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LABORATORY STUDIES OF DEPTH DETERMINATION OF THE WAVE VELOCITY METHOD

BY

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TABLE OF CONTENTS

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I. ABSTRACT

The wave velocity method of depth determination has been studied in a laboratory wave channel. The data were recorded on movie film and were evaluated for wave travel diagrams (distance-time diagrams) which were then used to make depth predictions. Three sets of conditions were considered: 1) uniform waves in water of constant depth (not used for depth determination), 2) non-uniform waves in water of constant depth and 3) non-uniform waves on a uniformly sloping beach. The computed results were tabulated and the predicted depth obtained by averaging a large number of individual values. The resulting data are presented in a series of graphs.

II. INTRODUCTION

For military operations on enemy-held beaches, it is very important to know the water depths and characteristics of the coast line. Large scale hydrographic surveys of beach areas are rare and the areas covered usually are small. Furthermore, changes in the beach form can take place quite rapidly.(5)* It is obvious that direct measurements of enemy-held beaches are very difficult. Some measurements have been made by sending boats or swimmers ashore at night to make the soundings, but this is a very dangerous task, and furthermore, there are no means of knowing exactly where the measurements were made. Although improvements have been made recently, during World War II considerable attention was given to the problem of depth determination, and different methods were developed to make indirect measurements of beach profiles. This report deals with the wave velocity method of depth determination. Several publications have described the application of this method (1-4). Photographs have been taken of a large variety of types of beaches and evaluated for depths. The results have been satisfactory insofar as the beach slopes were concerned; however, it was found that relatively large errors have occurred in determining depths at individual points. The difficulties in comparing the computed depths with actually measured depths may sometimes be traced back to the fact that the surf conditions often prevented soundings from being taken on the same day as the aerial sorties, and the actual profile may have changed considerably between the time of taking the pictures and the time that the soundings were completed.

Considering these difficulties, and also to obtain a larger variety of beach and wave conditions, it was decided to conduct some laboratory investigations on the wave velocity method of depth determination. Four sets of conditions were considered:

1. The velocities of uniform waves in constant depth of water were measured at different distances from the wave generator in order to determine the wave tank characteristics.

2. Non-uniform waves in water of constant depth, for several depths.

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* Numbers in parentheses refer to References at end of paper.

3. Non-uniform waves over a beach of a constant slope of 1:40. This slope was chosen so as to be similar to field conditions previously analyzed.(9)

4. Non-uniform waves over beaches with slopes of 1:11, 1:20 and 1:40 . Each of these beaches was used under two conditions, a) uniformly sloping without an offshore bar, and b) uniformly sloping with an offshore bar.

Evaluations of the data for the first three sets of conditions have been completed and are presented in this report. The results and evaluation of the fourth condition, however, will be presented in a separate report.

III. THEORY

If waves are of small amplitude compared to their length (height less than 1/200 of length) and depth of water, and are of constant length and height, the wave velocity C, in water of constant depth may be written as:

$$C^2 = (g\,L/\,2\pi)\tanh(2\pi d/L) \qquad (1)$$

or, considering also the definition for periodic waves

$$L = C\,T \qquad (2)$$

Equation (1) may be rewritten as

$$C = (g\,T/\,2\pi)\tanh(2\pi d/L) \qquad (1a)$$

or

$$L = (g\,T^2/\,2\pi)\tanh(2\pi d/L) \qquad (1b)$$

where
C = wave velocity in feet per second,
L = wave length in feet (the distance from crest to crest),
T = wave period in seconds (the time interval between the appearance of successive crests at the same point),
d = water depth in feet, and
g = acceleration of gravity in feet/second^2.

Equation (1) indicates that the wave velocity and length depend upon the depth of water and the wave period. Considering also Equation (2), it is seen that the depth can be found if:

1. the velocity C and length L are known (Equation 1),
2. the velocity C and period T are known (Equation 1a), and
3. the length L and period T are known (Equation 1b).

If the depth is very shallow as compared with the wave length, $\tanh(2\pi d/L)$ approaches the value of $(2\pi d/L)$ and Equation (1) becomes

$$C^2 = gd \qquad (3)$$

As we see in Figure 1, the two functions $(2\pi d/L)$ and $\tanh(2\pi d/L)$ are nearly equal for $d/L = 0.04$, or less.

At $d/L = 0.05$, the difference is 3% and at $d/L = 0.04$ the difference is only 2%. In other words, for $d/L = 0.04$ the wave length (and period) practically cease to influence the wave velocity and the depth may be determined by measuring only the wave velocities (Equation 3). For $T = 10$ seconds, the simplified Equation (3) may be used for depths approximately 5 feet or less, and $T = 15$ seconds when depths are less than 12 feet.

For water deeper than one-half the wave length ($d/L > 0.5$) $\tanh 2\pi d/L$ is almost equal to 1 and Equation (1) reduces to

$$C_o^2 = (g L_o/ 2\pi) \qquad (4)$$

$$C_o = (g T/ 2\pi) \qquad (4a)$$

Subscript $-_o$ refers here to deep water conditions. In Equation (4) the wave velocity, length and period are not functions of the water depth, and so can not be used for depth determination.

For $d/L > 0.025$ the change in wave velocity seems to be rather insensitive to the change of depth, as can be seen in Figure 1, so it would be reasonable to limit the method in the laboratory studies to the region $d/L < 0.25$ (or the corresponding $d/L_o < 0.23$). To compare the laboratory studies with prototype conditions, we know that in many localities, such as the North Sea and the Baltic, and also wherever the locality is near a storm area, wave periods of 4 seconds may be encountered. This means that the method may be used for depths of less than 19 feet, which seems to be sufficient for most landing operations.

For $T = 3$ seconds, the method seems to be rather limited to a depth of approximately 10 feet. Considering also a relatively large error for higher d/L values, it seems to be reasonable to limit the method for wave periods $T \geq 4$ seconds. The above named limits are set considering only the results obtained under laboratory conditions. The actual application of the method has shown, however, that no satisfactory results may be obtained for such high values of d/L. For practical purposes $d/L = 0.1$ may be considered as the upper limit. On many occasions it was found that for satisfactory results the wave period T should be longer than 12 seconds. Wave crests of waves of shorter periods are scarcely distinguishable in aerial photographs.

As was previously mentioned, the wave velocity method has been applied on numerous occasions. The slopes of the beaches have been predicted satisfactorily in most cases; however, relatively large errors have been noted in the depths predicted at individual points. These errors can not all be traced to the accuracy of measurements; it seems rather that the theory breaks down upon occasions. To understand and minimize this difficulty it seems to be necessary to list and keep firmly in mind the assumptions and definitions that have led to Stokes' theory and Equation (1). The assumptions are as follows:

1. the water depth is constant,
2. the wave steepness is small, and
3. the waves are periodic and of uniform permanent form.

At first glance it appears that none of these conditions is fulfilled in the ocean. The first assumption (that the water depth should be constant) is almost never fulfilled when the theory is used to determine the depths offshore from beaches, because the bottom is almost always sloping. Some of wave energy is reflected by the sloping bottom, but all the experiments indicate that reflections are very small and negligible when the slope is flatter than 1:10. The fact that the gradients of beaches were predicted very closely for flat beaches indicates also that the average wave velocities as predicted by the Stokes theory are not affected very much by sloping beaches.

The second assumption (that the wave steepness is small) is usually fulfilled in the ocean. However, it is preferable to use steeper waves, since the definition of the crest is always much better for steeper waves than for flat ones, and the error due to error in measurement will be reduced. Equation (1), known as Stokes' first approximation, neglects the effect of wave height. Stokes' third approximation takes this into account, that is,

$$C^2 = (g\ L/2\pi)\tanh(2\pi d/L)\left\{\frac{1 + e^{(8\pi d/L)} + e^{-(8\pi d/L)} + 2\left(e^{(4\pi d/L)} - e^{(-4\pi d/L)}\right) + 12}{\left(e^{(2\pi d/L)} - e^{(-2\pi d/L)}\right)^4} \cdot \frac{\pi^2 H^2}{L^2}\right\} \qquad (5)$$

where L, C and d are as defined before, and H = wave height.

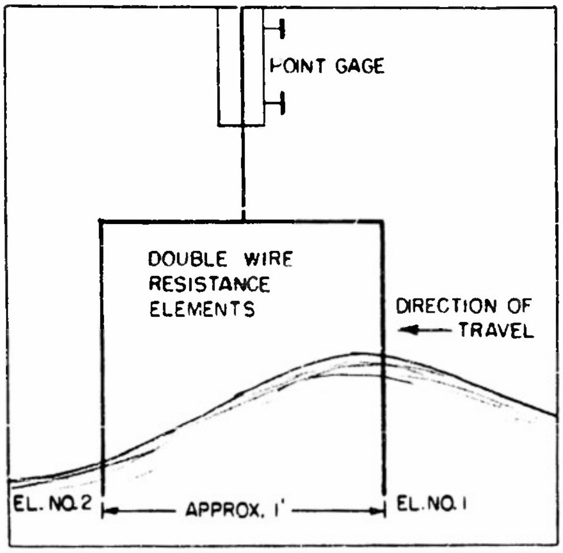
This formula, however, can not be used for depth determination, since it is practically impossible to measure wave heights from aerial photographs taken under operational conditions. However, one can estimate the relative wave steepness for a given photograph, and it has been the practice (particularly in Great Britain) to reduce the depths computed by 10 percent if the photographs indicate very steep waves, or by 5 percent for flatter waves(4).

Violation of the assumption that the waves are uniform seems to be the most critical. Ocean waves are always non-uniform, with the waves having different periods, lengths and heights. Thus wave forms are constantly changing due to their dispersive qualities; however, the changes become much less rapid in the shallow water near the beach, as this quality depends upon the relative depth, i.e., d/L.

IV. LABORATORY EQUIPMENT AND PROCEDURE

Experiments were perfomred in a wave channel 1 foot wide, 60 feet long and 3 feet deep, located in the Fluid Mechanics Laboratory of the University of California, Berkeley. One side of the channel consisted of plate-glass, framed in 3 ft. x 3 ft. steel frames, through which moving pictures of the wave motion were taken. The wave generator, of the flapper type, was located at one end of the channel. Both the amplitude and period of the flapper movement were adjustable. The period of the flapper movement could be varied between approximately 0.4 second and 2 seconds. At the opposite end of the channel from the wave generator an aluminum beach was installed. The slope of the beach could be varied from the horizontal to approximately 1:10.

To measure wave velocities at a particular point, two double-wire elements were mounted on a single point gage, as shown in the sketch. The distance between the two elements was approximately 1 foot. The elements were connected to a Brush Recorder and the surface time history recorded simultaneously for both elements(7). The time required for a wave crest to pass from element 1 to element 2 can be read very accurately from the records, and knowing the exact distance between the elements one is able



to compute the wave velocity. A sample of the record is given in Fig. 3a.

The first experiments were made to determine the influence of the particular channel upon the wave motion, and to determine the minimum distance between the wave-generator and the point of measurement that is required for steady conditions. For this purpose constant depths and uniform waves were used. The wave velocities were measured at different distances from the wave generator (see Figure 2).

For the remaining experiments, non-uniform waves were generated by moving the flapper manually in order to vary the periods and amplitudes. To obtain a continuous record of the waves a 35 mm Bell and Howell "Eymo" camera was used. The section covered by the camera was between 7 and 9 feet in length.

Experimentation with photography showed that clear water gave a surface line in the photographs which was difficult to read. Therefore, it was decided to cover the glass windows in the channel with tracing paper, stretched tightly against the surface of the glass. A grid was drawn on the paper to obtain a scale for the evaluation of the data. When a strong light was directed to the water surface a very clearly distinguished shadow line was obtained on the tracing paper; hence, the shadow of the water-surface profile was actually photographed. The results were satisfactory. Special care was taken to keep the tracing paper as tight as possible to the glass, otherwise the shadow image would not be clear and would result in erroneous readings. In order to obtain a time-scale for the measurements an electrically operated clock, graduated in 0.01 second increments, was installed in the field of view. The arrangement of the set-up is shown in Figure 4.

V. EVALUATION OF THE DATA

Uniform waves

The wave velocities for the uniform waves were obtained from the Brush records by measuring the time necessary for a wave crest to travel the known distance (approximately 1 foot) between the two resistance elements. The accuracy of the time measurements may be considered to be ± 2/1000 of a second, provided that the definition of the wave crest was good, as is the case, for example, in Figure 3a.

In many cases it is very difficult to determine the exact location of a wave crest. The maximum elevation is not necessarily always in the middle of the wave, and in addition to that it seems to shift back and forth. The change in wave shape might be considerable even at such a short distance as 1 foot, as demonstrated clearly in Figure 3b. At element 1 the maximum elevation was at the front of the wave, but upon reaching element 2 it had already shifted considerably backward. It was obvious that the maximums in

Figure 3b could not be used to determine the wave velocity and that such data should be disregarded. The wave velocities were obtained for a carefully selected series of waves and averages were computed for at least ten waves. The measured wave velocities were compared with theoretical velocities as computed by Equation (1). Results are shown in Figure 2 as the ratio of C_m/C_c against the distance from the wave generator, measured in wave length D/L. Here C_m is the measured wave velocity, C_c the theoretical velocity, D the distance of measurement from the wave generator in feet and L the wave length.

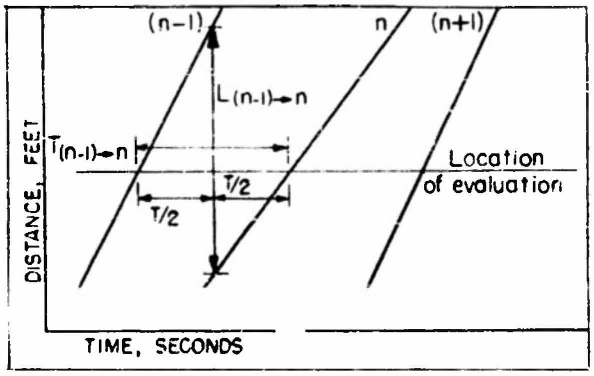
Non-uniform waves

For the non-uniform waves it was necessary to obtain a continuous record of the wave travel, so the waves were photographed on 35 mm movie film as described above. The movies were analyzed frame by frame, each wave in the photographs being assigned a number, and the time and location of these waves were measured as they advanced down the channel. The data obtained were plotted as wave travel diagrams (see Figures 5, 10, 15, 20, 25 and 30.)

To compute the water depth, the wave velocities, periods and lengths were measured from wave travel diagrams. The wave lengths and periods were the distances between the successive wave crests in distance and time scale, respectively. The velocities were obtained by measuring the slopes of the time-distance curves. For the case of a constant depth of water, it was relatively easy to obtain the slope of the curve, since the curves could be represented by straight lines through the experimental points. The lines intercepted sometimes only through the caps, and shifts in lines (for example, in Figure 5, wave No. 18; and Figure 20, waves number 10, 12 and 16) were caused by the transformation of the waves and shifts in the position of wave crests. Much of the difficulty was experienced in obtaining the wave velocities for a sloping beach. The lines representing the travel of wave crests were curved, but the change in curvature was very small as the wave approached the beach. The velocity measurements had to be made as accurately as possible, since a relatively small error in velocity might cause a large error in depth. For the case of shallow water, where Equation (3) can be used, the error in depth would be the square of the error in velocity, as can easily be seen from this equation. It was found that the most reliable measurements of the curved lines representing the travel of wave crests were obtained by approaching the curve with a transparent ruler or triangle from the concave side until the straight edge established the best estimated tangent to this point; thus the velocity was obtained from as large as possible right triangle formed by the tangent and the length and time ordinates. The final value for the velocity was obtained as an average of at least five independent measurements at the given point. The measured values are tabulated in the first part of Tables 1, 2 etc.

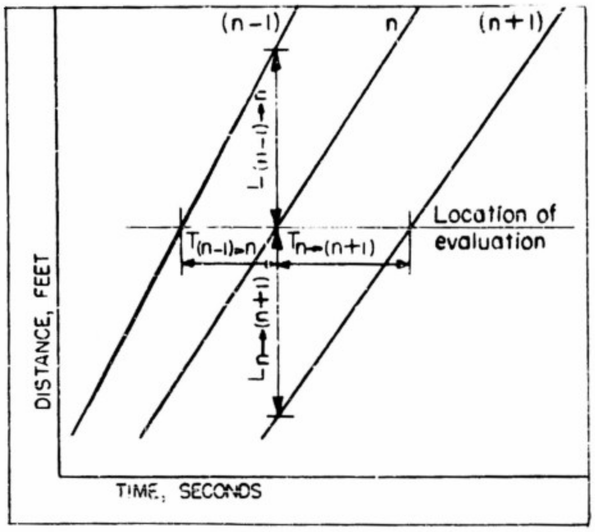
Before starting the computations, it was necessary to decide which combination of C, T and L values should be used in Equation (1) for depth determination. There were many possibilities, such as using: (a) the preceeding period and length to the crest where the velocity was measured, (b) the following period and length and (c) some combination of the preceeding and following wave periods and lengths. To demonstrate the different possibilities for computation and to determine which of the methods was most reliable and simple to handle, it was decided to use three different methods to evaluate Equation (1) for the depth. For comparison the simplified Equation (3) also was used for depth determination. Here it was necessary to measure only the crest velocity, and the method was introduced as Method 4. The other three methods used were as follows.

Method 1:



The depths were computed using the following combinations: (a) wave period $T_{(n-1)\rightarrow n}$, wave length $L_{(n-1)\rightarrow n}$, wave velocity $C_{(n-1)}$ of the preceeding crest; (b) wave period $T_{(n-1)\rightarrow n}$ and wave length $L_{(n-1)\rightarrow n}$ as under (a), but the velocity of the following crest C_n. Thus, two computations were made for each wave, as shown in Table 1, 3 , etc., labeled Method 1. The final depth was obtained by averaging all the single results.

Method 2: For each crest velocity C_n an average wave period T_n and L_n were computed as follows:



$$T_n = \frac{T_{(n-1)\rightarrow n} + T_{n\rightarrow(n+1)}}{2} \qquad (7)$$

$$L_n = \frac{L_{(n-1)\rightarrow n} + L_{n\rightarrow(n+1)}}{2} \qquad (8)$$

The values C_n, T_n, and L_n were used in Equation (1); the computations were completed in Tables 2, 4 etc. under Method 2.

Method 3:

Method 2 is satisfactory for more or less uniform wave trains. To consider also the location of crest n as compared with (n-1) and (n+1) (non-uniformity of waves) Method 3 was introduced. In this method a balanced wave period T_{n_b} and length L_{n_b} (linearly interpolated values and effective at the location where the velocity C_n was measured) was computed as follows:

$$T_{n_b} = \frac{2\,T_{(n-1)\rightarrow n} \times T_{n\rightarrow(n+1)}}{T_{(n-1)\rightarrow n} + T_{n\rightarrow(n+1)}} \qquad (9)$$

$$L_{n_b} = \frac{2L_{(n-1)\rightarrow n} \times L_{n\rightarrow(n+1)}}{L_{(n-1)\rightarrow n} + L_{n\rightarrow(n+1)}} \qquad (10)$$

The values C_n, T_{n_b} and L_{n_b} were used in Equation (1). The computations were completed in Tables 2, 4 etc., under Method 3.

Method 4:

The only measurement necessary here was wave velocity, and the depth was computed in Tables 2, 4 etc., under Method 4, using the simplified Equation (3):

$$d_c = \frac{C^2}{g}$$

The computation procedure was the same for Methods 1 to 3 inclusive. Rewriting Equation (1a) we have

$$\tanh(2\pi d/L) = C_n / 5.12\ T = C_n / C_o \qquad (11)$$

C_n and T were measured, so the value for $\tanh(2\pi d/L)$ could be computed at once, and referring this value to existing tables(8) the value for d/L was obtained. With L known, the depth was easily computed.

As an example, a wave given in Table 2 under Crest 3 will be considered. Under Method 2 it was found that the average period $T_n = 0.96$ second, average length $L_n = 5.45$ feet, and the velocity $C_n = 4.43$ feet/second. Therefore $C_n / 5.12\ T_n = \tanh(2\pi d/L)$ was found to be $\frac{4.43}{5.12 \times 0.96} = 0.903$ Referring this value to Wiegel's tables(8) page 45, we obtained $d/L = 0.237$; knowing L_n we have $d_c = 0.237 \times 5.45 = 1.29$ feet. Knowing also the actual depth of water, $d_m = 2.00$ feet, the absolute error and the percentage of error are computed as shown in Table 2. The negative sign indicates that the depth was underestimated; the positive sign designates overestimated depths. The distribution of errors was plotted for different methods in Figures 6-9, 11-14, 16-19, 21-24, and 26-29.

The computed wave lengths $L_c = C_n T_n$ (C_n and T_n were measured in wave travel diagrams) and the measured wave lengths L_n also were compared in Table 1 etc. under general data, but no attempt was made to use them for the depth determination.

At first it seemed reasonable to use only that part of the data where the values of L_c and L_n were approximately the same, but later it was discovered that there was no definite relationship between the error in measured wave length, L_n, as compared with the computed value, L_c; hence it was decided to use only the measured wave lengths, L_n, for the computations.

IV. RESULTS AND DISCUSSION

Uniform waves

The first set of experiments were made using uniform waves in order to determine the characteristics of the wave channel. The results are given in Figure 2 which shows a comparatively wide scatter of the data close to the wave generator. In this region the measured wave velocities, C_m, seem to be higher than the theoretical velocities, indicating that the waves need a certain time to become stabilized after they are generated by the flapper. At a distance of approximately three wave lengths from the generator, the wave velocity seemed to develop a constant value, with measured values approximately 5 percent less than the theoretical. There were not enough data available to make this statement more conclusive; however, considering other observations, it seemed reasonable to maintain the points of measurement as far as possible from the generator.

