TURBULENCE MEASUREMENTS IN A TIDAL CURRENT

by

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Turbulence Measurements in a Tidal Current

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Abstract

Measurements were made of the component of turbulent velocity along the axis of a 3-knot tidal current 1.5 meters below the water surface using a ducted impeller current meter. Values of the one-dimensional energy spectra were computed on a digital computer at wave numbers from 0 cm^{-1} to 0.157 cm^{-1}. The composite energy spectrum obtained from the individual spectra was of the -5/3 power law form predicted by the Kolmogoroff hypothesis for wave numbers from 0.01 cm^{-1} to 0.026 cm^{-1}. At higher wave numbers the energy spectrum decreased more rapidly than predicted because of attenuation of the turbulent velocity variations caused by the relatively large size of the current meter. The average variance for the field of turbulence was 55.6 $cm^2 - sec^{-2} \pm 25.0$ (standard error) and the average rate of energy dissipation by viscosity was estimated using the Kolmogoroff hypothesis as 0.84 $cm^2 - sec^{-3}$.

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Table of Contents

Table of Contents - Cont'd

List of Figures

List of Figures - Cont'd

Page No.

List of Tables

Nomenclature

$E(\kappa, t)$ = three-dimensional energy spectrum function (cm^3-sec^{-2})

$E(t)$ = energy of the turbulence per unit mass (cm^2-sec^{-2})

ϵ = rate of dissipation of energy by viscosity (cm^2-sec^{-3})

$\phi(\kappa, t)$ = one-dimensional energy spectrum (cm^3-sec^{-2})

κ = wave number (cm^{-1})

t = time (sec)

$u(x)$ = component of velocity along axis of current relative to boat (cm-sec^{-1})

$U(x)$ = velocity of towing along axis of current (cm-sec^{-1})

$x(t)$ = distance of advance of the current meter relative to the water along axis of current (cm)

x' = distance along axis of current relative to channel buoys (meters)

$U_c(x')$ = component of current along axis (meters-sec^{-1})

$u'(x)$ = component of turbulent velocity along axis of current; $u(x) = U(x) + u'(x)$ (cm-sec^{-1})

Δx = intervals at which data is spaced; $x = k\Delta x$, $k = 0, \pm 1, \pm 2, \ldots$ (cm)

ξ = lag (cm)

$\Delta\xi$ = intervals at which values of the autocovariance series are computed; $\Delta\xi = n\Delta x$, $n = 1, 2, 3, 4, \ldots$ (cm)

ξ_m = maximum lag at which a value of the autocovariance series is computed (cm)

L = length of sample (cm)

κ_N = Nyquist wave number (cm^{-1})

t_i = time from start of run to beginning of ith rotation of impeller (sec)

T = period of rotation of the impeller (sec)

T_i = period of ith rotation of impeller (sec)

$R_a(k\Delta\xi)$ = apparent autocovariance function (cm^2-sec^{-2})

$f_h(\xi)$ = hanning lag function (non-dimensional)

$\gamma_h(\kappa)$ = hanning spectral function; the Fourier transform of $f_h(\xi)$(cm)

$R_m(k\Delta\xi)$ = modified apparent autocovariance function (cm^2-sec^{-2})

$\phi_{am}(\kappa)$ = aliased, modified, one-dimensional energy spectrum; the Fourier transform of the autocovariance series $R_m(k\Delta\xi)$(cm^3-sec^{-2})

u = velocity of water flowing through current meter (cm-sec^{-1})

ω = angular velocity of impeller (rad-sec^{-1})

D = diameter of impeller (cm)

J = advance diameter ratio; $J = u/(\omega D)$(non-dimensional)

I = moment of inertia of impeller (gram-cm^2)

k = calibration coefficient of the current meter (cm)

K = resultant driving torque on impeller (dyne-cm)

U = constant component of velocity (cm-sec^{-1})

u' = varying component of velocity (cm-sec^{-1})

Ω = constant component of impeller angular velocity (rad-sec^{-1})

ω' = varying component of impeller angular velocity (rad-sec^{-1})

τ = response time (sec)

λ = response distance (cm)

ν = kinematic viscosity (cm^2-sec^{-1})

ρ = density (gram-cm^{-3})

$\vec{x}$ = vector position of point in space (cm)

$\vec{\xi}$ = vector displacement with respect to $\vec{x}$ (cm)

$u_i(\vec{x}, t)$ = ith component of turbulent velocity (cm-sec^{-1})

$R_{ij}(\vec{\xi}, t)$ = covariance tensor; the covariance between the ith component of turbulent velocity at $\vec{x}$ and the jth component at $\vec{x} + \vec{\xi}$ (cm^2-sec^{-2})

$\rho_{ij}(\vec{\xi}, t)$ = correlation tensor (non-dimensional)

$\vec{\kappa}$ = vector wave number (cm^{-1})

$dZ_i(\vec{\kappa}, t)$ = Fourier transform of the ith component of the turbulent velocity $u_i(\vec{x}, t)$(cm-sec^{-1})

$\Phi_{ij}(\vec{\kappa}, t)$ = energy spectrum tensor; Fourier transform of the covariance tensor (cm^3-sec^{-2})

$E(t)$ = total kinetic energy per unit volume of the turbulence (gram-cm^{-1}-sec^{-2})

$\Theta_{ij}(\kappa_1, t)$ = one-dimensional energy spectrum tensor; the integral over κ_2 and κ_3 of the energy spectrum tensor (cm^3-sec^{-2})

κ = scalar wave number; $\kappa = |\vec{\kappa}|$ (cm^{-1})

κ_1 = component of wave number corresponding to the direction x_1 (taken along the axis of the current)(cm^{-1})

$\Psi_{ij}(\kappa, t)$ = energy spectrum tensor function of the scalar wave number

κ = the average of $\Phi_{ij}(\vec{\kappa}, t)$ over all directions of the vector argument $\vec{\kappa}$ (cm^3-sec^{-2})

$E(\kappa, t)$ = three-dimensional energy spectrum function (cm^3-sec^{-2})

$R(\xi, t)$ = one-dimensional covariance function (cm^2-sec^{-2})

$\phi(\kappa, t)$ = one-dimensional energy spectrum function; the Fourier transform of $R(\xi, t)$ (cm^3-sec^{-2})

Addendum

κ_e = wave number at which the maximum in the energy spectrum is located (cm^{-1})

κ_d = wave number at which the maximum in the dissipation spectrum is located (cm^{-1})

θ = angle between axis of current meter and the direction of towing (degrees)

f_{max} = highest frequency at which the current meter is responsive to variations in velocity (Hz)

κ_{max} = wave number corresponding to f_{max} (cm^{-1})

$\bar{u}(x)$ = average value of the instantaneous velocity $u(x)$ over the interval Δx ($cm\text{-}sec^{-1}$)

$\phi'_{am}(\kappa)$ = Fourier transform of the autocorrelation series; $\phi_{am}(\kappa)$ divided by the variance $R_m(0)$ (cm)

e_i = error in the ith value of u_i ($cm\text{-}sec^{-1}$)

R_{ek} = error in the kth value of the autocovariance series ($cm^2\text{-}sec^{-2}$)

$R_{im}(0)$ = variance of the ith sample ($cm^2\text{-}sec^{-2}$)

$\phi_{iam}(\kappa)$ = value of the computed energy spectrum for the ith sample ($cm^3\text{-}sec^{-2}$)

$\phi'_{iam}(\kappa)$ = $\phi_{iam}(\kappa)$ divided by the variance of the ith sample (cm)

u_f = final, constant value of the step function change in the velocity ($cm\text{-}sec^{-1}$)

ω_f = angular velocity corresponding to u_f ($rad\text{-}sec^{-1}$)

T_0 = initial period of rotation of the impeller (sec)

T_f = final period of rotation of the impeller (sec)

Introduction

The important problems in the theory of turbulence are: the determination of the energy spectrum function, $E(\kappa, t)$, and hence the total kinetic energy of the turbulence, E, and the rate, ϵ, at which the energy is dissipated by viscosity; the change in $E(\kappa, t)$, E and ϵ with decay. A limited amount of theoretical predictions are available concerning the form of the energy spectrum function in the low wave number range of the spectrum, the reason being that the structure of turbulence in the low wave number range is, in general, inhomogeneous, anisotropic and strongly dependent on the mean flow from which the energy of the turbulence is derived. Such characteristics result in an intractable theoretical analysis.

The structure of turbulence in the high wave number range of the spectrum, however, has been hypothesized (Kolmogoroff, 1941) to be homogeneous, isotropic and statistically independent of the mean flow. The Kolmogoroff hypothesis states that at sufficiently high wave numbers the statistical structure of turbulence has a universal form and is uniquely determined by the parameters ϵ and ν, the kinematic viscosity. The range of wave numbers for which the preceding is applicable is known as the universal equilibrium range. Within this range it can be shown through dimensional analysis that the energy spectrum function can be written as

$$E(\kappa,t) = \epsilon^{2/3}\kappa^{-5/3}F(\kappa/\kappa_d) \tag{1}$$

where $F(\kappa/\kappa_d)$ is a universal function and

$$\kappa_d = (\epsilon/\nu^3)^{1/4} \tag{2}$$

is the wave number (approximately) at which the maximum in the energy dissipation spectrum is located.

It has further been hypothesized (Kolmogoroff, 1941) that is there exists within the equilibrium range of wave numbers a range (the inertial subrange) where dissipation is negligible then $E(\kappa, t)$ is independent of ν and therefore of κ_d and consequently $F(\kappa/\kappa_d)$ must be a constant so that, within the inertial subrange,

$$E(\kappa, t) = K \epsilon^{2/3} \kappa^{-5/3} \qquad (3)$$

The necessary condition for the existence of an inertial subrange of wave numbers has been shown (Batchelor, 1) to be that the Reynolds number of the turbulence must be sufficiently large that the wave numbers corresponding to the maximum dissipation of energy and to the maximum energy are considerably separated on the wave number scale. This condition is satisfied (Grant, Stewart and Moilliet, 2) in large scale oceanographic flows, wherein the wave numbers corresponding to the maximum energy are several orders of magnitude smaller than those corresponding to the maximum dissipation of energy (the wave numbers corresponding to the maximum dissipation of energy are of the same order of magnitude for oceanographic turbulence as for laboratory turbulence).

Measurements of the turbulent velocity component parallel to the axis of a tidal current were made by Grant, Stewart and Moilliet (2) using a hot film anemometer mounted on the front of a heavy towed body. The instrument was towed from the research vessel C. N. A. V. Oshawa at a depth of 15 meters in Discovery Passage, adjacent to Vancouver Island. One-dimensional energy spectra were found from samples of the data using analog filtering techniques over the range of wave numbers from 0.01 cm^{-1} to 35 cm^{-1}. The spectra followed the -5/3 power law predicted by the Kolmogoroff hypothesis from wave numbers of around 0.01 cm^{-1} to cm^{-1}, thus indicating the extensiveness and importance of the inertial subrange in oceanographic turbulence. Similar measurements have been made by Grant and Moilliet (3) of the turbulent velocity component perpendicular to the axis of a tidal current (Discovery Passage south of Cape Mudge). Although a calibration of the hot film anemometer was not obtained the spectra were of the -5/3 power law form when represented on an arbitrary scale. The first set of measurements allowed the energy dissipation spectra to be calculated from which values of ϵ and hence the universal constant K could be determined.

Additional measurements have been made by Grant and Stewart (5) of the turbulence spectra in a tidal current (Georgia Straight and Juan De Fuca Straight) near the water surface in the presence of surface waves and noise. The results of the previous measurements were used to determine values of ϵ although the energy dissipation spectra could not be calculated because of the interference.

Complimentary measurements to those of Grant et al were made over the low wave number anisotropic range of the spectrum from approximately 0.01 meters^{-1} to 2.0 meters^{-1} by Bowden (6) and by Bowden and Howe (4). The instrument used was an electromagnetic flowmeter. Although the Kolmogoroff hypothesis does not apply to the low wave number range, the spectra obtained from the measurements by Bowden and Howe were reported to follow a power law similar to that predicted by the Kolmogoroff hypothesis but with an exponent of the order of -1.3 instead of -5/3 for wave numbers from approximately 0.001 cm^{-1} to 0.01 cm^{-1}.

Shonting (8, 9, 15, 16) has used a ducted impeller ocean current meter to make measurements of the particle motions in ocean waves to frequencies of 2.5 Hz. The results demonstrated the potential of the current meter for measuring relatively high frequency and/or wave number oceanographic turbulence. The hot film anemometer used previously (2, 3, 5) is a complex instrument requiring considerable electronic equipment to obtain an output suitable for data analysis. In addition, difficulties are encountered in using the hot film anemometer probe at sea because of the corrosive and electrolytic properties and the high level of contamination of sea water. The advantages of the ducted impeller current meter in comparison are simplicity, sturdiness and reliability, desirable characteristics in an oceanographic instrument; the output of the current meter is of the appropriate form for digital spectral analysis with respect to wave number. The objects of the measurements reported herein, then, are to: (1) obtain using the current meter additional turbulence spectra from a tidal current which can be compared with the spectra obtained using the hot film anemometer in order to determine the applicability and/or the limitations of the current meter for measuring oceanographic turbulence; (2) provide additional experimental confirmation of the Kolmogoroff hypothesis.

Instrumentation

A. Description of Current Meter. The ducted impeller oceanographic current meter (figures 1 and 2) consists of a six bladed impeller axially mounted in the center of a brass cylinder approximately 8.5 cm in diameter and 15 cm long. The impeller is manufactured of micarta (laminated phenol formaldehyde). The impeller shaft is terminated at either end with carbide pins which rest in quartz V-bearings mounted in neoprene; it is supported at either end by three struts spaced 120 degrees apart. A miniature magnet (weighing around 5 grams) is imbedded in the tip of each blade and a coil is potted with epoxy resin in a housing mounted externally on the cylinder.

In operation the instrument is aligned with the water flow which, impinging on the blades of the impeller, is deflected with a resultant force exerted on the blade surface causing the impeller to rotate. When a constant angular velocity has been achieved, the angular velocity is directly proportional to the water current over the specified linear operating range of the instrument; the constant of proportionality is the calibration coefficient, k, for the current meter. The rotation of the impeller and consequently the passage of the magnets in the tip of each blade past the coil induces a series of voltage pulses which is transmitted through two conductor waterproof cable to appropriate recording instrumentation. The frequency of the pulses generated thus becomes a measure of the water velocity. The waveform obtained from the current meter is shown in figure 3.

B. Calibration. The current meter was calibrated in a water tank by towing the instrument at various known, constant velocities and measuring the frequency of the pulses generated. For the calibration the axis of the current meter was aligned with the towing direction. The calibration curve is given in figure 5 from which the calibration coefficient, the slope of the calibration curve in the linear range, was determined as 3.12 cm. Thus

$$U \text{ (cm-sec}^{-1}) = \Omega \text{ (rad-sec}^{-1})(3.12 \text{ cm}) \qquad (1)$$

Additional tests were performed to determine the variation of the calibration coefficient with flow direction. For these tests the axis of the current meter was set at various known angles relative to the towing direction and the frequency output measured at known, constant velocities. The variation of k as a function of θ, the angle between the axis of the current meter and the towing direction, is shown in figure 6 which indicates that k is given very closely by

$$k(\theta) = k(0) \cos\theta = 3.12 \cos\theta \qquad (2)$$

the largest deviation occurring at values of θ near $\pi/2$ and probably caused by asymmetry in the mounting arrangement. Since the component of velocity

$$\vec{q} = \hat{i}u + \hat{j}v + \hat{k}w$$

in the x direction (taken along the axis of the current meter) is

$$u = |\vec{q}| \cos \theta \ ,$$

the current meter is sensitive to the component of velocity along the axis and insensitive to the components perpendicular to the axis. A second calibration of the current meter was obtained using a low speed wind tunnel (appendix II). The calibration curve is shown in figure 7. The slope of the straight line is the same as that obtained from the in-water calibration but the straight line intercepts the U axis at 10 cm-sec^{-1} instead of passing through the origin. Since the measurements were performed at relatively low wind tunnel velocities, the difference is attributed to error in measuring the low velocities with a pitot static probe. The correct value of the calibration coefficient is assumed to be the in-water value.

C. Response to Accelerated Flow. The current meter has been used (Shonting, 8, 9, 15, 16) previously to make measurements of the particle motions in ocean waves. For those measurements the mean water velocity was zero or near zero. Under such conditions it was determined through wind tunnel and in-water tests (8, 22) that the response time of the current meter for a step function change in water velocity is of the order of 50-70 milliseconds. In making the turbulence measurements reported herein, however, a towing velocity of approximately 400 cm-sec^{-1} was superimposed on the turbulent velocity field. Therefore it was necessary to determine the response of the current meter to a step function change in velocity superimposed on a mean velocity. Wind tunnel measurements of the response time of the current meter are described in appendix II. It was found that the response time for a relatively small step function change in water velocity varies inversely with the mean velocity such that the product of the response time and the mean velocity (the response distance) is a constant with a value of 0.97 cm. The frequency response of the instrument is determined by the response time; the instrument is insensitive to variations in velocity occurring at frequencies greater than

$$f_{max} << \frac{1}{2\pi\tau} \text{ hz} \tag{3}$$

Assuming that Taylor's hypothesis is applicable, that is,

$$\left(\frac{\partial u}{\partial t}\right)^2 = U^2 \left(\frac{\partial u}{\partial x}\right)^2 \tag{4}$$

this corresponds to a wave number of

$$\kappa_{max} << \frac{1}{U\tau} ; \quad \kappa = 2\pi f/U \tag{5}$$

which, from the previous measurements of response time, is

$$\kappa_{max} << \frac{1}{\lambda} = 1.03 \text{ cm}^{-1} \tag{6}$$

Thus the current meter had the capability for measuring turbulence over the constant range of wave numbers from 0 to 0.103 cm^{-1}, regardless of the mean velocity superimposed on the turbulent field by towing (actually the value given for κ_{max} is optimistic because of the size of the current meter -15 cm long; a more reasonable value is of the order of 1/150 cm = 0.0068 cm^{-1}). Since spectral analysis of turbulence is more correctly performed with respect to wave number than frequency, this is an important result.

D. <u>Sensitivity</u>. The lowest water velocity sufficient to maintain a constant angular velocity of the impeller is of the order of 5 to 7 $cm\text{-}sec^{-1}$. No measurements were made to determine the sensitivity of the current meter as a function of velocity but typical commercially available turbine flow meters have sensitivities equal to $\pm 0.25\%$ or less of the mean velocity. If the performance of the ducted impeller current meter is assumed equal to that of commercial flow meters, it has a sensitivity of ± 1 cm-sec^{-1} at a mean velocity of 400 cm-sec^{-1}.

E. Output. From the calibration coefficient the distance required for the current meter to advance relative to the water in order for the impeller to complete one rotation is

$$2\pi k = (6.28)(3.12 \text{ cm}) = 19.61 \text{ cm}$$

The output of the current meter is six pulses per rotation or 6 pulses 19.61 cm = 0.306 pulses per cm advance. In practice the output of the current meter was modified using a Schmidt trigger-binomial counter circuit in a divide-by-six mode to obtain one pulse instead of six per rotation of the impeller. This was found necessary because of the approximately +10% variation in angular spacing between adjacent impeller blades, which otherwise would have resulted in a noise level (measureable) corresponding to variations in velocity ± 40 cm-sec^{-1}. The practical output of the current meter is 1/19.61 cm = 0.051 pulses per cm advance.

The recorded data consists of successive periods per rotation of the impeller; corresponding values of the water velocity can be computed using the calibration coefficient:

$$u_i = 2\pi k / T_i ; \quad i = 0, 1, 2, \cdots \tag{7}$$

u_i is the average value of the instantaneous velocity $u(x)$ over the interval of time T_i. Since a mean velocity is superimposed on the turbulent velocity component,

$$u_i = U_i + u'_i$$

Multiplying by T_i,

$$u_i T_i = 19.61 \text{ cm} = U_i T_i + u'_i T_i$$

$U_i T_i$ is the distance relative to the water which the current meter had advanced in the interval T_i. Hence if u'_i is negligible compared to U_i, the values u_i are obtained at distances x_i approximately equally spaced at intervals of $x = 19.61$ cm, regardless of the mean velocity. The error in assuming the data is equally spaced is of the order of $\pm u'_i/U_i = \pm 10/400 = \pm 2.5\%$ for the measurements reported herein, which is not greater than the existing ambiguity in corresponding the values u_i with the series of times

$$t_i = \sum_{j=0}^{i+1} T_j$$

Such equally spaced data is of the appropriate form for digital spectral analysis with respect to wave number.

F. Aliasing. A discussion of the problem of aliasing is given by Blackman and Tukey (17) (see appendix IV also) wherein it is shown that if there is significant contributions to the energy from velocity variations occuring at wave numbers greater than the Nyquist wave number given by

$$\kappa_N = \frac{\pi}{\text{sampling interval}} = \frac{\pi}{\Delta x} \tag{8}$$

then the computed energy spectrum is in error at all wave numbers. The Nyquist wave number for the data obtained from the current meter is $\pi/19.61$ cm = 0.157 cm^{-1}.

The equally spaced values of velocity can be considered to result from sampling the average velocity

$$\bar{u}(x) = \frac{1}{\Delta x}\int_{x-\frac{\Delta x}{2}}^{x+\frac{\Delta x}{2}} u(x')\,dx' \tag{9}$$

at intervals of Δx. Equation (9) can be written as a centered moving average:

$$\bar{u}(x) = \int_{-\infty}^{\infty} u(x')h(x-x')\,dx' \tag{10}$$

where

$$h(x) = \begin{cases} \frac{1}{\Delta x}, & -\frac{\Delta x}{2} \leq x \leq \frac{\Delta x}{2} \\ 0, & \text{otherwise} \end{cases} \tag{11}$$

If the Fourier transform of u(x) is $dZ(\varkappa)$ and that of $\bar{u}(x)$ is $d\bar{Z}(\varkappa)$ (appendix II) then, applying the convolution theorem,

$$d\bar{Z}(\varkappa) = \frac{\sin^2\left(\frac{\varkappa\Delta x}{2}\right)}{\left(\frac{\varkappa\Delta x}{2}\right)^2}\, dZ(\varkappa) \tag{12}$$

The quantity

$$\frac{\sin^2\left(\frac{\varkappa\Delta x}{2}\right)}{\left(\frac{\varkappa\Delta x}{2}\right)^2}$$

is the Fourier transform of h(x) and operates on the energy spectrum as a low pass filter. Variations in velocity occuring at wave numbers greater than around $\pi/\Delta x = 0.157\ cm^{-1}$ are strongly attenuated. Since this value is equal to the Nyquist wave number, and since velocity variations at wave numbers greater than about $0.007\ cm^{-1}$ (section C) can be expected to be attenuated because of the dimensions of the current meter, aliasing is not considered a problem.

Field Observations

Figure 8 is a section of C. & G. S. chart no. 353 showing the area within which measurements were made. The area is located in the Sakonnet River between the north end of Aquidneck Island and Tiverton, R. I. The area indicated on the chart as station I is formed from stone breakwaters projecting from the island and the mainland. The tidal current at station I is given in table I which was constructed from information given in the tide and current tables (20).

Table I

Time with respect to high tide at Newport, R. I.	Current at station I
High tide	1.7 knots South
1 hour after	2.6 " "
2 " "	3.0 " "
3 " "	2.2 " "
4 " "	1.2 " "
5 " "	1.1 knots North
6 " "	- see Note
7 " "	- " "
8 " "	- " "
9 " "	- " "
10 " "	2.3 knots North
11 " "	2.0 knots South
12 " "	1.0 " "

Note: The current during this time interval is unpredictable and can change rapidly from North to South or from South to North and can be as much as 3.0 knots in either direction.

Measurements were made on 4 November 1966 from 1300 hours to 1400 hours. The time of high tide at Newport was given as 1130 hours and therefore measurements were made during the interval when the current was a maximum of 3.0 knots South.

The width of the channel at station I is approximately 116 meters and the depth

6.7 meters. North of station I the depth is 18.6 meters and in the area from station I to station II, 800 meters South of I, the depth varies from around 10 to 20 meters, with a width of the order of 400 meters. The width Reynolds number at station I is approximately 1.3×10^8.

Figures 9, 10 and 11 show the method of mounting the current meter on the bow of the boat, a U.S. Naval Underwater Weapons Station 74 ft OAL torpedo retriever. Brackets were fabricated to support the mounting strut, an 11 1/2 ft long section of 1 1/2 nominal size steel pipe to the lower end of which was clamped a 3 ft length of 3/6" x 3" steel bar stock, along the bow. When in position the lower end of the strut extended approximately 1 1/2 meters below the surface of the water. The current meter was affixed to the end of the strut in a horizontal position; the clamping arrangement allowed the bar stock to be rotated so that the axis of the current meter could be aligned with the centerline of the boat.

