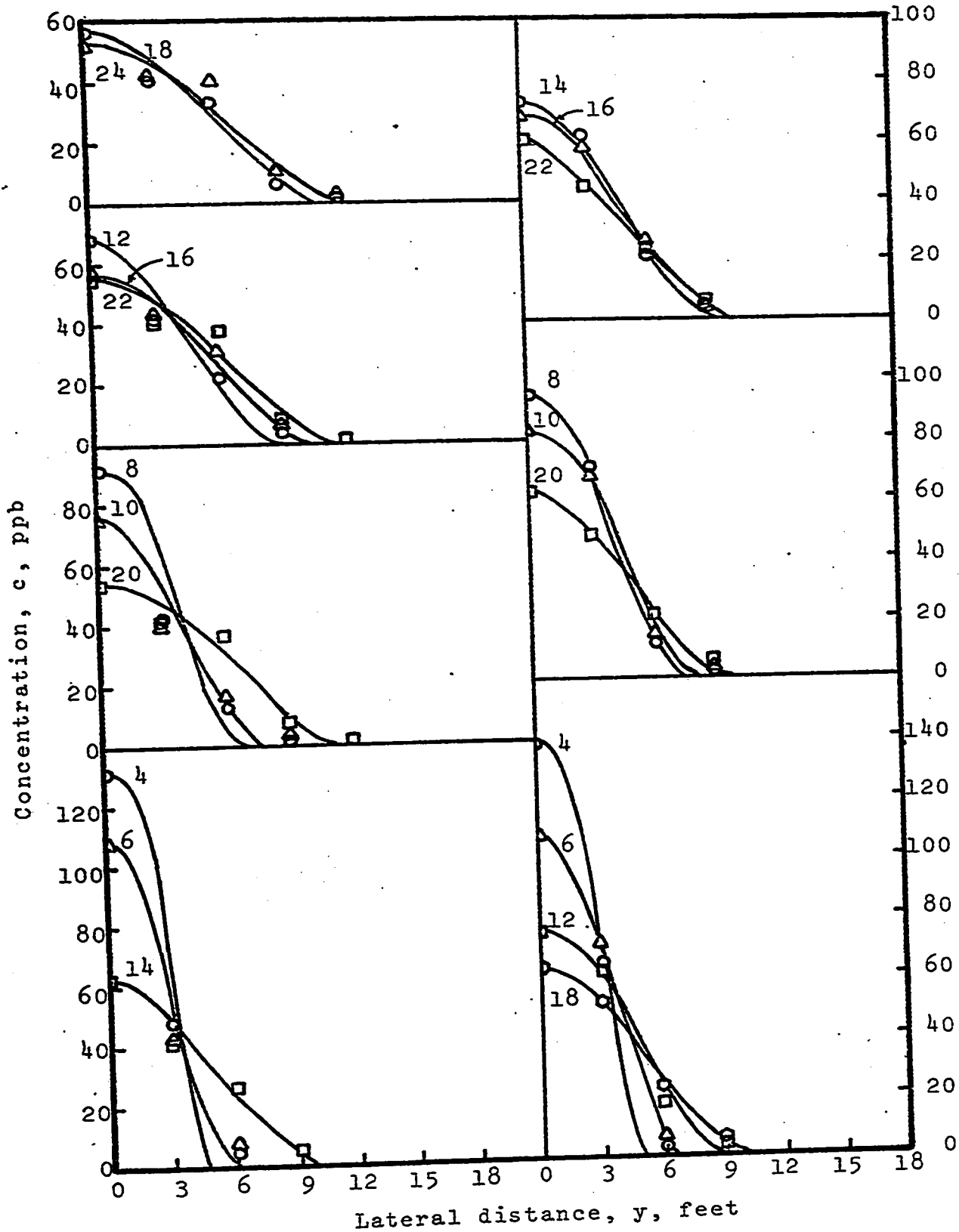


FIG. C.12.--CONCENTRATION vs LATERAL DISTANCE FOR TEST NO. 12
Numbers on curves and symbols as explained in Fig. C.1



(a) DEPTH: 0-1

(b) DEPTH: 1-2

FIG. C.13.--CONCENTRATION vs LATERAL DISTANCE FOR TEST NO. 13
Numbers on curves and symbols as explained in Fig. C.1

TABLE C- 1.---COMPUTATIONAL RESULTS OF TFST NO. 1

TIME MIN	DEPTH FT	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET							VARIANCE SQ.FT.	YD FT	WD GRAM
		0.0	3.0	6.0	9.0	12.0	15.0	NOREQ 2NDMOM			
0.0	0-1	65.08	7.4	0.0	0.0	0.0	0.0	0.0	1.22	0.0639	
	1-3	62.24	0.0	0.0	0.0	0.0	0.0	0.0	1.13		
	2-4	5.03	0.0	0.0	0.0	0.0	0.0	0.0	1.12		
2.0	0-1	225.60	78.07	95.9	0.0	0.0	0.0	0.0	18.37	0.0627	
	1-3	178.09	13.1	10.2	0.0	0.0	0.0	0.0	5.10		
	2-4	17.4	0.0	4.2	0.0	0.0	0.0	0.0	6.73		
4.0	0-1	178.1	113.8	108.6	4.2	0.0	0.0	0.0	19.48	0.0847	
	1-3	192.05	151.6	144.6	1.0	0.0	0.0	0.0	8.58		
	2-4	29.0	11.2	11.1	0.0	0.0	0.0	0.0	8.57		
6.0	0-1	157.04	111.7	102.4	13.4	0.0	0.0	0.0	40.59	0.1015	
	1-3	105.08	179.0	21.1	1.0	0.0	0.0	0.0	10.51		
	2-4	11.6	11.6	21.1	0.0	0.0	0.0	0.0	7.0		
8.0	0-1	140.6	115.4	89.1	30.6	0.0	0.0	0.0	17.80	0.1110	
	1-3	124.8	187.0	31.6	20.2	0.0	0.0	0.0	10.51		
	2-4	17.6	26.0	16.3	1.6	0.0	0.0	0.0	7.0		
10.0	0-1	108.6	98.0	80.9	50.6	0.0	0.0	0.0	12.05	0.1167	
	1-3	11.6	11.6	10.7	37.2	0.0	0.0	0.0	10.61		
	2-4	114.5	81.5	71.3	2.1	0.0	0.0	0.0	13.48		
12.0	0-1	106.5	106.5	82.6	61.0	0.0	0.0	0.0	12.05	0.1184	
	1-3	132.5	29.5	42.6	13.2	0.0	0.0	0.0	17.67		
	2-4	10.5	9.4	2.6	1.7	0.0	0.0	0.0	15.25		
14.0	0-1	101.6	101.6	76.2	43.0	0.0	0.0	0.0	16.95	0.1178	
	1-3	101.6	82.7	66.2	19.6	0.0	0.0	0.0	19.21		
	2-4	10.5	10.5	4.2	1.6	0.0	0.0	0.0	16.51		

NOREQ: NORMAL EQUATION 2NDMOM: SECOND MOMENT

TABLE C-1.--CONTINUED

TIME	DEPTH	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET							VARIANCE SQ.FT.	YO	WD
		0.0	3.0	6.0	9.0	12.0	15.0	2NDMOM			
16.0	0-1	98.0	81.2	59.0	55.9	15.8	7.4	18.87	16.2	0.1153	
	1-3	95.5	76.9	70.6	45.3	10.5	3.2	14.14	14.5		
	2-4	20.5	33.5	42.6	23.2	3.2	1.1	14.03	13.5		
18.0	0-1	90.6	75.9	56.8	45.3	17.8	1.6	23.50	17.0	0.1125	
	1-3	91.5	71.7	66.4	27.4	8.4	3.2	17.12	15.0		
	2-4	20.5	32.5	41.6	27.4	4.2	1.8	22.24	15.0		
20.0	0-1	84.3	71.5	50.6	44.3	19.0	4.2	28.28	18.0	0.1089	
	1-3	86.3	67.5	61.1	44.3	9.5	2.8	20.28	17.0		
	2-4	26.5	36.5	40.6	27.4	5.3	4.2	24.66	16.0		
22.0	0-1	79.0	64.5	47.9	41.1	19.0	2.5	41.35	18.6	0.1055	
	1-3	83.2	60.5	56.9	29.5	9.9	3.2	27.58	17.0		
	2-4	24.5	35.3	44.4	29.5	6.3	5.3	22.48	16.0		
24.0	0-1	74.1	61.4	41.6	37.9	17.0	3.9	55.61	18.6	0.1004	
	1-3	80.1	57.3	52.7	37.9	9.0	6.3	31.12	17.5		
	2-4	29.6	42.5	49.7	28.5	6.3	4.9	27.39	16.5		
26.0	0-1	69.6	52.0	33.5	34.8	16.0	8.4	73.70	19.2	0.0954	
	1-3	76.9	49.2	49.7	34.8	8.4	3.8	32.82	18.5		
	2-4	29.0	35.5	41.5	27.4	6.3	8.4	23.16	16.5		
28.0	0-1	66.4	49.0	30.5	37.4	12.0	6.3	47.66	19.5	0.0910	
	1-3	73.0	45.8	46.6	37.4	6.3	3.8	33.82	18.0		
	2-4	29.5	34.5	40.1	28.0	6.3	6.3	28.16	17.0		
30.0	0-1	61.5	42.5	31.5	32.6	17.0	8.8	51.47	19.5	0.0871	
	1-3	67.0	39.7	46.6	32.6	8.8	5.3	32.82	18.0		
	2-4	27.9	35.9	39.5	28.0	6.3	8.8	23.20	17.0		
32.0	0-1	51.6	34.0	29.5	30.5	15.0	8.8	32.53	19.5	0.0832	
	1-3	59.1	31.3	43.5	30.5	6.4	5.3	26.66	18.5		
	2-4	27.5	28.4	36.1	28.0	6.4	8.8	23.12	17.0		

TABLE C-1.--CONTINUED

TIME	DEPTH	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET				VARIANCE SQ.FT.		YO	WD
MIN	FT	1.0	3.0	6.0	9.0	12.0	15.0	FT	GRAM
24.0	0-1	59.0	53.8	35.0	27.4	13.7	13.7	19.5	0.0798
	1-2	66.4	49.9	27.0	23.2	14.6	13.5	18.0	
	2-3	18.4	17.9	25.3	23.4	12.7	10.5		
36.0	0-1	56.4	47.5	34.8	27.4	13.7	12.6	19.5	0.0772
	1-2	64.9	48.9	35.2	22.1	12.6	11.6	16.5	
	2-3	16.7	16.4	23.4	22.4	12.6	11.6		
38.0	0-1	55.9	46.4	33.4	27.4	12.6	11.6	19.5	0.0742
	1-2	62.9	47.8	32.7	23.2	12.6	11.6	16.5	
	2-3	15.4	15.4	22.7	21.4	12.6	11.6		
40.0	0-1	54.8	46.4	32.7	27.4	12.6	11.6	19.5	0.0724
	1-2	60.8	46.4	32.7	22.0	12.6	11.6	16.5	
	2-3	15.8	14.8	21.4	20.4	12.6	11.6		
42.0	0-1	53.8	45.8	31.6	27.4	12.6	11.6	19.5	0.0706
	1-2	58.8	43.7	30.4	21.9	12.6	11.6	16.5	
	2-3	15.7	14.6	20.4	17.4	12.6	11.6		
44.0	0-1	52.9	44.6	30.4	27.4	12.6	11.6	19.5	0.0688
	1-2	55.8	42.6	29.0	21.9	12.6	11.6	16.5	
	2-3	14.7	12.6	19.0	17.4	12.6	11.6		
46.0	0-1	51.4	42.6	29.0	27.4	12.6	11.6	19.5	0.0681
	1-2	54.8	42.6	28.0	21.9	12.6	11.6	16.5	
	2-3	14.8	12.6	17.9	17.4	12.6	11.6		
48.0	0-1	50.6	42.6	27.4	27.4	12.6	11.6	19.5	0.0670
	1-2	52.7	42.6	27.4	21.9	12.6	11.6	16.5	
	2-3	14.7	12.6	17.4	16.3	12.6	11.6		

NOREO	2NDMOM
31.31	22.678
31.19	22.996
76.70	34.776
16.67	22.281
30.10	32.816
96.70	34.405
16.44	22.140
29.78	33.676
12.85	32.747
74.60	32.284
29.54	33.644
25.42	22.418
75.69	37.123
28.16	32.044
29.48	32.150
18.00	32.372
26.83	32.105
260.20	32.015
27.10	32.149
28.29	35.497
260.20	32.047
25.38	21.915
28.07	20.359
260.94	35.09

TABLE C-2--COMPUTATIONAL RESULTS OF TEST NO. 2

TIME MIN	DEPTH FT	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET										VARIANCE SQ.FT.	2NDMDM	YO FT	WD GRAM
		0.0	3.0	6.0	9.0	12.0	15.0	18.0	NREQ	NREQ					
0.0	0-1	508.0	299.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.56	0.1147
	0-2	214.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.33	
	0-3	40.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.12	
2.0	0-1	210.8	139.1	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.90	0.0762
	0-2	137.4	10.5	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.40	
	0-3	127.4	5.3	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.00	
4.0	0-1	142.9	194.6	58.4	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.91	0.0809
	0-2	40.1	50.2	47.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.56	
	0-3	119.1	28.4	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.73	
6.0	0-1	184.2	84.0	62.8	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.52	0.0838
	0-2	43.2	59.6	24.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.76	
	0-3	115.6	11.6	1.0	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.26	
8.0	0-1	176.4	105.9	54.8	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.29	0.0885
	0-2	43.7	73.8	11.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.37	
	0-3	155.9	32.6	4.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.47	
10.0	0-1	71.2	12.6	11.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.49	0.0922
	0-2	14.6	3.2	5.4	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.25	
	0-3	42.6	13.0	2.6	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.80	
12.0	0-1	189.2	159.0	114.8	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.87	0.0964
	0-2	68.3	22.0	7.8	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.59	
	0-3	15.3	14.8	1.6	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.77	
14.0	0-1	65.1	14.8	21.6	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.72	0.1001
	0-2	40.1	5.3	1.7	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.98	
	0-3	16.9	2.5	0.8	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.65	

NUREQ: NORMAL EQUATION

2NDMDM: SECOND MOMENT

TABLE C- 2--CONTINUED

TIME	DEPTH	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET										YD	WD
		0.0	3.0	6.0	9.0	12.0	15.0	18.0	NOREQ	2NDMOM	FT		
16.0	0	79.0	50.6	51.6	30.6	27.4	15.8	18.0	31.57	32.18	19.2	0.1028	
	1	62.0	61.1	52.0	25.0	23.0	13.0	6.3	32.91	35.18	17.4		
	2	39.0	27.4	20.5	19.0	18.0	10.5	7.0	34.04	35.18	16.5		
18.0	0	75.0	47.0	50.6	24.0	22.0	20.0	1.5	39.04	33.95	20.3	0.1030	
	1	60.0	60.0	51.0	17.0	17.0	17.0	1.5	39.04	33.95	19.0		
	2	37.0	23.0	19.0	19.0	19.0	11.0	6.0	48.09	37.04	17.0		
20.0	0	72.0	45.0	48.0	28.0	27.0	21.0	1.3	49.04	35.42	22.0	0.1027	
	1	56.0	55.0	55.0	16.0	17.0	19.0	5.0	49.04	35.42	19.0		
	2	36.0	23.0	19.0	19.0	19.0	12.0	3.0	65.03	40.01	17.0		
22.0	0	70.0	44.0	49.0	22.0	22.0	22.0	1.5	55.12	45.28	22.0	0.1011	
	1	55.0	48.0	55.0	18.0	19.0	23.0	5.0	55.12	45.28	19.0		
	2	35.0	24.0	20.0	19.0	22.0	23.0	3.0	85.03	50.17	16.5		
24.0	0	68.0	42.0	47.0	21.0	22.0	22.0	1.6	73.01	46.29	22.0	0.0980	
	1	53.0	45.0	54.0	19.0	19.0	23.0	6.0	73.01	46.29	19.0		
	2	33.0	22.0	20.0	18.0	22.0	23.0	5.0	149.02	51.63	19.0		
26.0	0	65.0	41.0	46.0	20.0	22.0	22.0	1.8	77.07	48.46	22.0	0.0952	
	1	50.0	44.0	54.0	18.0	19.0	23.0	6.0	77.07	48.46	19.0		
	2	30.0	21.0	20.0	18.0	22.0	23.0	5.0	160.08	51.63	19.0		
28.0	0	63.0	40.0	45.0	19.0	22.0	22.0	1.9	82.03	49.58	21.0	0.0928	
	1	48.0	43.0	53.0	17.0	19.0	23.0	8.0	82.03	49.58	19.0		
	2	28.0	20.0	20.0	18.0	22.0	23.0	6.0	227.05	55.87	21.0		
30.0	0	61.0	39.0	44.0	18.0	21.0	21.0	1.8	86.06	50.61	21.0	0.0904	
	1	46.0	42.0	52.0	16.0	18.0	22.0	8.0	86.06	50.61	19.0		
	2	26.0	19.0	20.0	17.0	21.0	22.0	6.0	196.04	56.10	21.0		
32.0	0	59.0	38.0	43.0	17.0	20.0	20.0	1.8	90.09	51.63	21.0	0.0875	
	1	44.0	41.0	51.0	15.0	18.0	21.0	8.0	90.09	51.63	19.0		
	2	24.0	18.0	20.0	16.0	20.0	21.0	6.0	214.03	56.10	21.0		