Non-uniform waves in water of constant depth

In the wave theory used, an assumption of a finite and constant depth of water is made and then extended to shoaling water by assuming the waves to have the same characteristics in water of any depth as they would have in water of the same, but constant depth. The second set of experiments were made to test the validity of theory in water of constant depth. The experiments were made in five different depths of water: 2 feet; 1.5 feet; 1 foot; 0.533 foot and 0.253 foot with corresponding average $d/L_{o_{av.}}$ values of 0.41; 0.34; 0.33; 0.104 and 0.067. The wave travel diagrams are given in Figures 5, 10, 15, 20, and 25, and the computations completed in Tables 1 to 8.

Effect of methods of computation: As already mentioned, the computations were completed using four different methods (see page 7). Method 1 was tedious as the computations had to be repeated twice for each crest; also, there seemed to be considerably more scatter in the results than in other methods (see Figures 6, 11, 16, 21, and 26). Because of this, the method is not recommended.

Methods 2 and 3 seemed to be of equal value and the computations indicated the least scatter in results, as can be seen in Figures 7, 8, 12, 13, 17, 18, 22, 23, 27 and 28. Method 2, which was slightly simpler to handle, is recommended for the case where the wave travel diagrams indicate a more or less uniform train of waves. Method 3 should be used in case of highly non-uniform waves.

Method 4, as mentioned before, should be used only for the case where the d/L value is less than 0.04. To demonstrate this, all the computations were completed for the fourth method also, and the results can be compared with other methods in Figures 9, 14, 19, 24 and 29. The results present little scatter, but the depths are considerably underestimated. The greater the relative depth of water, the larger the error. At $d/L_{o_{av}} = 0.41$ (Figure 9) the average error is - 63 percent; at $d/L_{o_{av.}} = 0.10$ (Figure 24) the error is - 34 percent; and at $d/L_{o_{av.}} = 0.067$ the error has been reduced to - 14 percent. There are no experimental results available for smaller d/L_o values, but all the available data$^{(9)}$ indicate a very good agreement for small d/L_o values. Consequently, this method is recommended for the region of $d/L \leq 0.04$. The advantages of this method are the simplicity of application and the fact that only one measurement - the wave velocity - is necessary.

Effect of relative water depth d/L: The lower the value of d/L, the less scatter in results, as can be seen in the error distribution plots. This is to be expected because the shallower the water, the more depth affects the wave velocity, and hence, the less the importance of phase shift and period of the non-uniform waves. On the other hand, for the higher d/L values, the velocity is rather insensitive to the depth, and the curve $\tanh(2\pi d/L)$ develops a flatter and flatter shape (see Figure 1), so that it is very difficult to select the proper value for d/L for experimental values of $\tanh(2\pi d/L) = C_n/5.12\,T_n$. This results in an uncertain determination of depth. Thus, it is recommended that those data be used which have the longest possible wave lengths.

Effect of non-uniformity of the waves: In addition to the variation of lengths and periods, there are the phenomena of:

a) the disappearance and reappearance of wave crests (see Figure 5, Crests 18-19; Figure 30, Crest 50; etc.);

b) the instability of the wave crests, so that it is not possible to describe the travel of the crest by a single, well-defined curve (Figure 20, Crest 10);

c) the shift in the crest (Figure 20, Crests 12, 16 etc.);

d) the crossing of different wave crests (Figure 30, Crests 21 and 22); and

e) the breaking of waves.

All the above-named irregularities in wave shape and appearance seem to affect considerably the wave characteristics as described by Equation (1). To demonstrate this fact, the error in depth determination was plotted in the upper portion of the wave travel diagrams (Figures 5, 10, 15, 20 and 25) at the location of the wave where the computations were made. As the case of $\tanh(2\pi d/L) = C_n / 5.12\ T_n > 1$ is indeterminent, no values could be determined; the blank spots in the error graphs usually are because of this factor. Large errors in computations usually can be traced to some kind of irregularity in wave shape, as described above under a) to e). The error is large, not only for the computations where the velocities of the unstable crests were used, but also for the neighboring crests, even when the travel diagram indicated a perfect crest for this wave. This condition is very clearly demonstrated in Figure 5 at Crests 18-19, Figure 10 at Crests 6-9, and Figure 20 at Crests 10 and 12. The errors usually started a couple of crests before the unstable crest, increased to a maximum at the location of the unstable crest and decreased again after that.

Thus, it is recommended that ample data be obtained to assure a definite and unique interpretation of crest lines in wave travel diagrams before starting the procedure of depth determination. All crests which indicate instability in plots should be excluded from the computations. Furthermore, the crests preceeding and following the unstable crests (even when they seem perfect) should be excluded.

Effect of wave steepness: There were not many data available from this phase of the experiments to show the affect of wave steepness on the results of depth determination. Only Run 4 was evaluated for wave heights, and the corresponding steepnesses were plotted for each wave in the upper portion of the wave travel diagram (Figure 20). However, additional experiments will be evaluated for this affect and the results will be given in a separate report. Comparing the errors in computation and the corresponding wave steepnesses for Crests 5 to 8 (Figure 20) (these crests being reasonably well defined and not surrounded by unstable crests), it can be seen that the smaller steepnesses have resulted in a higher percentage of error. The error being always negative for the given case, a decrease in error indicated a higher velocity of travel for steeper waves, as mentioned and demonstrated previously by Equation (5). Definite conclusions cannot be stated without the support of more data.

Non-uniform waves on a uniformly sloping beach

The third set of experiments was done with non-uniform waves over a uniformly sloping beach with a slope of 1:40. The wave travel diagram is shown in Figure 30, and the results as averaged from the data of 26 waves are plotted in Figure 31. The computations were completed for seven stations according to Methods 2 and 3, and were given in Tables 9 to 15. The distribution of error is given in Figures 32 to 45. In this experiment it was found that all the statements made for the non-uniform waves in water of constant depth were also valid for the non-uniform waves on a sloping beach.

Effect of methods of computation: Method 2 and 3 were found to be of equal value, with Method 2 resulting in slightly smaller depths. But this might be of only local importance and might not be true for different cases.

Effect of relative water depth: It appears that less scatter in predicted depths occurs for the shallower depths, as can be seen in Figures 32 to 39. Figures 40 to 44, which are for relatively shallow water, indicate an increasing degree of scatter again. This latter can be traced to the steadily increasing number of breakers as the depth decreases. Breaking waves can not be used very well for depth determination.

Effect of non-uniformity of waves: It is recommended here again to use data only where the wave travel diagrams indicate well defined unique crest lines. Comparing the results in Tables 8 to 14 with the wave travel diagram in Figure 30, one can see clearly that the high percentage of errors can often be traced to unstable or breaking waves. As an example, Crests 38 and 39 yield the highest error at Station 32. At Station 35 the highest error of +100 percent is encountered at Crest 40 which breaks at this station and crosses with Crest 39. Naturally a great number of large errors are due to the high d/L value (short wave lengths) where depth determination results in uncertain values.

Effect of wave steepness: The wave heights were not evaluated for this run and so nothing definite can be stated. It seems, however, that the depths were overestimated for the shallower portions of the water, which indicates higher wave velocities than predicted by Equation (1). We know that the wave steepness increases as the wave moves over a sloping beach, and so the steadily increasing wave steepness might be the reason for higher wave velocities, hence, overestimation of the depth. Thus, the remark on Page 4 regarding the reduction of computed depths for steep waves seems to be warranted.

VII. CONCLUSIONS

Depth determination by the wave velocity method gives satisfactory results for relatively shallow water in the laboratory, provided many measurements are made to give a good average. The computations are relatively easy to complete and do not require highly trained personnel. However, it is necessary for the operations to be supervised by a person having a good understanding of the mechanism of wave motion; it is his task to make the choice as to which data to use. The remainder of the analysis can be completed using tabular computation forms by almost any intelligent person with a minimum of training. The computations for this report were made by different persons without any special training; and it was found that there was no appreciable difference in results obtained by different individuals.

The most important part of the procedure is the proper choice of data. It is suggested the following points should be kept in mind in making the choice:

1. The definition of the wave crests in the wave travel diagram should be unique and without any shift or break in line.

2. The neighboring wave crests to unstable crests (even when perfect in shape) should be excluded from the computations.

3. Exclude all crests at or in the immediate neighborhood of the breaking point.

4. Waves of the longest wave lengths (or periods) should be used.

5. As much data as possible should be amassed and the final result obtained by averaging all of the single results at a given location. The more irregular the waves the more data that is necessary to obtain a satisfactory average prediction of depth.

Concerning the different methods of computation, it might be said that:

1. For more or less uniform waves, Method 2 may be used.

2. For highly non-uniform waves Method 3 seems to be the most reasonable.

3. Method 4, utilizing the equation $d = C^2/g$ may be used only where there is enough proof available that $d/L \leq 0.04$.

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DEPTH DETERMINATION

TABLE 1

RUN NO 1
STATION —
LOCATION WAVE CHANNEL
DATE 8-19-53

WAVES NON-UNIFORM
MEASURED DEPTH d_m 2.00 ft
SLOPE CONSTANT DEPTH
PROFILE —

GENERAL DATA										METHOD 1					
CREST NO	PERIOD $T_{crest-trough}$ (sec)	PERIOD $T_{trough-crest}$ (sec)	AVER T_o	WAVE LENGTH $L_{crest-trough}$ (ft)	WAVE LENGTH $L_{trough-crest}$ (ft)	AVER L_o (ft)	WAVE VELOCITY C_o (ft/sec)	$L_o' = C_oT_o$ (ft)	$\frac{L_o-L_o'}{L_o}$ (%)	$5.12\,T_o$	$\frac{C_o}{5.12\,T} = \frac{C_o}{C_o'}$	$\frac{d}{L}$	d_o	$d_o - d_m$	$\frac{d_o-d_m}{d_m}$ (%)
1		1.04			5.53		4.96	5.00	-10.5	5.17	0.957	0.304	1.80	-0.20	-10.0
2	1.01			5.53			5.51	5.01	9.0	5.17	1.18	—	—	—	—
2		1.08			5.48		5.08	[illegible]	10.5	5.53	1.18	—	—	—	—
3	1.08			5.40			4.48	4.83	-22.5	5.53	0.937	0.195	1.06	-0.94	-47.0
3		0.88			4.30		4.48	3.98	-12.5	4.51	0.979	0.233	1.59	-0.41	-20.5
4	0.88			4.08			5.40	4.80	8.1	4.51	1.21	—	—	—	—
4		1.00			5.08		5.40	4.80	-7.5	5.12	1.07	—	—	—	—
5	1.00			5.09			4.96	4.96	-2.5	5.12	0.898	0.231	1.18	-0.82	-41.0
5		0.90			4.46		4.58	4.13	-6.5	4.61	0.995	0.477	2.10	0.10	5.0
6	0.90			4.40			4.90	4.41	-0.2	4.61	1.06	—	—	—	—
6		0.90			3.88		4.90	4.41	5.5	4.61	1.06	—	—	—	—
7	0.90			3.99			3.82	3.44	-10.0	4.61	0.829	0.188	0.75	-1.25	-62.5
7		0.88			2.70		3.82	3.40	-5.5	3.38	1.15	—	—	—	—
8	0.98			3.70			4.88	3.86	-5.4	5.53	1.08	—	—	—	—
8		0.88			3.53		4.88	4.09	10.5	4.54	1.008	—	—	—	—
9	0.83			3.88			3.40	3.51	-4.2	4.88	0.804	0.206	0.76	-1.24	-62.0
9		0.85			2.88		3.48	2.40	-4.4	5.23	1.02	—	—	—	—
10	0.58			2.59			4.24	2.97	4.5	3.23	1.31	—	—	—	—
10		0.87			4.07		4.94	4.30	-10.5	4.48	0.88	0.292	1.19	-0.81	-40.5
11	0.87			4.07			5.15	4.48	5.2	4.46	1.15	—	—	—	—
11		1.00			5.53		5.10	5.10	-7.3	5.18	0.997	0.193	1.22	-0.78	-39.0
12	1.20			5.83			5.06	5.49	-5.5	5.15	0.975	0.315	1.43	-0.57	-28.5
12		1.08			5.90		5.06	5.70	-5.9	5.44	0.980	0.481	2.49	0.49	24.5
13	1.06			5.90			5.21	5.53	-9.7	5.44	0.960	0.310	1.83	-0.17	-8.5
13		1.10			5.88		5.81	5.74	-3.7	5.64	0.920	0.230	1.60	-0.40	-20.0
14	1.10			5.95			5.50	5.05	1.7	5.64	0.975	0.304	2.09	0.09	4.5
14		1.08			5.70		5.50	5.94	4.0	5.54	0.993	0.450	2.56	0.56	28.0
15	1.00			5.70			5.15	5.06	-5.5	5.53	0.991	0.266	1.51	-0.49	-24.5
15		0.97			4.70		5.15	5.00	5.0	4.97	1.04	—	—	—	—
16	0.97			4.70			4.54	4.40	-5.5	4.97	0.913	0.246	1.16	-0.84	-42.0
16		0.91			4.40		4.54	4.13	-5.8	4.66	0.973	0.324	1.51	-0.49	-24.5
17	0.91			4.40			4.55	4.80	5.5	4.66	1.08	—	—	—	—
17		1.20			5.35		4.55	4.94	-5.5	5.15	0.808	0.177	0.95	-1.05	-52.5
18	1.20			5.88			3.97	4.76	-18.4	5.15	0.846	0.133	0.66	-1.34	-67.0
18		1.10			5.87		3.97	4.36	-7.1	5.64	0.705	0.140	0.65	-1.35	-67.5
19	1.10			4.87			4.80	4.88	5.7	5.64	0.796	0.174	0.81	-1.19	-59.5
19		1.30			5.57		4.80	6.24	-10.6	7.00	0.637	0.120	0.83	-1.17	-58.5
20	1.36			5.57			5.30	7.30	5.5	7.00	0.758	0.156	1.07	-0.93	-46.5
Aver			0.96			4.96	4.79	4.74	7.3				1.56	-0.44	-22.0

DEPTH DETERMINATION

TABLE 2

RUN NO 1
STATION —
LOCATION WAVE CHANNEL
DATE 8-19-53

WAVES NON-UNIFORM
MEASURED DEPTH d_m 2.00 ft
SLOPE CONSTANT DEPTH
PROFILE —

GENERAL DATA										METHOD 2						METHOD 3								METHOD 4			GENERAL	
CREST NO	PERIOD $T_{crest-trough}$ (sec)	PERIOD $T_{trough-crest}$ (sec)	AVER T_o	WAVE LENGTH $L_{crest-trough}$ (ft)	WAVE LENGTH $L_{trough-crest}$ (ft)	AVER L_o (ft)	WAVE VELOCITY C_o (ft/sec)	$L_o' = C_oT_o$ (ft)	$\frac{L_o-L_o'}{L_o}$ (%)	$5.12\,T_o$	$\frac{C_o}{5.12\,T_o} = \frac{C_o}{C_o'}$	$\frac{d}{L_o}$	d_o	$d_o - d_m$	$\frac{d_o-d_m}{d_m}$ (%)	T_{o_3}	L_{o_3}	$5.12\,T_{o_3}$	$\frac{C_o}{5.12\,T_{o_3}}$	$\frac{d_{o_3}}{L_{o_3}}$	d_{o_3}	$d_{o_3}-d_m$	$\frac{d_{o_3}-d_m}{d_m}$ (%)	$d_{o_4} = \frac{C_o^2}{g}$	$d_{o_4}-d_m$	$\frac{d_{o_4}-d_m}{d_m}$ (%)	AVER WAVE STEEPNESS H/L	CREST NO.
2	1.01	1.04	1.025	4.94	4.63	4.785	5.76	5.88	16.78	5.24	1.098	—	—	—	—	1.024	4.78	5.243	1.099	—	—	—	—	1.044	-0.956	-49.8	—	2
3	1.04	0.95	0.995	5.15	4.71	5.440	4.48	4.46	-9.1	4.316	0.908	0.3370	1.29	-0.71	-35.5	0.994	[illegible]	[illegible]	0.901	[illegible]	1.292	-0.708	-35.4	0.910	-1.090	-54.5	—	3
4	0.88	1.00	0.94	[illegible]	[illegible]	[illegible]	5.30	5.17	10.5	4.81	1.143	—	—	—	—	0.957	4.18	4.79	1.140	—	—	—	—	0.940	-1.060	-53.0	—	4
5	1.00	0.80	0.90	5.40	4.86	4.86	4.58	4.32	-12.1	4.88	0.944	0.2827	1.35	-0.64	-30.5	0.940	4.86	4.88	0.945	[illegible]	1.375	-0.682	-31.1	0.652	-1.348	-67.4	—	5
6	0.90	0.88	0.885	4.30	3.88	3.79	4.88	4.34	15.7	4.58	1.067	—	—	—	—	0.890	4.78	4.578	1.060	—	—	—	—	0.751	-1.253	-63.46	—	6
7	0.88	0.66	0.775	4.88	3.86	3.67	3.88	3.00	-22.0	3.97	0.965	0.2968	1.16	-0.84	-42.0	0.780	3.88	3.99	0.969	[illegible]	1.377	-0.683	-31.15	0.456	-1.546	-77.30	—	7
8	0.82	0.67	0.755	2.44	3.56	3.18	4.83	3.54	17.5	3.816	1.180	—	—	—	—	0.751	3.88	3.846	1.200	—	—	—	—	0.667	-1.333	-66.6	—	8
9	0.87	0.68	0.740	4.07	2.89	3.66	4.03	3.06	-10.5	3.81	1.088	—	—	—	—	0.722	3.88	3.71	1.088	—	—	—	—	0.503	-1.497	-74.88	—	9
10	0.88	0.87	0.745	3.47	4.47	3.47	4.21	3.13	10.88	3.81	1.105	—	—	—	—	0.780	3.10	3.71	1.136	—	—	—	—	0.551	-1.449	-72.46	—	10
11	0.87	1.10	1.035	3.66	7.07	5.38	5.51	5.38	-0.37	5.38	0.996	0.4764	2.56	0.56	27.8	1.037	4.82	5.296	0.993	[illegible]	2.188	-0.102	-5.1	0.846	-1.146	-57.06	—	11
12	1.18	1.04	1.11	6.27	5.47	5.87	5.26	6.02	11.88	5.88	1.046	—	—	—	—	1.104	5.88	5.65	1.062	—	—	—	—	1.120	-0.880	-44.0	—	12
13	1.04	1.10	1.07	5.30	5.17	5.185	5.33	5.75	-7.85	5.475	0.984	0.3641	2.08	0.08	4.0	1.37	5.18	5.475	0.983	[illegible]	2.336	0.336	16.78	0.901	-1.096	-54.80	—	13
14	1.10	1.06	1.08	5.83	5.97	5.70	5.50	5.94	4.04	5.53	0.995	0.4764	2.71	0.71	35.5	1.08	5.70	5.53	0.995	[illegible]	2.715	0.715	35.8	0.940	-1.000	-53.0	—	14
15	1.06	0.88	1.002	5.04	4.28	5.08	5.27	5.40	5.30	5.15	1.023	—	—	—	—	1.002	4.88	5.13	1.027	—	—	—	—	0.864	-1.136	-56.8	—	15
16	0.86	0.88	0.88	4.86	4.66	4.76	4.88	4.32	-10.88	4.35	0.983	0.2740	1.31	-0.69	-34.5	0.88	4.77	4.88	0.937	[illegible]	1.298	-0.702	-35.1	0.646	-1.355	-67.75	—	16
17	0.88	1.30	1.075	4.97	4.78	4.285	4.88	5.33	16.1	5.50	0.900	0.2344	1.06	-0.94	-47.0	1.08	4.81	5.429	0.918	[illegible]	1.108	-0.892	-44.6	0.763	-1.237	-61.85	—	17
18	1.20	1.10	1.15	5.08	5.07	5.525	3.87	4.87	-20.9	5.88	0.676	0.1307	0.722	-1.28	-64.0	1.14	5.40	5.83	0.665	[illegible]	0.74	-1.260	-63.0	0.409	-1.591	-79.55	—	18
19	1.10	1.37	1.235	4.56	7.88	5.66	4.48	5.47	-5.41	6.32	0.706	0.1567	0.883	-1.12	-56.0	1.22	5.66	6.24	0.710	[illegible]	0.785	-1.215	-60.8	0.640	-1.360	-68.0	—	19
Aver			0.972			4.782	4.62						1.54	-0.46	-23.0	0.968	4.88				1.56	-0.44	-22.0	0.738	-1.261	-63.05		Aver.