The current meter output was recorded on FM magnetic tape at 30 inches/sec on a Precision Instrument PI-2100 recorder. It was necessary to include an attenuator in the circuit to reduce the signal level 8 db to an appropriate level for the recorder. A gasoline engine driven 115 VAC generator followed by a Sorensen voltage regulator was used to supply power to the recorder.

The original intention was to proceed against the current from station II to station I along the centerline of the channel at as slow a velocity as possible in order to obtain the maximum amount of data with a minimum change in position or downstream distance from the channel buoys. The ideal technique would have been to tow the instrument at a velocity equal to that of the current. The first run showed that this was impracticable as it was impossible to control the boat in the turbulence at such low velocities. The remaining runs were made at a velocity of 4 meters-sec^{-1} relative to the water; the engine RPM was maintained constant throughout. A typical run consisted of steaming against and along the center of the current from the vicinity of station II to station I. Four runs were made proceeding with the current and four against (including the first, the data from which was not analyzed). On each run the instant when the boat passed between the channel buoys was observed and recorded.

A light southerly breeze prevailed during the time measurements were made; surface waves were limited to wave heights of a few centimeters and therefore no wave particle motions should have been recorded although the current meter was only 1 1/2 meters below the water surface.

Data Analysis

A. Analog to Digital Conversion. The data analysis follws the procedure given by Blackman and Tukey (17); the equations used are derived in appendix II for reference. Figure 12 is a block diagram indicating the process involved in obtaining data in digital form appropriate for computer analysis. The original data was recorded on 1/2 inch magnetic tape at 30 inches-sec^{-1} and has the waveform shown in figure 3 (top trace). It was reproduced at 30 inches-sec^{-1}, amplified 10 db and modified using a Schmidt trigger so that the waveform was as shown in figure 3 (lower trace). A binomial counter was used to divide the original frequency by six thus resulting in the square wave shown in figure 4 (lower trace), where one cycle of the square wave corresponds to one rotation of the impeller or 19.61 cm advance of the current meter through the water. The average frequency of the original data was (at 30 inches-sec^{-1}) 120 Hz and that of the modified data 20 Hz. The modified data was recorded on 1 inch FM magnetic tape at 30 inches-sec^{-1} on an Ampex FR-1100 recorder.

The square wave data was converted using a Honeywell analog to digital converter to digital data at a conversion rate of 2500 counts-sec^{-1} and recorded on digital magnetic tape. The reproduce speed was 7 1/2 inches-sec so that the average frequency of the square wave was 5 Hz and therefore the number of counts per square wave cycle was approximately 500. The maximum error in determining the period of one square wave cycle is ± 1 count or approximately $\pm 0.2\%$. At an average towing velocity of 400 cm-sec^{-1} this error corresponds to variations in velocity of ± 0.5 cm-sec^{-1}.

B. Computation of Auto Covariance Series and Energy Spectra. The data processing was performed on the NUWS CDC 3200 digital computer. The FORTRAN programs are included (appendix III) for reference. The following were determined for every run and for $i = 1, 2, 3, \ldots,$ N = number of square wave cycles in run:

1. the time t_i from the start of the run (taken to be the start of the digital recording) to the completion of the ith cycle

2. the period T_i of the ith cycle from

$$T_i = t_i - t_{i-1} \tag{1}$$

3. the velocity u_i for the ith cycle using the calibration coefficient

$$u_i = 2\pi k / T_i \tag{2}$$

The u_i were assumed equally spaced at intervals of 19.61 cm. Each run was divided into samples of 500 values of velocity per sample; a computer printout of all of the digitized velocity data was obtained. Examination of the data revealed that all except 7 of the 49 samples contained several obviously erroneous points. A section from the printout (Run No. 2, Sample No. 3) is given in table II which shows a typical series of values containing erroneous points, which are indicated.

Table II

Square Wave Cycle No.	Velocity (cm-sec^{-1})
1010	341.6
1011	339.8
1012	339.8
1013	338.1
1014	339.2
1015	406.8*
1016	340.4
1017	338.1
1018	342.2
1019	343.4
1020	411.9*
1021	340.4
1022	340.4
1023	405.1*

The values of erroneous points were replaced with the values of the immediately preceding points.

For each sample a straight line was fitted through the data by the least squares method (18):

$$u(x) = U_0 + a\,x \tag{3}$$

where U_0 and a were computed from

$$U_0 = \frac{\sum_{k=1}^{500} x_k^2 \sum_{k=1}^{500} u_k - \sum_{k=1}^{500} x_k \sum_{k=1}^{500} x_k u_k}{500 \sum_{k=1}^{500} x_k^2 - \left[\sum_{k=1}^{500} x_k \right]^2} \tag{4}$$

$$a = \frac{500 \sum_{k=1}^{500} x_k u_k - \sum_{k=1}^{500} x_k \sum_{k=1}^{500} u_k}{500 \sum_{k=1}^{500} x_k^2 - \left[\sum_{k=1}^{500} x_k \right]^2} \tag{5}$$

$$x_k = k\Delta x = 19.61\,k\,; \quad k = 1, 2, \ldots, n = 500$$

The mean velocity and the trend in the data were eliminated:

$$
\begin{aligned}
u'_k &= u_k - (U_0 + a\,k\,\Delta x) \\
&= u_k - (U_0 + 19.61\,a\,k)
\end{aligned} \qquad (6)
$$

The apparent autocovariance series was computed at lags equally spaced at intervals of $\Delta\xi = \Delta x = 19.61$ cm to a maximum lag of $m\,\Delta x = 50\Delta x = (50)(19.61$ cm$)$ $= 980.5$ cm using equation (33), appendix IV.

$$
\begin{aligned}
R_a(k\Delta\xi) &= \frac{1}{500-k}\sum_{q=1}^{500-k} u'[q\Delta x]\,u'[(q+k)\Delta x] \\
&= \frac{1}{500-k}\sum_{q=1}^{500-k} u'_q\,u'_{q+k}
\end{aligned} \qquad (7)
$$

for k = 0, 1, 2, 3, ..., 50. The apparent autocovariance series was modified according to hanning (equation (34), appendix IV):

$$
R_m(k\Delta\xi) = R_a(k\Delta\xi)\begin{cases} \frac{1}{2}\left(1+\cos\frac{\pi k}{50}\right), & k < 50 \\ 0, & \text{otherwise} \end{cases} \qquad (8)
$$

The Fourier transform of the modified autocovariance series was computed at values of wave number $\varkappa$ equally spaced at intervals of $\Delta\varkappa = \pi/50\Delta x = 0.00320\ \text{cm}^{-1}$ from equation (38), appendix IV.

$$
\begin{aligned}
\Phi_{am}(q\Delta\varkappa) &= \Phi_{am}\left(\frac{q\pi}{50\Delta x}\right) \\
&= \frac{19.61\,\sigma_q}{\pi}\left[2\sum \cos\frac{kq\pi}{50} R_m(k\Delta\xi) + R_m(0) + \cos q\pi\, R_m(50\Delta\xi)\right]
\end{aligned} \qquad (9)
$$

$$
\sigma_q = \begin{cases} 1/2, & q = 0 \\ 1, & \text{otherwise} \end{cases}
$$

Values of the computed energy spectrum were obtained for wave numbers up to the Nyquist wave number $\varkappa_N = 0.157\ \text{cm}^{-1}$; the values are referred to positive wave numbers only. The values of the computed energy spectrum function were divided by the sample variance:

$$\varphi'_{am}(q\Delta k) = \frac{\varphi_{am}(q\Delta k)}{R_m(0)} \tag{10}$$

C. Location of Samples. From the original data and the computer printout of the digitized velocity data were determined:

t_0 = time from the start of the run to the instant the boat passed between the channel buoys (sec);

n_0 = the number of impeller rotations from the start of the run to time t_0;

t_k = time from the start of the run to the start of the kth sample;

n_k = the number of impeller rotations from the start of the run to time t_k

If the average current from t_0 to t_k is U_c (meters-sec^{-1}) then the position of the kth sample relative to the channel buoys is

$$X_k(\text{meters}) = U_c(t_k - t_0) \pm 0.1961(n_k - n_0).$$

Accurate measurements of U_c over the distance between stations I and II were not available. However a large error in U_c does not result in a corresponding large error in x_k; for

$$t_k - t_0 \simeq \frac{n_k - n_0}{U} \, 0.1961$$

Thus

$$= \frac{0.1961}{4}(n_k - n_0)$$

$$x_k \cong (n_k - n_o)(0.1961)\left[1 + U_c/4\right] ;$$

$$\frac{\Delta x_k}{x_k} = \frac{\Delta U_c/4}{1 + U_c/4}$$

If a value of 1/2 the current through station I is used for U_c and if this value is in error by $\pm$ 50% then

$$\frac{\Delta x_k}{x_k} \times 100\% = \frac{\pm 0.4/4}{1 \pm 0.8/4} \times 100\% = \pm 8.4\%, \ \pm 12.5\%$$

Table III gives the positions of the samples relative to the channel buoys as determined from

$$x_k = 0.8\,(t_k - t_o) \pm 0.1961\,(n_k - n_o)$$

and are assumed to be correct to within around 10%.

Results and Discussion

Figures 13 through 17 are graphs of the digitized velocity data for several typical samples. The mean velocity is superimposed on the u'_i and the least squares straight line used to eliminate the mean and trend is indicated. The autocovariance series corresponding to the samples are shown in figures 18 through 22. Thirty seven useful samples were obtained from seven runs. It is not necessary to show the autocovariance series and energy spectra for the individual samples; the autocovariance series shown in figures 18 through 22 and the energy spectra given in figures 23 through 27 are representative of the results. The results from the 37 samples are tabulated numerically in appendix V. The values of the

Table III

Positions of Samples

Run No.	Sample No.	Downstream distance of Center of Sample from Channel Buoys (meters)
1	1	-164
	2	- 44
	3	73
	4	181
	5	308
	6	427
	7	544
	8	661
2	1	300
	2	305
	3	229
	4	152
	5	75
3	1	- 70
	2	50
	3	168
	4	286
	5	404
	6	523
4	1	-218
	2	- 95
	3	26
	4	146
	5	226
	6	386
5	1	443
	2	416
	3	338
	4	260
	5	183
	6	105
6	1	-112
	2	7
	3	126
	4	245
	5	364
	6	482
7	1	38
	2	116
	3	144
	4	272
	5	350
	6	428
	7	507

energy spectra have been divided by the corresponding sample variances previous to being plotted. Before proceeding to a discussion of the results it is appropriate to consider the deficiencies in the data and/or measurements which are apparent in the autocovariance series and the energy spectra.

A. <u>Noise</u>. The energy spectra do not continue to decrease for wave numbers greater than around $\varkappa = 0.06\ \text{cm}^{-1}$ as expected but approach a constant value of the order of $\phi_{am}(\varkappa) = 20\ \text{cm}^3\text{-sec}^{-2}$, with considerable variation among samples. This can be shown to result from random error in the digitized velocity data. If for a sample consisting of N equally spaced values of velocity the error which the ith value, u'_i, is subject to is e_i then the corresponding error in the kth value of the autocovariance series is

$$R_{ek} = \frac{1}{N-k}\sum_{j=1}^{N-k}[u'_j+e_j][u'_{j+k}+e_{j+k}] - \frac{1}{N-k}\sum_{j=1}^{N-k}u'_j u'_{j+k}$$

$$= \frac{1}{N-k}\sum_{j=1}^{N-k}u'_j u'_{j+k} + \frac{1}{N-k}\sum_{j=1}^{N-k}u'_j e_{j+k} + \frac{1}{N-k}\sum_{j=1}^{N-k}u'_{j+k}e_j \qquad (1)$$

$$+ \frac{1}{N-k}\sum_{j=1}^{N-k}e_j e_{j+k} - \frac{1}{N-k}\sum_{j=1}^{N-k}u'_j u'_{j+k}$$

$$R_{ek} = \frac{1}{N-k}\sum_{j=1}^{N-k}u'_j e_{j+k} + \frac{1}{N-k}\sum_{j=1}^{N-k}u'_{j+k}e_j + \frac{1}{N-k}\sum_{j=1}^{N-k}e_j e_{j+k} \qquad (2)$$

Since the e_i are assumed random, statistically independent variables, the u'_j and the e_{j+k} are uncorrelated, as are the u'_{j+k} and the e_j. Therefore

$$\frac{1}{N-k}\sum_{j=1}^{N-k}u'_j e_{j+k} = \frac{1}{N-k}\sum_{j=1}^{N-k}u'_{j+k}e_j = 0 \qquad (3)$$

In addition, the e_j are uncorrelated with the e_{j+k} unless k = 0. Then we have

$$R_{ek} = \frac{1}{N-k}\sum_{j=1}^{N-k} e_j e_{j+k} = \begin{cases} \frac{1}{N}\sum_{j=1}^{N} e_j^2 , & k = 0 \\ 0 , & \text{otherwise} \end{cases}$$

$$R(k\Delta\xi) + R_{ek} = \frac{1}{N-k}\sum u_j' u_{j+k}' + \frac{1}{N}\delta_{k0}\sum_{j=1}^{N} e_j^2 \qquad (4)$$

where

$$\delta_{k0} = \begin{cases} 1 , & k = 0 \\ 0 , & \text{otherwise} \end{cases}$$

This demonstrates that the presence of random error in the digitized velocity data has an effect on only the value of the autocovariance series at k = 0 (the variance). The expected form of the autocovariance function for small values of ξ is (Batchelor, 1)

$$R(\xi) = R(0)\left(1 - \frac{\xi^2}{\lambda^2}\right); \quad \lambda = \text{constant} \qquad (5)$$

Comparison of this with the autocovariance series given in figures 18 through 22 indicates that the sample variances are larger than expected by around 3 cm^2-sec^{-2}. The Fourier transform of equation (4b) is

$$\frac{\Delta\xi}{\pi}\sum_{k=-\infty}^{\infty}\left[R(k\Delta\xi) + \frac{1}{N}\delta_{k0}\sum_{j=1}^{N} e_j^2\right]\cos \varkappa k\Delta\xi$$

$$= \phi_a(\varkappa) + \frac{\Delta\xi}{\pi}\,\frac{1}{N}\sum_{j=1}^{N} e_j^2 \qquad (6)$$

$$= \phi_a(\varkappa) + \frac{19.61\ cm}{\pi}\,(3\ cm^2\text{-}sec^{-2})$$

The sources of error in the digitized velocity data have been discussed previously:

1. sensitivity of the current meter of $\pm 0.25\%$ of mean velocity corresponding to an error of ± 1 cm-sec^{-1}

2. analog to digital conversion rate resulting in an error of ± 1 cm-sec^{-1}

The total expected error, then, is of the order of ± 2 cm-sec^{-1}, which agrees well with the observed noise levels for the energy spectra.

B. <u>Statistical Variations Among Samples</u>. Figure 28 is a plot of the sample variance as a function of the estimated downstream distance, x', of the sample from the channel buoys. Because of the large amount of variation it was not possible to determine the change in variance with respect to x'. According to Batchelor (1) the change in variance is

$$\frac{\partial u^2}{\partial t} = -Au^3 \frac{\kappa_e}{2\pi} \tag{7}$$

where A is a number of the order of one and κ_e is the wave number at which the maximum in the energy spectrum is located. Applying the Taylor hypothesis this is

$$\frac{\partial u^2}{\partial x} = -\frac{A}{U} u^3 \frac{\kappa_e}{2\pi} \tag{8}$$

An order of magnitude estimate of the change in variance with respect to x' can be obtained from this. The average value for the variance for 34 samples is 55.6 cm^2-sec^{-2} ± 25.0 (standard error) (the variances from the third and fourth samples from run no. 4 and the first sample from run no. 7 were not included in the average since the values are excessively large, probably caused by non-linear motion of the boat) and from the energy spectra is 3.2×10^{-3} or less. Then

$$\frac{\partial u^2}{\partial x} \simeq \frac{(55.6)^{3/2}}{400} \frac{3.2 \times 10^{-3}}{5.28} = -5.3 \times 10^{-4} \text{ cm - sec}^{-2}$$

For a change in x' of 100 meters (the average sample length) the change in variance is about 8.3 cm^2-sec^{-2} which is not significant compared to the statistical variations among successive samples. The large variations are attributed to inhomogeneity of the field of turbulence, short sample lengths and non-linear variations in the towing velocity.

A more precise indication of the accuracy of the results is obtained from the energy spectra. A measure of the accuracy of any computed value of the energy spectrum is the equivalent number of degrees of freedom of the value (Blackman and Tukey, 17). The equivalent number of degrees of freedom is approximately given by

$$k = \frac{2(\text{sample length})}{\text{maximum lag}}$$

which for all of the samples is

$$k = \frac{2(500)}{50} = 20 \text{ degrees of freedom}$$

The distribution of computed values of the energy spectrum $\phi_{\partial m}(\kappa)$ obtained from a large number of similar samples having an equivalent number of degrees of freedom, k, is assumed to be equal to a Chi-Square distribution with k degrees of freedom. That is

$$\frac{k\,\phi_{\partial m}(\kappa)}{\phi(\kappa)} = \chi^2 \qquad (10)$$

where $\phi(\kappa)$ is the value of the energy spectrum function that would be obtained from a sample of infinite length. Using this assumption confidence limits can be assigned to the computed values of the energy spectrum function. From the tables in reference 18 values of χ^2 corresponding to the probabilities of occurrence of deviations greater than χ^2 can be found. For a probability of 0.10 of a deviation greater than χ^2, the value of χ^2 for 20 degrees of freedom is 28.412. Similarly, for a probability of 0.90 $\chi^2 = 12.443$. Thus the probability is 0.80 that the deviation from χ^2 is within the interval 12.443 to 28.412, or that

$$12.443 \leq \frac{k\,\varphi_{am}(\varkappa)}{\varphi(\varkappa)} \leq 28.412$$

for $k = 20$. Then we have 80% confidence that the correct value of the energy spectrum function is within the interval

$$\frac{\varphi_{am}(\varkappa)}{1.42} \leq \varphi(\varkappa) \leq \frac{\varphi_{am}(\varkappa)}{0.62}$$

or that

$$\log \varphi_{am}(\varkappa) - 0.152 \leq \log \varphi(\varkappa) \leq \log \varphi_{am}(\varkappa) + 0.208$$

The 80% confidence limits are indicated on the energy spectrum given in figure 26. The confidence limits for the other spectra are the same. Examination of the energy spectra indicates that the 80% confidence limits are reasonably correct.

The predominant characteristic of the spectra is the linear range (on a plot of $\log \varphi(\varkappa)$ as a function of $\log \varkappa$) extending from wave numbers of 0.01 cm^{-1} to 0.06 cm^{-1}. At larger wave numbers the computed values of $\varphi_{am}(\varkappa)$ are subject to large error because of the relatively high noise level. Since any actual variations among the spectra are considered negligible with respect to statistical variations, a composite spectrum was formed from the individual spectra:

$$\bar{\varphi}'_{am}(\varkappa) = \frac{1}{37}\sum_{i=1}^{37} \varphi'_{i\,am}(\varkappa)\ ;\ \varphi'_{am}(\varkappa) = \frac{\varphi_{i\,am}(\varkappa)}{R_{i\,m}(0)} \qquad (11)$$

to determine more certainly the existance of the linear range. The composite spectrum is shown in figure 32. The effective sample length is 37 times longer than that of the individual samples and the equivalent number of degrees of freedom is 740. The 80% confidence limits are indicated on the spectrum. Several of the individual spectra display secondary maxima at wave numbers ranging from 0.02 cm^{-1} to 0.03 cm^{-1}. This feature, however, is not apparent on the composite spectrum so no significance is attached to it.

If the approximate noise level, as estimated from the composite spectrum, is taken as

$$\frac{19.61}{\pi}\frac{1}{500}\sum_{j=1}^{500} e_j^2 \simeq 30\ cm^3\text{-}sec^{-2}$$

and a noise correction applied to the composite spectrum, the result is as shown in figure 33. Within the range of wave numbers from $\varkappa = 0.01\ cm^{-1}$ to $\varkappa = 0.026\ cm^{-1}$ the composite spectrum is of the expected form, viz.

$$\bar{\varphi}'_{\partial m}(\varkappa) \sim \varkappa^{-5/3}$$

For wave numbers greater than $\varkappa = 0.026\ cm^{-1}$ $\bar{\varphi}'_{\partial m}(\varkappa)$ decreases more rapidly with increasing wave number than $\varkappa^{-5/3}$ which reflects attenuation of the higher wave number variations in velocity because of the size of the current meter. At $\varkappa = 0.0353\ cm^{-1}$ $\bar{\varphi}'_{\partial m}(\varkappa)$ is 3 db below the $-5/3 \log \varkappa$ line.

The necessary condition for the existance of the inertial subrange can be stated precisely as (Batchelor, 1)

$$\left(\frac{u\ell}{\nu}\right)^{3/8} \gg 1 \qquad (12)$$

where u is the RMS value of the turbulent velocity and ℓ is the length corresponding to the wave number at which the maximum in the energy spectrum is located.

Using the values obtained herein:

$$u \simeq 7.5 \text{ cm-sec}^{-1}$$

$$\ell \geq 2.0 \times 10^3 \text{ cm}$$

$$\nu = 0.15 \text{ cm}^2\text{-sec}^{-1}$$

this is

$$\left(\frac{u\ell}{\nu}\right)^{3/8} = 74.7,$$

a value sufficiently large that the condition (12) is probably satisfied.

Values of the energy spectrum were not obtained at wave numbers large enough to allow calculation of the dissipation spectrum $\kappa^2 \phi_{am}(\kappa)$ and subsequently the rate of energy dissipation by viscosity

$$\epsilon = 30\,\nu^2 \int_0^\infty \kappa^2 \phi_{am}(\kappa)\,d\kappa$$

since dissipation occurs at wave numbers of the order of 10 cm^{-1} (Grant, Stewart and Moilliet, 2). Regardless, if the Kolmogoroff hypothesis is assumed, an estimate of the average value of ϵ can be obtained from the spectra using

$$\frac{1}{37}\sum_{i=1}^{37} R_{im}(0)\,\phi'_{iam}(\kappa) = \bar{\phi}_{am}(\kappa) = K'\,\epsilon^{-2/3}\,\kappa^{-5/3} \qquad (13)$$

At $\kappa = 0.01 \text{ cm}^{-1}$ the average value of the computed energy spectra is

$$\bar{\phi}_{am}(\kappa) = 9.15 \times 10^2 \text{ cm}^3\text{-sec}^{-2}$$

It is necessary to have a value for the universal constant K'. If the value obtained by Grant, et al (2) is used then the average value of K' is 0.47 ± 0.02 (standard error). Substituting this value along with the average value of $\bar{\phi}_{am}(\kappa)$ into equation (13),

$$\bar{\epsilon} = \left[\frac{9.15 \times 10^2}{(0.47)(2.2 \times 10^3)}\right]^{3/2} = 0.840 \text{ cm}^2\text{-sec}^{-3}$$

The result is of the same order of magnitude as the values reported in reference 2. No attempt has been made to determine ϵ for the individual spectra because of the statistical variations. The individual spectra would, in general, yield different values of ϵ ; because of inhomogeneity of the field of turbulence ϵ is a function of position as well as time.

Conclusions

1. The ducted impeller current meter, with a constant wave number response of from 0 cm^{-1} to 0.0353 cm^{-1}, is a practical instrument for measuring oceanographic turbulence. The high wave number response is limited by the dimensions of the current meter instead of the response distance (also constant), measured as 0.75 cm. The data obtained from the instrument is approximately equally spaced at intervals of 19.61 cm, resulting in a Nyquist wave number of 0.157 cm^{-1}; the sampling process further attenuates velocity variations at wave numbers greater than the Nyquist wave number. Since the Nyquist wave number is greater than the highest wave number at which the current meter is responsive to velocity variations by a factor of four, aliasing is negligible.

2. The average sample variance is 55.6 cm^2-sec^{-2} $\pm$ 25.0 (standard error). Superficial comparison of the distribution of the values of the energy spectra with the expected Chi-Square distribution, however, indicated that the variation is statistical. The variation is attributed primarily to short sample lengths and inhomogeneity of the field of turbulence.

3. The composite energy spectrum is of the form predicted by the Kolmogoroff hypothesis within the range of wave numbers from 0.01 cm^{-1} to 0.026 cm^{-1}; at wave numbers greater than 0.026 cm^{-1} the energy spectrum decreases more rapidly

than predicted because of attenuation of the higher wave number velocity variations. At wave numbers less than 0.01 cm^{-1} the turbulence is assumed anisotropic and inhomogeneous. The maxima in the individual energy spectra are located at wave numbers less than 0.003 cm^{-1}.

4. The average rate of energy dissipation by viscosity is estimated as 0.84 cm^2-sec^{-3}.

5. The energy spectra are subject to a high noise level - of the order of 20 cm^3-sec^{-2} - resulting from random error in the digitized velocity data. The sources of error are an insufficiently high analog to digital conversion rate and insufficient sensitivity of the current meter combined with a large towing velocity compared to the variations in velocity.

