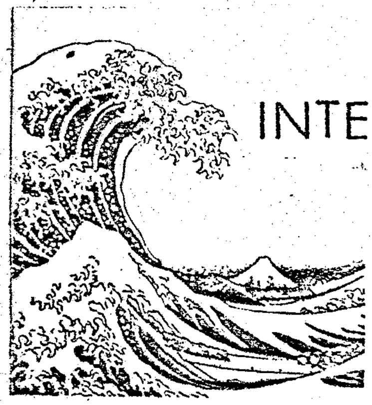

INTERNATIONAL TSUNAMI INFORMATION CENTER

NEWSLETTER

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honolulu, hawaii 96822 usa

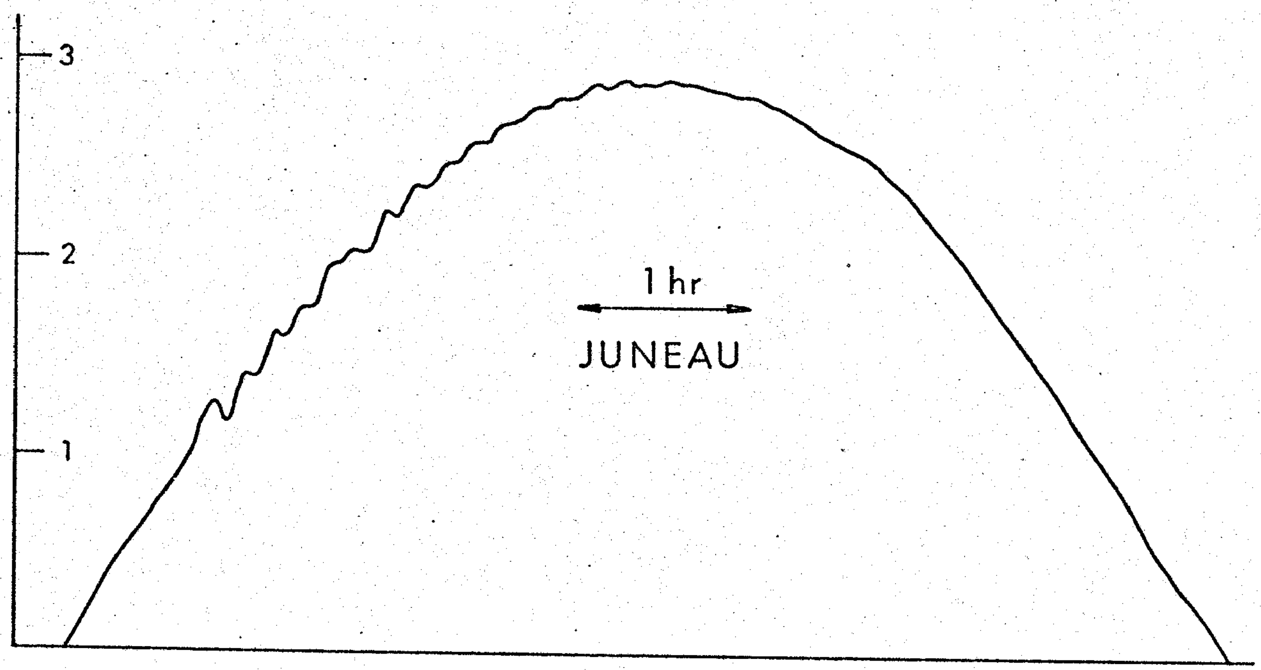
15 SEPTEMBER 1972

During the meetings of the ICG in Tokyo last May at one of the many fine parties given by our Japanese hosts, a special song relating to tsunamis was composed. The tune is the American folk song, "I've Been Working on the Railroad." The words follow.

> I've been working on the breakwater all the live long day.
> I've been working on the breakwater just to keep the tsunamis away.
> Can't you hear the earthquake rumbling, all the buildings crumbling,
> Can't you see the water rising, might wash the town away.
> Tsunami don't you rise, tsunami don't you rise,
> Tsunami don't you wash the town away.
> You bring in the research projects,
> You bring in the research grants,
> You bring in the research projects, and keep our jobs always.

At the next meeting dealing with tsunamis in New Zealand, participants are going to be requested to supply additional verses which may be either of a technical and scientific nature or on more descriptive topics.