TABLE C- 2.--CONTINUED

TIME MIN	DEPTH FT	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET							VARIANCE SQ.FT.	YO FT	WD GRAM
		0.0	3.0	6.0	9.0	12.0	15.0	18.0			
34.0	0-1	91.1	37.9	42.2	24.9	20.0	16.9	18.0	43.64	21.0	0.0862
	1-3	32.7	32.0	45.8	17.6	13.7	21.5	14.4	56.12	21.0	0.0846
	3-4	15.7	18.4	44.2	23.4	20.0	15.4	8.4	69.32	21.0	0.0829
36.0	0-1	59.0	37.7	44.3	16.9	13.7	21.5	13.4	41.20	21.0	0.0806
	1-2	50.0	27.9	44.7	12.6	13.4	15.4	8.4	55.72	21.0	0.0790
	3-4	13.7	18.4	41.4	17.4	13.7	14.8	7.4	39.94	21.0	0.0770
38.0	0-1	50.0	37.9	41.2	23.9	16.9	14.8	13.4	38.52	20.0	0.0759
	1-2	31.0	17.9	33.7	12.4	13.4	17.4	8.4	69.32	20.0	0.0749
	3-4	12.6	18.4	40.1	18.4	15.4	13.7	6.4	32.08	20.0	0.0739
40.0	0-1	50.0	32.0	42.6	15.8	12.6	13.0	13.4	36.61	20.0	0.0729
	1-2	30.6	16.9	32.7	11.3	12.6	14.4	8.4	54.15	20.0	0.0719
	3-4	12.6	18.4	37.4	16.3	13.7	13.0	6.4	42.07	20.0	0.0709
42.0	0-1	22.9	18.4	39.0	11.3	12.6	13.0	12.6	79.76	20.0	0.0699
	1-2	12.6	16.9	32.6	15.8	13.7	14.4	8.4	52.07	20.0	0.0689
	3-4	12.6	18.4	37.4	16.3	13.7	13.0	6.4	43.07	20.0	0.0679
44.0	0-1	48.5	35.0	41.6	20.8	14.8	12.6	12.6	34.07	20.0	0.0669
	1-2	28.0	17.9	31.4	11.6	12.6	14.4	8.4	52.07	20.0	0.0659
	3-4	12.6	18.4	37.4	16.3	13.7	13.0	6.4	43.07	20.0	0.0649
46.0	0-1	53.6	35.0	37.0	20.8	14.8	12.6	12.6	34.07	20.0	0.0639
	1-2	27.4	17.9	31.4	11.6	12.6	14.4	8.4	52.07	20.0	0.0629
	3-4	12.6	18.4	37.4	16.3	13.7	13.0	6.4	43.07	20.0	0.0619
48.0	0-1	47.4	35.0	41.6	20.8	14.8	12.6	12.6	34.07	20.0	0.0609
	1-2	27.4	17.9	31.4	11.6	12.6	14.4	8.4	52.07	20.0	0.0599
	3-4	12.6	18.4	37.4	16.3	13.7	13.0	6.4	43.07	20.0	0.0589

TABLE C-3--COMPUTATIONAL RESULTS OF TEST NO. 3

TIME	DEPTH	CONCENTRATION IN PPB AT						VARIANCE	WD
		STATED LATERAL DISTANCE IN FEET							
MIN	FT	0.0	3.0	6.0	9.0	12.0	15.0	2NDMOM	GRAM
0.0	0-1	50.2	40.1	0.0	0.0	0.0	0.0	0.0	0.0668
	1-2	50.1	7.4	0.0	0.0	0.0	0.0	0.0	
	2-3	47.6	0.0	0.0	0.0	0.0	0.0	0.0	
2.0	0-1	217.1	106.5	113.2	0.0	0.0	0.0	16.42	0.0709
	1-2	60.6	14.9	0.0	0.0	0.0	0.0	0.0	
	2-3	47.6	1.1	0.0	0.0	0.0	0.0	0.0	
4.0	0-1	22.2	12.2	10.6	0.0	0.0	0.0	0.0	0.0890
	1-2	17.9	1.9	0.0	0.0	0.0	0.0	0.0	
	2-3	44.2	14.4	1.6	0.0	0.0	0.0	0.0	
6.0	0-1	10.6	2.5	9.5	6.3	0.0	0.0	20.21	0.0988
	1-2	147.6	10.6	4.9	6.3	0.0	0.0	15.0	
	2-3	112.2	2.5	27.5	6.3	0.0	0.0	8.9	
8.0	0-1	11.4	1.8	6.4	2.0	0.0	0.0	11.0	0.1237
	1-2	125.6	12.0	9.6	9.4	0.0	0.0	11.0	
	2-3	11.4	1.8	27.5	2.0	0.0	0.0	11.0	
10.0	0-1	107.5	2.2	17.0	1.2	0.0	0.0	11.0	0.1355
	1-2	11.4	1.6	41.0	8.4	0.0	0.0	16.0	
	2-3	107.5	2.2	17.0	1.2	0.0	0.0	11.0	
12.0	0-1	102.2	2.8	20.1	4.0	0.0	0.0	13.0	0.1388
	1-2	10.6	1.6	87.0	1.3	0.0	0.0	13.0	
	2-3	102.2	2.8	20.1	4.0	0.0	0.0	13.0	
14.0	0-1	10.6	3.8	51.0	6.5	0.0	0.0	15.0	0.1354
	1-2	10.6	3.8	51.0	6.5	0.0	0.0	15.0	
	2-3	10.6	3.8	51.0	6.5	0.0	0.0	15.0	

NOREQ: NORMAL EQUATION 2NDMOM: SECOND MOMENT

TABLE C-3.--CONT INJUED

TIME	DEPTH	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET							VARIANCE SQ.FT.	NOREQ 2NDMOM	YO	WD
		0.0	3.0	6.0	9.0	12.0	15.0	FT				
16.0	0-1	71.6	59.0	44.3	41.0	31.8	15.0	32	26.42	19.0	0.1270	
	1-2	91.7	70.6	63.2	67.8	35.0	15.3	52	59.19	15.0		
	2-3	37.9	33.5	17.9	12.6	19.0	2.9	29	30.59	20.5	0.1149	
18.0	0-1	62.4	54.0	37.9	30.6	27.5	1.5	14	24.31	16.0		
	1-2	36.9	30.4	15.8	14.3	15.8	1.4	6	29.72	19.5	0.1049	
	2-3	36.4	30.6	15.8	14.3	15.8	1.4	6	24.31	16.0		
20.0	0-1	55.2	52.7	40.8	36.1	25.7	1.9	4	22.39	19.5		
	1-2	35.8	32.4	18.5	15.2	17.0	1.3	4	30.19	15.0	0.0964	
	2-3	35.4	32.4	18.5	15.2	17.0	1.3	4	22.39	19.5		
22.0	0-1	51.6	51.1	40.5	36.2	20.6	2.1	8	30.57	18.0	0.0898	
	1-2	38.4	35.4	22.6	20.9	16.3	2.2	8	30.57	15.0		
	2-3	47.6	49.0	35.4	32.6	23.9	2.2	8	21.91	18.0		
24.0	0-1	45.3	42.5	32.6	29.7	16.5	2.1	4	28.58	16.5	0.0858	
	1-2	33.7	30.7	22.5	20.5	13.9	2.8	4	33.72	15.0		
	2-3	45.0	48.1	35.0	32.0	23.0	2.8	4	21.09	16.5		
26.0	0-1	45.0	42.5	32.6	29.7	16.5	2.1	4	28.58	16.5	0.0858	
	1-2	33.7	30.7	22.5	20.5	13.9	2.8	4	33.72	15.0		
	2-3	45.0	48.1	35.0	32.0	23.0	2.8	4	21.09	16.5		
28.0	0-1	41.6	37.4	27.4	24.0	16.0	2.1	3	33.03	16.5	0.0829	
	1-2	31.6	27.9	19.5	17.0	13.5	2.8	3	39.35	15.0		
	2-3	41.0	45.0	31.5	28.5	20.5	2.8	3	21.09	16.5		
30.0	0-1	41.0	37.4	27.4	24.0	16.0	2.1	3	33.03	16.5	0.0829	
	1-2	31.6	27.9	19.5	17.0	13.5	2.8	3	39.35	15.0		
	2-3	41.0	45.0	31.5	28.5	20.5	2.8	3	21.09	16.5		
32.0	0-1	40.6	36.4	26.5	23.1	15.5	2.1	3	33.03	16.5	0.0787	
	1-2	31.6	27.9	19.5	17.0	13.5	2.8	3	39.35	15.0		
	2-3	41.0	45.0	31.5	28.5	20.5	2.8	3	21.09	16.5		

TABLE C-3---CONTINUED

TIME	DEPTH	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET							VARIANCE SO.FT.	YD	WD
		0.0	3.0	6.0	9.0	12.0	15.0	2NDMOM			
34.0	0-1	39.0	45.3	55.3	12.7	8.4	2.6	16.7	18.6	0.0770	
	1-3	47.5	49.5	31.6	12.3	10.5	2.6	31.1	22.6		
	3-0	25.3	17.2	10.5	12.6	5.4	4.2	88.6	33.5		
36.0	1-3	42.2	47.4	25.6	12.4	8.5	1.6	17.6	12.3	0.0754	
	1-3	48.3	49.0	30.6	11.6	5.6	2.6	31.1	33.7		
	2-4	35.3	42.3	15.3	11.6	5.3	6.0	93.6	37.0		
38.0	0-1	39.0	40.3	25.5	11.6	3.5	1.9	14.2	12.3	0.0738	
	1-3	27.4	40.2	10.5	12.6	6.5	2.4	99.3	31.9		
	2-4	20.4	33.2	20.5	11.6	3.5	4.4	146.7	35.9		
40.0	0-1	37.4	42.2	25.5	11.6	3.5	1.9	16.6	12.3	0.0728	
	1-3	37.0	42.0	27.4	12.6	5.3	2.6	49.3	37.0		
	2-4	20.4	33.2	20.5	11.6	3.5	4.4	146.7	35.9		
42.0	0-1	37.4	42.2	25.5	11.6	3.5	1.9	16.6	12.3	0.0710	
	1-3	37.0	42.0	27.4	12.6	5.3	2.6	49.3	37.0		
	2-4	20.4	33.2	20.5	11.6	3.5	4.4	146.7	35.9		
44.0	0-1	37.4	42.2	25.5	11.6	3.5	1.9	16.6	12.3	0.0692	
	1-3	37.0	42.0	27.4	12.6	5.3	2.6	49.3	37.0		
	2-4	20.4	33.2	20.5	11.6	3.5	4.4	146.7	35.9		
46.0	0-1	37.4	42.2	25.5	11.6	3.5	1.9	16.6	12.3	0.0678	
	1-3	37.0	42.0	27.4	12.6	5.3	2.6	49.3	37.0		
	2-4	20.4	33.2	20.5	11.6	3.5	4.4	146.7	35.9		
48.0	0-1	37.4	42.2	25.5	11.6	3.5	1.9	16.6	12.3	0.0672	
	1-3	37.0	42.0	27.4	12.6	5.3	2.6	49.3	37.0		
	2-4	20.4	33.2	20.5	11.6	3.5	4.4	146.7	35.9		

TABLE C-4--COMPUTATIONAL RESULTS OF TEST NO. 4

TIME MIN	DEPTH FT	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET										NOPEQ	VARIANCE SQ#6T.	2NDMOM	YD FT	WD GRAM
		0.0	3.0	6.0	9.0	12.0	15.0	18.0	21.0	24.0	27.0					
0.0	0-1	565.2	232.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.15	0.1761
	1-2	185.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.12	0.0	
	2-3	24.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	3-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
2.0	0-1	228.9	122.2	27.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.08	0.0637
	1-2	117.9	7.4	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.04	0.0	
	2-3	37.1	0.0	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.12	0.0	
	3-4	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.79	0.0668	
4.0	0-1	119.1	103.1	75.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.76	0.0	
	1-2	80.6	22.1	40.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.02	0.0798	
	2-3	44.1	1.1	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.13	0.0	
	3-4	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.85	0.0	
6.0	0-1	105.4	87.6	69.6	12.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.83	0.0	
	1-2	86.3	76.5	50.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.85	0.0	
	2-3	42.2	32.7	27.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.34	0.0	
	3-4	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.33	0.0805	
8.0	0-1	65.3	75.0	53.8	27.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.96	0.0	
	1-2	53.3	63.0	39.5	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.25	0.0	
	2-3	41.1	17.2	11.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.61	0.0	
	3-4	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.96	0.0832	
10.0	0-1	59.3	68.5	54.8	30.6	14.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.74	0.0	
	1-2	52.1	67.2	45.3	10.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.55	0.0	
	2-3	40.1	42.2	25.6	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.47	0.0	
	3-4	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.89	0.0891	
12.0	0-1	33.3	62.4	47.4	28.5	27.4	3.1	0.0	0.0	0.0	0.0	0.0	0.0	1.43	0.0	
	1-2	29.0	65.3	53.1	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.88	0.0	
	2-3	35.0	60.3	42.6	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.66	0.0	
	3-4	3.0	50.3	43.7	25.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.95	0.0911	
14.0	0-1	79.0	66.3	52.6	39.0	22.2	6.6	0.0	0.0	0.0	0.0	0.0	0.0	1.76	0.0	
	1-2	69.0	60.3	43.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.61	0.0	
	2-3	78.0	65.3	52.7	29.5	28.5	11.6	0.0	0.0	0.0	0.0	0.0	0.0	2.75	0.0	
	3-4	3.4	27.4	21.6	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.12	0.0	

