運輸省港湾技術研究所

港湾技術研究所報告

REPORT OF THE PORT AND HARBOUR RESEARCH INSTITUTE

MINISTRY OF TRANSPORT

VOL. 8 NO. 4 DEC. 1969

NAGASE, YOKOSUKA, JAPAN

港湾技術研究所報告は第7巻第1号より年4回定期的に刊行する。ただし第1巻から第6巻および欧文編第1号から第15号までは下記のとおり不定期に刊行された。

報告の入手を希望する方は論文番号を明記して港湾技術研究所長に申し込んで下さい。

和 文 篇 (Japanese Edition)

Vol. 1. No. 1 (1963)
Vol. 2. Nos. 1～3 (1963～1964)
Vol. 3. Nos. 1～7 (1964)
Vol. 4. Nos. 1～11 (1965)
Vol. 5. Nos. 1～15 (1966)
Vol. 6. Nos. 1～8 (1967)

欧 文 篇 (English Edition)

Report Nos. 1～15 (1963～1967)

The Report of the Port and Harbour Research Institute is published quarterly, either in Japanese or in occidental languages. The title and synopsis are given both in Japanese and in occidental languages.

The report prior to the seventh volume were published in two series in Japanese and English as listed above.

The copies of the Report are distributed to the agencies interested on the basis of mutual exchange of technical publication.

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港湾技術研究所報告 (REPORT OF P.H.R.I.)

第8巻　第4号 (Vol. 8, No. 4), 1969年12月 (Dec. 1969)

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REPORT OF THE PORT AND
HARBOUR RESEARCH INSTITUTE
Vol. 8 No. 4 (Dec. 1969)

2. Determination of Approximate Directional Spectra for Coastal Waves*

Yoshimi SUZUKI

Synopsis

The knowledge of the directional spectra for surface waves is essential to the problem of the wave generating mechanism by wind, and to the related problem of wave forecasting. It is important to the understanding of coastal phenomena, and consequently to the design of coastal works.

The author proposed a new method of determining the directional spectra of sea waves using the record of a wave meter and the record of a wave direction meter which can record X and Y component wave force acting on a bottom mounted sphere.

The accuracy of the method was investigated by means of simulated wave properties with directional spectra.

One set of actual data was analyzed by the method proposed herein, to obtain the approximate directional spectra. In addition, the value of C_D and C_M in the conventional wave force formula for the sphere were obtained as a function of component wave frequency.

* Partly reported in HEL 1-11, U.C. Berkeley, 1968.[21]

港湾技術研究所報告
第8巻 第4号 (1969.12)

2. 沿岸波浪の近似的方向スペクトルの決定

鈴 木 禧 実

要 旨

風波の発生機構の解明，波浪の予報の問題において方向スペクトルを知ることは必須のことである。また，沿岸の諸現象および海岸における構造物の設計にも重要である。

著者は先に港湾技術研究所で開発された水圧式波高計およびストレインゲージ式波向計の同時観測記録から，沿岸波浪の近似的方向スペクトルを算定する新しい方法を提案した。

この方法の近似の精度について，方向スペクトルをもつ波の諸元をシミュレーションにより発生させたデータにより調べ，波向きの算定精度は極めて良好なことを明らかにした。また，通常，水中の球に作用する波力の公式で用いられる C_D, C_M の値を周波数の関数として求めうることを示した。一例として酒田港における現地観測資料の解析を行ない近似的方向スペクトル，波向，C_D, C_M を求めた。

CONTENTS

1. Introduction

In order to describe ocean waves in the generating area, characteristics of the irregularity of the sea surface waves including directional properties, must be measured. For design problems, wave direction is defined as the direction normal to the wave crest. The instantaneous wave direction, however, is different at any other space and time location. These conditions may be described by a directional spectrum which describes the distribution of wave energy with respect to direction and frequency. It is not easy to determine the directional spectrum either in the laboratory or in the ocean.

Four methods have been developed to obtain the directional spectrum for ocean waves. One is the method which makes use of a number of wave meters arranged in an array. Barber[1] proposed this method and Cummins[1] (1959) used it in the experimental study in the U.S. Naval Taylor Model Basin. Barber[2] (1961) developed this method by studying the directional resolution properties. Mobarek[3] (1965) applied this method to the determination of the directional spectra for wind waves in a model basin. Another method makes use of stereo photographs taken from airplane (or shoreline). Cote[4] et. al. (1960) estimated the directional spectrum of sea waves by taking stereo photographs of the sea surface and measuring wave heights from these photographs at certain chosen grids point. Ijima et. al.[5] (1968) obtained the spectrum at Kanazawa Coast by using the data taken by a stereo photographic camera. The third method is, so called, "Buoy method." Longuet-Higgins and Cartwrite[6] (1961) succeeded in obtaining the directional spectra by measuring the heave, pitch and roll of buoy in the sea. Ewing[7] (1969) has obtained a sequence of ten records of the directional wave spectra from the motions of a floating buoy located in the North Atlantic. The fourth method was developed by Nagata[8] (1964). He measured the orbital motion in waves using an electromagnetic current meter; he studied the statistical properties of the motion, and proposed the method to obtain the directional spectra.

The purpose of the investigation reported herein is to propose a new method to determine the approximate directional spectra, using one set of a wave meter record together with the records of a specially developed wave direction meter.

2. Pseudo-integral Representation of Wave Properties

Wind generated waves can be thought of as being composed of an infinite number of waves with infinitesimal amplitudes each having its own frequency, f, traveling in its own particular direction, θ, and having random phase, Φ. Let the origin of the three space coordinates be on the sea floor. The vertical axis, z, is positive upward, while the two horizontal axes, x and y, are directed so that the x, y, z coordinate system is right-handed. Time will be denoted by t. Each wave has properties described by the small amplitude theory[9] (Linear theory).

Suppose that the sea surface, represented by $\hat{\eta}(x, y, t)$, is a Gaussian stationary stochastic process with parameters x, y and t then, after Pierson[10] (1954), it can be written as

$$\hat{\eta}(x, y, t)=\lim_{Q\to\infty}\lim_{\substack{M\to\infty\\N\to\infty}}\sum_{m=1}^{M}\sum_{n=1}^{N}\sqrt{4p(f_m, \theta_n)\Delta f\Delta\theta}$$

$$\times\cos(k_m x\cos\theta_n+k_m y\sin\theta_n-2\pi f_m t+\Phi_{mn}) \tag{1}$$

where $p(f_m, \theta_n)$ is the directional power spectral density for surface wave in the (f, θ) plane at $f=f_m$ and $\theta=\theta_n$. The values, f_m, θ_n and Δf, $\Delta\theta$ are defined as follows:

$$f=0,\ \frac{Q}{M},\ \frac{2Q}{M},\ \cdots\cdots\frac{MQ}{M} \tag{2}$$

$$\theta=0,\ \frac{2\pi}{N},\ \frac{4\pi}{N},\ \cdots\cdots\frac{2\pi N}{N} \tag{3}$$

$$\Delta f=\frac{Q}{M} \tag{4}$$

$$\Delta\theta=\frac{2\pi}{N} \tag{5}$$

f_m and θ_n denote the mid points of the intervals

$$\frac{(m-1)Q}{M}<f_m<\frac{mQ}{M} \tag{6}$$

and

$$\frac{2\pi(n-1)}{N}<\theta_n<\frac{2\pi n}{N} \tag{7}$$

Φ_{mn} is an independent random variable which is uniformly distributed over the interval $(0, 2\pi)$.

According to the small amplitude theory, a wave number, k_m, and a frequency, f_m, are interrelated by

$$(2\pi f_m)^2=gk_m\tanh k_m d \tag{8}$$

Conventionally, Eq. (1) is often replaced by the following equation

$$\eta(x, y, t)=\int_0^\infty\int_0^{2\pi}\sqrt{4p(f, \theta)d\theta df}\cdot\cos(kx\cos\theta+ky\sin\theta-2\pi ft+\Phi) \tag{9}$$

This represents a limiting form of Eq. (1). Equation (9), however, is neither an integral in the sense of analysis, nor a stochastic integral. This integral will be called a pseudo-integral.

Similary, most wave properties can be written in terms of the pseudo-integral. The x and y component of horizontal water particle velocities at the space point (x, y, z) in the water depth of d are written as follows:

$$V_x(x, y, z;\ t)=2\int_0^\infty\int_0^{2\pi}\sqrt{p(f, \theta)d\theta df}\cdot(2\pi f)\cdot\cos\theta\cdot\frac{\cosh kz}{\sinh kd}$$

$$\times\cos(kx\cos\theta+ky\sin\theta-2\pi ft+\Phi) \tag{10}$$

$$V_y(x, y, z;\ t)=2\int_0^\infty\int_0^{2\pi}\sqrt{p(f,\ \theta)d\theta df}\cdot(2\pi f)\cdot\sin\theta\frac{\cosh kz}{\sinh kd}$$

$$\times\cos(kx\cos\theta+ky\sin\theta-2\pi ft+\Phi) \tag{11}$$

Acceleration can be expressed as

$$A_x(x,\ y,\ z;\ t)=2\int_0^\infty\int_0^{2\pi}\sqrt{p(f,\ \theta)d\theta df}\cdot(2\pi f)^2\cdot\cos\theta\left(\frac{\cosh kz}{\sinh kd}\right)$$

$$\times\sin(kx\cos\theta+ky\sin\theta-2\pi ft+\Phi) \tag{12}$$

$$A_y(x,\ y,\ z;\ t)=2\int_0^\infty\int_0^{2\pi}\sqrt{p(f,\ \theta)d\theta df}\cdot(2\pi f)^2\cdot\sin\theta\left(\frac{\cosh kz}{\sinh kd}\right)$$

$$\times\sin(kx\cos\theta+ky\sin\theta-2\pi ft+\Phi) \tag{13}$$

Pressure fluctuation, η_p, can be described as

$$\eta_p(x, y, z;\ t)=2\int_0^\infty\int_0^{2\pi}\sqrt{p(f,\ \theta)d\theta df}\cdot\left(\frac{\cosh kz}{\cosh kd}\right)\cdot\omega$$

$$\times\cos(kx\cos\theta+ky\sin\theta-2\pi ft+\Phi) \tag{14}$$

where ω: specific weight of sea water.

3. Representation for Wave Force Acting on a Sphere in the Water

A statistical theory for the force on a submerged object, caused by ocean waves has been developed by Pierson[11] (1963), Pierson and Holmes[12] (1965), Borgman[13] (1967), and Brown and Borgman[14] (1967). The basic underlying assumptions for the theory are that:

(a) The surface is a stationary, Gaussian stochastic process, and (b) the force is determined by the conventional engineering formula[15]

$$F=C_1V|V|+C_2A_\sigma \tag{15}$$

where V is water particle velocity and A_σ is water particle acceleration. In this paper, it will be assumed that: (1) V and A_σ are two component Gaussian stochastic processes over the space and time coordinates, at a fixed space position, (x, y, z), and instant in time, t, the random variables V and A_σ are independent with mean zero, and (2) the force formula given by Eq. (15) holds.

Then, the force equation for a sphere in the sea near the bottom can be as follows:

$$F=\frac{C_D\omega}{2g}\times(\pi r^2)\times V|V|+\frac{C_M\omega}{g}\left(\frac{4\pi r^3}{3}\right)\cdot A_\sigma \tag{16}$$

where r: radius of the sphere,
C_D: drag coefficient,
C_M: inertial coefficient,

g: acceleration of gravity,
and ω: specific weight of sea water.

In an approximate calculation, the term $V|V|$ in Eq. (15) can be assumed to be linearized by CV. According to Borgman[16] (1967), C is described in terms of the root-mean-square particle velocity, V_{rms}, as

$$C = V_{\rm rms}\sqrt{\frac{8}{\pi}} \tag{17}$$

Then, Eq. (16) becomes

$$F \doteqdot \frac{C_D\omega}{2g}(\pi r^2)\cdot C\cdot V + \frac{C_M\omega}{g}\left(\frac{4}{3}\pi r^3\right)A_O \tag{18}$$

Further, let us assume that x and y component of the wave force can be expressed as

$$F_x \doteqdot \frac{C_D\omega}{2g}(\pi r^2)\cdot C\cdot V_x + \frac{C_M\omega}{g}\left(\frac{4}{3}\pi r^3\right)A_x \tag{19}$$

and

$$F_y \doteqdot \frac{C_D\omega}{2g}(\pi r^2)\cdot C\cdot V_y + \frac{C_M\omega}{g}\left(\frac{4}{3}\pi r^3\right)A_y \tag{20}$$

Inserting Eq. (10) through Eq. (13) into Eq. (19) and (20), the pseudo-integral representation for the components of the wave force are obtained as

$$\begin{aligned} F_x(x, y, z; t) \doteqdot & \frac{C_D\omega}{2g}(\pi r^2)\cdot C\cdot 2\int_0^\infty\int_0^{2\pi}\sqrt{p(f, \theta)d\theta df}\cdot(2\pi f)\left(\frac{\cosh kz}{\sinh kd}\right) \\ & \times\cos\theta\cdot\cos(kx\cos\theta + ky\sin\theta - 2\pi ft + \Phi) \\ & + \frac{C_M\omega}{g}\left(\frac{4}{3}\pi r^3\right)\cdot 2\int_0^\infty\int_0^{2\pi}\sqrt{p(f, \theta)d\theta df}\cdot(2\pi f)^2\left(\frac{\cosh kz}{\sinh kd}\right) \\ & \times\cos\theta\sin(kx\cos\theta + ky\sin\theta - 2\pi ft + \Phi) \end{aligned} \tag{21}$$

$$\begin{aligned} F_y(x, y, z; t) \doteqdot & \frac{C_D\omega}{2g}(\pi r^2)\cdot C\cdot 2\int_0^\infty\int_0^{2\pi}\sqrt{p(f, \theta)d\theta df}\cdot(2\pi f)\left(\frac{\cosh kz}{\sinh kd}\right) \\ & \times\sin\theta\cdot\cos(kx\cos\theta + ky\sin\theta - 2\pi ft + \Phi) \\ & + \frac{C_M\omega}{g}\left(\frac{4}{3}\pi r^3\right)\cdot 2\int_0^\infty\int_0^{2\pi}\sqrt{p(f, \theta)d\theta df}\cdot(2\pi f)^2\left(\frac{\cosh kz}{\sinh kd}\right) \\ & \times\sin\theta\sin(kx\cos\theta + ky\sin\theta - 2\pi ft + \Phi) \end{aligned} \tag{22}$$

4. Determination of the Directional Spectra for Surface Waves

Suppose we have the following data:

(a) $\eta(x, y, t)$; a record of the sea surface variation at a space point (x, y) with respect to time t,

(b) $F_x(x, y, z; t)$; a record of x component wave force acting on a sphere at a space point, (x_1, y_1, z_1), with respect to time, t, and

(c) $F_y(x, y, z; t)$; a record of y component wave force acting on a sphere at a space point, (x_2, y_2, z_2), with respect to time, t.

The problem to be solved is how to determine the approximate two-dimensional spectra using the records.

Since these data are considered to be one realization of a random stochastic process which is stationary and has a zero mean, cross-spectrum densities in terms of the directional spectral density can be determined by taking the Fourier transform of cross covariance functions for the data.

The calculations for the cross-covariance function and the cross-spectrum density for the wave properties will be discussed first and the method of the determination of the approximate directional spectra will be discussed next in this section.

4.1 Cross-covariance functions

Let $X_1(x, y, t)$ and $X_2(x, y, t)$ be two real Gaussian stationary stochastic processes with parameters x, y and t, and with zero mean, then, the cross-covariance function, $C_{X_1X_2}$, for X_1 and X_2 is defined as

$$C_{X_1X_2}(g, h, \tau)=\mathrm{COV}[X_1(x, y, t), X_2(x+g, y+h, t+\tau]$$
$$=E[X_1(x, y, t)X_2(x+g, y+h, t+\tau)] \tag{23}$$

where g is the lag in x, h the lag in y, and τ the lag in t. $E[\ ]$ denotes the expectation operation.

Using Eq. (9), covariance function for η, $C_{\eta\eta}$, can be obtained as follows:

$$C_{\eta\eta}(g, h, \tau)=E[\eta(x, y, t)\eta(x+g, y+h, t+\tau)] \tag{24}$$

Let $C_{\eta\eta(mn)}(g, h, \tau)$ be the covariance of the (m, n)-th term in the sum in Eq. (1) with itself lagged. Then referring to Eq. (1),

$$C_{\eta\eta(mn)}(g, h, \tau)=E[4p(f_m, \theta_n)\Delta f\Delta\theta\cos(k_m x\cos\theta_n+k_m y\sin\theta_n$$
$$-2\pi f_m t+\Phi_{mn})\cdot\cos\{k_m(x+g)\cos\theta_n+k_m(y+h)\sin\theta-2\pi f_m(t+\tau)+\Phi_{mn}\}]$$
$$=E[4p(f_m, \theta)\Delta f\Delta\theta\cdot\frac{1}{2}\{\cos(k_m g\cos\theta_n+k_m h\sin\theta-2\pi f_m\tau)$$
$$+\cos(k_m(2x+g)\cos\theta_n+k_m(2y+h)\sin\theta_n-2\pi f_m(2t+\tau)+2\Phi_{mn})\}] \tag{25}$$

Since the expectation of cosine term including random phase, Φ is zero,

$$E[\cos(\varphi+\Phi)]=\frac{1}{2\pi}\int_0^{2\pi}\cos(\varphi+\Phi)d\Phi=0 \tag{26}$$

then, the second term in Eq. (25) is zero. Eq. (25) becomes

$$C_{\eta\eta(mn)}(g, h, \tau)=2p(f_m, \theta_n)\cos(k_m g\cos\theta_n+k_m h\sin\theta_n-2\pi f\tau) \tag{27}$$

Since the cross products are zero by the assumption of independence, the covariance function for η is obtained by taking summation of Eq. (27) with respect to f and θ, and in the limit, $C_{\eta\eta}$ becomes

$$C_{\eta\eta}(g,\ h,\ \tau)=\int_0^\infty\int_0^{2\pi}2p(f,\ \theta)\cos(kg\cos\theta+kh\sin\theta-2\pi f\tau)d\theta df \tag{28}$$

Similary, covariance functions for the wave properties are obtained as follows:

Let

$$K_D=C_D\frac{\omega}{2g}\pi r^2C$$

$$K_M=C_M\frac{\omega}{g}\frac{4}{3}\pi r^3$$

so that

$$F_x=K_DV_x+K_MA_x$$

$$F_y=K_DV_y+K_MA_y$$

$$\begin{aligned}
C_{\eta F_x}(g,\ h,\ \tau)&=\mathrm{COV}\,[\eta(x,\ y,\ t),\ F_x(x+g,\ y+h,\ t+\tau)]\\
&=\mathrm{COV}\,[\eta(x,\ y,\ t),\ K_DV_x+K_MA_x]\\
&=E[\eta(x,\ y,\ t)K_DV_x(x+g,\ y+h,\ t+\tau)]\\
&\quad+E[\eta(x,\ y,\ t)K_MA_x(x+g,\ y+h,\ t+\tau)]\\
&=E\Big[2\int_0^\infty\int_0^{2\pi}\sqrt{p(f,\ \theta)d\theta df}\cos(kx\cos\theta+ky\sin\theta-2\pi ft+\Phi)\\
&\quad\times2\int_0^\infty\int_0^{2\pi}\sqrt{p(f,\ \theta)d\theta df}\cdot K_D\cdot2\pi f\cdot\frac{\cosh kz}{\sinh kd}\cos\theta\\
&\quad\times\cos\{k(x+g)\cos\theta+k(y+h)\sin\theta-2\pi f(t+\tau)+\Phi\}\Big]\\
&\quad+E\Big[2\int_0^\infty\int_0^{2\pi}\sqrt{p(f,\ \theta)d\theta df}\cos(kx\cos\theta+ky\sin\theta-2\pi ft+\Phi)\\
&\quad\times2\int_0^\infty\int_0^{2\pi}\sqrt{p(f,\ \theta)d\theta df}\cdot K_M\cdot(2\pi f)^2\left(\frac{\cosh kz}{\sinh kd}\right)\cdot\cos\theta\\
&\quad\times\sin\{k(x+g)\cos\theta+k(y+h)\sin\theta-2\pi f(t+\tau)+\Phi\}\Big]\\
&=2\int_0^\infty\int_0^{2\pi}p(f,\ \theta)K_D2\pi f\frac{\cosh kz}{\sinh kd}\cos\theta\\
&\quad\times\cos(kg\cos\theta+kh\sin\theta-2\pi f\tau)d\theta df\\
&\quad+2\int_0^\infty\int_0^{2\pi}p(f,\ \theta)K_M(2\pi f)^2\left(\frac{\cosh kz}{\sinh kd}\right)\cos\theta\\
&\quad\times\sin(kg\cos\theta+kh\sin\theta-2\pi f\tau)d\theta df
\end{aligned}$$

Let

$$C_D''=K_D\frac{\cosh kz}{\sinh kd}(2\pi f) \tag{29}$$

$$C_M''=K_M\left(\frac{\cosh kz}{\sinh kd}\right)(2\pi f)^2 \tag{30}$$

then

$$C_{\eta F_x}(g,\ h,\ \tau)=\int_0^\infty\int_0^{2\pi} C_D'' 2p(f,\ \theta)\cos\theta$$
$$\times\cos(kg\cos\theta+kh\sin\theta-2\pi f\tau)d\theta df$$
$$+\int_0^\infty\int_0^{2\pi} C_M''\cdot 2p(f,\ \theta)\cos\theta$$
$$\times\sin(kg\cos\theta+kh\sin\theta-2\pi f\tau)d\theta df \qquad (31)$$

$$C_{\eta F_y}(g,\ h,\ \tau)=\int_0^\infty\int_0^{2\pi} C_D''\cdot 2p(f,\ \theta)\sin\theta$$
$$\times\cos(kg\cos\theta+kh\sin\theta-2\pi f\tau)d\theta df$$
$$+\int_0^\infty\int_0^{2\pi} C_M''\cdot 2p(f,\ \theta)\sin\theta$$
$$\times\sin(kg\cos\theta+kh\sin\theta-2\pi f\tau)d\theta df \qquad (32)$$

$$C_{F_xF_x}(g,\ h,\ \tau)=\mathrm{COV}\,[F_x(x,\ y,\ t),\ F_x\{(x+g),\ (y+h),\ (t+\tau)\}]$$
$$=E[F_x(x,\ y,\ t)F_x(x+g,\ y+h,\ t+\tau)]$$
$$=E[\{K_DV_x(x,\ y,\ t)+K_MA_x(x,\ y,\ t)\}$$
$$\times\{K_DV_x(x+g,\ y+h,\ t+\tau)+K_MA_x(x+g,\ y+h,\ t+\tau)\}]$$
$$=K_D^2E[V_x(x,\ y,\ t)V_x(x+g,\ y+h,\ t+\tau)]$$
$$+K_M^2E[A_x(x,\ y,\ t)A_x(x+g,\ y+h,\ t+\tau)]$$
$$+K_DK_ME[A_x(x,\ y,\ t)V_x(x+g,\ y+h,\ t+\tau)]$$
$$+K_MK_DE[V_x(x,\ y,\ t)A_x(x+g,\ y+h,\ t+\tau)] \qquad (33)$$

Since

$$E[A_x(x,\ y,\ t)V_x(x+g,\ y+h,\ t+\tau)]$$
$$=-E[V_x(x,\ y,\ t)A_x(x+g,\ y+h,\ t+\tau)]$$

the last two terms in Eq. (33) are cancelled.

$$C_{F_xF_x}(g,\ h,\ \tau)=K_D^2E\Bigg[\Bigg\{2\int_0^\infty\int_0^{2\pi}\sqrt{p(f,\ \theta)d\theta df}\cdot(2\pi f)\cdot\frac{\cosh kz}{\sinh kd}\cos\theta$$
$$\times\cos(kx\cos\theta+ky\sin\theta-2\pi ft+\Phi)\Bigg\}$$
$$\times\Bigg\{2\int_0^\infty\int_0^{2\pi}\sqrt{P(f,\ \theta)d\theta df}\cdot(2\pi f)\cdot\frac{\cosh kz}{\sinh kd}\cos\theta$$
$$\times\cos(k(x+g)\cos\theta+k(y+h)\sin\theta-2\pi f(t+\tau)+\Phi)\Bigg\}\Bigg]$$
$$+\text{inentia term}$$
$$=2\int_0^\infty\int_0^{2\pi}(C_D''^2+C_M''^2)P(f,\ \theta)\cos^2\theta$$
$$\times\cos(kg\cos\theta+kh\sin\theta-2\pi f\tau)d\theta df \qquad (34)$$

Similarly $C_{F_yF_y}$ and $C_{F_xF_y}$ are obtained as follows.

$$C_{F_yF_y}(g,\ h,\ \tau)=2\int_0^\infty\int_0^{2\pi}(C_D''^2+C_M''^2)p(f,\ \theta)\sin^2\theta$$

$$\times\cos(kg\cos\theta+kh\sin\theta-2\pi f\tau)d\theta df \tag{35}$$

$$C_{F_xF_y}(g,\ h,\ \tau)=2\int_0^\infty\int_0^{2\pi}(C_D''^2+C_M''^2)p(f,\ \theta)\sin\theta\cos\theta$$

$$\times\cos(kg\cos\theta+kh\sin\theta-2\pi f\tau)d\theta df \tag{36}$$

4.2 Spectral densities; Auto-, Co-, and Quadrature-spectrum

For the one-dimensional and real Gaussian stationary processes $X_1(t)$ and $X_2(t)$, covariance function for them, $C_{x_1x_2}(\tau)$, is formulated by cross-spectral density, $P_{x_1x_2}(f)$, as

$$C_{x_1x_2}(\tau)=\int_{-\infty}^\infty P_{x_1x_2}(f)e^{-i2\pi f\tau}df \tag{37}$$

$P_{x_1x_2}(f)$ is represented by real and imaginary part as

$$P_{x_1x_2}(f)=co(f)-iq(f) \tag{38}$$

$co(f)$ is called co-spectral density and $q(f)$ is called quadrature spectral density. Using Eq. (38), $C_{x_1x_2}(\tau)$ is formulated in terms of $co(f)$ and $q(f)$ as follows.

$$\begin{aligned}C_{x_1x_2}(\tau)&=\int_{-\infty}^\infty P_{x_1x_2}(f)e^{i2\pi f\tau}df\\&=\int_{-\infty}^\infty[co(f)-iq(f)][\cos 2\pi f\tau+i\sin 2\pi f\tau]df\\&=\int_{-\infty}^\infty co(f)\cos 2\pi f\tau df+\int_{-\infty}^\infty q(f)\sin 2\pi f\tau df\\&\quad+i\int_{-\infty}^\infty co(f)\sin 2\pi f\tau df-i\int_{-\infty}^\infty q(f)\cos 2\pi f\tau df\end{aligned} \tag{39}$$

The last two integrals are zero since the integrands are odd functions of f. Since the remaining integrands are even, integrand may be restricted to $(0\sim\infty)$.

$$C_{x_1x_2}(\tau)=2\int_0^\infty co(f)\cos 2\pi f\tau df+2\int_0^\infty q(f)\sin 2\pi f\tau df \tag{40}$$

Using trigonometric identity, Eq. (28) can be written as

$$\begin{aligned}C_{\eta\eta}(g,\ h,\ \tau)&=\int_0^\infty\int_0^{2\pi}2p(f,\ \theta)\cos(kg\cos\theta+kh\sin\theta-2\pi f\tau)d\theta df\\&=2\int_0^\infty\left\{\int_0^{2\pi}p(f,\ \theta)\cos(kg\cos\theta+kh\sin\theta)d\theta\right\}\cos 2\pi f\tau df\\&\quad+2\int_0^\infty\left\{\int_0^{2\pi}p(f,\ \theta)\sin(kg\cos\theta+kh\sin\theta)d\theta\right\}\sin 2\pi f\tau df\end{aligned} \tag{41}$$

Comparing Eq. (41) with Eq. (40), co-spectrum and quadrature spectrum for

$\eta(x, y, t)$ can be obtained as a function of frequency in terms of $p(f, \theta)$ as follows:

$$\left.\begin{aligned} co_{\eta\eta}(f)&=\int_0^{2\pi} p(f, \theta)\cos(kg\cos\theta+kh\sin\theta)d\theta \\ q_{\eta\eta}(f)&=\int_0^{2\pi} p(f, \theta)\sin(kg\cos\theta+kh\sin\theta)d\theta \end{aligned}\right\} \tag{42}$$

Therefore, the cross- spectral density for η, $P_{\eta\eta}$, is obtained as

$$\begin{aligned} P_{\eta\eta}(f)&=co_{\eta\eta}(f)-iq_{\eta\eta}(f) \\ &=\int_0^{2\pi} p(f, \theta)\cos(kg\cos\theta+kh\sin\theta)d\theta \\ &\quad -i\int_0^{2\pi} p(f, \theta)\sin(kg\cos\theta+kh\sin\theta)d\theta \end{aligned} \tag{43}$$

Similarly, co- and quadrature- spectral density can be obtained for the wave properties as a function of f, in terms of $p(f, \theta)$.

Hereafter, (   ) denotes $(kg\cos\theta+kh\sin\theta)$.

$$\left.\begin{aligned} co_{F_xF_x}(f)&=\int_0^{2\pi} (C_D''^2+C_M''^2)p(f, \theta)\cos^2\theta\cos(\quad)d\theta \\ q_{F_xF_x}(f)&=\int_0^{2\pi} (C_D''^2+C_M''^2)p(f, \theta)\cos^2\theta\sin(\quad)d\theta \end{aligned}\right\} \tag{44}$$

$$\left.\begin{aligned} co_{F_yF_y}(f)&=\int_0^{2\pi} (C_D''^2+C_M''^2)p(f, \theta)\sin^2\theta\cos(\quad)d\theta \\ q_{F_yF_y}(f)&=\int_0^{2\pi} (C_D''^2+C_M''^2)p(f, \theta)\sin^2\theta\sin(\quad)d\theta \end{aligned}\right\} \tag{45}$$

$$\left.\begin{aligned} co_{\eta F_x}(f)&=\int_0^{2\pi} C_D''p(f, \theta)\cos\theta\cos(\quad)d\theta \\ &\quad+\int_0^{2\pi} C_M''p(f, \theta)\cos\theta\sin(\quad)d\theta \\ q_{\eta F_y}(f)&=\int_0^{2\pi} C_D''p(f, \theta)\cos\theta\sin(\quad)d\theta \\ &\quad+\int_0^{2\pi} C_M''p(f, \theta)\cos\theta\cos(\quad)d\theta \end{aligned}\right\} \tag{46}$$

$$\left.\begin{aligned} co_{\eta F_y}(f)&=\int_0^{2\pi} C_D''p(f, \theta)\sin\theta\cos(\quad)d\theta \\ &\quad+\int_0^{2\pi} C_M''p(f, \theta)\sin\theta\sin(\quad)d\theta \\ q_{\eta F_y}(f)&=\int_0^{2\pi} C_D''p(f, \theta)\sin\theta\sin(\quad)d\theta \\ &\quad+\int_0^{2\pi} C_M''p(f, \theta)\sin\theta\cos(\quad)d\theta \end{aligned}\right\} \tag{47}$$

$$\left.\begin{aligned} co_{F_xF_y}(f) &= \int_0^{2\pi} (C_D''^2 + C_M''^2) p(f, \theta) \sin\theta \cos\theta \cos(\quad) d\theta \\ q_{F_xF_y}(f) &= \int_0^{2\pi} (C_D''^2 + C_M''^2) p(f, \theta) \sin\theta \cos\theta \sin(\quad) d\theta \end{aligned}\right\} \tag{48}$$

4.3 Directional spectrum for surface waves.

Since the co- and quadrature- spectrum in Eq. (43) through Eq. (48) can be obtained by the data, the problem becomes how to determine $p(f, \theta)$ in Eq. (43) through Eq. (48).