On July 30, 1972 a very small tsunami was generated by an earthquake at approximately 57°N 136°E.* Copies of the wave records are shown for the Juneau and Sitka tide gages. The maximum peak to trough height of the wave appears not to have been as great as 20 cm as may be seen. The wave period was roughly 10 minutes as recorded at these two tide stations.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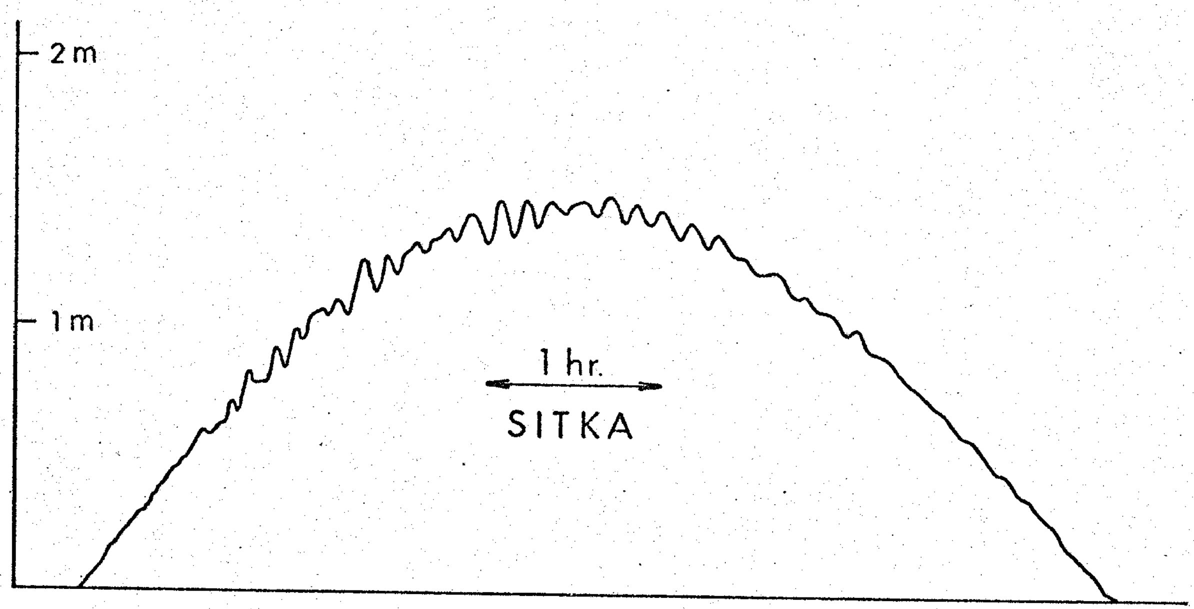
JUNEAU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SITKA

<u>"Historical" Account of a Tsunami</u>

A brief account by Mark Twain (Samuel L. Clemens) in "Roughing It" published in 1872 describes a tsunami associated with an 1840 (approx.) eruption and earthquake on the island of Hawaii. "The earthquakes caused some loss of human life, and a prodigious tidal wave swept inland, carrying everything before it and drowning a number of natives. The devastation consummated along the route traversed by the river of lava was complete and incalculable. Only a Pompeii and a Herculaneum were needed at the foot of Kilauea to make the story of the irruption immortal."

A TIDAL WAVE.

In a recent report entitled "Relative Spectra of Tsunamis" (Hawaii Institute of Geophysics Report HIG-72-8) the ratio of tsunami spectra are presented. From this one is able to determine the relative wave-number of the disturbing phenomena from the various tsunamigenic events. In a sense, the departures in the spectra of tsunamis at a fixed station are compared to the "normal" tsunami spectrum at this station. The November 1952 Kamchatka event was taken as the reference tsunami. By examining the spectral ratios, one removes the effects of local resonances and compares the generations spectra for different locations. These spectral ratios are smooth as compared to the spectra themselves, thus indicating an absence of strong resonances in the generating process. Tsunamis generated in shallow water are relatively rich in low frequency energy. This is as expected because a given wavelength in shallow water is a longer period wave than the same wavelength in deeper water due to the slower propagation velocity. The April 1946 tsunami was a very high frequency event. It is worth noting that in an attempt to determine the dimensions of the generation function for that wave, Dr. William Van Dorn concluded that the event was small in horizontal extent as well as in deep water.

Charles Mader of the University of California at Los Alamos is currently visiting the Joint Tsunami Research Effort of the University of Hawaii at the Hawaii Institute of Geophysics. He is working on the problem of adapting finite element numerical techniques developed at Los Alamos to the tsunami problem. The techniques developed at the University of California at Los Alamos Scientific Laboratory are specifically directed toward the solution of problems related to relatively short water wavelengths as compared to the water depth. Tsunamis, of course, have a long wavelength compared to water depth and therefore represent a special class of problems in the field of fluid dynamics. The particular technique utilized in this study of fluid motions is called a "Marker And Cell" or MAC technique for the solution of the basic Navier-Stokes' equations. Fig. 1 shows an example of such a calculation. In the example shown, the vertical scale is roughly commensurate with the horizontal scale. Such is not the case for tsunamis. A typical tsunami amplitude as the wave approaches the shoreline

is perhaps a fraction of a meter. A typical tsunami wavelength at the same time is of the order of 100 km. The ratio between height and wavelength perhaps is as great as one in 10^5 or 10^6. Clearly, a numerical technique where vertical and horizontal dimensions are approximately equal will be inadequate for the tsunami problem. The major question that will hopefully be answered during Charles Mader's stay at the JTRE is how to utilize the technology developed at the University of California at Los Alamos to answer some of the major questions which arise in attempts to solve tsunami-shoreline interaction problems.