Planned Research

Two much improved versions of the ducted impeller current meter are presently being considered for making additional turbulence measurements. The first is a Braincon Corporation Type 430 Ducted Impeller Current Meter, shown in figures 31 and 32. It is similar to the current meter used herein except that it is manufactured of type 316 stainless steel instead of brass, has a lighter weight impeller resulting in a smaller response distance, and has improved bearings and hence increased sensitivity. The Type 430 current meter has approximately the same dimensions as the current meter used herein and thus the high wave number response is similarly limited; the estimated useful wave number range is from 0 cm^{-1} to 0.04 cm^{-1}. The primary advantage of the Type 430 current meter is its sensitivity which is expected to result in a very low noise level.

The second version is a Cox Instruments Model 12-SCRX turbine flow meter which has been modified by machining the pipe threads from the body (figures 33 and 34). The modified flow meter is 1.8 cm dia and 8.3 cm long. The advantages of the Cox unit are its small size, sensitivity (0.1% of mean flow) and simple disassembly for ball bearing replacement. The estimated wave number response range is 0 cm^{-1} to 0.1 cm^{-1}.

It is intended to mount the instruments on 2 ft Braincon "V"-Fins and to tow the instruments at different depths in the Cape Cod Canal against the 4 knot tidal current existing there. Measurements are also planned for the open ocean. It is expected that much longer samples can be obtained than for the measurements described herein.

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Figure 1. 3/4 View of Current Meter

Figure 2. End View of Current Meter

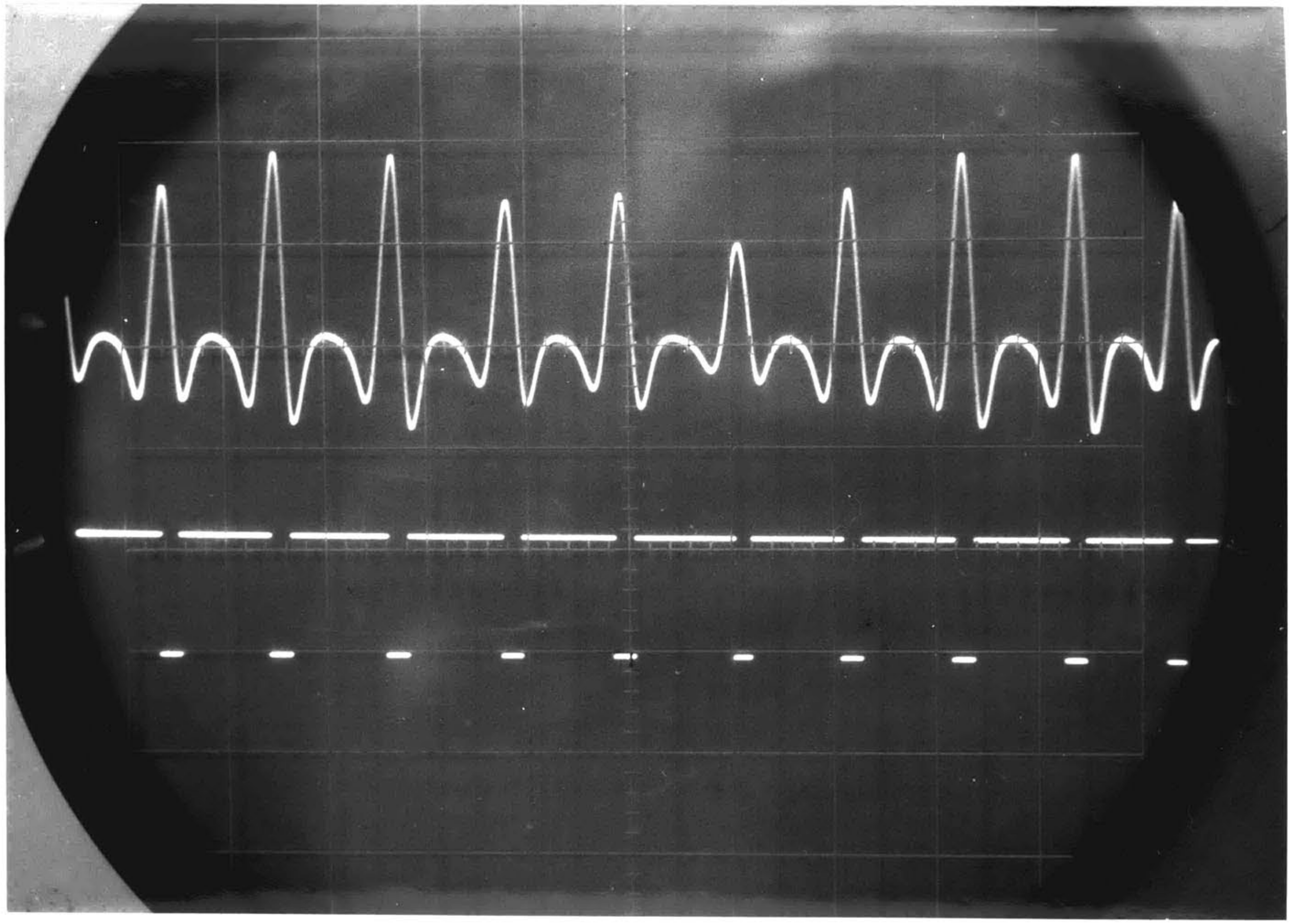


Figure 3. Output of Current Meter (upper trace); Output of Schmidt Trigger (lower trace)

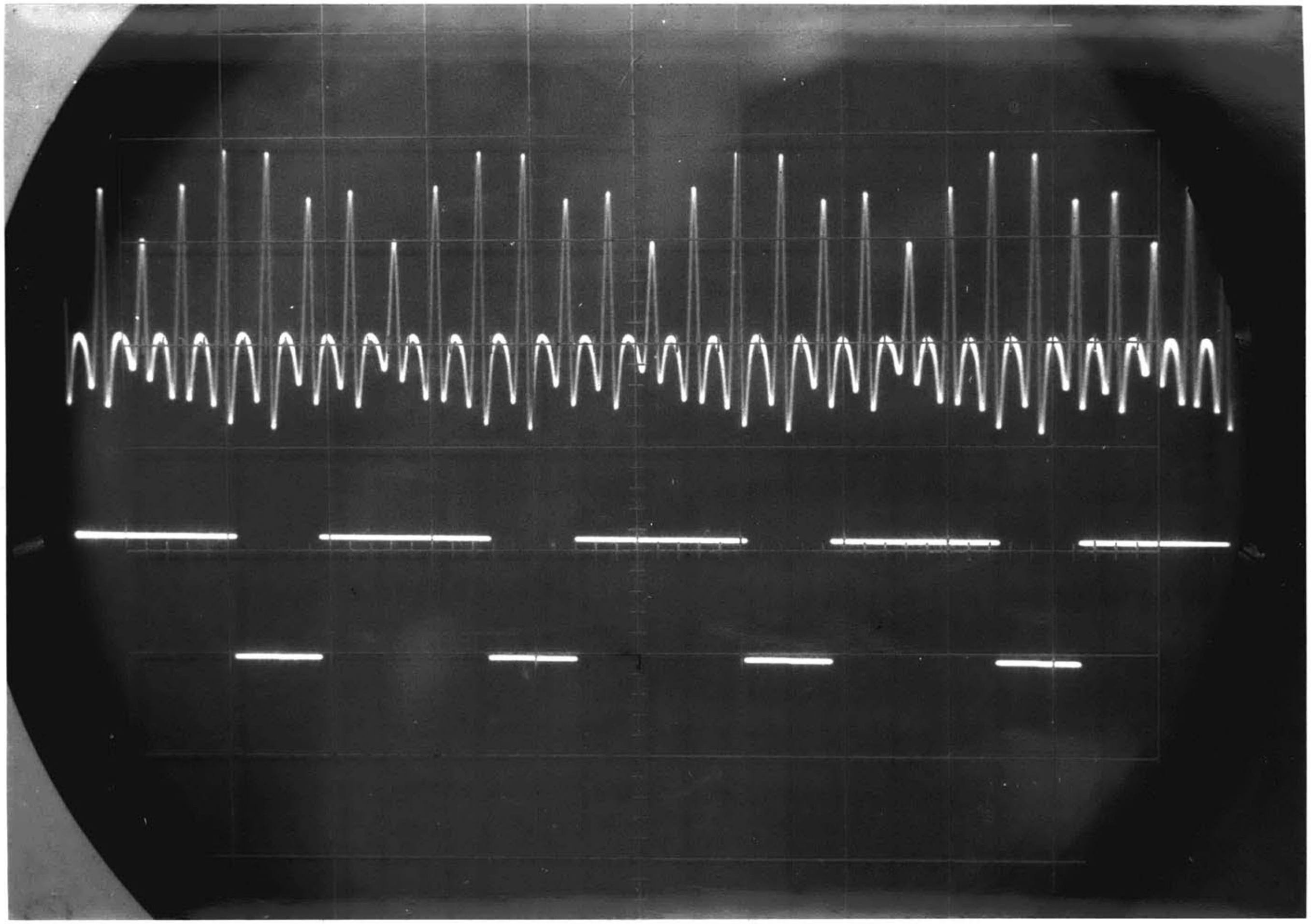


Figure 4. Output of Current Meter (upper trace); Output of Binomial Counter (lower trace)

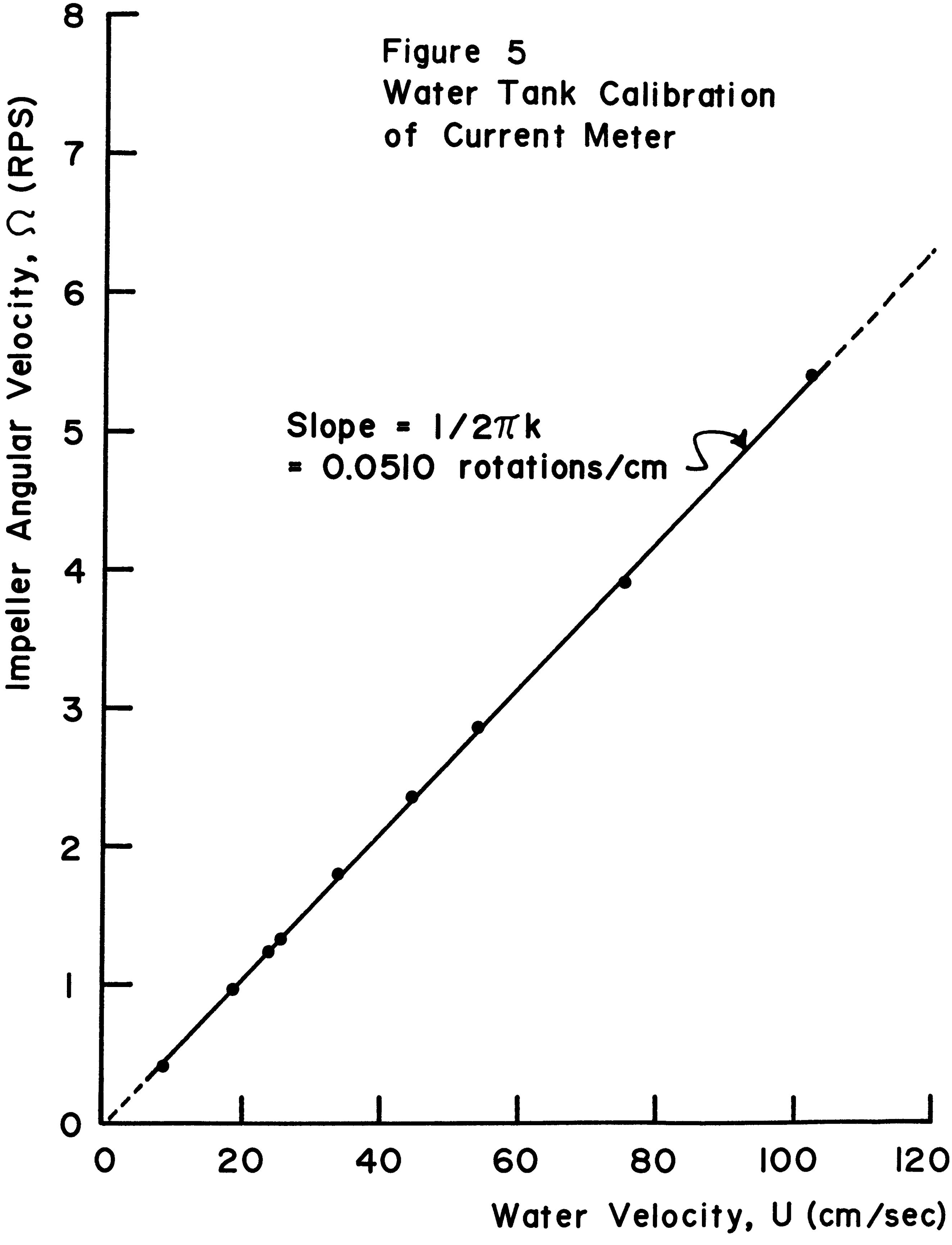
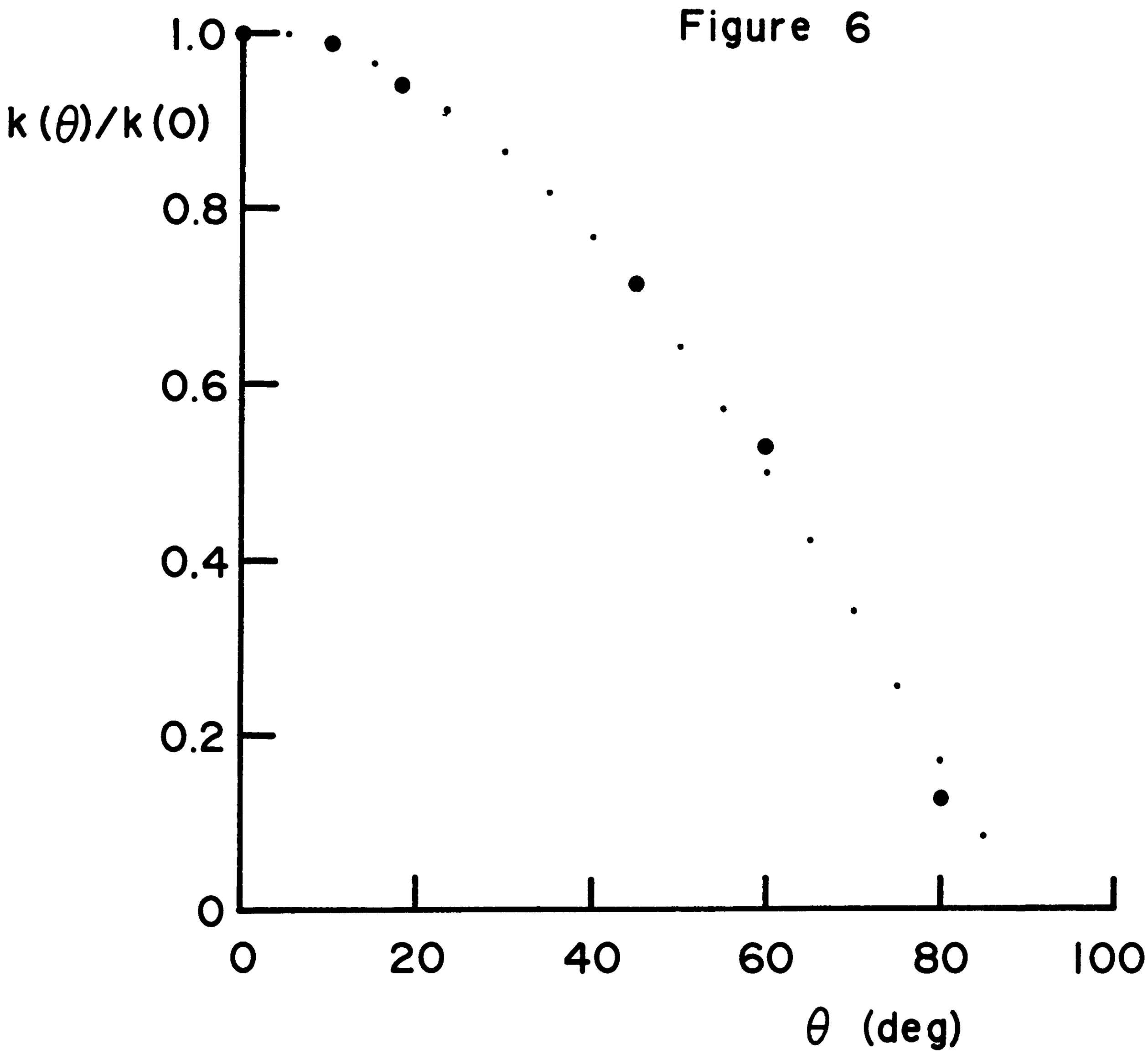


Figure 5
Water Tank Calibration
of Current Meter
Slope = 1/2πk
= 0.0510 rotations/cm
Impeller Angular Velocity, Ω (RPS)
Water Velocity, U (cm/sec)
0
1
2
3
4
5
6
7
8
0
20
40
60
80
100
120



Variation of Calibration Coefficient with Angle between Current Meter Axis and Flow Direction (• = measured values; · · · = cosine θ)

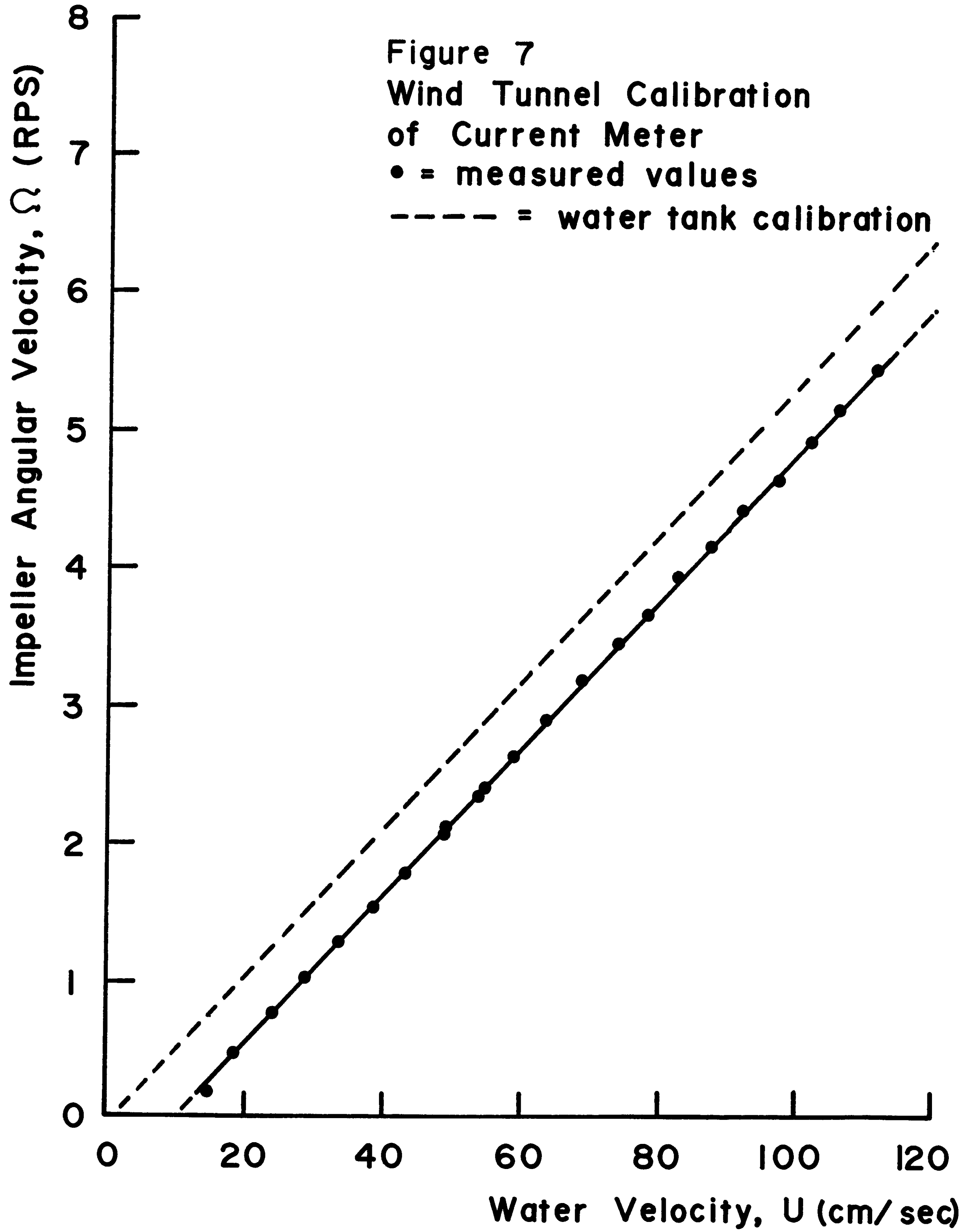


Figure 7
Wind Tunnel Calibration
of Current Meter
• = measured values
---- = water tank calibration
Impeller Angular Velocity, Ω (RPS)
0
1
2
3
4
5
6
7
8
0
20
40
60
80
100
120
Water Velocity, U (cm/sec)

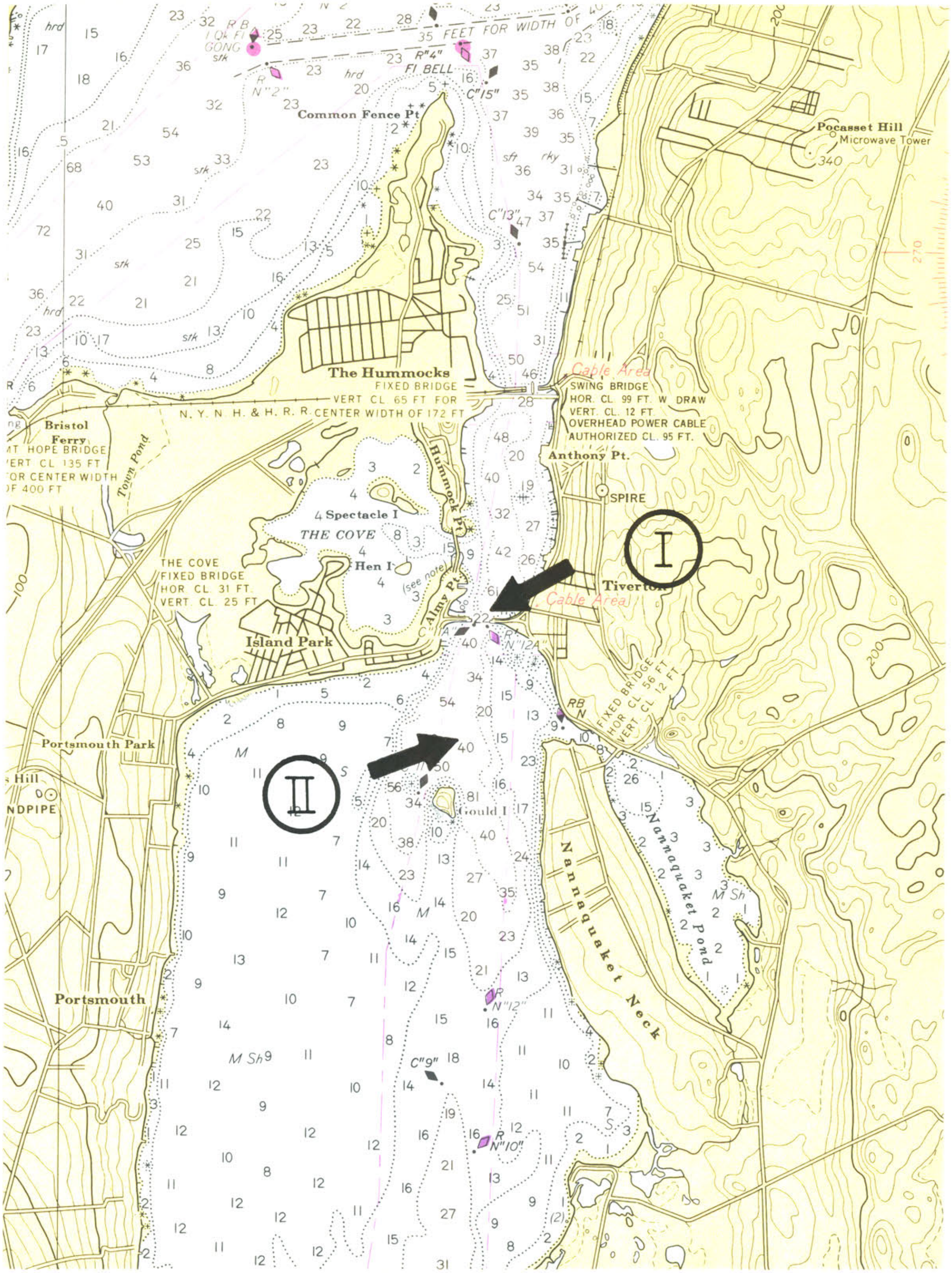


Figure 8. Section of C. and G. S. Chart 353 Scale = 1:40,000; Soundings in Feet at Mean Low Water