Let us assume that $p(f, \theta)$ can be formulated as

$$p(f, \theta) = P_\eta(f) h(\theta) \tag{49}$$

$P_\eta(f)$ is power spectrum for sea surface. According to Mobarek[3], $h(\theta)$ can be well represented by the probability density of the circular normal distribution[17,18] as follows:

$$h(\theta) = \frac{e^{a\cos(\theta-\gamma)}}{2\pi I_0(a)} \tag{50}$$

where a is a constant and a measure of the concentration around the mean, γ is a constant angle and at which the maximum energy is advancing, θ is the direction of advance for the wavelet, and $I_0(a)$ is the modified Bessel function of 1st kind. $\frac{1}{2\pi}$ is a normalizing factor which makes the integral, $\int_0^{2\pi} h(\theta) d\theta$, be unity. Because $I_n(a)$ is defined as

$$I_n(a) = \frac{1}{2\pi} \int_0^{2\pi} e^{a\cos\theta} \cos n\theta d\theta$$

when n is an integer, then

$$\frac{1}{2\pi I_0(a)} \int_0^{2\pi} e^{a\cos\theta} d\theta = 1$$

Some properties of the function given by Eq. (50) are that:

(a) $h(\theta)$ is symmetric about $\theta = \gamma$

(b) $h(\theta)$ has the maximum value, $\frac{e^a}{2\pi I_0(a)}$, at $\theta = \gamma$

(c) $h(\theta)$ has approximate inflection point at $\theta = \gamma + \frac{1}{\sqrt{a}}$

Let $g = D\cos\beta$ and $h = D\sin\beta$, then,

$$kg\cos\theta + kh\sin\theta = kD\cos\beta\cos\theta + kD\sin\beta\sin\theta = kD\cos(\theta-\beta)$$

Eq. (43) becomes

$$\begin{aligned} P_{\eta\eta}(f) &= \int_0^{2\pi} p(f, \theta)[\cos\{kD\cos(\theta-\beta)\} - i\sin\{kD\cos(\theta-\beta)\}] d\theta \\ &= \int_0^{2\pi} p(f, \theta) e^{-ikD\cos(\theta-\beta)} d\theta \end{aligned}$$

Using Eq. (49) and Eq. (50),

$$P_{\eta\eta}(f)=\frac{P_\eta(f)}{2\pi I_0(a)}\int_0^{2\pi}e^{a\cos(\theta-\gamma)}e^{-ikD\cos(\theta-\beta)}d\theta.$$

Changing the variable so that

$$\theta-\gamma=\alpha \tag{55}$$

then, $\theta-\beta=\alpha+\gamma-\beta$ and

$$P_{\eta\eta}(f)=\frac{P_\eta(f)}{2\pi I_0(a)}\int_{-\gamma}^{2\pi-\gamma}e^{a\cos\alpha}e^{-ikD\cos(\alpha+\gamma-\beta)}d\alpha$$

Using the well known relation given by Eq. (56)

$$e^{a\cos\alpha}=I_0(a)+2\sum_{p=1}^{\infty}I_p(a)\cos(p\alpha) \tag{56}$$

the periodicity of the function, $e^{a\cos\alpha}$, and changing the order of integration and summation, then we obtain

$$P_{\eta\eta}(f)=\frac{P_\eta(f)\times 2\times I_0(a)}{2\pi I_0(a)}\int_0^{\pi}e^{-ikD\cos(\alpha+\gamma-\beta)}d\alpha$$

$$+\frac{P_\eta(f)}{\pi I_0(a)}\cdot 2\sum_{p=1}^{\infty}I_p(a)\int_0^{\pi}\cos(p\alpha)e^{-ikD\cos(\alpha+\gamma-\beta)}d\alpha$$

where p is an integer.
Changing the variable again so that

$$\alpha+\gamma-\beta=\lambda,\ \text{then,}$$

$$P_{\eta\eta}(f)=\frac{2I_0(a)p_\eta(f)}{2\pi I_0(a)}\int_0^{\pi}e^{-ikD\cos\lambda}d\lambda$$

$$+\frac{P_\eta(f)}{\pi I_0(a)}\times 2\sum_{p=1}^{\infty}I_p(a)\int_0^{\pi}\cos\{p(\lambda-\gamma+\beta)\}e^{-ikD\cos\lambda}d\lambda$$

Using the trigonometric identity

$$\cos\{p(\lambda-\gamma+\beta)\}=\cos(p\lambda)\cos\{p(\gamma-\beta)\}+\sin p\lambda\sin\{p(\gamma-\beta)\} \tag{57}$$

and paying attention to the fact that

$$\int_0^{\pi}e^{-ikD\cos\lambda}\cdot b\cdot\sin n\lambda d\lambda=0 \tag{58}$$

then, the second term in the above equation becomes

$$\frac{P_\eta(f)}{\pi I_0(a)}\cdot 2\sum_{p=1}^{\infty}I_p(a)\int_0^{\pi}\cos(p\lambda)\cos\{p(\gamma-\beta)\}e^{-ikD\cos\lambda}d\lambda$$

Using the expression for the Bessel function of 1st kind as follows:

$$J_n(x)=\frac{1}{\pi(-i)^n}\int_0^{\pi}e^{-ix\cos\alpha}\cos n\alpha d\alpha$$

$$=\frac{1}{\pi(i)^n}\int_0^{\pi} e^{ix\cos\alpha}\cos n\alpha d\alpha \tag{59}$$

The cross-spectral density between the time series $\eta(x, y, t)$ and $\eta(x+g, y+h, t)$ denoted as $P_{\eta\eta}(f)$, can be written

$$P_{\eta\eta}(f)=P_{\eta}(f)\left[J_0(kD)+\frac{2}{I_0(a)}\sum_{p=1}^{\infty} I_p(a)J_p(kD)\cos p(\gamma-\beta)(-i)^p\right] \tag{60}$$

After similar calculation for the wave property, the cross-spectrum density can be obtained in terms of the Bessel function and $p_\eta(f)$ as follows:
Let $P_{F_xF_x}(f)$ be the cross-spectral density between the time series $F_x(x, y, t)$ and $F_x(x+g, y+h, t)$ then

$$\begin{aligned}P_{F_xF_x}(f)=\frac{p_\eta(f)(C_D''^2+C_M''^2)}{2}\Big[&J_0(kD)+\cos 2\beta J_2(kD)(-i)^2\\&+\sum_{p=1}^{\infty}\left\{\frac{2\cdot I_p(a)}{I_0(a)}J_p(kD)\cos p(\gamma-\beta)(-i)^p\right.\\&+\frac{I_p(a)}{I_0(a)}\cos\{p\gamma+(2-p)\beta\}(-i)^{p-2}J_{p-2}(kD)\\&\left.+\frac{I_p(a)}{I_0(a)}\cos\{p\gamma-(2+p)\beta\}(-i)^{p+2}J_{p+2}(kD)\right\}\Big]\end{aligned} \tag{61}$$

$$\begin{aligned}P_{F_yF_y}(f)=\frac{P_\eta(f)(C_D''^2+C_M''^2)}{2}\Big[&J_0(kD)-\cos 2\beta J_2(kD)(-i)^2\\&+\sum_{p=1}^{\infty}\left\{\frac{2\times I_p(a)}{I_0(a)}J_p(kD)\cos p(\gamma-\beta)(-i)^p\right.\\&-\frac{I_p(a)}{I_0(a)}\cos\{p\gamma+(2-p)\beta\}(-i)^{p-2}J_{p-2}(kD)\\&\left.-\frac{I_p(a)}{I_0(a)}\cos\{p\gamma-(2+p)\beta\}(-i)^{p+2}J_{p+2}(kD)\right\}\Big]\end{aligned} \tag{62}$$

$$\begin{aligned}P_{F_xF_y}(f)=\frac{P_\eta(f)(C_D''^2+C_M''^2)}{2}\Big[&\sin 2\beta J_2(kD)(-i)^2\\&+\sum_{p=1}^{\infty}\frac{I_p(a)}{I_0(a)}\sin\{(2+p)\beta-p\gamma\}J_{p+2}(kD)(-i)^{p+2}\\&+\sum_{p=1}^{\infty}\frac{I_p(a)}{I_0(a)}\sin\{(2-p)\beta+p\gamma\}\cdot J_{p-2}(kD)(-i)^{p-2}\end{aligned} \tag{63}$$

$$\begin{aligned}P_{\eta F_x}(f)=&C_D''\cdot \boldsymbol{Real}\{L(a,\gamma)\}+C_M''\cdot \boldsymbol{Imag}\{L(a,\gamma)\}\\&-iC_D''\times \boldsymbol{Imag}\{L(a,\gamma)\}-iC_M''\boldsymbol{Real}\{L(a,\gamma)\}\end{aligned}$$

where

$$L(a,\gamma)=P_\eta(f)\left[i\cos\beta\cdot J_1(kD)+\sum_{p=1}^{\infty}\frac{I_p(a)}{I_0(a)}\cos\{p\gamma+(1-p)\beta\}i^{p-1}J_{p-1}(kD)\right.$$

$$+\sum_{p=1}^{\infty}\frac{I_p(a)}{I_0(a)}\cos\{p\gamma-(1+p)\beta\}i^{p+1}J_{p+1}(kD)\Big] \tag{64}$$

$$P_{\eta F_y}(f)=C''_D\cdot Real\{L'(a,\gamma)\}+C''_M\cdot Imag\{L'(a,\gamma)\}$$
$$-iC''_D Imag\{L'(a,\gamma)\}-iC''_M\cdot Real\{L'(a,\gamma)\}$$

where

$$L'(a,\gamma)=P_\eta(f)\Big[i\sin\beta\cdot J_1(kD)+\sum_{p=1}^{\infty}\frac{I_p(a)}{I_0(a)}\sin\{p\gamma+(1-p)\beta\}(i)^{p-1}J_{p-1}(kD)$$
$$-\sum_{p=1}^{\infty}\frac{I_p(a)}{I_0(a)}\sin\{p\gamma-(1+p)\beta\}(i)^{p+1}J_{p+1}(kD)\Big] \tag{65}$$

The unknown parameters, a and γ, in Eq. (50) can be determined by means of the least square fitting method using the Eq. (60) through (65). For the actual computation, co- and quadrature- spectrum should be written separately and the values, a and γ, should be calculated for each co- and quadrature- spectrum.

4.4 Simplification of the Representations for the Wave Properties

The geographical condition of the wave meter and the wave direction meter

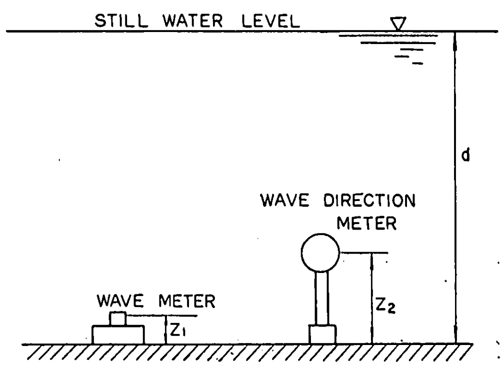

Fig. 1. Schematic figure of the installation of the wave meter and the wave direction meter

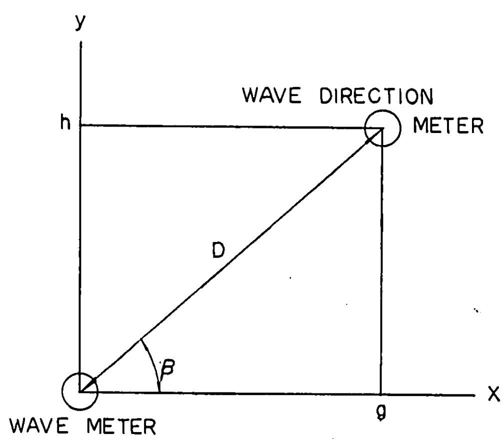

Fig. 2. Relationship between the wave meter installation point and the wave direction meter installation point

may be as shown in Fig. 1 and Fig. 2. The horizontal distance, D, between the wave meter and the wave direction meter could be small enough to be neglected in comparison with the wave length, that is

$$D \doteqdot 0 \tag{66}$$

then, g and h may be approximately zero. Therefore, the term, $(kg\cos\theta+kh\sin\theta)$, in Eqs. (43) through (48) may be approximately zero, that is

$$kg\cos\theta+kh\sin\theta \doteqdot 0 \tag{67}$$

In substituting Eq. (67) into Eqs. (43) through (48), following results are obtained.

$$\hat{P}_{\eta\eta}(f)=\hat{co}_{\eta\eta}(f)=\int_0^{2\pi} p(f,\theta)d\theta=P_\eta(f) \tag{68}$$

$$\hat{P}_{F_xF_x}(f)=\hat{co}_{F_xF_x}(f)=\{(C_D''^2)+(C_M''^2)\}\int_0^{2\pi} p(f,\theta)\cos^2\theta d\theta=P_{F_x}(f) \tag{69}$$

$$\hat{P}_{F_yF_y}(f)=\hat{co}_{F_yF_y}(f)=\{(C_D''^2)+(C_M''^2)\}\int_0^{2\pi} p(f,\theta)\sin^2\theta d\theta=P_{F_y}(f) \tag{70}$$

where $P_{F_x}(f)$ and $P_{F_y}(f)$ denote power spectra for F_x and F_y respectively.

$$\hat{P}_{\eta F_x}(f)=co_{\eta F_x}(f)-i\hat{q}_{\eta F_x}(f)$$

$$=C_D''\int_0^{2\pi} p(f,\theta)\cos\theta d\theta-iC_M''\int_0^{2\pi} p(f,\theta)\cos\theta d\theta \tag{71}$$

$$\hat{P}_{\eta F_y}(f)=\hat{co}_{\eta F_y}(f)-i\hat{q}_{\eta F_x}(f)$$

$$=C_D''\int_0^{2\pi} p(f,\theta)\sin\theta d\theta-iC_M''\int_0^{2\pi} p(f,\theta)\sin\theta d\theta \tag{72}$$

$$\hat{P}_{F_xF_y}(f)=\hat{co}_{F_xF_y}(f)=\{(C_D'')^2+(C_M'')^2\}\int_0^{2\pi} p(f,\theta)\sin\theta\cos\theta d\theta \tag{73}$$

These relationships can can obtained by Eqs. (28), (31) through (36), assuming g and $h=0$.

Eqs. (69) through (73) are written in terms of the modified Bessel function of 1st kind assuming that $p(f,\theta)$ can be formulated by Eq. (49) and Eq. (50) as before.

$$\hat{P}_{F_xF_x}(f)=\{(C_D'')^2+(C_M'')^2\}\frac{P_\eta(f)}{2}\left\{1+\cos 2\gamma\frac{I_2(a)}{I_0(a)}\right\} \tag{74}$$

$$\hat{P}_{F_yF_y}(f)=\{(C_D'')^2+(C_M'')^2\}\frac{P_\eta(f)}{2}\left\{1-\cos 2\gamma\frac{I_2(a)}{I_0(a)}\right\} \tag{75}$$

$$\hat{P}_{\eta F_x}(f)=\hat{co}_{\eta F_x}(f)-i\hat{q}_{\eta F_x}(f)$$

$$=C_D''P_\eta(f)\cos\gamma\frac{I_1(a)}{I_0(a)}-iC_M''P_\eta(f)\cos\gamma\frac{I_1(a)}{I_0(a)} \tag{76}$$

$$\hat{P}_{\eta F_y}(f)=\hat{co}_{\eta F_y}(f)-i\hat{q}_{\eta F_x}(f)$$

$$=C''_D P_\eta(f)\sin\gamma\frac{I_1(a)}{I_0(a)}-iC''_M P_\eta(f)\sin\gamma\frac{I_1(a)}{I_0(a)} \tag{77}$$

$$\hat{P}_{F_xF_y}(f)=\{(C''_D)^2+(C''_M)^2\}\frac{P_\eta(f)}{2}\sin 2\gamma\frac{I_2(a)}{I_0(a)} \tag{78}$$

Since Eq. (76) and Eq. (77) consist of co- and quadrature- spectrum while the others such as Eq. (74), (75), and (78) contain only co-spectrum, seven relations are available to determine the values, a and γ, in Eq. (50). Therefore the values can be determined by ${}_7C_2=21$ pairs of the relations in the sense of the least square method. Plotting the obtained a and γ values in (a, γ) plane, the most probable value for a and γ can be obtained. Since the relations given by Eq. (75) through Eq. (78) would hold for each frequency, f, then a and γ might be a function of frequency.

The values, a and γ, also can be determined by the only one time use of whole relations given by Eq. (68), and Eq. (74) through Eq. (78).

Subtracting Eq. (74) from Eq. (75), we obtain

$$\hat{co}_{F_xF_x}(f)-\hat{co}_{F_yF_y}(f)=\{(C''_D)^2+(C''_M)^2\}P_\eta(f)\cos 2\gamma\frac{I_2(a)}{I_0(a)} \tag{79}$$

By Eq. (78), Eq. (79) and well known trigonometric identity such as

$$\cos^2 2\gamma+\sin^2 2\gamma=1$$

$\dfrac{I_0(a)}{I_2(a)}$ can be obtained in terms of the results of the calculation of the data.

$$\frac{I_0(a)}{I_2(a)}=\frac{\{(C''_D)^2+(C''_M)^2\}P_\eta(f)}{\sqrt{\{\hat{co}_{F_xF_x}(f)-\hat{co}_{F_yF_y}(f)\}^2+\{2\cdot\hat{co}_{F_xF_y}(f)\}^2}} \tag{80}$$

Substituting Eq. (80) into Eq. (78) and Eq. (79), $\cos 2\gamma$ and $\sin 2\gamma$ can be obtained as

$$\cos 2\gamma=\frac{\hat{co}_{F_xF_x}(f)-\hat{co}_{F_yF_y}(f)}{\sqrt{\{\hat{co}_{F_xF_x}(f)-\hat{co}_{F_yF_y}(f)\}^2+\{2\cdot\hat{co}_{F_xF_y}(f)\}^2}} \tag{81}$$

$$\sin 2\gamma=\frac{2\cdot\hat{co}_{F_xF_y}(f)}{\sqrt{\{\hat{co}_{F_xF_x}(f)-\hat{co}_{F_yF_y}(f)\}^2+\{2\cdot\hat{co}_{F_xF_y}(f)\}^2}} \tag{82}$$

Similarly, by Eq. (77) and Eq. (76), $\dfrac{I_0(a)}{I_1(a)}$, $\cos\gamma$, and $\sin\gamma$ values can be obtained as follows:

$$\frac{I_0(a)}{I_1(a)}=\frac{C''_D P_\eta(f)}{\sqrt{\{\hat{co}_{\eta F_x}(f)\}^2+\{\hat{co}_{\eta F_y}(f)\}^2}}=\frac{C''_M P_\eta(f)}{\sqrt{\{\hat{q}_{\eta F_x}(f)\}^2+\{\hat{q}_{\eta F_y}(f)\}^2}} \tag{83}$$

$$\cos\gamma=\frac{\hat{co}_{\eta F_x}(f)}{\sqrt{\{\hat{co}_{\eta F_x}(f)\}^2+\{\hat{co}_{\eta F_y}(f)\}^2}}=\frac{\hat{q}_{\eta F_x}(f)}{\sqrt{\{\hat{q}_{\eta F_x}(f)\}^2+\{\hat{q}_{\eta F_y}(f)\}^2}} \tag{84}$$

$$\sin\gamma=\frac{\hat{co}_{\eta F_x}(f)}{\sqrt{\{\hat{co}_{\eta F_x}(f)\}^2+\{\hat{co}_{\eta F_y}(f)\}^2}}=\frac{\hat{q}_{\eta F_y}(f)}{\sqrt{\{\hat{q}_{\eta F_x}(f)\}^2+\{\hat{q}_{\eta F_y}(f)\}^2}} \tag{85}$$

Taking the average value of a and γ, which are estimated by Eqs. (80) through (85), an approximate pair of a and γ can be obtained for each frequency. It is very interesting to note that the expressions for sine and cosine values do not include the unknown factors C_D and C_M.

4.5 Application for the Use of a Pressure-type Wave Meter

Since the pressure fluctuation η_p, at the pressure gauge, caused by the surface wave can be given by Eq. (14), the cross- and auto-spectral density for the fluctuation and the x, y component of the wave force in terms of power spectral density of the pressure fluctuation, $P_{\eta_p}(f)$, can be written as follows in the simplified method.

$$P_{\eta_p}(f)=w^2\left(\frac{\cosh kz_1}{\cosh kd}\right)^2 P_\eta(f) \tag{86}$$

$$\hat{P}_{F_xF_x}(f)=\{(C_D''')^2+(C_M''')^2\}\frac{\hat{P}_{\eta_p}(f)}{2}\left\{1+\cos 2\gamma\frac{I_2(a)}{I_0(a)}\right\} \tag{87}$$

$$\hat{P}_{F_yF_y}(f)=\{(C_D''')^2+(C_M''')^2\}\frac{\hat{P}_{\eta_p}(f)}{2}\left\{1-\cos 2\gamma\frac{I_2(a)}{I_0(a)}\right\} \tag{88}$$

$$\begin{aligned}\hat{P}_{\eta_pF_x}(f)&=\hat{co}_{\eta_pF_x}(f)-i\hat{q}_{\eta_pF_x}(f)\\&=\{C_D'''-iC_M'''\}\hat{P}_{\eta_p}(f)\cos\gamma\frac{I_1(a)}{I_0(a)}\end{aligned} \tag{89}$$

$$\begin{aligned}\hat{P}_{\eta_pF_y}(f)&=\hat{co}_{\eta_pF_y}(f)-i\hat{q}_{\eta_pF_y}(f)\\&=\{C_D'''-iC_M'''\}\hat{P}_{\eta_p}(f)\sin\gamma\frac{I_1(a)}{I_0(a)}\end{aligned} \tag{90}$$

$$\hat{P}_{F_xF_y}(f)=\{(C_D''')^2+(C_M''')^2\}\frac{\hat{P}_{\eta_p}(f)}{2}\sin 2\gamma\frac{I_2(a)}{I_0(a)} \tag{91}$$

where C_D''' and C_M''' are redefined as

$$\begin{aligned}C_D'''&=C_D''\times\left(\frac{\cosh kd}{\cosh kz_1}\right)\cdot\frac{1}{w}\\&=\frac{C_D}{2g}(\pi r^2)\cdot V_{rms}\sqrt{\frac{8}{\pi}}\cdot\left(\frac{\cosh kd}{\cosh kz_1}\right)\left(\frac{\cosh kz_2}{\sinh kd}\right)(2\pi f)\end{aligned} \tag{92}$$

$$\begin{aligned}C_M'''&=C_M''\times\left(\frac{\cosh kd}{\cosh kz_1}\right)\cdot\frac{1}{w}\\&=\frac{C_M}{g}\left(\frac{4}{3}\pi r^3\right)\left(\frac{\cosh kd}{\cosh kz_1}\right)\left(\frac{\cosh kz_2}{\sinh kd}\right)(2\pi f)^2\end{aligned} \tag{93}$$

where z_1 is the installation depth of the wave meter measured along the z axis (from the bottom of the sea) and z_2 is the position of the center of the sphere (from the bottom, See Fig. 1).

The constant, V_{rms}, can be calculated by the following equation.

$$V_{rms}=\sqrt{2\int_0^\infty P_v(f)df} \tag{94}$$

where $P_v(f)$ is power spectral density for the velocity and can be written as[19]

$$P_v(f)=(2\pi f)^2\left(\frac{\cosh kz_2}{\sinh kd}\right)^2 P_\eta(f) \tag{95}$$

Combining Eq. (86) with Eq. (95) and substituting it into Eq. (94), V_{rms} value can be obtained in terms of the power spectral density for the pressure fluctuation, $P_{\eta_p}(f)$, as follows:

$$V_{rms}=\sqrt{2\int_0^\infty (2\pi f)^2\left(\frac{\cosh kz_2}{\sinh kd}\right)^2\frac{1}{\omega^2}\left(\frac{\cosh kd}{\cosh kz_1}\right)^2 P_{\eta_p}(f)df} \tag{96}$$

For the engineering problems, C_D and C_M can be assumed to be constants. These values, however, might be a function of frequency. By the relationships given by Eq. (86) through Eq. (91), C_D''' and C_M''' are obtained as

$$C_{DX}'''=\sqrt{\frac{(\hat{P}_{F_xF_x}(f)+\hat{P}_{F_yF_y}(f))\times(\hat{co}_{\eta_pF_x}(f))^2}{\hat{P}_{\eta_p}(f)\{(\hat{co}_{\eta_pF_x}(f))^2+(\hat{q}_{\eta_pF_x}(f))^2\}}} \tag{97}$$

$$C_{DY}'''=\sqrt{\frac{(\hat{P}_{F_xF_x}(f)+\hat{P}_{F_yF_y}(f))\times(\hat{co}_{\eta_pF_y}(f))^2}{\hat{P}_{\eta_p}(f)\{(\hat{co}_{\eta_pF_y}(f))^2+(\hat{q}_{\eta_pF_x}(f))^2\}}} \tag{98}$$

$$C_{MX}'''=C_{DX}'''\cdot\sqrt{\left\{\frac{\hat{q}_{\eta_pF_x}(f)}{\hat{co}_{\eta_pF_x}(f)}\right\}^2} \tag{99}$$

$$C_{MY}'''=C_{DY}'''\cdot\sqrt{\left\{\frac{\hat{q}_{\eta_pF_y}(f)}{\hat{co}_{\eta_pF_y}(f)}\right\}^2} \tag{100}$$

Here, X means that the values are estimated by F_x, and Y by F_y.

Inserting Eq. (92) and Eq. (93) into Eqs. (97) through (100), C_D and C_M values are obtained as

$$C_D=\begin{pmatrix}C_{DX}'''\\C_{DY}'''\end{pmatrix}\cdot\left[\frac{1}{2g}(\pi r^2)\cdot V_{rms}\sqrt{\frac{8}{\pi}}\cdot\left(\frac{\cosh kd}{\cosh kz_1}\right)\left(\frac{\cosh kz_2}{\sinh kd}\right)(2\pi f)\right]^{-1} \tag{101}$$

$$C_M=\begin{pmatrix}C_{MX}'''\\C_{MY}'''\end{pmatrix}\cdot\left[\frac{4}{3g}\pi r^3\left(\frac{\cosh kd}{\cosh kz_1}\right)\left(\frac{\cosh kz_2}{\sinh kd}\right)(2\pi f)^2\right]^{-1} \tag{102}$$

a and γ values can be obtained by $\frac{I_0(a)}{I_2(a)}$, $\frac{I_0(a)}{I_1(a)}$, $\cos 2\gamma$, $\sin 2\gamma$, $\cos\gamma$, and $\sin\gamma$ in Eq. (80) through Eq. (85) replacing C_D'', C_M'', and η by C_D''', C_M''', and η_p, respectively. For example, $\frac{I_0(a)}{I_2(a)}$ and $\frac{I_0(a)}{I_1(a)}$ are to be obtained as follows.

$$\frac{I_0(a)}{I_2(a)}=\frac{\hat{P}_{F_xF_x}(f)+\hat{p}_{F_yF_y}(f)}{\sqrt{\{\hat{P}_{F_xF_x}(f)-\hat{P}_{F_yF_y}(f)\}+\{2\cdot\hat{co}_{F_xF_y}(f)\}^2}} \tag{103}$$

$$\frac{I_0(a)}{I_1(a)}=\left[\frac{P_{\eta_p}(f)\{P_{F_xF_x}(f)+P_{F_yF_y}(f)\}\cdot(\hat{co}_{\eta_pF_x}(f))^2}{\{(\hat{co}_{\eta_pF_x}(f))^2+(\hat{q}_{\eta_pF_x}(f))^2\}\{(\hat{co}_{\eta_pF_x}(f))^2+(\hat{co}_{\eta_pF_y}(f))^2\}}\right]^{1/2} \tag{104}$$

5. Investigation of the Accuracy of the Method by Means of Simulated Wave Properties

Three types of simulation are generally used; by hydraulic models, analogue models, and digital models. The former two have been used widely for many years. However, due to the space limit and financial difficulties, hydraulic models are often not feasible. More over, it can easily understood that to generate surface waves with directional spectra is almost impossible in the hydraulic model. An analogue model which is a mechanical or electric device that is designed to have properties equivalent to that of the system in consideration, sometimes, can not give the results with the desired accuracy.

On the other hand, digital models are relatively new approach. It is not only more accurate, but has also advantages of possessing convenient high speed.

Borgman[16] (1967) has suggested two possible ways such as linear digital filter and wave superposition, for carrying out a digital simulation process for wind waves. In this study, only the latter one was used.

5.1 Simulation for sea surfaces having a directional spectral density by wave superposition

Eq. (1), in the previous section, directly shows how to generate random sea surfaces by wave superposition. If the directional spectrum is known, sea surfaces, $\eta(x, y, t)$, can be obtained by carrying out the operation in Eq. (1). However, it is impossible to integrate the equation upto infinity in the frequency domain by discrete method. The maximum frequency should be determined for the completion of the integration. If a certain value is selected as the maximum frequency, f_{MAX}, and if an equally spaced subdivision, $f_n - f_{n-1}$, of the interval $(0, f_{\mathrm{MAX}})$ is used, the obtained sea surface would have periodicity with the period of, $1/f$ where $f = \dfrac{f_{\mathrm{MAX}}}{2M}$ and M is the number of the subdivided intervals.

In order to avoid the periodicity, one could select the set of f values with a random number table. Borgman[16] (1967), however, proposed another way based on the cumulative spectrum.

Let the directional spectrum be the form as given by Eq. (49) and $h(\theta)$ be the probability density of the circular normal distribution.