The ratio between tsunami height and tsunami wavelength is not appropriate for numerical computation in the usual simplified sense. In order to avoid his problem, an extension of the marker and cell technique was devised. In this extended computational procedure, the surface of the fluid is defined by an extra set of markers. These markers are directly analogous to the markers used in the usual marker and cell computational procedure. It is worth noting that these surface markers are, in fact, the most important markers in this computational technique. For the relatively long period waves we are concerned with, the hydrostatic approximation is almost adequate. Thus, although the nonlinear aspects of the tsunami shoreline interaction problem are accounted for in the computation, the solution is well approximated by the linear long wave theory except in the region of the shoreline. Examples of computational results from a Los Alamos group are shown in Figs. 2 and 3. One example shows waves passing over a broad reef. These waves are large in amplitude compared to tsunamis. A second example shows wave run-up on a sloping beach. In this case, the slope of the beach was simulated by a redirection of the gravitational vector, thus, there is no limitation on bottom slope as compared to mesh size or mesh aspect ratio. The technique of deviating the gravitational vector relative to the vertical cannot be generalized. That is to say, only one angle of deviation from the vertical may be used in any given computation.

The new technique developed by Charles Mader involves the use of a very high aspect ratio cell perhaps as much as 15 times as broad in horizontal extent as in vertical. Such a cell is adequate to describe the interior of the wave but is not adequate to describe the surface of the long period wave. In order to describe this surface, many new markers have been introduced. These markers are followed by the computation procedure much in the fashion that small cork floats would be followed on the surface of the water.

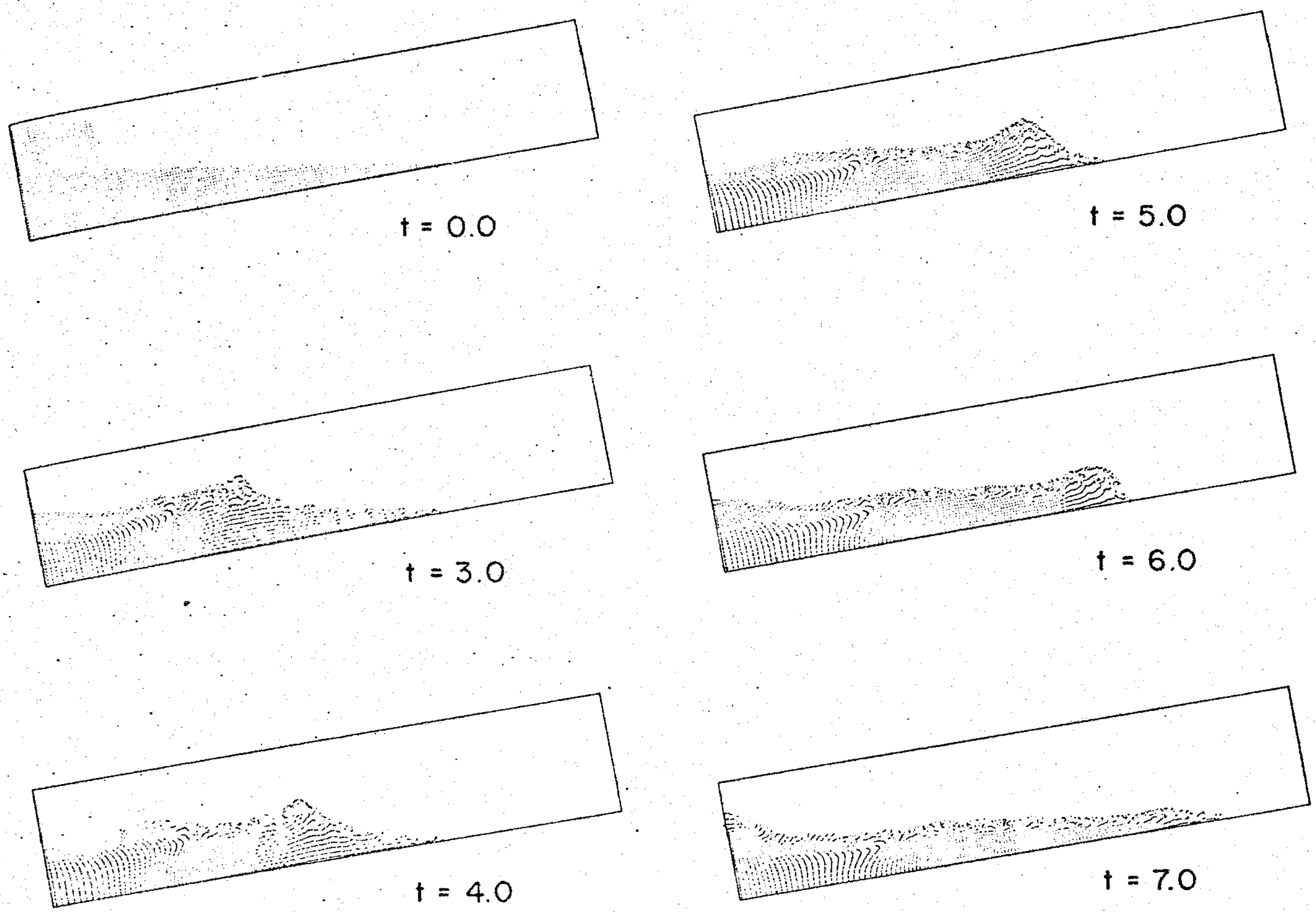


Fig. 3.1. Wave on a Sloping Beach

The figures are tilted to give downward direction to gravity; in the actual calculation, the bottom of the tank was level, and there was a negative horizontal component of the body acceleration. The wave was generated by dropping the blob of fluid shown to the left at t = 0. By the time t = 6.0, the resulting wave reached the tip of water; subsequently, it ran up on the shore with decreasing amplitude. The bottom allows free slip, and the viscosity is negligible.