DEPTH DETERMINATION

TABLE 3

RUN NO 2
STATION —
LOCATION WAVE CHANNEL
DATE 8-18-53

WAVES NON-UNIFORM
MEASURED DEPTH d_m 1.50 ft
SLOPE CONSTANT DEPTH
PROFILE —

GENERAL DATA										METHOD 1					
CREST NO	PERIOD $T_{crest-trough}$ (sec)	PERIOD $T_{trough-crest}$ (sec)	AVER T_o	WAVE LENGTH $L_{crest-trough}$ (ft)	WAVE LENGTH $L_{trough-crest}$ (ft)	AVER L_o (ft)	WAVE VELOCITY C_o (ft/sec)	$L_o' = C_oT_o$ (ft)	$\frac{L_o-L_o'}{L_o}$ (%)	$5.12\,T_o$	$\frac{C_o}{5.12\,T_o} = \frac{C_o}{C_o'}$	$\frac{d}{L_o}$	d_o	$d_o - d_m$	$\frac{d_o-d_m}{d_m}$ (%)
1		0.90			3.91		4.39	3.95	-1.5	4.61	0.879	0.336	1.32	-0.18	-12.0
2	[illegible]			[illegible]			[illegible]	[illegible]	[illegible]	4.81	1.003	—	—	—	—
2		0.91			4.81		4.64	4.06	-3.2	4.61	0.984	0.362	1.61	0.11	7.3
3	0.90			4.21			4.64	4.08	-3.2	4.61	0.984	0.363	1.61	0.11	7.4
3		0.87			3.94		4.64	3.96	2.8	4.44	1.017	—	—	—	—
4	0.87			3.84			4.76	4.16	8.1	4.46	1.065	—	—	—	—
4		0.93			4.15		4.76	4.44	6.6	4.76	1.00	—	—	—	—
5	0.93			4.16			4.27	3.97	-8.3	4.76	0.896	0.231	0.97	-0.53	-35.4
5		0.79			3.36		4.27	3.38	6.9	4.05	1.06	—	—	—	—
6	0.79			3.34			4.35	3.44	2.5	4.05	1.07	—	—	—	—
6		0.91			4.24		4.35	3.96	-7.1	4.66	0.934	0.268	1.14	-0.36	-24.0
7	0.91			4.24			4.63	4.21	-0.7	4.66	0.992	0.439	1.86	0.36	24.0
7		1.00			4.62		4.63		0.8	5.15	0.904	0.236	1.10	-0.40	-26.7
8	1.00			4.88			4.84	4.84	-1.8	5.12	0.938	0.283	1.03	-0.47	-31.4
8		1.06			4.36		4.84	4.81	9.6	5.44	0.854	0.181	0.87	-0.63	-42.0
9	1.06			4.30			3.39	3.59	-21.9	5.44	0.626	0.116	0.51	-0.99	-66.0
9		1.00			4.38		3.38	3.38	-17.4	5.39	0.605	0.112	0.44	-1.06	-70.7
10	1.00			4.38			4.36	4.76	8.1	5.39	0.778	0.166	0.72	-0.78	-52.0
10		0.88			3.84		4.35	3.87	0.6	4.56	0.953	0.297	1.14	-0.36	-24.0
11	0.88			3.84			4.24	3.77	-1.4	4.54	0.935	0.242	1.01	-0.49	-32.7
11		0.92			4.11		4.24	3.90	5.3	4.71	0.898	0.235	0.97	-0.53	-35.4
12	0.92			4.17			4.95	4.55	8.4	4.71	1.05	—	—	—	—
12		0.99			4.70		4.95	4.90	4.1	5.07	0.976	0.301	1.65	0.15	10.0
13	0.98			4.70			4.42	4.38	-7.3	5.07	0.872	0.213	1.00	-0.50	-33.3
13	0	0.92			4.22		4.41	4.07	3.7	4.71	0.936	0.274	1.16	-0.34	-22.7
14	0.72			4.22			4.71	4.34	2.9	4.71	1.00	—	—	—	—
14		0.78			4.02		4.71	3.72	9.1	4.05	1.16	—	—	—	—
15	0.79			4.02			5.44	5.00	19.6	4.05	1.34	—	—	—	—
Aver			0.92			4.15	4.47	4.14	0.7				[illegible]	[illegible]	[illegible]

DEPTH DETERMINATION

TABLE 4

RUN NO 2
LOCATION WAVE CHANNEL
DATE 5-19-53

WAVES NON-UNIFORM
MEASURED DEPTH d_m 1.50 ft
SLOPE CONSTANT DEPTH

GENERAL DATA										METHOD 2						METHOD 3								METHOD 4			GENERAL	
CREST NO.	PERIOD T_{crest} (sec)	PERIOD T_{trough} (sec)	AVER T_o	WAVE LENGTH L_{crest} (ft)	WAVE LENGTH L_{trough} (ft)	AVER L_o (ft)	WAVE VELOCITY C_o (ft/sec)	$L_o = C_o T_o$ (ft)	$\frac{L_o - L_o}{L_o}$ (%)	$5.12\,T_o$	$\frac{C_o}{5.12\,T_o} = \frac{C_o}{C_o}$	$\frac{d_c}{L_o}$	d_c	$d_c - d_m$	$\frac{d_c - d_m}{d_m}$ (%)	T_{o_2}	L_{o_2}	$5.12\,T_{o_2}$	$\frac{C_o}{5.12\,T_{o_2}}$	$\frac{d_{c_2}}{L_{o_2}}$	d_{c_2}	$d_{c_2} - d_m$	$\frac{d_{c_2} - d_m}{d_m}$ (%)	$d_{c_4} = \frac{C_o^2}{g}$	$d_{c_4} - d_m$	$\frac{d_{c_4} - d_m}{d_m}$ (%)	AVER WAVE STEEPNESS H/L	CREST NO
2	0.96	0.91	0.90	3.27	4.13	[illegible]	4.945	4.06	1.47	4.41	0.986	0.3045	1.478	0.078	2.07	0.90	4.00	4.60	0.989	.406	1.655	0.142	10.2	0.643	-0.857	-57.1	—	2
3	0.91	0.86	0.88	4.50	3.91	4.086	4.542	4.00	1.36	4.2	1.01	—	—	—	—	0.879	4.08	4.49	1.04	—	—	—	—	0.643	-0.857	-57.1	—	3
4	0.92	0.92	0.888	3.96	3.98	3.966	4.78	4.215	4.17	4.53	1.08	—	—	—	—	0.884	3.966	4.45	1.053	—	—	—	—	0.705	-0.795	-53.0	—	4
5	0.98	0.79	0.856	4.42	3.36	3.916	4.31	3.688	-4.25	4.37	0.988	0.4088	1.601	0.091	6.07	0.96	3.84	4.35	0.992	.4510	1.600	0.100	16.63	0.578	-0.922	-61.5	—	5
6	0.79	0.91	0.83	3.32	4.52	2.775	4.275	3.63	4.0	4.36	0.983	0.3785	1.429	-0.072	-4.80	0.842	3.72	4.32	0.990	.4210	1.586	0.086	4.32	0.569	-0.931	-62.0	—	6
7	0.91	1.00	0.955	4.06	4.41	4.235	4.72	4.50	5.89	4.66	0.967	0.3253	1.377	-0.123	-8.20	0.983	4.23	4.875	0.969	.3506	1.390	-0.108	-6.4	0.638	-0.862	-57.5	—	7
8	1.06	1.07	1.065	4.65	3.96	4.305	4.545	4.305	4.47	4.3	0.898	0.3046	0.869	-0.639	-42.1	1.033	4.22	2.84	0.860	.3016	0.879	-0.622	-41.4	0.453	-0.857	-57.1	—	8
9	1.07	1.09	1.08	4.76	4.63	4.706	3.68	3.975	2.35	3.53	0.664	0.1279	0.602	-0.898	-59.2	1.08	4.70	4.83	0.666	.1279	0.602	-0.898	-59.2	0.422	-1.078	-71.8	—	9
10	1.09	0.96	0.98	3.94	3.74	3.84	4.36	4.308	10.8	3.06	0.860	0.2058	0.790	-0.780	-47.0	0.98	3.839	20.5	0.866	.208	0.804	-0.692	-46.2	0.589	-0.311	-20.7	—	10
11	0.88	0.91	0.90	3.84	4.40	4.12	4.80	3.78	-2.0	4.4	0.914	0.2472	1.016	-0.482	-32.1	0.90	4.10	4.6	0.914	.2472	1.03	-0.487	-33.4	0.549	-0.951	-63.4	—	11
12	0.91	0.96	0.942	3.86	4.33	4.09	4.80	4.63	-11.66	4.33	1.044	—	—	—	—	0.944	4.08	5.82	1.044	—	—	—	—	0.746	-0.754	-50.3	—	12
13	0.961	0.94	0.945	4.67	4.96	4.616	4.47	4.82	-7.0	4.65	0.962	0.2804	1.167	-0.333	-22.2	0.944	4.616	4.83	0.828	.2804	1.192	0.308	-20.2	0.620	-0.880	-58.5	—	13
14	0.91	0.80	0.855	3.97	4.17	4.07	4.86	4.16	1.93	4.37	1.11	—	—	—	—	0.855	4.07	4.36	1.112	—	—	—	—	0.730	-0.770	-51.3	—	14
Aver			0.929			4.118	4.473	4.144					1.156	-0.344	-22.9	0.929	4.11				1.199	-0.301	-20.03	0.628	-0.872	-58.3	—	Aver

DEPTH DETERMINATION

TABLE 5

RUN NO 3
LOCATION WAVE CHANNEL
DATE 5-18-53

WAVES NON-UNIFORM
MEASURED DEPTH d_m 1.00 ft
SLOPE CONSTANT DEPTH

GENERAL DATA										METHOD 2						METHOD 3								METHOD 4			GENERAL	
CREST NO.	T_{crest} (sec)	T_{trough} (sec)	AVER T_o	WAVE LENGTH L_{crest} (ft)	WAVE LENGTH L_{trough} (ft)	AVER L_o (ft)	WAVE VELOCITY C_o (ft/sec)	$L_o = C_o T_o$ (ft)	$\frac{L_o - L_o}{L_o}$ (%)	$5.12\,T_o$	$\frac{C_o}{5.12\,T_o} = \frac{C_o}{C_o}$	$\frac{d_c}{L_o}$	d_c	$d_c - d_m$	$\frac{d_c - d_m}{d_m}$ (%)	T_{o_2}	L_{o_2}	$5.12\,T_{o_2}$	$\frac{C_o}{5.12\,T_{o_2}}$	$\frac{d_{c_2}}{L_{o_2}}$	d_{c_2}	$d_{c_2} - d_m$	$\frac{d_{c_2} - d_m}{d_m}$ (%)	$d_{c_4} = \frac{C_o^2}{g}$	$d_{c_4} - d_m$	$\frac{d_{c_4} - d_m}{d_m}$ (%)	AVER WAVE STEEPNESS H/L	CREST NO
2	0.72	0.76	0.74	2.79	3.02	2.90	3.67	2.886	1.19	3.79	1.047	—	—	—	—	0.736	2.886	3.76	1.060	—	—	—	—	0.490	-0.410	-51.0	—	2
3	0.76	0.83	0.795	3.08	2.21	3.113	4.07	3.31	3.96	4.07	1.000	—	—	—	—	0.794	3.110	4.065	1.001	—	—	—	—	0.531	-0.469	-46.9	—	3
4	0.82	0.78	0.80	3.40	3.10	3.25	3.96	3.108	-4.67	4.06	0.948	0.2800	0.930	-0.081	-6.1	0.80	3.249	4.09	0.948	.2800	0.937	0.063	-2.3	0.468	-0.532	-43.2	—	4
5	0.76	0.73	0.795	3.07	2.78	2.925	4.07	3.07	3.92	3.96	1.064	—	—	—	—	0.764	2.92	3.905	1.066	—	—	—	—	0.531	-0.496	-46.9	—	5
6	0.73	0.71	0.72	3.00	2.88	2.96	3.76	2.71	-0.81	3.69	1.021	—	—	—	—	0.720	2.93	3.96	1.021	—	—	—	—	0.439	-0.561	-56.1	—	6
7	0.71	0.77	0.76	2.71	3.14	2.885	3.97	2.96	1.85	3.64	1.034	—	—	—	—	0.760	2.190	3.23	1.034	—	—	—	—	0.490	-0.510	-41.0	—	7
8	0.79	0.81	0.80	2.16	3.20	3.178	4.03	3.225	1.25	4.09	0.988	0.3048	1.253	0.253	25.3	0.80	3.178	4.09	0.988	.3048	1.253	0.232	25.3	0.507	-0.493	-49.3	—	8
9	0.81	0.81	0.81	3.20	3.16	3.19	4.10	3.32	0.76	4.14	0.990	0.4212	1.343	0.343	34.3	0.81	3.19	4.14	0.990	.4212	1.343	0.343	34.3	0.523	-0.477	-47.7	—	9
10	0.84	0.76	0.795	3.56	3.08	3.17	3.87	3.160	-0.46	4.07	0.876	0.4040	1.280	0.280	28.0	0.796	3.17	4.07	0.876	.4040	1.280	0.280	28.0	0.490	-0.310	-21.0	—	10
11	0.79	0.77	0.78	3.09	2.96	3.04	3.67	3.085	1.76	3.99	0.986	0.4764	1.467	0.447	44.7	0.78	3.04	3.99	[illegible]	[illegible]	[illegible]	0.447	44.7	0.490	-0.510	-31.0	—	11
12	0.76	0.73	0.746	3.07	2.96	2.986	3.97	2.96	-1.12	3.21	1.041	—	—	—	—	0.746	2.98	3.91	1.041	—	—	—	—	0.490	-0.810	-31.0	—	12
13	0.73	0.76	0.74	2.98	3.80	3.088	4.00	2.96	-3.86	3.79	1.088	—	—	—	—	0.74	3.08	3.79	1.088	—	—	—	—	0.498	-0.502	-50.2	—	13
14	0.75	0.80	0.775	2.96	3.20	3.12	4.31	3.36	2.96	3.27	1.086	—	—	—	—	0.775	3.11	3.47	1.086	—	—	—	—	0.378	0.438	42.9	—	14
15	0.80	0.96	0.83	6.38	3.43	3.404	4.24	3.52	3.27	4.24	1.000	—	—	—	—	0.829	3.405	4.24	1.000	—	—	—	—	0.560	-0.440	-44.0	—	15
16	0.86	0.76	0.81	3.47	2.96	3.148	4.17	3.36	2.13	4.14	1.002	—	—	—	—	0.807	3.145	4.13	1.000	—	—	—	—	0.540	-0.460	-46.0	—	16
17	0.76	0.76	0.74	3.00	2.80	2.79	3.76	2.746	-2.01	3.706	0.994	0.4618	1.287	0.887	88.7	0.74	2.79	2.706	0.994	.4618	1.273	0.273	27.3	0.439	-0.561	-56.1	—	17
18	0.71	0.80	0.686	2.72	2.90	2.81	3.06	2.327	-11.36	2.36	1.080	—	—	—	—	0.684	2.805	3.33	1.036	—	—	—	—	0.393	-0.607	-60.7	—	18
19	0.66	0.76	0.675	2.13	2.77	2.46	3.79	2.580	-4.12	3.46	1.080	—	—	—	—	0.667	2.41	3.41	1.111	—	—	—	—	0.448	-0.552	-55.2	—	19
Aver			0.782			3.01	6.96						1.256	0.256	25.2	0.781	3.002				1.256	0.256	25.6	0.488	-0.505	-50.2	—	Aver

DEPTH DETERMINATION

TABLE 6

RUN NO 4-A
LOCATION WAVE CHANNEL
DATE 5-18-53

WAVES NON-UNIFORM
MEASURED DEPTH d_m 0.833 ft
SLOPE CONSTANT DEPTH

GENERAL DATA										METHOD 2						METHOD 3								METHOD 4	GENERAL	
CREST NO.	PERIOD T_{crest} (sec)	PERIOD T_{trough} (sec)	AVER T_o	WAVE LENGTH L_{crest} (ft)	WAVE LENGTH L_{trough} (ft)	AVER L_o (ft)	WAVE VELOCITY C_o (ft/sec)	$L_o = C_o T_o$ (ft)	$\frac{L_o - L_o}{L_o}$ (%)	$5.12\,T_o$	$\frac{C_o}{5.12\,T_o} = \frac{C_o}{C_o}$	$\frac{d_c}{L_o}$	d_c	$d_c - d_m$	$\frac{d_c - d_m}{d_m}$ (%)	T_{o_2}	L_{o_2}	$5.12\,T_{o_2}$	$\frac{C_o}{5.12\,T_{o_2}}$	$\frac{d_{c_2}}{L_{o_2}}$	d_{c_2}	$d_{c_2} - d_m$	$\frac{d_{c_2} - d_m}{d_m}$ (%)		AVER WAVE STEEPNESS H/L	CREST NO
2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
3	1.27	0.96	1.115	4.12	2.80	4.475	3.73	4.52	1.21	2.28	0.600	0.1104	0.494	-0.039	7.32	1.11	3.86	4.64	0.827	.214	0.485	-0.080	-8.37	—	—	3
4	0.84	0.96	0.675	3.28	3.30	3.88	3.28	2.96	-13.9	4.46	0.676	0.1304	0.496	-0.107	-20.1	0.876	3.28	4.46	0.136	.1404	0.488	-0.046	-2.44	—		4
5	0.96	1.07	0.96	2.80	3.21	3.006	3.76	3.69	14.4	2.02	0.750	0.1547	0.466	-0.068	-12.79	0.473	2.99	4.47	0.737	.1675	0.471	-0.062	-11.8	—		5
6	1.07	0.96	0.946	4.06	3.28	3.66	3.01	2.84	-25.4	4.43	0.624	0.1186	0.436	-0.106	-19.7	0.926	2.54	4.76	0.636	.1451	0.436	0.086	-14.4	—	0.0201	6
7	0.89	1.09	0.990	2.47	3.30	2.91	4.05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.844	0.011	2.08	0.63	3.36	4.79	0.843	.1188	0.502	-0.027	-5.07	—	0.0802	7
8	1.09	0.96	0.986	4.23	2.96	3.74	3.11	3.06	-22.2	2.04	0.612	0.1148	0.430	-0.103	-18.3	0.278	3.56	4.46	0.834	.1461	0.480	-0.116	-21.6	—	0.0188	8
9	0.96	1.21	1.046	2.76	4.43	3.41	3.03	3.17	-13.8	2.33	0.567	0.1023	0.366	-0.164	-30.8	1.08	3.42	5.21	0.363	.1063	0.364	-0.169	-31.7	—	0.0556	9
10	1.21	1.80	1.605	4.10	3.52	3.81	3.22	3.92	3.81	4.17	0.627	0.0833	0.366	-0.177	-33.2	1.205	3.74	6.17	0.527	.0855	0.364	0.179	33.6	—	0.0420	10
11	1.50	0.77	0.923	4.46	3.43	3.896	3.82	2.96	-14.4	5.04	0.680	0.1036	0.348	-0.188	-34.7	0.238	3.07	4.60	0.609	.1128	0.346	0.187	35.1	—	0.0330	11
12	0.77	1.28	1.04	2.22	3.64	2.63	2.13	3.12	7.26	4.17	0.807	0.1120	0.328	0.204	-38.3	0.955	2.76	4.89	0.242	.1212	0.336	0.198	37.2	—	[illegible]	12
13	1.26	0.67	0.36	3.30	3.44	3.18	2.94	2.82	13.1	4.81	0.603	0.1104	0.353	-0.180	-37.4	0.874	3.03	4.47	0.556	.1257	0.381	0.152	28.5	—	0.0214	13
14	0.67	1.13	0.80	2.00	3.44	2.74	3.66	3.32	17.5	4.81	0.796	0.1741	0.477	-0.088	-10.2	0.842	2.54	4.31	0.855	.2019	0.516	-0.067	[illegible]	—	[illegible]	14
15	1.13	0.81	0.97	4.12	3.37	3.775	3.11	3.02	-35.0	4.96	0.628	0.1179	0.443	-0.090	-14.8	0.944	3.76	4.45	0.644	.1717	0.456	0.077	-4.45	—	[illegible]	15
16	0.81	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—			16
17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—			17
Aver			1.002			3.417	3.3	3.32					0.430	-0.115	21.7	0.967	3.25				0.427	-0.104	[illegible]		[illegible]	Aver