Then the cumulative spectrum, $S(f, \theta)$, for the directional spectrum is represented as

$$S(f, \theta) = 2\int_0^f \int_0^\theta h(\theta')p(f')d\theta' df'$$

$$= 2\int_0^f p(f') \left\{ \int_0^\theta h(\theta')d\theta' \right\} df' \tag{105}$$

Therefore,

$$S(f, 2\pi) = 2\int_0^f p(f')df' = \Pi(f) \tag{106}$$

Thus the corresponding value to $p(f_m)\Delta f_m$ in Eq. (1) nearly equals to $[\Pi(f_m) - \Pi(f_{m-1})]/2$.

Eq. (1) becomes

$$\eta'(x, y, t)=\sqrt{2}\sum_{m=1}^{M}\sum_{n=1}^{N}\sqrt{\Pi(f_m)-\Pi(f_{m-1})}\sqrt{h(\theta_n)\Delta\theta_n}$$

$$\cdot\cos(k_m x\cos\theta_n+k_m y\sin\theta_n-2\pi f_m t+\Phi_{mn}) \qquad (107)$$

The periodicity due to f is avoided if the set of f_m values are chosen to make $\Pi(f_m)-\Pi(f_{m-1})$ constant, say equal to G^2, for all m values. Then Eq. (107) becomes

$$\eta'(x, y, t)=\sqrt{2}\sum_{m=1}^{M}\sum_{n=1}^{N}G\sqrt{h(\theta_n)\Delta\theta_n}$$

$$\cdot\cos(k_m x\cos\theta_n+k_m y\sin\theta-2\pi f_m t+\Phi_{mn}) \qquad (108)$$

with f_m defined as the solution of

$$\Pi(f_m)=\frac{m}{M}\Pi(\infty)\doteqdot\frac{m}{M}\Pi(f_{\mathrm{MAX}}) \qquad (109)$$

If the Bretschneider-Pierson spectral density is used as a theoretical model, Eq. (109) is easy to solve. The spectrum has the form

$$p_B(f)=\frac{AB}{f^5}e^{-B/f^4} \qquad (110)$$

and the cumulative spectra is

$$\Pi(f)=2\int_0^f p_B(f')df'=\frac{A}{2}e^{-B/f^4} \qquad (111)$$

Hence $\Pi(\infty)=A/2$ and the solution of Eq. (109) is

$$f_m=\left[\frac{B}{\log_e\left(\frac{M}{m}\right)}\right]^{1/4} \qquad (112)$$

The energy density for the directional spectrum, $p(f, \theta)$, can be completely determined if the maximum frequency, f_{MAX}, power spectral peak frequency, f_p, total energy of the directional spectrum, $\Pi(\infty)$, a value and γ value are given.

The value B is determined from f_p if the derivative of $p_B(f)$ with respect to f is made equal to zero as

$$\frac{dp_B(f)}{df}=(-5+4Bf^{-4})ABf^{-6}\cdot e^{-B/f^4}=0 \qquad (113)$$

$$B=\frac{5}{4}f_p^4 \qquad (114)$$

The value A is determined as follows

$$\Pi(\infty)=2\int_0^\infty p_B(f)df\doteqdot 2\int_0^{f_{\mathrm{MAX}}}p_B(f)df=\frac{A}{2}e^{-B/f^4_{\mathrm{MAX}}} \qquad (115)$$

$$A\doteqdot 2\Pi(\infty)\cdot e^{B/f^4_{\mathrm{MAX}}} \qquad (116)$$

Equations for other wave properties are analogously obtained with the reference of Eqs. (106), (10), (11), (12), (13), (14), (21), and Eq. (22) as follows.

$$V_x'(x, y, z; t)=\sqrt{2}\sum_{m=1}^{M}\sum_{n=1}^{N} G\sqrt{h(\theta_n)\Delta\theta_n}\cdot 2\pi f_m \times\cos\theta_n \frac{\cosh k_m z}{\sinh k_m d}\cos(k_m x\cos\theta_n+k_m y\sin\theta_n-2\pi f_m t+\Phi_{mn}) \tag{117}$$

$$V_y'(x, y, z; t)=\sqrt{2}\sum_{m=1}^{M}\sum_{n=1}^{N} G\sqrt{h(\theta_n)\Delta\theta_n}\cdot 2\pi f_m \times\sin\theta_n \frac{\cosh k_m z}{\sinh k_m d}\cos(k_m x\cos\theta_n+k_m y\sin\theta_n-2\pi f_m t+\Phi_{mn}) \tag{118}$$

$$A_x'(x, y, z; t)=\sqrt{2}\sum_{m=1}^{M}\sum_{n=1}^{N} G\sqrt{h(\theta_n)\Delta\theta_n}(2\pi f_m)^2 \times\cos\theta_n \left(\frac{\cosh k_m z}{\sinh k_m d}\right)\sin(k_m x\cos\theta_n+k_m y\sin\theta_n-2\pi f_m t+\Phi_{mn}) \tag{119}$$

$$A_y'(x, y, z; t)=\sqrt{2}\sum_{m=1}^{M}\sum_{n=1}^{N} G\sqrt{h(\theta_n)\Delta\theta_n}(2\pi f_m)^2 \times\sin\theta_n \left(\frac{\cosh k_m z}{\sinh k_m d}\right)\sin(k_m x\cos\theta_n+k_m y\sin\theta_n-2\pi f_m t+\Phi_{mn}) \tag{120}$$

$$\eta_p'(x, y, z; t)=\sqrt{2}\sum_{m=1}^{M}\sum_{n=1}^{N} G\sqrt{h(\theta_n)\Delta\theta_n}\cdot\left(\frac{\cosh k_m z}{\cosh k_m d}\right)\cdot\omega \times\cos(k_m x\cos\theta_n+k_m y\sin\theta_n-2\pi f_m t+\Phi_{mn}) \tag{121}$$

G in Eq. (108), Eq. (117)~(121) is obtained as follows

$$G=\sqrt{\Pi(f_m)-\Pi(f_{m-1})}=\sqrt{\frac{\Pi(\infty)}{M}}\doteqdot\sqrt{\frac{\frac{A}{2}e^{-B/f^4_{\mathrm{MAX}}}}{M}} \tag{122}$$

5.2 Method of generating random phases

The random phases, Φ_{mn}, in Eq. (108) could be obtained by means of a random number table. In this study, however, the pseudo-random phases have been generated by the multicative congruence method as follows.

Let the sequence of pseudo-random numbers be denoted by

$$\{X_n\},\ n=0, 1, 2,\cdots\cdots .$$

Then the multicative congruence method is

$$X_{n+1}=K\cdot X_n(mod M_0) \tag{123}$$

The choice of M_0 is determind by the capacity and base of the computer which is to be used; K is chosen so that: 1) the resulting sequence $\{X_n\}$ possesses the desired statistical properties of random numbers, 2) the period of the sequence is as long as possible, and 3) the speed of generation is fast.

In this case, M_0 and K were determined as 18731 and 399 respectively. The initial value, X_0, was selected as 2581.

The random phases which distribute uniformly between $[0, 2\pi]$ are obtained as follows.

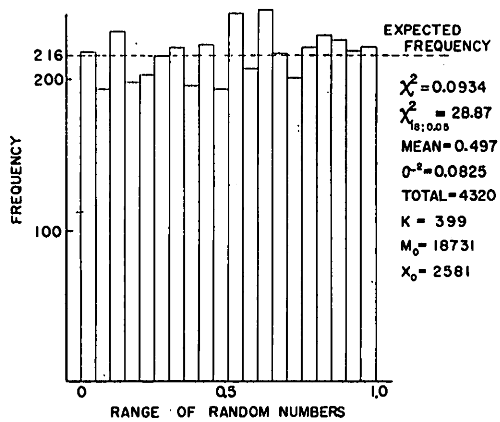

Fig. 3. Frequency histogram of the psuedo-random numbers used

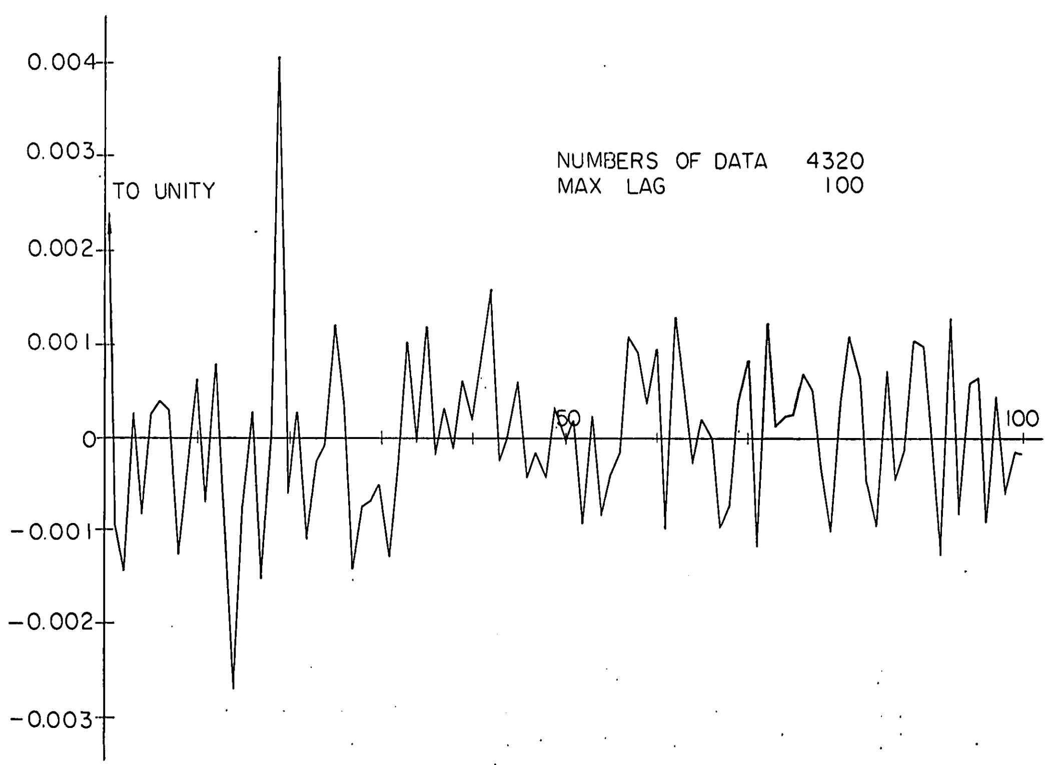

Fig. 4. Auto-correlogram for the pseudo-random numbers

$$\left.\begin{aligned} X_0 &= 2581 \\ X_n &= 399X_{n-1}(Mod\ 18731) \\ \Phi_n &= 2\pi \cdot X_n/18731 \end{aligned}\right\} \tag{124}$$

Since the random phases Φ_n are the pseudo-random numbers, the quality of the random phase must be determined by several statistical tests. The results of the uniformness test for X_0 is shown in Fig. 3. Two kinds of the run tests based on runs above and below, and runs up and down proved the randomness of the random phases. Fig. 4 shows the auto-correlogram for the random phases. The largest correlation coefficient was 0.00409 up to the lag number of 100.

5.3 Generating the simulated wave properties

For the generation of the simulated wave properties, the directional spectra with one peak in frequency and in azimuth was used. The dimensions in Table 1. were used in order to generate the simulated wave properties.

Only two cases 1-*d* and 2-*b* were generated by the direct use of Eq. (108), and Eqs. (117)~(121). It is evident that the other cases in the same class can be obtained by multiplying the square root of the ratio of A. The simulated data for case 1-*d* and 2-*b* are shown in Table A-1 and A-2 in the appendix.

In these calculation, the (f, θ) plan was subdivided into 60 intervals in frequency and 72 in azimuth. Reduction of the range for the numerical integration was considered so that the computation time became fast. The range of the integration with respect to azimuth was descided to be $\pm 90°$ centered γ instead of $\pm 180°$. It is clear that the procedure is allowable if a value is large. The error due to the reduction was estimated as less than 0.01% of the maximum amplitude in the calculated series with the a value of 16.

After obtaining the simulated wave properties, it is easy to generate the simulated wave force acting on the sphere. The force was obtained by Eq. (19) and (20) as the linearized one and also by Eq. (125) and (126) as the non-linear one.

$$F_x = \frac{C_D\omega}{2g}\pi r^2 V_x|V| + \frac{C_M\omega}{g}\left(\frac{4\pi r^3}{3}\right)A_x \tag{125}$$

$$F_y = \frac{C_D\omega}{2g}\pi r^2 V_y|V| + \frac{C_M\omega}{g}\left(\frac{4\pi r^3}{3}\right)A_y \tag{126}$$

Table 1. Constants for the generation of simulated wave properties

CASE	f_{p}(Hz)	f_{max}(Hz)	A	B	a	γ	$I_0(a)$	d	z_1	z_2	x	y
1-*a*	0.1	0.5	≒7200	1.25×10^{-4}	16	60	893446.2	8.5	1.0	1.60	0	0
1-*b*	0.1	0.5	≒4050	1.25×10^{-4}	16	60	893446.2	8.5	1.0	1.60	0	0
1-*c*	0.1	0.5	≒1800	1.25×10^{-4}	16	60	893446.2	8.5	1.0	1.60	0	0
1-*d*	0.1	0.5	≒450	1.25×10^{-4}	16	60	893446.2	8.5	1.0	1.60	0	0
2-*a*	0.1	0.5	≒7200	1.25×10^{-4}	15	40	339649.4	8.5	1.0	1.60	0	0
2-*b*	0.1	0.5	≒4050	1.25×10^{-4}	15	40	339649.4	8.5	1.0	1.60	0	0
2-*c*	0.1	0.5	≒1800	1.25×10^{-4}	15	40	339649.4	8.5	1.0	1.60	0	0
2-*d*	0.1	0.5	≒450	1.25×10^{-4}	15	40	339649.4	8.5	1.0	1.60	0	0

where $|V|$ is equal to $\sqrt{V_x^2+V_y^2}$.

In calculating the simulated force, the radius of the sphere, r, was set to be 6 cm and C_D and C_M values were considered as constants for each case. The root-mean-square value of horizontal component of water particle velocity in unidirectional case must be obtained when the force by Eq. (19) and (20) are used. The following two equations are available for the estimation of the root-mean-square value as well as Eq. (96).

$$V_{rms}=\sqrt{2\int_0^\infty (2\pi f)^2\left(\frac{\cosh k_m z_1}{\sinh k_m d}\right)^2 P_\eta(f)df} \tag{127}$$

$$V_{rms}=\sqrt{\frac{1}{N}\sum_{i=1}^{N}(V_{x_i}^2+V_{y_i}^2)} \tag{128}$$

The difference among the three was small. Then Eq. (96) was used for the calculation.

5.4 Accuracy of the method

Each wave property was generated at a period of one second for 600 seconds. In this section, the directional spectrum which are obtained by means of the simulation data will be compared with the given directional spectrum. For the wave force, both pair of Eq. (19), (20) and of Eq. (125), (126) were used and their results will be dicussed. Since the directional spectrum is determined a and γ value in the method, the discussion will mainly be done on the two values. For the calculation of a and γ value and other values, η_p, F_x, and F_y were used.

Fig. 5 and Fig. 6 show the change of a value with respect to the frequency

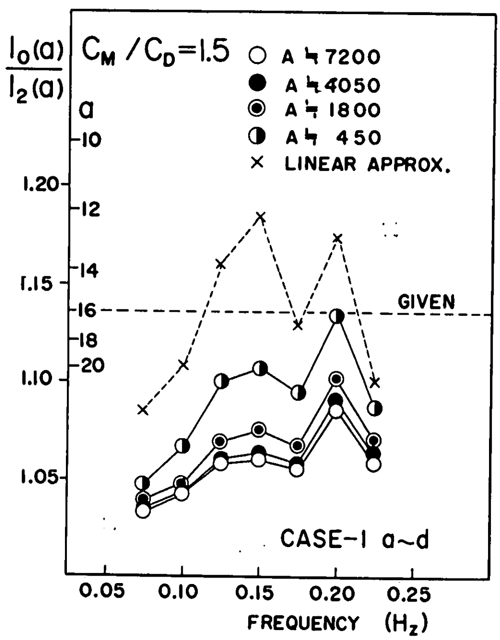

Fig. 5. Change of $\frac{I_0(a)}{I_2(a)}$ value due to A in case 1

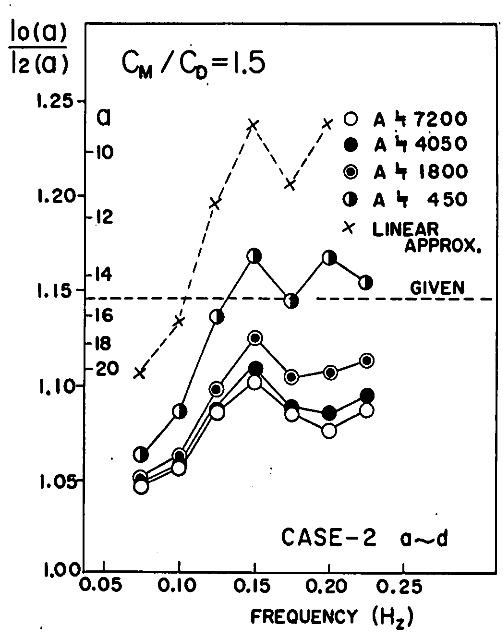

Fig. 6. Change of $\frac{I_0(a)}{I_2(a)}$ value due to A in case 2

and A value. Resulting a value from the force by linearized drag term denoted, $\times$, deviates from the given value. The deviation may correspond to the errors due to the spectral analysis, the method of simulation, and the many assumptions made. Because there might be no difference between the values provided that there had not been any errors in the calculations. The change of the a value by means of the linearized force was not large enough to plot separately with respect to A value. This can be also said of other values which will be discussed here. The difference between the value resulting from the use of linearized drag term for force component and the values which were obtained by means of the force calculated by the non-linear drag term, would be caused by the linear approximation for the drag term in the force formula. The difference decreases when A value decreases. However, the a value obtained by the use of the non-linear drag term is larger than the given a value by two or more times. This means that the a value obtained by the method is larger than the actual value.

Fig. 7 and Fig. 8 show the behaviour of the a value obtaind from Eq. (83). The behaviour seems to be the seme as the a value in Fig. 5 and Fig. 6. But the $\frac{I_0(a)}{I_1(a)}$ values in Fig. 7 and Fig. 8, sometimes, fall down below 1.00. Since $I_0(a)$ is always larger than $I_1(a)$, a value obtained by $\frac{I_0(a)}{I_2(a)}$ value should be used for the estimation of the value.

Fig. 9 and Fig. 10 show the change of γ value with respect to A value and frequency. It was obtained by the results from Eq. (82). It could be said that there was little difference between the plotted points for fixed frequency. This means that the γ value is not affected much by the linear-approximation. However, the deviation from the given value changes remarkably when γ value changes.

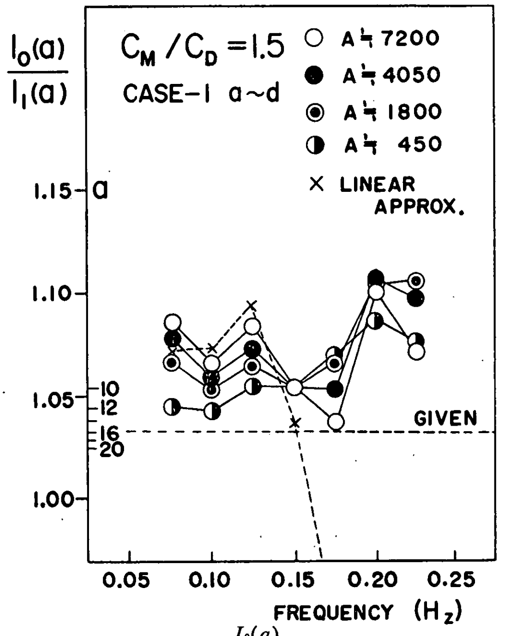

Fig. 7. Change of $\frac{I_0(a)}{I_1(a)}$ value due to A in case 1

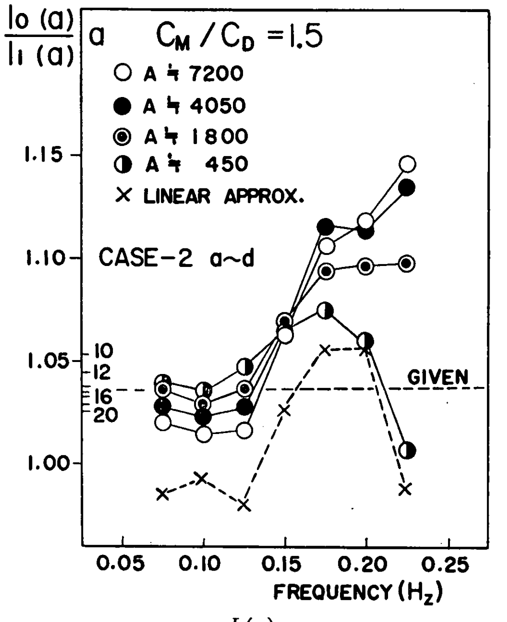

Fig. 8. Change of $\frac{I_0(a)}{I_1(a)}$ value due to A in case 2

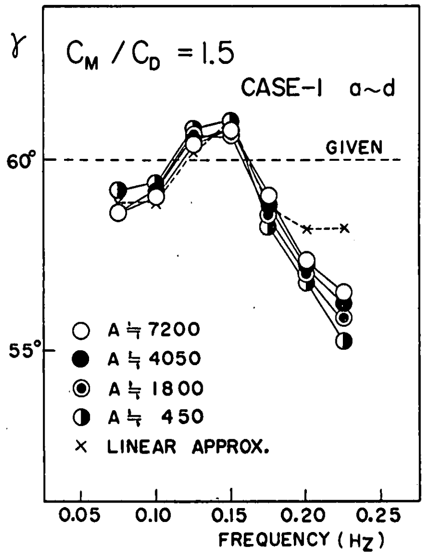

Fig. 9. Change of γ value due to A in case 1

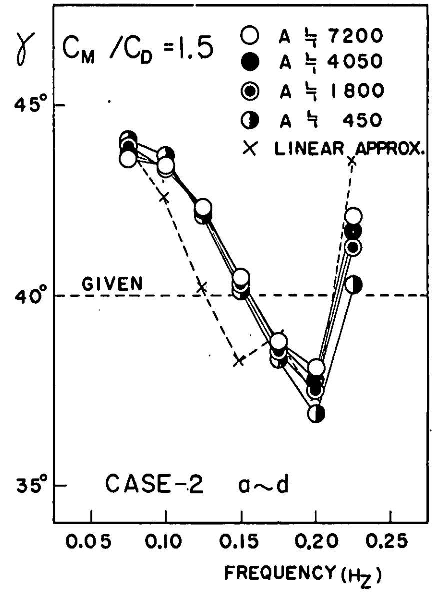

Fig. 10. Change of γ value due to A in case 2

Looking at Fig. 11~14 where the obtained C_D and C_M values are shown, the same features as γ value may be recognized, that is, the value C_D and C_M are not affected either by the change of A value or by the linear-approximation.

Let the value A be fixed and C_M/C_D value be changed.

Fig. 15 and Fig. 16 show the change of a and γ value for fixed A with respect to C_M/C_D value and frequency. The value γ is not affected by the change

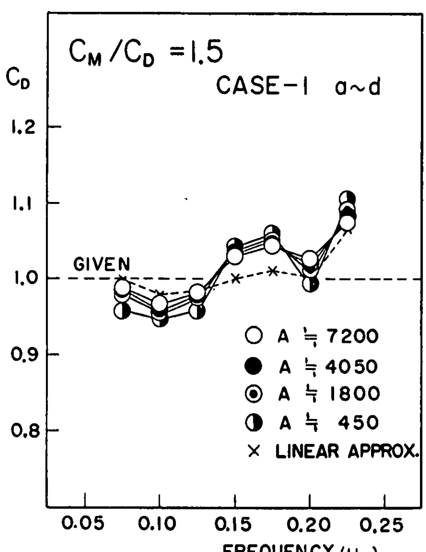

Fig. 11. Change of C_D value due to A in case 1

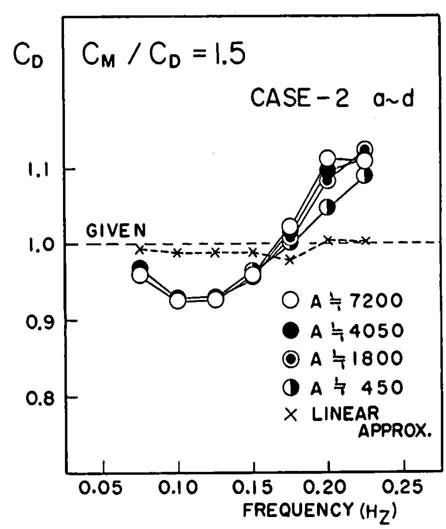

Fig. 12. Change of C_D value due to A in case 2

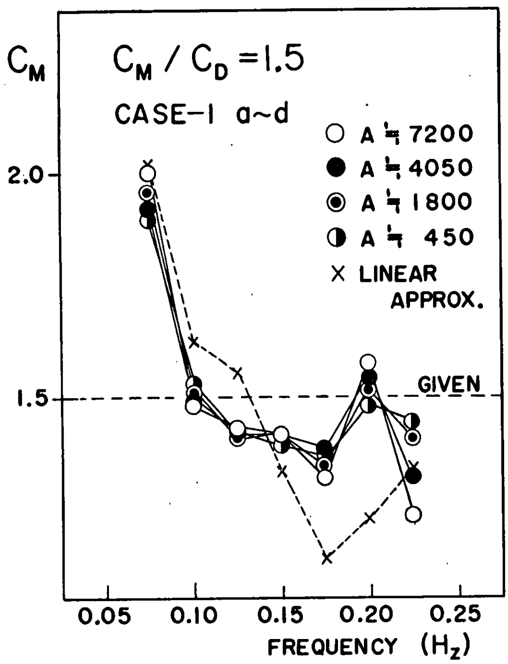

Fig. 13. Change of C_M value due to A in case 1

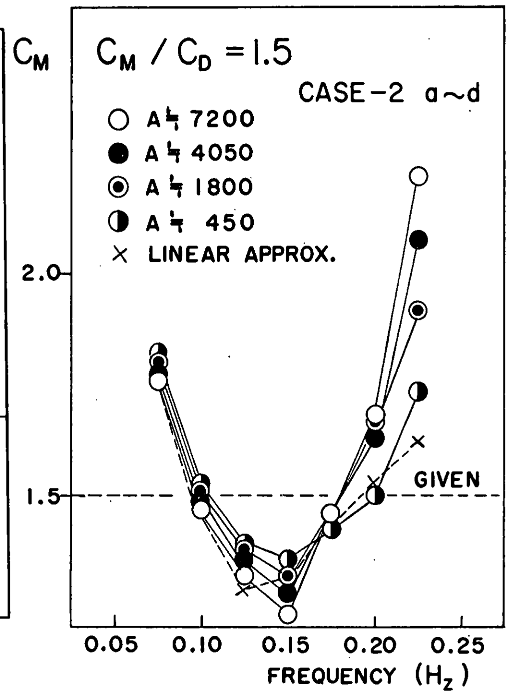

Fig. 14. Change of C_M value due to A in case 2

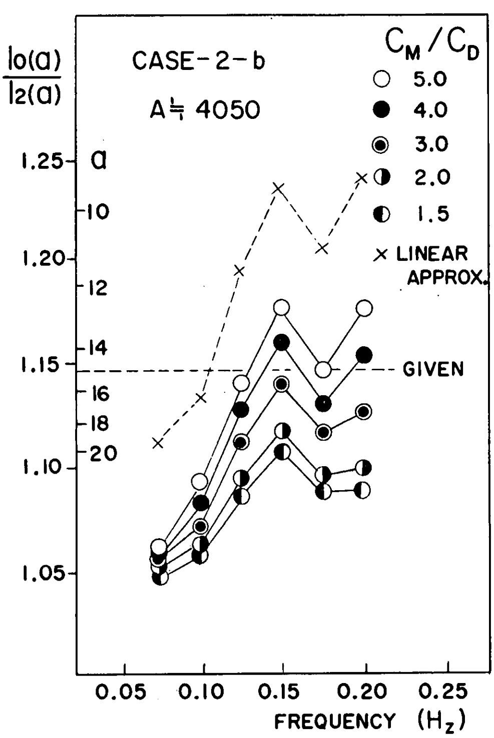

Fig. 15. Change of $I_0(a)/I_2(a)$ value due to C_M/C_D

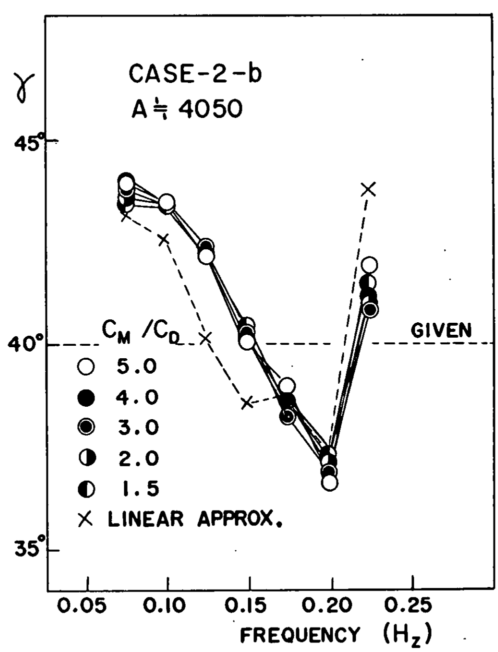

Fig. 16. Change of γ value due to C_M/C_D

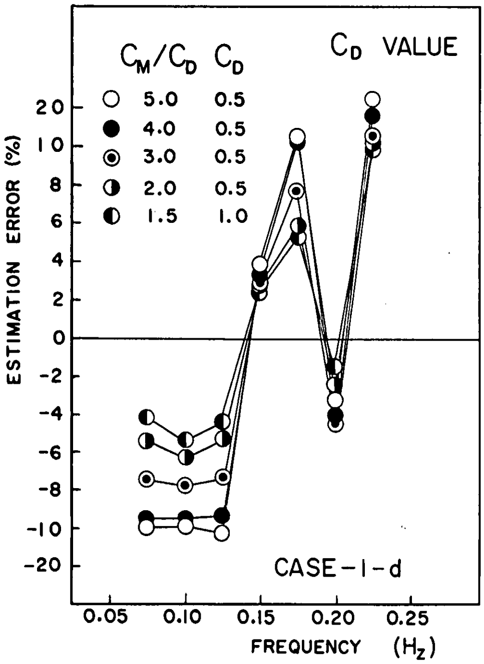

Fig. 17. Effect of the C_M/C_D on the estimation error of C_D

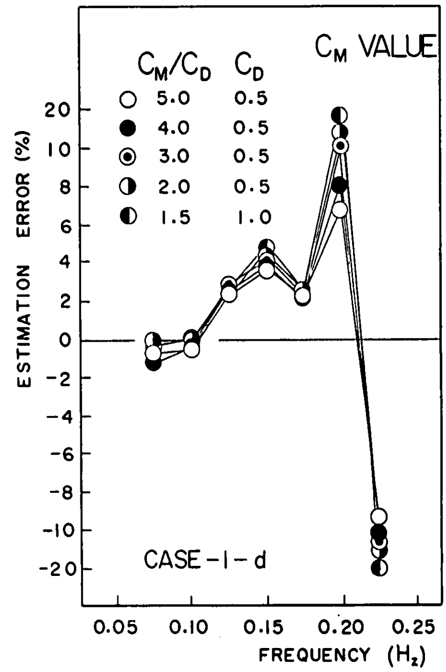

Fig. 18. Effect of the C_M/C_D on the estimation error of C_M

of C_M/C_D. Comparing Fig. 16 with Fig. 10, the obtained γ value for each frequency is almost the same for each other. The value a in Fig. 16 remarkably changes with respect to C_M/C_D. It becomes close to the a value from the linearized force, when C_M/C_D value increases. This is reasonable, because C_D is the constant of the linearized drag term.