$g = -1.0$
Height of mesh = 2.1
$\nu = 0.01$
No. cells in vertical direction = 23

Figure 1.

Figures taken from Los Alamos Scientific Laboratory Report #LA-3425, pp. 99, 101, and 102.

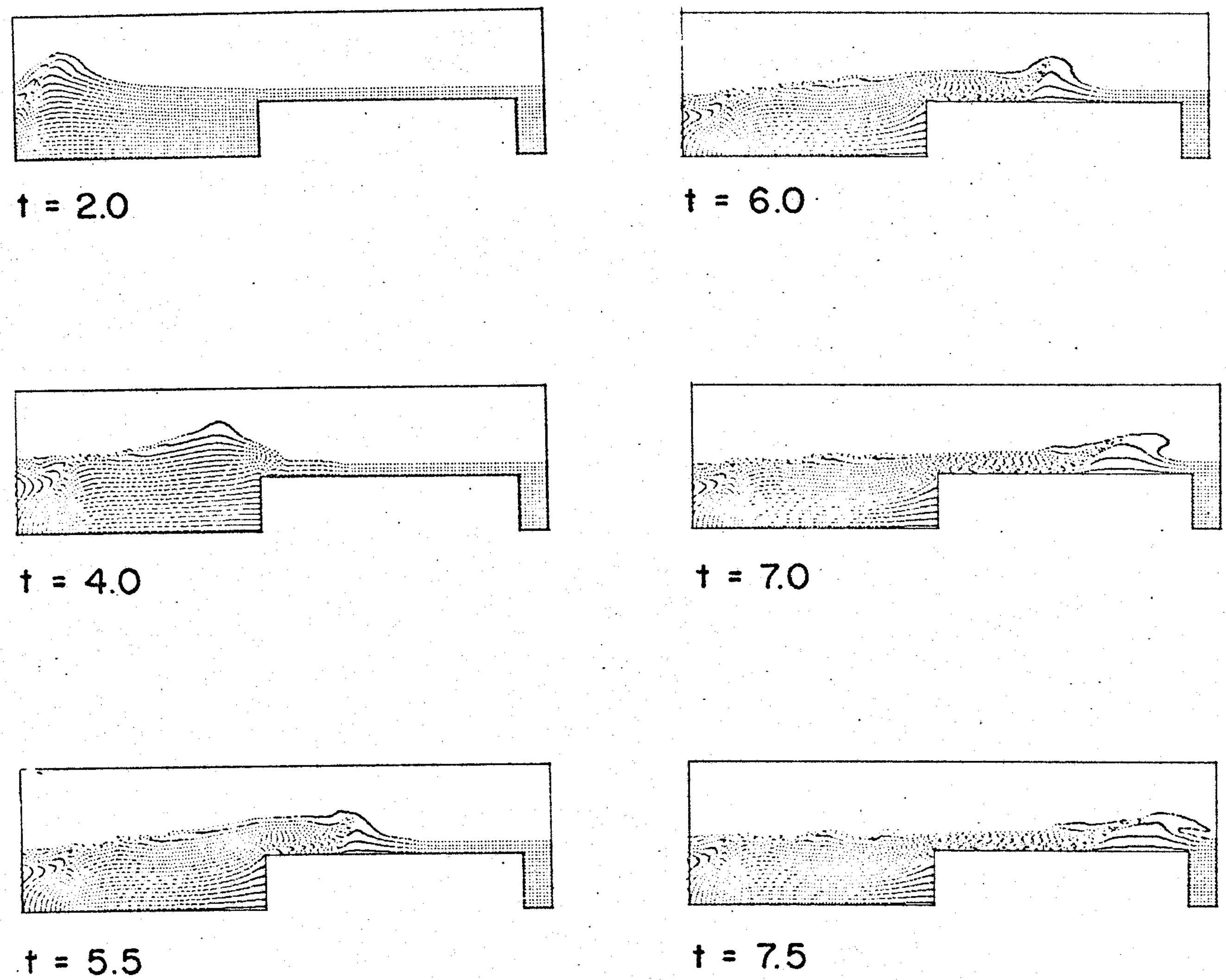


Fig. 3.4. Wave on a Reef

The calculation is similar to that in Fig. 3.3, but the breakwater has been widened into a shelf or reef. Note that the wave breaks at late times.

$g = -1.0$
Length of mesh = 9.0
Height of mesh = 2.1
$\nu = 0.01$
No. cells = 92 × 23 (2116)

Figure 2.