NOPEQ: NORMAL EQUATION 2NDMOM: SECOND MOMENT

TABLE C-4--CONTINUED

TIME MIN	DEPTH FT	CONCENTRATION IN PDB AT STATED LATERAL DISTANCE IN FEET										VARIANCE SQ#KT.	YO FT	WD GRAM	
		0.0	3.0	6.0	9.0	12.0	15.0	18.0	21.0	NOREQ	2NDMOM				
16.0	0-1	72.0	55.0	40.0	23.0	19.0	0.5	1.1	0.0	18.0	21.0	18.0	25.0	17.0	0.0902
	1-3	76.0	62.0	50.0	28.0	24.0	1.0	3.0	0.0	3.0	0.0	0.0	30.0	15.0	
	2-4	36.0	24.0	20.0	8.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	12.0	
18.0	0-1	70.0	53.0	37.0	21.0	16.0	1.0	4.0	1.0	4.0	1.0	1.0	22.0	18.0	0.0877
	1-3	75.0	61.0	47.0	27.0	20.0	1.0	6.0	0.0	6.0	0.0	0.0	27.0	16.0	
	2-4	37.0	25.0	21.0	8.0	3.0	1.0	1.0	0.0	1.0	0.0	0.0	23.0	13.0	
20.0	0-1	67.0	52.0	36.0	21.0	14.0	1.0	5.0	1.0	5.0	1.0	1.0	23.0	19.0	0.0865
	1-3	74.0	59.0	45.0	27.0	21.0	1.0	8.0	1.0	8.0	1.0	1.0	24.0	16.0	
	2-4	37.0	22.0	17.0	8.0	3.0	1.0	1.0	0.0	1.0	0.0	0.0	23.0	13.0	
22.0	0-1	45.0	31.0	20.0	10.0	6.0	1.0	3.0	1.0	3.0	1.0	1.0	23.0	22.0	0.0858
	1-3	73.0	58.0	44.0	26.0	16.0	1.0	7.0	1.0	7.0	1.0	1.0	24.0	16.0	
	2-4	36.0	21.0	17.0	8.0	4.0	1.0	1.0	0.0	1.0	0.0	0.0	23.0	13.0	
24.0	0-1	41.0	28.0	19.0	10.0	6.0	1.0	3.0	1.0	3.0	1.0	1.0	23.0	22.0	0.0829
	1-3	71.0	56.0	42.0	24.0	15.0	1.0	6.0	1.0	6.0	1.0	1.0	24.0	17.0	
	2-4	35.0	20.0	17.0	8.0	4.0	1.0	1.0	0.0	1.0	0.0	0.0	23.0	13.0	
26.0	0-1	35.0	21.0	14.0	8.0	4.0	1.0	3.0	1.0	3.0	1.0	1.0	23.0	21.0	0.0811
	1-3	70.0	49.0	33.0	19.0	12.0	1.0	5.0	1.0	5.0	1.0	1.0	24.0	17.0	
	2-4	34.0	18.0	15.0	7.0	4.0	1.0	1.0	0.0	1.0	0.0	0.0	23.0	13.0	
28.0	0-1	31.0	18.0	13.0	7.0	4.0	1.0	3.0	1.0	3.0	1.0	1.0	23.0	21.0	0.0780
	1-3	66.0	47.0	32.0	17.0	11.0	1.0	4.0	1.0	4.0	1.0	1.0	24.0	17.0	
	2-4	33.0	16.0	14.0	7.0	4.0	1.0	1.0	0.0	1.0	0.0	0.0	23.0	13.0	
30.0	0-1	64.0	46.0	32.0	17.0	11.0	1.0	4.0	1.0	4.0	1.0	1.0	24.0	21.0	0.0753
	1-3	67.0	50.0	37.0	19.0	12.0	1.0	5.0	1.0	5.0	1.0	1.0	25.0	18.0	
	2-4	34.0	17.0	15.0	7.0	4.0	1.0	1.0	0.0	1.0	0.0	0.0	24.0	13.0	
32.0	0-1	63.0	48.0	33.0	18.0	12.0	1.0	4.0	1.0	4.0	1.0	1.0	24.0	21.0	0.0726
	1-3	65.0	49.0	36.0	19.0	13.0	1.0	5.0	1.0	5.0	1.0	1.0	25.0	18.0	
	2-4	35.0	18.0	16.0	8.0	4.0	1.0	1.0	0.0	1.0	0.0	0.0	24.0	13.0	

TABLE C- 4.--CONTINUED

TIME MIN	DEPTH FT	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET										VARIANCE SQ#/6T.	YO FT	WD GRAM
		5.0	3.0	6.0	9.0	12.0	15.0	18.0	21.0	NOPEQ	2NDMOM			
24.0	0-1	51.0	42.0	32.7	16.0	11.6	7.4	3.6	1.2	1.0	27.6	25.8	0.0703	
	1-2	62.0	46.0	35.9	21.0	13.0	9.5	6.7	3.2	1.0	31.5	34.0		
	2-3	50.0	16.0	16.9	4.0	3.0	4.2	2.1	3.0	1.1	47.8	51.0		
36.0	0-1	50.0	42.0	31.6	16.0	11.6	7.4	3.6	1.2	1.0	27.6	25.8	0.0690	
	1-2	63.0	45.0	35.0	21.0	13.0	9.5	6.7	3.2	1.0	31.5	34.0		
	2-3	51.0	16.0	16.9	4.0	3.0	4.2	2.1	3.0	1.1	47.8	51.0		
38.0	0-1	60.0	40.0	31.6	16.0	11.6	7.4	3.6	1.2	1.0	27.6	25.8	0.0671	
	1-2	63.0	44.0	34.0	21.0	13.0	9.5	6.7	3.2	1.0	31.5	34.0		
	2-3	60.0	16.0	16.9	4.0	3.0	4.2	2.1	3.0	1.1	47.8	51.0		
40.0	0-1	49.0	39.0	31.6	16.0	11.6	7.4	3.6	1.2	1.0	27.6	25.8	0.0655	
	1-2	62.0	42.0	34.0	21.0	13.0	9.5	6.7	3.2	1.0	31.5	34.0		
	2-3	40.0	15.0	16.9	4.0	3.0	4.2	2.1	3.0	1.1	47.8	51.0		
42.0	0-1	40.0	37.0	31.6	16.0	11.6	7.4	3.6	1.2	1.0	27.6	25.8	0.0645	
	1-2	61.0	42.0	34.0	21.0	13.0	9.5	6.7	3.2	1.0	31.5	34.0		
	2-3	40.0	15.0	16.9	4.0	3.0	4.2	2.1	3.0	1.1	47.8	51.0		
44.0	0-1	47.0	42.0	31.6	16.0	11.6	7.4	3.6	1.2	1.0	27.6	25.8	0.0641	
	1-2	61.0	42.0	34.0	21.0	13.0	9.5	6.7	3.2	1.0	31.5	34.0		
	2-3	40.0	15.0	16.9	4.0	3.0	4.2	2.1	3.0	1.1	47.8	51.0		
46.0	0-1	46.0	42.0	31.6	16.0	11.6	7.4	3.6	1.2	1.0	27.6	25.8	0.0640	
	1-2	61.0	42.0	34.0	21.0	13.0	9.5	6.7	3.2	1.0	31.5	34.0		
	2-3	40.0	15.0	16.9	4.0	3.0	4.2	2.1	3.0	1.1	47.8	51.0		
48.0	0-1	46.0	42.0	31.6	16.0	11.6	7.4	3.6	1.2	1.0	27.6	25.8	0.0638	
	1-2	61.0	42.0	34.0	21.0	13.0	9.5	6.7	3.2	1.0	31.5	34.0		
	2-3	40.0	15.0	16.9	4.0	3.0	4.2	2.1	3.0	1.1	47.8	51.0		

TABLE C- 5. ---COMPUTATIONAL RESULTS OF TEST NO. 5

TIME MIN	DEPTH FT	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET							18.0	VARIANCE SQ.FT.	YO FT	WD GRAM
		0.0	3.0	6.0	9.0	12.0	15.0	18.0				
0.0	0-1	553.3	402.6	0.0	0.0	0.0	0.0	0.0	0.0	3.79	0.1606	
	1-2	517.5	1.1	0.0	0.0	0.0	0.0	0.0	0.0	1.14		
	2-3	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.13		
2.0	0-1	458.5	352.0	247.7	4.2	0.0	0.0	0.0	0.0	8.58	0.2003	
	1-2	231.2	118.0	50.6	0.0	0.0	0.0	0.0	0.0	6.19		
	2-3	23.0	144.3	0.0	0.0	0.0	0.0	0.0	0.0	4.62		
4.0	0-1	339.4	221.3	172.9	10.5	0.0	0.0	0.0	0.0	9.22	0.1730	
	1-2	197.1	141.2	89.6	1.1	0.0	0.0	0.0	0.0	7.0		
	2-3	198.0	154.8	3.2	0.0	0.0	0.0	0.0	0.0	5.7		
6.0	0-1	236.1	196.0	99.1	14.8	0.0	0.0	0.0	0.0	10.5	0.1551	
	1-2	179.2	146.5	127.5	5.3	0.0	0.0	0.0	0.0	8.5		
	2-3	193.8	153.8	9.5	0.0	0.0	0.0	0.0	0.0	6.0		
8.0	0-1	167.0	179.5	88.5	17.8	1.1	0.0	0.0	0.0	11.0	0.1528	
	1-2	181.2	146.5	131.6	14.0	3.2	0.0	0.0	0.0	10.0		
	2-3	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0	6.8		
10.0	0-1	175.0	165.3	86.3	21.5	2.6	0.0	0.0	0.0	12.0	0.1581	
	1-2	157.5	144.4	45.6	18.0	1.6	0.0	0.0	0.0	11.4		
	2-3	67.0	51.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0		
12.0	0-1	191.3	154.3	86.4	22.1	3.0	0.0	0.0	0.0	13.0	0.1625	
	1-2	152.8	141.2	147.7	81.2	2.3	0.0	0.0	0.0	13.0		
	2-3	155.9	148.5	152.0	1.1	0.0	0.0	0.0	0.0	9.0		
14.0	0-1	146.5	144.0	85.4	23.2	4.2	0.0	0.0	0.0	13.5	0.1653	
	1-2	146.4	136.0	148.6	97.6	0.0	0.0	0.0	0.0	14.0		
	2-3	46.4	47.4	0.0	11.1	0.0	0.0	0.0	0.0	10.0		

NOREQ: NORMAL EQUATION 2NDDMM: SECOND MOMENT

TABLE C- 5. ---CONTINUED

TIME	DEPTH	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET										VARIANCE SQ. FT.	YD	WD
		0.0	3.0	6.0	9.0	12.0	15.0	18.0	2NDMOM	FT	GRAM			
16.0	0-1	141.0	134.0	85.4	24.0	6.0	0.0	0.0	0.0	0.0	0.0	12.2	14.0	0.1669
	1-3	141.0	130.7	147.6	104.3	60.1	0.0	0.0	0.0	0.0	0.0	24.0	15.0	
	2-3	140.0	146.4	149.5	22.1	1.0	0.0	0.0	0.0	0.0	0.0	16.0	12.0	
18.0	0-1	133.0	125.0	84.0	26.0	8.0	0.0	0.0	0.0	0.0	0.0	10.3	15.0	0.1677
	1-2	136.0	124.4	144.0	103.6	79.0	0.0	0.0	0.0	0.0	0.0	13.0	16.0	
	2-3	134.0	144.0	148.0	27.0	1.0	0.0	0.0	0.0	0.0	0.0	18.0	13.5	
20.0	0-1	127.0	115.0	84.0	27.0	11.0	0.0	0.0	0.0	0.0	0.0	11.0	16.0	0.1677
	1-2	130.7	117.0	141.0	110.6	19.0	0.0	0.0	0.0	0.0	0.0	13.0	16.0	
	2-3	131.0	115.0	146.0	100.0	15.0	0.0	0.0	0.0	0.0	0.0	14.0	13.0	
22.0	0-1	122.0	107.0	84.0	28.0	13.0	0.0	0.0	0.0	0.0	0.0	10.0	17.0	0.1670
	1-2	125.0	111.0	138.0	110.7	10.0	0.0	0.0	0.0	0.0	0.0	17.0	16.0	
	2-3	129.0	111.0	144.0	131.0	22.0	0.0	0.0	0.0	0.0	0.0	19.0	13.0	
24.0	0-1	118.0	99.0	84.0	30.0	15.0	0.0	0.0	0.0	0.0	0.0	10.0	17.0	0.1657
	1-2	120.0	106.0	133.0	109.6	11.0	0.0	0.0	0.0	0.0	0.0	14.0	17.0	
	2-3	127.0	100.0	142.0	110.0	7.0	0.0	0.0	0.0	0.0	0.0	16.0	17.0	
26.0	0-1	115.0	91.0	84.0	32.0	17.0	0.0	0.0	0.0	0.0	0.0	11.0	18.0	0.1637
	1-2	115.0	101.0	129.0	107.0	14.0	0.0	0.0	0.0	0.0	0.0	14.0	18.0	
	2-3	120.0	107.0	141.0	113.0	9.0	0.0	0.0	0.0	0.0	0.0	17.0	18.0	
28.0	0-1	108.0	84.0	84.0	34.0	20.0	0.0	0.0	0.0	0.0	0.0	13.0	17.0	0.1609
	1-2	110.0	95.0	125.0	108.0	17.0	0.0	0.0	0.0	0.0	0.0	17.0	17.0	
	2-3	116.0	95.0	135.0	120.0	10.0	0.0	0.0	0.0	0.0	0.0	19.0	17.0	
30.0	0-1	103.0	78.0	83.0	37.0	22.0	0.0	0.0	0.0	0.0	0.0	13.0	17.0	0.1582
	1-2	105.0	91.0	121.0	107.0	17.0	0.0	0.0	0.0	0.0	0.0	15.0	17.0	
	2-3	120.0	94.0	136.0	127.0	10.0	0.0	0.0	0.0	0.0	0.0	18.0	17.0	
32.0	0-1	99.0	70.0	83.0	39.0	24.0	0.0	0.0	0.0	0.0	0.0	13.0	16.0	0.1534
	1-2	99.0	87.0	118.0	100.0	13.0	0.0	0.0	0.0	0.0	0.0	15.0	16.0	
	2-3	26.0	32.0	35.0	27.0	6.0	0.0	0.0	0.0	0.0	0.0	15.0	16.0	

TABLE C- 5.--CONTINUED

TIME	DEPTH	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET							YO	WD	VARIANCE SQ. FT.
		0.0	3.0	6.0	9.0	12.0	15.0	18.0			
34.0	0-1	93.8	63.2	83.3	41.0	25.3	1.8	18.0	0.1483	22.38	
	1-2	94.9	63.3	113.8	97.0	117.4	14.1	14.0	0.1483	36.82	
	2-3	26.3	30.6	40.7	24.3	5.4	0.0	0.0	0.1430	24.93	
	3-4	88.5	40.9	33.7	42.9	27.4	1.7	13.0	0.1430	33.87	
36.0	0-1	87.5	50.1	110.7	94.1	107.4	11.0	18.0	0.1376	23.80	
	1-2	26.2	38.2	32.2	25.3	5.4	0.1	0.0	0.1376	24.16	
	2-3	83.2	50.6	82.5	44.8	29.5	2.5	12.0	0.1376	25.38	
	3-4	82.2	75.3	106.6	92.0	103.4	1.0	11.0	0.1376	26.49	
38.0	0-1	29.2	25.3	30.6	20.0	4.2	2.5	10.0	0.1323	24.94	
	1-2	30.2	30.2	32.2	25.3	7.0	0.0	0.0	0.1323	27.14	
	2-3	75.9	45.2	82.2	46.7	32.0	2.5	10.0	0.1323	26.66	
	3-4	76.9	75.9	102.2	91.0	38.0	2.5	11.0	0.1323	23.88	
40.0	0-1	25.3	22.2	25.2	19.3	5.2	1.0	3.0	0.1290	23.99	
	1-2	70.6	40.2	81.9	49.0	35.8	2.5	10.0	0.1290	28.11	
	2-3	62.2	37.8	99.1	90.0	33.2	1.0	9.0	0.1290	25.61	
	3-4	62.2	73.0	123.2	90.0	36.0	2.4	10.0	0.1290	23.88	
42.0	0-1	30.2	21.9	25.2	20.0	8.0	1.0	2.5	0.1238	23.61	
	1-2	64.2	31.8	79.1	51.0	39.0	2.5	10.0	0.1238	24.35	
	2-3	26.2	20.2	23.0	16.0	6.0	1.0	3.0	0.1238	23.61	
	3-4	30.2	37.8	93.2	90.0	37.0	2.4	9.0	0.1238	23.61	
44.0	0-1	40.2	21.6	24.0	16.0	6.0	1.0	2.5	0.1192	23.46	
	1-2	26.2	31.7	73.2	50.0	37.0	2.4	10.0	0.1192	23.46	
	2-3	58.0	22.0	24.0	15.0	2.0	1.0	1.0	0.1192	23.46	
	3-4	54.0	29.6	78.0	58.0	42.0	2.4	9.0	0.1192	23.46	
46.0	0-1	26.2	20.0	22.0	16.0	2.0	1.0	1.0	0.1156	23.46	
	1-2	38.0	31.3	70.6	54.0	31.0	2.4	9.0	0.1156	23.46	
	2-3	54.0	22.0	22.0	16.0	2.0	1.0	1.0	0.1156	23.46	
	3-4	54.0	22.0	76.0	54.0	31.0	2.4	9.0	0.1156	23.46	
48.0	0-1	30.2	20.0	22.0	16.0	2.0	1.0	1.0	0.1156	23.46	
	1-2	30.2	20.0	76.0	54.0	31.0	2.4	9.0	0.1156	23.46	
	2-3	30.2	20.0	22.0	16.0	2.0	1.0	1.0	0.1156	23.46	
	3-4	30.2	20.0	76.0	54.0	31.0	2.4	9.0	0.1156	23.46	