How does the estimation error of C_D and C_M change when C_M/C_D value changes? Fig. 17 and 18 show the relative error to the given value.

In summary, the linear-approximation has little effect on the estimation of γ, C_D, and C_M for the given directional spectrum at the given geographical situation. The value a, however, is affected by the magnitude of the total energy of the given wave system and the ratio of C_M and C_D value.

The directional spectrum can be easily figured out by using Eq. (49). For $C_D=0.5$, $C_M=1.5$, $A\fallingdotseq 450$, $a=16$, and $\gamma=60°$, the given directional spectrum is shown as Fig. 19, the directional spectrum by the method using the linearized force formula, as Fig. 20, and the directional spectrum by the method using the non-linear drag term for force equation, as Fig. 21. Comparing Fig. 20 with Fig. 21, it is found that there is no significant difference between them.

The method of the spectral analysis followed the method by Bendat and Piersol[19] (1966) with the Hamming spectral window of 0.23, 0.54, and 0.23. In order to get higher degree of freedom in spectral analysis, the maximum lag time was chosen as 20 second. This results in the degree of freedom being about 60. In finding the a value from the ratio of the modified Bessel functions, $I_0(a)/I_1(a)$ and $I_0(a)/I_2(a)$, the Handbook of Mathematical Function with Formulas, Graphs, and Mathematical Tables[20] was used. For large value of a, following polynomial approximations were used.

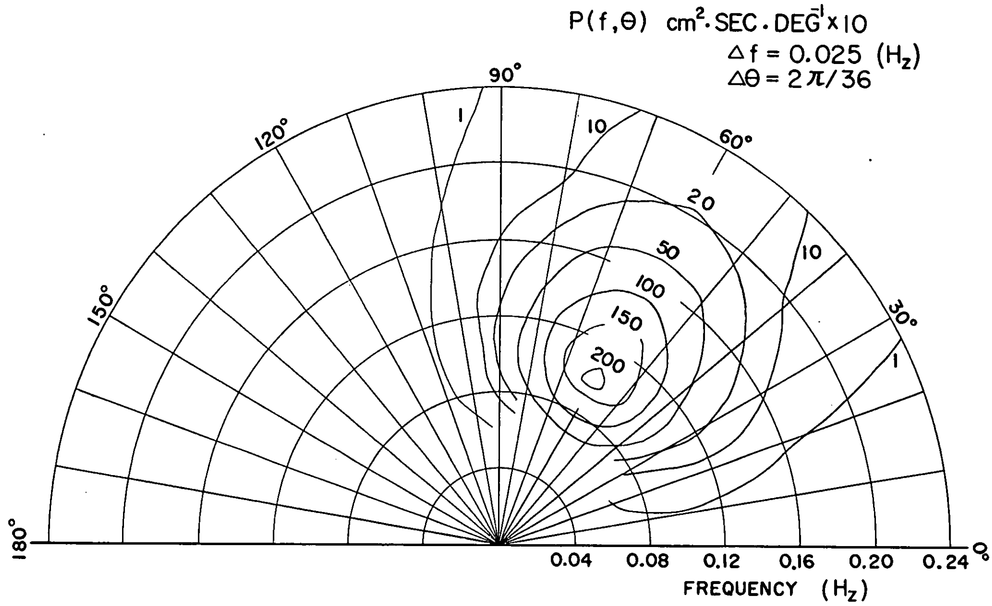

Fig. 19. Given directional spectrum

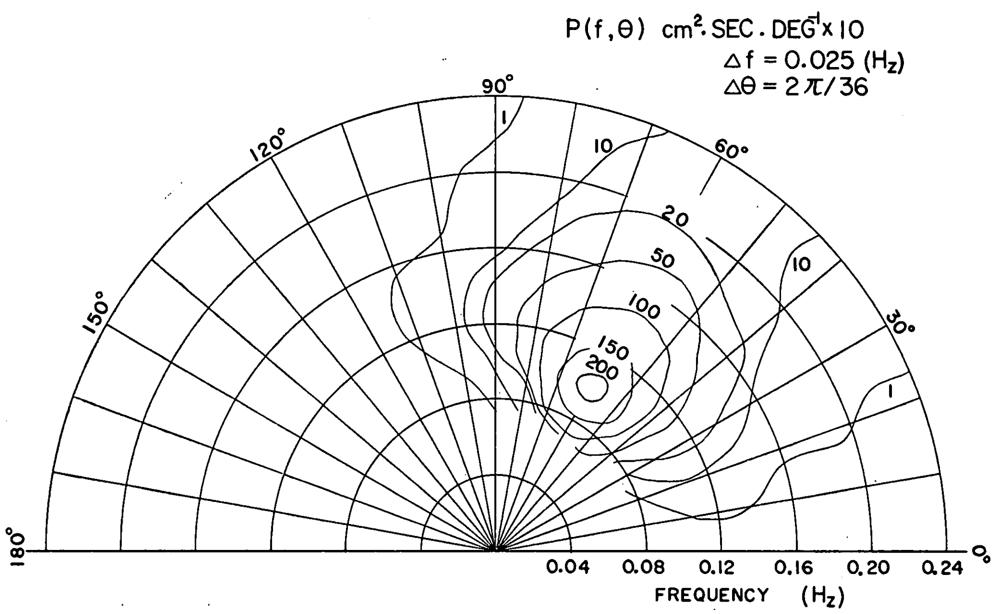

Fig. 20. Directional spectrum obtained from the linearized wave force

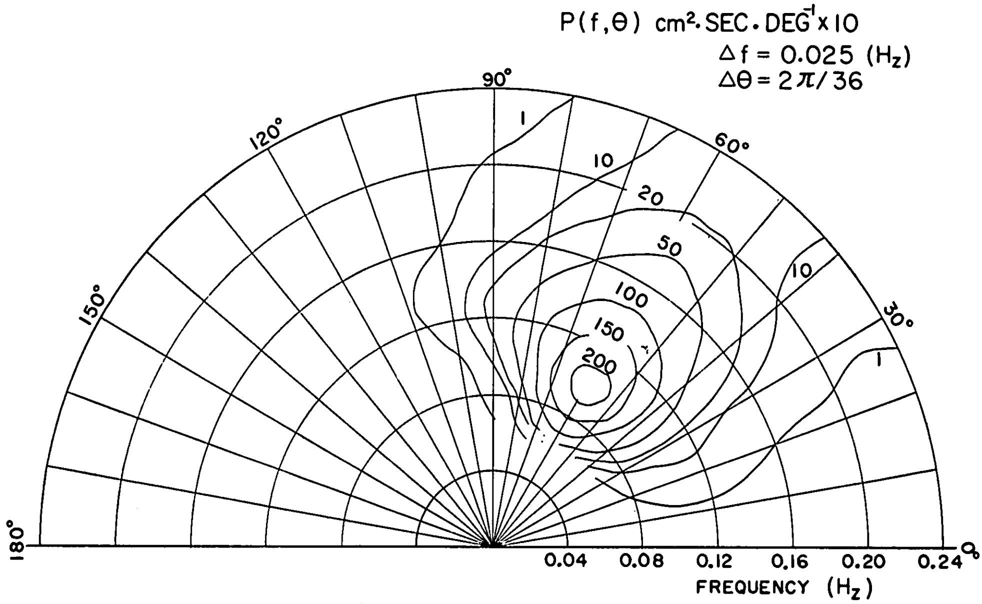

Fig. 21. Directional spectrum obtained from the non-linear wave force

For $3.75 \leq a < \infty$

$$a^{1/2}e^{-a}I_0(a)=0.39894228+0.01328592t^{-1}+0.00225319t^{-2}-0.00157565t^{-3}+0.00916281t^{-4}-0.02057706t^{-5}+0.02635537t^{-6}-0.01647633t^{-7}+0.00392377t^{-8}+\varepsilon$$
$$|\varepsilon|<1.9\times10^{-7} \qquad (129)$$

$$a^{1/2}e^{-a}I_1(a)=0.39894228-0.03988024t^{-1}-0.00362018t^{-2}+0.00163801t^{-3}-0.01031555t^{-4}+0.02282967t^{-5}-0.02895312t^{-6}+0.01787654t^{-7}-0.00420059t^{-8}+\varepsilon$$
$$|\varepsilon|<2.2\times10^{-7} \qquad (130)$$

where $t=a/3.75$

The following equation was used for obtaining higher order values.

$$I_{n+1}(a)=-\frac{2n}{a}I_n(a)+I_{n-1}(a) \qquad (131)$$

5.5 Characteristics of the simulated data

The characteristics of the simulated data which were used in the previous section will be discussed here.

The histograms of η, η_p, V_x, V_y, A_x, A_y, F_x and F_y from the non-linear drag term for case 1-*d* or 2-*b* are shown in Fig. 22~31. The total number of data is 600

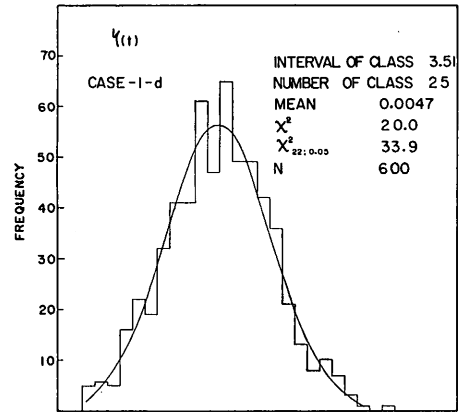

Fig. 22. Frequency histogram of simulated surface wave, $\eta(t)$, case 1-*d*

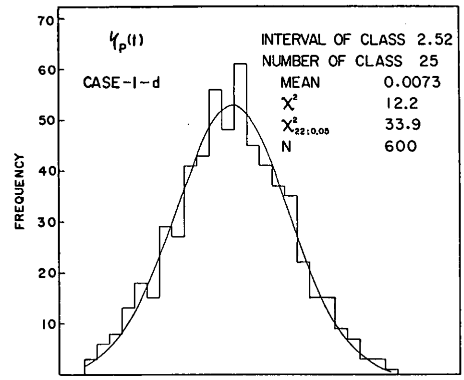

Fig. 23. Frequency histogram of simulated underwater pressure fluctuation, $\eta_p(t)$, case 1-*d*

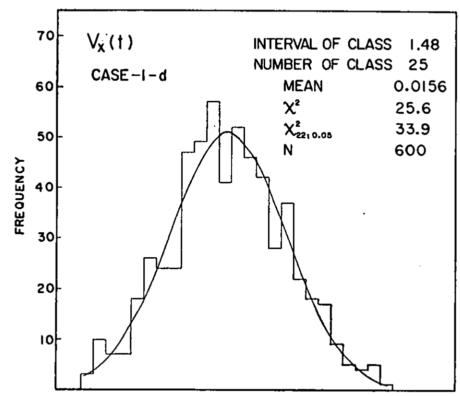

Fig. 24. Frequency histogram of simulated x component of water particle velocity, $V_x(t)$, case 1-*d*

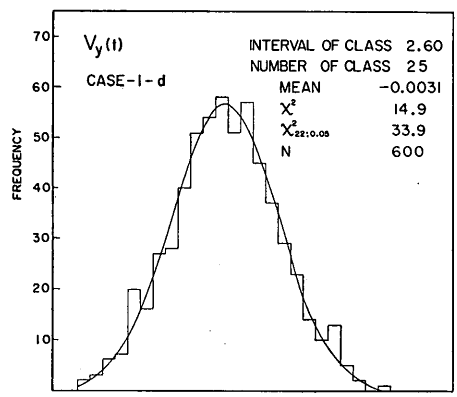

Fig. 25. Frequency histogram of simulated y component of water particle velocity, $V_y(t)$, case 1-*d*

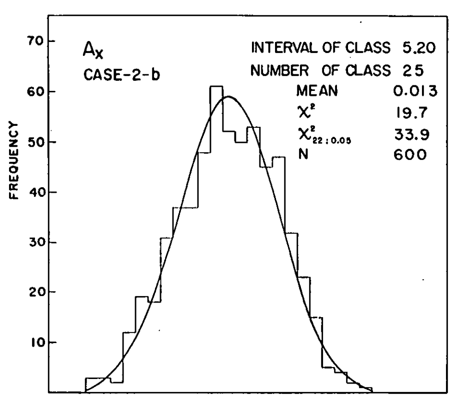

Fig. 26. Frequency histogram of simulated x component of water particle acceleration $A_x(t)$, case 2-*b*

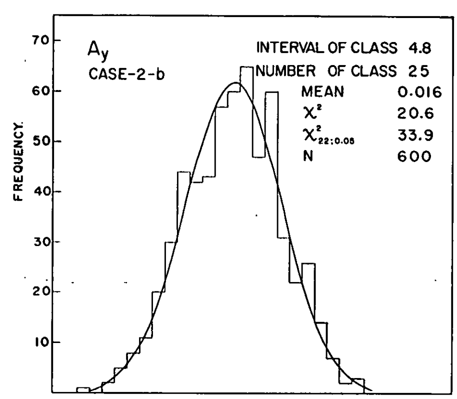

Fig. 27. Frequency histogram of simulated y component of water particle acceleration $A_y(t)$, case 2-*b*

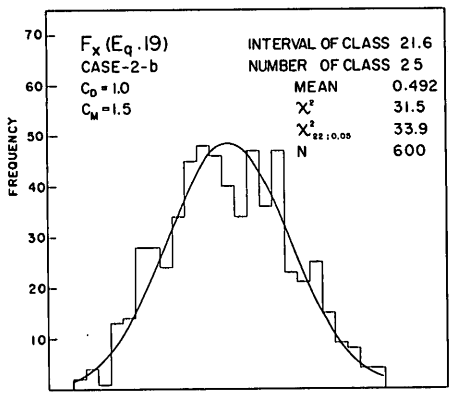

Fig. 28. Frequency histogram of simulated x component of linearized wave force, $F_x(t)$ (Eq. 19), case 2-*b*

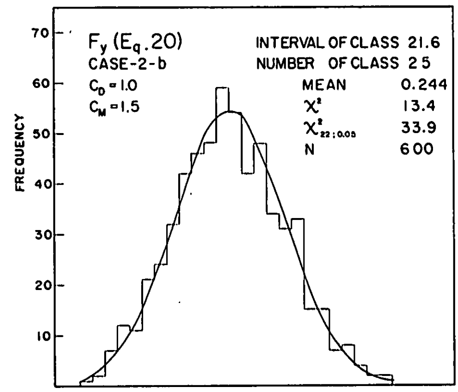

Fig. 29. Frequency histogram of simulated y component of linearized wave force, $F_y(t)$ (Eq. 20), case 2-*b*

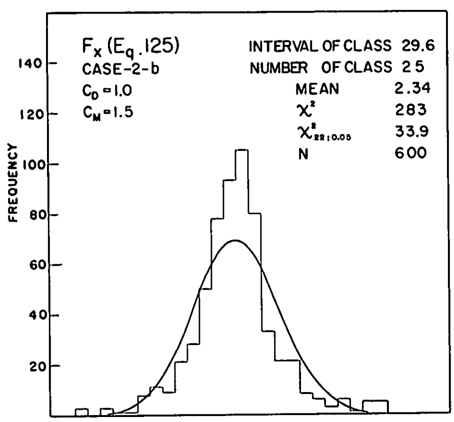

Fig. 30. Frequency histogram of simulated x component of non-linear wave force, $F_x(t)$ (Eq. 125), case 2-*b*

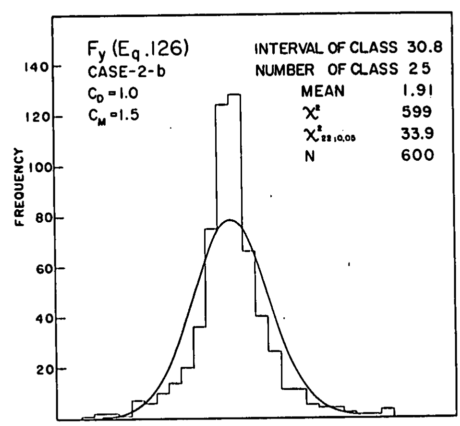

Fig. 31. Frequency histogram of simulated y component of non-linear wave force, $F_y(t)$ (Eq. 126), case 2-*b*

for each case. In these figures, the results of the Chi-square goodness-of-fit test are shown. For sample size 600 and the probability of a Type I Error of 5%, the minimum optimum number of class intervals is known[19] as 24. All wave properties, except F_x and F_y obtained from the non-linear drag term, have the Gaussian distribution. For the F_x and F_y from Eq. (125) and (126), the deviation from the Gaussian distribution becomes large when the A value in the Bretschneider-Pierson spectrum becomes large. However, their distribution approaches to the Gaussian distribution when C_M/C_D value becomes large. Since the simulated wave particle velocity and acceleration have the Gaussian distribution, it is natural that the F_x and F_y from the linearized drag term have the Gaussian distribution. The same can be said for the distribution properties of the other simulated data, case 2-*b* or case 1-*d*.

Power spectra for surface waves are shown in Fig. 32. In the Fig. 32, given power spectrum and power spectrum of case 1-*a* and of case 2-*a* are shown for the convenience of comparison. The difference of the root-mean-square-value among them may be caused by the reduction of the range for the numerical integration. The root-mean-square value of case 1-a is larger than that of case 2-a. It is because the a value for case 1-a is larger than that of case 2-a.

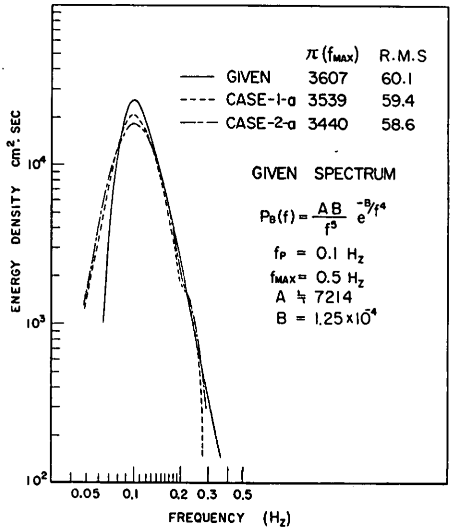

Fig. 32. Comparison of power spectrum Given spectra, case 1-a and case 2-a

6. Sample Calculation

6.1 Method of observation

In order to obtain the actual data for the wave properties, a pressure type wave meter and a strain-gauge type wave direction meter were used. The strain-gauge type wave direction meter has been developed by the Port and Harbour Research Institute, Ministry of Transport, Japan and has been used tentatively for the determination of wave direction at a point in shallow water.

The principle of the observation of the wave direction is as follows:

The apparatus consists of a transducer, conductor cable and a recording instrument. The schematic figure of the transducer is shown in Fig. 33. The rod, R, is bent by the wave force acting on the sphere. The strain at part A along the surface of the rod is mearsured by four wire strain-gauges attached on the rod as shown in Fig. 34. The four wire strain-gauges compose a bridge circuit, and detect the magnitude of the x and y component of the wave force. The resultant direction of the wave force can be determined by the instantaneous value of x and y component of the wave force.

In order to obtain the wave direction for the surface wave, it is assumed

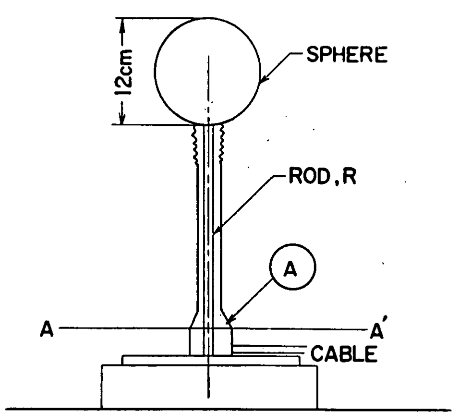

Fig. 33. Schematic figure of the wave direction meter

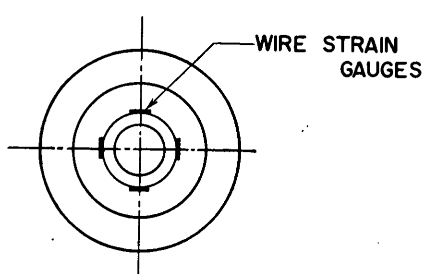

Fig. 34. Section A-A′

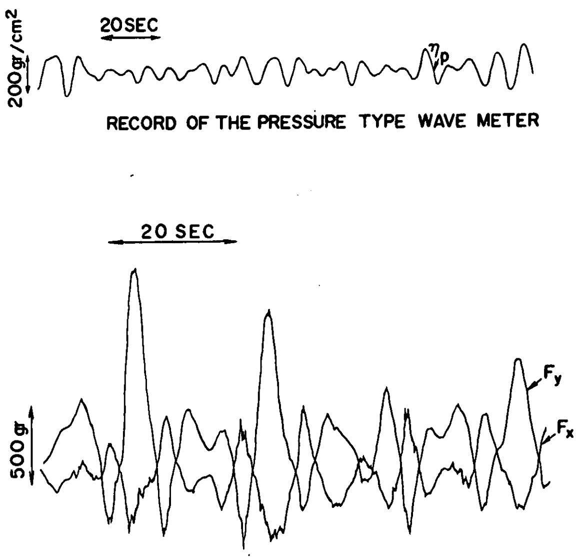

Fig. 35. Example of the record obtained at SAKATA

conventionally that the resultant wave force direction coincides with the direction of the surface wave. Examples of the records taken by the instrument as well as the one by the wave meter are shown in Fig. 35. These data were taken at Sakata Port along the Japan Sea Coast in the northern part of Japan, and the geographic relations for the instruments are shown in Fig. 36.

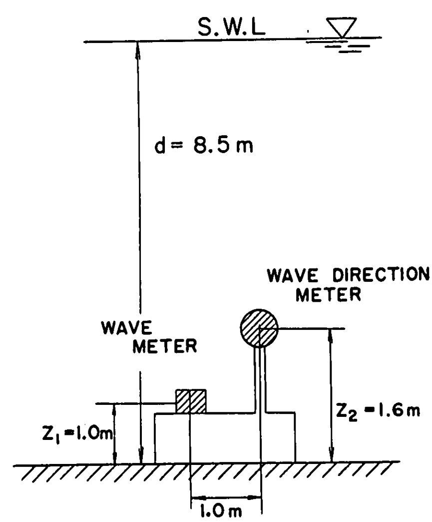

Fig. 36. Geographic relation between the wave meter and the wave direction meter installed at SAKATA

6.2 Results of calculation

The data which were used here had been taken at Sakata Port during 15.50~16.00 on November 14, 1966. The maximum lag time was chosen to be 24.5 seconds. This results in the degree of freedom being about 50. The distance between the wave meter and the wave direction meter was assumed to be zero.

The power spectrum of η_p, F_x, F_y are shown in Fig. 37. The co- and quadratur-spectra for η_p, F_x and η_p, F_y and F_x, F_y are shown in Fig. 38~40. The values C_D and C_M were calculated by the relation given by Eq. (101) and Eq. (102), These values are plotted in Fig. 41.

The values a and γ were obtained by Eq. (80) to Eq. (89) replaced by C_D''', C_M''', and η_p instead of C_D'', C_M'', and η, respectively. The ratio of the modified Bessel function of the first kind, $I_0(a)/I_2(a)$, and a value are shown in Fig. 42 as well as

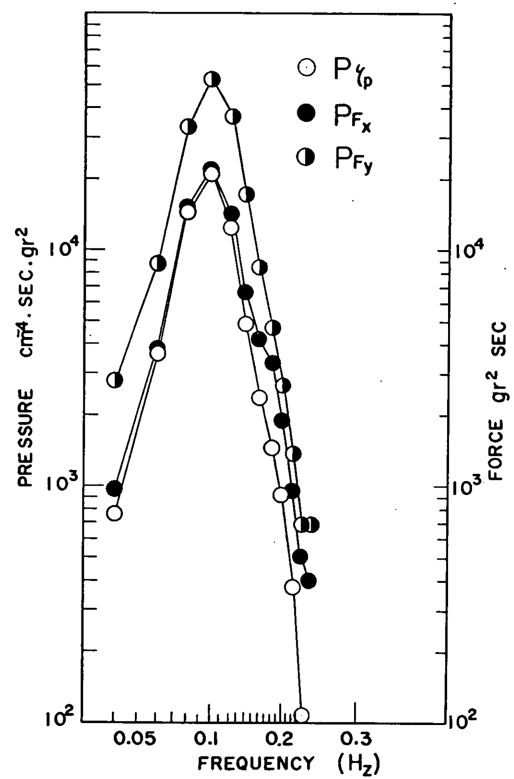

Fig. 37. Power spectra of pressure fluctuation, x component of wave force, and y component of wave force at SAKATA

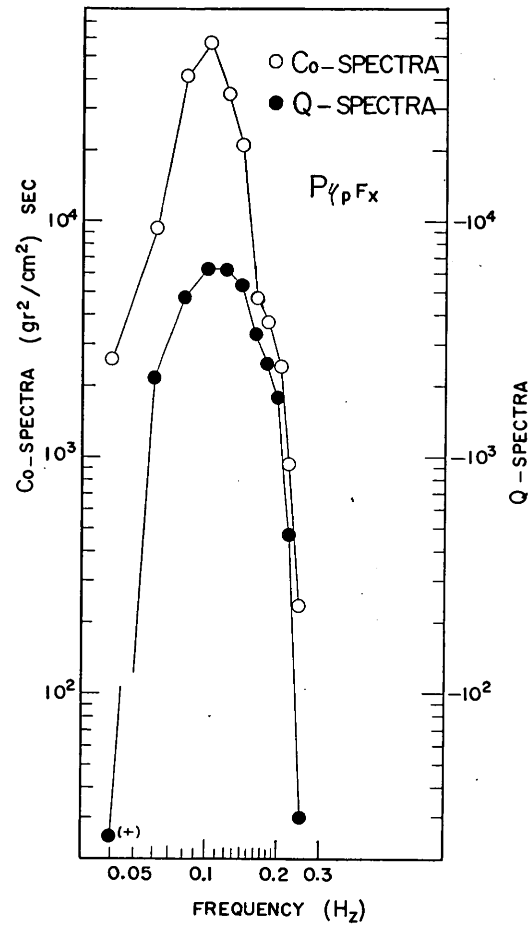

Fig. 38. Co- and quadrature-spectra of pressure fluctuation and x component of wave force at SAKATA

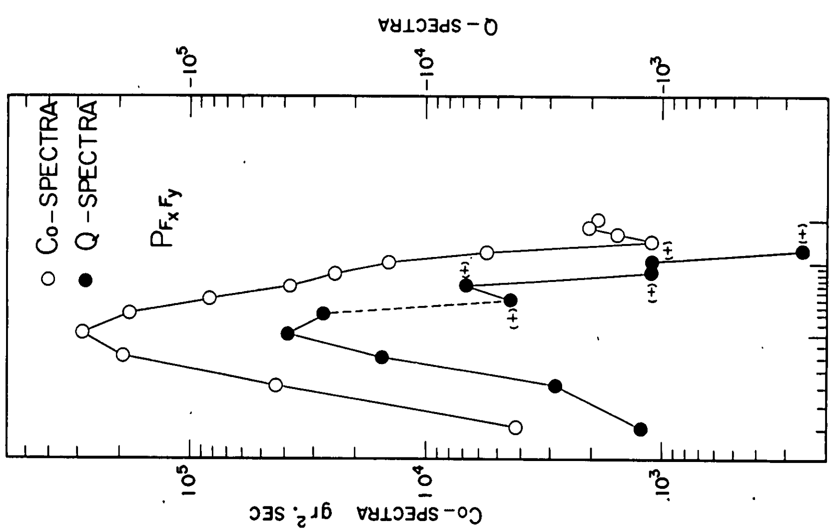

Fig. 40. Co- and quadrature-spectra of x and y component wave force at SAKATA

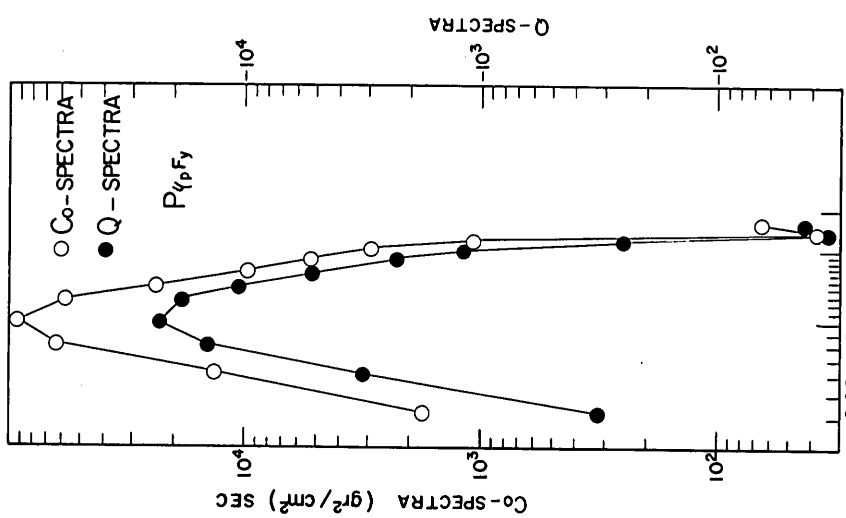

Fig. 39. Co- and quadrature-spectra of pressure fluctuation and y component of wave force at SAKATA

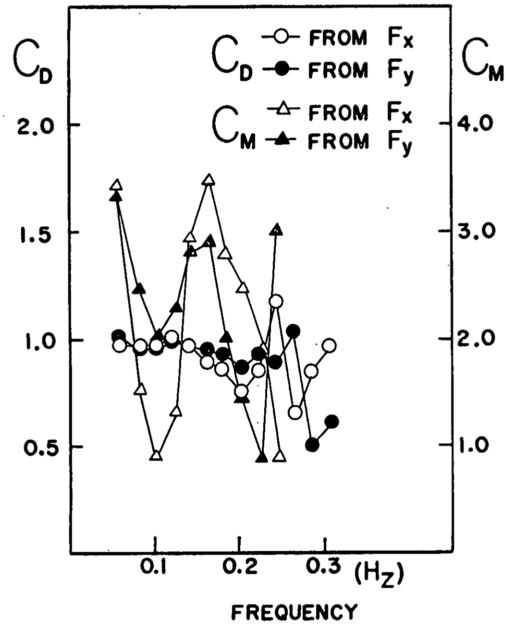

Fig. 41. C_D and C_M obtained in the sample calculation

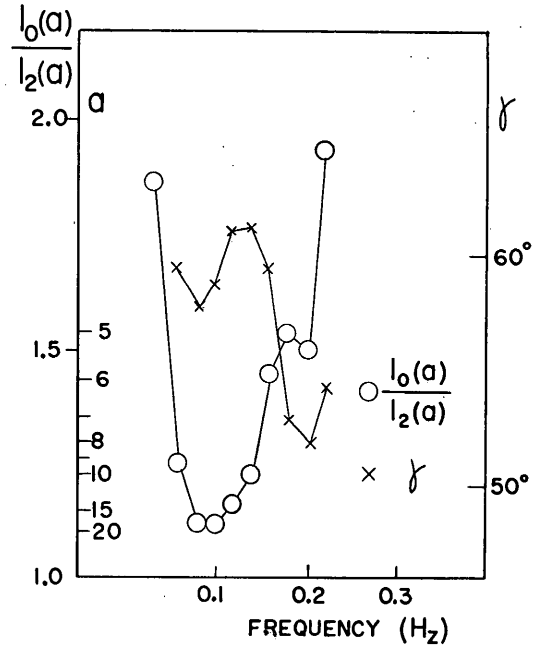

Fig. 42. $I_0(a)/I_2(a)$ and γ value obtained in the sample calculation

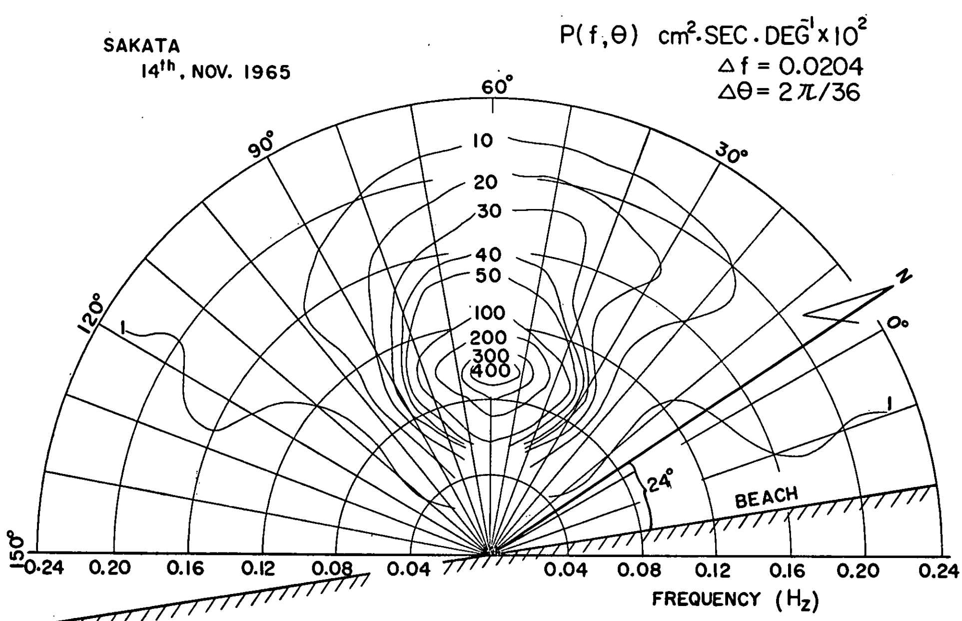

Fig. 43. Directional spectra obtained in the sample calculation

γ value obtained by Eq. (81). Fig. 43 shows the directional spectra which were calculated by the a and γ value.