DEPTH DETERMINATION

TABLE 7

RUN NO. 5
STATION —
LOCATION WAVE CHANNEL
DATE 5-10-53

WAVES NON-UNIFORM
MEASURED DEPTH d_m 0.253 ft.
SLOPE CONSTANT DEPTH
PROFILE —

GENERAL DATA										METHOD 2						METHOD 3								METHOD 4			GENERAL		
CREST NO.	PERIOD $T_{n-(n-1)}$ (sec)	PERIOD $T_{n-(n+1)}$ (sec)	AVER T_n	WAVE LENGTH $L_{n-(n-1)}$ (ft)	WAVE LENGTH $L_{n-(n+1)}$ (ft)	AVER L_n (ft)	WAVE VELOCITY C_n (ft/sec)	$L_c = C_n T_n$ (ft)	$\frac{L_c - L_n}{L_c}$ (%)	5.12 T_n	$\frac{C_n}{5.12 T_n} = \frac{C_n}{C_0}$	$\frac{d_t}{L_n}$	d_t	$d_t - d_m$	$\frac{d_t - d_m}{d_m}$ (%)	T_{n_p}	L_{n_p}	5.12 T_{n_p}	$\frac{C_n}{5.12 T_{n_p}}$	$\frac{d_{t_p}}{L_{n_p}}$	d_{t_p}	$d_{t_p} - d_m$	$\frac{d_{t_p} - d_m}{d_m}$ (%)	$d_{c_4} = \frac{C_n^2}{g}$	$d_{c_4} - d_m$	$\frac{d_{c_4} - d_m}{d_m}$ (%)	AVER WAVE STEEPNESS H/L	CREST NO	
2	1.00	0.79	0.895	2.42	1.89	2.15	2.94	2.63	18.3	4.58	0.642	0.1213	0.318	0.065	26.1	0.884	2.15	4.53	0.649	.1232	0.263	0.010	3.95	0.268	0.015	5.93	—	2	
3	0.79	0.75	0.77	2.57	2.30	2.33	2.38	1.83	-27.3	3.94	0.605	0.1118	0.260	0.007	2.76	0.77	2.33	3.94	0.605	.1116	0.260	0.007	2.79	0.176	-0.077	-30.3	—	3	
4	0.97	0.80	0.885	1.75	2.28	2.016	3.105	2.56	21.3	4.22	0.736	0.1500	0.302	0.049	18.4	0.816	1.98	4.18	0.743	.1522	0.302	0.049	19.4	0.299	0.046	18.2	—	4	
5	0.80	1.15	1.075	2.88	2.97	2.895	2.522	2.568	-11.75	5.24	0.482	0.08374	0.242	-0.011	-4.35	1.01	2.89	5.17	0.488	[illegible]	.246	-0.007	-2.76	0.198	-0.055	-21.37	—	5	
6	1.12	0.88	1.010	2.86	2.09	2.475	2.86	2.58	4.46	5.12	0.492	0.08075	0.212	-0.041	-16.2	0.99	2.416	5.07	0.504	[illegible]	.215	-0.038	-15.0	0.222	-0.031	-12.24	—	6	
7	0.88	0.60	0.74	2.32	1.60	1.96	2.37	1.753	-11.9	3.78	0.625	0.1162	0.228	-0.025	-9.88	0.714	1.895	3.66	0.650	.1236	0.234	-0.019	-7.52	0.175	-0.078	-30.4	—	7	
8	0.60	0.92	0.76	1.37	2.06	1.715	2.745	2.087	17.8	3.89	0.706	0.1380	0.240	-0.013	-5.14	0.727	1.645	3.72	0.739	.1505	0.248	-0.005	-1.98	0.234	-0.019	-7.51	—	8	
9	0.92	0.66	0.79	2.66	1.90	2.28	2.24	1.77	-25.7	4.04	0.554	0.0983	0.221	-0.032	-12.65	0.758	2.18	3.93	0.570	.1050	0.222	-0.031	-12.3	0.156	-0.091	-39.3	—	9	
10	0.66	1.07	0.865	1.46	2.36	1.91	2.89	2.50	23.6	4.425	0.654	0.1245	0.238	-0.015	-5.93	0.815	1.795	4.17	0.695	.1346	0.246	-0.007	-2.76	0.259	0.006	2.28	—	10	
11	1.07	0.50	0.785	3.06	1.50	2.275	2.20	1.725	-31.9	4.02	0.548	0.09904	0.223	-0.030	-11.75	0.682	2.085	3.49	0.631	.1183	0.249	-0.004	-1.58	0.151	-0.102	-40.4	—	11	
12	0.50	0.87	0.685	1.10	1.92	1.51	2.94	2.015	25.00	3.51	0.938	0.1633	0.292	0.039	15.4	0.636	1.40	3.25	0.905	[illegible]	0.320	0.067	26.5	0.268	0.015	5.93	—	12	
13	0.87	0.85	0.86	2.56	2.42	2.49	2.22	1.91	-30.4	4.40	0.505	0.07734	0.193	-0.060	-23.7	0.860	2.49	4.40	0.505	[illegible]	.220	-0.033	-13.1	0.153	-0.100	-39.6	—	13	
14	0.85	0.95	0.90	1.65	2.30	2.025	2.94	2.565	20.75	4.61	0.617	0.1146	0.232	-0.021	-8.31	0.880	2.04	4.50	0.618	[illegible]	0.231	-0.022	-8.70	0.251	-0.002	-0.79	—	14	
15	0.95	0.74	0.845	2.86	2.16	2.43	2.336	1.97	-23.38	4.325	0.540	0.09823	0.234	-0.019	-7.32	0.835	2.405	4.27	0.548	[illegible]	.236	-0.017	-6.73	0.170	-0.083	-32.9	—	15	
16	0.74	0.94	0.84	1.72	2.16	1.94	2.925	2.455	20.9	4.30	0.680	0.1319	0.257	0.004	1.58	0.825	1.925	4.24	0.700	.1381	0.266	0.013	5.14	0.265	0.012	4.78	—	16	
17	0.94	0.65	0.795	2.72	1.87	2.30	2.325	1.85	-24.3	4.07	0.572	0.1036	0.238	-0.015	-5.93	0.789	2.22	3.936	0.591	.1082	0.240	-0.013	-5.14	0.169	-0.084	-33.2	—	17	
18	0.65	0.95	0.80	1.80	2.80	1.85	2.925	2.34	20.8	4.09	[illegible]	0.1427	0.264	0.011	4.35	0.771	1.785	3.945	0.742	[illegible]	0.271	0.018	7.12	0.265	0.012	4.75	—	18	
19	0.95	0.69	0.82	2.77	2.00	2.385	2.293	1.88	-26.9	4.19	0.546	0.09804	0.234	-0.019	-7.52	0.80	2.30	4.09	0.560	[illegible]	0.233	-0.020	-7.91	0.154	-0.089	-35.2	—	19	
20	0.69	0.91	0.78	1.66	1.67	1.710	2.920	2.18	21.7	3.94	0.762	0.1564	0.273	0.020	7.91	0.740	1.70	3.81	0.786	[illegible]	0.275	0.022	8.70	0.265	0.012	4.75	—	20	
21	0.91	0.80	0.855	2.35	2.73	2.54	2.510	1.96	-28.4	4.37	0.530	0.08386	0.238	-0.014	-5.53	0.726	2.54	3.716	0.624	[illegible]	0.296	0.043	17.0	0.166	-0.087	-34.4	—	21	
22	0.80	0.94	0.870	2.06	1.97	2.025	3.025	[illegible]	22.85	4.45	0.690	0.1319	0.267	-0.014	5.53	0.870	2.025	4.46	0.680	[illegible]	0.267	0.014	5.54	0.284	0.031	12.24	—	22	
23	0.94	0.91	0.875	2.46	2.79	2.60	2.37	2.075	-25.0	4.46	0.529	0.08574	0.244	-0.009	-3.56	0.874	2.66	4.47	0.531	[illegible]	.244	-0.009	-3.56	0.174	-0.079	-34.2	—	23	
24	0.91	0.91	0.92	2.17	1.88	2.025	2.94	2.65	19.95	4.40	0.668	0.1266	0.281	0.028	8.16	0.878	2.37	4.30	0.970	[illegible]	.305	0.052	20.56	0.268	0.015	5.93	—	24	
25	0.91	1.13	0.97	2.35	3.16	2.75	2.336	2.265	-21.05	4.97	0.470	0.07869	0.224	-0.029	-11.46	0.944	2.70	4.83	0.484	[illegible]	.227	-0.026	-10.28	0.170	-0.083	-32.8	—	25	
26	1.12	0.96	1.06	2.56	2.16	2.37	2.86	2.99	20.75	5.42	0.521	0.08864	0.216	-0.036	-13.83	1.055	2.355	5.40	0.523	[illegible]	.217	-0.034	-14.22	0.249	-0.005	1.98	—	26	
Aver.			0.857			2.187	2.610						0.246	-0.007	-2.77	0.888	2.187				0.265	0.012	4.74	0.217	-0.036	-14.23		Aver.	

DEPTH DETERMINATION

TABLE 8

RUN NO —
STATION 32'
LOCATION WAVE CHANNEL
DATE 10-23-52

WAVES NON-UNIFORM
MEASURED DEPTH d_m 0.650 ft.
SLOPE 1:40
PROFILE UNIFORM SLOPE

GENERAL DATA										METHOD 2						METHOD 3								METHOD 4			GENERAL		
CREST NO.	PERIOD $T_{n-(n-1)}$ (sec)	PERIOD $T_{n-(n+1)}$ (sec)	AVER T_n	WAVE LENGTH $L_{n-(n-1)}$ (ft)	WAVE LENGTH $L_{n-(n+1)}$ (ft)	AVER L_n (ft)	WAVE VELOCITY C_n (ft/sec)	$L_c = C_n T_n$ (ft)	$\frac{L_c - L_n}{L_c}$ (%)	5.12 T_n	$\frac{C_n}{5.12 T_n} = \frac{C_n}{C_0}$	$\frac{d_t}{L_n}$	d_t	$d_t - d_m$	$\frac{d_t - d_m}{d_m}$ (%)	T_{n_p}	L_{n_p}	5.12 T_{n_p}	$\frac{C_n}{5.12 T_{n_p}}$	$\frac{d_{t_p}}{L_{n_p}}$	d_{t_p}	$d_{t_p} - d_m$	$\frac{d_{t_p} - d_m}{d_m}$ (%)	$d_{c_4} = \frac{C_n^2}{g}$	$d_{c_4} - d_m$	$\frac{d_{c_4} - d_m}{d_m}$ (%)	AVER WAVE STEEPNESS H/L	CREST NO.	REMARKS
22		0.86			2.03		3.70																						
24	0.88	0.56	0.72	2.35	3.09	2.720	3.28	2.36	-15.3	3.69	0.891	0.2272	0.618	-0.032	-4.93	0.708	2.87	3.61	0.910	.2431	0.650	0	0						
25	0.82	0.86	0.836	2.73	3.02	2.875	3.97	3.06	9.06	4.27	0.930	0.2056	0.591	-0.059	-9.06	0.836	2.87	4.28	0.928	.2046	0.587	-0.063	-9.7						
26	0.86	0.72	0.790	3.08	2.62	2.850	3.48	2.73	-4.4	4.02	0.867	0.2101	0.600	-0.050	-7.70	0.780	2.83	3.99	0.873	.2142	0.607	-0.043	-6.62						
27	0.72	0.75	0.735	2.60	2.38	2.540	3.67	2.62	3.06	3.76	0.950	0.2946	0.740	0.090	13.85	0.736	2.54	3.76	0.950	[illegible]	0.740	0.090	13.85						
28	0.75	0.84	0.795	2.70	3.04	2.870	3.36	2.67	-7.5	4.07	0.827	0.1875	0.539	-0.111	-17.10	0.793	2.86	4.06	0.868	[illegible]	0.539	-0.111	-17.1						
29	0.84	1.28	1.06	2.86	4.90	3.875	3.67	3.78	-2.61	5.42	0.658	0.1267	0.487	-0.163	-25.10	1.015	3.61	5.19	0.689	.1346	0.496	-0.154	-23.7						
30	1.28	0.70	0.99	4.81	2.30	3.455	3.66	3.61	-6.32	5.07	0.760	0.1686	0.548	-0.102	-15.7	0.908	3.07	4.65	0.832	.1801	0.584	-0.066	-10.16						
31	0.70	1.30	1.00	2.88	4.88	3.915	3.31	3.31	-9.22	5.12	0.647	0.1226	0.443	-0.207	-31.9	0.810	3.38	4.88	0.710	.1413	0.472	-0.178	-26.6						
32	1.30	0.66	0.98	4.33	2.11	3.220	3.42	3.38	4.74	5.02	0.680	0.1343	0.433	-0.217	-33.4	0.875	2.94	4.48	0.770	[illegible]	0.561	-0.089	-13.7						
33	0.66	0.74	0.70	2.27	2.66	2.465	3.23	2.26	-8.87	3.58	0.903	0.2770	0.573	-0.077	-11.82	0.698	2.41	3.58	0.929	[illegible]	0.634	-0.016	-2.46						
34	0.74	0.48	0.61	2.38	1.72	2.055	3.48	2.12	2.90	3.12	1.112	—	—	—	—	0.583	2.03	2.98	1.164	—	—	—	—						
35	0.48	0.85	0.665	1.88	3.10	2.49	3.70	2.46	2.03	3.40	1.090	—	—	—	—	0.616	2.18	3.18	1.174	—	—	—	—						
36	0.85	1.25	1.04	3.04	4.63	3.836	3.74	3.89	1.41	5.32	0.704	0.1362	0.524	-0.212	-32.8	1.006	3.87	5.15	0.727	.1467	0.536	-0.112	-17.6						
37	1.25	0.83	1.03	4.72	3.16	3.950	3.70	3.81	-3.66	5.27	0.703	0.1390	0.549	-0.101	-15.55	0.986	3.80	5.05	0.729	.1475	0.561	-0.089	-13.7						
38	0.83	0.68	0.755	3.16	2.66	2.875	3.70	2.81	-2.31	3.89	0.952	0.2951	0.849	0.199	30.40	0.756	2.66	3.87	0.956	[illegible]	0.860	0.210	32.4						
39	0.68	0.78	0.728	2.81	2.76	2.635	3.60	2.61	-0.98	3.71	0.970	0.3330	0.877	0.227	35.0	0.725	2.63	3.70	0.814	.3446	0.907	0.257	39.5						
40	0.78	0.96	0.86	2.42	3.38	2.900	3.47	3.16	8.23	4.40	0.856	0.1917	0.556	-0.094	-14.46	0.860	2.82	4.39	0.846	.1970	0.556	-0.094	-14.5						
41	0.96	0.71	0.836	3.92	2.42	2.670	3.61	2.93	-1.37	4.27	0.823	0.1956	0.551	-0.099	-15.23	0.817	2.97	4.18	0.840	.1943	0.558	-0.092	-14.2						
42	0.71	0.60	0.655	2.47	1.96	2.210	3.46	2.28	1.90	3.35	1.030	—	—	—	—	0.661	2.18	3.33	1.037	—	—	—	—						
43	0.60	0.89	0.745	2.09	3.12	2.605	3.31	2.47	-2.07	3.81	0.870	0.2121	0.551	-0.099	-15.23	0.717	2.46	3.67	0.903	[illegible]	0.583	-0.067	-10.3						
44	0.89	0.88	0.885	2.92	3.27	3.095	3.64	3.13	1.12	4.53	0.782	0.1973	0.518	-0.132	-20.3	0.886	3.09	4.53	0.782	.1672	0.516	-0.134	-20.6						
45	0.88	0.54	0.71	3.13	1.86	2.495	3.70	2.63	2.54	3.63	1.019	—	—	—	—	0.670	2.33	3.43	1.080	—	—	—	—						
46	0.54	0.86	0.70	1.90	2.62	2.435	3.35	2.33	-4.5	3.58	0.930	0.2640	0.643	-0.007	-1.08	0.665	2.54	3.40	0.980	[illegible]	0.856	0.206	31.7						
47	0.86	0.96	0.905	2.72	3.96	3.340	3.46	3.12	-1.29	4.63	0.746	0.1634	0.485	-0.165	-25.4	0.903	3.11	4.62	0.748	.1541	0.480	-0.169	-26.0						
48	0.96	0.73	0.845	3.31	2.55	2.93	3.81	3.26	10.1	4.31	0.872	0.2136	0.626	-0.024	-3.70	0.846	2.68	4.33	0.880	[illegible]	0.666	0.016	2.92						
Aver.			0.863			2.980	3.64						0.586	-0.064	-9.85	0.787	2.84				0.610	-0.040	-6.16						

DEPTH DETERMINATION

TABLE 9

RUN NO —
STATION 35'
LOCATION WAVE CHANNEL
DATE 10 - 23 - 52

WAVES NON-UNIFORM
MEASURED DEPTH d_m 0.575 ft.
SLOPE 1:40
PROFILE UNIFORM SLOPE

GENERAL DATA										METHOD 2						METHOD 3								[illegible]	[illegible]
CREST NO.	PERIOD $T_{(n-1)-n}$ (sec)	PERIOD $T_{n-(n+1)}$ (sec)	AVER T_n	WAVE LENGTH $L_{(n-1)-n}$ (ft)	WAVE LENGTH $L_{n-(n+1)}$ (ft)	AVER L_n (ft)	WAVE VELOCITY C_n (ft/sec)	$L_c = C_n T_n$ (ft)	$\frac{L_c - L_n}{L_c}$ (%)	5.12 T_n	$\frac{C_n}{5.12 T_n} = \frac{C_n}{C_o}$	$\frac{d_s}{L_n}$	d_s	$d_s - d_m$	$\frac{d_s - d_m}{d_m}$ (%)	T_{n_o}	L_{n_o}	5.12 T_{n_o}	$\frac{C_n}{5.12 T_{n_o}}$	$\frac{d_{cs}}{L_{n_o}}$	d_{cs}	$d_{cs} - d_m$	$\frac{d_{cs} - d_m}{d_m}$ (%)	[illegible]	[illegible]
22		0.74			2.44		3.70																		
24	0.76	0.72	0.738	2.72	2.68	2.70	3.28	2.41	-1.2	3.78	0.873	0.2142	0.579	0.004	0.7	0.733	2.70	3.76	0.873	2147	0.578	0.004	0.7		
25	0.72	0.88	0.805	2.38	3.13	2.755	3.81	2.90	5.0	4.12	0.877	0.2168	0.597	0.022	-3.83	0.798	2.70	4.00	0.885	2228	0.604	-0.028	-4.83		
26	0.88	0.70	0.79	3.15	2.48	2.815	3.45	2.73	-3.11	4.04	0.858	0.2030	0.571	-0.004	-0.7	0.780	2.78	3.98	0.865	2030	0.582	0.007	1.22		
27	0.70	0.80	0.75	2.38	2.70	2.528	3.24	2.43	-3.91	3.84	0.845	0.1871	0.498	-0.077	-13.4	0.747	2.58	3.82	0.849	1884	0.503	-0.072	-12.5		
28	0.80	0.78	0.79	2.58	2.43	2.84	3.20	2.33	-12.25	4.04	0.783	0.1717	0.448	-0.127	-15.1	0.790	2.84	4.08	0.780	1708	0.500	-0.075	-13.0		
29	0.78	1.25	1.005	2.50	4.73	3.615	3.34	3.36	-1.55	5.14	0.890	0.1549	0.487	-0.088	-15.3	0.955	3.27	4.89	0.725	1461	0.470	0.097	-18.8		
30	1.23	0.81	1.02	4.38	2.68	3.53	3.78	3.84	8.08	5.22	0.720	0.1445	0.510	-0.065	-11.3	0.878	3.33	3.01	0.750	1648	0.516	-0.059	-10.3		
31	0.81	1.26	1.035	2.98	4.45	3.72	3.30	3.42	-8.78	3.29	0.624	0.1165	0.433	-0.142	-24.7	[illegible]	3.58	3.05	0.834	1245	0.446	-0.129	-22.4		
32	1.26	0.72	0.99	4.17	3.36	3.865	3.41	3.36	-14.35	5.07	0.673	0.1300	0.503	-0.072	-12.5	0.917	3.84	4.70	0.726	1465	0.563	-0.012	-2.09		
33	0.72	0.68	0.70	2.39	2.29	2.34	3.20	2.24	-4.38	3.58	0.895	0.2302	0.539	-0.036	-6.27	0.700	2.34	3.58	0.895	2302	0.539	-0.036	-6.27		
34	0.68	0.41	0.546	2.18	1.48	1.83	3.38	1.84	0.54	2.79	1.210	—	—	—	—	0.515	1.76	2.83	1.285	—	—	—	—		
35	0.41	0.82	0.615	1.40	3.03	2.215	3.81	2.22	0.23	3.15	1.145	—	—	—	—	0.547	1.91	2.80	1.290	—	—	—	—		
36	0.62	1.24	1.03	4.03	4.68	4.355	3.74	3.85	-13.1	5.27	0.708	0.1309	0.605	0.030	5.23	0.980	4.53	5.07	0.739	1608	0.654	0.079	13.7		
37	1.24	0.87	1.055	4.85	3.20	3.925	3.70	3.91	-0.38	5.40	0.685	0.1334	0.524	-0.051	-8.88	1.022	3.79	5.24	0.708	1402	0.533	-0.042	-7.31		
38	0.87	0.80	0.835	3.20	2.56	2.88	3.59	3.00	4.0	4.27	0.842	0.1954	0.563	-0.012	-2.09	0.835	2.85	4.28	0.840	1942	0.554	-0.021	-3.66		
39	0.80	0.63	0.715	2.81	2.30	2.555	2.98	2.13	-19.9	3.66	0.815	0.1818	0.464	-0.111	-19.3	0.705	2.53	3.61	0.828	1871	0.474	-0.101	-17.6		
40	0.63	0.98	0.805	5.08	3.49	4.285	3.68	2.96	-44.8	4.12	0.894	0.2293	0.983	0.408	71.0	0.769	4.14	3.94	0.842	2798	1.157	0.582	101.0		
41	0.98	0.74	0.86	4.66	2.48	3.58	3.50	3.01	-18.9	4.40	0.796	0.1732	0.621	0.046	8.0	0.844	3.25	4.32	0.810	1795	0.584	0.009	1.57		
42	0.74	0.63	0.685	2.50	2.05	2.275	3.37	2.31	1.51	3.50	0.964	0.1184	0.725	0.150	26.1	0.681	2.25	3.49	0.966	2330	0.727	0.152	26.5		
43	0.83	0.83	0.73	2.06	2.91	2.485	3.25	2.36	-5.3	3.73	0.867	0.2103	0.523	-0.052	-9.05	0.717	2.41	3.67	0.880	2190	0.528	-0.047	-8.18		
44	0.83	0.85	0.84	2.60	3.13	2.865	3.52	2.95	2.88	4.29	0.821	0.1848	0.528	-0.046	-8.0	0.840	2.84	4.30	0.820	1841	0.525	-0.052	-9.05		
45	0.68	0.64	0.745	3.00	2.03	2.515	3.57	2.66	5.45	3.81	0.937	0.2726	0.646	0.071	12.35	0.730	2.42	3.74	0.955	3008	0.726	0.151	26.3		
46	0.64	0.78	0.71	2.29	2.62	2.455	3.10	2.20	-11.6	3.63	0.855	0.2030	0.498	-0.077	-13.4	0.703	2.44	3.80	0.861	2064	0.504	-0.071	-12.4		
47	0.78	0.88	0.83	2.36	3.34	2.85	3.45	2.86	0.35	4.24	0.810	0.1796	0.512	-0.063	-10.8	0.827	2.77	4.23	0.817	1827	0.506	-0.069	-12.0		
48	0.88	0.85	0.865	2.98	2.39	2.936	3.76	3.25	9.7	4.43	0.849	0.1983	0.585	0.010	1.74	0.865	2.985	4.43	0.850	2000	0.587	0.012	2.09		
Aver.			0.819			2.985	3.48						0.584	-0.011	-1.91	0.799	2.90				0.581	0.006	1.04		