TABLE C- 6.--COMPUTATIONAL RESULTS OF TEST NO. 6

TIME MIN	DEPTH FT	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET							VARIANCE SQ.FT.	YD FT	WD GRAM
		0.0	4.0	8.0	12.0	16.0	20.0	NOREQ			
0.0	0-1	771.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.00	0.0999
	1-3	107.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	2-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
2.0	0-1	234.0	0.0	16.9	0.0	0.0	0.0	0.0	0.0	8.02	0.0942
	1-2	58.0	134.3	12.6	0.0	0.0	0.0	0.0	0.0	10.49	
	2-4	0.0	10.0	1.1	0.0	0.0	0.0	0.0	0.0	34.00	
4.0	0-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.13	0.0851
	1-2	85.6	63.2	85.4	18.6	5.0	0.0	0.0	0.0	22.19	
	2-4	52.7	47.5	4.0	5.3	0.0	0.0	0.0	0.0	21.59	
6.0	0-1	21.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.93	0.0773
	1-2	10.0	40.1	61.4	13.7	0.1	0.0	0.0	0.0	24.46	
	2-4	54.8	39.0	46.4	16.6	1.1	0.0	0.0	0.0	28.43	
8.0	0-1	36.9	19.0	8.0	5.0	2.0	0.0	0.0	0.0	30.12	0.0873
	1-2	49.5	36.8	50.1	13.7	5.0	1.1	0.0	0.0	35.16	
	2-4	44.3	35.3	42.6	21.0	3.3	1.1	0.0	0.0	43.36	
10.0	0-1	24.0	1.0	1.6	1.0	0.3	1.1	0.0	0.0	31.79	0.0951
	1-2	47.4	35.8	42.2	13.0	3.3	2.2	1.2	0.0	35.36	
	2-4	46.4	30.6	36.9	26.9	3.3	2.4	1.2	0.0	47.05	
12.0	0-1	47.4	7.4	13.2	17.8	6.4	1.3	0.5	0.0	38.69	0.1012
	1-2	46.4	34.8	36.8	14.0	4.4	3.3	2.3	0.0	43.50	
	2-4	47.4	35.0	39.0	29.1	5.4	4.4	3.4	0.0	50.80	
14.0	0-1	45.4	14.0	16.0	21.8	7.4	4.5	3.4	0.0	39.25	0.1051
	1-2	47.4	33.0	33.7	15.3	4.4	5.4	4.4	0.0	45.84	
	2-4	45.4	34.9	31.0	26.0	7.4	8.6	8.6	0.0	57.68	

NOREQ: NORMAL EQUATION 2NDMOM: SECOND MOMENT

TABLE C- 6.--CONTINUED

TIME MIN	DEPTH FT	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET							VARIANCE SQ.FT.	NCREQ 2NDMDM	YO FT	WD GRAM
		0.0	4.0	8.0	12.0	16.0	20.0	24.0				
16.0	1-1	47.4	32.8	30.6	15.8	8.4	7.4	7.4	46.12	20.4	0.1086	
	1-2	45.4	34.1	32.7	25.3	7.4	8.4	7.4	39.62	20.5		
	1-3	46.4	29.5	24.2	28.2	12.6	7.4	9.4	39.57	20.0		
18.0	1-1	44.3	32.0	31.6	24.3	7.4	7.4	9.4	59.27	21.5	0.1108	
	1-2	47.4	34.0	31.0	27.4	7.4	7.4	5.5	39.95	21.0		
	1-3	46.4	24.8	26.9	25.9	12.6	7.4	9.4	39.18	20.0		
20.0	1-1	44.3	34.0	32.0	24.3	7.4	7.4	9.4	54.20	23.0	0.1130	
	1-2	47.4	32.0	30.0	27.4	7.4	7.4	5.5	39.54	23.0		
	1-3	44.3	42.0	37.0	24.3	7.4	7.4	10.5	39.51	22.5		
22.0	1-1	43.4	32.0	30.0	23.9	7.4	7.4	6.5	43.02	22.0	0.1142	
	1-2	47.4	42.0	37.0	26.3	7.4	7.4	5.5	41.17	22.5		
	1-3	45.4	22.7	20.4	23.9	12.6	7.4	10.5	44.02	22.0		
24.0	1-1	42.3	32.0	31.0	23.3	7.4	7.4	6.5	50.94	22.0	0.1159	
	1-2	47.4	42.0	37.0	26.3	7.4	7.4	5.5	42.47	22.5		
	1-3	43.4	22.7	20.4	23.3	12.6	7.4	10.5	44.15	22.0		
26.0	1-1	42.3	32.0	30.0	23.9	7.4	7.4	6.5	51.62	22.0	0.1171	
	1-2	47.4	42.0	37.0	26.3	7.4	7.4	5.5	44.50	22.5		
	1-3	44.3	22.7	20.4	23.9	12.6	7.4	10.5	44.09	22.0		
28.0	1-1	43.4	32.0	31.0	23.3	7.4	7.4	6.5	67.69	23.0	0.1175	
	1-2	47.4	42.0	37.0	26.3	7.4	7.4	5.5	47.01	23.0		
	1-3	44.3	22.7	20.4	23.3	12.6	7.4	10.5	44.75	22.5		
30.0	1-1	42.3	32.0	30.0	23.9	7.4	7.4	6.5	82.03	23.0	0.1176	
	1-2	47.4	42.0	37.0	26.3	7.4	7.4	5.5	46.13	23.0		
	1-3	44.3	22.7	20.4	23.9	12.6	7.4	10.5	44.75	22.5		
32.0	1-1	41.3	32.0	30.0	23.9	7.4	7.4	6.5	95.74	22.5	0.1185	
	1-2	47.4	42.0	37.0	26.3	7.4	7.4	5.5	47.04	23.0		
	1-3	44.3	22.7	20.4	23.9	12.6	7.4	10.5	44.75	22.5		

TABLE C- 6--CONTINUED

TIME	DEPTH	CONCENTRATION IN PPB AT					VARIANCE	YO	WD
		0.0	4.0	8.0	12.0	16.0			
34.0	0-1	45.3	31.6	25.3	20.0	14.8	19.0	22.0	0.1195
	1-2	40.1	33.9	28.5	22.4	11.5	12.6	49.73	
	2-3	37.9	33.0	30.8	24.6	10.5	14.8	44.37	
	3-4	44.3	31.6	27.4	22.1	14.8	20.0	44.37	
36.0	0-1	44.3	33.6	27.4	22.4	12.6	15.0	50.61	
	1-2	41.9	33.6	34.8	30.6	11.4	13.8	46.55	
	2-3	36.0	33.6	31.6	22.4	14.8	17.0	45.75	
	3-4	43.0	33.6	24.4	22.4	13.8	14.8	51.97	
38.0	0-1	43.0	33.6	27.4	22.4	12.6	17.0	48.03	
	1-2	40.0	33.6	27.4	22.4	11.4	14.8	51.97	
	2-3	37.0	33.6	27.4	22.4	15.0	14.8	48.03	
	3-4	41.0	33.6	27.4	22.4	14.8	14.8	52.80	
40.0	0-1	42.0	33.6	27.4	22.4	12.6	14.8	49.06	
	1-2	39.0	33.6	27.4	22.4	11.4	14.8	52.80	
	2-3	36.0	33.6	27.4	22.4	15.0	14.8	49.06	
	3-4	41.0	33.6	27.4	22.4	14.8	14.8	52.80	
42.0	0-1	42.0	33.6	27.4	22.4	12.6	14.8	50.06	
	1-2	39.0	33.6	27.4	22.4	11.4	14.8	52.80	
	2-3	36.0	33.6	27.4	22.4	15.0	14.8	49.06	
	3-4	41.0	33.6	27.4	22.4	14.8	14.8	52.80	
44.0	0-1	42.0	33.6	27.4	22.4	12.6	14.8	52.80	
	1-2	39.0	33.6	27.4	22.4	11.4	14.8	52.80	
	2-3	36.0	33.6	27.4	22.4	15.0	14.8	49.06	
	3-4	41.0	33.6	27.4	22.4	14.8	14.8	52.80	
46.0	0-1	42.0	33.6	27.4	22.4	12.6	14.8	52.80	
	1-2	39.0	33.6	27.4	22.4	11.4	14.8	52.80	
	2-3	36.0	33.6	27.4	22.4	15.0	14.8	49.06	
	3-4	41.0	33.6	27.4	22.4	14.8	14.8	52.80	
48.0	0-1	42.0	33.6	27.4	22.4	12.6	14.8	52.80	
	1-2	39.0	33.6	27.4	22.4	11.4	14.8	52.80	
	2-3	36.0	33.6	27.4	22.4	15.0	14.8	49.06	
	3-4	41.0	33.6	27.4	22.4	14.8	14.8	52.80	

TABLE C-7. COMPUTATIONAL RESULTS OF TEST NO. 7

TIME MIN	DEPTH FT	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET						2ND MOM	VARIANCE SQ. FT.	YO FT	WD GRAM
		0.0	4.0	8.0	12.0	16.0	20.0				
0.0	0-1	761.0	0.0	0.0	0.0	0.0	0.0	0.0	2.00	0.1152	
0.0	1-2	252.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
0.0	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
2.0	0-1	244.5	225.6	6.3	1.0	0.0	0.0	0.0	5.39	0.1169	
2.0	1-2	103.3	102.2	1.0	0.0	0.0	0.0	0.0	7.50		
2.0	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.00		
4.0	0-1	92.8	97.0	61.5	13.0	0.0	0.0	0.0	15.71	0.0832	
4.0	1-2	84.5	81.5	10.0	0.0	0.0	0.0	0.0	19.37		
4.0	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.33		
6.0	0-1	73.0	76.3	65.8	44.3	0.0	0.0	0.0	17.01	0.0905	
6.0	1-2	16.0	14.8	1.0	0.0	0.0	0.0	0.0	14.00		
6.0	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.35		
8.0	0-1	75.9	67.5	67.4	52.7	0.0	0.0	0.0	20.55	0.0946	
8.0	1-2	66.4	52.0	43.2	30.0	0.0	0.0	0.0	18.07		
8.0	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.36		
10.0	0-1	71.0	61.0	58.0	50.6	0.0	0.0	0.0	30.00	0.0955	
10.0	1-2	62.8	42.2	46.4	21.1	0.0	0.0	0.0	25.73		
10.0	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.06		
12.0	0-1	34.0	23.0	47.0	45.3	0.0	0.0	0.0	41.58	0.0961	
12.0	1-2	1.5	58.8	51.3	26.2	0.0	0.0	0.0	13.45		
12.0	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.57		
14.0	0-1	47.0	25.9	47.4	40.1	0.0	0.0	0.0	40.64	0.0990	
14.0	1-2	55.3	33.5	43.2	26.3	0.0	0.0	0.0	15.67		
14.0	2-3	44.6	25.5	12.6	7.4	0.0	0.0	0.0	16.76		
									47.83		
									31.71		
									21.64		

NOREQ: NORMAL EQUATION 2NDMOM: SECOND MOMENT

TABLE C- 7.--CONTINUED

TIME MIN	DEPTH FT	CONCENTRATION IN PPB AT STATFC LATERAL DISTANCE IN FEET							VARIANCE SQ.FT.	WD GRAM
		0.0	4.0	8.0	12.0	16.0	20.0	2ND MOM		
16.0	0-1	66.4	53.8	44.3	35.8	35.9	10.5	56.0	0.1024	
	1-2	47.4	30.6	14.2	9.3	5.0	1.4	35.6		
	2-2	48.4	7.4	4.2	2.7	2.1	1.0	27.6		
18.0	0-1	45.7	22.7	11.8	3.5	1.9	0.6	30.3	0.1055	
	1-3	51.6	9.6	6.3	3.5	2.0	1.0	38.6		
	2-4	11.2	6.5	3.3	1.6	0.8	0.3	30.3		
20.0	0-1	51.6	11.6	8.3	2.1	1.2	0.4	41.0	0.1075	
	1-2	51.6	6.7	4.1	1.6	0.8	0.2	34.6		
	2-4	13.3	6.6	4.1	2.0	1.0	0.5	37.6		
22.0	0-1	51.6	11.6	8.3	2.1	1.2	0.4	41.0	0.1093	
	1-2	14.6	6.7	4.1	2.0	1.0	0.5	37.6		
	2-4	13.3	6.6	4.1	2.0	1.0	0.5	37.6		
24.0	0-1	51.6	11.6	8.3	2.1	1.2	0.4	41.0	0.1100	
	1-2	14.6	6.7	4.1	2.0	1.0	0.5	37.6		
	2-4	13.3	6.6	4.1	2.0	1.0	0.5	37.6		
26.0	0-1	51.6	11.6	8.3	2.1	1.2	0.4	41.0	0.1109	
	1-2	14.6	6.7	4.1	2.0	1.0	0.5	37.6		
	2-4	13.3	6.6	4.1	2.0	1.0	0.5	37.6		
28.0	0-1	51.6	11.6	8.3	2.1	1.2	0.4	41.0	0.1105	
	1-2	14.6	6.7	4.1	2.0	1.0	0.5	37.6		
	2-4	13.3	6.6	4.1	2.0	1.0	0.5	37.6		
30.0	0-1	51.6	11.6	8.3	2.1	1.2	0.4	41.0	0.1094	
	1-2	14.6	6.7	4.1	2.0	1.0	0.5	37.6		
	2-4	13.3	6.6	4.1	2.0	1.0	0.5	37.6		
32.0	0-1	51.6	11.6	8.3	2.1	1.2	0.4	41.0	0.1082	
	1-2	14.6	6.7	4.1	2.0	1.0	0.5	37.6		
	2-4	13.3	6.6	4.1	2.0	1.0	0.5	37.6		