7. Discussion

There exist some ambiguities in the method although some results have been obtained. First of all, the assumption that the conventional wave force formula can be expressed by Eq. (18) should be discussed. The results from section 5 where the accuracy of the method was discussed, show that the linear-approximation does not affect much the estimation of γ and C_D and C_M values. The a value, however, is affected by the linear approximation very much. Since the small change of $I_0(a)/I_2(a)$ causes significant change of a value, the accuracy of the spectral analysis might have some effects on the estimation of a value.

As shown in section 5.5, the distribution of F_x and F_y obtained from Eqs. (125) and (126) deviate from the Gaussian distribution for large A and relatively small C_M/C_D. This means that the assumption of the Gaussian distribution for the force component does not hold when the amount of wave energy is large and C_M/C_D is small.

The results from the sample calculation show that $C_M \doteqdot 1.5$ and $C_D \doteqdot 1.0$ around the peak frequency of energy spectra (0.1 Hz). The value C_M is very close to the theoretical one and C_D may be reasonable. This means that the actual wave force may not have the Gaussian distribution. The distribution of the component wave force of the actual data which were analyzed as an example is shown in Fig. 44 and 45. Both distribution are not the Gaussian distribution. Since the restriction mentioned above is inevitable, the value a would be estimated well provided that the A value is small. For examining the accuracy of the example

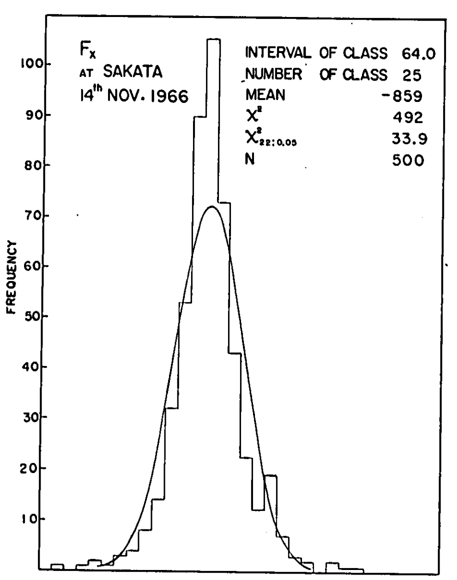

Fig. 44. Frequency histogram of x component wave force observed at SAKATA

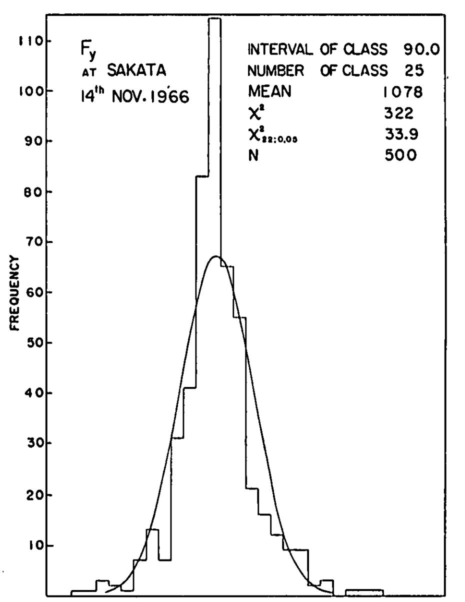

Fig. 45. Frequency histogram of y component wave force observed at SAKATA

calculation, small a value like 8～12 should have been used. Further investigation of the accuracy is remained.

In the example calculation, C_D was about 1.0 and C_M was about 1.5. These values, however, change magnitude considerably as frequency changes. Especially, for the higher frequency, the values reached are three times or more larger than that at the peak frequency. Since the obtained power spectrum densities have less accuracy in higher frequency, the facts mentioned above might not explain that C_D and C_M value change remarkably for higher frequency.

The directional spectra which were used for generating the simulated wave properties are considered to be special cases such that they had one peak in frequency and in azimuth. Various other cases should be investigated to clear the accuracy of the method. The results of field observation will give us fruitful information on the use of the method.

8. Conclusion

1) This method can be applied for the determination of the approximate directional spectra of sea waves at one location, if the instrument be suitably installed so that the distance between the wave meter and the wave direction meter are considered to be zero compared with the wave length.

2) This method is very useful for the investigation of the wave direction at which main wave energy is advancing. Indeed, the procedure should prove useful for the investigation of the directions of the waves from several storms, provided there is a frequency difference between the energy associated with each of the storms.

3) The value C_D and C_M can be estimated by this method as a function of frequency.

4) Other advantages may be that:

a) By the method, long term, continuous, and all-weather wave direction observation would be secured,

b) The observation cost may be cheaper than any other method.

Acknowledgement

The author wishes to express his deepest appreciation to professor L. E. Borgman at the Univ. of California, Berkeley. He suggested the method of derivation and offered help and criticism for which the author is very grateful. The author also wishes to express his thanks to Dr. T. Hamada whose criticism enabled the author to accomplish this study.

Expression of indebtness is also due to Chief T. Takahashi, Mr. H. Sasaki, and the rest of the staff of the Inquiry and Investigation Section, Hydraulics Division, Port and Harbour Research Institute, for permitting the author to analyze the actual data taken at Sakata Port, and for encouraging the auther. Figures are made by Mr. T. Nakai.

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List of Symbols

A: constant in the Bretschneider-Pierson spectrum
A_c: water particle acceleration
A_x: x component of water particle acceleration
A_y: y component of water particle acceleration
$A_x(x, y, z; t)$: pseudo-integral representation for x component of water particle acceleration at space-point (x, y, z) and time t
$A_y(x, y, z; t)$: pseudo-integral representation for x component of water particle acceleration at space-point (x, y, z) and time t
$A'_x(x, y, z; t)$: simulated x component of water particle acceleration at space-point (x, y, z) and time t
$A'_y(x, y, z; t)$: simulated y component of water particle acceleration at space-point (x, y, z) and time t
a: constant, a measure of the concentration around the mean
B: constant in the Bretschneider-Pierson spectrum
C: coefficient for drag term (Eq. 17)
C_1: coefficient for drag term (Eq. 15)
C_2: coefficient for inertial term (Eq. 15)
C_D: drag coefficient
C''_D: parameter related to drag coefficient (Eq. 29, for surface wave)
C'''_D: parameter related to drag coefficient (Eq. 92, for underwater pressure fluctuation)
C'''_{DX}: C'''_D calculated from x component terms
C'''_{DY}: C'''_D calculated from y component terms
C_M: inertial coefficient
C''_M: parameter related to inertial coefficient (Eq. 30, for surface wave)
C'''_M: parameter related to inertial coefficient (Eq. 93, for underwater pressure fluctuation)
C'''_{MX}: C'''_M calculated from x component terms
C'''_{MY}: C'''_M calculated from y component terms
$C_{F_xF_x}(g, h, \tau)$: cross-covariance between $F_x(x, y, z; t)$ and $F_x(x+g, y+h, z; t+\tau)$
$C_{F_xF_y}(g, h, \tau)$: cross-covariance between $F_x(x, y, z; t)$ and $F_y(x+g, y+h, z; t+\tau)$
$C_{F_yF_y}(g, h, \tau)$: cross-covariance between $F_y(x, y, z; t)$ and $F_y(x+g, y+h, z; t+\tau)$
$C_{\eta F_x}(g, h, \tau)$: cross-covariance between $\eta(x, y; t)$ and $F_x(x+g, y+h, z; t+\tau)$
$C_{\eta F_y}(g, h, \tau)$: cross-covariance between $\eta(x, y; t)$ and $F_y(x+g, y+h, z; t+\tau)$
$C_{\eta\eta}(g, h, \tau)$: cross-covariance between $\eta(x, y; t)$ and $\eta(x+g, y+h; t+\tau)$
$C_{\eta\eta(m,n)}(g, h, \tau)$: cross-covariance of the (m, n)th term in the sum in Eq. (1)
$co(f)$: co-spectral density of $X_1(t)$ and $X_2(t)$
$co_{F_xF_x}(f)$: co-spectral density of $F_x(x, y, z; t)$ and $F_x(x+g, y+h, z; t)$
$co_{F_xF_y}(f)$: co-spectral density of $F_x(x, y, z; t)$ and $F_y(x+g, y+h, z; t)$
$co_{F_yF_y}(f)$: co-spectral density of $F_y(x, y, z; t)$ and $F_y(x+g, y+h, z; t)$
$co_{\eta F_x}(f)$: co-spectral density of $\eta(x, y; t)$ and $F_x(x+g, y+h, z; t)$
$co_{\eta F_y}(f)$: co-spectral density of $\eta(x, y; t)$ and $F_y(x+g, y+h, z; t)$
$co_{\eta\eta}(f)$: co-spectral density of $\eta(x, y; t)$ and $\eta(x+g, y+h, t)$
$\hat{co}_{F_xF_x}(f)$: co-spectral density of $F_x(t)$ and $F_x(t)$ $=P_{F_x}(f)$, power spectral density of $F_x(t)$
$\hat{co}_{F_xF_y}(f)$: co-spectral density of $F_x(t)$ and $F_y(t)$

$\hat{co}_{F_yF_y}(f)$: co-spectral density of $F_y(t)$ and $F_y(t)$
$=P_{F_y}(f)$, power spectral density of $F_y(t)$
$\hat{co}_{\eta F_x}(f)$: co-spectral density of $\eta(t)$ and $F_x(t)$
$\hat{co}_{\eta F_y}(f)$: co-spectral density of $\eta(t)$ and $F_y(t)$
$\hat{co}_{\eta\eta}(f)$: co-spectral density of $\eta(t)$ and $\eta(t)$
$=P_\eta(f)$, power spectral density of $\eta(t)$
$C_{X_1X_2}(\tau)$: cross-covariance between $X_1(t)$ and $X_2(t)$
$C_{X_1X_2}(g, h, \tau)$: cross-covariance between $X_1(x, y, t)$ and $X_2(x+g, y+h, t+\tau)$
D: horizontal distance between wave meter and wave direction meter
d: depth of water at the installation point
F: wave force, unidirectional case
F_x: x component of wave force F
F_y: y component of wave force F
$F_x(x, y, z; t)$: x component wave force at space-point (x, y, z) and time t (with directional spectrum)
$F_y(x, y, z; t)$: y component wave force at space-point (x, y, z) and time t (with directional spectrum)
f: frequency (Hz)
f_m: frequency defined by Eq. 6.
f_{MAX}: frequency at which energy density of the power spectrum can be assumed to be zero
f_p: frequency at which energy density of the power spectrum becomes largest value
G: constant, see Eq. 122
g: acceleration of gravity, also space lag in x axis
h: space lag in y axis
$h(\theta)$: probability density of the circular normal distribution
$I_n(a)$: modified Bessel Function of 1st kind, order n
$J_p(kD)$: Bessel Function of 1st kind
K: constant for generating of the pseudo-random numbers
K_D: constant$=(C_D\omega/2g)\pi r^2C$
K_M: constant$=(C_M\omega/g)(4/3)\pi r^3$
k: wave number
k_m: wave number for the wave with the frequency of f_m at the water depth of d
$L(a, \gamma)$: see Eq. 64
$L'(a, \gamma)$: see Eq. 65
M: numbers of subdivisions in frequency
M_0: constant for generating of the pseudo-random numbers
m: subscript referring to frequency
N: numbers of subdivisions in azimuth
n: subscript referring to azimuth, also integer for $I_n(a)$, $J_n(KD)$, X_n
p: subscript referring to underwater pressure fluctuation, also integer
$p(f, \theta)$: directional spectral density
$p_B(f)$: Bretschneider-Pierson spectral density
$P_{F_x}(f)$: power spectral density of $F_x(t)$, $=\hat{P}_{F_xF_x}(f)=\hat{co}_{F_xF_x}(f)$
$P_{F_xF_x}(f)$: cross-spectral density of $F_x(x, y, t)$ and $F_x(x+g, y+h, t)$
$P_{F_xF_y}(f)$: cross-spectral density of $F_x(x, y, t)$ and $F_y(x+g, y+h, t)$
$P_{F_y}(f)$: power spectral density of $F_y(t)$, $=\hat{P}_{F_yF_y}(f)=\hat{co}_{F_yF_y}(f)$

$P_{F_yF_y}(f)$: cross-spectral density of $F_y(x, y, t)$ and $F_y(x+g, y+h, t)$
$P_\eta(f)$: power spectral density of $\eta(t), =\hat{P}_{\eta\eta}(f)=\hat{co}_{\eta\eta}(f)$
$\eta_{\eta F_x}(f)$: cross-spectral density of $\eta(x, y, t)$ and $F_x(x+g, y+h, t)$
$P_{\eta F_y}(f)$: cross-spectral density of $\eta(x, y, t)$ and $F_y(x+g, y+h, t)$
$P_{\eta_p}(f)$: power spectral density of $\eta_p(f)$
$P_{\eta\eta}(f)$: cross-spectral density of $\eta(x, y, t)$ and $\eta(x+g, y+h, t)$
$P_V(f)$: power spectral density of water particle velocity
$P_{X_1X_2}(f)$: cross-spectral density of $X_1(t)$ and $X_2(t)$
$\hat{P}_{F_xF_x}(f)$: cross-spectral density of $F_x(t)$ and $F_x(t)$
$=P_{F_x}(f)$, power spectral density of $F_x(t)$
$\hat{P}_{F_xF_y}(f)$: cross-spectral density of $F_x(t)$ and $F_y(t)$
$\hat{P}_{F_yF_y}(f)$: cross-spectral density of $F_x(t)$ and $F_y(t)$
$=P_{F_y}(f)$, power spectral density of $F_y(t)$
$\hat{P}_{\eta F_x}(f)$: cross-spectral density of $\eta(t)$ and $F_x(t)$
$\hat{P}_{\eta F_y}(f)$: cross-spectral density of $\eta(t)$ and $F_y(t)$
$\hat{P}_{\eta\eta}(f)$: cross-spectral of $\eta(t)$ and $\eta(t)$
$=P_\eta(f)$, power spectral density of $\eta(t)$
Q: maximum frequency (Eq. 1)
$q(f)$: q-spectral density of $X_1(t)$ and $X_2(t)$
$q_{F_xF_x}(f)$: q-spectral density of $F_x(x, y, z; t)$ and $F_x(x+g, y+h, z; t)$
$q_{F_yF_y}(f)$: q-spectral density of $F_y(x, y, z; t)$ and $F_y(x+g, y+h, z; t)$
$q_{\eta F_x}(f)$: q-spectral density of $\eta(x, y; t)$ and $F_x(x+g, y+h, z; t)$
$q_{\eta F_y}(f)$: q-spectral density of $\eta(x, y; t)$ and $F_y(x+g, y+h, z; t)$
$q_{\eta\eta}(f)$: q-spectral density of $\eta(x, y; t)$ and $\eta(x+g, y+h, t)$
$\hat{q}_{\eta F_x}(f)$: q-spectral density of $\eta(t)$ and $F_x(t)$
$\hat{q}_{\eta F_y}(f)$: q-spectral density of $\eta(t)$ and $F_y(t)$
r: radius of the sphere
$S(f, \theta)$: cumulative spectrum of $p(f, \theta)$
t: time, also$=a/3.75$ (Eq. 129, 130)
V: water particle velocity, unidirectional case
V_{rms}: root-mean-square value of V
V_x: x component of V
V_y: y component of V
$V_x(x, y, z; t)$: x component of water paticle velocity at space-point (x, y, z) and time t (with directional spectrum)
$V_y(x, y, z; t)$: y component of water particle velocity at space-point (x, y, z) and time t (with directional spectrum)
$V'_x(x, y, z; t)$: simulated x component of water particle velocity at space-point (x, y, z) and time t
$V'_y(x, y, z; t)$: simulated y component of water particle velocity at space-point (x, y, z) and time t
X_0: initial value for generating of the pseudo-random numbers by congruence method
$X_1(t)$: time series, real Gaussian stationary prosses
$X_2(t)$: time series, real Gaussian stationary prosses
$X_1(x, y, t)$: time series with the parameters, x, y and t, real Gaussian stationary prosses

$X_2(x, y, t)$: time series with the parameters, x, y and t, real Gaussian stationary prosses

X_n: pseudo-random numbers

$\{X_n\}$: sequence of pseudo-random numbers

x: subscript referring to x component

y: subscript referring to y component

z: subscript referring to vertical component

z_1: installation depth of wave measured from the bottom

z_2: installation depth of wave direction meter measured from the bottom

α: parameter $(=\theta-\gamma)$

β: angle between x axis and the line on which wave meter and wave direction meter lie

γ: constant angle at which the maximum energy of waves is advancing

ε: error in calculating the modified Bessel Function of 1st kind by Eqs. 129, 130

η: subscript referring to sea surface

$\eta(x, y, t)$: pseudo-integral representation for sea surface at space-point (x, y) and time t

$\hat{\eta}(x, y, t)$: Pierson's representation for sea surface at space-point (x, y) and time t

$\eta'(x, y, t)$: simulated sea surface at space-point (x, y) and time t

$\eta_p(x, y, z; t)$: pseudo-integral representation for underwater pressure fluctuation at space-point (x, y, z) and time t

$\eta_p'(x, y, z; t)$: simulated underwater pressure fluctuation at space-point (x, y, z) and time t

θ: direction of wave advancing

θ_n: direction of wave advancing defined by Eq. 7

λ: parameter $(=\alpha+\gamma-\beta)$

$\Pi(f)$: cumulative spectrum of $p(f, \theta)$ at $\theta=2\pi$

π: constant $(3.14159\cdots\cdots)$

τ: lag in time

Φ: random phase

Φ_{mn}: random phase for each wavelet

Φ_n: pseudo-random phase

φ: constant

ω: specific weight of sea water

Appendix: Simulated wave properties for case 1-d

PAGE 1

NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
1	-14.30164	-7.91752	0.55037	-10.12832	-2.90844	-4.18178
2	-10.53404	-7.52198	-1.66505	-10.17344	-0.95145	5.00183
3	-3.15697	1.11393	-0.63652	-0.23367	3.15589	13.98617
4	14.77517	13.80442	4.05552	14.55003	5.34579	13.32292
5	33.14754	20.14350	7.71403	21.98159	1.03881	0.13339
6	13.01817	14.25432	5.95269	15.11698	-3.85326	-12.33330
7	0.61025	1.45889	1.80301	1.06819	-3.77013	-14.19325
8	-12.19311	-9.95364	-1.03940	-11.21754	-1.95746	-9.71087
9	-20.05700	-15.74259	-2.62355	-17.42659	-1.61889	-2.49957
10	-12.72237	-14.90493	-4.76607	-16.16978	-2.42394	5.08048
11	-16.17614	-6.59097	-5.77867	-6.80587	1.46992	13.69971
12	9.12612	7.03919	-1.03045	9.38592	7.39331	16.59749
13	29.89361	19.67044	6.32004	21.43721	5.83853	5.55121
14	22.16920	19.20644	8.78357	19.30072	-1.19350	-9.10656
15	11.38672	7.62538	4.49644	6.21814	-6.59597	-15.08405
16	-14.36813	-5.21495	-2.18634	-6.72000	-5.63165	-8.99944
17	-13.82385	-10.17687	-5.53517	-10.15170	-1.12214	1.76456
18	-4.79195	-6.87502	-5.19601	-5.35670	1.47330	6.61992
19	-4.22643	-0.79721	-2.85651	1.22492	3.00663	5.68795
20	11.10360	1.64139	-0.37308	3.86041	1.09178	-1.51408
21	-1.44557	-4.04140	-1.78979	-2.46829	-3.85589	-10.34363
22	-17.45275	-14.02001	-6.72753	-13.44998	-4.95577	-9.55078
23	-23.50728	-17.58086	-9.35325	-17.87962	0.84417	2.09228
24	-18.79732	-7.15213	-3.67902	-8.19584	10.31779	16.54627
25	20.34168	12.21291	8.66034	10.85787	12.23872	18.41602
26	34.18528	25.00703	16.85747	23.12284	2.89787	4.51861
27	26.12499	21.15272	13.78831	19.44962	-8.60879	-11.05744
28	7.71482	4.06346	1.63576	3.80196	-14.16430	-18.34051
29	-24.94869	-14.20164	-10.94701	-12.94328	-9.37001	-13.20869
30	-25.18788	-22.74957	-15.43211	-20.55340	0.34405	-1.98949
31	-22.31863	-19.42028	-11.33756	-17.83593	7.17470	6.91345
32	-11.38856	-7.91604	-2.37744	-7.73871	10.02760	12.52049
33	11.90891	5.88473	7.14631	4.94871	8.33208	11.63322
34	14.81272	15.72024	13.40361	13.80965	3.86794	5.61290
35	24.81007	17.62343	14.03580	15.48505	-3.05016	-2.48288
36	13.56500	11.42413	7.42663	9.51158	-9.30017	-8.32982
37	-5.06796	3.02209	-1.68590	1.91778	-7.46144	-5.57215
38	0.32420	-1.17288	-5.90813	-0.96941	-0.96121	-0.73526
39	-3.60162	-1.67476	-4.60920	-1.07813	2.73879	-0.13700
40	1.72153	-2.62074	-2.24167	-2.12376	1.23240	-2.15641
41	-5.04458	-5.31924	-2.49831	-4.82894	-1.20171	-2.38313
42	-14.36876	-5.90420	-2.96159	-4.85634	0.85790	2.86459
43	2.73104	-1.88858	-1.06762	0.13342	2.24669	5.98885
44	2.59082	3.21357	0.40296	5.17393	0.53898	3.58917
45	7.29607	5.52988	0.30519	6.85287	-0.51641	-0.47899
46	7.75702	3.50341	-0.30545	3.73215	-0.54425	-5.70532
47	-5.48094	-1.91214	-0.53356	-3.41560	0.04315	-7.68410
48	-4.53695	-7.27518	-0.70610	-9.87503	-0.61123	-4.42143
49	-15.62369	-8.49302	-1.44752	-10.62484	-0.38105	3.56502
50	-6.02759	-3.65334	-0.86935	-3.13398	1.31216	10.07878

PAGE 2

NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
51	11.08156	2.44671	-0.06406	5.55845	-0.27397	5.51444
52	2.29600	3.65752	-1.46093	6.63664	-2.01784	-2.79705
53	2.32810	1.11538	-2.81276	2.18920	-0.11794	-4.88257
54	-5.04242	-0.13631	-0.97312	-1.16726	3.85494	-1.24383
55	1.11584	1.34874	3.89937	-0.59461	4.78906	1.42010
56	10.05995	1.08642	6.15697	-0.76779	-1.05476	-2.51824
57	-8.28083	-3.54383	2.10782	-4.94046	-6.09021	-4.62163
58	-8.92899	-7.93456	-3.78329	-7.75657	-4.73837	-0.43882
59	-10.32542	-7.38497	-6.01705	-5.79515	0.67589	4.04904
60	-4.24261	-2.14240	-2.52663	-0.69106	5.66522	5.39631
61	10.57486	3.79498	3.27172	3.47980	4.96349	2.61000
62	2.86937	8.00934	6.62574	5.41093	1.92814	2.19326
63	12.42739	11.93214	7.76139	8.95690	0.52780	4.63447
64	17.55674	14.77474	7.70911	12.93022	-0.70693	2.28479
65	14.02164	12.61634	5.94318	12.03817	-3.22492	-4.48679
66	10.89415	3.44626	0.51283	4.02414	-7.59552	-10.82097
67	-16.70194	-8.36146	-7.61506	-6.62579	-7.27379	-8.65433
68	-18.81960	-14.67667	-11.77184	-11.16923	-0.64419	-0.62910
69	-11.03355	-13.07790	-9.65797	-10.09419	4.06039	1.50056
70	-12.27379	-10.77108	-5.19510	-9.39625	4.27739	0.04421
71	-4.37284	-6.72282	-1.65547	-8.67177	2.94420	2.41523
72	-7.51375	0.93952	1.72869	-2.53031	4.39999	10.44645
73	13.89868	12.73027	7.09772	10.96428	5.52632	14.56755
74	31.63011	20.93511	10.53802	21.65696	0.52169	4.81661
75	18.17990	17.09660	8.01455	19.31555	-5.01220	-8.87880
76	9.31387	5.69390	1.83957	6.31078	-6.77713	-15.68401
77	-13.47357	-8.67617	-4.61929	-8.97464	-5.75420	-13.36539
78	-21.74612	-18.43099	-9.25064	-18.30844	-3.50996	-4.98351
79	-20.13469	-21.12836	-11.59536	-19.48741	-0.91700	2.14352
80	-24.25604	-17.39109	-10.23452	-14.80953	3.86365	6.73981
81	-4.29292	-9.84271	-4.68816	-7.66408	6.29059	6.54621
82	-1.85185	-2.53463	0.73355	-2.62187	4.27188	3.96538
83	0.04276	4.39726	4.32666	2.12890	3.36379	6.34408
84	14.85183	13.05830	8.09641	10.25664	4.31547	9.34568
85	19.36060	21.64904	12.78378	19.01475	4.61724	7.03628
86	33.80784	24.19550	15.58576	21.82439	-0.07938	-2.49044
87	19.75055	15.93522	11.44339	13.67035	-8.00062	-12.84725
88	-4.30222	0.35886	1.26845	-0.58973	-11.26521	-14.05715
89	-13.16634	-14.26531	-9.21999	-12.51724	-8.92237	-9.38746
90	-29.82517	-22.25871	-15.16343	-18.80003	-2.47622	-2.94809
91	-21.70010	-21.85467	-14.25145	-18.50233	3.72941	3.17634
92	-15.24078	-14.63418	-9.01875	-13.09709	6.33551	7.62410
93	-7.91610	-2.45705	-1.78406	-2.98895	8.06777	12.42784
94	17.42353	11.82818	6.46817	10.12585	7.90730	12.56417
95	22.73368	22.71780	13.01328	20.09989	4.72950	6.79267
96	31.34369	25.69326	14.95158	23.05519	-1.31267	-1.07715
97	23.30316	19.73039	10.32379	18.18714	-7.31954	-8.03470
98	2.80390	8.35613	2.38311	8.77099	-7.61335	-10.11856
99	0.99612	-4.40964	-4.25902	-1.95058	-5.90720	-11.65246
100	-19.38267	-17.17932	-9.95260	-14.35792	-5.47236	-12.36071