DEPTH DETERMINATION

TABLE 10

RUN NO —
STATION 38'
LOCATION WAVE CHANNEL
DATE 10 - 23 - 32

WAVES NON-UNIFORM
MEASURED DEPTH d_m 0.500 ft.
SLOPE 1:40
PROFILE UNIFORM SLOPE

GENERAL DATA										METHOD 2						METHOD 3								[illegible]	[illegible]
CREST NO.	PERIOD $T_{(n-1)-n}$ (sec)	PERIOD $T_{n-(n+1)}$ (sec)	AVER T_n	WAVE LENGTH $L_{(n-1)-n}$ (ft)	WAVE LENGTH $L_{n-(n+1)}$ (ft)	AVER L_n (ft)	WAVE VELOCITY C_n (ft/sec)	$L_c = C_n T_n$ (ft)	$\frac{L_c - L_n}{L_c}$ (%)	5.12 T_n	$\frac{C_n}{5.12 T_n} = \frac{C_n}{C_o}$	$\frac{d_s}{L_n}$	d_s	$d_s - d_m$	$\frac{d_s - d_m}{d_m}$ (%)	T_{n_o}	L_{n_o}	5.12 T_{n_o}	$\frac{C_n}{5.12 T_{n_o}}$	$\frac{d_{cs}}{L_{n_o}}$	d_{cs}	$d_{cs} - d_m$	$\frac{d_{cs} - d_m}{d_m}$ (%)	[illegible]	[illegible]
23		0.83			2.75		3.58																		
24	0.83	0.68	0.755	2.90	2.34	2.62	3.20	2.42	-8.27	3.86	0.830	0.1891	0.496	-0.004	-0.8	0.748	2.59	3.83	0.856	1821	0.500	0	0		
25	0.68	0.94	0.81	2.14	3.14	2.64	3.46	2.80	5.72	4.14	0.836	0.1921	0.507	0.007	1.4	0.789	2.65	4.04	0.857	2041	0.521	0.021	4.2		
26	0.94	0.64	0.79	3.13	2.55	2.84	3.33	2.63	-8.00	4.04	0.825	0.1866	0.530	0.030	6.0	0.762	2.81	3.90	0.854	2025	0.568	0.068	13.6		
27	0.64	0.96	0.796	2.10	2.85	2.475	3.46	2.74	9.68	4.07	0.848	0.1988	0.492	-0.008	-1.6	0.765	2.42	3.92	0.880	2180	0.530	0.030	6.0		
28	0.96	0.67	0.81	3.08	2.58	2.72	3.09	2.50	8.80	4.14	0.748	0.1545	0.421	-0.079	-15.8	0.786	2.67	4.03	0.768	1648	0.432	-0.068	-13.6		
29	0.67	1.21	0.94	2.05	4.50	3.275	3.48	3.27	-0.15	4.81	0.728	0.1458	0.477	-0.023	-4.6	0.862	2.82	4.42	0.788	1637	0.479	-0.021	-4.2		
30	1.21	0.81	1.08	4.17	3.04	3.605	3.62	3.84	6.08	5.42	0.668	0.1284	0.463	-0.037	-7.4	1.038	3.52	5.31	0.682	1325	0.467	-0.033	-6.6		
31	0.81	1.24	1.075	3.23	4.23	3.73	3.25	3.50	-6.56	5.50	0.592	0.1065	0.406	-0.093	-19.0	1.049	3.66	5.37	0.606	1117	0.408	-0.092	-18.4		
32	1.24	0.76	1.0	3.82	2.43	3.15	3.33	3.33	4.51	5.12	0.651	0.1248	0.396	-0.104	-20.8	0.943	3.00	4.83	0.690	1360	0.408	-0.098	-18.0		
33	0.76	0.64	0.70	2.50	2.14	2.32	3.16	2.21	-4.98	3.58	0.883	0.2210	0.513	0.013	2.4	0.695	2.31	3.56	0.887	2241	0.518	0.018	3.6		
34	0.64	1.11	0.875	1.99	4.18	3.085	3.30	2.88	-8.75	4.47	0.739	0.1509	0.436	-0.034	-6.8	0.812	2.70	4.16	0.794	1721	0.465	-0.035	-7.0		
35																									
36	1.11	1.24	1.175	3.58	4.78	4.18	3.73	4.32	4.57	6.01	0.621	0.1165	0.483	-0.017	-3.4	1.170	4.10	5.99	0.623	1162	0.476	-0.024	-4.8		
37	1.24	0.92	1.08	4.66	3.23	3.89	3.65	3.94	1.27	5.53	0.660	0.1282	0.491	-0.009	-1.8	1.055	3.78	5.40	0.667	1310	0.495	-0.005	-1.0		
38	0.82	1.06	0.986	3.28	2.85	3.065	3.68	3.51	12.7	5.04	0.725	0.1482	0.448	-0.052	-10.4	0.980	3.05	5.02	0.710	1413	0.432	-0.068	-13.6		
39																									
40	1.06	1.37	1.21	3.78	4.73	4.205	3.48	4.18	-0.58	6.19	0.558	0.1005	0.422	-0.078	-15.6	1.190	4.25	6.10	0.567	1023	0.435	-0.065	-13.0		
41	1.27	0.78	1.025	4.90	2.55	3.575	3.46	3.55	-0.71	5.24	0.661	0.1285	0.475	-0.025	-5.0	1.041	3.28	5.33	0.650	1234	0.405	-0.095	-19.0		
42	0.76	0.68	0.72	2.60	2.12	2.36	3.29	2.37	0.42	3.68	0.895	0.2302	0.544	0.044	8.8	0.718	2.34	3.67	0.897	2258	0.543	0.043	8.6		
43	0.66	0.74	0.70	2.21	2.54	2.375	3.19	2.23	-6.50	3.58	0.891	0.2268	0.539	0.039	7.8	0.698	2.37	3.56	0.891	2272	0.538	0.038	7.6		
44	0.79	0.88	0.795	2.28	3.03	2.655	3.46	2.74	3.10	4.07	0.848	0.1992	0.528	0.028	5.6	0.781	2.60	4.03	0.862	2034	0.523	0.023	4.6		
45	0.86	0.80	0.825	2.89	2.34	2.615	3.51	2.90	9.84	4.22	0.832	0.1900	0.497	-0.003	-0.6	0.825	2.59	4.23	0.830	1891	0.490	-0.010	-2.0		
46	0.80	0.67	0.735	2.75	3.50	3.125	2.94	2.16	-44.7	3.76	0.782	0.1671	0.523	0.023	4.6	0.730	3.08	3.74	0.786	1688	0.520	0.020	4.0		
47	0.67	0.79	0.73	2.56	2.96	2.76	3.34	2.44	-13.1	3.73	0.893	0.2302	0.636	0.139	27.2	0.725	2.75	3.71	0.900	2345	0.646	0.148	29.2		
48	0.79	0.67	0.68	2.59	3.19	2.60	3.66	3.22	10.2	4.50	0.814	0.1812	0.524	0.024	4.8	0.844	2.86	4.42	0.828	1861	0.536	0.036	7.6		
Aver.			0.890			3.07	3.40						0.490	-0.010	-2.0	0.871	2.96				0.493	-0.007	-1.40		

DEPTH DETERMINATION

TABLE 11

RUN NO —
STATION 41'
LOCATION WAVE CHANNEL
DATE 10-23-52

WAVES NON-UNIFORM
MEASURED DEPTH d_m 0.425 ft.
SLOPE 1:40
PROFILE UNIFORM SLOPE

GENERAL DATA										METHOD 2						METHOD 3								METHOD 4			GENERAL		
CREST NO.	PERIOD $T_{(n-1)-n}$ (sec)	PERIOD $T_{n-(n+1)}$ (sec)	AVER T_a	WAVE LENGTH $L_{(n-1)-n}$ (ft)	WAVE LENGTH $L_{n-(n+1)}$ (ft)	AVER L_a (ft)	WAVE VELOCITY C_a (ft/sec)	$L_c = C_a T_a$ (ft)	$\frac{L_c - L_a}{L_c}$ %	$5.12\,T_a$	$\frac{C_a}{5.12\,T_a} = \frac{C_a}{C_o}$	$\frac{d_s}{L_a}$	d_s	$d_s - d_m$	$\frac{d_s - d_m}{d_m}$ %	T_{a_0}	L_{a_0}	$5.12\,T_{a_0}$	$\frac{C_a}{5.12\,T_{a_0}}$	$\frac{d_{c0}}{L_{a_0}}$	d_{c0}	$d_{c0} - d_m$	$\frac{d_{c0} - d_m}{d_m}$ %	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	REMARKS
23		0.91			2.90		3.34																						
24	0.91	0.63	0.77	3.98	2.05	2.97	3.16	2.43	-22.2	3.94	0.803	0.1762	0.524	0.099	23.3	0.745	2.75	3.81	0.630	[illegible]	0.520	0.096	22.6						
25	0.83	0.96	0.795	1.98	3.13	2.555	3.15	2.50	-2.2	4.07	0.775	0.1644	0.420	-0.005	-1.18	0.781	2.43	3.90	0.809	1799	0.435	0.010	2.35						
26	0.96	0.62	0.79	2.88	2.04	2.46	3.18	2.51	1.99	4.04	0.788	0.1696	0.417	-0.008	-1.88	0.754	2.39	3.86	0.826	[illegible]	0.446	0.021	4.95						
27	0.62	1.01	0.815	1.95	3.05	2.50	3.29	2.68	6.72	4.17	0.789	0.1700	0.425	0	0	0.769	2.38	3.94	0.835	[illegible]	0.456	0.031	7.30						
28	1.04	0.56	0.79	3.34	1.85	2.595	2.97	2.32	-11.4	3.99	0.745	0.1530	0.396	-0.029	-6.83	0.713	2.36	3.65	0.814	[illegible]	0.428	0.003	0.71						
29	0.55	1.17	0.86	1.60	4.35	2.975	3.36	2.89	-1.21	4.40	0.763	0.1597	0.467	0.042	9.89	0.749	2.52	3.85	0.873	[illegible]	0.487	0.062	14.6						
30	1.17	1.0	1.085	3.64	3.20	3.52	3.49	3.79	7.13	5.55	0.630	0.1180	0.415	-0.010	-2.35	1.076	3.40	5.52	0.633	[illegible]	0.414	-0.011	-2.59						
31	1.0	1.22	1.11	3.37	4.00	3.685	3.15	3.50	-5.28	5.68	0.555	0.0996	0.367	-0.058	-13.6	1.099	3.46	5.63	0.560	[illegible]	0.369	-0.056	-13.2						
32	1.22	0.82	1.02	3.71	2.52	3.115	3.14	3.20	2.66	5.22	0.602	0.1109	0.346	-0.079	-18.6	0.980	3.11	5.02	0.626	1170	0.364	-0.061	-14.4						
33	0.82	0.60	0.71	3.06	1.92	2.49	3.02	2.14	-16.4	3.63	0.832	0.1900	0.473	0.048	11.3	0.693	2.16	3.55	0.851	[illegible]	0.473	0.048	11.3						
34	0.60	1.0	0.80	1.76	3.69	2.725	3.17	2.54	-7.3	4.09	0.775	0.1644	0.448	0.023	5.42	0.750	2.38	3.84	0.826	[illegible]	0.446	0.021	4.95						
35																													
36	1.0	1.27	1.135	3.10	4.64	3.87	3.62	4.11	5.84	5.81	0.623	0.1162	0.450	0.025	5.88	1.115	3.72	5.73	0.632	[illegible]	0.441	0.016	3.77						
37	1.27	0.91	1.09	4.55	3.32	3.935	3.57	3.89	-1.16	5.58	0.640	0.1207	0.475	0.050	11.76	1.060	3.84	5.43	0.658	[illegible]	0.482	0.057	13.4						
38	0.91	1.10	1.005	3.18	3.75	3.455	3.50	3.51	1.57	5.14	0.682	0.1325	0.458	0.033	7.77	0.995	3.43	5.09	0.688	1343	0.461	0.036	8.48						
39																													
40	1.10	1.37	1.235	3.75	4.64	4.195	3.36	4.15	1.08	6.32	0.532	0.0945	0.396	-0.029	6.83	1.220	4.15	6.25	0.538	[illegible]	0.397	-0.028	-6.60						
41	1.37	0.81	1.09	4.51	2.65	3.58	3.34	3.64	1.65	5.58	0.599	0.1101	0.394	-0.031	-7.30	1.017	3.34	5.20	0.643	1216	0.406	-0.019	-4.47						
42	0.81	0.70	0.755	2.60	2.24	2.42	3.20	2.42	0	3.86	0.830	0.1891	0.458	0.033	7.77	0.750	2.41	3.84	0.834	1715	0.413	-0.012	-2.82						
43	0.70	0.66	0.68	2.22	2.24	2.23	3.12	2.12	-5.15	3.48	0.897	0.2319	0.517	0.092	21.6	0.680	2.23	3.48	0.897	[illegible]	0.517	0.092	21.6						
44	0.66	0.85	0.755	2.02	2.88	2.45	3.36	2.54	3.54	3.86	0.871	0.2128	0.522	0.097	22.8	0.744	2.37	3.81	0.883	[illegible]	0.523	0.098	23.0						
45	0.86	0.96	0.906	2.76	2.76	2.78	3.39	3.07	10.1	4.63	0.733	0.1489	0.411	-0.014	-3.29	0.901	2.76	4.61	0.735	[illegible]	0.413	-0.012	-2.82						
46	0.96	0.55	0.756	3.16	1.75	2.455	2.86	2.16	9.05	3.86	0.741	0.1516	0.372	-0.053	-12.47	0.700	2.25	3.58	0.800	[illegible]	0.394	-0.031	-7.30						
47	0.56	0.68	0.62	1.55	2.50	2.025	3.19	1.98	2.27	3.17	1.006					0.613	1.92	3.14	1.017										
48	0.69	1.07	0.88	2.14	3.45	2.795	3.54	3.13	10.7	4.50	0.792	0.1713	0.475	0.054	12.7	0.840	2.64	4.30	0.826	[illegible]	0.497	0.072	16.9						
Aver			0.888			2.945	3.27						0.438	0.013	3.06	0.858	2.81				0.445	0.020	4.71						

DEPTH DETERMINATION

TABLE 12

RUN NO —
STATION 44'
LOCATION WAVE CHANNEL
DATE 10-23-52

WAVES NON-UNIFORM
MEASURED DEPTH d_m 0.350 ft.
SLOPE 1:40
PROFILE UNIFORM SLOPE

GENERAL DATA										METHOD 2						METHOD 3								METHOD 4			GENERAL		
CREST NO.	PERIOD $T_{(n-1)-n}$ (sec)	PERIOD $T_{n-(n+1)}$ (sec)	AVER T_a	WAVE LENGTH $L_{(n-1)-n}$ (ft)	WAVE LENGTH $L_{n-(n+1)}$ (ft)	AVER L_a (ft)	WAVE VELOCITY C_a (ft/sec)	$L_c = C_a T_a$ (ft)	$\frac{L_c - L_a}{L_c}$ %	$5.12\,T_a$	$\frac{C_a}{5.12\,T_a} = \frac{C_a}{C_o}$	$\frac{d_s}{L_a}$	d_s	$d_s - d_m$	$\frac{d_s - d_m}{d_m}$ %	T_{a_0}	L_{a_0}	$5.12\,T_{a_0}$	$\frac{C_a}{5.12\,T_{a_0}}$	$\frac{d_{c0}}{L_{a_0}}$	d_{c0}	$d_{c0} - d_m$	$\frac{d_{c0} - d_m}{d_m}$ %	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	REMARKS
23		0.96			2.95		3.10																						
24	0.96	0.66	0.81	2.74	1.95	2.345	3.04	2.46	4.68	4.14	0.735	0.1497	0.351	0.001	0.25	0.783	2.28	4.01	0.758	[illegible]	0.360	0.010	2.86						
25	0.66	0.91	0.785	1.94	2.87	2.405	2.75	2.16	-10.3	4.02	0.685	0.1365	0.329	-0.021	-6.0	0.765	2.32	3.91	0.704	1425	0.331	-0.019	-5.44						
26	0.91	0.59	0.75	2.37	1.94	2.155	3.14	2.36	8.7	3.84	0.818	0.1832	0.395	0.045	12.86	0.717	2.14	3.67	0.855	[illegible]	0.441	0.091	26.0						
27	0.59	1.12	0.855	1.85	3.30	2.575	3.20	2.74	2.01	4.38	0.730	0.1478	0.381	0.031	8.86	0.773	2.37	3.96	0.809	[illegible]	0.424	0.074	21.2						
28	1.12	0.45	0.785	3.55	1.39	2.47	2.85	2.27	-8.81	4.02	0.720	0.1445	0.357	0.007	2.0	0.645	2.00	3.29	0.879	[illegible]	0.437	0.087	24.8						
29	0.45	1.15	0.80	1.25	3.91	2.58	3.23	2.58	0	4.09	0.790	0.1706	0.440	0.090	25.7	0.640	1.90	3.32	0.967	[illegible]	0.618	0.268	76.6						
30	1.15	1.10	1.125	3.50	3.35	3.425	3.17	3.57	4.07	5.76	0.550	0.0980	0.337	-0.013	-3.72	1.125	3.485	5.76	0.550	[illegible]	0.337	-0.013	-5.72						
31	1.10	1.01	1.055	3.35	3.68	3.52	3.11	3.28	-7.3	5.40	0.576	0.1045	0.368	0.018	5.15	1.054	3.52	5.39	0.577	[illegible]	0.380	0.030	8.44						
32	1.01	1.04	1.025	3.23	3.06	3.145	3.07	3.15	0.16	5.24	0.587	0.1072	0.337	-0.013	-3.72	1.127	3.14	5.77	0.532	[illegible]	0.297	-0.053	-15.15						
33	1.04	0.54	0.79	3.08	1.65	2.365	2.86	2.26	-4.65	4.04	0.709	0.1409	0.333	-0.017	-4.86	0.710	2.18	3.64	0.786	[illegible]	0.366	0.016	4.58						
34	0.54	0.86	0.70	1.52	3.27	2.395	3.05	2.14	-11.9	3.58	0.853	0.2017	0.483	0.133	38.0	0.683	2.08	3.39	0.900	[illegible]	0.487	0.137	39.2						
35																													
36	0.88	1.31	[illegible]	2.60	4.55	3.575	3.53	[illegible]	[illegible]	[illegible]	0.656	0.1249	0.447	0.097	27.7	1.038	3.31	5.32	0.663	[illegible]	0.440	0.090	25.7						
37	1.31	0.94	1.125	4.35	3.19	3.77	3.31	3.73	-1.07	5.76	0.575	0.1042	0.393	0.043	12.3	1.094	3.68	5.60	0.591	[illegible]	0.398	0.048	13.7						
38	0.94	1.13	1.035	2.88	3.78	3.33	3.34	3.46	3.76	5.30	0.630	0.1180	0.393	0.043	12.3	1.025	3.27	5.25	0.637	[illegible]	0.392	0.042	12.0						
39																													
40	1.13	1.37	1.250	3.78	4.49	4.12	3.27	4.08	9.8	6.40	0.512	0.0900	0.370	0.020	5.72	1.237	4.08	6.33	0.517	[illegible]	0.372	0.022	6.30						
41	1.37	0.83	1.10	4.38	2.63	3.505	3.20	3.52	0.43	5.63	0.568	0.1026	0.360	0.010	2.86	1.034	3.29	5.30	0.606	[illegible]	0.367	0.017	4.86						
42	0.83	0.75	0.79	2.58	2.24	2.41	3.09	2.44	1.23	4.04	0.766	0.1609	0.388	0.038	10.88	0.788	2.40	4.03	0.767	[illegible]	0.387	0.037	10.58						
43	0.75	0.60	0.675	2.24	1.94	2.09	3.00	2.02	-3.46	3.45	0.870	0.2121	0.444	0.094	26.9	0.667	2.08	3.41	0.880	[illegible]	0.446	0.096	27.4						
44	0.80	0.63	0.715	1.75	2.67	2.21	3.20	2.29	3.48	3.66	0.875	0.2155	0.477	0.127	36.3	0.690	2.11	3.57	0.897	[illegible]	0.489	0.139	39.7						
45	0.83	1.10	0.965	2.55	3.10	2.825	3.17	3.06	7.68	4.94	0.643	0.1215	0.343	-0.007	-2.0	0.948	2.80	4.85	0.654	[illegible]	0.349	-0.001	-0.29						
46	1.10	0.45	0.796	3.25	1.43	2.34	2.82	2.24	-4.46	4.07	0.694	0.1362	0.319	-0.031	-8.86	0.678	1.99	3.47	0.813	1804	0.359	0.009	2.57						
47	0.49	0.36	0.535	1.38	1.94	1.66	1.92	1.56	6.4	2.74	1.065					0.532	1.61	2.72	1.074										
48	0.58	1.22	0.90	1.65	3.67	2.66	3.24	2.92	8.90	4.61	0.703	0.1389	0.370	0.020	5.72	0.788	2.28	4.03	0.805	[illegible]	0.404	0.054	15.4						
Aver			0.889			2.77	3.12						0.383	0.033	9.44	0.849	2.62				0.403	0.053	15.1						