TABLE C-7.--CONTINUED

TIME	DEPTH	CONCENTRATION IN PPR AT STATED LATERAL DISTANCE IN FEET										YD	WD		
		0.0	4.0	8.0	12.0	16.0	20.0	NREQ	ZNDMOM	SO.FT.	FT			GRAM	
34.0	0-1	56.0	47.4	35.0	21.0	19.0	19.0	19.0	19.0	19.0	19.0	77.4	45.1	22.5	0.1072
	1-2	47.4	31.6	34.0	15.8	19.0	12.6	10.5	10.5	10.5	74.6	47.3	22.5		
	2-3	50.6	31.6	11.0	13.7	13.7	10.5	10.5	10.5	10.5	74.6	44.8	22.5		
	3-4	30.6	31.6	27.9	14.5	17.0	12.6	12.6	12.6	12.6	145.7	45.1	22.5		
36.0	0-1	54.0	46.4	33.0	21.0	19.0	19.0	19.0	19.0	19.0	75.4	44.0	22.0	0.1054	
	1-2	47.4	31.6	11.0	13.7	13.7	10.5	10.5	10.5	10.5	76.1	45.0	22.0		
	2-3	53.0	31.6	10.5	13.7	15.8	12.6	12.6	12.6	12.6	74.0	46.3	22.0		
	3-4	47.4	31.6	27.9	14.5	17.0	12.6	12.6	12.6	12.6	74.0	45.0	22.0		
38.0	0-1	57.4	46.4	33.0	21.0	19.0	19.0	19.0	19.0	19.0	74.0	45.0	22.0	0.1032	
	1-2	47.4	31.6	11.0	13.7	13.7	10.5	10.5	10.5	10.5	74.0	45.0	22.0		
	2-3	57.4	31.6	10.5	13.7	15.8	12.6	12.6	12.6	12.6	74.0	45.0	22.0		
	3-4	47.4	31.6	27.9	14.5	17.0	12.6	12.6	12.6	12.6	74.0	45.0	22.0		
40.0	0-1	53.0	46.4	33.0	21.0	19.0	19.0	19.0	19.0	19.0	75.0	45.0	22.0	0.1007	
	1-2	47.4	31.6	11.0	13.7	13.7	10.5	10.5	10.5	10.5	75.0	45.0	22.0		
	2-3	53.0	31.6	10.5	13.7	15.8	12.6	12.6	12.6	12.6	75.0	45.0	22.0		
	3-4	47.4	31.6	27.9	14.5	17.0	12.6	12.6	12.6	12.6	75.0	45.0	22.0		
42.0	0-1	56.0	46.4	33.0	21.0	19.0	19.0	19.0	19.0	19.0	75.0	45.0	22.0	0.0988	
	1-2	46.4	31.6	11.0	13.7	13.7	10.5	10.5	10.5	10.5	75.0	45.0	22.0		
	2-3	56.0	31.6	10.5	13.7	15.8	12.6	12.6	12.6	12.6	75.0	45.0	22.0		
	3-4	46.4	31.6	27.9	14.5	17.0	12.6	12.6	12.6	12.6	75.0	45.0	22.0		
44.0	0-1	52.0	46.4	33.0	21.0	19.0	19.0	19.0	19.0	19.0	79.0	46.0	22.0	0.0960	
	1-2	46.4	31.6	11.0	13.7	13.7	10.5	10.5	10.5	10.5	79.0	46.0	22.0		
	2-3	52.0	31.6	10.5	13.7	15.8	12.6	12.6	12.6	12.6	79.0	46.0	22.0		
	3-4	46.4	31.6	27.9	14.5	17.0	12.6	12.6	12.6	12.6	79.0	46.0	22.0		
46.0	0-1	51.0	46.4	33.0	21.0	19.0	19.0	19.0	19.0	19.0	80.0	46.0	22.0	0.0935	
	1-2	46.4	31.6	11.0	13.7	13.7	10.5	10.5	10.5	10.5	80.0	46.0	22.0		
	2-3	51.0	31.6	10.5	13.7	15.8	12.6	12.6	12.6	12.6	80.0	46.0	22.0		
	3-4	46.4	31.6	27.9	14.5	17.0	12.6	12.6	12.6	12.6	80.0	46.0	22.0		
48.0	0-1	50.6	46.4	33.0	21.0	19.0	19.0	19.0	19.0	19.0	80.0	46.0	22.0	0.0915	
	1-2	46.4	31.6	11.0	13.7	13.7	10.5	10.5	10.5	10.5	80.0	46.0	22.0		
	2-3	50.6	31.6	10.5	13.7	15.8	12.6	12.6	12.6	12.6	80.0	46.0	22.0		
	3-4	46.4	31.6	27.9	14.5	17.0	12.6	12.6	12.6	12.6	80.0	46.0	22.0		

TABLE C-8.---COMPUTATIONAL RESULTS OF TEST NO. 8

TIME	DEPTH	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET							2ND MOM	VARIANCE SQ.FT.	YD	WD
		0.0	4.0	8.0	12.0	16.0	20.0	NOREQ				
0.0	0-1	750.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.00	0.1153	
	1-2	264.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.00		
	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	3-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
2.0	0-1	232.3	246.6	7.4	0.0	0.0	0.0	0.0	0.0	7.03	0.1169	
	1-2	103.2	87.5	0.0	0.0	0.0	0.0	0.0	0.0	7.33		
	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	3-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
4.0	0-1	111.7	102.3	55.9	32.7	0.0	0.0	0.0	0.0	23.07	0.1033	
	1-2	187.5	182.4	25.3	1.0	0.0	0.0	0.0	0.0	22.13		
	2-3	17.0	7.0	2.0	0.0	0.0	0.0	0.0	0.0	10.57		
	3-4	95.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.74		
6.0	0-1	79.0	86.4	46.4	49.5	8.4	0.0	0.0	0.0	30.74	0.1068	
	1-2	10.0	72.5	6.0	0.0	0.0	0.0	0.0	0.0	18.30		
	2-3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.75		
	3-4	88.7	79.0	76.2	45.3	0.0	0.0	0.0	0.0	35.04		
8.0	0-1	72.0	64.3	43.6	19.0	0.0	0.0	0.0	0.0	16.44	0.1061	
	1-2	21.0	12.0	1.0	0.0	0.0	0.0	0.0	0.0	10.71		
	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.40		
	3-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10		
10.0	0-1	67.0	56.9	39.0	24.0	0.0	0.0	0.0	0.0	12.33	0.1051	
	1-2	31.0	14.0	1.0	0.0	0.0	0.0	0.0	0.0	15.54		
	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.33		
	3-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10		
12.0	0-1	78.0	64.0	65.0	35.0	0.0	0.0	0.0	0.0	12.16	0.1049	
	1-2	64.0	47.0	16.0	27.0	3.0	0.0	0.0	0.0	15.33		
	2-3	35.0	13.0	1.0	0.0	0.0	0.0	0.0	0.0	0.39		
	3-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.16		
14.0	0-1	74.0	65.0	61.0	31.0	0.0	0.0	0.0	0.0	13.04	0.1051	
	1-2	61.0	45.0	17.0	22.0	0.0	0.0	0.0	0.0	15.54		
	2-3	39.0	13.0	1.0	0.0	0.0	0.0	0.0	0.0	0.43		
	3-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.19		

2ND MOM: SECOND MOMENT

NOREQ: NORMAL EQUATION

TABLE C- 8 ---CONT INUED

TIME	DEPTH	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET						YO	WD
		0.0	4.0	8.0	12.0	16.0	20.0		
16.0	0-1	71.0	60.1	58.0	28.5	33.7	11.6	23.5	0.1058
	1-3	59.0	42.2	33.0	28.5	11.6	1.5	20.0	
	2-4	45.0	21.5	19.0	8.4	1.6	1.0	16.0	
	3-1	69.0	58.0	4.2	2.3	1.7	0.6	23.5	0.1068
18.0	0-1	56.0	40.0	32.0	27.4	12.6	2.6	20.5	
	1-3	47.0	21.0	20.0	9.2	1.8	2.1	16.5	
	2-4	77.0	15.0	13.0	3.2	2.0	1.7	23.5	0.1075
	3-1	65.0	39.0	30.0	2.3	1.6	1.3	20.5	
20.0	0-1	46.0	24.0	20.0	1.5	1.4	4.2	16.5	
	1-3	60.0	12.0	11.0	3.6	2.4	2.1	23.0	0.1084
	2-4	54.0	15.0	15.0	2.6	1.8	1.8	20.5	
	3-1	47.0	36.0	29.0	2.3	2.4	2.5	16.5	
22.0	0-1	66.0	15.0	11.0	2.6	2.4	4.8	23.0	0.1090
	1-3	47.0	36.0	31.0	2.6	1.1	4.2	20.5	
	2-4	11.0	4.8	4.5	1.5	1.6	1.9	23.0	0.1090
	3-1	63.0	27.0	22.0	2.4	2.5	2.8	20.0	
24.0	0-1	14.0	3.8	3.5	1.7	1.2	1.5	23.0	0.1090
	1-3	43.0	15.0	15.0	2.1	1.7	1.9	20.0	
	2-4	16.0	4.8	4.5	1.5	1.6	1.5	23.0	0.1090
	3-1	48.0	27.0	22.0	2.4	2.5	2.8	20.0	
26.0	0-1	16.0	4.8	4.5	1.5	1.2	1.5	23.0	0.1090
	1-3	43.0	15.0	15.0	2.1	1.7	1.9	20.0	
	2-4	16.0	4.8	4.5	1.5	1.2	1.5	23.0	0.1082
	3-1	48.0	27.0	22.0	2.4	2.5	2.8	20.0	
28.0	0-1	14.0	3.8	3.5	1.7	1.2	1.5	23.0	0.1082
	1-3	43.0	15.0	15.0	2.1	1.7	1.9	20.0	
	2-4	16.0	4.8	4.5	1.5	1.2	1.5	23.0	0.1074
	3-1	48.0	27.0	22.0	2.4	2.5	2.8	20.0	
30.0	0-1	16.0	4.8	4.5	1.5	1.2	1.5	23.0	0.1074
	1-3	43.0	15.0	15.0	2.1	1.7	1.9	20.0	
	2-4	16.0	4.8	4.5	1.5	1.2	1.5	23.0	0.1061
	3-1	48.0	27.0	22.0	2.4	2.5	2.8	20.0	
32.0	0-1	16.0	4.8	4.5	1.5	1.2	1.5	23.0	0.1061
	1-3	43.0	15.0	15.0	2.1	1.7	1.9	20.0	
	2-4	16.0	4.8	4.5	1.5	1.2	1.5	23.0	0.1061
	3-1	48.0	27.0	22.0	2.4	2.5	2.8	20.0	

VARIANCE SQ.FT.
 NOREQ 2NDMOM
 52.70
 37.82
 26.93
 28.33
 56.16
 42.05
 33.06
 39.04
 59.56
 38.44
 54.16
 61.68
 54.20
 64.02
 56.97
 46.73
 74.61
 62.64
 51.44
 85.84
 65.65
 55.29
 108.65
 68.07
 59.77
 130.64
 67.25
 71.58
 15

TABLE C-8--CONTINUED

TIME	DEPTH	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET										VARIANCE SQ.FT.	YO	WD
		0.0	4.0	8.0	12.0	16.0	20.0	NREQ	2NDMOM					
34.0	0-1	61.0	51.0	45.0	21.0	17.0	17.0	9	66.0	73	42.0	50	23.0	0.1058
	1-2	46.0	31.0	29.0	17.0	14.0	14.0	9	68.0	57	44.0	165		
	2-3	46.0	15.0	12.0	13.0	12.0	11.0	4	21.0	15	62.0	175		
	3-4	61.0	30.0	27.0	13.0	14.0	11.0	4	68.0	57	44.0	175		
36.0	0-1	51.0	31.0	27.0	13.0	13.0	11.0	4	79.0	12	44.0	239		
	1-2	46.0	11.0	10.0	13.0	13.0	11.0	4	70.0	25	43.0	00		
	2-3	60.0	29.0	27.0	13.0	15.0	14.0	4	68.0	92	47.0	245		
	3-4	45.0	10.0	9.0	13.0	14.0	11.0	4	85.0	92	46.0	01		
40.0	0-1	150.0	100.0	90.0	27.0	25.0	21.0	6	47.0	11	43.0	218		
	1-2	50.0	29.0	27.0	13.0	15.0	14.0	6	72.0	37	47.0	50		
	2-3	41.0	10.0	9.0	13.0	14.0	11.0	6	33.0	23	64.0	1153		
	3-4	50.0	29.0	27.0	13.0	16.0	14.0	6	72.0	60	45.0	245		
42.0	0-1	110.0	70.0	60.0	17.0	16.0	13.0	6	96.0	31	48.0	81		
	1-2	50.0	29.0	27.0	13.0	15.0	14.0	6	61.0	31	43.0	1253		
	2-3	45.0	10.0	9.0	13.0	16.0	14.0	6	72.0	60	45.0	245		
	3-4	50.0	29.0	27.0	13.0	15.0	14.0	6	72.0	60	45.0	245		
44.0	0-1	150.0	100.0	90.0	27.0	26.0	21.0	6	36.0	31	43.0	1253		
	1-2	50.0	29.0	27.0	13.0	16.0	14.0	6	72.0	60	45.0	245		
	2-3	45.0	10.0	9.0	13.0	16.0	14.0	6	72.0	60	45.0	245		
	3-4	50.0	29.0	27.0	13.0	15.0	14.0	6	72.0	60	45.0	245		
46.0	0-1	150.0	100.0	90.0	27.0	26.0	21.0	6	102.0	19	43.0	329		
	1-2	50.0	29.0	27.0	13.0	16.0	14.0	6	72.0	60	45.0	245		
	2-3	45.0	10.0	9.0	13.0	16.0	14.0	6	72.0	60	45.0	245		
	3-4	50.0	29.0	27.0	13.0	15.0	14.0	6	72.0	60	45.0	245		
48.0	0-1	150.0	100.0	90.0	27.0	26.0	21.0	6	115.0	12	43.0	339		
	1-2	50.0	29.0	27.0	13.0	16.0	14.0	6	72.0	60	45.0	245		
	2-3	45.0	10.0	9.0	13.0	16.0	14.0	6	72.0	60	45.0	245		
	3-4	50.0	29.0	27.0	13.0	15.0	14.0	6	72.0	60	45.0	245		

TABLE C- 9.--COMPUTATIONAL RESULTS OF TEST NO. 9

TIME MIN	DEPTH FT	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET						VARIANCE SQ.FT.	YD FT	WD GRAM
		0.0	4.0	8.0	12.0	16.0	20.0			
0.0	0-1	723.0	0.0	0.0	0.0	0.0	20.0	2.00	0.1094	
	1-2	240.0	0.0	0.0	0.0	0.0	0.0	2.00		
	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
2.0	0-1	228.0	0.0	0.0	0.0	0.0	0.0	0.49	0.1353	
	1-2	147.6	260.3	13.7	0.0	0.0	0.0	8.71		
	2-3	2.1	114.0	11.1	0.0	0.0	0.0	14.00		
4.0	0-1	94.9	2.0	0.6	0.0	0.0	0.0	2.21	0.1106	
	1-2	120.2	109.6	59.0	16.5	1.0	0.0	16.87		
	2-3	8.4	55.9	2.1	0.5	0.0	0.0	15.33		
6.0	0-1	78.4	1.4	0.3	0.7	0.0	0.0	6.60	0.1133	
	1-2	105.8	81.2	60.1	32.5	5.3	0.0	27.26		
	2-3	15.0	17.9	5.3	0.0	0.0	0.0	21.14		
8.0	0-1	67.8	5.7	2.1	0.9	0.2	0.0	4.44	0.1182	
	1-2	93.0	68.3	48.7	35.8	19.2	0.0	38.64		
	2-3	4.0	27.4	8.4	0.5	0.3	0.0	34.37		
10.0	0-1	62.0	10.0	4.6	1.7	0.4	0.0	4.56	0.1187	
	1-2	86.0	64.6	46.4	32.8	27.4	0.0	44.16		
	2-3	5.0	31.6	11.0	4.0	1.6	0.0	39.55	0.1155	
12.0	0-1	51.0	10.6	5.7	2.3	1.6	0.0	7.85	0.1109	
	1-2	81.0	59.3	41.7	34.0	31.5	0.0	41.07		
	2-3	6.0	34.8	13.5	6.0	2.4	0.0	43.81		
14.0	0-1	55.0	14.8	7.4	3.0	2.3	0.0	11.42	0.1109	
	1-2	76.0	53.8	36.9	26.0	27.4	0.0	46.81		
	2-3	42.0	35.8	14.8	17.0	16.5	1.0	41.24		