PAGE 3

NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
101	-30.15558	-26.59396	-14.62748	-24.29842	-3.44653	-6.40842
102	-30.69604	-27.63078	-15.88629	-25.79120	1.42998	3.71961
103	-25.58030	-18.42468	-11.23749	-17.13779	7.62146	12.84741
104	3.73452	-3.17718	-2.29896	-2.74770	9.18815	14.42571
105	10.68652	11.11746	5.89615	9.91881	7.19470	10.76958
106	20.56404	21.06815	12.42426	18.96430	5.74209	6.97646
107	32.50657	24.01135	16.16005	22.14187	0.88820	-1.57425
108	17.94620	16.69822	13.06455	15.20400	-7.19322	-11.81347
109	4.91953	1.22147	2.61182	0.64241	-12.70947	-15.83046
110	-21.81952	-13.65655	-9.24525	-12.98186	-9.18296	-9.68836
111	-26.52371	-18.62995	-13.20821	-16.82061	1.49768	1.76470
112	-8.52245	-13.27192	-7.80712	-11.89408	7.98496	6.58981
113	-7.16939	-4.34547	0.45489	-5.40916	7.69901	6.16221
114	7.16290	2.87160	6.23961	0.24786	3.30560	4.88925
115	7.96517	5.74374	6.56505	3.74101	-2.44765	1.97562
116	3.09639	4.37597	2.43531	4.42526	-5.15003	-0.42072
117	4.50719	1.66036	-2.43218	3.37664	-3.85048	-1.18218
118	-7.16928	2.13492	-3.64415	3.72463	2.03378	2.68228
119	8.87670	7.91254	1.36627	8.65798	7.01677	6.07545
120	19.69439	13.36048	7.74155	12.72351	4.53938	0.72203
121	12.93510	11.30127	9.03479	9.11412	-2.20177	-7.63873
122	6.38317	1.88583	3.66639	-0.81023	-7.86093	-10.81047
123	-17.19262	-7.24896	-4.28836	-9.02279	-6.62063	-3.99336
124	-11.86737	-8.71969	-7.75492	-7.74710	-0.26713	5.61882
125	0.53169	-5.06337	-6.16927	-1.51562	2.45097	4.84725
126	-2.87358	-4.39748	-4.48347	-0.46827	0.40359	-3.00875
127	-4.35739	-8.86167	-5.54936	-6.36120	-2.07484	-7.42293
128	-22.05576	-11.91213	-6.65026	-11.59560	1.03426	-1.18867
129	-10.67266	-6.42200	-2.51194	-7.16274	6.69139	9.34066
130	11.64275	4.48256	4.20391	3.58578	5.39657	10.22206
131	12.06122	12.08268	6.92429	10.97910	0.11777	4.26893
132	17.45104	13.27668	5.49983	12.39638	-2.21501	-1.10969
133	7.17625	10.25718	3.87765	9.58170	-0.63062	-4.11784
134	6.55402	4.71513	3.75819	4.28388	-0.48400	-6.85640
135	2.42767	-4.92087	1.10955	-4.80827	-5.14667	-11.05980
136	-23.28295	-15.36940	-5.35763	-15.49013	-6.57910	-8.64346
137	-22.66984	-20.60265	-9.93178	-19.71189	-1.97537	0.59162
138	-20.26457	-16.08218	-8.94178	-14.65299	3.88666	9.09022
139	-6.19053	-3.80585	-2.76730	-2.84670	7.84839	13.48295
140	16.45197	9.77203	5.14212	9.64523	7.20773	10.23193
141	17.41239	17.69840	10.61559	16.11383	3.37877	2.45387
142	24.11333	16.89291	11.15856	14.53516	-2.55656	-5.37012
143	8.47110	9.91163	6.08663	7.04067	-6.58838	-8.10973
144	-5.73575	2.83160	0.51575	1.40111	-3.58765	-2.31989
145	4.69227	1.24948	-0.76975	1.68037	0.46840	[illegible]
146	0.91299	0.92492	-0.11282	2.12140	0.07813	.55825
147	2.13211	-3.06817	-1.75811	-1.96590	-3.60417	-6.34564
148	-11.41072	-9.67116	-6.52949	-8.79374	-4.87082	-5.86013
149	-21.50544	-12.06123	-9.01635	-10.96056	0.75735	2.15757
150	-3.25776	-6.64178	-4.98798	-5.47712	6.59232	7.53705

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NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
151	0.97665	2.46126	2.29618	1.83711	7.02814	6.43100
152	12.42126	8.37012	7.26004	6.72683	2.10859	3.13067
153	12.69189	9.17477	5.90560	7.97273	-4.39328	-0.37919
154	1.18126	6.18177	0.45111	6.88447	-5.41137	-1.50559
155	6.94134	2.17135	-3.62885	4.58744	-2.61183	-3.52161
156	-4.70331	-2.12203	-4.92468	-0.19973	-0.10881	-5.47402
157	-6.69187	-5.94127	-4.25718	-4.84827	1.13102	-3.32948
158	-5.42454	-7.15090	-3.11635	-6.77348	1.18050	-0.74761
159	-11.51336	-7.57344	-1.53760	-6.99143	1.99709	-0.18879
160	-1.37963	-8.57372	0.09793	-8.42036	0.69419	-3.05932
161	-13.64380	-10.05618	-0.41329	-11.97121	-1.17362	-2.43814
162	-14.78290	-6.48247	-0.50999	-9.79373	1.68956	7.80443
163	6.29269	5.09465	3.17122	2.82357	5.17864	15.78500
164	19.67086	17.45064	8.07277	17.40810	3.48181	11.09391
165	32.46126	19.49815	8.02657	21.38208	-4.13394	-4.00907
166	8.11480	8.44173	0.75018	10.72642	-8.93753	-15.18343
167	-14.51029	-5.91420	-6.44199	-3.96892	-4.21973	-12.24191
168	-12.84346	-13.18249	-7.09738	-12.14121	2.48213	-4.17431
169	-17.29886	-11.66091	-2.70163	-12.82640	5.69728	2.55197
170	-2.27204	-4.79670	3.04611	-7.90480	5.16574	6.58367
171	3.82309	2.53817	6.72061	-1.13019	1.99440	6.42246
172	6.88888	6.70096	6.89519	4.17870	-1.74922	3.81217
173	12.90993	6.48712	3.17499	5.92730	-5.33996	-0.14957
174	-3.30179	4.82503	-1.95235	5.63182	-3.72210	0.79959
175	5.13268	6.62774	-2.88322	8.74038	1.71813	4.94945
176	14.72218	10.21676	-0.08608	13.03900	2.86034	2.22938
177	11.01784	8.81692	1.22467	11.29002	-0.74949	-6.13615
178	6.28525	-0.48649	-1.81078	1.07749	-4.89793	-13.44237
179	-20.48454	-12.55082	-6.61412	-12.43186	-3.47449	-11.60652
180	-22.77220	-18.34518	-7.20484	-19.26251	2.31019	-1.58791
181	-14.49151	-14.66991	-3.11688	-16.25270	5.09714	6.96411
182	-8.92451	-4.94656	1.69100	-6.53536	3.96659	11.77596
183	12.08447	5.39361	3.87453	5.27399	0.17564	10.66188
184	10.98017	11.50445	2.59000	13.05146	-2.06526	4.46370
185	14.13629	11.24261	0.82227	13.63403	-1.39526	-3.63550
186	10.35085	4.10258	-0.79414	5.57351	-2.14251	-11.90517
187	-12.83466	-6.55098	-3.32544	-7.21479	-2.51380	-11.67645
188	-14.96111	-12.80475	-4.83120	-14.49586	-0.00703	-1.94845
189	-16.47184	-9.32452	-2.50249	-10.72648	4.84397	8.97132
190	2.28785	1.19156	3.92408	0.80376	6.79871	12.02557
191	20.02589	9.07706	8.24223	9.22576	0.83826	3.55858
192	5.62273	8.20542	5.60134	8.14161	-5.26137	-4.55849
193	3.18091	2.07783	-0.18245	2.55308	-5.43718	-5.82029
194	-5.94015	-3.83713	-4.16451	-2.74985	-2.24355	-4.61383
195	-8.94942	-7.32561	-4.68089	-6.54532	0.91441	-3.06842
196	-5.19490	-8.23400	-2.99112	-8.99470	2.37747	-1.54444
197	-13.87709	-5.20015	0.48496	-8.16652	4.75656	4.00654
198	4.77428	2.97564	5.78657	-0.74502	4.91819	10.11028
199	15.31702	12.63539	8.53771	9.97871	0.19539	10.47027
200	17.71905	18.94190	6.67306	19.01191	-3.32071	6.97185

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NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
201	26.21284	18.03059	2.96690	22.12118	-3.71379	-1.69084
202	10.65519	10.90688	-0.30403	14.83685	-2.81413	-12.56623
203	0.21880	-3.51764	-3.21063	-1.30589	-3.41773	-18.45013
204	-21.60796	-18.39213	-7.27148	-18.62657	-4.18568	-14.08548
205	-36.29561	-24.88606	-9.92287	-25.86884	-0.45783	0.40877
206	-16.78675	-19.22266	-8.09517	-19.06255	3.66421	11.53909
207	-8.25361	-6.54229	-3.53696	-6.05168	5.13559	13.36061
208	8.82799	6.45019	1.62825	6.31790	4.84978	10.89429
209	19.14282	15.44685	5.53195	14.91074	2.81941	6.03129
210	17.06539	18.06974	7.24354	17.98227	0.50888	-0.25060
211	22.00090	12.71671	5.96437	13.32315	-3.34012	-9.38554
212	-2.10014	0.57978	0.93957	0.50797	-6.00646	-14.54236
213	-16.48214	-10.97195	-4.41930	-11.76229	-4.11109	-8.41444
214	-16.48579	-14.82470	-6.69428	-14.97273	-0.30716	1.86347
215	-15.76961	-10.77696	-5.01046	-9.43649	3.39827	7.96078
216	3.64465	-4.66486	-1.28566	-2.26693	3.16320	4.87476
217	-1.83284	-2.03067	0.35839	-0.72283	0.29189	-1.08481
218	-5.64365	-1.13270	0.44502	-1.82399	0.48511	0.05257
219	3.38277	2.15427	1.93041	0.18989	2.48124	3.67994
220	4.66492	6.73689	4.84142	4.23694	2.73065	3.54418
221	16.50856	7.71288	5.73939	5.50490	-1.62173	-1.56578
222	1.86880	3.48082	1.82099	1.87174	-5.16748	-4.32669
223	-8.34083	0.03029	-1.83280	-0.12641	-1.10612	1.13675
224	5.14912	1.78879	-0.16404	3.28419	3.74878	4.37594
225	4.83428	4.88602	3.72714	6.15640	3.09963	0.63295
226	9.47311	4.51552	4.76599	4.28794	-1.20672	-3.95160
227	-1.55483	1.54900	2.15406	0.08234	-3.11786	-3.23621
228	-5.16240	0.41168	0.00821	-0.57252	-1.05881	1.79586
229	8.95348	0.88990	-1.07969	1.57123	-1.88995	1.15502
230	-2.88576	-0.99061	-4.25167	0.55218	-4.02308	-2.84888
231	-5.07771	-4.64133	-7.70671	-2.66049	-2.24850	-2.93905
232	-7.54726	-6.64199	-7.99682	-4.65416	1.81358	-0.88723
233	-9.16739	-5.60459	-4.33292	-4.39579	5.03701	1.15219
234	2.74209	-3.07117	0.69647	-3.30461	4.42826	0.65799
235	-5.25627	-0.49741	4.24116	-2.69257	2.88184	1.24050
236	2.89960	3.05191	6.63532	0.14596	1.63719	4.35761
237	10.44678	6.99251	6.71513	5.05807	-1.65883	4.98851
238	5.78846	9.34709	3.75441	9.62626	-3.84900	3.87631
239	14.83068	8.34254	-0.46064	11.46923	-4.48703	-1.14564
240	2.47250	1.76665	-4.95199	6.05357	-4.26880	-9.71131
241	-8.22135	-9.06209	-8.69399	-6.88085	-3.21675	-15.21675
242	-22.06192	-21.85797	-11.22918	-21.59009	-1.44155	-12.24128
243	-38.45148	-24.81830	-10.12820	-27.05964	4.32340	2.94843
244	-14.73153	-12.77671	-2.40673	-15.34520	10.53958	19.06512
245	9.15840	8.37550	9.03836	6.38680	11.21795	21.72304
246	32.86264	24.64390	17.53604	23.12858	4.47006	9.67870
247	37.55084	24.87259	16.17937	23.53398	-7.20726	-8.52730
248	5.21666	10.89487	5.35210	9.79723	-12.51748	-16.15975
249	-8.23657	-4.08917	-5.12946	-3.94770	-7.12940	-9.86261
250	-15.70484	-10.07516	-7.87012	-9.00385	1.38748	-0.54370

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NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
251	-8.31835	-7.70541	-4.25797	-6.66542	4.38115	3.99192
252	3.75576	-3.82687	-1.66045	-3.31209	0.29060	2.16333
253	-8.05947	-1.54148	-2.58893	-1.62316	-0.90530	2.11590
254	2.01848	1.97204	-1.52970	1.92106	3.26949	4.72244
255	8.87656	6.98750	3.07898	6.48268	5.15233	3.78629
256	9.71736	10.09172	7.16358	8.88653	2.28313	0.84631
257	14.86547	8.35879	6.64395	7.67716	-3.40503	-3.46011
258	-1.59748	1.52074	1.19788	2.22302	-6.76898	-7.03910
259	-5.17875	-7.64735	-5.74367	-5.62023	-6.75920	-8.31073
260	-16.73068	-14.85582	-11.38964	-13.04938	-3.72766	-5.30709
261	-25.25149	-14.14518	-11.37214	-13.47702	4.29912	5.25053
262	-0.80518	-3.67389	-3.49445	-3.56195	10.30124	12.92375
263	11.16576	9.14849	6.44684	8.57003	8.30957	9.75398
264	21.64090	15.18216	11.29556	13.97166	0.90928	0.65161
265	14.90426	11.65833	8.52506	10.41162	-5.68679	-6.81805
266	-2.97477	2.86298	1.91140	2.71365	-6.77879	-7.70634
267	-0.99202	-6.57644	-4.65554	-4.73917	-6.51838	-7.52153
268	-18.14043	-14.92389	-10.89535	-12.19631	-5.35221	-6.64708
269	-23.75468	-18.53887	-13.71983	-16.02961	0.37024	-0.30150
270	-14.81619	-13.95068	-9.63438	-12.61930	7.69751	6.73494
271	-7.09127	-2.69282	0.77306	-3.79706	12.21678	10.04121
272	17.18312	9.01913	12.12918	5.26827	9.02708	7.05340
273	16.09388	14.98573	16.92966	9.60102	0.38456	2.06439
274	13.56821	14.66385	13.61377	10.74904	-6.42882	0.55361
275	14.96653	10.04823	5.31468	10.14537	-9.43926	-2.31553
276	-1.11315	2.31925	-3.60057	5.58373	-7.66945	-6.69782
277	-3.10796	-6.32433	-9.38907	-2.53689	-3.91929	-8.90791
278	-16.99233	-11.59761	-11.23469	-9.92734	0.63463	-4.25911
279	-16.89219	-8.03016	-7.27376	-8.49805	7.31128	7.33787
280	8.38007	3.45004	2.04853	2.34531	10.13477	12.16369
281	16.17595	13.11260	10.44553	11.58795	5.52274	4.77004
282	21.36057	12.42044	11.51225	10.47852	-3.63389	-6.76275
283	0.92439	2.49002	4.39724	0.55660	-9.17987	-11.00497
284	-16.25579	-7.29981	-3.79822	-7.62536	-6.21252	-4.31868
285	-6.73736	-10.93811	-7.83658	-8.59946	-2.37289	1.29525
286	-13.09346	-10.00513	-9.28895	-6.63535	-0.49016	2.49574
287	-7.00397	-5.59358	-8.16486	-3.04136	3.10709	5.01334
288	1.07233	2.88031	-2.70825	3.54361	7.70695	7.95984
289	11.80163	12.71689	6.03668	11.62089	8.56875	6.99511
290	29.01565	16.35568	11.46404	14.55559	1.10220	-2.29270
291	8.48819	8.83662	7.91349	7.06211	-7.32880	-11.45754
292	-7.22103	-4.66673	-0.68899	-5.05767	-8.76238	-11.36805
293	-16.68103	-15.41855	-8.16705	-13.92374	-5.72846	-5.83221
294	-25.76739	-18.57515	-11.44888	-16.01714	-0.67768	1.65832
295	-11.14438	-14.34189	-9.77411	-11.67782	3.72452	6.10363
296	-8.78854	-6.50177	-4.48701	-5.32831	6.65564	6.18965
297	2.92886	1.33336	2.69730	0.20678	6.96639	4.60666
298	11.32431	6.79657	7.95621	3.62610	3.19164	2.53790
299	3.82717	10.32786	9.46811	6.67226	0.29890	4.14385
300	17.56876	13.03849	8.98317	11.39460	-1.39713	4.17267

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NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
301	14.83037	11.97605	6.30806	12.50551	-3.98361	-2.76022
302	6.25815	4.49895	1.25252	5.73573	-5.95267	-10.21536
303	-4.85185	-6.39433	-4.94682	-5.71211	-5.79312	-11.01475
304	-24.45269	-12.47844	-8.44222	-12.54587	-0.30213	-1.18171
305	-8.63805	-7.76662	-5.03126	-7.69588	6.62880	9.69900
306	5.38029	3.50450	2.93597	3.21045	8.20027	10.30720
307	15.26610	11.51330	9.12909	10.23170	3.07713	2.83719
308	18.95772	9.64294	7.55629	8.15399	-6.25788	-6.59480
309	-5.98200	-0.15655	-1.48187	-0.48875	-10.16105	-9.01043
310	-11.13327	-9.32128	-9.67138	-7.38210	-5.19970	-4.28411
311	-14.36045	-11.73671	-11.04466	-8.94798	2.43555	1.18333
312	-11.77080	-6.17223	-5.47543	-4.73468	8.02975	7.22637
313	8.50984	4.92586	3.28888	4.54646	8.68969	10.47948
314	14.00926	15.81151	10.79254	14.27817	5.86755	7.89604
315	28.53593	19.12875	13.63091	17.70883	-1.11151	-2.38244
316	17.54152	9.63215	7.51213	8.50237	-10.77043	-15.11970
317	-15.62599	-7.60282	-5.23690	-8.11356	-12.84090	-15.37869
318	-23.77394	-19.74003	-14.91321	-18.26059	-5.47494	-4.06375
319	-26.59242	-19.94572	-15.55823	-16.62887	3.78009	6.32251
320	-8.29517	-12.28174	-9.38531	-8.63338	7.20924	7.96911
321	0.13626	-4.92528	-3.12503	-2.94235	5.07104	3.29152
322	-6.45420	-0.27835	1.54299	-0.63706	4.78563	2.20902
323	8.26316	3.72632	6.46499	1.99077	4.55460	2.68265
324	6.15709	6.97301	9.61667	4.09167	1.52329	1.61731
325	8.00635	9.30534	9.67521	5.97184	-1.17752	2.43013
326	13.23985	11.37341	7.81140	8.85888	-2.20705	3.05827
327	9.30651	12.18885	5.80783	11.20472	-1.82523	0.92787
328	17.61006	8.29121	3.25866	8.79930	-3.89967	-6.57393
329	-2.24041	-2.54642	-2.37693	-1.75725	-6.92861	-13.29682
330	-20.74934	-15.22694	-9.05509	-14.19724	-5.70988	-9.93086
331	-22.56937	-21.65853	-12.89765	-19.69291	-1.65246	-0.66524
332	-26.32109	-17.57490	-11.64409	-15.26222	4.43138	9.36329
333	-2.45987	-3.80611	-4.27067	-2.35527	9.77807	15.26751
334	14.16947	13.82742	6.53349	12.85291	11.14324	14.16954
335	29.74549	27.42778	16.43622	24.17921	7.62222	7.38112
336	41.75142	28.89741	19.52819	25.19068	-2.25470	-6.18505
337	15.59643	14.96240	11.88547	12.32582	-12.25181	-18.16943
338	-7.32694	-6.93608	-2.50890	-7.25813	-15.04978	-18.87232
339	-32.21822	-23.00090	-14.93910	-21.31248	-8.15990	-7.41070
340	-34.77256	-22.90651	-16.70777	-20.15430	4.60045	9.30300
341	-2.84975	-9.54191	-8.26327	-6.47052	10.22540	15.35098
342	7.60804	3.62059	-0.00050	6.01157	5.10885	8.32194
343	13.01329	7.68102	1.33740	9.53414	-1.93366	-0.87802
344	3.51254	4.62107	-1.66004	6.00638	-2.62392	-4.96592
345	-5.28295	1.27942	-1.80970	1.64875	2.49633	-3.36943
346	6.99120	-0.28058	1.75785	-1.49668	3.39140	-3.58826
347	-4.76186	-2.51251	3.46606	-5.63732	0.06839	-3.96055
348	-7.14249	-4.32384	2.95583	-7.61687	-0.50384	0.48601
349	-2.36704	-3.36106	3.02248	-5.04451	0.61519	4.04533
350	-2.99557	-0.87880	3.63217	-0.84933	0.07525	3.68837

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NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
351	6.88557	-0.10480	2.00287	1.17809	-3.64799	0.10775
352	-5.76604	-1.66073	-2.94625	0.19571	-5.29656	-1.09500
353	-5.06360	-2.02438	-6.74814	0.55015	-1.83139	1.89704
354	4.12431	0.27690	-6.59043	2.92349	1.99945	2.18419
355	-0.90947	3.48743	-2.77597	4.36711	5.62822	0.71720
356	10.37389	5.89402	4.00190	4.11043	7.21748	-1.55116
357	6.05286	5.57450	10.03903	0.99875	4.14971	-4.37278
358	1.99637	2.23561	11.22747	-3.43256	-2.13640	-3.86204
359	0.25263	-1.89668	5.86035	-5.67508	-7.91388	-0.08239
360	-11.90994	-2.98434	-2.12059	-2.63573	-6.69232	6.19914
361	3.83849	0.24336	-6.04623	4.87124	-1.19786	7.06232
362	6.93011	3.02087	-5.41182	8.32474	1.96630	-0.85285
363	0.50231	1.81441	-2.87877	4.03573	2.75006	-6.52103
364	0.58496	-0.75798	-0.53090	-1.99163	1.83482	-4.22396
365	-8.16328	0.05934	1.16281	-2.44712	1.83906	3.63017
366	8.39715	4.84491	3.06361	3.71740	1.51800	6.96983
367	13.10987	7.77580	3.22797	8.04568	-1.40393	0.68661
368	3.51980	4.55582	0.51904	5.12630	-3.71250	-5.83017
369	0.70396	-2.83398	-3.54196	-2.00191	-3.96911	-7.62633
370	-16.38629	-9.66237	-6.20945	-8.56624	-0.81880	-4.91094
371	-11.56279	-12.98928	-5.20752	-11.78783	2.14431	-2.07569
372	-10.97037	-13.71260	-3.61907	-13.53207	0.53296	-1.11148
373	-18.92897	-10.84387	-3.75359	-11.85434	-0.09056	5.75101
374	-1.80927	-0.73571	-2.29231	-1.02231	3.57935	15.34044
375	12.32239	14.52037	3.71337	15.84144	7.99442	16.21191
376	35.19387	24.50641	11.31040	26.42787	5.45435	2.60170
377	30.40362	18.43781	11.77624	18.69978	-4.97915	-17.41619
378	-7.85225	-1.64458	2.85823	-3.68236	-11.30634	-24.08302
379	-24.69723	-21.63273	-7.82038	-23.90096	-8.90178	-14.51700
380	-38.24051	-29.37938	-13.37105	-30.67671	-1.69919	1.40687
381	-26.67669	-20.99249	-10.91925	-21.32977	6.34160	16.49393
382	0.21139	-0.56435	-1.76875	-0.38724	11.29671	23.72617
383	21.14290	21.00998	10.04788	22.42054	11.17780	19.71802
384	49.29923	33.14694	17.52011	34.18537	2.24949	1.65208
385	31.72090	24.01154	13.34202	24.36364	-9.92814	-20.00036
386	-4.42116	0.95357	0.97480	-0.14896	-12.76166	-25.51408
387	-25.09009	-18.51177	-8.79316	-20.53805	-5.65370	-13.01552
388	-34.18692	-21.77542	-9.51409	-23.83811	3.82661	6.31989
389	-6.79752	-10.04808	-3.36339	-10.78472	6.96640	17.34394
390	9.10373	5.12732	2.08016	6.01850	3.41290	14.47029
391	15.76202	13.86983	3.48611	16.07586	-0.40497	5.08112
392	21.01603	13.07227	1.58310	15.69393	-3.14904	-5.54931
393	0.49736	5.62498	-1.74597	7.12168	-2.82396	-9.99692
394	-2.62700	-1.95444	-3.23199	-1.66257	-0.14111	-6.91448
395	-6.81082	-5.03486	-2.41345	-6.49070	1.60049	-2.87855
396	-9.68427	-6.85218	-0.37231	-7.89955	2.14397	-0.40076
397	-0.78216	-7.36120	0.81267	-8.50310	-0.24758	-1.18583
398	-13.19567	-8.46662	-0.91888	-9.58702	-2.78665	-0.01286
399	-8.90161	-6.93174	-3.66751	-6.81271	-2.24080	5.84533
400	-1.17275	-0.53872	-4.57156	1.41612	0.85555	9.88866

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NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
401	5.73329	8.14745	-1.55123	11.06770	4.86578	8.15147
402	23.55850	12.49405	3.30795	14.85721	3.68160	-1.68385
403	8.06767	7.59837	4.47733	7.72396	-1.26148	-11.34539
404	-5.27006	-2.68816	1.92594	-4.34978	-3.13818	-11.22330
405	-12.18195	-10.67590	-0.71767	-12.77471	-1.79697	-5.15882
406	-18.14854	-12.54212	-1.47600	-14.41393	0.03588	1.62754
407	-4.40581	-9.36527	-1.54744	-10.67114	-0.48973	5.26264
408	-8.08061	-3.10725	-1.87318	-4.12232	0.65933	8.16041
409	3.38999	6.01241	1.01153	5.71129	5.00411	10.72992
410	22.53623	13.91762	6.29992	14.37954	4.26738	5.05950
411	15.40295	13.86414	7.60016	14.34806	-2.05993	-4.92310
412	9.38691	5.49380	2.64310	6.17641	-7.03011	-10.19912
413	-10.94150	-3.93465	-3.91273	-3.13857	-4.65799	-6.94553
414	-12.41120	-6.37759	-4.94622	-5.93634	2.53901	1.28367
415	3.06096	-1.48370	-0.43913	-2.23747	5.41381	5.06723
416	1.83456	5.06984	4.38715	2.88034	3.81153	4.81135
417	14.33786	8.15823	6.36685	6.29382	-0.31346	1.19241
418	8.15913	4.61417	3.30746	4.11305	-5.56723	-5.43777
419	-6.84684	-3.45861	-3.43846	-2.85454	-7.06302	-7.24551
420	-10.69711	-10.04238	-9.16689	-8.09945	-3.61521	-2.33744
421	-18.08913	-9.16994	-9.42859	-6.48993	3.29239	5.41857
422	2.26938	-2.46496	-3.71960	0.50393	6.88158	6.69436
423	8.50295	2.42574	1.88224	3.77592	3.61619	-0.65094
424	-1.45421	2.22827	3.48083	0.70310	-0.00793	-4.01262
425	2.08541	1.35415	2.75808	-1.62951	-1.01722	0.18260
426	-2.10891	3.80417	2.24889	1.59601	0.24980	5.87414
427	12.40733	7.41936	2.84241	7.71609	0.25356	4.54060
428	13.02487	5.43739	1.37676	7.60692	-3.45924	-5.30649
429	-7.35940	-3.86010	-3.40914	-1.49147	-5.38282	-11.37129
430	-13.66414	-13.91834	-7.87697	-12.10784	-2.85371	-8.61827
431	-25.58580	-17.27496	-7.91105	-16.84173	3.12523	-0.28070
432	-12.58151	-11.75830	-2.23645	-12.91514	7.21840	7.25799
433	2.78581	-1.94265	4.15256	-4.51455	4.72454	8.77537
434	2.88007	7.05339	6.91523	4.20619	1.11608	8.62223
435	18.72392	12.73474	6.89635	11.68641	-1.10707	5.32341
436	14.54186	12.40550	4.67660	13.10334	-3.26566	-2.77015
437	7.06122	6.16402	0.71770	7.08027	-4.35934	-8.21281
438	-2.40820	-0.20375	-2.88632	-0.37629	-1.90779	-4.95001
439	-11.41956	1.02086	-1.26424	-0.05544	5.46899	5.88770
440	15.95512	8.09573	6.27015	8.52927	7.65453	8.44935
441	21.40333	11.32692	10.04174	11.37692	-1.42491	-4.34217
442	2.97769	0.10909	3.16539	0.14012	-11.36400	-16.51021
443	-19.63913	-17.10518	-9.34233	-16.83334	-11.57557	-14.67788
444	-40.03804	-25.24787	-16.28234	-24.46507	-1.19461	0.79368
445	-17.65217	-17.03585	-11.90283	-15.67635	8.83788	15.14122
446	2.71391	0.09852	-1.33359	1.69295	11.16921	17.79963
447	18.83911	18.01250	8.83990	17.34831	8.48567	12.48101
448	36.16924	26.22844	14.19525	24.77871	1.66737	1.78196
449	22.31619	22.77963	12.04962	21.22111	-5.53390	-8.05815
450	13.42309	10.81639	4.33702	10.58223	-9.26366	-12.44624

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NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
451	-4.96516	-4.42505	-5.09495	-2.38887	-8.79714	-12.80774
452	-22.15736	-16.91399	-11.87496	-13.72405	-4.43748	-9.49129
453	-21.14204	-24.61288	-14.13073	-21.29807	-0.28223	-5.62672
454	-33.30425	-25.53986	-12.32364	-23.99251	4.17373	1.08868
455	-20.47182	-17.69936	-5.71438	-18.16599	8.59512	10.25253
456	-1.07688	-3.37469	3.28835	-5.42049	8.57530	14.05421
457	10.35141	10.83065	10.09746	7.92922	4.47659	11.76437
458	27.70377	18.69279	11.30924	16.45895	-2.21060	4.72962
459	16.50167	18.20530	6.63474	17.55047	-6.07491	-1.86600
460	12.06833	12.84015	1.37282	14.04641	-3.68963	-4.90593
461	8.66857	5.97196	-0.23860	7.51845	0.33440	-8.20504
462	-5.27001	-1.44897	1.20382	-1.66744	1.80384	-9.55004
463	-4.06973	-8.69606	1.51673	-10.43553	-1.90391	-7.43556
464	-19.20084	-13.53767	-2.43028	-15.02939	-5.02599	-0.87225
465	-17.36769	-12.20623	-6.10281	-11.49659	-1.44337	7.30039
466	-0.62460	-5.62834	-5.05195	-3.32989	3.07492	7.41376
467	-0.18972	0.48653	-1.30313	1.53094	3.72814	2.28164
468	7.44211	3.57130	1.39883	2.34734	1.56150	0.26596
469	0.69246	6.58704	2.73939	4.16191	1.97445	4.27669
470	9.42847	12.85061	6.37842	11.06948	5.01832	8.46424
471	28.34842	18.37566	10.70755	17.47510	2.37645	2.63128
472	16.19887	16.10385	9.67620	15.09250	-4.48071	-6.87730
473	8.65819	5.73654	2.51964	5.65329	-9.22381	-11.05947
474	-9.32270	-7.78297	-7.27350	-5.52096	-9.49595	-10.63101
475	-22.98747	-19.02405	-14.94730	-14.56897	-5.36714	-7.20078
476	-22.74789	-24.16950	-17.48246	-19.64206	0.56241	-2.61780
477	-30.64544	-20.30656	-13.08074	-18.41918	8.44296	5.77270
478	-6.63684	-7.44815	-1.65831	-8.29035	13.05165	13.35789
479	14.17061	8.50633	9.81895	5.15665	8.61467	12.19144
480	19.02411	18.61255	14.44721	14.74657	0.71296	6.79581
481	26.46872	20.60635	12.09141	18.50969	-4.74990	0.63323
482	13.02175	15.67004	6.50240	16.06566	-5.78124	-5.43947
483	9.90270	5.42977	0.81291	7.38859	-5.96035	-12.20298
484	-6.46299	-10.27528	-6.09849	-8.01398	-7.74566	-17.51688
485	-34.17670	-25.00703	-13.28590	-23.77271	-5.65858	-11.82998
486	-32.75382	-29.75418	-15.89459	-28.75926	0.90298	2.38296
487	-28.28894	-20.15639	-10.99408	-19.37898	8.87504	15.62705
488	0.37987	-0.16777	0.72097	-0.24471	13.36446	20.67505
489	27.78354	19.80271	12.88841	17.96450	9.76839	14.25813
490	31.03006	30.40264	18.99875	26.96939	2.28648	3.65376
491	37.02331	28.20550	17.47505	25.10776	-5.18645	-7.47217
492	15.05616	14.42793	9.49010	12.66262	-10.06687	-16.46828
493	-6.66123	-4.72898	-1.20300	-5.08631	-10.74146	-17.54042
494	-22.39396	-20.08411	-10.85719	-19.49238	-7.78151	-9.76326
495	-36.58771	-23.25076	-14.86240	-22.01184	0.48514	5.28195
496	-11.10240	-12.99733	-10.18113	-10.65356	7.82077	15.26454
497	6.24272	1.23339	-2.00766	3.67810	7.29874	11.53925
498	12.38959	9.61431	3.04817	10.81063	2.67499	2.82389
499	13.81006	10.97596	4.01841	10.64216	0.00978	-2.10396
500	2.73154	10.01713	4.61917	8.71035	1.56182	-1.17307