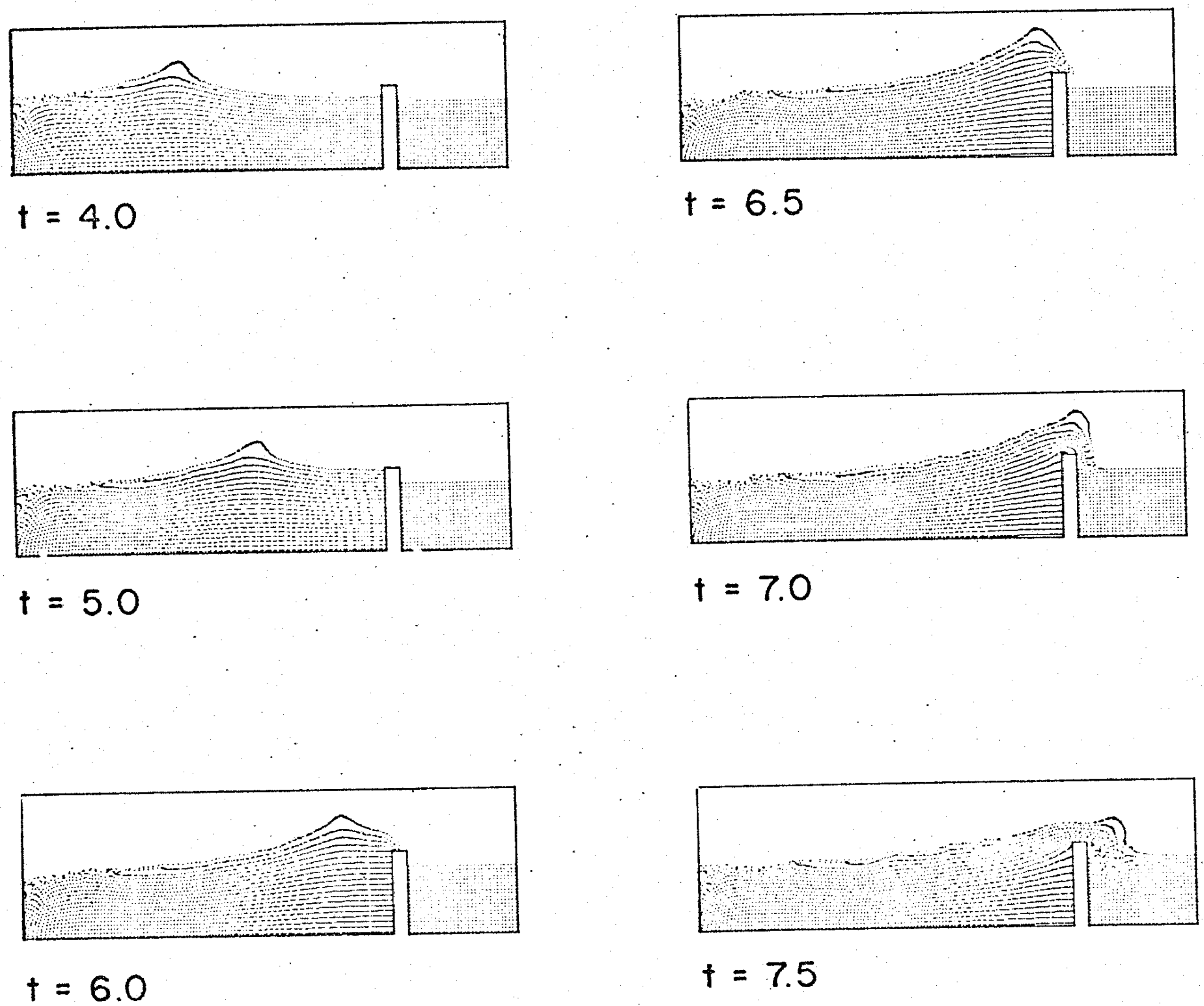


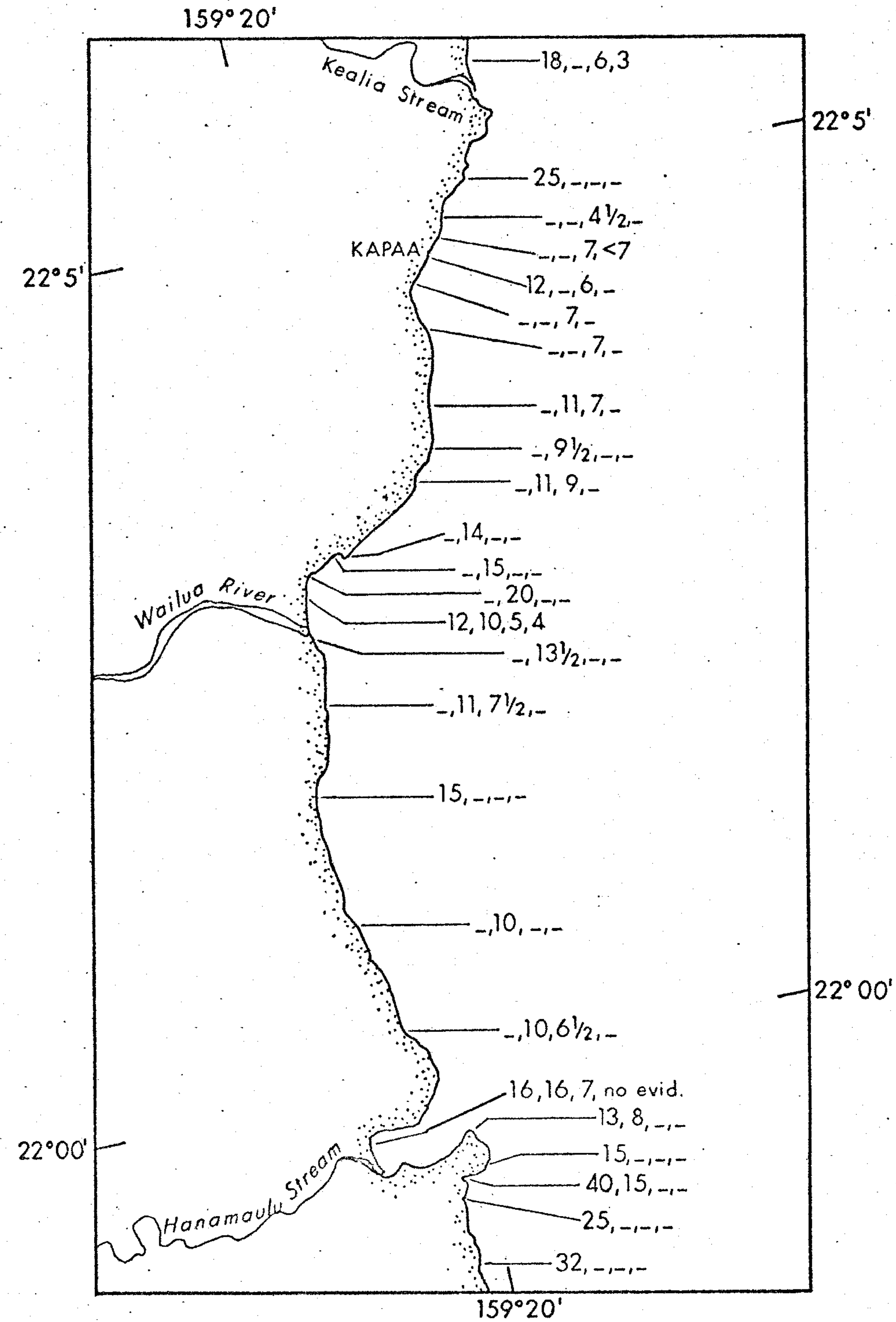
Fig. 3.3. Wave on a Breakwater

The wave is generated, as it was in Fig. 3.1, by dropping a blob of fluid at the left, outside the computing region shown. The relatively empty region just under the wave crest is treated, calculationally, as being full of water. As in Figs. 3.1 and 3.2, all rigid boundaries allow free slip; and the viscosity is small enough to have a negligible effect on