2ND MOM: SECOND MOMENT

NORFO: NORMAL EQUATION

TABLE C-9--CONT INUED

TIME	DEPTH	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET					VARIANCE SO. FT.	YD	WD
		0.0	4.0	8.0	12.0	16.0			
16.0	0-1	53.8	43.2	25.8	17.9	23.2	72.36	22.0	0.1085
	1-2	72.7	52.8	34.8	23.9	24.9	38.84	20.0	
	2-4	45.4	35.8	13.7	19.5	16.4	39.89	18.0	
	3-0	8.7	4.2	2.7	1.4	1.7	40.78	22.0	0.1063
18.0	0-1	52.6	42.6	23.9	17.9	22.6	42.05	20.0	
	1-2	70.5	55.8	31.7	21.5	19.5	74.00	18.0	
	2-4	49.5	35.8	16.7	15.8	16.0	42.31	22.0	0.1052
	3-0	6.5	4.1	1.6	1.9	1.9	42.27	20.0	
20.0	0-1	51.6	41.8	21.9	17.9	21.6	58.25	22.0	0.1042
	1-2	68.5	54.7	31.6	21.9	19.5	44.65	20.0	
	2-4	46.5	34.7	17.9	15.8	16.0	47.72	22.0	0.1029
	3-0	6.5	4.1	1.6	1.9	1.9	47.29	20.0	
22.0	0-1	50.8	41.8	21.9	17.9	21.6	87.42	22.0	0.1021
	1-2	67.8	54.7	31.6	21.9	19.5	52.91	20.0	
	2-4	46.5	34.7	17.9	15.8	16.0	49.32	22.0	0.1003
	3-0	6.5	4.1	1.6	1.9	1.9	49.29	20.0	
24.0	0-1	49.4	41.8	21.9	17.9	21.6	114.22	21.5	0.0991
	1-2	66.5	54.7	31.6	21.9	19.5	77.44	20.0	
	2-4	46.5	34.7	17.9	15.8	16.0	51.44	22.0	0.0977
	3-0	6.5	4.1	1.6	1.9	1.9	51.29	20.0	
26.0	0-1	48.9	41.8	21.9	17.9	21.6	177.94	21.5	0.0991
	1-2	65.3	54.7	31.6	21.9	19.5	117.44	20.0	
	2-4	46.5	34.7	17.9	15.8	16.0	53.24	22.0	0.0977
	3-0	6.5	4.1	1.6	1.9	1.9	53.29	20.0	
28.0	0-1	48.3	41.8	21.9	17.9	21.6	108.68	21.5	0.0991
	1-2	65.3	54.7	31.6	21.9	19.5	113.87	20.0	
	2-4	46.5	34.7	17.9	15.8	16.0	51.47	22.0	0.0977
	3-0	6.5	4.1	1.6	1.9	1.9	51.36	20.0	
30.0	0-1	47.6	41.8	21.9	17.9	21.6	103.35	21.5	0.0991
	1-2	64.6	54.7	31.6	21.9	19.5	112.87	20.0	
	2-4	46.5	34.7	17.9	15.8	16.0	53.63	22.0	0.0977
	3-0	6.5	4.1	1.6	1.9	1.9	53.40	20.0	
32.0	0-1	46.9	41.8	21.9	17.9	21.6	103.35	21.5	0.0991
	1-2	64.6	54.7	31.6	21.9	19.5	112.87	20.0	
	2-4	46.5	34.7	17.9	15.8	16.0	53.63	22.0	0.0977
	3-0	6.5	4.1	1.6	1.9	1.9	53.40	20.0	

TABLE C- 9.--CONTINUED

TIME	DEPTH	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET					YD	WD	VARIANCE SQ. FT.
		0.0	4.0	8.0	12.0	16.0			
34.0	0-1	46.0	39.0	19.0	13.7	12.6	20.6	0.0961	41.85
	1-3	65.0	42.0	29.0	14.9	12.6	11.8	0.0961	38.43
	2-4	51.0	39.0	19.0	14.5	12.6	11.8	0.0961	56.48
36.0	0-1	42.0	38.0	19.0	16.0	12.6	20.0	0.0953	41.37
	1-3	59.0	42.0	21.0	14.9	12.6	11.8	0.0953	48.73
	2-4	45.0	38.0	19.0	16.0	12.6	20.0	0.0953	48.91
38.0	0-1	45.0	38.0	19.0	16.0	12.6	20.0	0.0939	40.52
	1-3	65.0	42.0	21.0	16.0	12.6	11.8	0.0939	48.61
	2-4	51.0	38.0	19.0	16.0	12.6	20.0	0.0939	46.49
40.0	0-1	45.0	38.0	19.0	16.0	12.6	20.0	0.0927	40.52
	1-3	65.0	42.0	21.0	16.0	12.6	11.8	0.0927	48.91
	2-4	51.0	38.0	19.0	16.0	12.6	20.0	0.0927	46.49
42.0	0-1	45.0	38.0	19.0	16.0	12.6	20.0	0.0916	40.52
	1-3	65.0	42.0	21.0	16.0	12.6	11.8	0.0916	48.91
	2-4	51.0	38.0	19.0	16.0	12.6	20.0	0.0916	46.49
44.0	0-1	45.0	38.0	19.0	16.0	12.6	20.0	0.0902	40.52
	1-3	65.0	42.0	21.0	16.0	12.6	11.8	0.0902	48.91
	2-4	51.0	38.0	19.0	16.0	12.6	20.0	0.0902	46.49
46.0	0-1	45.0	38.0	19.0	16.0	12.6	20.0	0.0890	40.52
	1-3	65.0	42.0	21.0	16.0	12.6	11.8	0.0890	48.91
	2-4	51.0	38.0	19.0	16.0	12.6	20.0	0.0890	46.49
48.0	0-1	45.0	38.0	19.0	16.0	12.6	20.0	0.0885	40.52
	1-3	65.0	42.0	21.0	16.0	12.6	11.8	0.0885	48.91
	2-4	51.0	38.0	19.0	16.0	12.6	20.0	0.0885	46.49

TABLE C-10.--COMPUTATIONAL RESULTS OF TEST NO.10

TIME	DEPTH	CONCENTRATION IN PPF AT							VARIANCE	WD		
		STATFD LATERAL DISTANCE IN FEET										
MIN	FT	0.0	4.0	8.0	12.0	16.0	20.0	NOREQ	2NDMOM	SO.FT.	YD	GRAM
0.0	0-1	723.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.00		0.1114
	1-2	257.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.00		
	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
2.0	0-1	320.4	0.0	35.8	0.0	0.0	0.0	0.0	0.0	7.87	7.0	0.1306
	1-2	133.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.59		
	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
4.0	0-1	117.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.67	13.5	0.1002
	1-2	9.5	56.2	110.6	34.1	4.0	0.0	0.0	0.0	10.43	8.0	
	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
6.0	0-1	190.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.04	16.5	0.1064
	1-2	84.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.80	12.5	
	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
8.0	0-1	21.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.43	18.5	0.1066
	1-2	86.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.63	14.5	
	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
10.0	0-1	76.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.43	20.5	0.1098
	1-2	41.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.37	16.5	
	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
12.0	0-1	70.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.84	20.8	0.1145
	1-2	40.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.39	17.5	
	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
14.0	0-1	68.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.39	21.0	0.1167
	1-2	40.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.54	18.0	
	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		

2NDMOM: SECOND MOMENT

NOREQ: NORMAL EQUATION

TABLE C-10.--CONTINUED

TIME	DEPTH	CONCENTRATION IN PPM AT STATED LATERAL DISTANCE IN FEET										VARIANCE SQ.FT.	YO	WD	
		0.0	4.0	8.0	12.0	16.0	20.0	NREQ	2NDMOM	FT	GRAM				
16.0	0	50.0	44.0	33.0	21.0	26.0	13.0	7.0	47.8	32.0	13.0	3.0	47.8	23.0	0.1185
	1	60.1	47.8	29.0	20.6	16.3	0.0	2.0	3.9	0.0	0.0	1.7	3.9	18.0	
	2	75.8	45.1	14.0	16.3	10.3	0.0	0.8	2.0	0.0	0.0	0.5	2.0	14.0	
	3	68.0	55.6	33.0	21.9	22.1	14.0	3.1	1.6	0.8	14.0	3.2	1.6	3.0	0.1193
18.0	0	56.0	44.0	20.0	17.4	11.6	1.0	0.8	3.0	2.0	1.0	4.1	3.0	23.0	
	1	70.6	54.0	16.0	13.4	17.4	0.6	1.0	2.0	1.0	0.8	2.7	1.6	15.0	
	2	50.6	42.0	20.0	16.9	11.8	0.6	0.8	1.0	0.6	1.0	1.9	0.5	24.0	0.1188
	3	52.7	55.4	32.0	14.8	18.4	1.8	1.0	1.0	0.8	1.0	1.7	0.5	15.0	
20.0	0	75.0	45.0	13.0	14.0	11.0	0.7	0.7	2.0	1.0	1.8	2.5	2.0	24.0	0.1179
	1	71.4	54.1	27.0	15.0	16.0	1.8	0.7	1.0	0.7	1.8	1.7	0.5	15.0	
	2	40.6	45.3	19.0	14.0	12.0	0.6	0.5	1.0	0.6	0.6	2.6	0.5	24.0	0.1147
	3	70.8	55.4	32.0	15.0	15.0	1.8	0.6	1.0	0.6	1.8	1.7	0.5	16.0	
24.0	0	47.0	43.0	11.0	11.0	10.0	0.6	0.6	1.0	1.0	1.0	1.5	1.0	23.0	0.1112
	1	47.6	53.1	19.0	13.0	15.0	0.8	0.6	1.0	0.8	0.8	2.3	0.5	20.0	
	2	71.0	47.0	17.0	11.0	13.0	0.6	0.6	1.0	0.6	0.6	1.5	0.5	20.0	
	3	44.0	54.0	31.0	14.0	16.0	0.8	0.6	1.0	0.8	0.8	2.6	0.5	16.0	
26.0	0	66.0	46.0	11.0	12.0	11.0	0.6	0.6	1.0	1.0	1.0	1.5	1.0	23.0	0.1073
	1	44.0	35.2	11.0	13.0	14.0	0.8	0.6	1.0	0.8	0.8	2.4	0.5	20.0	
	2	66.0	52.8	17.0	12.0	14.0	0.8	0.6	1.0	0.8	0.8	1.8	0.5	20.0	
	3	45.0	46.0	11.0	12.0	11.0	0.6	0.6	1.0	0.6	0.6	1.6	0.5	16.0	
28.0	0	49.0	37.0	11.0	11.0	10.0	0.6	0.6	1.0	1.0	1.0	1.5	1.0	25.0	0.1020
	1	63.7	46.7	15.0	12.0	14.0	0.8	0.6	1.0	0.8	0.8	2.0	0.5	20.0	
	2	51.0	40.0	11.0	12.0	11.0	0.6	0.6	1.0	0.6	0.6	1.6	0.5	17.0	
	3	37.0	32.4	11.0	11.0	11.0	0.6	0.6	1.0	0.6	0.6	1.4	0.5	16.0	
30.0	0	56.0	43.0	11.0	12.0	11.0	0.6	0.6	1.0	1.0	1.0	1.5	1.0	24.0	0.0969
	1	55.0	56.0	14.0	12.0	11.0	0.6	0.6	1.0	0.6	0.6	1.6	0.5	24.0	
	2	34.0	36.0	11.0	12.0	11.0	0.6	0.6	1.0	0.6	0.6	1.4	0.5	17.0	
	3	40.6	43.0	11.0	11.0	11.0	0.6	0.6	1.0	0.6	0.6	1.4	0.5	16.0	
32.0	0	44.0	40.0	11.0	11.0	11.0	0.6	0.6	1.0	1.0	1.0	1.5	1.0	24.0	0.0969
	1	56.0	55.0	14.0	12.0	11.0	0.6	0.6	1.0	0.6	0.6	1.6	0.5	24.0	
	2	34.0	36.0	11.0	12.0	11.0	0.6	0.6	1.0	0.6	0.6	1.4	0.5	17.0	
	3	40.6	43.0	11.0	11.0	11.0	0.6	0.6	1.0	0.6	0.6	1.4	0.5	16.0	

TABLE C-10.--CONTINUED

TIME MIN	DEPTH FT	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET										VARIANCE SQ.FT.	YD FT	WD GRAM
		0.0	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0			
34.0	1	33.0	36.0	30.0	20.0	14.0	11.0	10.0	10.0	10.0	10.0	72.0	46.0	0.0936
34.0	2	34.0	34.0	16.0	10.0	12.0	10.0	10.0	10.0	10.0	82.0	46.0	0.0888	
34.0	3	46.0	35.0	30.0	20.0	14.0	10.0	10.0	10.0	10.0	64.0	36.0	0.0853	
36.0	1	32.0	30.0	16.0	10.0	12.0	10.0	10.0	10.0	10.0	74.0	46.0	0.0837	
36.0	2	32.0	30.0	16.0	10.0	12.0	10.0	10.0	10.0	10.0	74.0	46.0	0.0809	
36.0	3	41.0	30.0	16.0	10.0	12.0	10.0	10.0	10.0	10.0	82.0	46.0	0.0793	
38.0	1	32.0	30.0	16.0	10.0	12.0	10.0	10.0	10.0	10.0	74.0	46.0	0.0783	
38.0	2	32.0	30.0	16.0	10.0	12.0	10.0	10.0	10.0	10.0	74.0	46.0	0.0773	
40.0	1	34.0	30.0	16.0	10.0	12.0	10.0	10.0	10.0	10.0	82.0	46.0		
40.0	2	34.0	30.0	16.0	10.0	12.0	10.0	10.0	10.0	10.0	82.0	46.0		
42.0	1	37.0	30.0	16.0	10.0	12.0	10.0	10.0	10.0	10.0	82.0	46.0		
42.0	2	37.0	30.0	16.0	10.0	12.0	10.0	10.0	10.0	10.0	82.0	46.0		
44.0	1	35.0	30.0	16.0	10.0	12.0	10.0	10.0	10.0	10.0	82.0	46.0		
44.0	2	35.0	30.0	16.0	10.0	12.0	10.0	10.0	10.0	10.0	82.0	46.0		
46.0	1	32.0	30.0	16.0	10.0	12.0	10.0	10.0	10.0	10.0	82.0	46.0		
46.0	2	32.0	30.0	16.0	10.0	12.0	10.0	10.0	10.0	10.0	82.0	46.0		
48.0	1	30.0	30.0	16.0	10.0	12.0	10.0	10.0	10.0	10.0	82.0	46.0		
48.0	2	30.0	30.0	16.0	10.0	12.0	10.0	10.0	10.0	10.0	82.0	46.0		

TABLE C-11.---COMPUTATIONAL RESULTS OF TEST NO.11

TIME	DEPTH	CONCENTRATION IN PPR AT STATED LATERAL DISTANCE IN FEET							VARIANCE SQ.FT.	YO	WD
		0.0	4.0	8.0	12.0	16.0	20.0	NREQ			
6.0	0-1	761.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1134
	1-2	237.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	2-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	3-4	300.4	0.0	12.6	0.0	0.0	0.0	0.0	0.0	0.0	0.1219
4.0	0-1	142.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	1-2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	2-3	126.8	0.0	115.9	0.0	0.0	0.0	0.0	0.0	0.0	0.1099
	3-4	6.0	0.0	0.0	6.1	0.0	0.0	0.0	0.0	0.0	
6.0	0-1	192.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	1-2	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	2-3	103.2	0.0	50.6	0.0	0.0	0.0	0.0	0.0	0.0	0.1003
	3-4	2.0	0.0	19.0	0.0	0.0	0.0	0.0	0.0	0.0	
8.0	0-1	23.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	1-2	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	2-3	88.8	0.0	54.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0996
	3-4	74.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	
10.0	0-1	50.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	1-2	27.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	2-3	70.6	0.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0995
	3-4	71.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	
12.0	0-1	54.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	1-2	67.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	2-3	8.0	0.0	37.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0984
	3-4	68.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	
14.0	0-1	63.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	1-2	61.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	2-3	87.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0991
	3-4	67.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