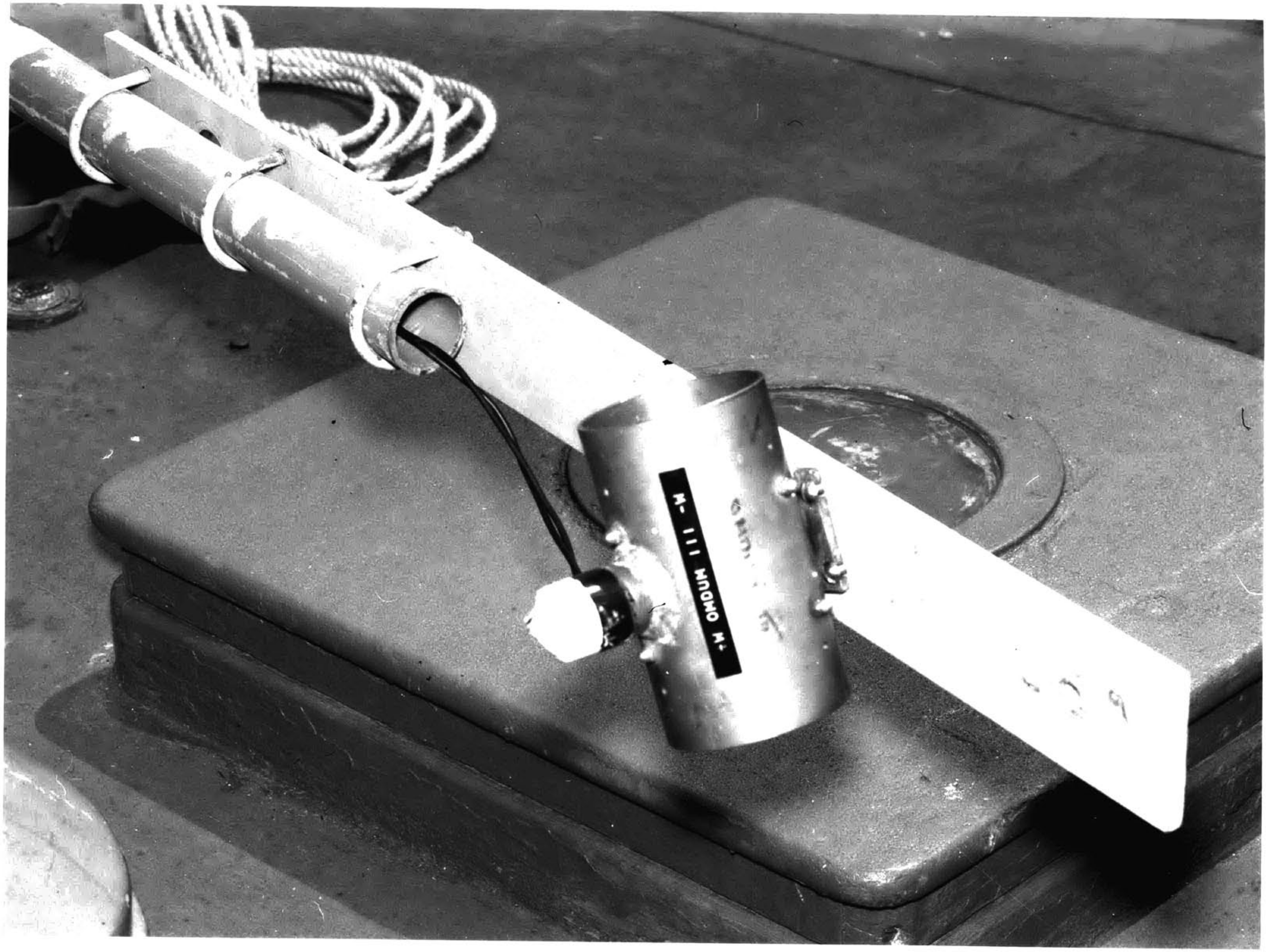
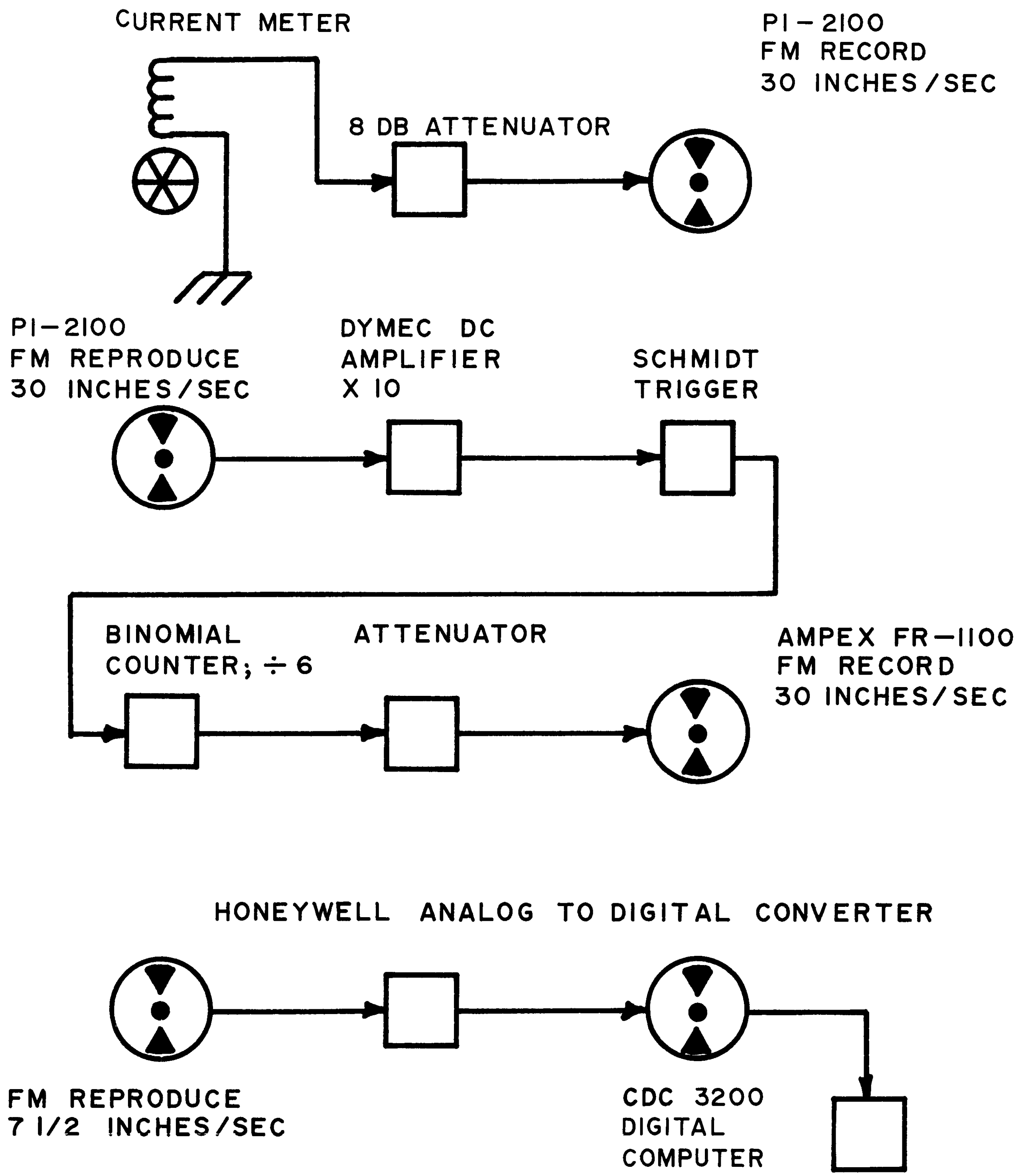