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NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
501	14.82688	8.66341	6.25463	7.58624	0.64826	-2.16034
502	7.50946	3.71139	4.30393	2.81823	-4.56984	-7.22692
503	-9.80432	-3.97803	-1.32159	-4.75955	-5.54446	-6.56697
504	-8.66913	-8.48240	-5.10947	-8.57377	-1.66222	-0.80403
505	-12.12381	-7.27497	-4.78659	-6.68820	1.83556	4.07131
506	1.55643	-3.67778	-2.97925	-2.16266	0.95220	3.89914
507	0.12097	-2.56501	-3.55674	-0.31202	-1.74765	-0.21020
508	-8.72144	-4.12728	-5.00511	-1.60297	-0.52310	-1.86300
509	-1.05443	-5.75524	-4.36089	-3.77979	1.57663	-2.53033
510	-10.65227	-5.91409	-2.13953	-6.01238	2.91902	-1.19943
511	-4.18592	-3.01557	1.48780	-4.97584	4.11353	3.35361
512	4.32632	2.50841	5.35304	-0.12674	3.29423	5.75992
513	5.65356	7.82840	7.64884	5.53375	1.06748	5.03787
514	17.02442	9.81999	6.90785	8.70989	-2.69989	0.81592
515	4.59826	7.23649	2.87245	7.23677	-4.64355	-3.22064
516	1.98313	2.16684	-1.04822	3.22202	-2.88611	-4.73911
517	-0.02187	-3.45993	-2.86733	-2.50589	-0.76987	-6.57274
518	-14.28005	-7.50846	-2.39203	-8.40477	1.76223	-4.11713
519	-6.26678	-7.03979	0.11048	-9.14405	2.72592	2.91299
520	-5.01236	-1.23306	2.26595	-2.87955	1.44175	9.09595
521	7.86216	6.19744	2.84107	6.88807	-0.48666	8.74471
522	18.06820	8.56871	0.83815	11.16898	-3.51450	-1.20325
523	0.22481	3.18454	-3.31436	5.16982	-4.06722	-9.25070
524	-4.82059	-3.77887	-5.96079	-3.53722	-0.69145	-6.39039
525	-12.02331	-3.94600	-3.76942	-5.09687	5.38861	3.82031
526	1.61106	4.22433	4.23172	2.90118	9.44358	10.28671
527	24.38227	11.65920	11.56861	10.48331	3.48425	2.74494
528	10.14651	8.83243	9.57875	7.19916	-7.13077	-8.28586
529	-2.23862	-1.54077	-0.35310	-2.42552	-11.09304	-9.02911
530	-16.08215	-9.35992	-9.36112	-8.04652	-5.64719	-1.53366
531	-13.02156	-9.49824	-10.83928	-6.06403	2.05380	4.23761
532	2.69464	-6.38713	-7.72870	-2.77009	2.99882	1.19591
533	-9.54079	-5.11914	-5.53376	-3.54224	1.84063	-1.63927
534	-5.21001	-3.84702	-2.90774	-3.88618	3.64921	1.38120
535	0.90259	-0.70461	1.32848	-1.34804	4.34685	3.08835
536	1.40684	2.22589	4.80805	1.30551	2.16899	1.86986
537	8.09070	2.83570	5.17744	1.99385	-1.28825	-0.40520
538	-3.89506	2.09137	3.42177	1.42879	-1.44622	-0.13857
539	3.41779	2.07188	2.96810	1.82994	0.25399	0.29782
540	6.17535	1.32470	2.83637	0.49209	-0.88482	-3.22957
541	-6.11148	-1.19668	1.31694	-3.48510	-1.87046	-3.69399
542	-0.82479	-3.08037	-0.61496	-5.39608	-2.00670	0.14950
543	-6.25568	-2.69834	-2.60695	-3.22472	-1.80770	3.98364
544	0.42192	-0.70797	-3.94980	1.54080	-0.85527	4.69296
545	4.45435	0.98829	-4.16947	4.62110	0.72506	1.21476
546	-3.85215	2.48671	-1.61277	4.74272	4.61915	-0.34030
547	9.02486	4.90173	4.30700	4.40842	6.31496	-0.53814
548	6.34340	6.48950	9.19488	3.27623	2.82541	-1.65446
549	5.90557	5.27455	9.26135	1.44729	-2.85416	-1.98707
550	5.34656	1.18398	3.75058	-0.90921	-7.54612	-2.65137

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NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
551	-10.26184	-3.16864	-3.66625	-2.95287	-6.10223	-0.87617
552	-2.64047	-4.40965	-7.12157	-2.44295	-0.80612	1.49136
553	-3.40826	-2.79699	-6.03819	-0.84997	2.47954	1.55513
554	-1.59190	-0.15115	-3.10453	0.87647	2.92652	1.96085
555	6.34409	2.43967	-0.77797	2.83645	1.78339	1.84963
556	-0.79006	4.75639	1.20658	4.71640	2.52515	1.96034
557	11.32147	5.95791	3.80870	5.98270	1.87182	-0.20353
558	6.69585	3.31948	3.42632	3.35713	-2.86609	-4.76966
559	-7.04347	-2.34768	-1.00307	-1.74324	-5.12580	-4.45046
560	-5.25865	-6.81455	-5.24050	-4.76033	-2.79082	-1.79548
561	-12.18065	-8.78990	-6.13572	-6.24788	0.80520	-1.70113
562	-5.08313	-10.45632	-4.86090	-9.10533	0.97212	-4.24280
563	-13.08621	-12.48731	-4.69954	-13.68260	-0.09934	-3.47907
564	-20.69892	-9.65877	-3.07199	-12.69201	4.15713	6.54191
565	4.19829	1.47882	3.46585	-1.28041	7.99722	14.67761
566	16.42747	14.51773	10.50345	12.77980	4.95597	11.71942
567	27.22167	20.00942	11.84565	19.70908	-2.58710	1.42821
568	18.63535	14.46288	5.97060	15.60870	-8.17657	-8.82248
569	-3.26954	2.74991	-1.99751	4.71752	-6.70355	-11.61549
570	-5.31504	-7.71691	-6.51295	-5.91160	-2.32966	-9.17148
571	-18.99484	-12.73550	-6.72416	-12.54559	1.94188	-3.43259
572	-13.47321	-11.05905	-2.99501	-12.21620	4.90963	3.62994
573	-0.70467	-5.76924	1.38488	-7.31328	3.11783	5.15180
574	-3.87107	-1.23616	2.74072	-2.80064	-0.22736	3.96820
575	5.02067	2.07393	1.65294	1.10844	-1.46845	4.09475
576	1.51326	6.15676	0.99934	5.90545	0.74112	5.67643
577	11.30766	11.30126	3.35308	11.76546	3.39461	4.97749
578	22.13987	12.96584	5.85143	13.25635	0.72881	-2.81589
579	4.96416	7.83560	4.27381	6.83512	-3.58206	-8.66380
580	0.19303	0.23916	-0.25424	-0.96155	-4.85874	-5.65144
581	-8.94694	-3.11610	-4.03679	-2.91797	-1.98464	1.96202
582	-3.04257	-0.50544	-3.59841	1.78040	2.46484	5.90929
583	12.08989	1.82310	-1.12813	5.00040	1.30257	-1.07021
584	-3.06324	-2.97047	-2.30462	-1.02199	-3.63042	-10.00923
585	-12.08237	-12.64288	-7.28695	-11.89186	-5.40751	-10.08612
586	-25.01762	-18.78559	-10.82857	-18.44714	-0.51882	-2.02304
587	-22.02021	-15.36099	-7.18433	-15.33696	7.42328	7.62937
588	1.93363	-4.58246	1.57214	-5.67780	8.58010	10.43479
589	3.95424	7.25174	8.07250	4.51602	4.20297	10.12301
590	18.58267	16.81704	10.29422	14.60971	0.43994	9.42959
591	26.44705	20.67671	9.11099	20.92958	-2.78006	1.87308
592	17.74920	14.60160	4.76862	16.68671	-5.90934	-10.51078
593	5.12224	-0.95169	-2.40355	1.32069	-7.87150	-18.52012
594	-27.43413	-15.50004	-8.80817	-15.34344	-3.67184	-12.13540
595	-25.54449	-19.40409	-8.52907	-19.93375	3.83548	2.74548
596	-8.43051	-12.94734	-3.31205	-12.89657	5.39410	9.34621
597	-4.07681	-3.44633	0.85908	-4.11308	2.79728	7.48695
598	7.41378	2.72714	2.63003	1.58614	1.11598	4.04047
599	2.29908	6.29075	3.93956	4.82187	1.79005	2.95815
600	10.11544	8.95095	5.83742	7.71709	1.33131	2.34487

Simulated wave properties for case 2–b

PAGE 1

NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
1	-9.62610	4.76820	9.11705	3.30189	2.15532	-8.80259
2	12.88234	4.55907	10.31976	-3.18812	-0.19417	-2.48798
3	-1.11381	10.00598	9.34307	0.44845	-0.49200	10.28653
4	15.97051	20.85401	10.97285	15.56227	2.97138	16.97867
5	52.87820	25.49224	11.18919	26.38317	-4.27797	1.49446
6	3.62207	15.23757	3.21685	18.19156	-9.39093	-15.26583
7	-0.38140	0.46081	-3.13488	2.29725	-2.16357	-14.08681
8	-13.38148	-7.05871	-1.16512	-7.76077	5.21802	-5.96917
9	-9.66581	-9.17476	3.73460	-11.27800	1.90665	-2.66695
10	6.81594	-14.56260	-1.62608	-15.53211	-12.56044	-5.37199
11	-47.95036	-18.20306	-14.82442	-16.49742	-8.64959	7.15500
12	-11.38914	-3.61836	-11.87306	1.53809	14.76134	26.65372
13	36.81219	23.94759	9.34803	27.31893	23.63071	19.76469
14	47.00974	39.53681	27.86483	34.56005	10.30005	-6.28921
15	51.48041	28.65092	26.25271	16.75879	-13.36644	-26.39264
16	-18.95072	1.17366	6.26389	-9.71041	-22.59263	-22.11491
17	-24.79179	-20.69506	-12.83038	-22.60175	-14.44497	-3.83035
18	-25.22738	-27.22201	-22.48310	-20.29333	-4.72056	7.12040
19	-38.68233	-21.34620	-21.51377	-9.76834	6.25516	12.88595
20	10.10694	-13.83746	-14.26929	0.44382	5.06095	4.11301
21	-15.55357	-19.26610	-15.36837	-5.68863	-7.14028	-15.94468
22	-37.51162	-34.90834	-24.91846	-25.90592	-9.19699	-20.26523
23	-51.80914	-37.90516	-27.26490	-36.97561	8.06933	2.56277
24	-42.76480	-7.05553	-3.99265	-15.67635	38.00106	39.14097
25	71.89987	46.88492	39.67031	30.90755	41.86250	45.85477
26	105.59383	80.55213	66.00503	61.30641	6.50813	10.48492
27	82.89461	63.53001	50.53271	50.03297	-35.81624	-31.15753
28	15.45512	6.23142	2.28218	6.64165	-54.46660	-50.03217
29	-89.95238	-50.80560	-44.11475	-37.35918	-32.22797	-32.44588
30	-78.91630	-71.75060	-57.13583	-53.10352	4.98316	0.41004
31	-61.99551	-54.44518	-39.97360	-40.50032	26.22701	22.65648
32	-19.73340	-16.06781	-10.05269	-11.66002	31.04981	32.81469
33	40.59350	22.95119	17.59155	20.05626	22.91402	28.38546
34	40.20618	49.31614	35.38263	42.32523	12.72281	15.10749
35	79.37828	54.98704	41.01601	47.04625	-3.22102	-7.50072
36	44.06891	37.17135	28.26481	27.29186	-20.00214	-29.08510
37	-12.16851	11.66234	9.10315	-1.18357	-14.42823	-22.86342
38	1.03438	-0.37297	2.61720	-13.29668	0.69082	-1.53014
39	-7.11915	0.45556	6.17384	-8.17979	3.41529	8.68711
40	19.84929	-3.30916	3.04557	-2.62874	-12.11141	-0.31177
41	-18.22857	-20.88823	-17.43236	-9.43914	-25.23285	-10.70466
42	-65.40823	-36.90304	-37.44295	-16.43364	-10.85416	-0.51261
43	-24.35980	-34.86744	-37.54499	-10.79155	8.90621	9.33715
44	-26.96298	-19.25358	-23.56516	-2.39098	17.84152	6.39217
45	3.38356	0.20065	-3.36726	1.81346	21.70109	2.20713
46	22.83191	17.61913	17.94186	2.46837	20.13948	-0.39754
47	21.42899	27.93286	34.77510	2.06997	11.46531	-0.46929
48	51.64175	23.65653	35.21047	-0.13556	-12.74384	-4.66936
49	-7.13020	3.25766	10.86628	-5.70300	-32.10809	-4.33586
50	-28.59816	-18.77472	-19.80944	-5.95302	-25.70400	3.26830

PAGE 2

NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
51	-23.57242	-30.08725	-37.02162	-3.40823	-8.02426	-0.23891
52	-45.95597	-28.91933	-35.13101	-6.84819	11.52760	-5.11814
53	-7.65654	-15.63917	-16.78209	-9.74879	23.06093	1.03313
54	-4.78435	6.66666	7.74835	-2.45039	25.00903	13.82039
55	34.17254	28.91189	30.10507	14.51780	16.83623	16.25737
56	63.86443	33.04505	34.99838	21.50835	-8.92053	-4.89456
57	1.58496	10.85645	14.18273	6.26627	-29.42102	-22.07110
58	-19.08001	-20.23794	-16.11178	-14.79913	-27.40899	-16.88146
59	-56.45181	-34.74673	-33.39637	-23.03493	-3.94233	1.80945
60	-36.36047	-20.00798	-21.60999	-11.34332	25.60351	19.47043
61	33.29432	11.59478	8.95663	9.10954	30.44567	18.27364
62	31.75109	37.46065	32.77736	22.86400	16.09480	9.88588
63	59.99854	49.07333	41.13686	30.53109	1.08496	5.59768
64	47.57891	47.47277	36.67498	33.25110	-8.83981	-0.70654
65	32.72407	32.14384	24.16034	27.39699	-17.40540	-12.50125
66	27.66218	-1.61963	-1.91402	5.56104	-35.38167	-30.90393
67	-68.43008	-45.88246	-41.08068	-27.92913	-37.21161	-30.64017
68	-90.41720	-71.32341	-64.76804	-46.61206	-6.29764	-4.83733
69	-68.82391	-59.18363	-51.68025	-39.55186	30.95296	16.25172
70	-25.83163	-20.56084	-10.07623	-19.95133	46.74801	20.26764
71	45.36911	17.68304	29.72389	-2.64966	28.01370	14.02307
72	29.54210	37.79094	42.57054	10.83237	-1.09185	14.92729
73	48.24129	40.22851	31.69403	27.53306	-18.84377	16.04884
74	41.83541	28.61905	8.70626	36.12643	-24.26757	-1.18249
75	-9.27852	10.45168	-9.71343	25.68875	-9.73189	-17.53819
76	4.37351	-3.35314	-10.24390	5.37353	6.38821	-21.56545
77	-17.65852	-13.20810	-3.40198	-15.21687	4.13218	-18.72755
78	-16.52707	-26.88084	-6.90306	-31.33695	-12.50964	-13.70083
79	-39.19148	-44.99468	-26.49912	-42.16342	-22.78333	-6.51094
80	-85.85534	-51.96859	-41.60128	-40.02609	-2.82907	12.13626
81	-26.93753	-35.05301	-30.32877	-20.41756	22.63245	23.59410
82	-2.88760	-5.29119	-4.15858	0.82095	26.39912	17.55117
83	21.84731	22.22402	18.71120	15.79030	18.58309	13.77242
84	51.23256	44.67613	33.39898	30.45411	12.04800	16.10750
85	47.04864	64.19894	45.77884	47.56056	13.05085	16.53082
86	99.97667	72.84529	55.13507	57.03386	1.60943	-1.53720
87	68.02716	53.15820	42.78978	40.35207	-26.84299	-30.82475
88	0.68025	5.56839	5.55596	2.09149	-44.06574	-41.54456
89	-45.47065	-46.51756	-37.44385	-35.79493	-37.66821	-31.37844
90	-109.66297	-75.95490	-61.64544	-55.68920	-8.02626	-6.78690
91	-69.36973	-70.62794	-54.06726	-50.07987	20.08534	15.72050
92	-39.47565	-41.04803	-28.58740	-29.25005	28.52168	24.46466
93	-12.75125	-1.14490	1.34559	-1.95641	31.05246	29.77866
94	54.81084	40.08839	31.68440	27.71608	28.19409	27.60784
95	66.27965	70.43903	54.76036	49.75452	16.21191	14.98196
96	101.44638	75.32226	59.19050	54.35521	-9.97416	-7.39298
97	60.71235	47.29788	33.69601	34.94863	-38.32461	-28.95137
98	-21.09454	1.52121	-7.47055	4.46375	-38.83199	-28.37380
99	-31.15418	-38.06040	-38.11238	-19.28515	-21.80065	-19.99755
100	-74.66678	-62.34009	-51.44003	-37.65192	-5.15627	-16.94503

PAGE 3

NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
101	-71.80726	-69.97891	-49.37817	-51.77396	8.50188	-10.09355
102	-64.30401	-58.95360	-35.44948	-54.70377	19.48705	6.12194
103	-48.22582	-29.14610	-10.57213	-37.25311	28.76482	28.00118
104	34.62827	7.41245	15.47909	-4.85510	19.62406	32.71441
105	31.06762	33.17395	25.90095	23.32553	2.77684	23.56889
106	41.12459	46.54993	26.42178	43.70437	0.23528	17.02108
107	64.43368	50.04408	26.59004	53.76526	-1.16246	0.54132
108	37.96013	36.22496	20.77786	41.38207	-12.21342	-25.64470
109	23.30734	1.15017	-0.06922	5.05456	-28.87114	-43.77711
110	-62.70800	-38.31264	-29.69107	-35.56275	-24.25232	-31.03804
111	-79.63767	-49.74192	-37.73735	-47.95420	10.55066	7.09897
112	-16.17222	-22.73341	-11.68203	-26.96626	37.25014	30.18110
113	15.29358	19.18980	26.72761	4.22758	34.44192	29.16655
114	74.61192	44.03824	47.49941	26.19319	3.31721	12.49660
115	44.93081	33.80384	31.59626	27.08850	-32.52187	-10.00042
116	-9.62808	-1.54965	-7.96329	10.23649	-41.23169	-21.19096
117	-35.70897	-33.87452	-41.56873	-10.14112	-21.93965	-16.56775
118	-74.48360	-36.81131	-45.22654	-16.32578	16.23358	6.61750
119	-2.00959	-4.10612	-12.47587	2.04492	44.34801	26.37325
120	54.11978	39.08991	31.53752	26.39848	38.37726	17.92572
121	70.55778	59.61481	56.74881	32.86935	9.49009	-5.80929
122	71.22875	43.48590	48.05328	15.98755	-25.96773	-25.60053
123	-16.75681	4.42232	12.21651	-10.09358	-40.14225	-21.77403
124	-37.37479	-28.67968	-22.79591	-21.89350	-27.31876	-2.03966
125	-42.20883	-43.06595	-41.17827	-19.10573	-9.83112	4.42348
126	-51.84783	-45.69438	-43.96185	-17.71525	2.99195	-2.87806
127	-28.56948	-44.07346	-38.04314	-24.65913	8.22013	-9.12330
128	-60.35254	-33.50752	-25.47793	-28.71967	18.76853	5.06017
129	-9.87607	-6.03675	-0.25830	-11.63644	28.99720	26.72080
130	48.56177	24.73782	24.11642	14.93722	16.08135	21.39459
131	37.19242	37.32249	29.51326	26.13269	-4.16080	1.25070
132	40.89973	31.45716	20.33550	21.28283	-11.34010	-8.16659
133	2.36720	22.29930	12.36352	15.09768	-2.79399	-2.60462
134	22.88730	16.39058	13.22909	14.37355	1.07408	-2.15086
135	27.29662	1.49482	6.91273	3.97256	-15.53946	-19.90319
136	-45.12583	-26.30285	-14.78310	-20.95053	-24.02714	-25.36996
137	-50.03867	-48.06025	-34.08157	-38.74144	-12.24688	-7.91680
138	-63.25853	-46.27238	-36.48556	-35.24814	8.23429	14.60454
139	-27.27356	-19.11422	-18.16529	-11.78278	26.61977	29.80961
140	34.03486	19.58867	11.32158	18.17295	29.71696	27.28663
141	44.27586	50.21836	37.34588	39.13592	20.44229	13.36072
142	86.82236	57.17657	47.09839	42.03186	-3.45811	-8.68084
143	39.53066	36.36804	30.10991	23.74989	-27.38583	-24.19631
144	-15.88299	7.27685	2.42318	3.09753	-23.12646	-13.47896
145	-5.55359	-6.84524	-11.00248	-1.89754	-3.50679	1.53829
146	-15.81361	-6.37138	-7.43386	0.46580	7.83157	0.30600
147	15.22774	-8.73663	-2.78732	-5.74393	-2.05915	-13.68617
148	-22.11276	-23.46246	-13.22945	-23.86150	-16.07630	-18.40274
149	-62.68486	-34.00223	-25.33812	-33.00419	-3.62019	3.35399
150	-18.59144	-20.76402	-16.89833	-17.23765	19.45204	25.39152

PAGE 4

NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
151	1.86268	9.09252	7.88825	10.51424	26.01314	26.44786
152	56.39164	29.35195	25.51304	28.69793	4.75342	6.92603
153	37.36794	20.93506	14.28627	22.27715	-24.57354	-17.97334
154	-28.83104	-4.14103	-12.18520	0.59162	-22.00225	-21.09823
155	-18.63704	-18.73339	-22.18335	-14.90452	2.52551	-9.33971
156	-26.45154	-15.85089	-10.88331	-18.75098	16.58239	0.96749
157	6.52584	-8.09670	2.50254	-15.21304	6.13502	4.53475
158	1.15604	-10.27740	-1.94409	-11.78754	-13.23739	2.53857
159	-40.44290	-17.61605	-15.54891	-8.01568	-9.54697	5.61254
160	-5.97473	-17.71969	-16.96305	-2.57937	6.35553	3.34282
161	-18.13706	-8.01091	-4.82113	-2.43453	17.22320	-1.40953
162	3.18977	11.68207	15.89429	-0.07652	22.60776	8.17586
163	46.37504	36.09233	35.61024	14.07029	14.31092	18.35037
164	50.95337	48.01814	40.28660	30.67406	-6.88981	10.99808
165	65.25968	29.31080	18.80730	28.73248	-36.01698	-16.86557
166	-26.74358	-16.06420	-24.77909	0.49035	-44.32545	-34.12617
167	-84.99363	-52.36225	-55.35144	-20.87635	-11.72695	-16.02752
168	-54.46296	-49.23882	-45.72632	-29.19722	29.02163	9.93291
169	-26.23388	-11.41101	-4.50431	-11.42901	48.68825	23.23502
170	56.16937	33.75132	40.70484	12.11392	36.31673	21.18756
171	69.47229	58.14099	61.10848	27.16229	3.56155	8.15377
172	56.47906	50.90100	49.49333	27.98028	-25.23531	-6.81764
173	37.10749	19.06795	14.79572	13.62148	-40.77726	-20.40056
174	-46.77163	-15.10904	-22.07515	-5.63886	-27.61249	-13.60015
175	-35.00496	-26.61440	-34.60409	-8.58778	2.06221	6.97029
176	-11.45003	-16.06835	-23.65930	2.08179	16.08011	10.47473
177	-0.38261	-5.33700	-9.22619	6.29751	9.91940	-3.90276
178	12.54463	-10.21594	-7.17166	-6.32040	-5.38465	-19.56262
179	-47.64100	-23.16662	-14.14104	-25.22048	-4.31119	-13.61984
180	-30.36607	-23.16157	-10.48396	-28.08910	11.49586	7.70315
181	-1.24080	-6.79357	4.47427	-14.19314	15.55496	17.36081
182	8.43495	10.58432	15.78997	2.45206	5.05609	14.24618
183	39.37754	14.64328	11.91647	11.33432	-12.56954	2.78148
184	-9.84071	5.97085	-3.97815	9.80827	-14.84737	-3.65978
185	-7.20440	-1.48071	-11.24704	7.02319	0.95206	-2.14489
186	7.89885	-3.55151	-5.47021	2.67738	7.99519	-7.75000
187	-14.88109	-6.58324	0.87279	-7.81180	3.54766	-11.60310
188	-0.10572	-10.48691	0.69587	-16.63662	-3.35234	-4.07112
189	-28.45060	-7.29132	-2.04975	-12.29704	0.34285	13.79063
190	6.47758	6.50468	2.98360	8.20328	7.89389	23.00015
191	43.51176	16.23984	7.41403	23.46685	-1.46414	3.87686
192	-1.38417	8.90120	0.24519	15.75447	-10.76511	-16.39592
193	-2.44550	-6.52198	-9.66066	-2.29330	-7.43695	-16.83424
194	-27.82391	-15.12845	-12.33455	-14.25193	2.92903	-6.13440
195	-15.43400	-10.82385	-3.82293	-14.72640	12.92371	4.05111
196	13.00928	2.95191	10.56983	-8.44945	15.15458	8.39112
197	-0.05196	22.51337	26.93109	4.16462	17.47312	17.75713
198	61.22022	41.19046	41.07609	24.44016	6.75339	19.19819
199	58.34480	41.90631	34.06061	35.40456	-21.23082	0.97038
200	13.89907	20.12785	3.95443	27.68352	-34.39557	-14.30662

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NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
201	-6.42139	-6.82463	-25.47353	11.01384	-20.50099	-17.22720
202	-44.45317	-21.40455	-32.40953	-4.06369	6.38324	-12.43684
203	-7.07081	-24.57686	-19.49291	-15.56408	14.00232	-12.21414
204	-21.93913	-30.05211	-12.59269	-29.40170	-1.03637	-13.76544
205	-56.90712	-36.31618	-17.03862	-37.33514	-4.26922	0.17587
206	-25.01727	-29.40467	-15.94982	-28.93057	7.65683	14.93787
207	-21.48610	-6.64548	-1.47835	-10.92229	20.21439	19.90174
208	33.91242	20.38482	19.04804	8.70390	16.89185	17.98173
209	49.33350	34.63636	26.28007	22.70769	-3.04531	9.63353
210	21.24031	30.57486	16.50260	28.20313	-13.72230	1.13342
211	30.62416	15.08115	2.92350	22.95421	-12.22160	-12.59238
212	-17.91526	-3.44854	-5.92664	4.43795	-4.76755	-21.92792
213	-17.64090	-17.26186	-7.71385	-15.40170	-0.82134	-15.91983
214	-17.67878	-25.21147	-11.57777	-25.82439	-7.49709	-4.50144
215	-45.18637	-28.43978	-20.36502	-23.81392	-8.26918	8.02518
216	-11.21914	-27.25146	-26.30594	-13.56481	-3.47077	9.89256
217	-32.25636	-22.46740	-25.90023	-6.56361	5.93717	4.85216
218	-19.36563	-7.64545	-11.41626	-0.38516	23.33391	8.93329
219	23.88858	20.98049	18.35431	11.75757	34.00749	14.60741
220	45.89475	51.34816	50.75854	25.90927	26.80262	11.31052
221	98.44137	59.43865	62.43032	28.38518	-7.45700	-8.69129
222	36.00635	32.60480	35.33444	9.99238	-42.45196	-23.83175
223	-31.12688	-6.63913	-8.92808	-8.29667	-39.34111	-8.56123
224	-30.85090	-26.35987	-34.85782	-5.56542	-10.92430	11.80179
225	-34.72028	-20.56461	-31.68378	8.53714	15.00234	12.88454
226	14.19477	-4.71192	-11.99125	14.82135	20.55166	-1.49715
227	3.29660	7.00852	5.13774	7.84798	13.67896	-9.33094
228	4.53729	13.70504	16.33417	1.56510	8.14679	-2.72632
229	39.19454	12.16607	17.59955	-1.47077	-7.47855	-6.05530
230	-11.74828	-3.72927	1.90559	-12.15384	-21.44694	-13.76661
231	-25.46771	-24.60895	-19.13291	-24.13404	-17.91434	-8.07585
232	-44.54121	-33.78036	-29.60649	-25.80241	-1.28508	5.28704
233	-38.03692	-23.06489	-20.37957	-14.28214	18.58352	16.14153
234	18.64472	0.28021	2.11941	1.76059	23.38186	13.99921
235	10.96295	22.51144	22.78942	13.16156	17.17466	9.75442
236	47.41841	34.76396	33.84993	21.76384	2.65125	6.20624
237	46.07371	28.42727	24.36448	22.14757	-21.58498	-6.21236
238	-7.11385	4.41360	-4.48592	11.08540	-32.34504	-14.19262
239	-16.80207	-23.62312	-33.33110	-3.84392	-22.42762	-15.10349
240	-60.32254	-40.30877	-44.57827	-17.99590	1.30445	-12.53881
241	-39.56695	-41.42454	-32.54632	-28.68753	19.41392	-9.44135
242	-22.74147	-34.29080	-13.42796	-37.18078	16.38957	-6.16108
243	-42.81264	-21.13776	0.28562	-35.32966	12.64126	12.72732
244	8.95101	5.29036	14.58585	-10.31187	16.61024	35.52940
245	32.86660	42.34116	33.64834	29.26965	20.78240	39.64931
246	87.59296	70.18406	51.06481	59.87278	9.59014	16.64673
247	99.97143	62.23119	44.41366	55.70550	-24.52371	-25.14963
248	2.92996	17.56727	7.30873	17.64444	-43.66557	-43.98298
249	-41.31337	-28.22325	-30.00205	-18.85633	-25.71008	-24.29950
250	-68.14389	-41.78966	-38.33475	-27.17233	9.16800	6.76659