NREQ: NORMAL EQUATION 2NDMOM: SECOND MOMENT

TABLE C-11.--CONT INUED

TIME MIN	DEPTH FT	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET					VARIANCE SQ.FT.	YO FT	WD GRAM
		0.0	4.0	8.0	12.0	16.0			
16.0	0-1	56.8	42.4	31.0	16.9	7.4	2.1	21.2	0.1011
	1-2	60.1	46.8	19.8	4.2	5.3	1.0	14.5	
	2-3	84.3	52.2	17.9	2.1	1.4	0.0	12.0	
18.0	0-1	60.6	40.2	21.0	14.2	7.5	1.1	22.0	0.1011
	1-2	56.9	44.5	17.9	4.2	5.1	1.1	14.5	
	2-3	83.7	45.0	23.4	2.7	1.4	1.1	12.0	
20.0	0-1	77.4	43.0	27.9	15.3	7.5	1.2	23.4	0.1011
	1-2	77.7	45.9	24.9	3.3	1.4	1.1	14.5	
	2-3	81.2	55.7	27.4	2.5	1.4	1.1	12.0	
22.0	0-1	72.2	47.7	24.9	15.3	7.5	1.2	23.4	0.0990
	1-2	45.9	33.6	17.7	2.6	1.4	1.1	14.5	
	2-3	76.8	47.6	21.6	10.5	7.5	1.1	12.0	
24.0	0-1	72.2	47.6	21.6	10.5	7.5	1.1	22.0	0.0954
	1-2	42.3	35.4	13.3	2.6	1.4	1.1	14.5	
	2-3	71.7	43.6	17.9	1.5	1.4	1.1	12.0	
26.0	0-1	72.2	47.6	21.6	10.5	7.5	1.1	22.0	0.0917
	1-2	42.3	35.4	13.3	2.6	1.4	1.1	14.5	
	2-3	71.7	43.6	17.9	1.5	1.4	1.1	12.0	
28.0	0-1	65.9	44.0	15.6	8.9	5.4	1.1	22.0	0.0874
	1-2	37.9	34.4	11.8	2.8	1.4	1.1	14.5	
	2-3	58.0	35.3	16.4	5.3	1.4	1.1	12.0	
30.0	0-1	55.9	42.3	14.0	9.5	5.3	1.1	21.5	0.0835
	1-2	36.0	34.2	11.8	3.9	1.4	1.1	14.5	
	2-3	51.0	33.7	17.4	5.3	1.4	1.1	12.0	
32.0	0-1	51.0	33.7	17.4	11.9	5.3	1.1	21.0	0.0800
	1-2	34.0	33.3	12.6	3.0	1.4	1.1	14.5	
	2-3	46.8	33.3	14.1	1.4	1.4	1.1	12.0	

NOREQ 2NDMOM
 27.44
 22.80
 12.31
 28.15
 23.01
 19.30
 27.17
 22.55
 18.96
 20.91
 13.68
 25.78
 21.52
 18.04
 22.47
 13.55
 25.62
 21.38
 18.57
 22.74
 12.56
 24.73
 21.92
 15.51
 22.41
 19.47
 23.09
 21.11
 22.88

TABLE C-11.--CONTINUED

TIME MIN	DEPTH FT	CONCENTRATION IN PPM AT STATED LATERAL DISTANCE IN FEET							VARIANCE SQ.FT.	YO FT	WD GRAM
		0.0	4.0	8.0	12.0	16.0	20.0	NOREQ			
34.0	0-1	32.0	33.0	10.5	9.5	7.5	9.5	68.85	38.41	0.0764	
	1-2	30.6	33.0	6.3	6.3	5.3	8.3	66.50	34.00		
	2-3	49.5	30.6	11.4	1.6	3.2	6.3	46.75	28.36		
36.0	0-1	29.5	33.0	4.9	1.9	5.3	1.5	26.30	35.17	0.0730	
	1-2	27.4	33.0	6.5	6.5	3.2	4.4	69.97	34.29		
	2-3	44.3	19.0	10.4	4.0	2.4	3.0	51.57	40.22		
38.0	0-1	27.0	33.0	9.5	19.5	5.4	2.5	76.46	45.11	0.0710	
	1-2	24.8	33.0	6.5	7.7	5.3	7.4	64.16	35.70		
	2-3	41.3	13.0	13.0	5.1	3.2	3.2	36.46	37.64		
40.0	0-1	25.0	33.0	8.0	2.0	4.3	4.3	74.07	39.86	0.0687	
	1-2	23.7	33.0	6.5	7.0	4.3	8.6	61.07	34.07		
	2-3	32.0	14.0	9.9	2.0	3.2	5.5	52.07	40.32		
42.0	0-1	23.0	33.0	9.4	2.0	3.5	3.3	71.07	40.45	0.0684	
	1-2	22.0	33.0	6.9	8.0	4.4	5.8	47.52	36.07		
	2-3	33.0	17.0	8.4	2.0	3.2	5.5	56.29	44.51		
44.0	0-1	22.0	33.0	8.4	2.0	4.5	3.3	74.07	40.35	0.0666	
	1-2	20.9	33.0	5.0	8.0	4.4	7.0	50.89	34.07		
	2-3	36.0	12.0	7.7	2.0	3.2	5.4	52.07	40.25		
46.0	0-1	22.0	33.0	6.0	2.0	3.4	3.2	78.04	40.25	0.0648	
	1-2	20.5	33.0	5.0	9.0	4.5	7.0	52.11	38.43		
	2-3	35.0	14.0	7.7	2.0	3.2	5.4	59.04	40.65		
48.0	0-1	22.0	33.0	7.0	2.0	4.5	3.2	79.07	40.38	0.0630	
	1-2	21.0	33.0	5.0	8.0	4.5	7.0	53.07	39.47		
	2-3	37.0	12.0	8.6	2.0	3.2	6.4	61.07	40.48		
50.0	0-1	22.0	33.0	8.5	2.0	4.5	3.2	74.07	40.31	0.0610	
	1-2	21.0	33.0	7.0	3.0	4.5	4.0	67.07	39.07		
	2-3	38.0	14.0	8.6	2.0	3.2	6.4	71.07	40.48		

TABLE C-12.--COMPUTATIONAL RESULTS OF TEST NO.12

TIME MIN	DEPTH FT	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET					VARIANCE SQ.FT.	YD FT	WD GRAM
		0.0	3.0	6.0	9.0	12.0			
0.0	0-1	632.4	415.3	0.0	0.0	0.0	3.68	0.1315	
	1-2	40.0	15.8	0.0	0.0	0.0	4.50		
	2-4	0.0	15.8	0.0	0.0	0.0	5.62		
2.0	0-1	382.5	278.3	97.3	0.0	0.0	6.41	0.1485	
	1-2	185.5	165.0	5.3	0.0	0.0	4.31		
	2-4	0.0	22.6	0.0	0.0	0.0	5.62		
4.0	0-1	269.8	230.1	99.1	0.0	0.0	7.21	0.1275	
	1-2	84.3	21.6	0.0	0.0	0.0	5.21		
	2-4	0.0	27.9	0.0	0.0	0.0	11.19		
6.0	0-1	189.0	192.7	102.1	35.8	8.4	8.16	0.1296	
	1-2	55.0	17.9	6.3	0.0	0.0	11.20		
	2-4	0.0	30.6	0.0	0.0	0.0	11.00		
8.0	0-1	137.0	164.2	119.1	89.6	16.0	9.09	0.1266	
	1-2	0.0	12.7	5.5	0.0	0.0	17.43		
	2-4	0.0	143.9	0.0	0.0	0.0	21.30		
10.0	0-1	115.9	137.6	98.8	109.6	39.9	8.66	0.1198	
	1-2	42.0	127.6	5.5	0.0	0.0	20.76		
	2-4	0.0	143.3	0.0	0.0	0.0	21.25		
12.0	0-1	97.0	28.3	84.4	111.5	0.0	9.30	0.1131	
	1-2	30.0	136.3	5.3	0.0	0.0	21.37		
	2-4	0.0	123.0	0.0	0.0	0.0	12.37		
14.0	0-1	84.8	109.6	90.1	107.5	0.7	10.12	0.1058	
	1-2	35.0	134.2	5.2	0.0	0.0	14.63		
	2-4	0.0	109.6	0.0	0.0	0.0	22.37		

NOREQ: NORMAL EQUATION

2NDMOM: SECOND MOMENT

TABLE C-12.--CONT INUED

TIME	DEPTH	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET				VARIANCE SQ.FT.	YD	WD
		0.0	3.0	6.0	9.0			
16.0	1-1	75.9	97.0	74.8	97.0	113.8	0.0970	
	1-2	33.7	34.8	91.2	26.3	154.0		
	2-3	0.0	3.2	7.2	0.0	0.0	0.0890	
18.0	1-1	0.5	3.4	8.7	0.3	111.7		
	1-2	32.7	34.8	71.4	26.3	161.1		
	2-3	0.0	1.0	4.2	0.0	0.0	0.0808	
20.0	1-1	0.0	7.9	7.5	0.5	101.2		
	1-2	62.6	33.7	64.3	26.3	164.0		
	2-3	0.0	1.7	7.2	0.0	0.0	0.0702	
22.0	1-1	0.0	7.7	7.4	0.6	59.3		
	1-2	56.6	73.2	63.3	26.3	269.0		
	2-3	0.0	1.1	4.2	0.0	0.0	0.0602	
24.0	1-1	0.0	2.2	4.1	0.7	28.5		
	1-2	0.0	1.3	7.1	0.0	61.0		
	2-3	51.6	32.1	64.8	36.3	210.0		
26.0	1-1	0.0	1.0	4.2	0.0	0.0	0.0535	
	1-2	29.0	32.1	64.2	0.0	155.9		
	2-3	0.0	1.0	5.2	0.3	155.9		
28.0	1-1	0.0	1.8	6.9	0.4	10.5		
	1-2	48.5	32.1	55.3	0.0	149.0		
	2-3	0.0	1.5	3.2	0.2	40.4		
30.0	1-1	0.0	2.1	3.3	0.3	50.0		
	1-2	48.0	33.2	53.3	0.2	181.0		
	2-3	0.0	1.3	3.6	0.3	45.0		
32.0	1-1	0.0	1.4	3.5	0.1	55.1		
	1-2	47.0	33.1	52.3	0.0	41.0		
	2-3	0.0	1.0	3.5	0.0	0.0		

NOREQ 2NDMOM
 94.64
 154.22
 78.07
 87.44
 0.00
 0.00
 90.57
 66.31
 0.00
 263.45
 0.00
 39.29
 35.00
 0.00
 22.08
 60.66
 0.00
 16.27
 71.81
 0.00
 12.76
 181.00
 0.00
 11.24
 96.00
 0.00

GRAM
 0.0970
 0.0890
 0.0808
 0.0702
 0.0602
 0.0535
 0.0480
 0.0445
 0.0421

YD

FT

VARIANCE SQ.FT.

NOREQ

2NDMOM

WD

TABLE C-12.--CONTINUED

TIME	DEPTH	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET					VARIANCE SQ.FT.	YD FT	WD GRAM
		0.0	3.0	6.0	9.0	12.0			
34.0	0-1	39.0	41.6	50.6	25.0	4.2	10.70	0.0408	
	1-3	27.0	31.2	22.3	25.0	36.0	139.11		
	2-4	0.0	1.9	5.6	0.0	0.0	0.0		
36.0	0-1	36.0	31.6	41.2	25.0	4.2	10.95	0.0393	
	1-3	26.0	3.2	1.2	0.0	33.0	180.00		
	2-4	0.0	1.8	4.6	0.0	0.0	0.0		
38.0	0-1	35.0	31.8	51.1	25.0	4.6	11.24	0.0386	
	1-3	26.0	31.2	22.3	25.0	30.0	379.00		
	2-4	0.0	1.7	2.6	0.0	0.0	0.0		
40.0	0-1	33.0	31.7	51.2	25.0	4.4	11.42	0.0373	
	1-3	26.0	31.2	22.3	25.0	27.0	1730.00		
	2-4	0.0	1.6	2.6	0.0	0.0	0.0		
42.0	0-1	32.0	31.6	51.1	25.0	4.0	11.63	0.0366	
	1-3	25.0	31.2	22.3	25.0	26.0	991.00		
	2-4	0.0	1.6	2.6	0.0	0.0	0.0		
44.0	0-1	31.0	31.4	50.1	25.0	4.3	11.93	0.0357	
	1-3	25.0	31.2	22.3	25.0	25.0	452.00		
	2-4	0.0	1.4	2.6	0.0	0.0	0.0		
46.0	0-1	30.0	31.2	50.1	25.0	4.2	12.19	0.0352	
	1-3	25.0	31.2	22.3	25.0	24.0	280.00		
	2-4	0.0	1.6	2.6	0.0	0.0	0.0		
48.0	0-1	29.0	31.2	50.1	25.0	4.2	12.48	0.0347	
	1-3	25.0	31.2	22.3	25.0	23.0	209.00		
	2-4	0.0	1.6	2.6	0.0	0.0	0.0		

TABLE C-13. --COMPUTATIONAL RESULTS OF TEST NO.13

TIME	DEPTH	CONCENTRATION IN PPB AT						VARIANCE	YD	WD
		0.0	3.0	6.0	9.0	12.0	2NDMCM			
0.0	1-1	286.8	56.9	6.0	0.0	0.0	0.0	2.15	0.0471	
	1-2	6.3	20.0	0.0	0.0	0.0	0.0	5.01		
	1-3	4.2	0.0	0.0	0.0	0.0	0.0	1.12		
2.0	2-4	2.1	0.7	0.0	0.0	0.0	0.0	1.69	0.0592	
	2-1	197.7	50.6	0.0	0.0	0.0	0.0	2.50		
	2-2	252.7	1.0	0.0	0.0	0.0	0.0	1.12		
4.0	3-4	27.4	0.0	0.0	0.0	0.0	0.0	1.60	0.0522	
	3-1	130.7	47.4	4.2	0.0	0.0	0.0	3.54		
	3-2	138.1	64.3	2.0	0.0	0.0	0.0	1.19		
6.0	4-4	65.9	0.0	0.0	0.0	0.0	0.0	4.22	0.0499	
	4-1	107.5	43.0	8.4	0.0	0.0	0.0	1.43		
	4-2	107.5	70.2	6.3	0.0	0.0	0.0	4.43		
8.0	5-2	63.2	2.1	0.0	0.0	0.0	0.0	1.30	0.0481	
	5-1	43.7	1.2	0.0	0.0	0.0	0.0	1.67		
	5-3	91.8	42.6	12.6	2.1	0.0	0.0	5.79		
10.0	6-3	83.6	2.0	0.0	0.0	0.0	0.0	1.47	0.0447	
	6-1	55.2	1.1	0.0	0.0	0.0	0.0	1.34		
	6-2	42.6	1.2	0.0	0.0	0.0	0.0	7.30		
12.0	7-2	76.3	4.7	16.8	3.2	0.0	0.0	6.61	0.0420	
	7-1	83.6	2.1	0.0	0.0	0.0	0.0	1.61		
	7-3	21.6	1.1	0.0	0.0	0.0	0.0	1.41		
14.0	8-4	68.5	4.3	17.9	4.2	0.0	0.0	8.51	0.0410	
	8-1	75.9	2.1	0.0	1.0	0.0	0.0	7.63		
	8-2	16.3	1.1	0.0	0.0	0.0	0.0	5.49		
	9-1	62.7	4.0	21.1	5.3	0.0	0.0	9.19		
	9-2	71.5	2.0	0.0	2.0	0.0	0.0	8.71		
	9-3	7.4	1.1	0.0	0.0	0.0	0.0	1.13		