all results, except for a slight smoothing of the particle arrangements.

$g = -1.0$
Length of mesh = 9.0
Height of mesh = 2.1
$\nu = 0.01$
No. cells = 92 × 23 (2116)

Figure 3.

A new report is in preparation showing all of the recorded tsunamis' run-up heights for the Hawaiian Islands.



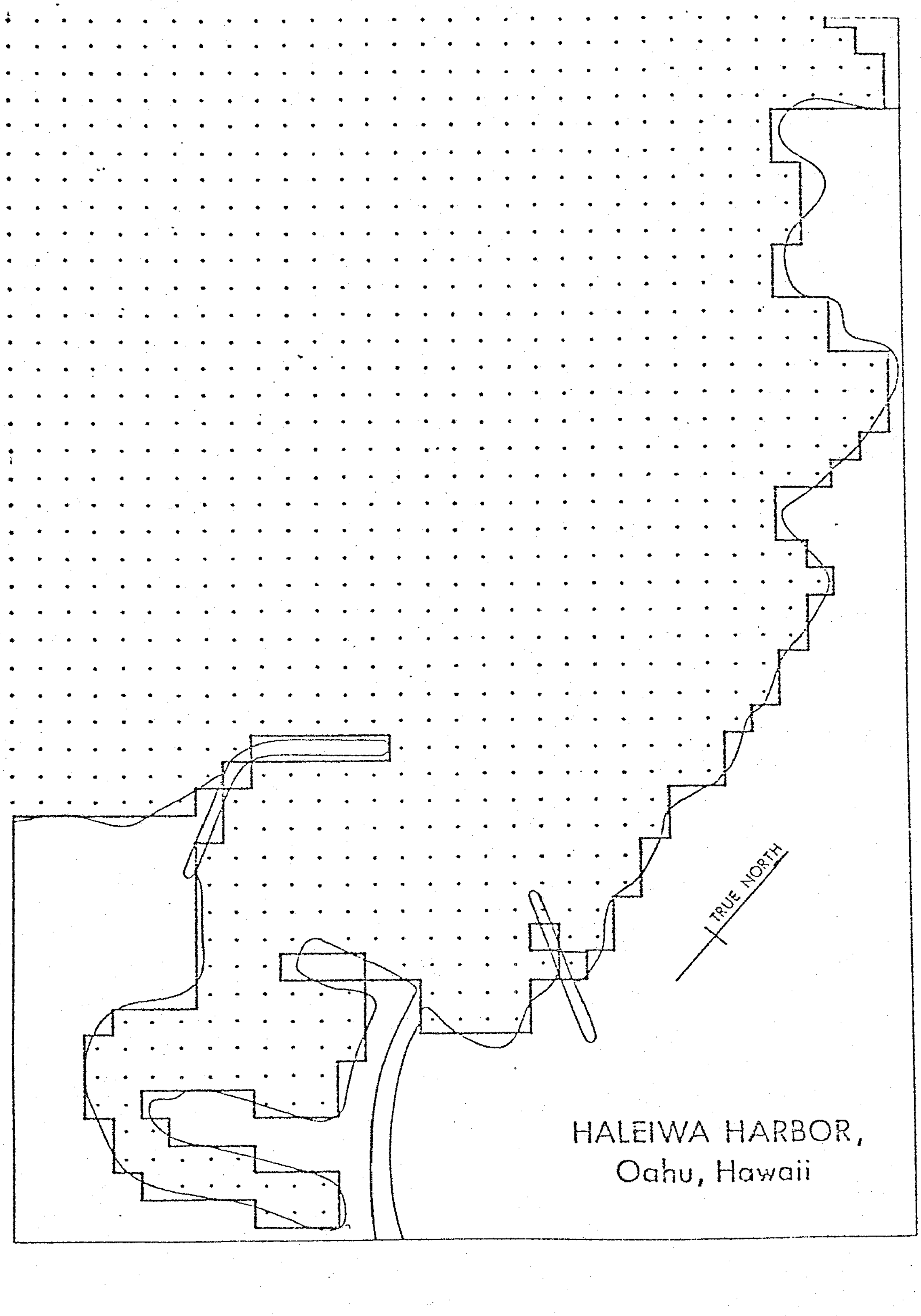
Sample page. A section of the coast of Kauai. Run-up heights are in feet for the April 1946, November 1952, March 1957, and May 1960 tsunamis.