Figure 9. Current Meter Mounted on Lower End of Strut

Figure 10. Strut, with Current Meter, Mounted on Bow of Boat

Figure 11. NUWS Torpedo Retriever



BLOCK DIAGRAM OF DATA CONVERSION PROCEDURE

Figure 12

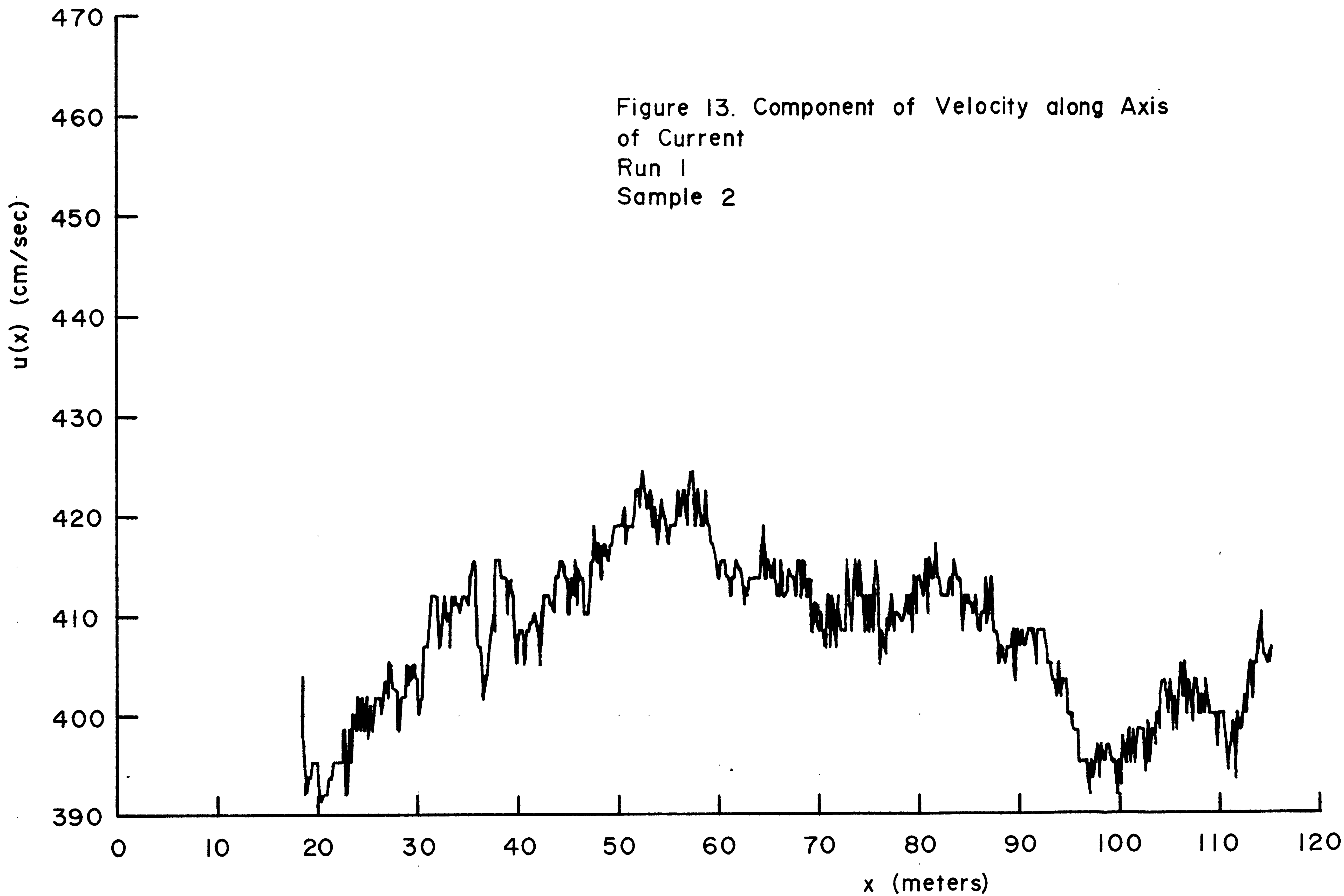


Figure 13. Component of Velocity along Axis of Current
Run 1
Sample 2

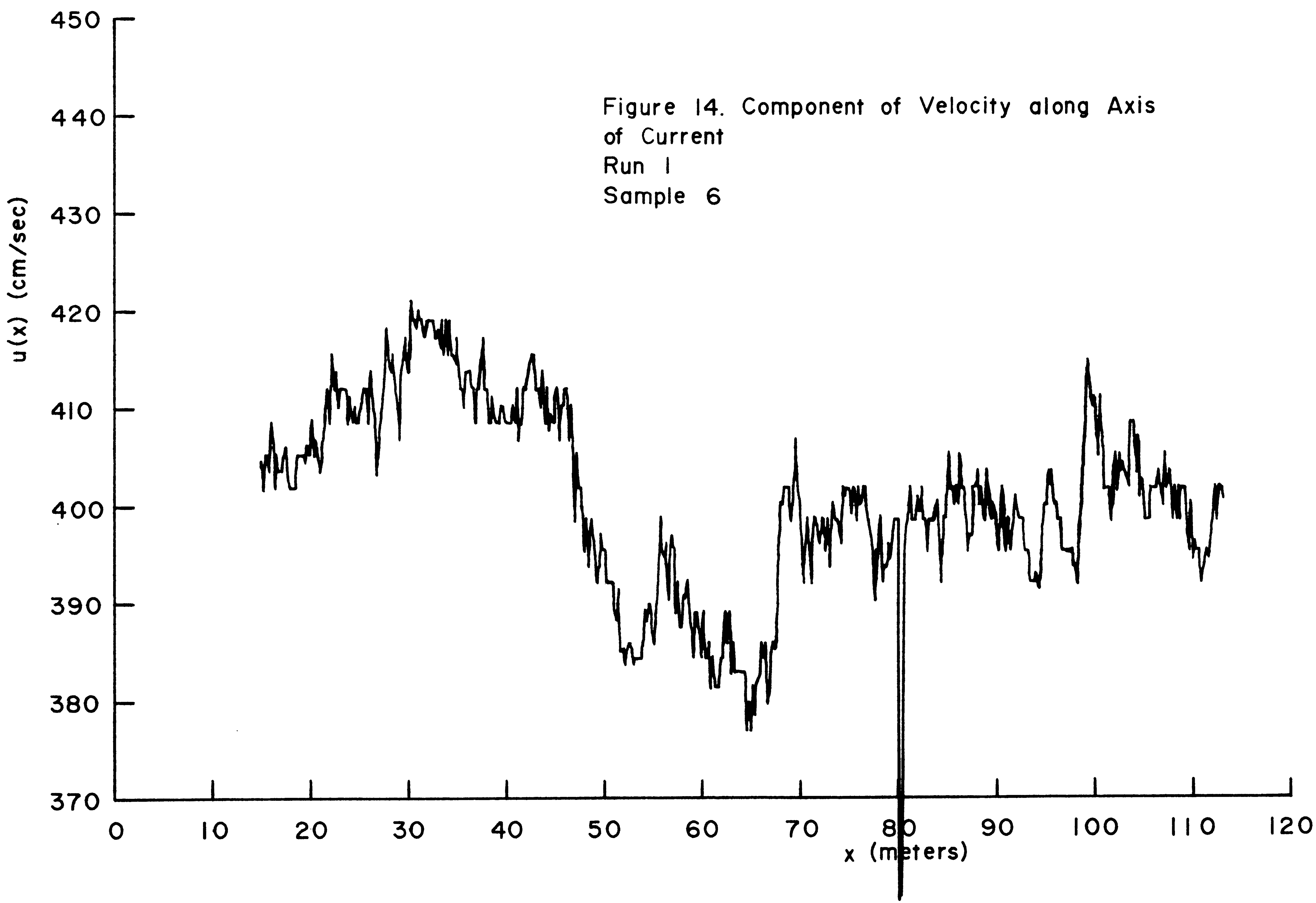


Figure 14. Component of Velocity along Axis of Current
Run 1
Sample 6

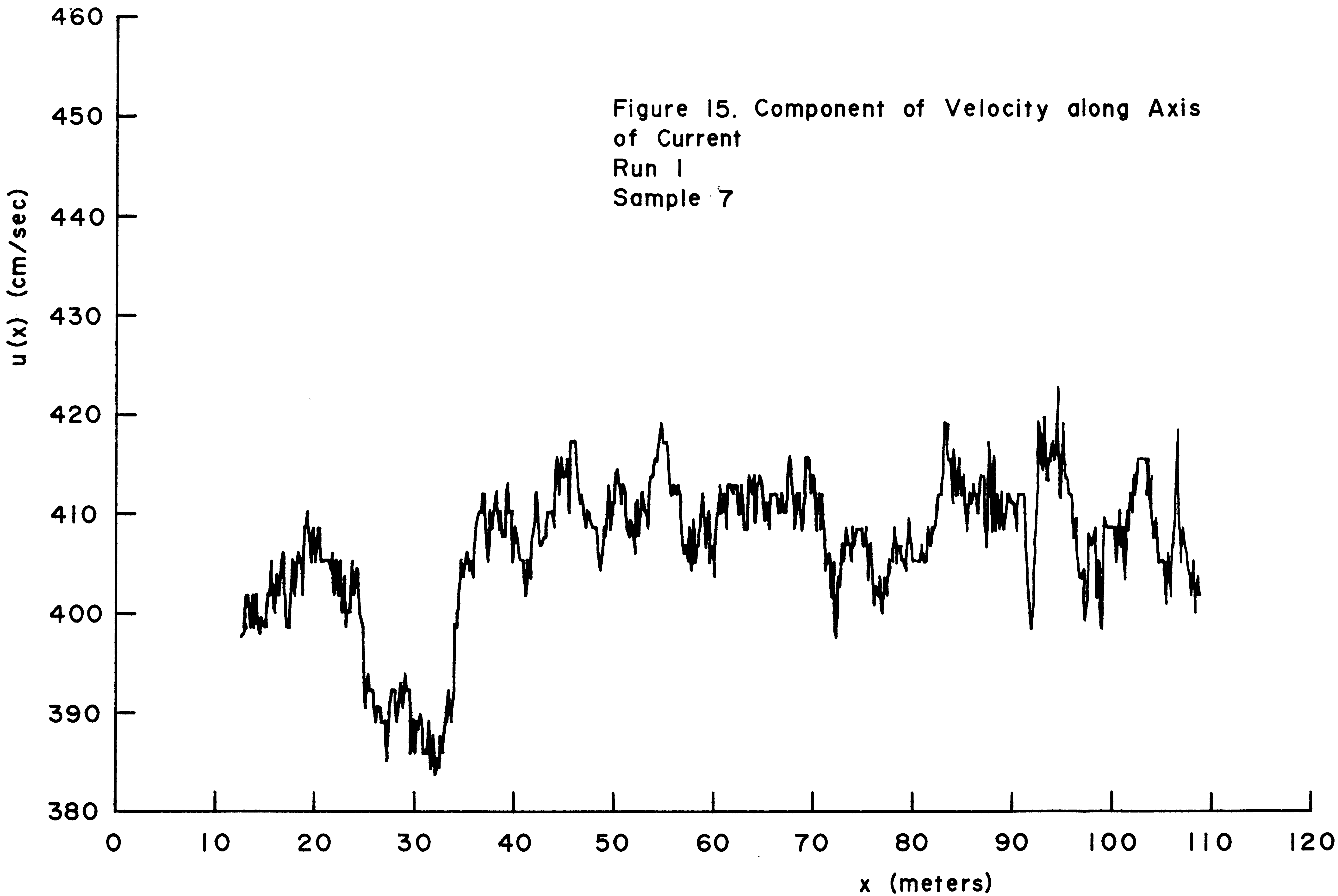


Figure 15. Component of Velocity along Axis of Current
Run 1
Sample 7

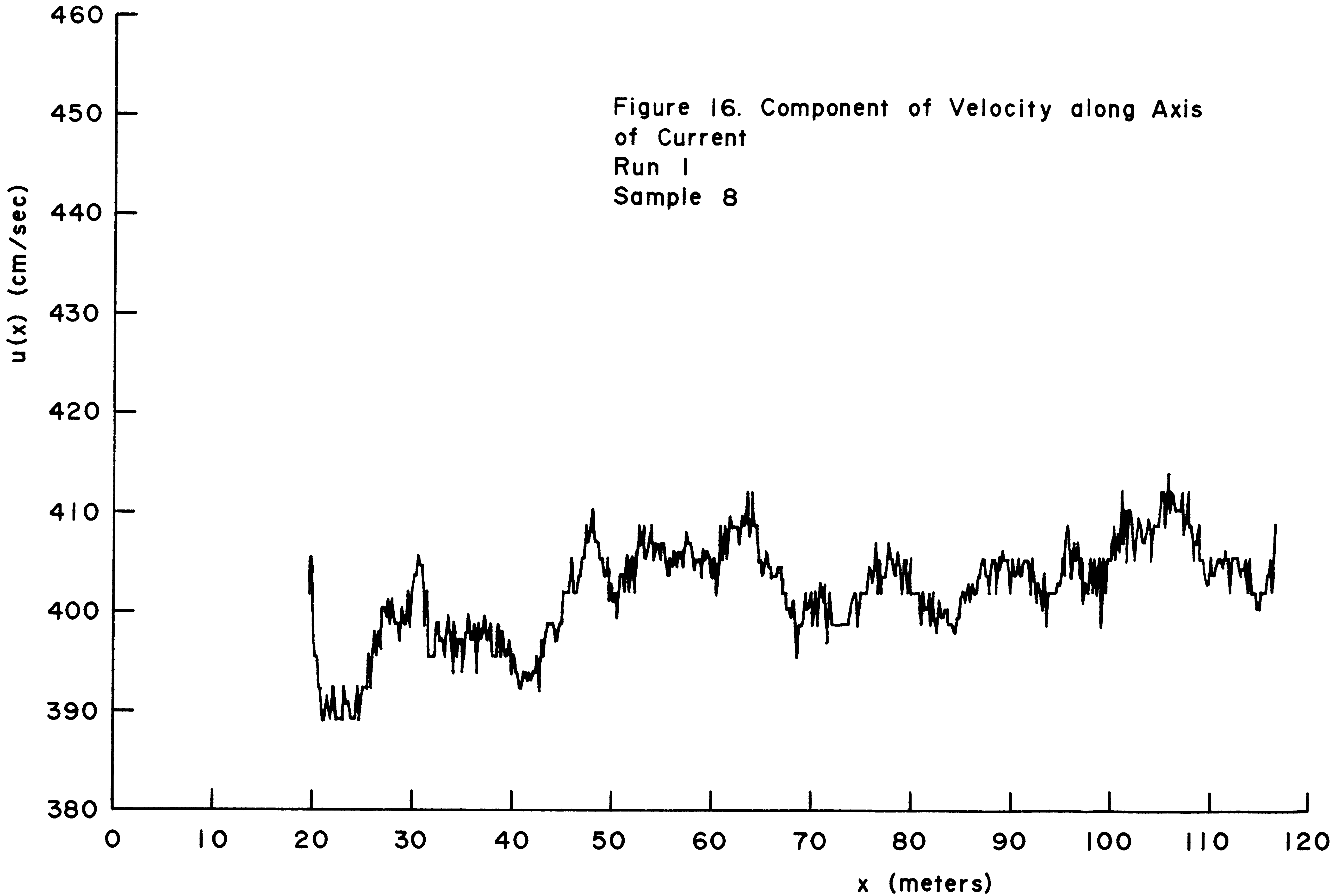


Figure 16. Component of Velocity along Axis of Current
Run 1
Sample 8

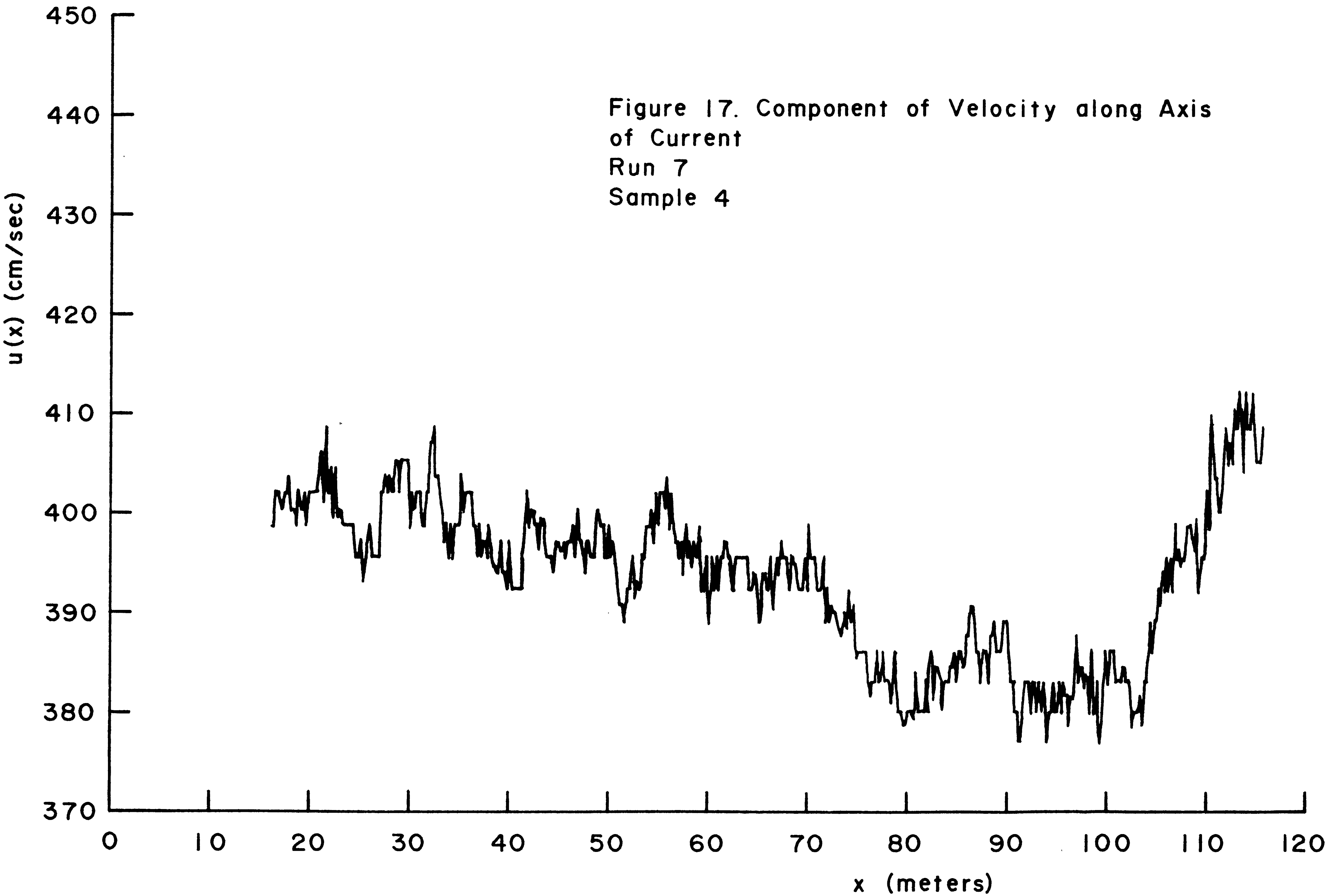


Figure 17. Component of Velocity along Axis of Current
Run 7
Sample 4

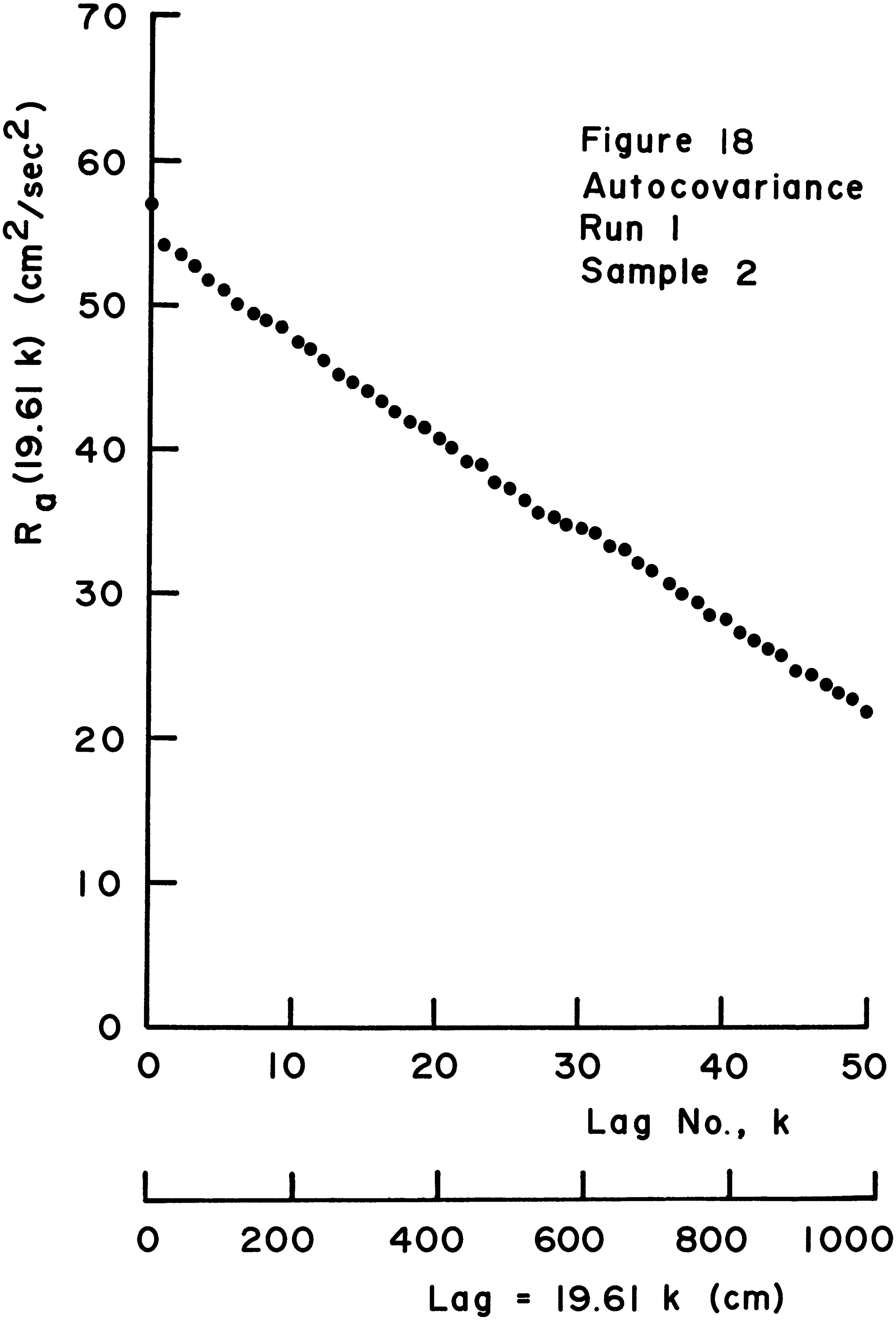


Figure 18
Autocovariance
Run 1
Sample 2

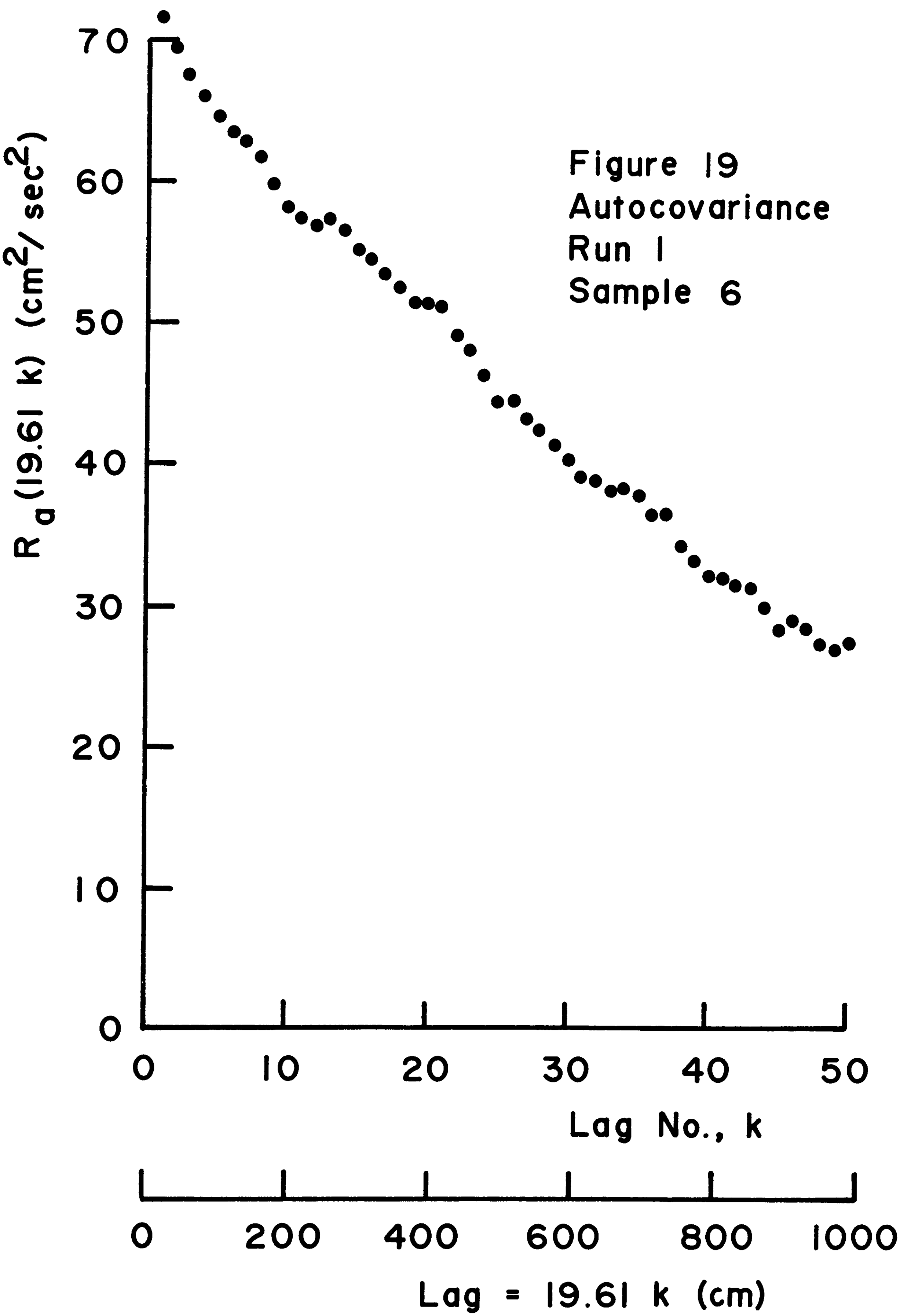
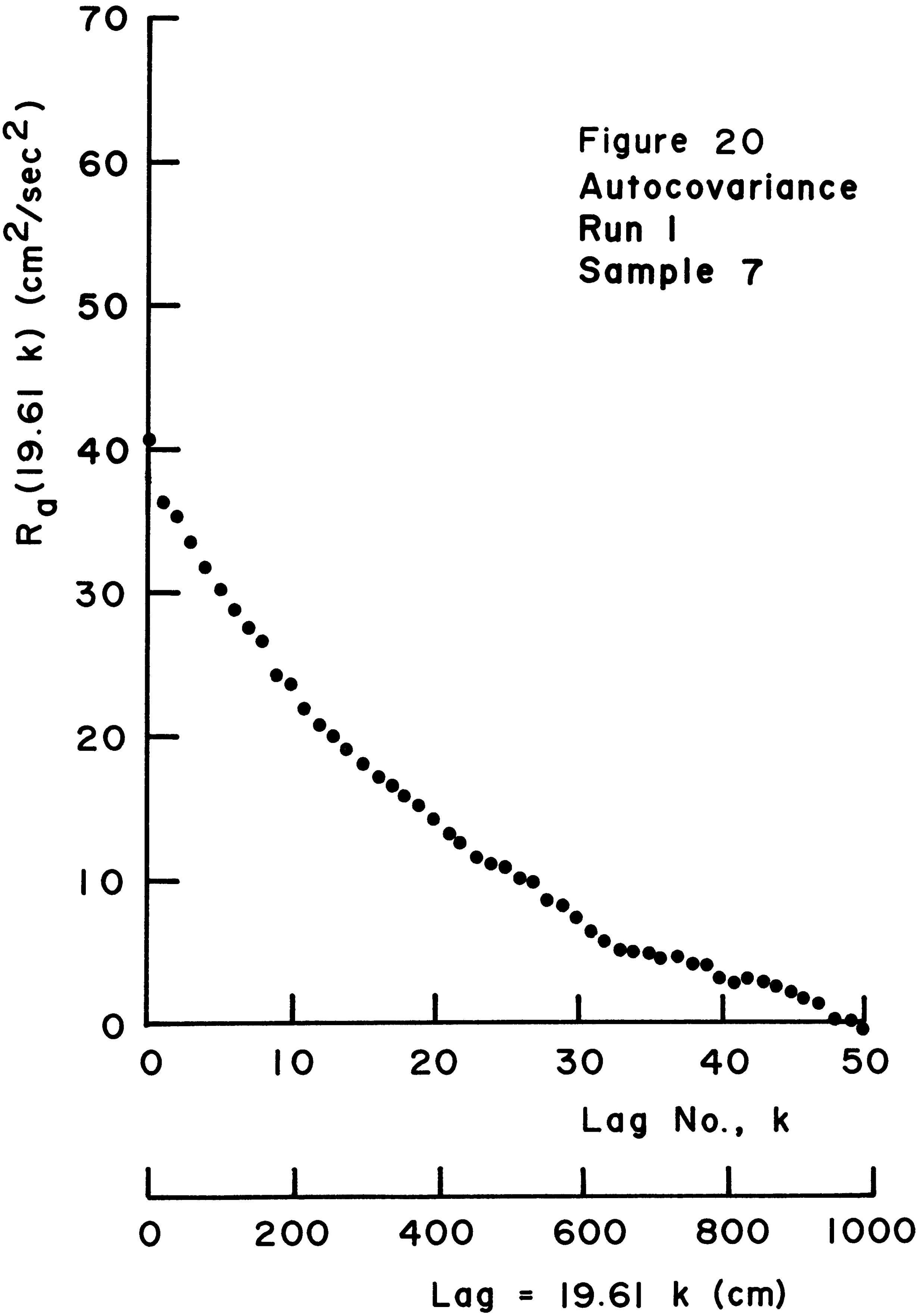


Figure 19
Autocovariance
Run 1
Sample 6
$R_a(19.61\ k)$ (cm^2/sec^2)
70
60
50
40
30
20
10
0
0
10
20
30
40
50
Lag No., k
0
200
400
600
800
1000
Lag = 19.61 k (cm)



70
60
50
40
30
20
10
0
R_a(19.61 k) (cm²/sec²)
Figure 20
Autocovariance
Run 1
Sample 7
0
10
20
30
40
50
Lag No., k
0
200
400
600
800
1000
Lag = 19.61 k (cm)

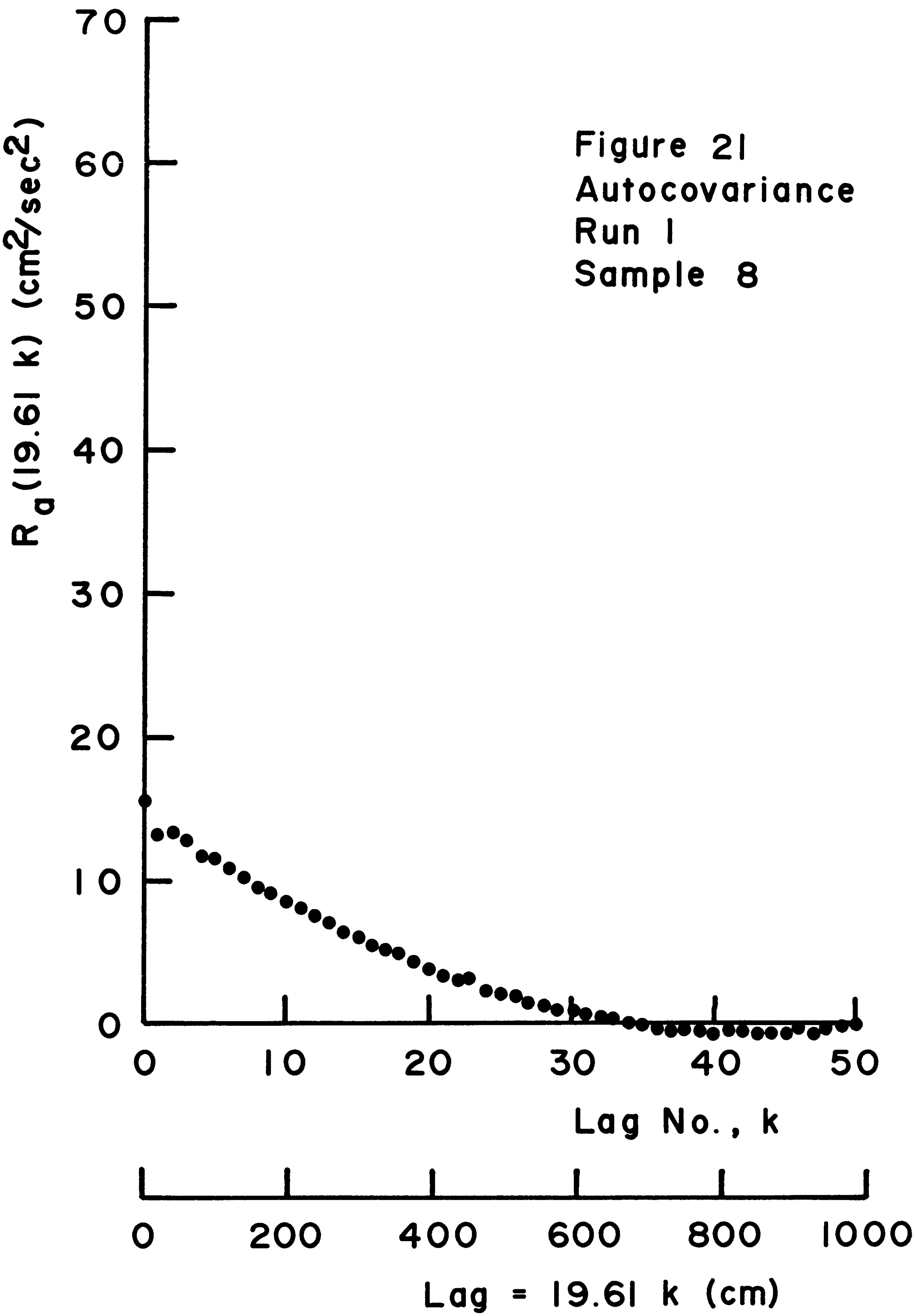


Figure 21
Autocovariance
Run 1
Sample 8

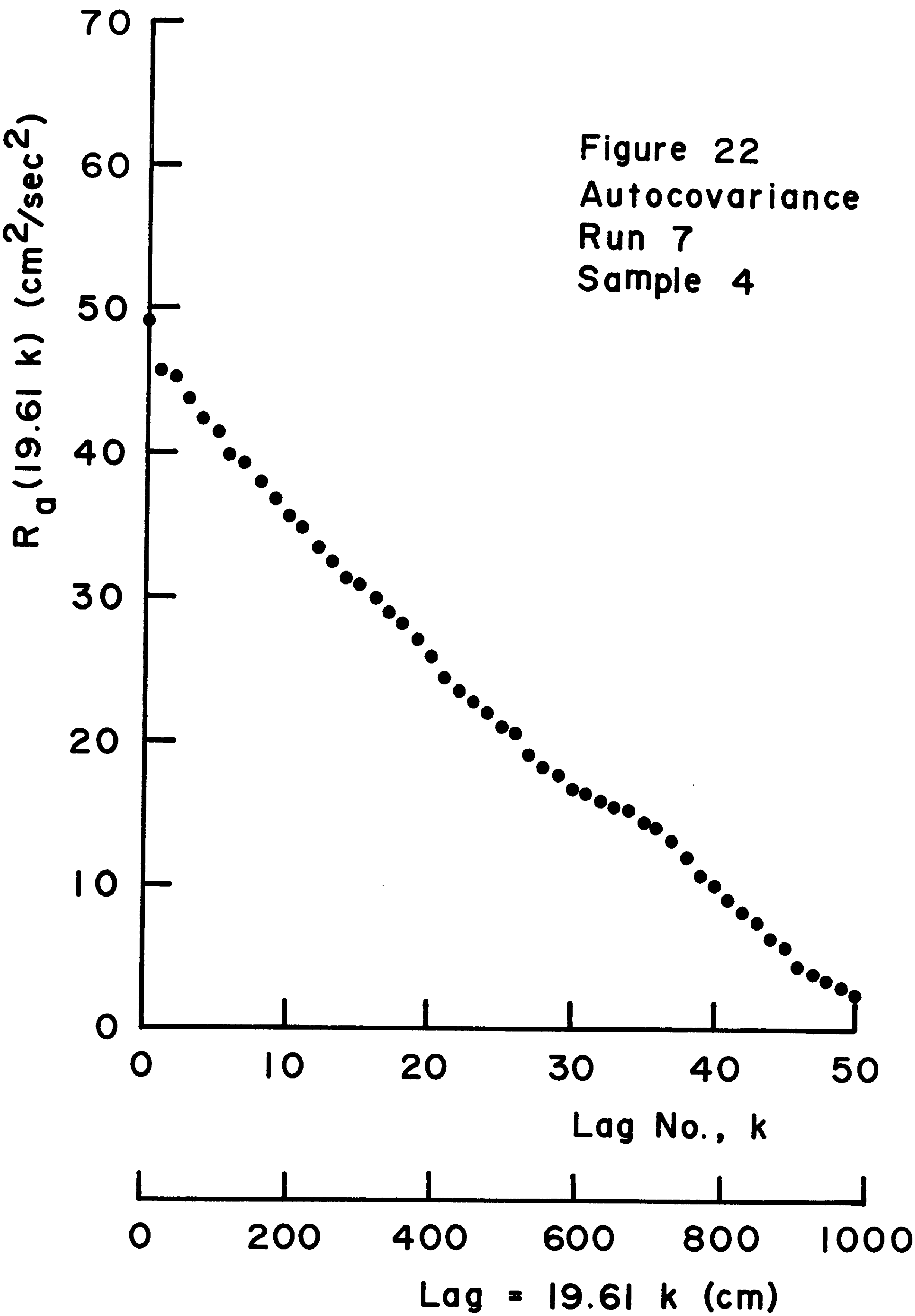


Figure 22
Autocovariance
Run 7
Sample 4
$R_a(19.61\,k)$ (cm^2/sec^2)
70
60
50
40
30
20
10
0
0
10
20
30
40
50
Lag No., k
0
200
400
600
800
1000
Lag = 19.61 k (cm)

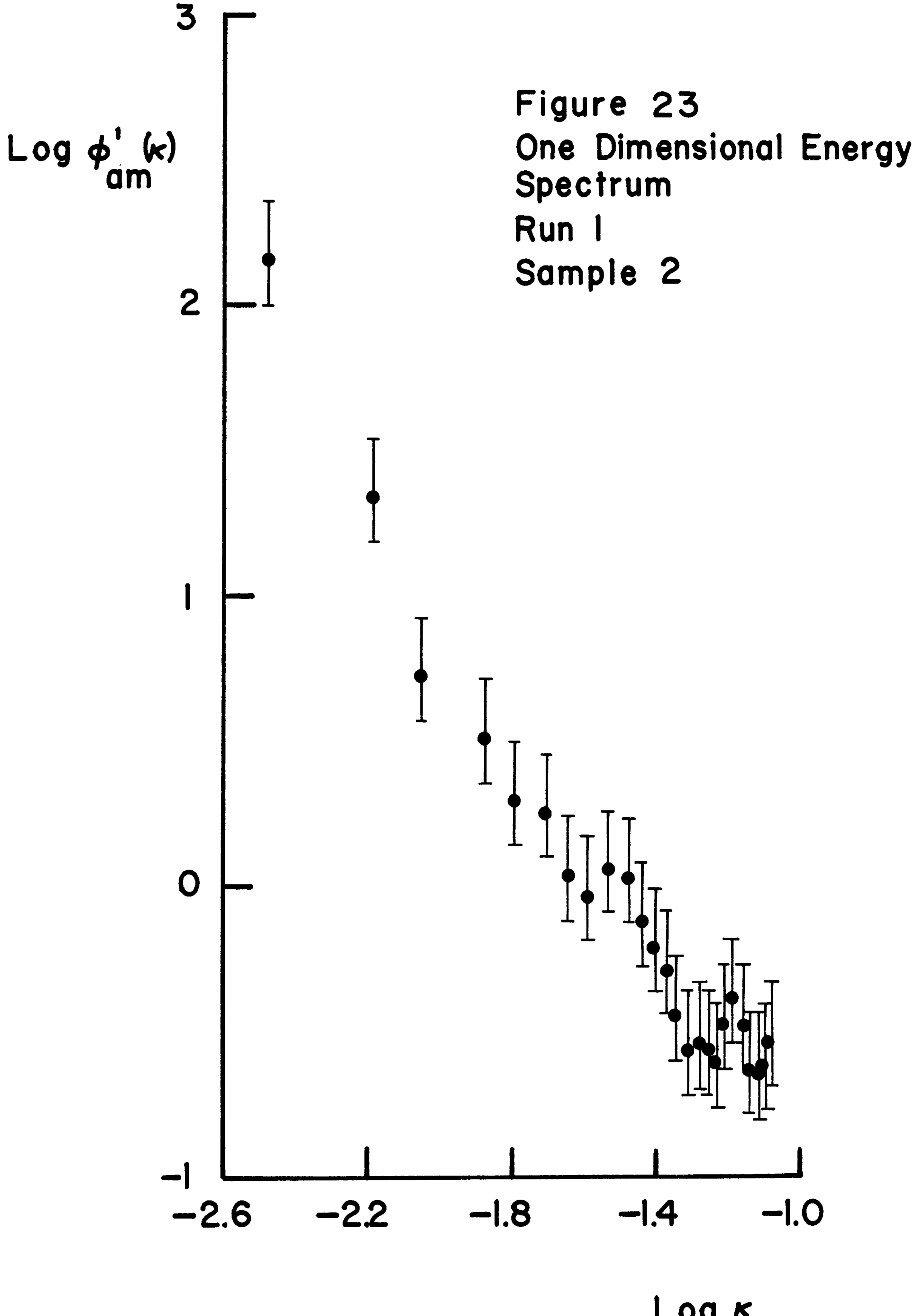


Figure 23
One Dimensional Energy Spectrum
Run I
Sample 2
Log $\phi'_{am}(\kappa)$
3
2
1
0
-1
-2.6
-2.2
-1.8
-1.4
-1.0
Log κ