DEPTH DETERMINATION

TABLE 13

RUN NO —
STATION 47'
LOCATION WAVE CHANNEL
DATE 10-23-52

WAVES NON-UNIFORM
MEASURED DEPTH d_m 0.275 ft
SLOPE 1:40
PROFILE UNIFORM SLOPE

GENERAL DATA										METHOD 2						METHOD 3								METHOD 4	GENERAL
CREST NO.	PERIOD $T_{(n-1)\to n}$ (sec)	PERIOD $T_{n\to(n+1)}$ (sec)	AVER T_n	WAVE LENGTH $L_{(n-1)\to n}$ (ft)	WAVE LENGTH $L_{n\to(n+1)}$ (ft)	AVER L_n (ft)	WAVE VELOCITY C_n (ft/sec)	$L_c = C_n T_n$ (ft)	$\frac{L_c - L_n}{L_c}$ (%)	$5.12\,T_n$	$\frac{C_n}{5.12\,T_n} = \frac{C_n}{C_o}$	$\frac{d_s}{L_n}$	d_s	$d_s - d_m$	$\frac{d_s - d_m}{d_m}$ (%)	T_{n_p}	L_{n_p}	$5.12\,T_{n_p}$	$\frac{C_n}{5.12\,T_{n_p}}$	$\frac{d_{sp}}{L_{n_p}}$	d_{sp}	$d_{sp} - d_m$	$\frac{d_{sp} - d_m}{d_m}$ (%)		
23		0.65			2.66		2.57																		
24	0.95	0.80	0.875	2.16	1.99	2.075	2.74	2.40	13.5	4.48	0.612	0.1133	0.235	-0.040	-14.5	0.969	2.07	4.48	0.616	.1143	0.237	-0.038	-15.8		
25	0.80	0.72	0.76	2.15	2.21	2.17	2.45	1.86	-16.7	3.89	0.630	0.1167	0.256	-0.019	-6.8	0.758	2.17	3.88	0.632	.1169	0.257	-0.016	-6.8		
26	0.72	0.88	0.80	1.96	1.80	1.73	3.06	1.99	13.1	3.33	0.920	0.2526	0.437	0.162	56.0	0.642	1.73	3.28	0.934	[illegible]	0.466	0.190	68.1		
27	0.88	1.22	0.90	1.78	3.50	2.625	3.13	2.82	6.92	4.61	0.676	0.1314	0.345	0.070	25.4	0.785	2.33	4.02	0.780	.1663	0.388	0.113	41.1		
28	1.22	0.38	0.80	3.70	1.08	2.39	2.83	2.26	-5.75	4.09	0.683	0.1356	0.325	0.050	18.2	0.580	1.67	2.97	0.954	.2984	0.502	0.227	82.6		
29	0.38	1.16	0.77	1.04	3.55	2.295	2.88	2.22	-3.38	3.94	0.734	0.1462	0.343	0.068	24.4	0.573	1.61	2.93	0.987	[illegible]	0.648	0.370	134.4		
30	1.16	1.06	1.11	3.18	3.33	3.255	2.94	3.15	3.34	5.68	0.518	0.0874	0.284	0.009	3.3	1.109	3.25	5.68	0.518	.0874	0.284	0.009	6.6		
31	1.06	1.06	1.075	2.82	3.21	3.015	2.99	3.22	6.36	5.50	0.544	0.0971	0.293	0.018	6.5	1.075	3.0	5.50	0.544	.0971	0.293	0.018	6.6		
32	1.09	1.12	1.105	3.31	3.05	3.18	2.74	3.03	-4.65	5.66	0.485	0.0843	0.266	-0.007	-2.5	1.105	3.18	5.66	0.484	.1021	0.325	0.050	18.2		
33	1.12	0.45	0.785	2.98	2.50	2.74	2.58	2.01	-36.3	4.02	0.638	0.1201	0.329	0.054	19.6	0.643	2.72	3.26	0.776	.1480	0.402	0.177	64.4		
34	0.48	0.74	0.595	1.12	2.49	1.805	2.96	1.76	2.56	3.04	0.970	0.3330	0.602	0.327	116.0	0.560	1.55	2.86							
35																									
36	0.74	1.40	1.07	2.20	4.45	3.325	3.22	3.45	3.62	5.43	0.586	0.1074	0.357	0.082	29.8	0.968	2.95	4.95	0.651	.1238	0.365	0.090	32.7		
37	1.40	0.88	1.145	4.18	2.86	3.515	2.65	3.22	7.82	5.86	0.467	0.0847	0.298	0.023	8.4	1.086	3.40	5.56	0.513	.0902	0.307	0.032	11.6		
38	0.89	1.14	1.015	2.33	3.69	3.01	3.12	3.17	5.05	5.16	0.602	0.1109	0.334	0.059	21.4	1.000	2.86	5.12	0.610	.1126	0.323	0.048	17.4		
39																									
40	1.14	1.42	1.28	3.45	4.41	3.93	3.15	4.03	2.72	6.55	0.481	0.0835	0.328	0.053	19.3	1.266	3.67	6.4	0.467	.0847	0.320	0.045	16.3		
41	1.42	0.88	1.135	4.28	2.55	3.415	2.93	3.33	-2.56	5.81	0.505	0.0883	0.302	0.027	9.8	1.063	3.20	5.48	0.536	.0987	0.330	0.055	20.0		
42	0.86	0.61	0.83	2.37	2.23	2.30	2.97	2.46	6.5	4.25	0.700	0.1361	0.316	0.043	15.6	0.830	2.30	4.25	0.700	.1361	0.316	0.043	15.6		
43	0.61	0.53	0.67	2.33	1.56	1.945	2.76	1.85	5.13	3.43	0.805	0.1771	0.344	0.069	25.1	0.640	1.87	3.27	0.845	.1971	0.369	0.094	34.2		
44	0.83	0.55	0.69	1.43	2.80	1.965	2.86	1.99	1.26	3.53	0.810	0.1818	0.357	0.082	29.8	0.653	1.82	3.34	0.856	.2063	0.379	0.104	37.8		
45	0.85	1.17	1.01	2.30	3.29	2.76	2.83	2.86	2.90	5.17	0.548	0.0980	0.272	-0.003	-1.1	0.985	2.70	5.04	0.562	.1012	0.273	-0.002	-0.7		
46	1.17	0.47	0.82	3.15	1.29	2.22	2.71	2.22	0	4.19	0.649	0.1228	0.273	-0.002	-0.7	0.671	1.63	3.43	0.790	.1708	0.312	0.037	13.4		
47	0.47	0.80	0.495	1.21	1.49	1.35	2.81	1.38	0.74	2.40						0.495	1.34	2.53							
48	0.80	1.26	0.95	1.34	3.72	2.58	3.00	2.67	4.5	4.85	0.620	0.1262	0.322	0.047	17.1	0.770	2.01	3.88	0.616	.1822	0.337	0.062	22.4		
Aver			0.880			2.59	2.97						0.328	0.053	19.3	0.829	2.41				0.358	0.083	30.2		

DEPTH DETERMINATION

TABLE 14

RUN NO —
STATION 50'
LOCATION WAVE CHANNEL
DATE 10-23-52

WAVES NON-UNIFORM
MEASURED DEPTH d_m 0.200 ft
SLOPE 1:40
PROFILE UNIFORM SLOPE

GENERAL DATA										METHOD 2						METHOD 3								METHOD 4	GENERAL
CREST NO.	PERIOD $T_{(n-1)\to n}$ (sec)	PERIOD $T_{n\to(n+1)}$ (sec)	AVER T_n	WAVE LENGTH $L_{(n-1)\to n}$ (ft)	WAVE LENGTH $L_{n\to(n+1)}$ (ft)	AVER L_n (ft)	WAVE VELOCITY C_n (ft/sec)	$L_c = C_n T_n$ (ft)	$\frac{L_c - L_n}{L_c}$ (%)	$5.12\,T_n$	$\frac{C_n}{5.12\,T_n} = \frac{C_n}{C_o}$	$\frac{d_s}{L_n}$	d_s	$d_s - d_m$	$\frac{d_s - d_m}{d_m}$ (%)	T_{n_p}	L_{n_p}	$5.12\,T_{n_p}$	$\frac{C_n}{5.12\,T_{n_p}}$	$\frac{d_{sp}}{L_{n_p}}$	d_{sp}	$d_{sp} - d_m$	$\frac{d_{sp} - d_m}{d_m}$ (%)		
23		0.74			1.88		1.66																		
24	0.74	0.99	0.865	1.31	2.10	1.705	2.41	2.09	18.4	4.43	0.544	0.0970	0.165	-0.035	-17.5	0.947	1.81	4.33	0.557	.1001	0.181	-0.038	-19.5		
25	0.99	0.36	0.675	2.36	1.03	1.695	2.06	1.39	-21.8	3.45	0.597	0.1120	0.189	-0.011	-5.5	0.516	1.43	2.65	0.765	.1684	0.241	0.041	20.5		
26	0.36	0.56	0.46	0.64	1.71	1.175	2.97	1.38	14.9	2.38	1.250					0.437	0.93	2.24	1.325						
27	0.56	1.33	0.945	1.85	3.65	2.65	2.94	2.81	5.7	4.86	0.603	0.1111	0.294	0.094	47.0	0.809	2.27	4.14	0.710	.1413	0.321	0.121	60.5		
28	1.33	0.40	0.865	3.65	1.02	2.335	2.69	2.33	-0.25	4.43	0.607	0.1120	0.281	0.081	40.5	0.616	1.60	3.15	0.853	.2030	0.325	0.125	62.5		
29	0.40	1.20	0.80	1.02	3.17	2.095	2.49	1.99	-5.28	4.09	0.609	0.1138	0.236	0.036	18.0	0.600	1.54	3.07	0.813	.1808	0.279	0.079	39.5		
30	1.20	0.92	1.06	2.65	2.73	2.76	2.37	2.51	-11.2	5.42	0.438	0.0748	0.208	0.008	4.0	1.042	2.76	5.34	0.446	.0781	0.212	0.012	6.0		
31	0.92	1.23	1.075	2.03	3.27	2.65	2.86	3.08	13.95	5.50	0.520	0.0918	0.243	0.043	21.5	1.081	2.51	5.53	0.517	.0943	0.236	0.036	18.0		
32	1.22	1.22	1.225	3.26	2.98	3.125	2.47	3.03	-3.14	6.27	0.394	0.0663	0.207	0.007	3.5	1.225	3.12	6.27	0.394	.0663	0.207	0.007	3.5		
32	1.22	0.23	0.725	2.83	0.65	1.74	2.32	1.68	-3.57	3.71	0.625	0.1166	0.204	0.004	2.0	0.388	1.08	1.99	1.166						
34	0.23	0.73	0.48	0.50	2.16	1.345	2.68	1.36	2.68	2.48	1.170					0.380	0.82	1.76	1.610						
35																									
36	0.73	1.58	1.16	2.11	4.21	3.16	2.84	3.30	4.25	5.94	0.476	0.0830	0.262	0.062	31.0	1.000	2.81	5.12	0.555	[illegible]	[illegible]	[illegible]	40.0		
37	1.58	0.71	1.15	3.67	2.09	3.03	2.27	2.61	-16.1	5.88	0.386	0.0645	0.196	-0.004	-2.0	0.983	2.74	5.03	0.452	.0778	0.213	0.013	6.5		
38	0.71	1.14	0.925	1.46	3.46	2.465	2.88	2.67	6.94	4.73	0.610	0.1127	0.280	0.080	40.0	0.877	2.09	4.46	0.645	.1215	0.254	0.054	27.0		
39																									
40	1.14	1.54	1.34	3.41	4.32	3.865	2.93	3.93	1.65	6.85	0.428	0.0728	0.281	0.081	40.5	1.313	3.61	6.72	0.437	.0746	0.284	0.084	42.0		
41	1.54	0.80	1.17	4.16	2.27	3.215	2.62	3.07	-4.73	5.98	0.438	0.0748	0.241	0.041	20.5	1.054	2.94	5.40	0.485	.0843	0.248	0.048	24.0		
42	0.80	0.96	0.88	2.02	2.30	2.16	2.72	2.36	6.83	4.50	0.605	0.1115	0.241	0.041	20.5	0.874	2.15	4.47	0.609	.1125	0.242	0.042	21.0		
43	0.96	0.46	0.71	2.51	1.14	1.825	2.19	1.55	-17.7	3.63	0.604	0.1113	0.203	0.003	1.5	0.623	1.57	3.19	0.687	.1340	0.211	0.011	5.5		
44	0.46	0.85	0.655	0.98	2.21	1.595	2.50	1.64	3.35	3.35	0.746	0.1534	0.243	0.043	21.5	0.597	1.34	3.05	0.820	.1841	0.247	0.047	23.5		
45	0.85	1.20	1.025	2.01	3.15	2.58	2.51	2.57	0.39	5.24	0.480	0.0833	0.215	0.015	7.5	0.995	2.46	5.09	0.494	.0862	0.212	0.012	6.0		
46	1.20	0.42	0.81	2.78	1.09	1.92	2.61	2.11	9.0	4.14	0.630	0.1180	0.226	0.026	13.0	0.623	1.56	3.19	0.818	.1832	0.286	0.086	43.0		
47	0.42	0.42	0.42	1.07	1.20	1.135	2.58	1.08	-5.09	2.15	1.200					0.418	1.13	2.14	1.252						
48	0.42	1.44	0.93	1.08	3.78	2.42	2.87	2.67	9.37	4.76	0.604	0.1113	0.269	0.069	34.5	0.651	1.66	3.33	0.863	.2078	0.344	0.144	72.0		
Aver			0.868			2.290	2.58	2.32					0.233	0.033	16.5	0.776	1.997				0.253	0.053	26.5		

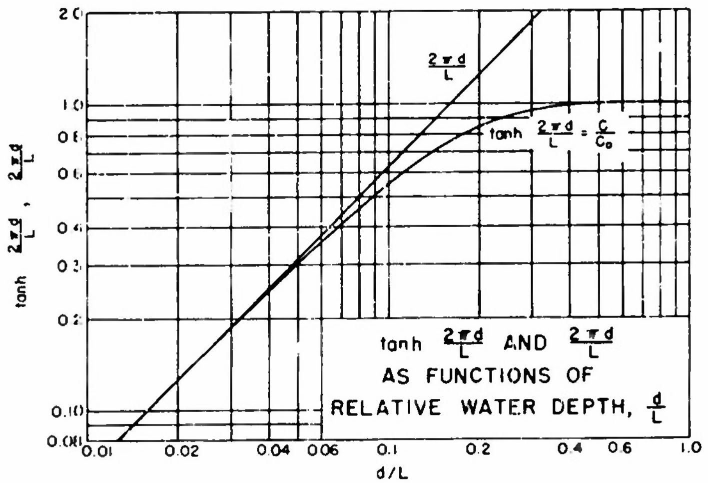


FIGURE 1

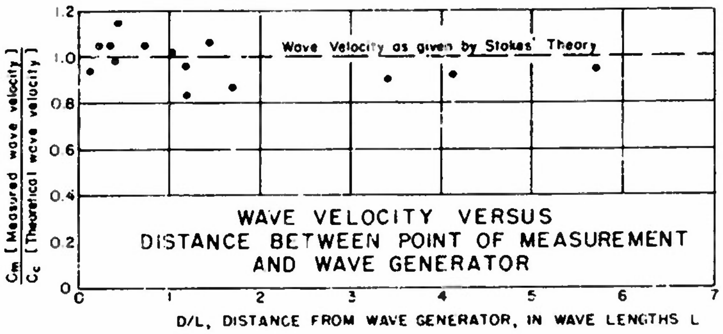


FIGURE 2

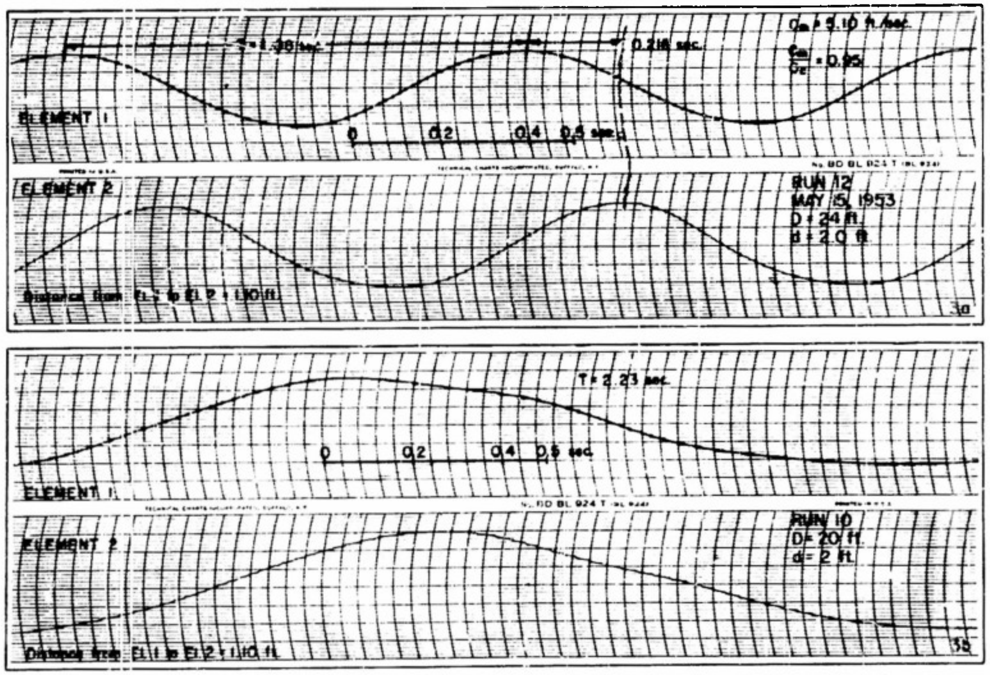
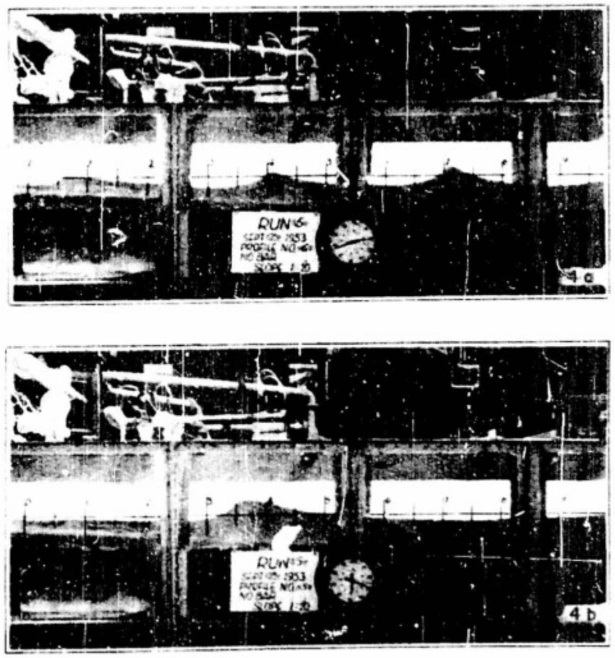


FIGURE 3



A sample of 35 mm movies taken of a section of wave channel for the purpose of depth determination by wave velocity method