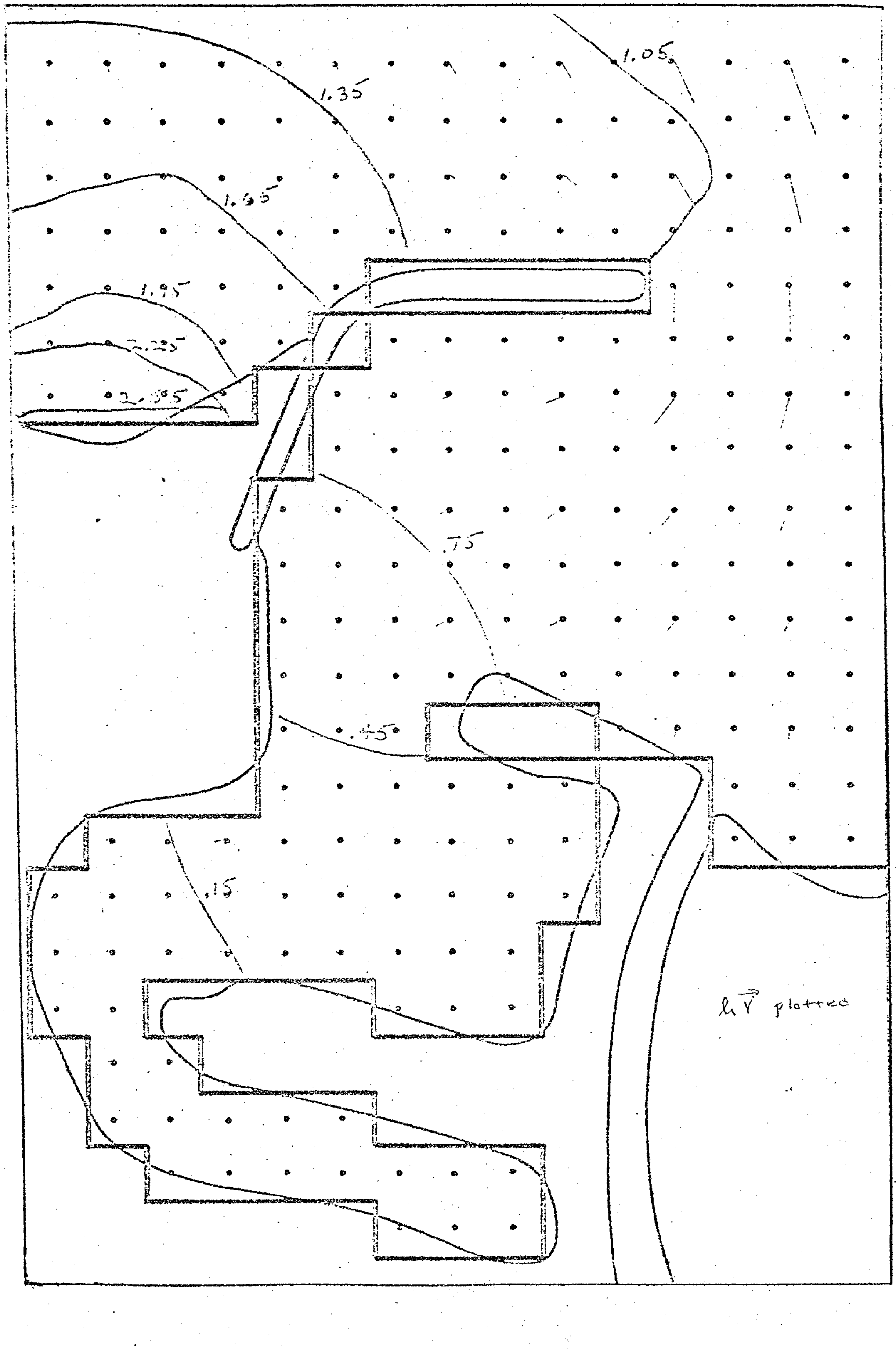
Dr. Harold Loomis of the Joint Tsunami Research Effort at the University of Hawaii has in preparation a manuscript describing a comparison between the measurements made on the hydraulic model of Haleiwa Harbor and numerical computations done on the computer.