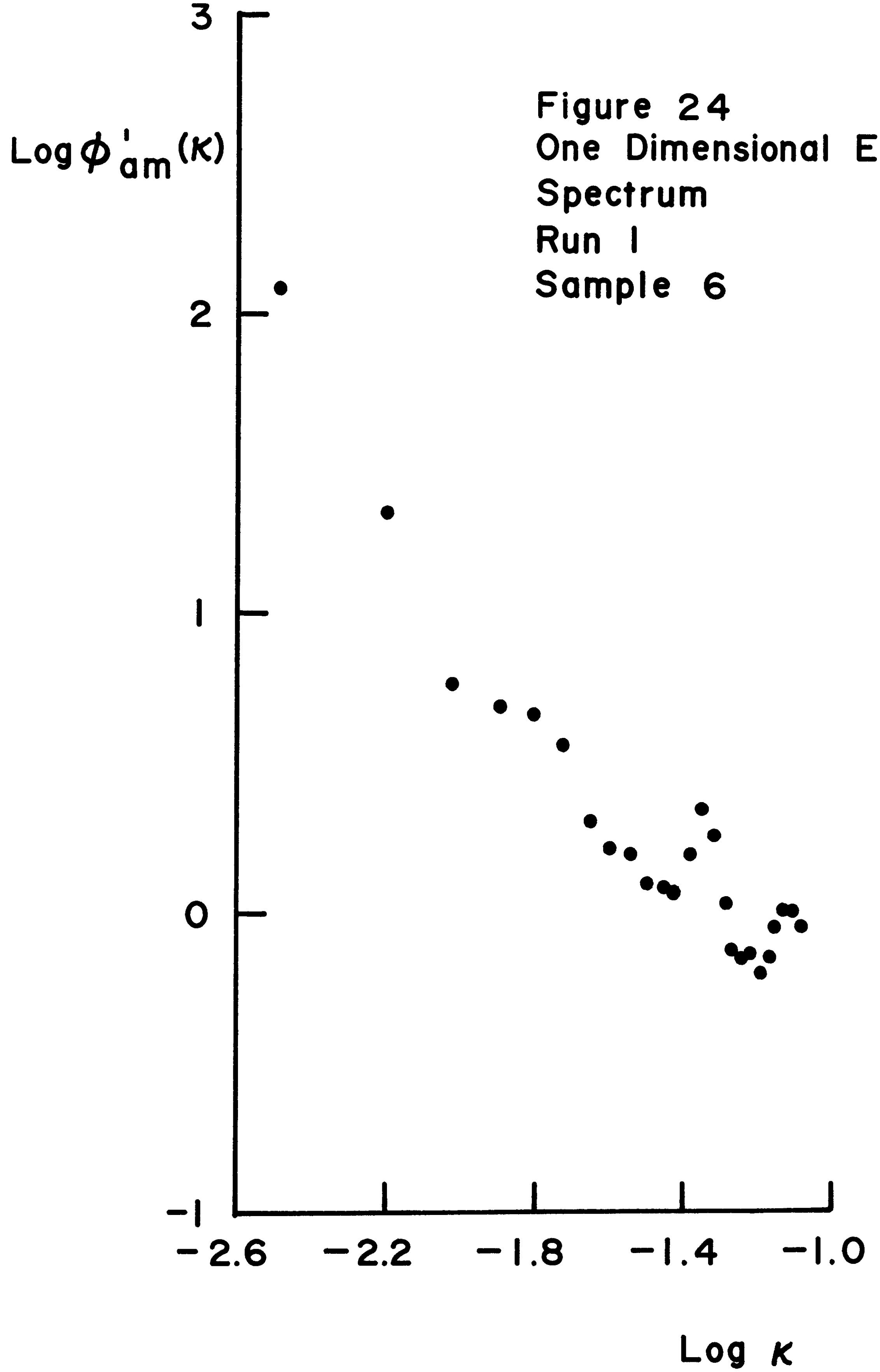


Figure 24
One Dimensional Energy Spectrum
Run 1
Sample 6

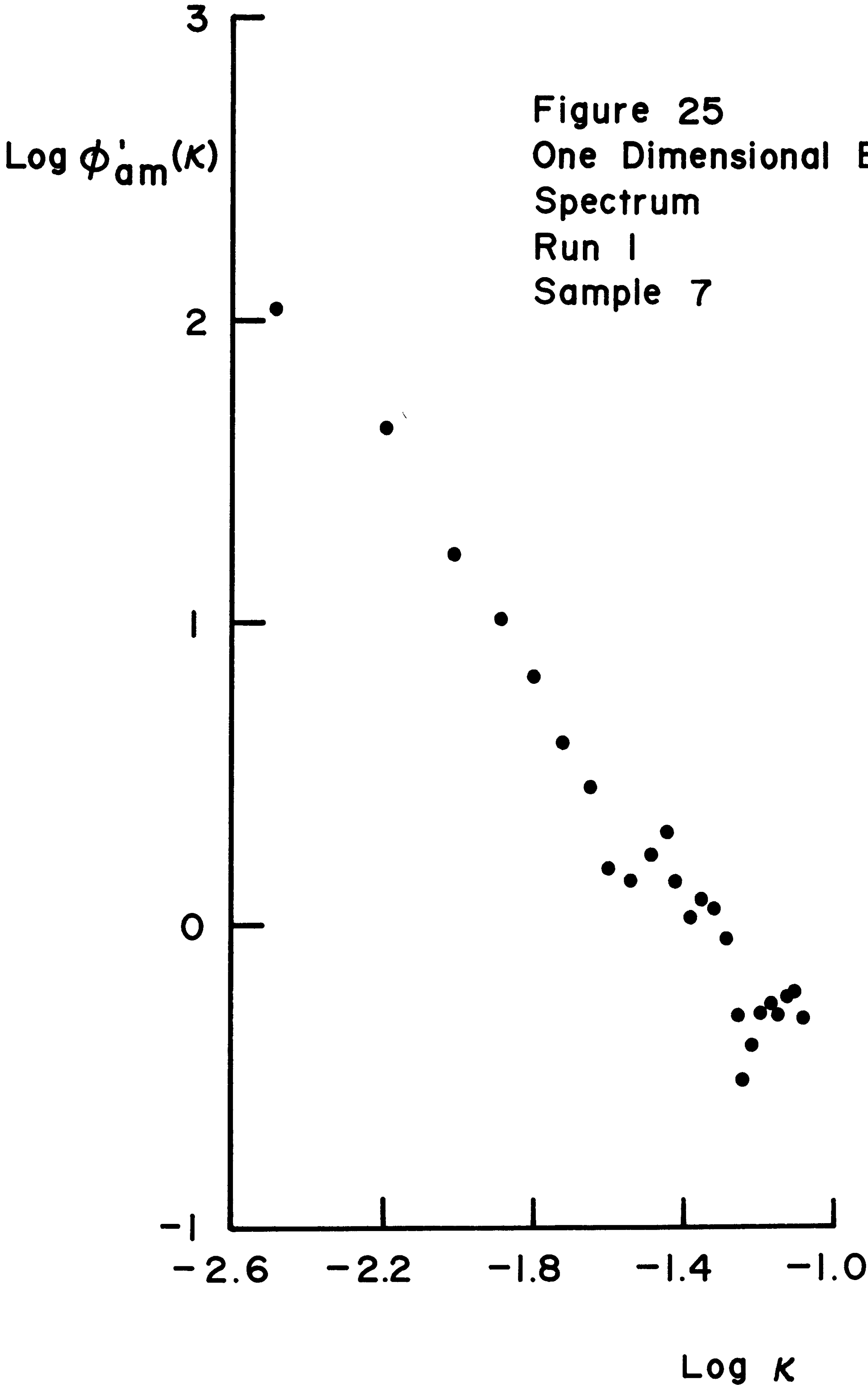


Figure 25
One Dimensional Energy Spectrum
Run 1
Sample 7

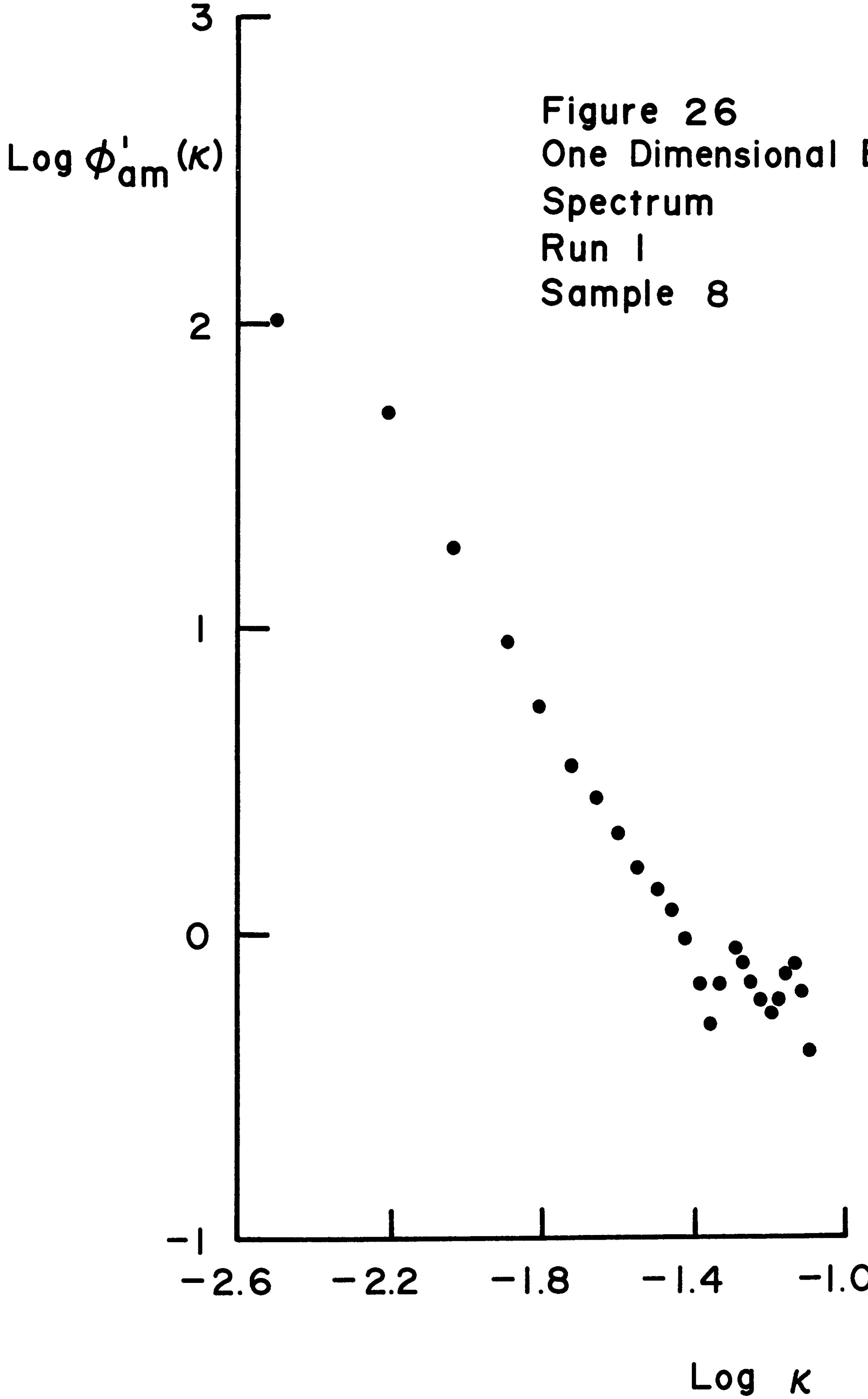


Figure 26
One Dimensional Energy
Spectrum
Run 1
Sample 8

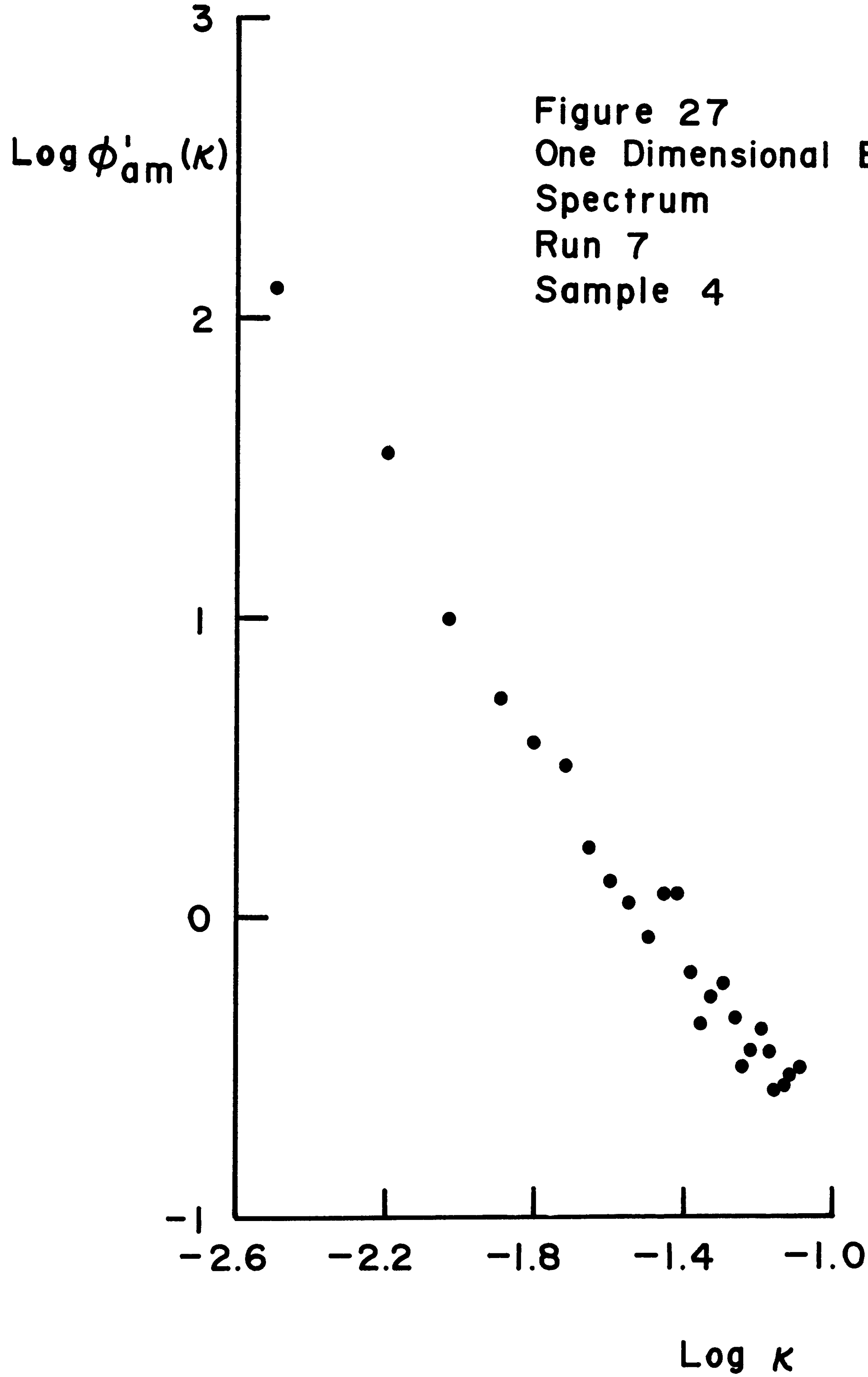
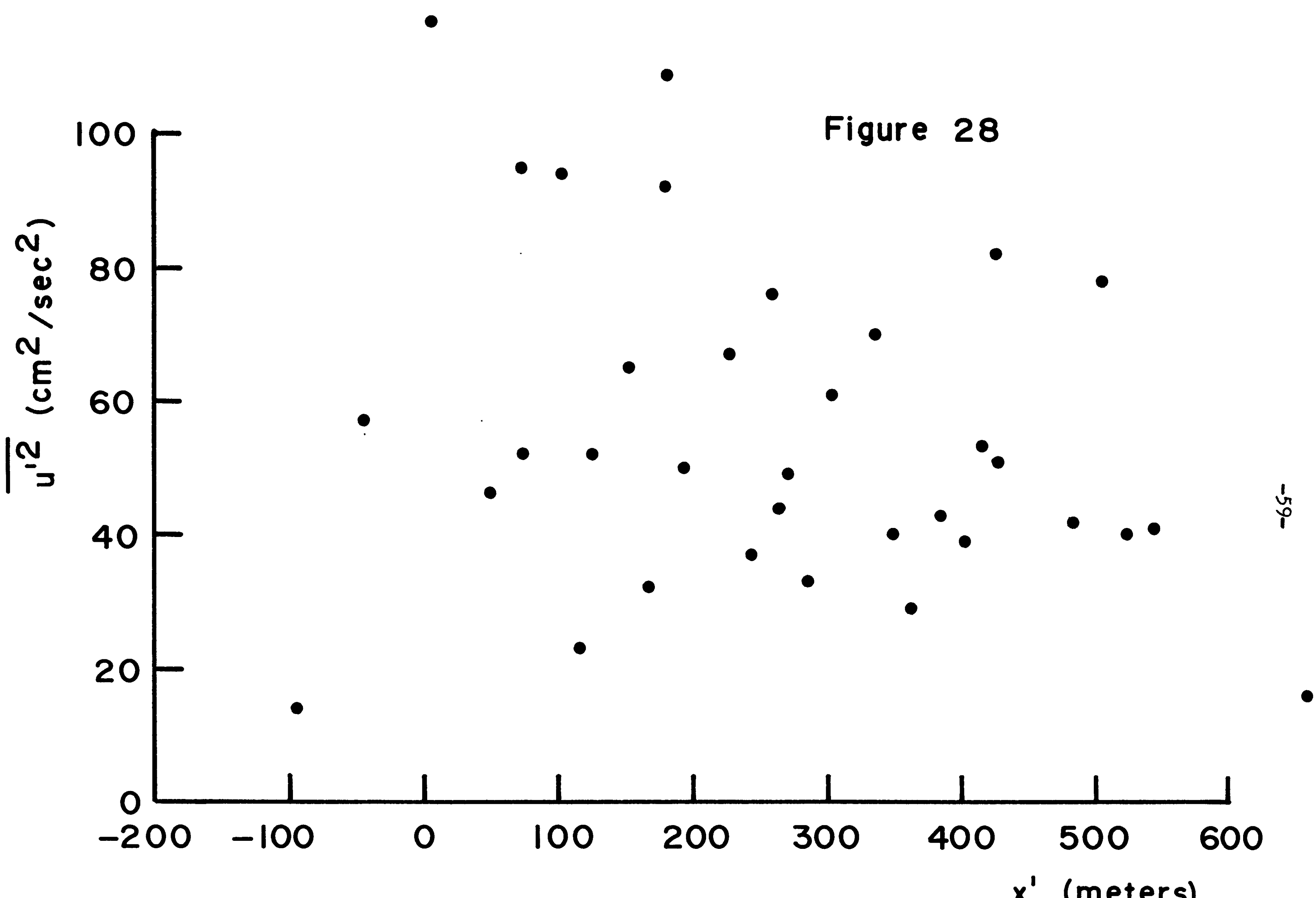


Figure 27
One Dimensional Energy Spectrum
Run 7
Sample 4



Sample Variance vs. Downstream Distance of Sample from Channel Buoys

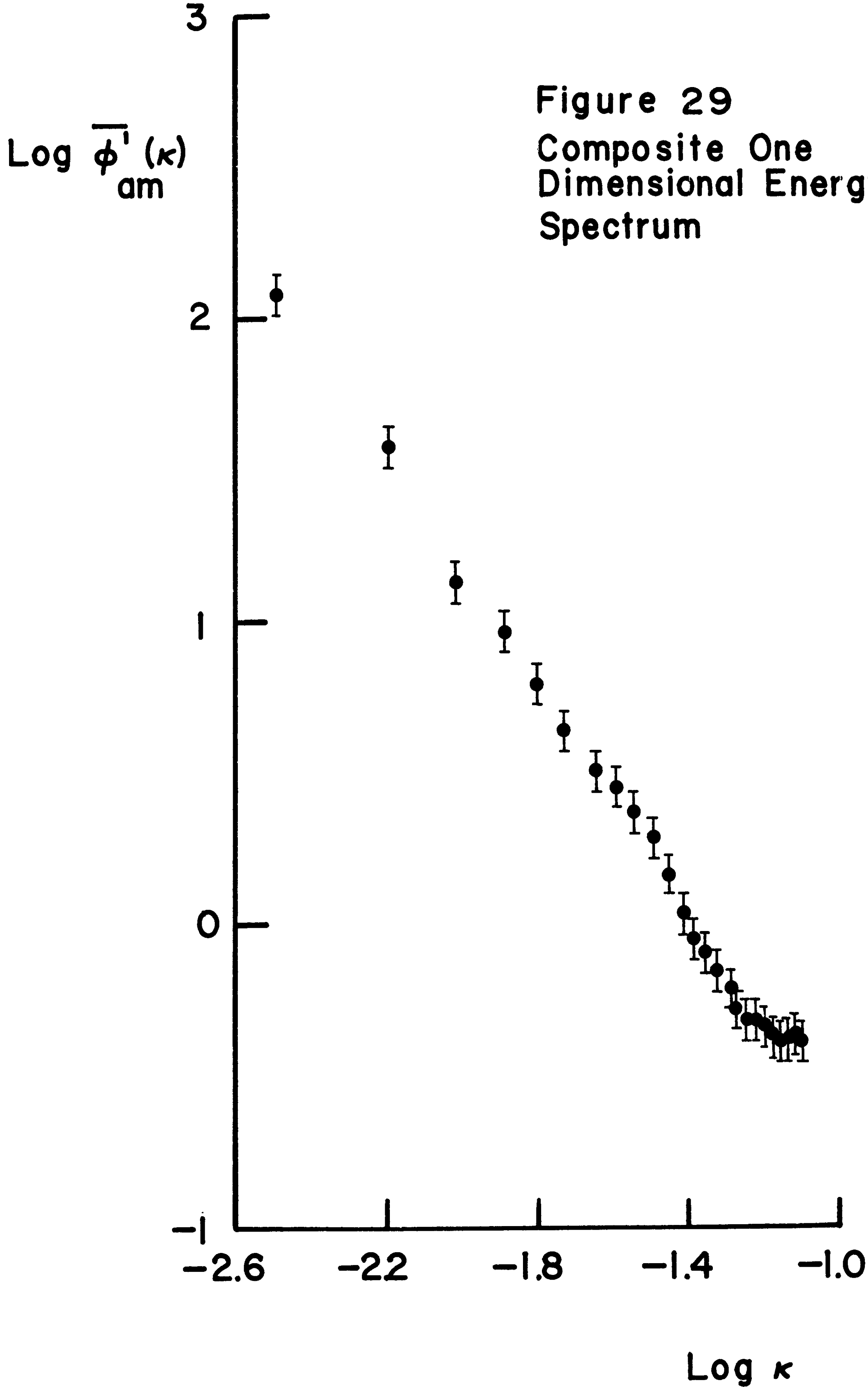
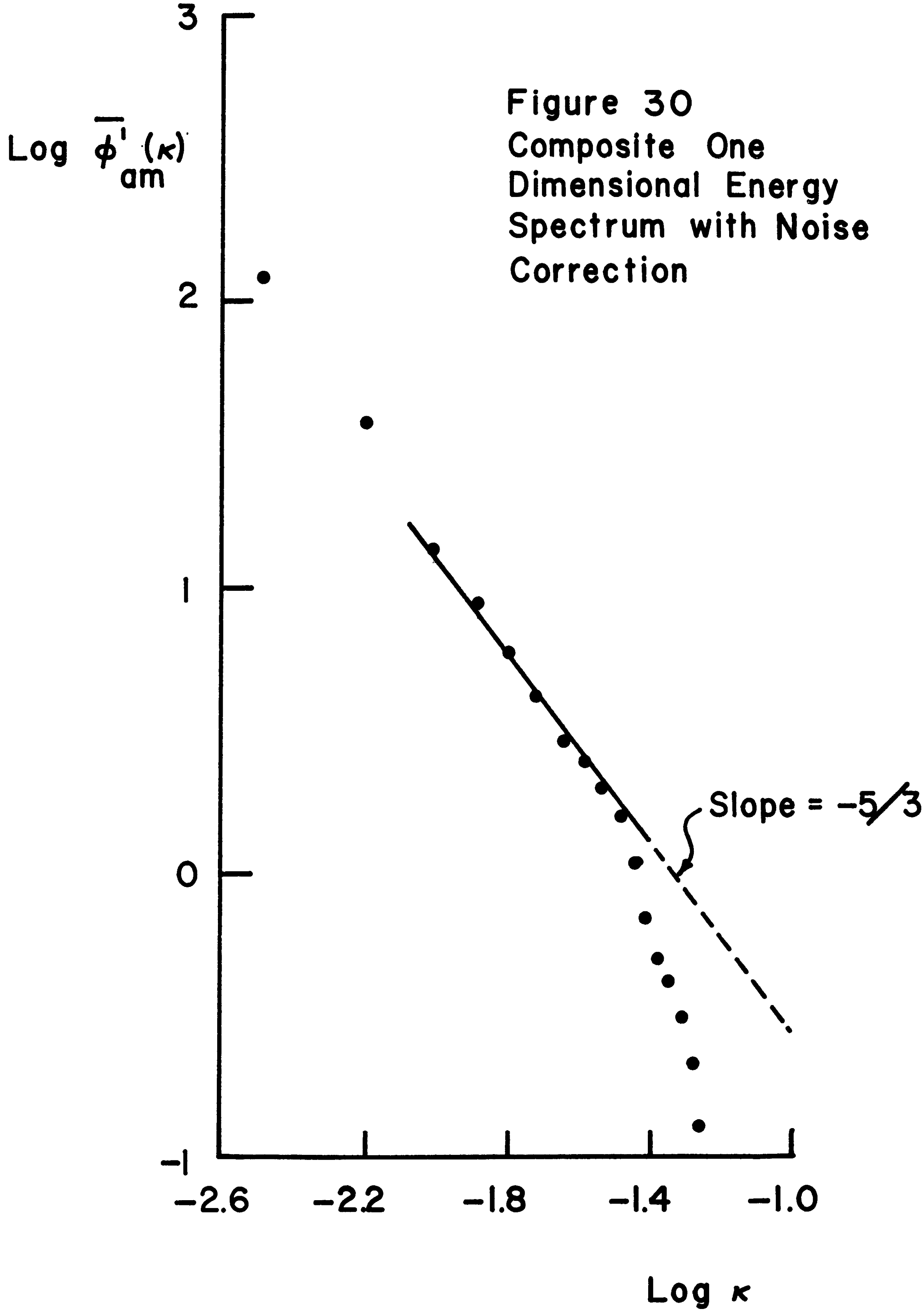