FIGURE 4

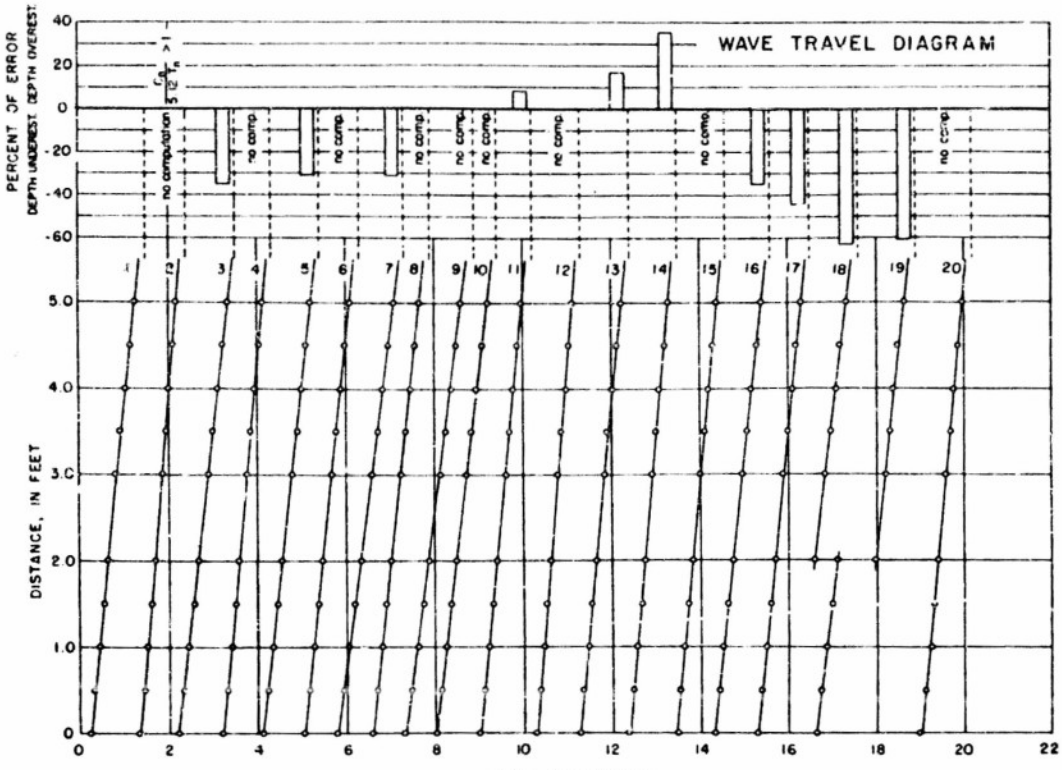


FIGURE 5

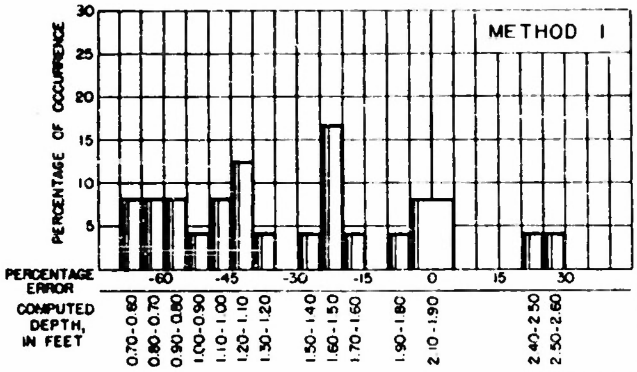


FIGURE 6

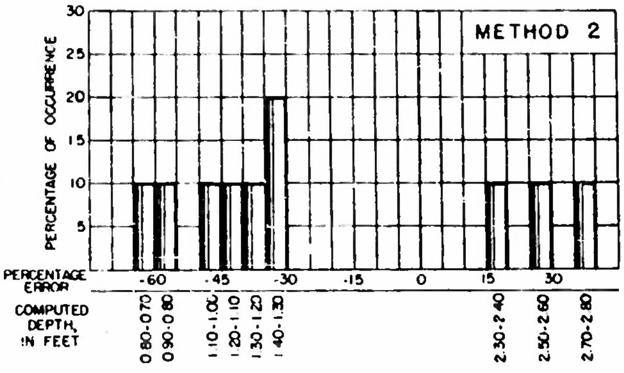


FIGURE 7

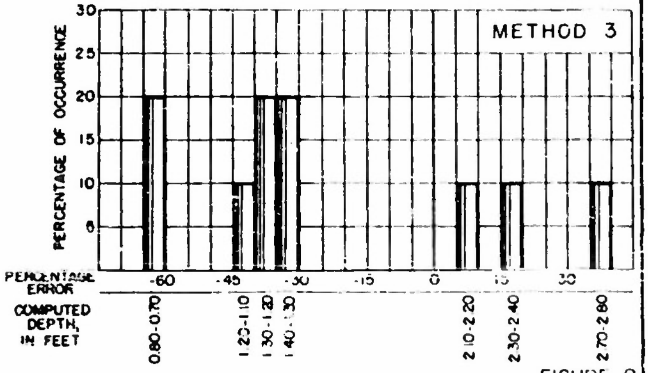


FIGURE 8

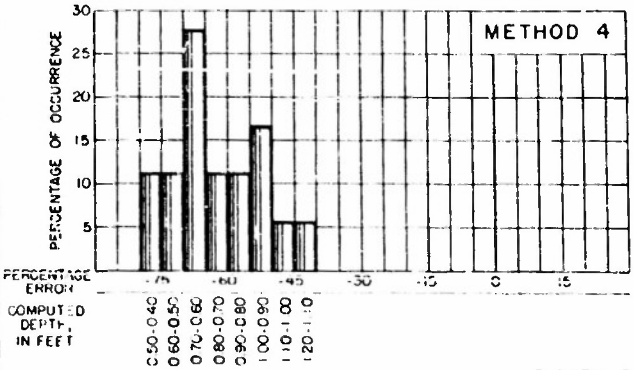


FIGURE 9

HYD 6757

RUN I

Non-uniform waves in constant depth

Depth of water d = 2.00 feet

$d/L_{o_{ave}} = 0.414$

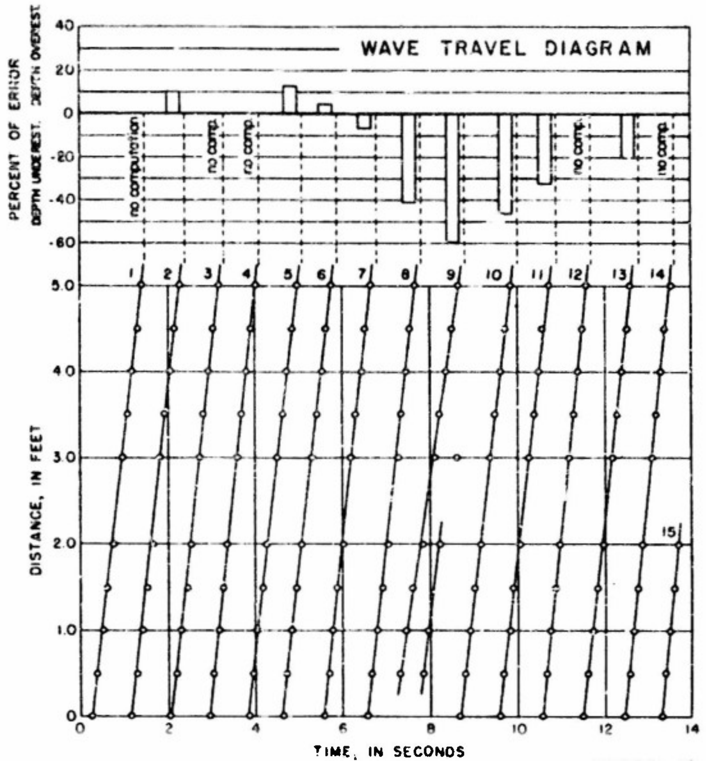


FIGURE 10

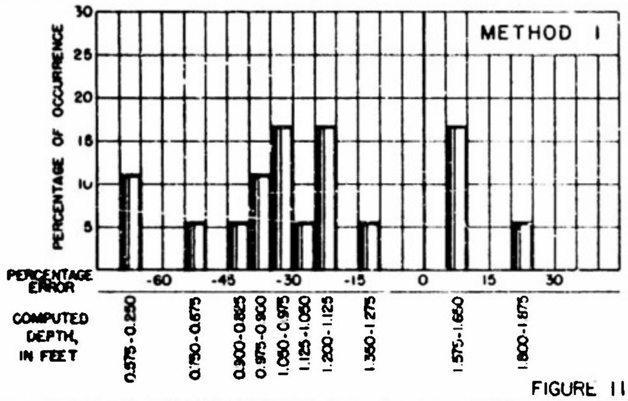


FIGURE 11

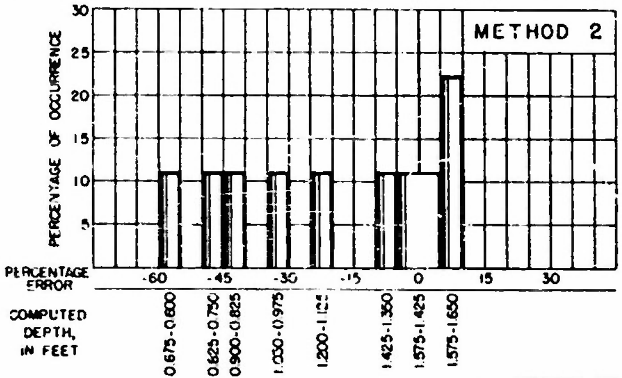


FIGURE 12

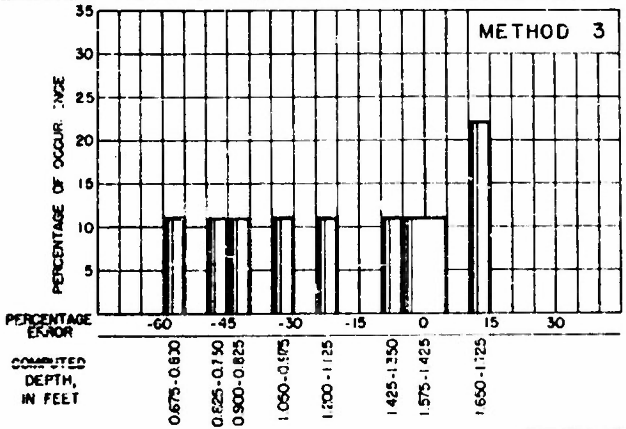


FIGURE 13

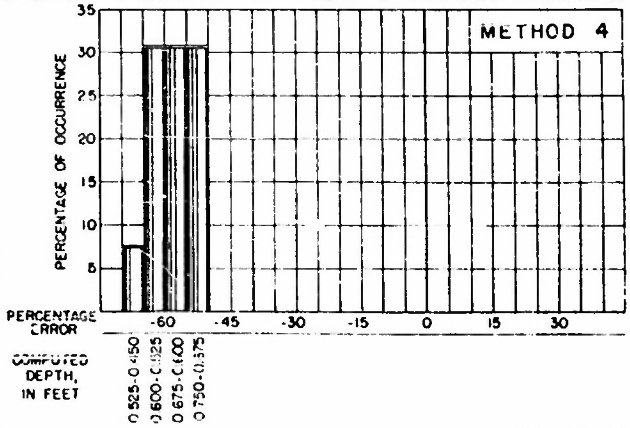


FIGURE 14

HYD-6759

RUN 2

Non-uniform waves in constant depth

Depth of water $d = 1.50$ feet

$d/L_{o_{ave}} = 0.34$

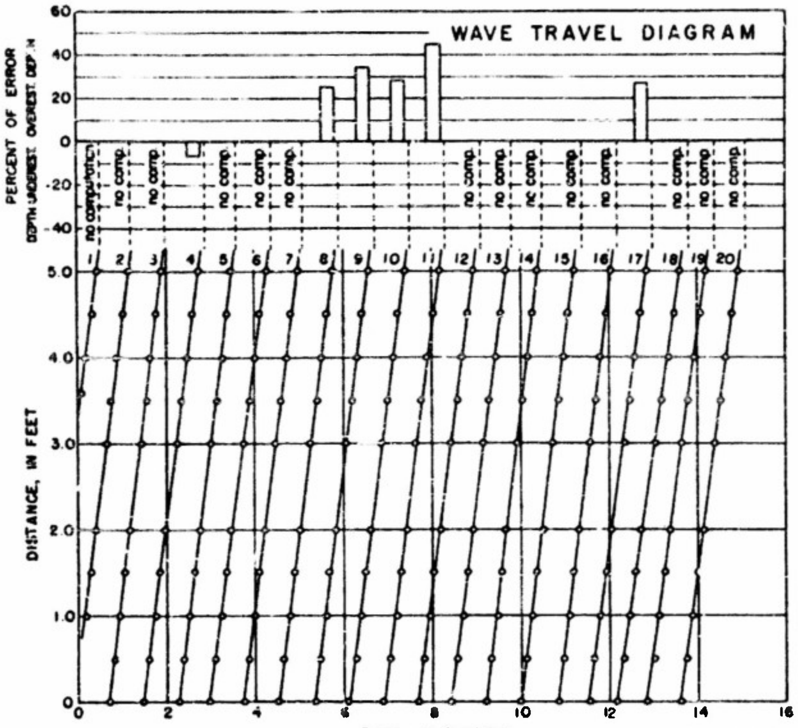


FIGURE 15

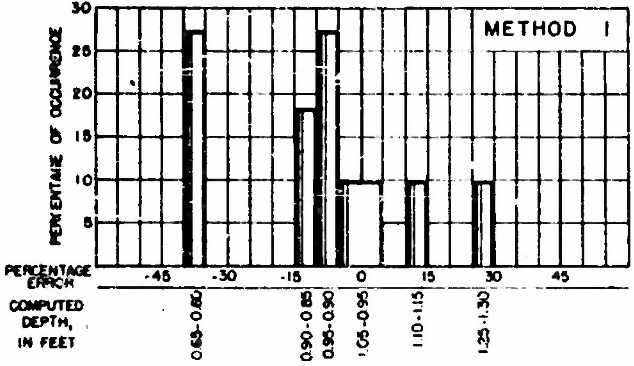


FIGURE 16

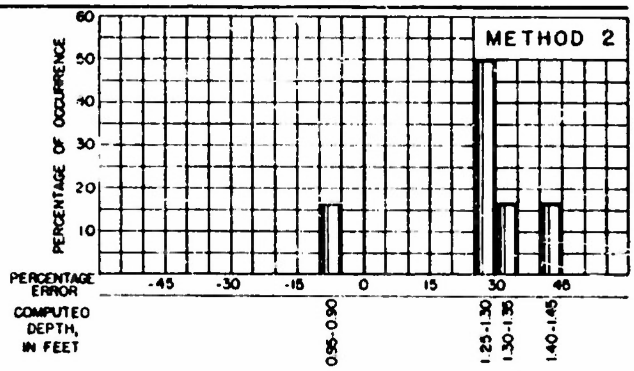


FIGURE 17

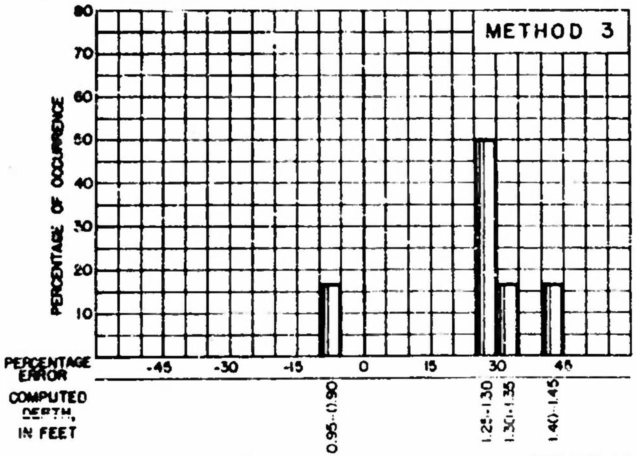


FIGURE 18

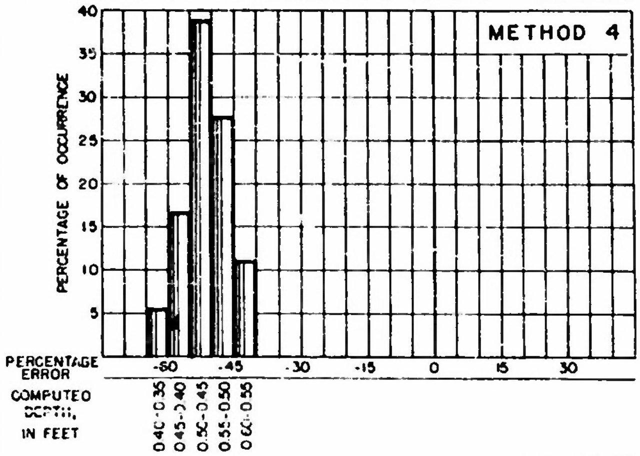


FIGURE 19

HYD-6759

RUN 3
Non-uniform waves in constant depth
Depth of water d = 1.00 foot
$d/L_{o_{ave}}$ = 0.335