The computing programs that were used for time-stepping a tsunami into Hilo Bay were reorganized and assembled into a package that any user could utilize for solving hydrodynamic problems involving long waves in coastal regions. The equations used are the basic hydrodynamic equations including optional inclusion of a quadratic friction term and an advection term. The user need only supply the bathymetry of the region, the input wave shape, the direction of arrival, and certain parameters about the grid spacing, and the packaged program sets up the problem and computes water level and velocities for subsequent times. This package has been documented in an HIG Report (in press) and an example is presented for which Haleiwa Harbor is the region in question.

Haleiwa Harbor was chosen because the U.S. Army Corps of Engineers has contracted with the Ocean Engineering Department, University of Hawaii, to build a model of the harbor. This provided an opportunity to compare a numerical model with a hydraulic model. Tests on the hydraulic model with waves of 10 sec. and 15 sec. were run. Amplitudes measured in the model at various points compare well with amplitudes computed with the numerical model; the comparison being always within 7%. The effects of wave absorbers and additional structures at Haleiwa can be readily checked out on the numerical model.

Figures show the grid approximation and a detailed presentation of a portion of the output of the calculations.


TRUE NORTH
HALEIWA HARBOR,
Oahu, Hawaii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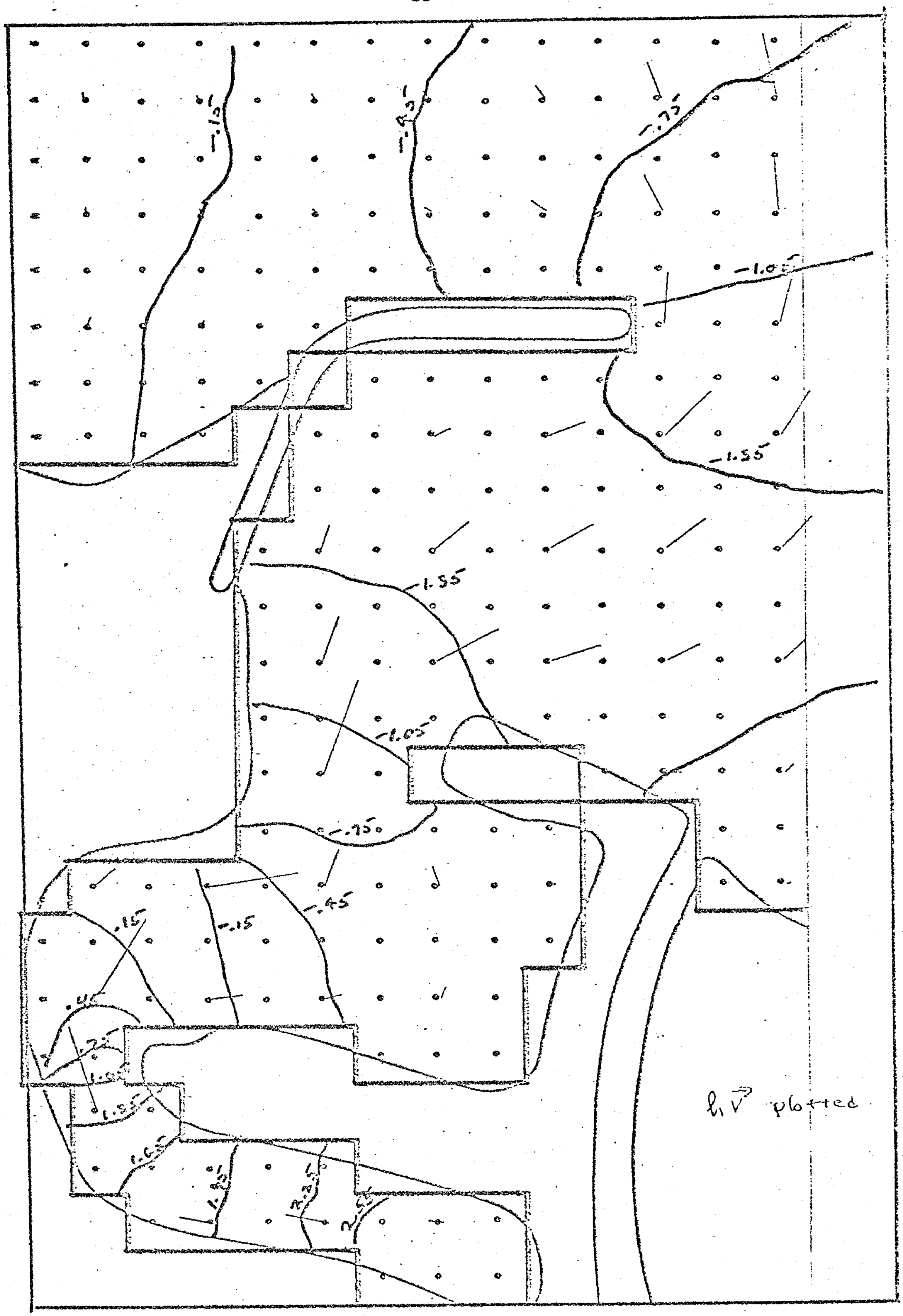
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