Figure 29
Composite One Dimensional Energy Spectrum



3
2
1
0
-1
Log $\overline{\phi}'_{am}(\kappa)$
Figure 30
Composite One
Dimensional Energy
Spectrum with Noise
Correction
Slope = -5/3
-2.6
-2.2
-1.8
-1.4
-1.0
Log κ

Figure 31. 3/4 View of Braincon Corp. Type 430 Ducted Impeller Current Meter

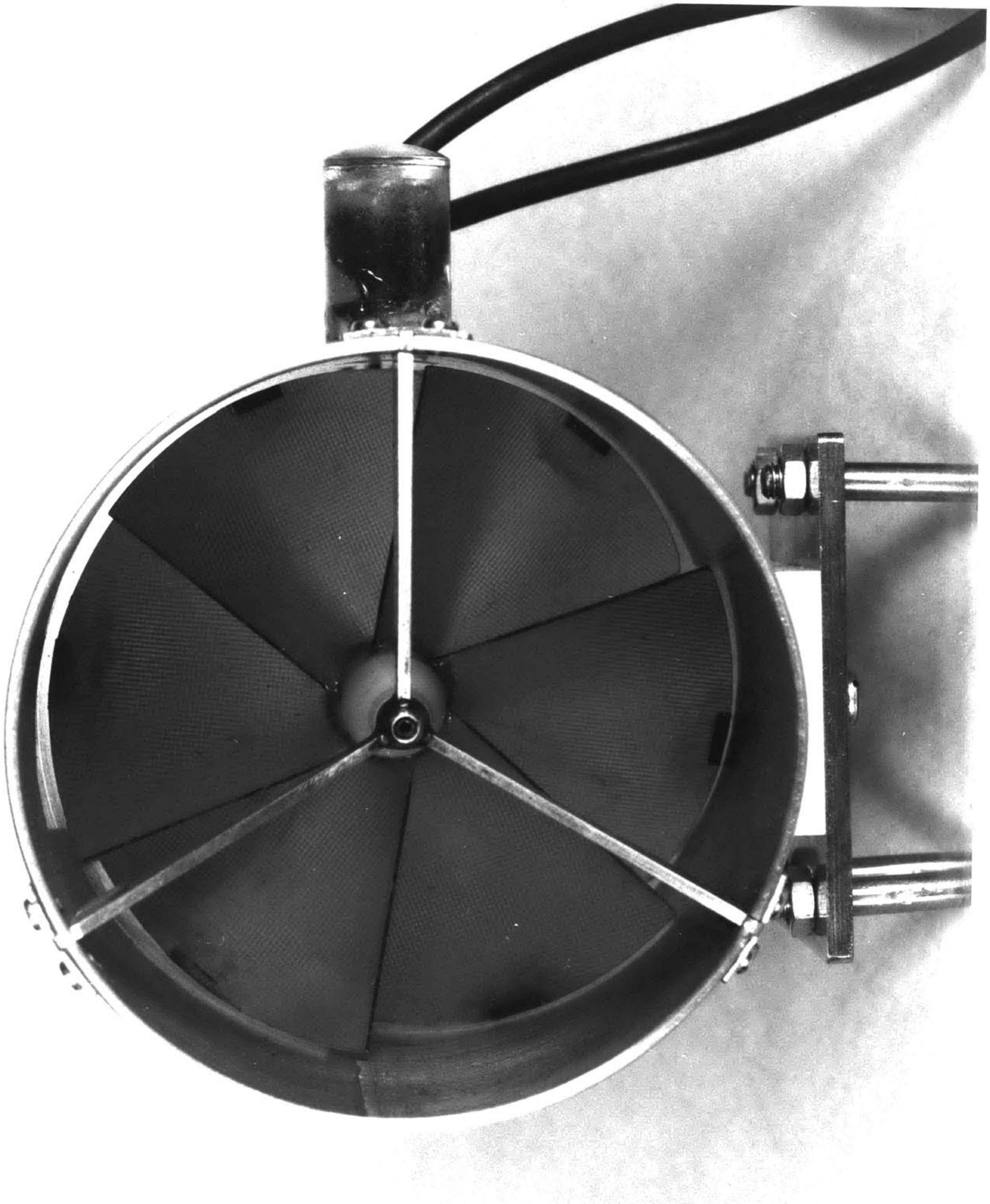


Figure 32. End View of Braincon Corp. Type 430 Ducted Impeller Current Meter

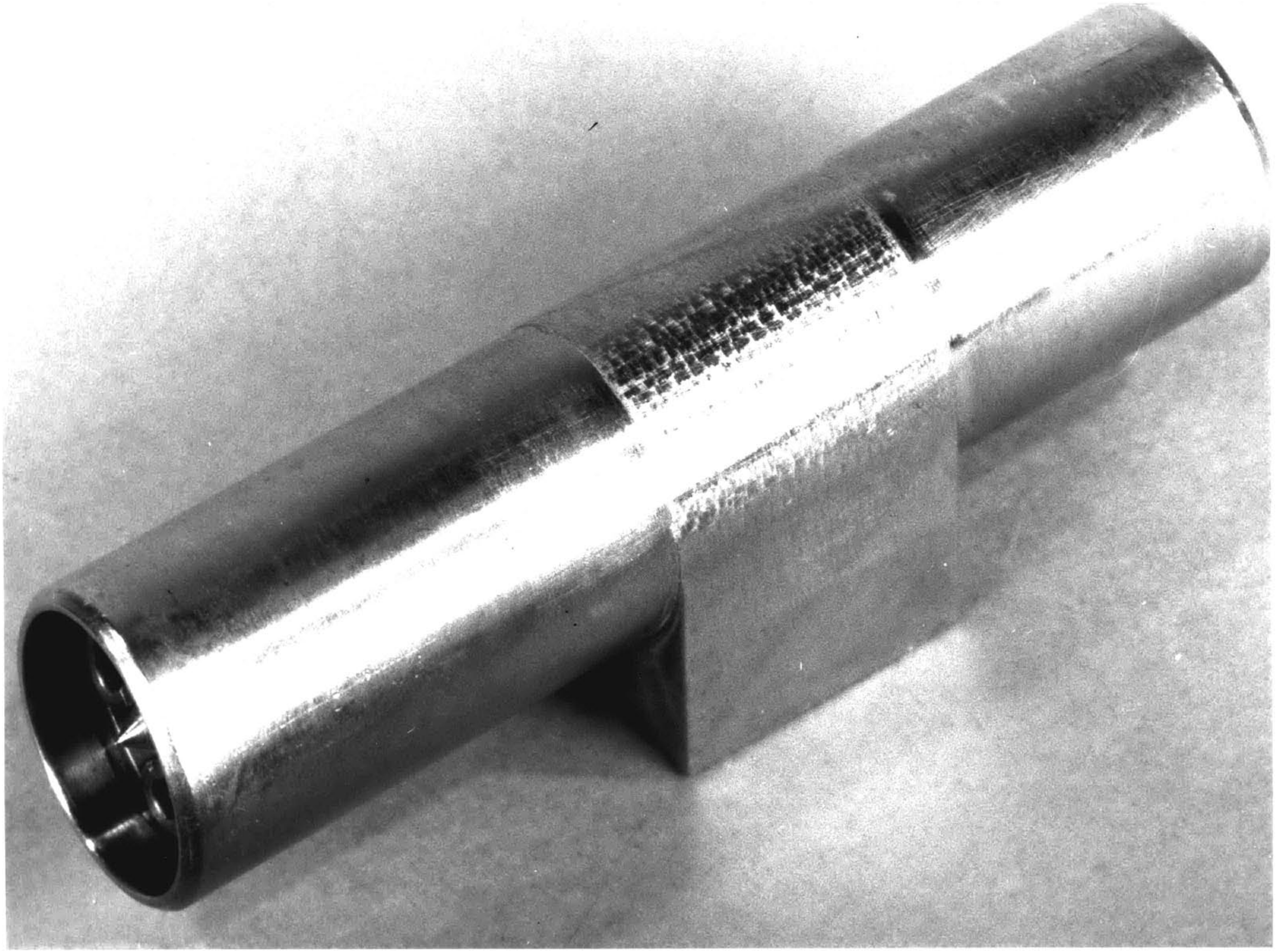


Figure 33. 3/4 View of Modified Cox Instruments Model 12 – SCRX Turbine Flow Meter

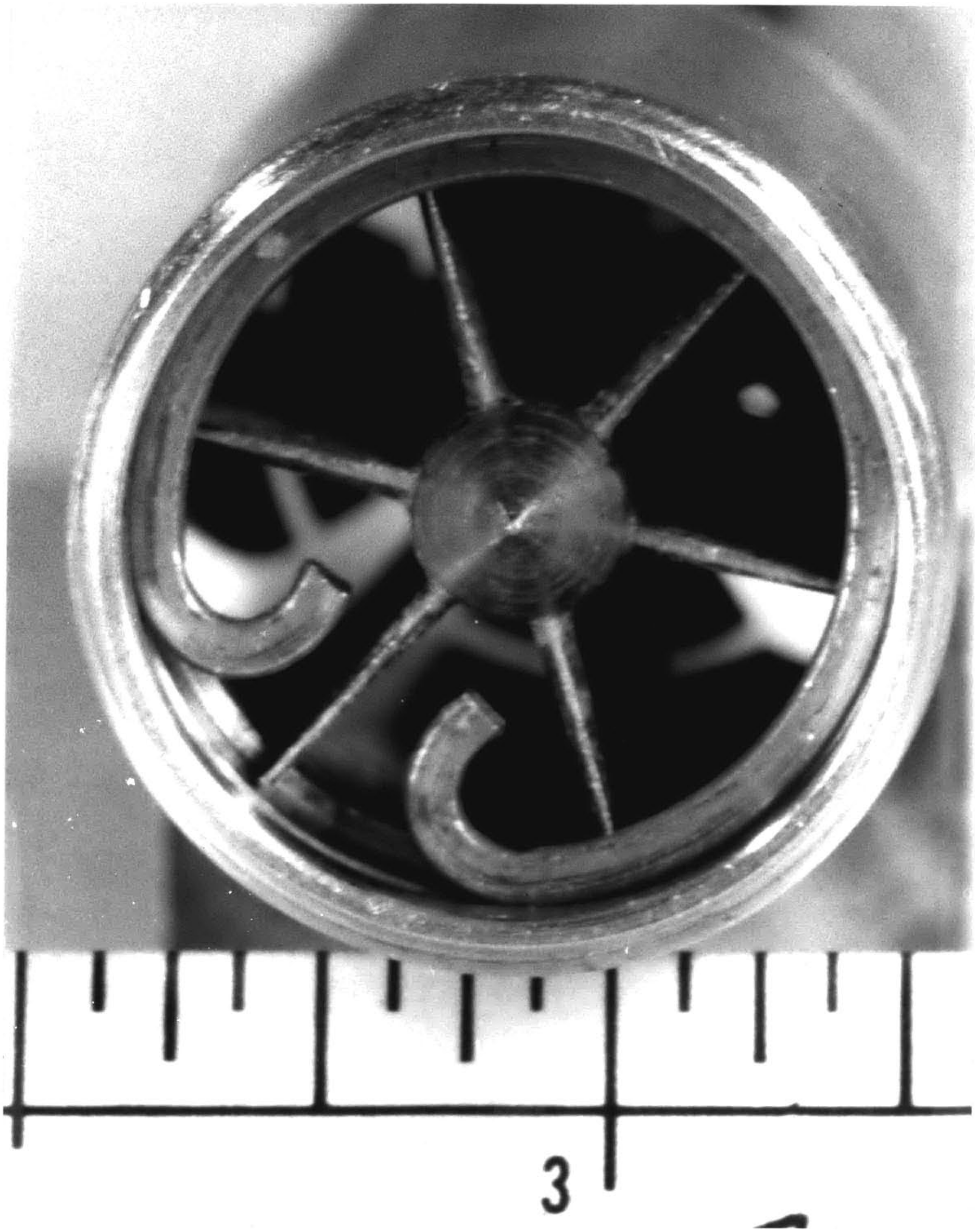


Figure 34. End View of Modified Cox Instruments Model 12—SCRX Turbine Flow Meter

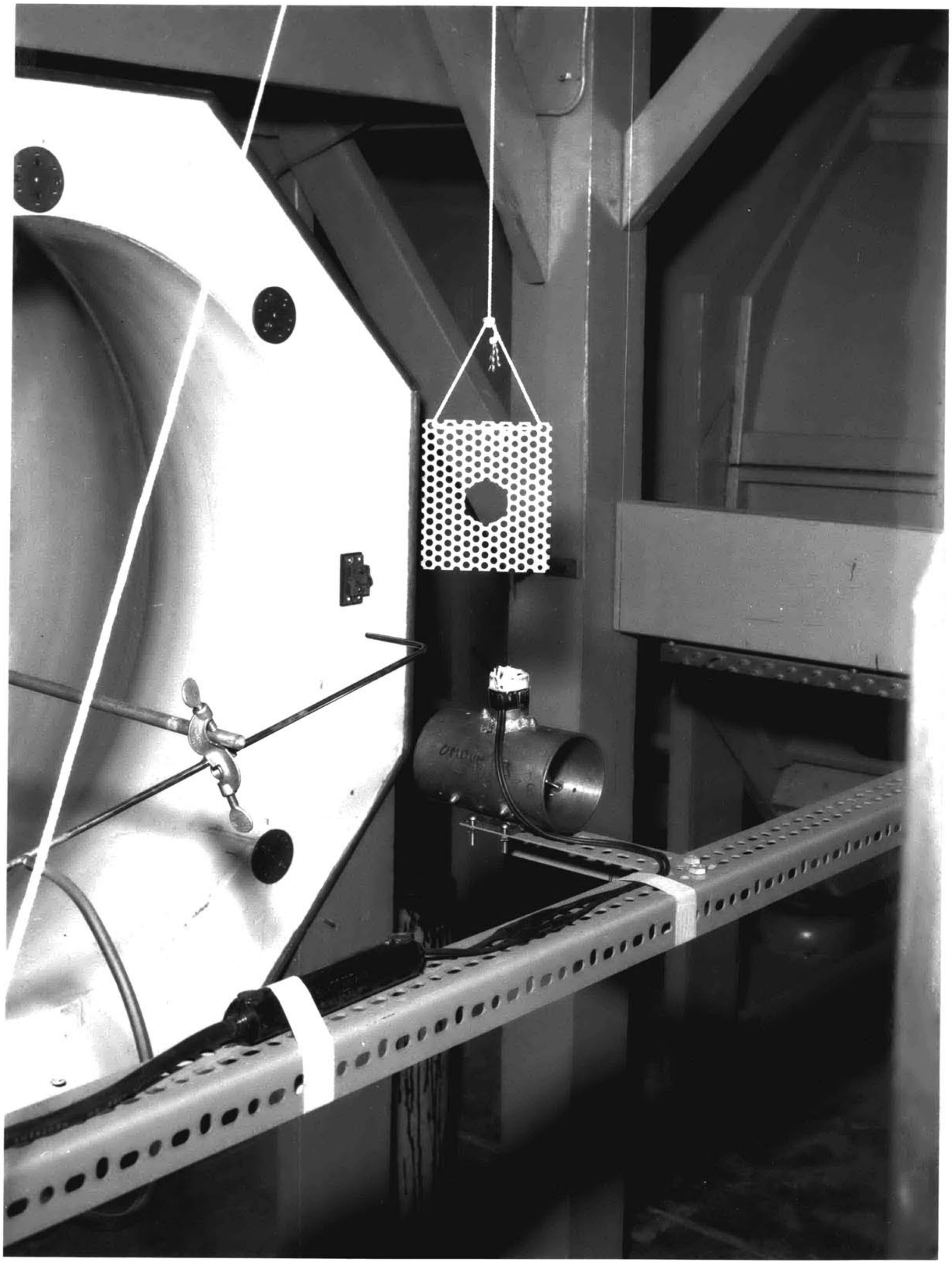


Figure 35. Current Meter Mounted in Wind Tunnel for Calibration and Response Time Measurements