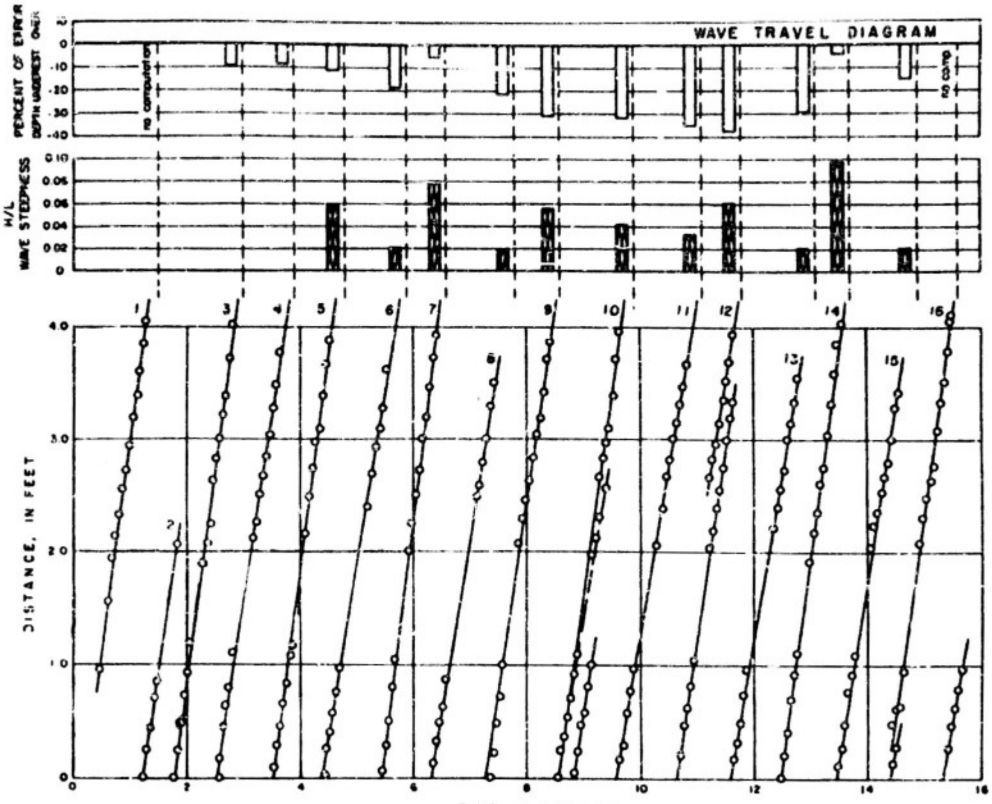


FIGURE 20

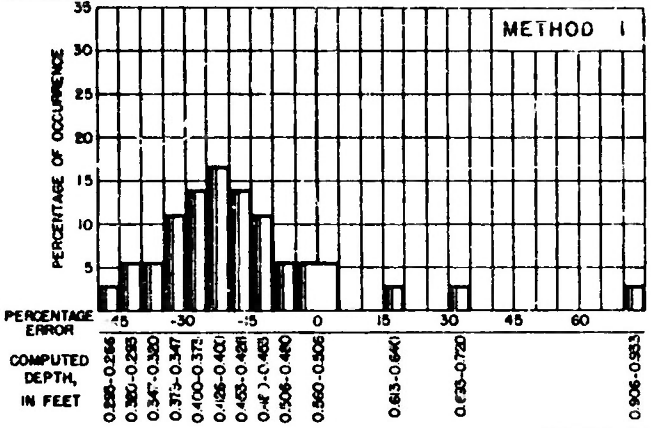


FIGURE 21

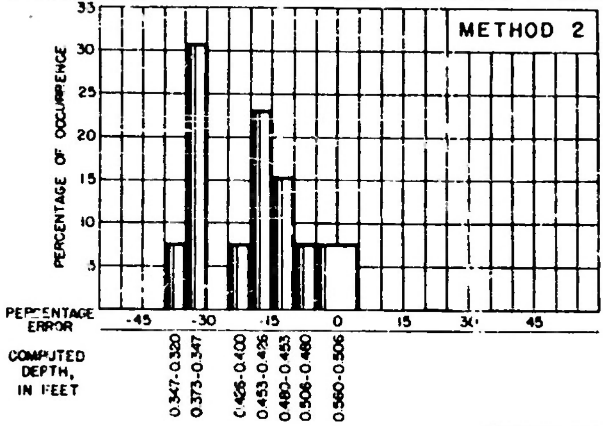


FIGURE 22

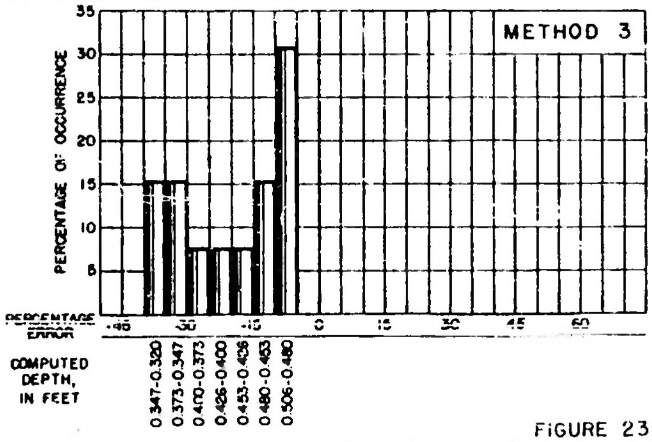


FIGURE 23

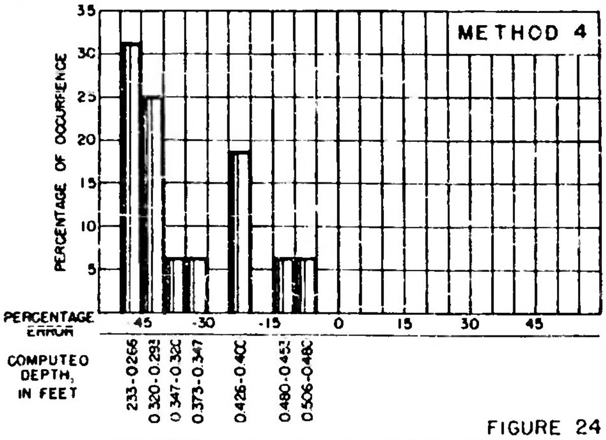


FIGURE 24

HYD-676D

RUN 9

Non-uniform waves in constant depth

Depth of water d = 0.533 foot, $d/L_{o_{ave}} = 0.104$

FIGURES 20-24

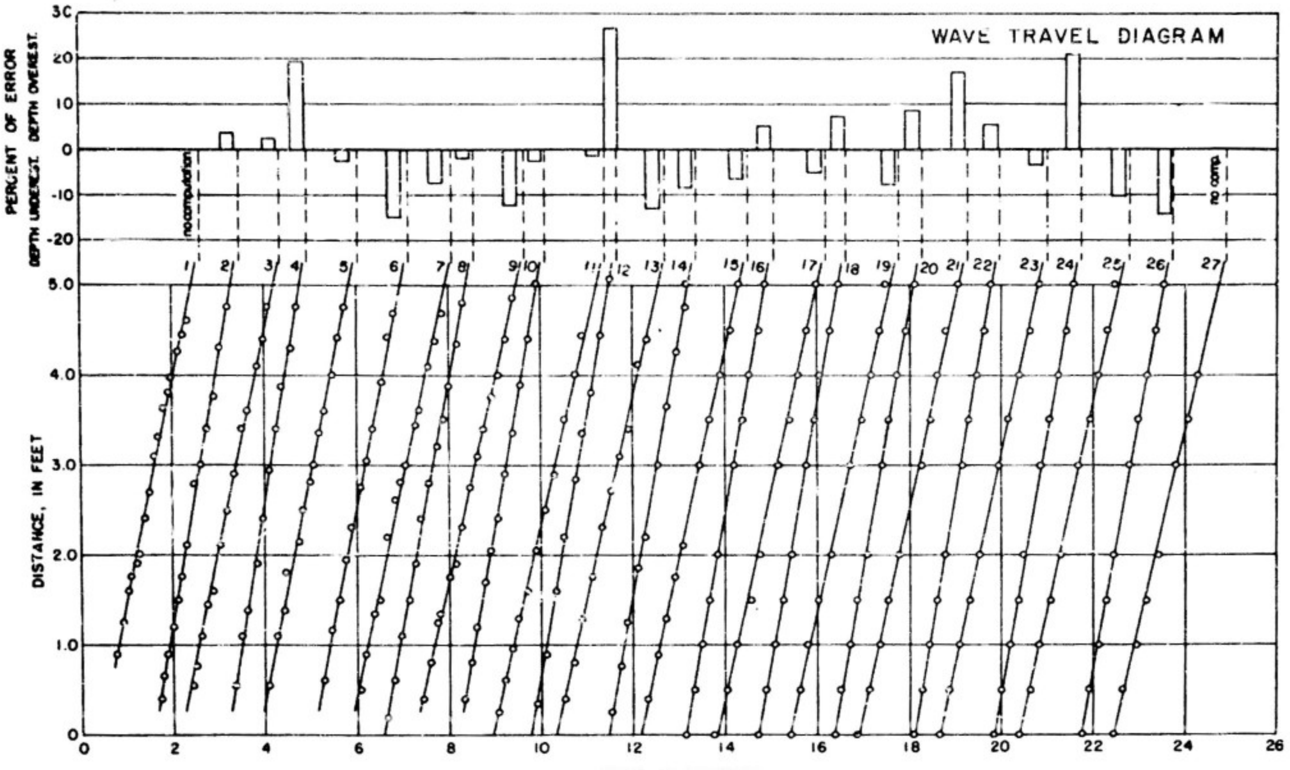


FIGURE 25

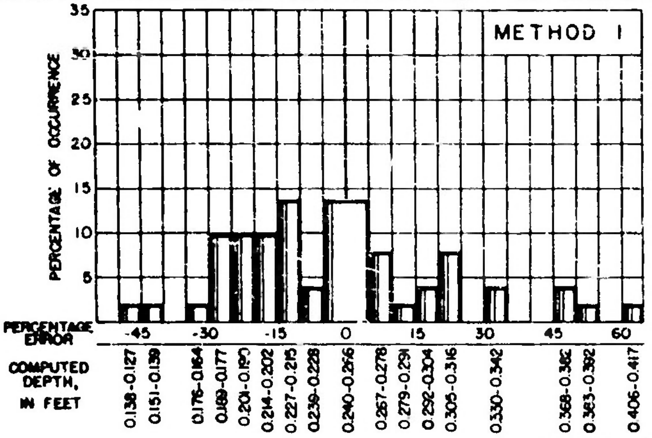


FIGURE 26

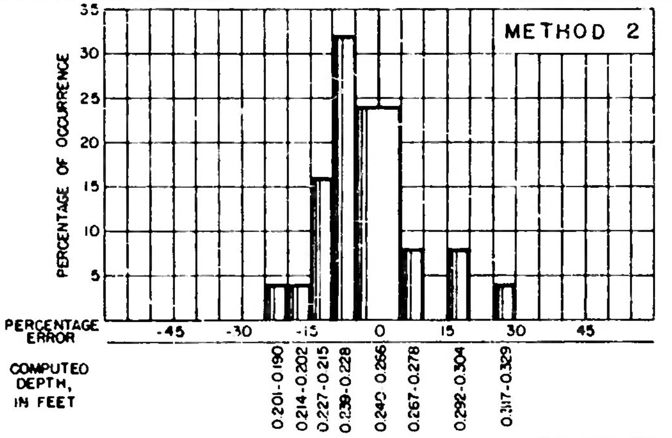


FIGURE 27

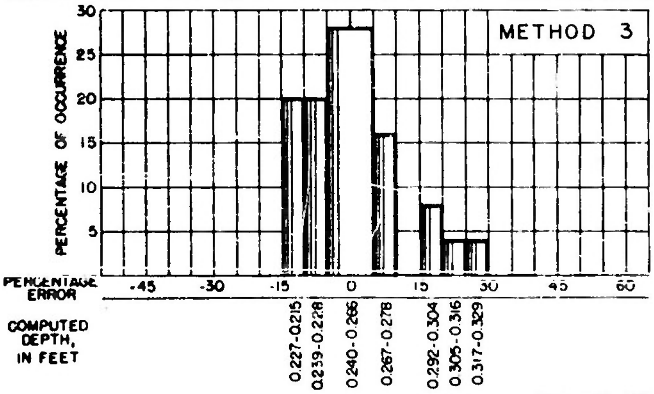


FIGURE 28

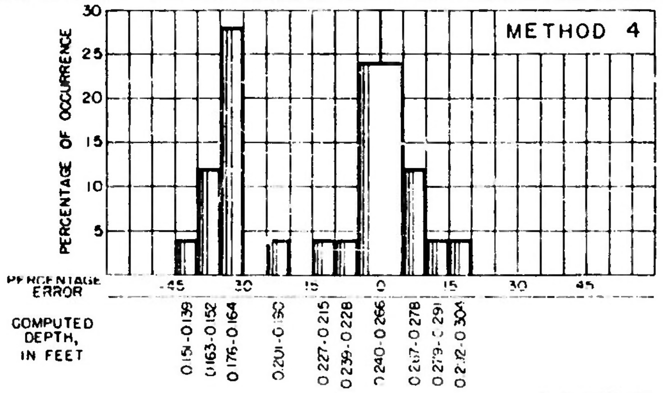
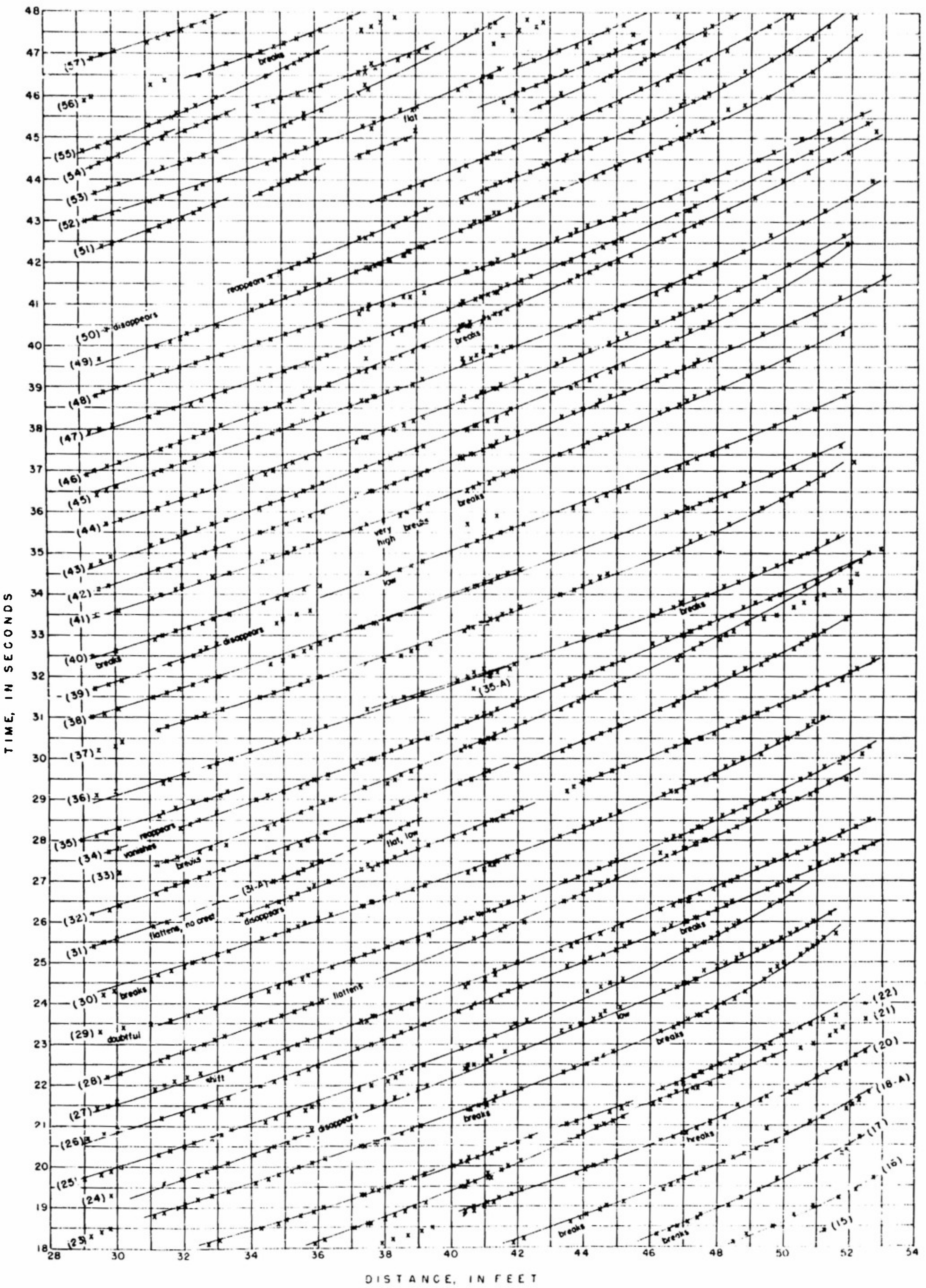


FIGURE 29

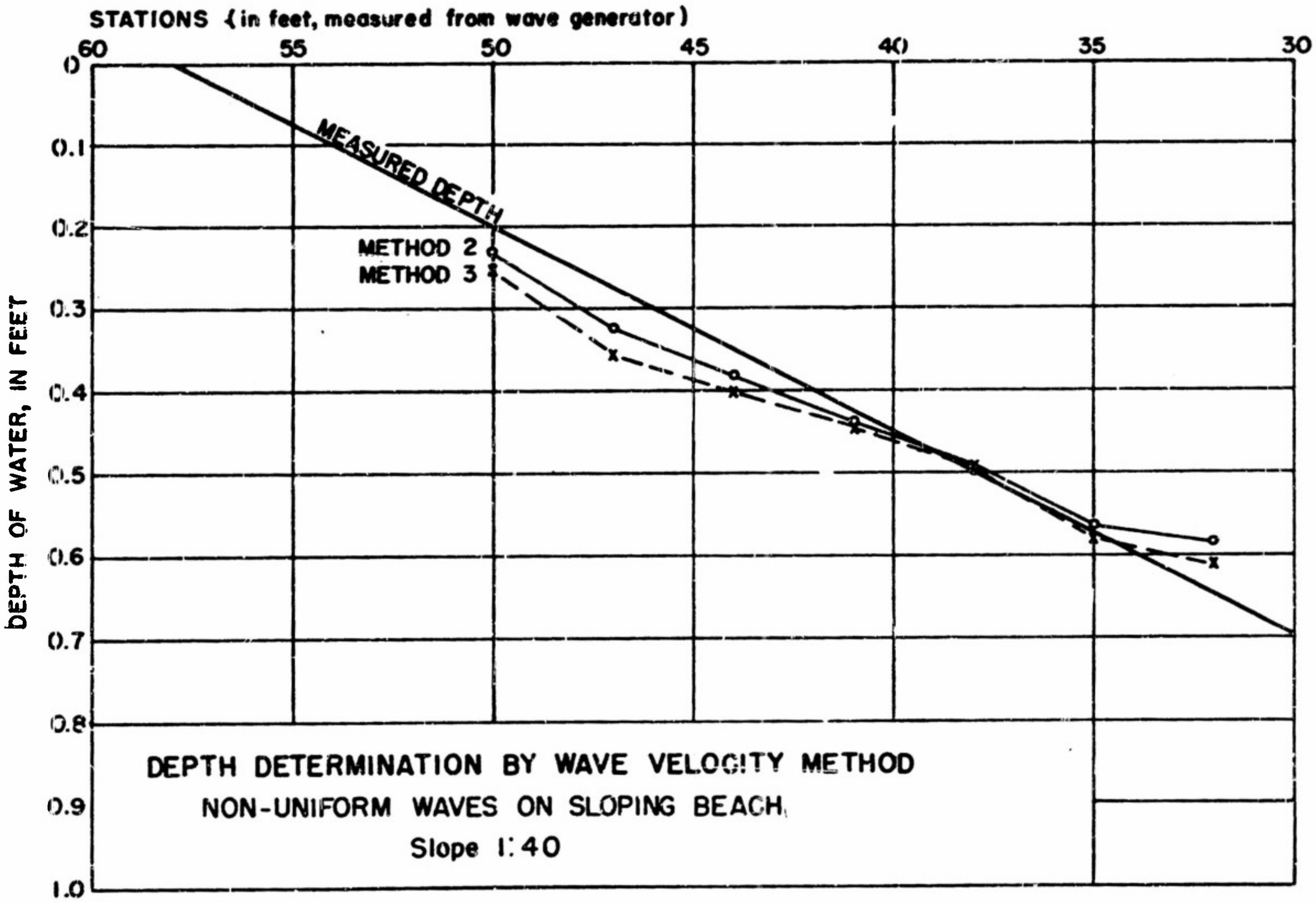
RUN 5
Non-uniform waves in constant depth
Depth of water d = 0.253 foot
$d/L_{o_{ave}} = 0.067$



WAVE TRAVEL DIAGRAM

NON-UNIFORM WAVES ON SLOPING (1:40) BEACH

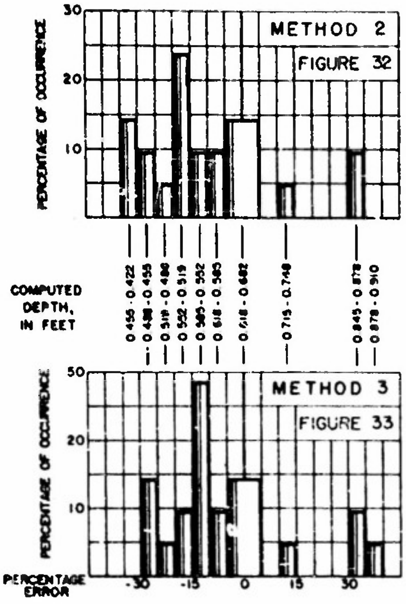
FIGURE 30



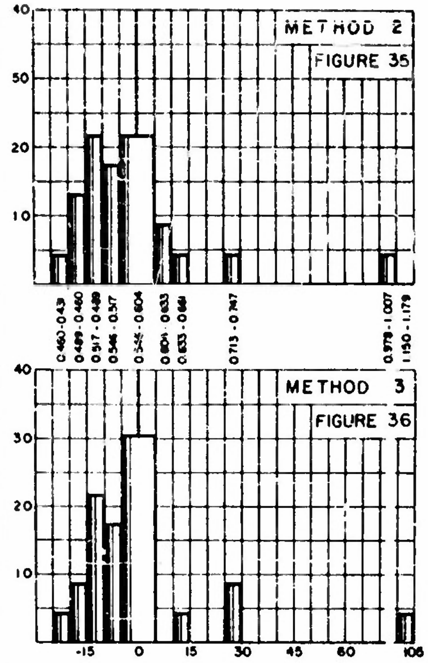
DEPTH DETERMINATION BY WAVE VELOCITY METHOD
NON-UNIFORM WAVES ON SLOPING BEACH
Slope 1:40

HYD-676B

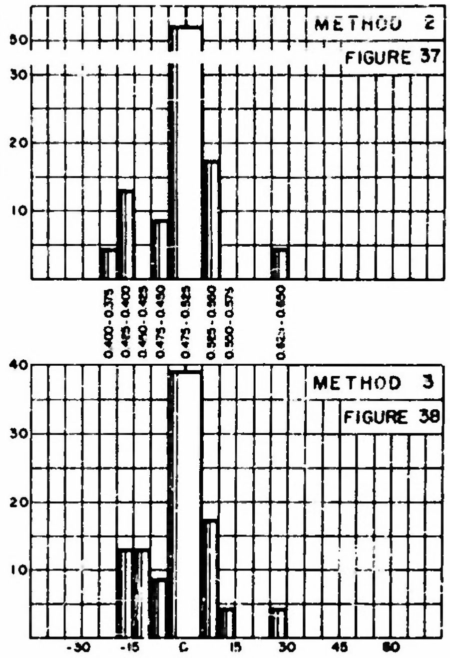
FIGURE 31



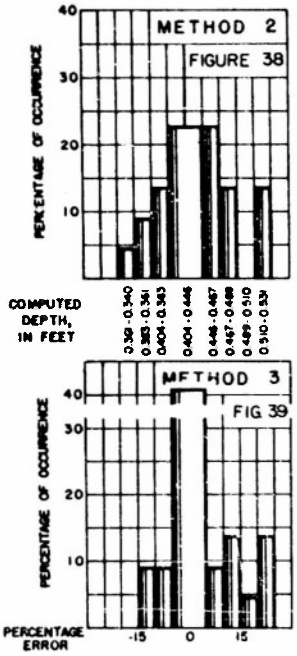
Station 32'
Depth d_m = 0.650 foot
$d/L_{o_{ave}}$ = 0.168



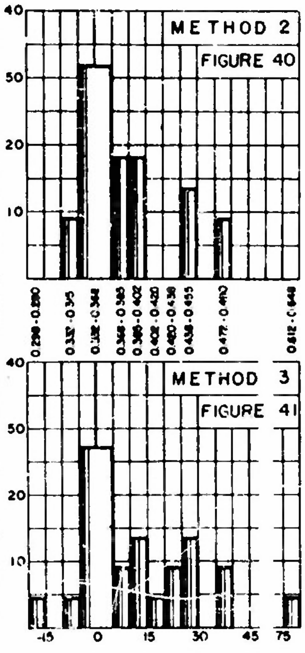
Station 35'
Depth d_m = 0.575 foot
$d/L_{o_{ave}}$ = 0.148



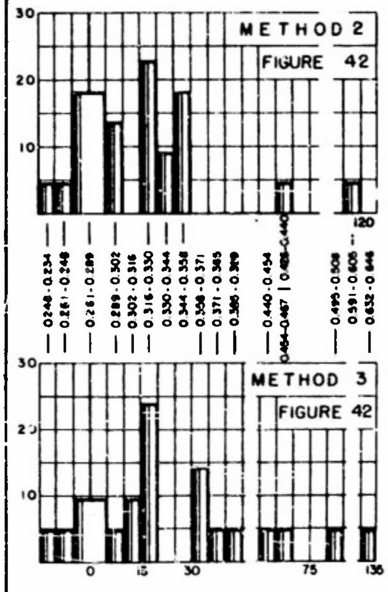
Station 38'
Depth d_m = 0.500 foot
$d/L_{o_{ave}}$ = 0.129



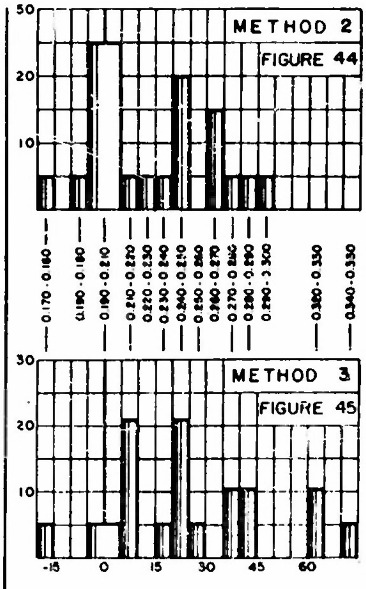
Station 41'
Depth d_m = 0.425 foot
$d/L_{o_{ave}}$ = 0.11



Station 44'
Depth d_m = 0.350 foot
$d/L_{o_{ave}}$ = 0.090



Station 47'
Depth d_m = 0.275 foot
$d/L_{o_{ave}}$ = 0.071



Station 50'
Depth d_m = 0.200 foot
$d/L_{o_{ave}}$ = 0.052

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