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NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
251	-22.49642	-24.50490	-17.89115	-12.33074	25.82543	17.44714
252	25.71564	-5.16777	1.65531	-1.98043	10.07061	1.22528
253	-18.40859	1.33105	4.38078	-5.86465	-0.56662	-4.34312
254	5.55347	8.22078	7.46140	-3.35012	7.94658	10.36010
255	23.61112	22.28942	18.26722	11.81445	11.37596	17.09713
256	37.59617	31.03356	24.96207	24.89527	-0.60516	6.32318
257	43.68179	20.41896	14.05508	20.93693	-20.55781	-14.25474
258	-24.96881	-6.60857	-10.13800	0.34324	-23.76760	-23.91030
259	-29.14150	-32.98795	-28.23674	-22.50154	-11.81814	-20.75908
260	-51.51031	-45.76740	-33.79155	-38.81546	1.29137	-9.55290
261	-62.04320	-35.70477	-23.61360	-36.04630	19.27183	16.65783
262	8.03070	-3.80932	1.22166	-8.26177	27.15293	34.93739
263	31.37390	29.51172	24.33756	24.63034	16.52285	26.75245
264	64.09376	41.33296	30.31204	39.33484	-5.79565	1.08814
265	33.34701	25.14759	14.02248	27.86907	-23.81970	-21.23464
266	-24.71727	-3.98763	-9.46123	3.99299	-20.12166	-23.89910
267	-14.49575	-29.81788	-25.02122	-18.96974	-12.10829	-22.78504
268	-59.51777	-48.18304	-34.84264	-40.80945	-6.78260	-18.61893
269	-62.07082	-51.87208	-35.75215	-50.18217	6.23163	2.25365
270	-38.27281	-31.11562	-20.54496	-34.57308	24.97625	28.51486
271	-6.65007	13.42122	14.10827	3.43282	42.26783	44.14390
272	91.03535	60.74917	54.43434	43.92284	32.01786	31.56780
273	94.29838	78.59279	68.21987	60.09951	-6.58843	0.37091
274	65.30850	54.81283	42.62005	47.55693	-41.80846	-23.35396
275	10.97858	5.81755	-6.42514	17.69826	-50.17329	-33.76931
276	-70.70118	-37.40317	-45.00347	-13.86108	-22.26013	-26.65830
277	-50.23785	-52.49761	-48.96452	-33.32241	11.89697	-12.40500
278	-49.08415	-39.98996	-27.96199	-38.25795	27.33489	3.78894
279	-19.56198	-8.88050	1.81822	-23.18224	30.37792	26.23274
280	43.97166	27.92717	28.60104	9.34425	21.35726	34.76110
281	51.65424	51.48664	42.32905	38.01574	5.31122	18.89201
282	75.33950	46.80770	37.08021	41.69323	-16.66425	-12.57647
283	13.31761	15.01261	11.07245	16.67726	-31.95907	-32.65039
284	-43.78700	-21.82475	-18.68061	-13.04885	-24.63758	-23.30589
285	-33.82391	-44.51237	-36.73740	-29.09173	-11.94917	-10.32533
286	-66.64725	-49.85759	-42.18765	-35.56955	2.17556	-2.10479
287	-40.12341	-35.38278	-30.46162	-30.64815	21.35277	13.18491
288	-9.44324	-0.75669	-1.23140	-8.35621	35.40194	30.71467
289	40.68057	39.97800	34.15176	25.60462	30.49866	32.36751
290	101.46832	57.10170	49.04614	44.96555	-4.44248	1.98679
291	31.42155	32.77825	26.02742	28.93292	-37.30210	-30.35043
292	-20.38077	-14.40656	-14.60934	-5.55943	-39.20476	-34.16345
293	-60.71038	-53.13628	-45.81177	-33.67266	-20.91523	-20.33352
294	-88.07504	-64.59353	-53.39821	-44.04349	6.07062	-0.20199
295	-39.78035	-46.45664	-35.78039	-35.80218	27.37617	15.28248
296	-24.10508	-8.67110	-1.74517	-15.46086	39.12106	24.72091
297	43.55792	32.35271	36.49968	10.59498	32.66062	24.62882
298	81.44127	54.40468	54.43587	28.39670	0.78328	9.81649
299	38.92335	47.99460	39.98736	32.19577	-26.20169	-0.20745
300	34.63134	25.46133	9.89962	29.98784	-30.31885	-4.57081

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NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
301	-10.86354	2.54575	-14.22491	21.67367	-15.49700	-12.34672
302	-15.18776	-13.41182	-20.23816	5.48033	1.49422	-19.82582
303	-10.69328	-23.14608	-17.00541	-16.20003	3.02831	-21.21276
304	-49.85439	-25.05541	-13.48345	-29.73415	5.92323	-2.33209
305	-8.76493	-9.36268	-2.27021	-18.51049	16.75670	23.17154
306	15.29097	20.66315	18.51107	10.15821	23.16749	30.31095
307	57.07325	44.40743	38.00131	34.00776	11.31383	13.18310
308	74.10332	36.96057	32.97454	30.34569	-22.86798	-20.96124
309	-18.22571	-2.49357	-2.21836	-1.50073	-41.43072	-36.88310
310	-53.16393	-42.31005	-37.37969	-32.33263	-24.19809	-21.01765
311	-71.47742	-52.76259	-45.69018	-40.01683	8.02136	5.93989
312	-41.36097	-29.43993	-24.50565	-22.33152	30.75595	27.12320
313	28.74608	9.05839	7.23589	8.06117	29.27413	30.79915
314	33.87096	43.52532	31.06305	35.55499	18.04977	22.72381
315	80.02271	54.97753	40.88301	48.46495	-0.90679	-0.45279
316	54.46457	31.61633	25.47953	30.08413	-29.44737	-35.46678
317	-33.02324	-17.04212	-11.34537	-13.65492	-39.14377	-45.53191
318	-66.62015	-57.52621	-43.26547	-49.43537	-20.91564	-22.08830
319	-93.19230	-64.32232	-48.71716	-54.70677	10.08118	10.56878
320	-30.58913	-41.66653	-28.62468	-35.08523	25.16605	23.79708
321	1.07925	-14.24140	-6.96290	-14.45944	16.37409	16.52004
322	-11.21678	5.76609	5.80529	0.84465	11.00502	16.05468
323	36.35722	21.70137	16.36108	17.94388	9.48023	16.47189
324	28.45253	32.62718	23.46921	30.35093	4.63757	7.60140
325	39.81195	36.47388	25.76316	33.49528	-0.19659	-0.79537
326	39.70272	34.81142	23.30224	30.04903	-3.79517	-5.14292
327	14.84006	30.92135	20.65881	24.79281	-1.16419	-5.60812
328	45.98397	21.34930	17.74908	15.38570	-7.43133	-15.43897
329	-1.98367	-3.00221	2.54937	-7.03993	-22.53990	-27.46589
330	-42.70347	-37.30730	-23.77095	-33.39917	-27.93108	-22.51795
331	-63.59818	-63.77509	-48.59407	-48.73728	-18.61528	-6.95010
332	-96.63930	-62.82848	-53.63544	-44.52028	11.55507	16.47997
333	-26.09653	-24.87344	-24.66739	-16.49985	43.96680	37.62045
334	32.68865	36.14780	26.44889	25.55515	53.70956	43.75945
335	102.71303	89.07043	72.60699	64.35973	32.91779	29.44907
336	143.22209	99.50328	82.36229	75.30791	-15.90240	-10.64186
337	56.22993	54.69317	43.80412	43.62741	-56.26031	-49.18401
338	-17.93296	-18.94611	-17.51690	-12.59106	-59.73524	-57.22455
339	-107.29229	-74.47687	-62.81289	-58.24400	-25.21294	-28.08829
340	-113.99005	-77.71482	-62.62123	-61.78496	23.70604	20.29134
341	-16.21044	-39.65595	-27.94083	-28.09980	37.14678	39.15428
342	9.35664	-5.57638	-1.95855	2.70671	11.31551	18.27551
343	16.63653	-1.56679	-4.96597	6.68209	-13.90110	-8.23904
344	-28.97213	-11.44640	-18.24116	-5.16779	-5.85239	-9.96559
345	-34.16517	-3.68108	-7.72622	-5.39636	-26.82671	9.99407
346	49.95169	22.59307	25.66378	8.41336	32.48646	12.68252
347	45.35245	38.74303	45.69966	13.92243	5.12672	-1.61315
348	37.10865	31.34648	36.86654	9.18686	-20.49210	-5.48486
349	10.15278	10.92974	10.90457	5.81789	-27.91204	-0.83447
350	-22.49361	-8.69653	-13.30915	6.27424	-19.34970	-0.02487

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NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
351	-5.23503	-24.42489	-28.93403	1.36137	-12.98462	-11.12812
352	-53.00081	-36.53696	-38.64737	-13.66817	-4.68584	-15.57979
353	-45.18253	-36.95771	-35.56407	-23.48094	10.70473	-2.61539
354	-14.99703	-21.90494	-19.65045	-19.49341	20.13751	9.77869
355	-13.70649	5.51747	4.81811	-4.34811	29.13841	20.44932
356	51.61921	39.92544	36.84724	19.10916	32.59770	24.08806
357	69.70607	66.72858	64.17129	38.57282	18.97894	12.59251
358	86.38069	66.86512	68.30022	40.69997	-13.90177	-9.69982
359	55.69290	31.05392	33.98049	19.33602	-52.31283	-30.55131
360	-51.71659	-21.86979	-23.72136	-11.15577	-54.73562	-25.33676
361	-65.94405	-55.07220	-61.93007	-25.74998	-17.92703	-3.95452
362	-66.50063	-51.44122	-58.16362	-22.30463	23.63112	9.00016
363	-23.98153	-22.66308	-22.84728	-10.75462	40.94413	12.62564
364	31.29225	6.35620	11.59328	0.29021	23.86672	8.93285
365	8.94858	21.12097	23.81780	8.35382	2.80183	8.18472
366	34.12151	24.93221	22.08124	16.14692	-4.75147	5.67379
367	23.79397	20.88318	15.73364	16.14316	-7.54875	-6.37363
368	5.85356	8.39201	7.00579	4.52012	-10.56355	-15.76681
369	5.01456	-10.52878	-6.56562	-13.02574	-15.88320	-17.64249
370	-52.66601	-25.73291	-19.42899	-25.85622	-6.38495	-5.64932
371	-25.47701	-26.02788	-16.62539	-23.71826	10.21491	7.70437
372	-5.43589	-18.73767	-6.23457	-16.49039	6.98415	4.77579
373	-21.23244	-16.47611	-6.26523	-13.61739	-6.97633	2.90484
374	-10.61270	-15.54936	-16.81573	-6.41428	-10.85696	13.22593
375	-29.92362	-2.60741	-19.87400	14.15427	8.03120	26.76820
376	33.40984	22.52209	-0.81156	39.47611	26.33076	17.95082
377	64.01119	36.73653	22.48682	40.19255	16.11755	-18.10826
378	17.17431	24.36268	28.43923	8.55746	-3.64799	-30.74947
379	5.14008	-3.45448	17.53638	-28.83898	-16.63267	-31.03750
380	-45.15194	-26.15312	-0.34451	-47.88539	-16.34629	-5.22565
381	-37.35515	-28.27071	-10.99069	-38.33266	-4.21338	23.23187
382	-8.05176	-7.85792	-9.05621	-5.55381	7.81771	39.95791
383	10.61907	23.86968	3.65521	36.02322	15.93731	30.20948
384	80.60640	43.97372	16.06653	62.09247	4.96512	7.57244
385	41.76454	31.81041	10.33828	47.09010	-14.72793	-35.01336
386	-15.38310	-1.52102	-5.81507	3.97965	-13.49171	-44.02528
387	-34.09996	-23.79206	-11.19418	-29.33236	3.95973	-18.86169
388	-41.56397	-17.40627	1.41969	-31.26705	19.00122	13.43594
389	28.69356	5.31047	18.73199	-10.57911	11.07544	22.64377
390	26.25692	18.47310	18.81534	6.35598	-10.20567	9.91548
391	8.52744	12.84252	3.41047	10.16566	-17.89125	-1.47120
392	9.34111	-3.03449	-13.45991	4.27929	-14.59134	-9.65635
393	-37.52576	-16.89529	-22.90566	-5.77617	-3.10075	-8.16810
394	-15.12076	-20.01311	-19.87907	-9.34800	7.76399	0.94787
395	-15.54615	-12.88549	-9.94029	-5.34687	11.72052	6.40551
396	-9.05239	-0.87586	3.31431	2.08666	13.84064	7.09015
397	29.84020	6.77014	13.51425	4.80642	4.30282	-3.27274
398	-5.63935	1.85732	10.37706	-4.03471	-9.75917	-12.46126
399	-5.52073	-10.67084	-3.19597	-15.63796	-15.81954	-8.98487
400	-26.36392	-18.05233	-16.97967	-19.16608	-8.87984	3.30672

NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
401	-30.65946	-10.44419	-16.60527	-7.92345	9.57518	17.82091
402	30.85875	4.79576	-3.48593	9.49319	12.48102	12.77638
403	9.46713	9.18547	3.05922	13.12848	0.39967	-4.96576
404	0.90371	1.04493	0.07817	4.05020	-4.44751	-10.56261
405	-10.93255	-6.28458	-2.31948	-4.00329	1.17316	-4.25506
406	-18.39694	-3.03248	3.54412	-3.94828	9.44068	3.21215
407	26.34635	3.23974	11.67744	-1.63716	4.57479	-0.10170
408	-6.01776	9.27386	12.92141	-2.41167	0.31142	1.56478
409	10.05606	19.54685	16.50779	6.29788	6.81316	15.66926
410	50.22340	29.43657	21.64830	22.69059	0.03950	12.59570
411	26.22235	21.10577	12.06853	24.76546	-19.68607	-9.78245
412	6.29851	-8.14396	-14.79266	4.93826	-30.45566	-26.74510
413	-65.45122	-34.37068	-38.05883	-18.96912	-10.19451	-15.62682
414	-51.02087	-28.97875	-28.94441	-19.94387	27.18621	13.22052
415	22.17915	4.72362	6.69760	0.65851	37.94763	23.57597
416	35.78714	37.53052	37.53728	20.94963	20.86703	15.23125
417	71.56006	46.70120	45.01990	28.13803	-6.61402	-2.31763
418	31.49297	26.48328	26.08010	15.40094	-28.64946	-21.89801
419	-18.01206	-10.56189	-5.94412	-10.43035	-32.74072	-26.69443
420	-41.04536	-43.31833	-35.44118	-32.39351	-24.17159	-14.59666
421	-85.05999	-53.47917	-49.04821	-35.22050	-0.79438	9.75286
422	-30.50041	-36.02521	-36.93367	-16.68540	22.64548	23.05553
423	0.69325	-6.73425	-10.13144	2.68600	28.24005	13.49936
424	13.68656	16.72473	15.60436	10.56137	21.39796	3.60306
425	46.09989	27.68881	29.08119	12.20468	4.61977	0.54989
426	13.55670	27.34045	26.37898	13.29331	-8.14188	2.02535
427	30.08189	18.74507	15.08406	14.24018	-14.63900	-2.52082
428	10.65826	-0.98469	-3.75413	4.20863	-22.50573	-17.76934
429	-41.37408	-28.51545	-26.24803	-17.42143	-20.08128	-22.37051
430	-45.83513	-47.32508	-39.63204	-34.79438	-4.64233	-9.96039
431	-71.24991	-40.42216	-31.48284	-33.34106	22.06815	13.90009
432	-4.40074	-6.97397	1.05620	-9.65861	38.08442	29.56201
433	52.99953	28.64886	32.81256	16.70061	20.79249	19.93115
434	40.01027	42.60653	39.43973	28.75862	-6.59962	5.14186
435	48.96691	33.57024	23.60521	28.61703	-22.48240	-5.19473
436	1.69315	12.83074	0.62741	18.81287	-20.33707	-13.80601
437	-7.71926	-6.11868	-13.21073	2.75924	-7.00077	-17.20410
438	-14.73767	-12.42543	-13.69101	-11.56366	6.46463	-8.10865
439	-29.35210	2.52386	1.28941	-6.80714	23.13393	18.83097
440	53.55718	30.36855	26.08064	19.81303	20.85485	27.48230
441	62.41650	38.37548	32.98260	33.95687	-9.60203	-3.83614
442	18.04152	7.45789	8.11023	11.13321	-36.93119	-38.54056
443	-47.22313	-41.38706	-30.97632	-31.57890	-35.04584	-39.60885
444	-110.36017	-66.32758	-50.55363	-55.00666	-0.71079	-3.36324
445	-44.18103	-46.56899	-33.65487	-39.16068	30.47508	30.98721
446	1.96860	-0.06943	1.21789	-2.56031	35.73119	38.47145
447	46.35547	44.17402	32.94205	32.70609	25.47652	29.76834
448	93.78805	64.85601	47.42271	51.79287	1.80867	6.26165
449	50.51602	52.86787	36.77752	44.38897	-21.45868	-19.77113
450	28.05062	16.25543	8.43768	16.19029	-33.27927	-34.46708

NO	WAVE(S)	WAVF(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
451	-35.40869	-27.39114	-24.87691	-19.36568	-30.20133	-33.48944
452	-77.94071	-59.20320	-46.68694	-45.34561	-12.47728	-17.20895
453	-59.06780	-70.62352	-51.53026	-54.40743	1.44823	-1.67667
454	-83.98992	-61.61190	-43.87033	-48.06829	15.03222	15.53317
455	-34.23138	-30.63055	-20.18030	-22.89592	31.55546	33.14779
456	18.56186	14.76434	15.35654	12.20544	37.09840	33.78757
457	56.32326	54.74042	48.35578	39.19597	25.24495	17.78293
458	103.42656	66.74217	58.05721	43.89059	-8.39817	-8.98575
459	39.00856	44.09670	33.56546	25.18587	-35.98652	-24.17486
460	-1.65724	9.25184	-2.09343	4.19828	-29.97555	-14.88355
461	-20.84711	-10.43116	-19.55737	-2.63628	-3.66107	0.73704
462	-23.14594	-9.93439	-11.97143	2.52791	14.67773	6.74189
463	25.57247	-8.37800	-1.76590	3.75046	0.64691	-7.06782
464	-26.91966	-21.10921	-12.55690	-10.91950	-18.47313	-18.59242
465	-53.37002	-32.36073	-27.01025	-24.17824	-5.16822	-4.56929
466	-24.95638	-21.17754	-18.29255	-18.88992	21.80585	13.44499
467	1.76729	6.55541	10.17537	-2.54201	30.09226	16.33361
468	57.43104	27.74050	31.55871	9.14496	9.25163	6.23802
469	21.36385	32.74952	29.71702	13.20346	-8.75158	5.31343
470	19.56049	35.38700	23.24122	24.47750	-1.73464	16.64243
471	60.19408	40.62814	24.63340	39.45783	1.60134	8.74163
472	34.04781	33.20457	20.77186	36.27468	-11.41969	-15.62930
473	22.76629	2.62518	-0.62023	10.26122	-31.33539	-34.40005
474	-50.08871	-43.18920	-37.55288	-26.88710	-38.21597	-36.38653
475	-99.24876	-80.36935	-67.54184	-56.20622	-18.03556	-20.24200
476	-90.21253	-86.35834	-69.50041	-65.32533	15.13202	2.91854
477	-86.37820	-51.89636	-36.60253	-47.88637	49.46130	32.51776
478	23.26193	11.05673	20.81833	-4.64894	58.17176	48.78314
479	92.49686	64.80066	64.95318	37.72005	24.74298	31.25491
480	89.67535	77.17892	66.54487	53.88777	-20.32028	1.41004
481	65.19920	49.77841	31.39064	43.79478	-44.44361	-18.99863
482	-17.88651	9.88572	-9.44459	21.91219	-31.56344	-22.26647
483	-17.33957	-18.61948	-27.28736	0.36125	-5.81049	-22.19890
484	-26.96067	-36.94452	-28.19782	-24.95263	0.61162	-27.91814
485	-64.11256	-52.50905	-29.47382	-50.27453	-3.45748	-19.24585
486	-53.70340	-59.37730	-33.84240	-58.28446	-3.47600	4.67125
487	-73.18190	-44.06676	-30.27733	-39.46186	13.96576	32.85041
488	-5.74679	-0.80480	-3.65427	3.34938	37.16244	48.52072
489	70.47297	51.96562	35.46164	47.46171	36.36162	35.44888
490	89.18748	85.20207	62.09665	69.66000	14.61556	8.17030
491	111.21105	82.47975	61.92180	63.39099	-15.06563	-20.28321
492	41.63035	47.04461	35.68778	32.60468	-33.97689	-38.24571
493	-5.51261	-3.03754	0.25542	-6.91540	-34.95983	-38.40716
494	-46.14791	-46.44609	-31.56497	-40.03400	-26.78343	-25.19999
495	-99.62698	-64.10446	-47.85600	-51.22796	-3.48840	4.86268
496	-43.99297	-48.38852	-38.70840	-32.36181	19.22517	28.74847
497	-11.90989	-16.34850	-16.03231	-3.75187	23.26938	24.33859
498	17.11865	9.25793	3.90515	12.10352	15.33293	7.18286
499	31.22836	21.22267	14.03025	13.51170	5.99148	-1.49341
500	4.99860	27.06919	19.49092	14.96540	6.02127	5.73133

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NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
501	51.57141	29.33476	23.74729	21.43976	-0.33549	3.14320
502	27.37117	18.19691	15.40327	15.13619	-15.44493	-15.82342
503	-18.81696	-2.64329	-1.16817	-4.41091	-14.34745	-19.09678
504	-15.38292	-15.85160	-9.71076	-16.97645	-2.66428	-4.73501
505	-28.79969	-16.51736	-8.81468	-14.61109	2.21682	7.53185
506	6.54444	-17.07103	-11.02192	-8.07913	-9.05037	2.30429
507	-26.22327	-27.92174	-26.38394	-12.38014	-18.12632	-9.28069
508	-62.00924	-37.02853	-37.53800	-20.46170	-0.38814	-4.25835
509	-20.84879	-28.29172	-25.73484	-19.69171	22.11080	4.95245
510	-16.13800	-4.36916	1.39811	-11.72950	29.44232	11.05751
511	33.02191	21.84025	27.44913	2.22946	19.76322	15.97776
512	47.36437	37.20264	37.31114	17.61557	-0.04052	13.72567
513	30.16790	36.46245	29.85497	28.16570	-13.55940	6.37830
514	42.08667	21.31193	11.45143	27.66041	-22.56306	-8.24826
515	-17.31353	-0.98077	-11.05856	13.59242	-19.07180	-17.27236
516	-23.03884	-15.22015	-21.07517	-1.97349	0.13248	-12.64519
517	-12.22081	-13.06158	-11.83383	-11.21947	17.01130	-5.60644
518	-13.02508	1.20440	9.27716	-11.77482	22.37925	4.94214
519	38.91132	15.01183	25.27157	-3.00127	5.99601	10.76718
520	13.93096	15.85649	19.08996	6.76584	-16.43239	8.07241
521	3.37464	5.35384	-0.86861	11.94163	-20.24879	1.15201
522	-0.77166	-8.04020	-17.04036	6.75987	-10.67934	-11.64102
523	-34.56450	-17.66279	-20.66854	-8.13999	3.12842	-15.46639
524	-7.71813	-18.30175	-13.73665	-19.25560	9.02204	-4.77608
525	-23.92280	-5.90895	-2.94835	-13.96674	14.04426	16.81505
526	10.57452	20.75689	16.28443	12.95779	23.10126	33.08156
527	76.05663	43.87152	35.59809	39.65062	10.79539	13.98938
528	45.32369	36.94491	31.87395	34.70279	-18.75450	-23.06768
529	10.49586	-0.13956	1.66621	1.01400	-37.84761	-38.78118
530	-63.87615	-38.44729	-33.14987	-31.31376	-25.96883	-21.04328
531	-70.44690	-49.66083	-43.19574	-37.50377	5.62424	6.61569
532	-14.43190	-36.41448	-28.77907	-26.85049	18.74966	10.43288
533	-29.59359	-18.30281	-10.97437	-19.30171	16.29283	6.17623
534	2.45651	-2.16576	3.69255	-10.62257	12.54255	11.96545
535	14.87319	10.30375	12.46013	3.14698	4.37501	14.00414
536	14.28651	13.66923	11.69083	14.10754	-6.35931	6.35073
537	23.63123	5.12408	-0.35099	14.08344	-16.37113	-5.81310
538	-31.46583	-5.59010	-14.34722	7.19166	-7.34001	-4.90257
539	-6.19043	-2.20877	-10.07107	7.05119	15.50713	3.58884
540	21.35568	14.54811	11.91489	10.18715	25.46077	1.15904
541	24.22824	30.38319	35.23620	9.17289	18.19142	-2.62161
542	57.07086	31.49208	41.80235	4.94569	-7.61648	-6.32739
543	8.30263	11.35022	19.68223	-3.54357	-34.17645	-9.94608
544	-19.62528	-20.48604	-19.00038	-13.26723	-39.01430	-8.87679
545	-51.81828	-43.47678	-49.63388	-19.36527	-17.61867	-1.45160
546	-71.96617	-36.89309	-46.93463	-11.93976	24.00932	17.22254
547	12.76333	0.32687	-7.68374	11.57870	48.25624	25.88219
548	48.63449	40.50147	36.32874	32.04642	34.27717	12.38331
549	73.63698	53.64056	53.37897	33.62837	-2.17104	-9.66821
550	49.97416	31.58667	33.11634	14.23506	-34.56549	-26.52839

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NO	WAVE(S)	WAVE(P)	X-VELOCITY	Y-VELOCITY	X-ACCEL	Y-ACCEL
551	-33.68569	-4.76590	-3.42283	-11.19567	-31.99877	-20.09817
552	-28.31687	-25.55275	-23.13380	-21.70335	-6.80461	-1.26522
553	-31.29268	-23.33091	-19.90555	-16.88077	10.85644	9.11445
554	-7.27188	-10.29513	-6.87293	-6.74395	12.35308	9.55306
555	15.17042	0.39190	1.06521	0.17377	3.60161	4.56139
556	-14.51999	7.32843	3.86687	5.27023	3.84016	6.92985
557	29.37025	11.66490	7.83144	12.35944	1.30320	4.30995
558	16.62391	3.49117	1.10230	8.51561	-15.50982	-12.65520
559	-27.81296	-19.36443	-19.62815	-9.22710	-22.56611	-19.52643
560	-40.87179	-38.26096	-36.92037	-24.51355	-8.79024	-8.88163
561	-62.09743	-37.21807	-33.09169	-25.21903	16.39063	6.65468
562	-2.08598	-19.79758	-9.87877	-16.39825	25.32146	7.64744
563	3.96540	-2.15518	10.63610	-12.69440	15.10950	1.49300
564	-7.52194	14.40271	23.56660	-6.30695	12.59340	14.28091
565	48.42090	35.13518	35.64558	15.63157	9.65934	26.45805
566	51.57089	48.35457	38.42804	38.26522	-5.88207	14.91274
567	59.50733	37.59121	21.89010	40.11456	-27.06119	-12.25372
568	5.52965	3.76907	-11.16065	16.53100	-34.43596	-30.99562
569	-58.08444	-29.26174	-36.68155	-12.23165	-12.97252	-22.65355
570	-33.87113	-39.53936	-36.08614	-25.89920	12.24086	-5.10844
571	-42.09912	-26.63649	-16.72381	-23.50935	24.56306	9.68583
572	1.92335	-1.98809	8.67463	-8.30269	23.33488	18.42417
573	35.67501	17.38915	24.40674	7.27086	6.62428	10.29688
574	14.48664	20.38018	22.49285	11.01310	-9.06382	-1.96457
575	24.26080	11.53142	9.38272	6.14971	-15.25736	-5.97265
576	-16.19184	5.30835	-2.32932	3.55930	-4.82688	2.96766
577	5.19598	13.64197	3.09626	12.79826	14.48014	13.27131
578	48.10918	27.54485	19.53144	22.71869	14.09896	3.30190
579	25.95794	26.76846	24.97483	17.42267	-5.02462	-12.80416
580	24.13322	5.41110	8.35018	0.83019	-27.08657	-18.22403
581	-39.90255	-21.97804	-21.80963	-13.90540	-27.44300	-8.51778
582	-53.62167	-32.12923	-36.48485	-13.61542	0.16102	7.83604
583	-6.54119	-22.66022	-25.04802	-5.18275	18.30509	4.96389
584	-12.79712	-15.12009	-9.03389	-8.32189	10.01037	-11.33147
585	-4.67029	-23.45558	-9.04039	-24.70610	-9.65913	-18.59921
586	-54.69692	-35.70276	-21.46639	-37.82756	-9.36457	-3.42095
587	-53.87885	-26.30871	-17.87891	-26.80670	18.16837	24.51363
588	26.09417	7.27281	9.72915	3.14689	31.85368	30.21688
589	40.20601	40.30727	36.36064	26.90731	18.20731	16.35460
590	69.63228	52.78431	42.63654	36.30200	-6.19619	2.76380
591	46.79952	40.40672	25.86171	32.59583	-24.87878	-10.05050
592	5.34217	10.25187	-1.45097	16.61027	-27.65377	-21.80680
593	-12.07829	-25.50177	-27.12675	-9.77705	-22.46885	-28.86206
594	-81.34729	-49.11408	-41.65928	-33.03729	-3.75993	-12.94678
595	-52.72088	-43.84951	-32.61726	-31.17554	20.14706	15.18209
596	-5.53503	-16.44852	-7.86423	-10.75448	26.19133	21.18034
597	8.26064	12.12796	15.94278	5.77264	20.37555	11.07251
598	46.58277	29.96409	31.03715	12.11166	9.13549	2.77897
599	25.17570	35.60347	34.21540	14.45954	-2.41029	3.15661
600	41.69910	29.53730	25.59758	17.63267	-15.85853	1.08770