NOREQ: NORMAL EQUATION

2NDMOM: SECOND MOMENT

TABLE C-13.--CONTINUED

TIME	DEPTH	CONCENTRATION IN PPS AT				VARIANCE	YO	WD
		STATED	6.0	9.0	12.0			
16.0	0-1	58.0	42.0	6.0	0.0	10.34	10.5	0.0407
	1-2	67.4	56.0	30.6	0.0	8.18	10.0	
	2-3	7.4	52.0	22.1	0.0	7.27		
	3-4	5.3	41.0	0.0	0.0	22.0		
18.0	0-1	56.3	41.0	3.0	1.0	10.94	11.0	0.0403
	1-2	6.3	52.0	24.0	0.0	7.76	10.5	
	2-3	4.0	41.0	0.0	0.0	7.48		
	3-4	5.0	49.0	0.0	0.0	25.0		
20.0	0-1	53.0	41.0	0.0	1.0	11.46	11.0	0.0406
	1-2	6.0	49.0	3.0	0.0	7.85	10.5	
	2-3	4.0	41.0	0.0	0.0	7.67		
	3-4	5.0	49.0	0.0	0.0	25.0		
22.0	0-1	54.0	41.0	0.0	1.0	13.85	11.5	0.0398
	1-2	6.0	49.0	3.0	0.0	7.28	10.0	
	2-3	4.0	41.0	0.0	0.0	7.53		
	3-4	5.0	49.0	0.0	0.0	12.0		
24.0	0-1	52.0	41.0	0.0	1.0	19.38	12.0	0.0398
	1-2	6.0	49.0	3.0	0.0	7.00		
	2-3	4.0	41.0	0.0	0.0	7.46		
	3-4	5.0	49.0	0.0	0.0	12.0		
26.0	0-1	50.0	41.0	0.0	1.0	29.38		0.0389
	1-2	6.0	49.0	3.0	0.0	8.00		
	2-3	4.0	41.0	0.0	0.0	7.53		
	3-4	5.0	49.0	0.0	0.0	12.0		
28.0	0-1	50.0	41.0	0.0	1.0	30.60		0.0383
	1-2	6.0	49.0	3.0	0.0	8.00		
	2-3	4.0	41.0	0.0	0.0	7.91		
	3-4	5.0	49.0	0.0	0.0	12.0		
30.0	0-1	50.0	41.0	0.0	1.0	37.25		0.0375
	1-2	6.0	49.0	3.0	0.0	8.15		
	2-3	4.0	41.0	0.0	0.0	7.90		
	3-4	5.0	49.0	0.0	0.0	12.0		
32.0	0-1	50.0	41.0	0.0	1.0	37.53		0.0369
	1-2	6.0	49.0	3.0	0.0	8.17		
	2-3	4.0	41.0	0.0	0.0	7.90		
	3-4	5.0	49.0	0.0	0.0	12.0		

TABLE C-13.---CONTINUED

TIME	DEPTH	CONCENTRATION IN PPB AT STATED LATERAL DISTANCE IN FEET					VARIANCE SO. FT.	NOREQ	2ND MOM	YO	WD
		0.0	3.0	6.0	9.0	12.0					
34.0	0-1	48.5	40.1	35.8	14.8	2.0	10.1	13.89	0.0362	GRAM	
	1-2	48.3	31.6	24.2	0.0	0.0	7.5	10.61			
	2-3	46.3	20.1	1.8	0.0	0.0	7.3	7.15			
	3-4	47.4	40.1	14.2	15.8	3.0	11.6	14.34			
36.0	0-1	47.4	20.1	2.1	0.0	0.0	9.2	14.05	0.0357	GRAM	
	1-2	46.3	20.1	1.7	0.0	0.0	7.9	7.10			
	2-3	45.3	40.1	1.1	0.0	0.0	9.2	14.06			
	3-4	46.3	20.1	1.7	16.2	3.0	7.5	7.13			
38.0	0-1	45.3	20.1	2.2	0.0	0.0	9.2	14.06	0.0344	GRAM	
	1-2	46.3	20.1	1.7	0.0	0.0	7.5	7.13			
	2-3	44.3	39.5	1.1	0.0	0.0	9.2	14.06			
	3-4	46.3	20.1	1.7	16.2	3.0	7.5	7.13			
40.0	0-1	44.3	20.1	2.2	0.0	0.0	9.2	14.06	0.0338	GRAM	
	1-2	43.3	39.5	1.1	0.0	0.0	7.5	7.13			
	2-3	46.3	20.1	1.7	0.0	0.0	9.2	14.06			
	3-4	44.3	20.1	1.7	16.2	4.0	7.5	7.13			
42.0	0-1	43.3	20.1	2.2	0.0	0.0	9.2	14.06	0.0327	GRAM	
	1-2	42.3	39.5	1.1	0.0	0.0	7.5	7.13			
	2-3	46.3	20.1	1.7	0.0	0.0	9.2	14.06			
	3-4	44.3	20.1	1.7	16.2	4.0	7.5	7.13			
44.0	0-1	42.3	20.1	2.2	0.0	0.0	9.2	14.06	0.0316	GRAM	
	1-2	41.3	39.5	1.1	0.0	0.0	7.5	7.13			
	2-3	46.3	20.1	1.7	0.0	0.0	9.2	14.06			
	3-4	44.3	20.1	1.7	16.2	5.0	7.5	7.13			
46.0	0-1	41.3	20.1	2.2	0.0	0.0	9.2	14.06	0.0309	GRAM	
	1-2	40.3	39.5	1.1	0.0	0.0	7.5	7.13			
	2-3	46.3	20.1	1.7	0.0	0.0	9.2	14.06			
	3-4	44.3	20.1	1.7	16.2	6.0	7.5	7.13			
48.0	0-1	40.3	20.1	2.2	0.0	0.0	9.2	14.06	0.0309	GRAM	
	1-2	39.3	39.5	1.1	0.0	0.0	7.5	7.13			
	2-3	46.3	20.1	1.7	0.0	0.0	9.2	14.06			
	3-4	44.3	20.1	1.7	16.2	6.0	7.5	7.13			

TABLE C-14.--COMPUTATIONS FOR DATA ANALYSIS OF TEST NO. 1
BY PROPOSED MATHEMATICAL MODEL

TIME MIN.	FTA RCY	0.0	3.0	6.0	9.0	12.0	15.0	XI	RCMAX
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.000
2.0	0.346	0.409	0.818	1.227	1.637	2.046	2.455	1.788	0.342
4.0	0.316	0.346	0.425	0.504	0.583	0.662	0.741	3.576	0.270
6.0	0.639	0.639	0.609	0.579	0.549	0.519	0.489	5.364	0.238
8.0	0.271	0.271	0.543	0.814	1.086	1.357	1.629	7.152	0.212
10.0	0.000	0.000	0.488	0.721	0.975	1.219	1.463	8.940	0.192
12.0	0.000	0.000	0.639	0.673	0.707	0.741	0.775	10.728	0.174
14.0	0.000	0.000	0.419	0.400	0.381	0.362	0.343	12.516	0.158
16.0	0.000	0.000	0.775	0.629	0.483	0.337	0.191	14.304	0.149
18.0	0.000	0.000	0.168	0.396	0.576	0.756	0.936	16.092	0.137
20.0	0.000	0.000	0.828	0.626	0.424	0.222	0.020	17.880	0.128
	0.000	0.000	0.128	0.302	0.476	0.650	0.824		
	0.000	0.000	0.365	0.540	0.715	0.890	1.065		
	0.000	0.000	0.605	0.547	0.493	0.439	0.385		
	0.000	0.000	0.346	0.519	0.693	0.866	1.039		
	0.000	0.000	0.600	0.525	0.450	0.375	0.300		

TABLE C-15.--COMPUTATIONS FOR DATA ANALYSIS OF TEST NO. 2
BY PROPOSED MATHEMATICAL MODEL

TIME MIN.	0.0	3.0	6.0	9.0	12.0	15.0	18.0	XI	RCMAX
0.0	0.0	0.409	0.818	1.227	1.637	2.046	2.455	0.0	1.000
2.0	1.000	0.660	0.175	0.947	0.263	0.0	0.0	1.788	0.415
4.0	1.000	0.316	0.632	0.015	1.000	1.579	1.0895	3.576	0.280
6.0	1.000	0.733	0.407	0.814	0.086	0.357	1.529	5.364	0.234
8.0	1.000	0.271	0.543	0.088	0.975	0.219	0.0	7.152	0.207
10.0	1.000	0.708	0.488	0.731	0.020	1.0	1.463	8.940	0.189
12.0	1.000	0.244	0.570	0.230	0.897	1.121	0.0	10.728	0.176
14.0	1.000	0.700	0.449	0.673	0.121	0.048	1.346	12.516	0.166
16.0	1.000	0.224	0.604	0.350	0.835	1.035	0.0	14.304	0.156
18.0	1.000	0.681	0.412	0.629	0.235	0.989	1.087	15.092	0.149
20.0	1.000	0.259	0.612	0.365	0.791	0.112	1.229	17.880	0.143
	1.000	0.698	0.396	0.593	0.312	0.941	0.080		
	1.000	0.150	0.625	0.375	0.347	0.200	1.039		
	1.000	0.188	0.653	0.387	0.340	0.264	0.0		
	1.000	0.180	0.667	0.389	0.347	0.264	0.0		
	1.000	0.125	0.667	0.389	0.347	0.264	0.0		
	1.000	0.173	0.646	0.391	0.362	0.304	0.0		
	1.000	0.623	0.667	0.391	0.362	0.304	0.0		

TABLE C-19.---COMPUTATIONS FOR DATA ANALYSIS OF TEST NO. 6
BY PROPOSED MATHEMATICAL MODEL

TIME MIN.	ETA	RCY	ETA	AT	STATED	LATERAL	DISTANCE	IN	FEET	XI	RCMAX
	0.0	0.0	4.0	8.0	12.0	16.0	20.0				
0.0	0.000	0.0	0.546	1.091	1.637	2.182	2.728			0.0	1.000
2.0	1.000	0.0	0.577	0.072	0.263	0.0	0.0			1.853	0.303
4.0	1.000	0.0	0.421	0.842	1.141	1.684	2.105			3.706	0.116
6.0	0.000	0.0	0.706	0.953	0.086	0.0	0.0			5.558	0.071
8.0	1.000	0.0	0.362	0.724	1.086	1.448	1.810			7.411	0.063
10.0	1.000	0.0	0.731	1.115	0.250	0.0	0.0			9.264	0.061
12.0	1.000	0.0	0.325	0.650	0.975	1.300	1.625			11.117	0.061
14.0	1.000	0.0	0.761	1.043	0.282	0.0	0.0			12.970	0.061
16.0	1.000	0.0	0.299	0.598	0.897	1.196	1.495			14.822	0.061
18.0	1.000	0.0	0.756	0.889	0.289	0.0	0.0			16.675	0.061
20.0	1.000	0.0	0.279	0.559	0.838	1.117	1.397			18.528	0.061
	1.000	0.0	0.733	0.778	0.311	0.0	0.0				
	1.000	0.0	0.264	0.527	0.791	1.055	1.319				
	1.000	0.0	0.711	0.680	0.333	0.0	0.0				
	1.000	0.0	0.251	0.502	0.733	1.004	1.255				
	1.000	0.0	0.689	0.644	0.333	0.0	0.0				
	1.000	0.0	0.240	0.480	0.720	0.960	1.201				
	1.000	0.0	0.689	0.600	0.333	0.0	0.0				
	1.000	0.0	0.231	0.462	0.656	0.923	1.154				
	1.000	0.0	0.689	0.578	0.356	0.0	0.0				

TABLE C-21.---COMPUTATIONS FOR DATA ANALYSIS OF TEST NO. 8
BY PROPOSED MATHEMATICAL MODEL

TIME MIN.	RCY	FTA	RCY	FTA	RCY	FTA	RCY	FTA	RCY	FTA	RCY	FTA	RCY	FTA	XI	RCMAX			
	0.0	4.0	8.0	12.0	16.0	20.0	0.0	4.0	8.0	12.0	16.0	20.0	0.0	4.0	8.0	12.0	16.0	20.0	
0.0	0.000	0.404	0.808	1.212	1.616	2.020	0.0	0.404	0.808	1.212	1.616	2.020	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	1.000	1.059	0.632	0.923	0.231	0.0	1.000	1.059	0.632	0.923	0.231	0.0	0.0	0.0	1.248	0.310	0.0	0.0	0.0
4.0	1.000	0.925	0.858	0.292	0.0	0.0	1.000	0.925	0.858	0.292	0.0	0.0	0.0	0.0	2.496	0.149	0.0	0.0	0.0
6.0	1.000	0.262	0.525	0.787	1.049	1.312	1.000	0.262	0.525	0.787	1.049	1.312	1.000	0.0	3.744	0.128	0.0	0.0	0.0
8.0	1.000	0.224	0.469	0.703	0.937	1.172	1.000	0.224	0.469	0.703	0.937	1.172	1.000	0.0	4.992	0.118	0.0	0.0	0.0
10.0	1.000	0.893	0.869	0.512	0.214	0.0	1.000	0.893	0.869	0.512	0.214	0.0	0.0	0.0	6.240	0.111	0.0	0.0	0.0
12.0	1.000	0.273	0.429	0.644	0.859	1.063	1.000	0.273	0.429	0.644	0.859	1.063	1.000	0.0	7.488	0.104	0.0	0.0	0.0
14.0	1.000	0.865	0.838	0.481	0.304	0.0	1.000	0.865	0.838	0.481	0.304	0.0	0.0	0.0	8.736	0.100	0.0	0.0	0.0
16.0	1.000	0.188	0.376	0.564	0.752	0.940	1.000	0.188	0.376	0.564	0.752	0.940	1.000	0.0	9.984	0.096	0.0	0.0	0.0
18.0	1.000	0.845	0.817	0.423	0.237	0.0	1.000	0.845	0.817	0.423	0.237	0.0	0.0	0.0	11.232	0.093	0.0	0.0	0.0
20.0	1.000	0.178	0.357	0.535	0.714	0.892	1.000	0.178	0.357	0.535	0.714	0.892	1.000	0.0	12.480	0.090	0.0	0.0	0.0
	1.000	0.170	0.341	0.511	0.681	0.852	1.000	0.170	0.341	0.511	0.681	0.852	1.000	0.0					
	1.000	0.163	0.327	0.490	0.654	0.817	1.000	0.163	0.327	0.490	0.654	0.817	1.000	0.0					
	1.000	0.844	0.797	0.359	0.453	0.203	1.000	0.844	0.797	0.359	0.453	0.203	1.000	0.0					

TABLE C-24.---COMPUTATIONS FOR DATA ANALYSIS OF TEST NO.11
BY PROPOSED MATHEMATICAL MODEL

TIME MIN.	ETA	RCY	AND	ETA	VALUES	AT	STATED	LATERAL	DISTANCE	IN	FEET	XI	RCMAX	
		0.0				4.0		8.0		12.0		16.0		20.0
0.0	ETA	0.000				0.404		0.808		1.212		1.616		2.020
2.0	RCY	1.000				0.579		0.642		0.923		0.931		0.538
4.0	ETA	1.000				0.517		0.617		0.542		0.625		0.000
6.0	RCY	1.000				0.262		0.525		0.787		0.049		0.312
8.0	ETA	1.000				0.510		0.878		0.378		0.204		0.000
10.0	RCY	1.000				0.224		0.469		0.703		0.250		0.172
12.0	ETA	1.000				0.548		0.619		0.333		0.859		0.073
14.0	RCY	1.000				0.215		0.429		0.645		0.173		0.014
16.0	ETA	1.000				0.600		0.575		0.315		0.799		0.999
18.0	RCY	1.000				0.200		0.400		0.599		0.123		0.031
20.0	ETA	1.000				0.646		0.554		0.308		0.752		0.940
	RCY	1.000				0.188		0.376		0.564		0.103		0.034
	ETA	1.000				0.707		0.552		0.310		0.714		0.892
	RCY	1.000				0.178		0.357		0.535		0.135		0.038
	ETA	1.000				0.769		0.577		0.308		0.681		0.852
	RCY	1.000				0.170		0.341		0.511		0.146		0.042
	ETA	1.000				0.792		0.583		0.292		0.654		0.817
	RCY	1.000				0.163		0.327		0.490		0.156		0.067
	ETA	1.000				0.822		0.578		0.289		0.000		0.000
	RCY	1.000				0.000		0.000		0.000		0.000		0.000