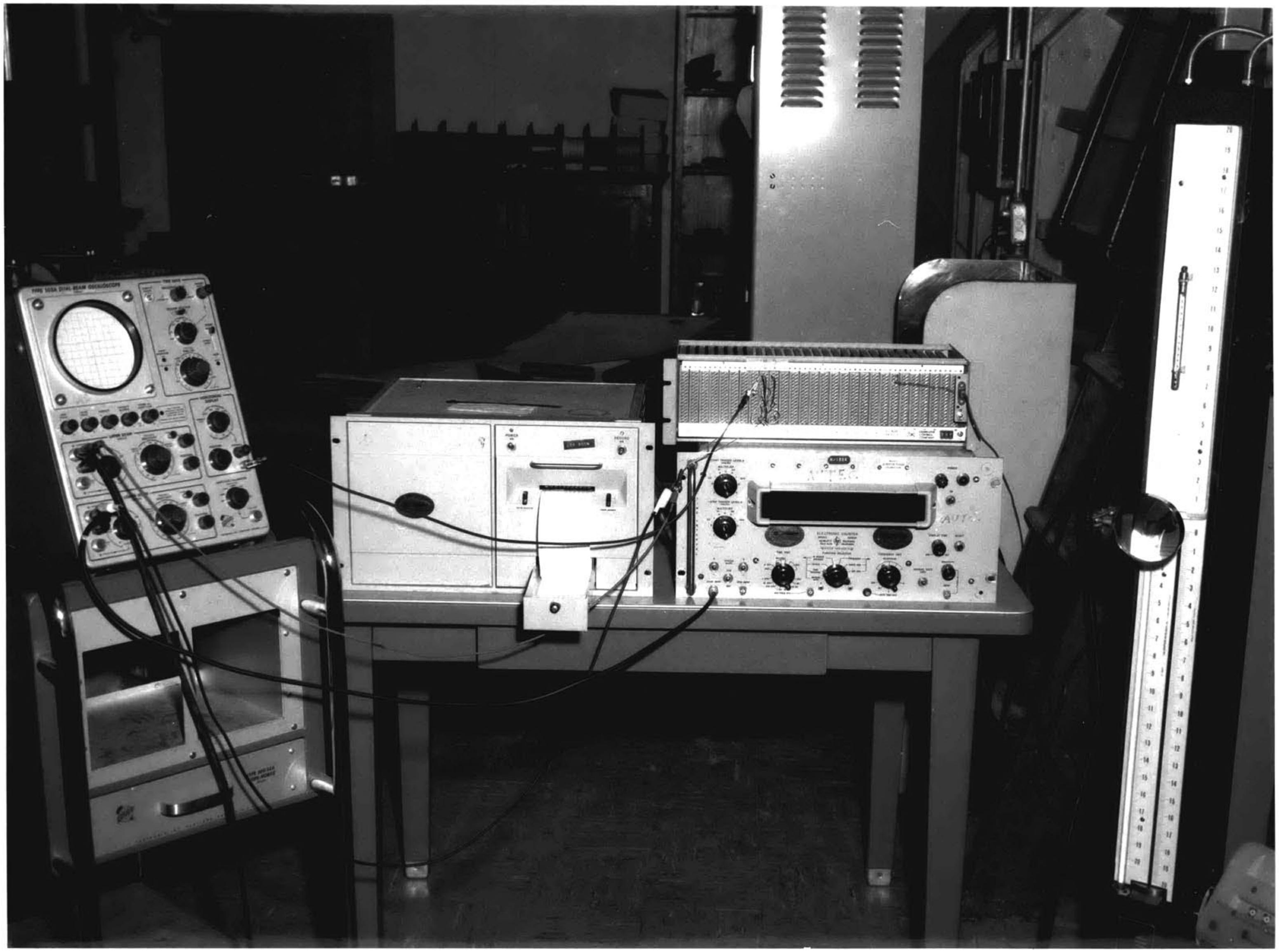


Figure 36. Instrumentation for Calibration and Response Time Measurements

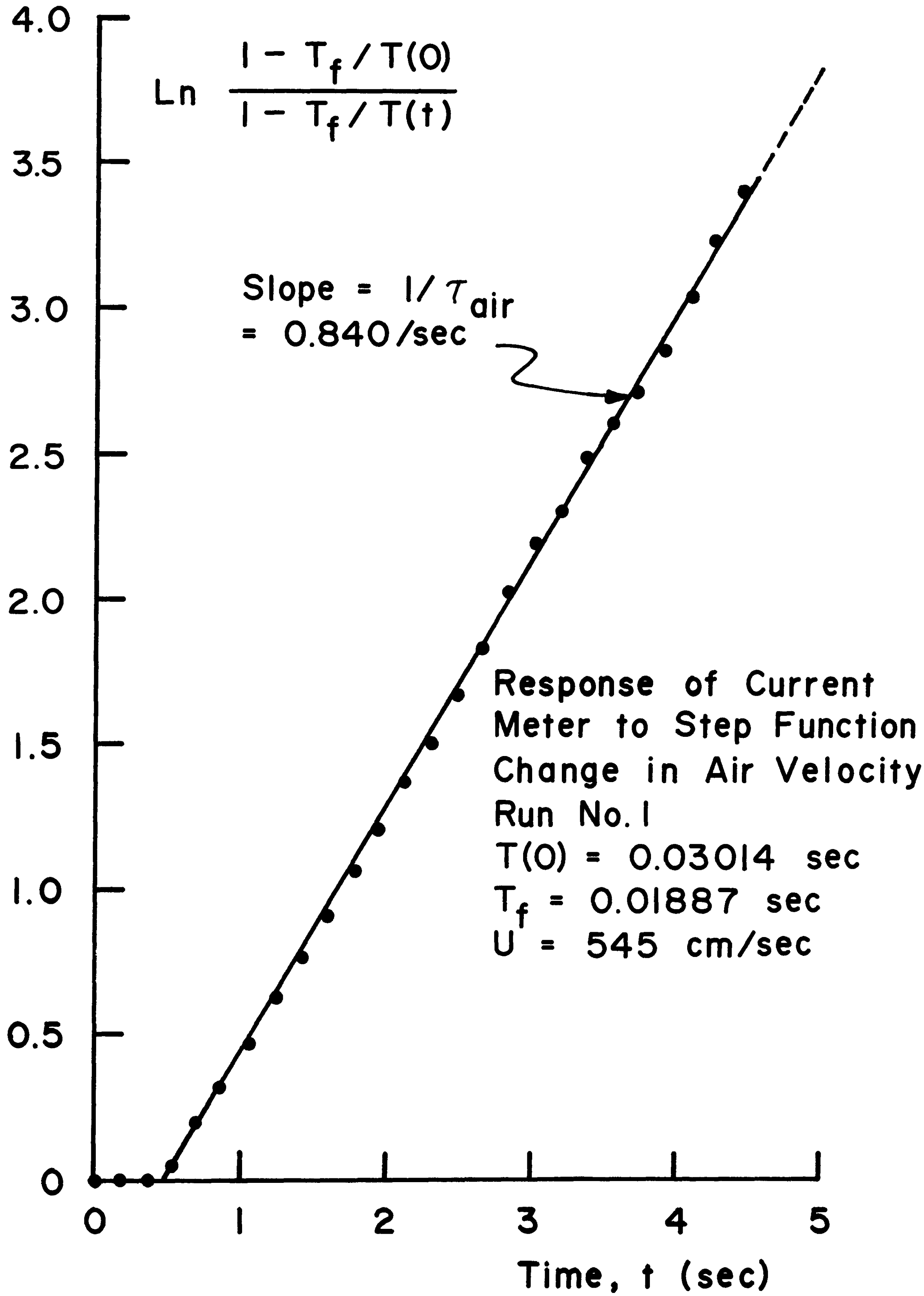
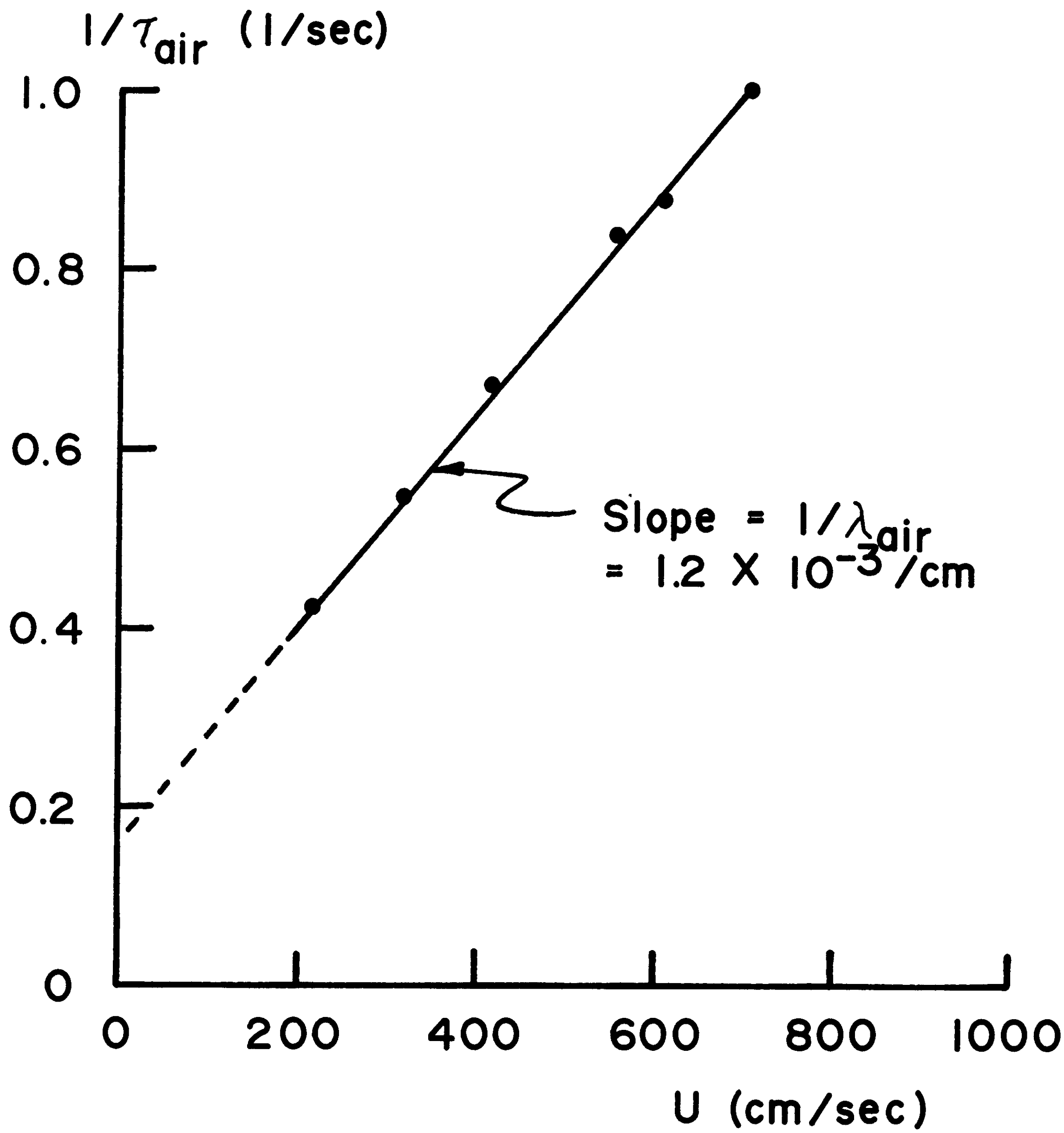

4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
Ln $\frac{1 - T_f / T(0)}{1 - T_f / T(t)}$
Slope = $1/\tau_{air}$
= 0.840/sec
Response of Current Meter to Step Function Change in Air Velocity
Run No. 1
T(0) = 0.03014 sec
T_f = 0.01887 sec
U = 545 cm/sec
0
1
2
3
4
5
Time, t (sec)

Figure 37



Variation of Response Time (in air) with Air Velocity

Figure 38

Appendix I. Outline of Pertinent Theory

A. General. For the present analysis the turbulence is assumed to be homogeneous and the mean velocity equal to zero. The primary quantity used in the statistical description of turbulence is the covariance tensor defined by

$$R_{ij}(\vec{x}, \vec{x}', t) = \text{avg}\left[u_i(\vec{x}, t)\, u_j(\vec{x}', t)\right] \tag{1}$$

where $u_i(\vec{x}, t)$ is the ith turbulent velocity component at the point $\vec{x}$ and $u_j(\vec{x}', t)$ is the jth component at the point $\vec{x}'$. If the displacement between the points $\vec{x}$ and $\vec{x}'$ is

$$\vec{\xi} = \vec{x}' - \vec{x} \tag{2}$$

then because of the assumption of homogeneity the covariance tensor is not a function of the points $\vec{x}$ and $\vec{x}'$ individually but only of the displacement $\vec{\xi}$ (and of t):

$$R_{ij}(\vec{x}, \vec{x}', t) = R_{ij}(\vec{\xi}, t) = \text{avg}\left[u_i(\vec{x}, t)\, u_j(\vec{x} + \vec{\xi}, t)\right] \tag{3}$$

since

$$R_{ij}(-\vec{\xi}, t) = R_{ij}(\vec{\xi}, t)$$

the covariance tensor is symmetric. The components of the covariance tensor are the covariances in the usual statistical meaning between the various velocity components at different points in space. The correlation tensor is the non-dimensional form of the covariance tensor and is defined by

$$\rho_{ij}(\vec{\xi}, t) = \frac{R_{ij}(\vec{\xi}, t)}{\sigma_i\ \sigma_i} \tag{4}$$

where σ_i and σ_i are the standard deviations of u_i and u_j respectively. Using the chain rule for differentiation and equation (2) (x_i and x'_i are independent variables), differentiation of equation (3) yields

$$\frac{\partial}{\partial x_k} R_{ij}(\vec{x}, \vec{x}', t) = -\frac{\partial}{\partial \xi_k} R_{ij}(\vec{\xi}, t) = \text{avg}\left[\frac{\partial u_i}{\partial x_k}(\vec{x},t)\, u_j(\vec{x}',t)\right] \quad (5)$$

Contracting the indices i and k and summing and applying the equation of continuity for an incompressible fluid, we get

$$\frac{\partial}{\partial \xi_i} R_{ij}(\vec{\xi}, t) = 0 \quad (6)$$

The turbulent velocity components $u_i(\vec{x}, t)$ are homogeneous random functions of position $\vec{x}$ and time t and as such do not satisfy the necessary conditions so that the usual Fourier series or integral representations are applicable. It is assumed, however, (1, 7) that the velocity somponents can be represented as Fourier transforms of other homogeneous random functions of wave number $\vec{\kappa}$ and time:

$$u_i(\vec{x},t) = \int_{-\infty}^{\infty} e^{i\vec{\kappa}\cdot\vec{x}}\, dZ_i(\vec{\kappa}, t) \quad (7)$$

Since the $u_i(\vec{x}, t)$ are real but not symmetric the $dZ_i(\vec{\kappa}, t)$ are symmetric and complex. Substituting equation (7) into equation (3) gives

$$R_{ij}(\vec{\xi},t) = \text{avg}\left[u_i(\vec{x},t)\, u_j(\vec{x}+\vec{\xi},t)\right]$$

$$= \text{avg}\left[\int_{-\infty}^{\infty} e^{-i\vec{\kappa}'\cdot\vec{x}}\, dZ_i^*(\vec{\kappa}',t) \int_{-\infty}^{\infty} e^{i\vec{\kappa}\cdot(\vec{x}+\vec{\xi})}\, dZ_j(\vec{\kappa},t)\right] \quad (8)$$

$$= \text{avg}\left[\iint_{-\infty}^{\infty} e^{i(\vec{\kappa}-\vec{\kappa}')\cdot\vec{x}}\, e^{i\vec{\kappa}\cdot\vec{\xi}}\, dZ_i^*(\vec{\kappa}',t)\, dZ_j(\vec{\kappa},t)\right]$$

$$= \iint_{-\infty}^{\infty} e^{i(\vec{\kappa}-\vec{\kappa}')\cdot\vec{x}}\, e^{i\vec{\kappa}\cdot\vec{\xi}}\, \text{avg.}\left[dZ_i^*(\vec{\kappa}',t)\, dZ_j(\vec{\kappa},t)\right]$$

where $dZ_i^*(\vec{\varkappa}', t)$ is the complex conjugate of $dZ_i(\vec{\varkappa}, t)$. The $dZ_i^*(\vec{\varkappa}', t)$, being completely random functions of $\vec{\varkappa}'$, are statistically independent of, and hence uncorrelated with, the $dZ_j(\vec{\varkappa}, t)$ unless $\vec{\varkappa}'$ is equal to $\vec{\varkappa}$. That is,

$$\text{avg}\left[dZ_i^*(\vec{\varkappa}', t)\, dZ_j(\vec{\varkappa}, t)\right] = 0 \text{ if } \vec{\varkappa}' \neq \vec{\varkappa} \tag{9}$$

Therefore equation (8) is

$$R_{ij}(\vec{\xi}, t) = \int_{-\infty}^{\infty} e^{i\vec{\varkappa}\cdot\vec{\xi}}\, \text{avg}\left[dZ_i^*(\vec{\varkappa}, t)\, dZ_j(\vec{\varkappa}, t)\right] \tag{10}$$

Denoting the Fourier transform of $R_{ij}(\vec{\xi}, t)$ by $\Phi_{ij}(\vec{\varkappa}, t)$ we have

$$R_{ij}(\vec{\xi}, t) = \int_{-\infty}^{\infty} \Phi_{ij}(\vec{\varkappa}, t)\, e^{i\vec{\varkappa}\cdot\vec{\xi}}\, d\vec{\varkappa} \tag{11}$$

$$\Phi_{ij}(\vec{\varkappa}, t)\, d\vec{\varkappa} = \text{avg}\left[dZ_i^*(\vec{\varkappa}, t)\, dZ_j(\vec{\varkappa}, t)\right] \tag{12}$$

Conversely

$$\Phi_{ij}(\vec{\varkappa}, t) = \frac{1}{8\pi^3}\int_{-\infty}^{+\infty} R_{ij}(\vec{\xi}, t)\, e^{-i\vec{\varkappa}\cdot\vec{\xi}}\, d\vec{\xi} \tag{13}$$

$R_{ij}(\vec{\xi}, t)$ is real and symmetric so that $\Phi_{ij}(\vec{\varkappa}, t)$ is symmetric and real. When $\vec{\xi} = 0$ equation (13) gives

$$R_{ij}(0, t) = \text{avg}\left[u_i(\vec{x})\, u_j(\vec{x})\right] = \int_{-\infty}^{\infty} \Phi_{ij}(\vec{\varkappa}, t)\, d\vec{\varkappa} \tag{14}$$

The energy per unit volume of the turbulence is defined as

$$E(t) = 1/2\,\rho\; g_{ij}\, R_{ij}\,(o,\, t) \tag{15}$$

where g_{ij} is the metric tensor for the coordinate system in which the velocity components and displacements are expresse . Therefore, from equation (14),

$$E(t) = 1/2\,\rho \int_{-\infty}^{\infty} g_{ij}\, \Phi_{ij}\, (\vec{\varkappa},\, t)\; d\,\vec{\varkappa} = 1/2\,\rho \int_{-\infty}^{\infty} \Phi\, (\vec{\varkappa},\, t)\; d\,\vec{\varkappa} \tag{16}$$

The quantity $1/2\,\Phi\,(\vec{\varkappa},\, t)$, then, represents the contribution to the total kinetic energy per unit volume of the turbulence from wave numbers within the interval $\vec{\varkappa}$ to $\vec{\varkappa} + d\,\vec{\varkappa}$. $\Phi_{ij}\,(\vec{\varkappa},\, t)$ is the energy spectrum tensor.

Functions of a scalar variable $\varkappa$ can be obtained from $\Phi_{ij}\,(\vec{\varkappa},\, t)$ and $\Phi\,(\vec{\varkappa},\, t)$ by integrating over a spherical surface of radius $\varkappa$ ($\varkappa = |\vec{\varkappa}|$):

$$\left.\begin{aligned} \Psi_{ij}\,(\varkappa, t) &= \oiint \Phi_{ij}\,(\vec{\varkappa}, t)\, d\sigma \\ E\,(\varkappa, t) &= \tfrac{1}{2}\rho \oiint \Phi\,(\vec{\varkappa}, t)\, d\sigma \end{aligned}\right\} \tag{17}$$

$E(\varkappa,\, t)$ is the three-dimensional energy spectrum function and represents the contribution to the energy from wave numbers within the interval $\varkappa$ to $\varkappa + d\varkappa$, regardless of direction.

B. Isotropic Turbulence. It can be shown (1, 19) that any second order isotropic tensor must be of the form

$$T_{ij}(\vec{x}) = A\,(x)\; x_i\; x_j + B\,(x)\; g_{ij}\;;\; x = |\vec{x}|$$

where g_{ij} is the metric tensor. Therefore the covariance and energy spectrum tensors for isotropic turbulence can be written as

$$R_{ij}(\vec{\xi}, t) = F(\xi, t)\, \xi_i\, \xi_j + G(\xi, t)\, g_{ij}$$

$$\Phi_{ij}(\vec{\varkappa}, t) = A(\varkappa, t)\, \varkappa_i\, \varkappa_j + B(\varkappa, t)\, g_{ij} \tag{18}$$

$F(\xi, t)$, $G(\xi, t)$, $A(\varkappa, t)$ and $B(\varkappa, t)$ are scalar functions of the scalar variables ξ, $\varkappa$ and t. The functions $F(\xi, t)$ and $G(\xi, t)$ are not independent; differentiating the first of equations (18) gives

$$\frac{\partial}{\partial \xi_k} R_{ij}(\vec{\xi}, t) = \frac{\partial}{\partial \xi_k}\left[F(\xi,t)\,\xi_i\,\xi_j + G(\xi,t)\,g_{ij}\right]$$

$$= F(\xi,t)\left[\xi_i\,\delta_{jk} + \xi_j\,\delta_{ik}\right] + \frac{\partial}{\partial \xi}F(\xi,t)\,\frac{\xi_k}{\xi}\,\xi_i\,\xi_j \tag{19}$$

$$+ \frac{\partial}{\partial \xi}G(\xi,t)\,\frac{\xi_k}{\xi}\,g_{ij}$$

Contracting the indices i and k and summing and using equation (6) we obtain

$$\left[4F(\xi,t) + \xi\,\frac{\partial F(\xi,t)}{\partial \xi} + \frac{1}{\xi}\,\frac{\partial G(\xi,t)}{\partial \xi}\right]\xi_j = 0 \tag{20}$$

Equation (20) must be satisfied for all values of ξ_j and therefore

$$4F(\xi,t) + \xi\,\frac{\partial F(\xi,t)}{\partial \xi} + \frac{1}{\xi}\,\frac{\partial G(\xi,t)}{\partial \xi} = 0 \tag{21}$$

Similarly, the functions $A(\varkappa, t)$ and $B(\varkappa, t)$ are not independent. The relation corresponding to the preceding is

$$\varkappa^2 A(\varkappa, t) + B(\varkappa, t) = 0 \tag{22}$$

In practice measurements are made of the turbulent velocity components parallel to and perpendicular to a single direction. Assume for convenience that the x_1 axis coincides with the direction of analysis so that the components of the one-dimensional covariance tensor

$$R_{ij}(\xi_1, o, o, t) = \text{avg}\left[u_i(x_1, t)\, u_j(x_1 + \xi_1, t)\right] \tag{23}$$

and subsequently the one-dimensional energy spectrum function

$$\begin{aligned} \Theta_{ij}(\varkappa_1, t) &= \frac{1}{2\pi}\int_{-\infty}^{\infty} R_{ij}(\xi_1, 0, 0, t)\, e^{-i\varkappa_1\xi_1}\, d\xi_1 \\ &= \iint_{-\infty}^{\infty} \Phi_{ij}(\varkappa_1, \varkappa_2, \varkappa_3)\, d\varkappa_2\, d\varkappa_3 \end{aligned} \tag{24}$$

are obtained. Thus from measurements of the velocity component parallel to the direction of analysis we get

$$R_{11}(\xi_1, o, o, t) = \text{avg}\left[u_1(x_1, t)\, u_1(x_1 + \xi_1, t)\right]$$

and from measurements of the velocity components perpendicular to the direction of analysis,

$$R_{22}(\xi_1, o, o, t) = \text{avg}\left[u_2(x_1, t)\, u_2(x_1 + \xi_1, t)\right]$$

and

$$R_{33}(\xi_1, o, o, t) = \text{avg}\left[u_3(x_1, t)\, u_3(x_1 + \xi_1, t)\right]$$

From equation (19)

$$\begin{aligned} R_{11}(\xi, t) &= F(\xi, t)\,\xi^2 + G(\xi, t) \\ R_{22}(\xi, t) &= G(\xi, t) \\ R_{33}(\xi, t) &= G(\xi, t), \end{aligned} \tag{25}$$

omitting the subscript henceforth. The relationship between $R_{11}(\xi, t)$ and $R_{22}(\xi, t)$ or $R_{33}(\xi, t)$ is equation (21).

$$R_{22}(\xi, t) = R_{11}(\xi, t) + 1/2\, \xi \frac{\partial}{\partial \xi} R_{11}(\xi, t) \tag{26}$$

Substituting equations (25) into the first of equations (18), we have

$$R_{ij}(\vec{\xi}, t) = \frac{R_{11}(\xi, t) - R_{22}(\xi, t)}{\xi^2} \xi_i \xi_j + R_{22}(\xi, t) g_{ij} \tag{27}$$

The one-dimensional energy spectrum functions corresponding to the measured covariance functions are then, from equation (24),

$$\left.\begin{aligned} \Theta_{11}(\varkappa_1, t) &= \frac{1}{2\pi}\int_{-\infty}^{\infty} R_{11}(\xi_1, 0, 0, t)\, e^{-i\varkappa_1\xi_1}\, d\xi_1 \\ \Theta_{22}(\varkappa_1, t) &= \frac{1}{2\pi}\int_{-\infty}^{\infty} R_{22}(\xi_1, 0, 0, t)\, e^{-i\varkappa_1\xi_1}\, d\xi_1 \\ \Theta_{33}(\varkappa_1, t) &= \frac{1}{2\pi}\int_{-\infty}^{\infty} R_{33}(\xi_1, 0, 0, t)\, e^{-i\varkappa_1\xi_1}\, d\xi_1 \end{aligned}\right\} \tag{28}$$

The preceding equations and equation (26) give

$$\Theta_{22}(\varkappa_1, t) = \Theta_{33}(\varkappa_1, t) = \frac{1}{2}\left[\Theta_{11}(\varkappa_1, t) - \varkappa_1 \frac{\partial}{\partial \varkappa_1}\Theta_{11}(\varkappa_1, t)\right] \tag{29}$$

The three-dimensional energy spectrum function is related to the energy spectrum tensor by equations (16) and (17)

$$E(\varkappa, t) = 1/2\, \rho \oiint g_{ij}\, \Phi_{ij}(\vec{\varkappa}, t)\, d\sigma \tag{30}$$

where the integration is over a spherical surface of radius χ. Since there is no dependence on direction for isotropic turbulence this gives

$$E(\chi, t) = 1/2\rho\, 4\pi\chi^2\, g_{ij}\, \Phi_{ij}(\vec{\chi}, t)$$

$$= 1/2\rho\, 4\pi\, \chi^2\, g_{ij}\left[A(\chi, t)\,\chi_i\,\chi_j + B(\chi, t)\, g_{ij}\right] \qquad (31)$$

$$= -4\pi\rho\,\chi^4\, A(\chi, t),$$

using equations (18) and (22). Therefore

$$\Phi_{ij}(\vec{\chi}, t) = \frac{E(\chi, t)}{4\pi\rho\chi^4}\left(\chi^2 g_{ij} - \chi_i\,\chi_j\right) \qquad (32)$$

$\Phi_{ij}(\vec{\chi}, t)$ is the Fourier transform of $R_{ij}(\vec{\xi}, t)$ and therefore equation (31) can be written as

$$E(\chi,t) = \frac{2\pi\rho\chi^2}{8\pi^3}\iiint_{-\infty}^{\infty} g_{ij}\, R_{ij}(\vec{\xi},t)\, e^{-i\vec{\chi}\cdot\vec{\xi}}\, d\vec{\xi}$$

$$= \frac{\rho\chi^2}{4\pi^2}\iiint_{-\infty}^{\infty} g_{ij}\left\{\left[\frac{R_{11}(\xi,t)-R_{22}(\xi,t)}{\xi^2}\right]\xi_i\xi_j + R_{22}(\xi,t)\, g_{ij}\right\} e^{-i\vec{\chi}\cdot\vec{\xi}}\, d\vec{\xi} \qquad (31a)$$

$$= \frac{\rho\chi^2}{4\pi^2}\iiint_{-\infty}^{\infty}\left[R_{11}(\xi,t) + 2R_{22}(\xi,t)\right] e^{-i\vec{\chi}\cdot\vec{\xi}}\, d\vec{\xi}$$

$$= \frac{\rho\chi^2}{4\pi^2}\iiint_{-\infty}^{\infty}\left[R_{11}(\xi,t) + 2R_{22}(\xi,t)\right] e^{-i\chi\xi\cos\theta}\, \xi^2 d\xi\, \sin\phi\, d\phi\, d\theta$$

$$= \frac{\rho\chi^2}{\pi}\int_0^{\infty}\left[R_{11}(\xi,t) + 2R_{22}(\xi,t)\right]\frac{\sin\chi\xi}{\chi\xi}\,\xi^2\, d\xi$$

Substituting equation (26) into this results in

$$E(\varkappa,t) = \frac{\rho\varkappa^2}{\pi}\int_0^\infty \left[3R_{11}(\xi,t) + \xi\frac{\partial}{\partial\xi}R_{11}(\xi,t)\right]\frac{\sin\varkappa\xi}{\varkappa\xi}\xi^2 d\xi \quad (33)$$

Integrating by parts changes equation (33) to

$$E(\varkappa,t) = \frac{\rho}{\pi}\int_0^\infty R_{11}(\xi,t)\,\varkappa^2\xi^2\left(\frac{\sin\varkappa\xi}{\varkappa\xi} - \cos\varkappa\xi\right)d\xi \quad (34)$$

Recall that the one-dimensional energy spectrum is given by

$$\varphi(\varkappa,t) \equiv \Theta_{11}(\varkappa,t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} R_{11}(\xi,t)\,e^{-i\varkappa\xi}d\xi \quad (35)$$

Differentiating with respect to $\varkappa$,

$$\frac{\partial\varphi(\varkappa,t)}{\partial\varkappa} = \frac{1}{2\pi}\int_{-\infty}^{\infty} R_{11}(\xi,t)(-i\xi)\,e^{-i\varkappa\xi}d\xi$$

Multiplying by $1/\varkappa$ and differentiating again,

$$\frac{\partial}{\partial\varkappa}\left[\frac{1}{\varkappa}\frac{\partial\varphi(\varkappa,t)}{\partial\varkappa}\right]$$

$$= \frac{1}{2\pi}\int_{-\infty}^{\infty} R_{11}(\xi,t)(-i\xi)\left(\frac{-i\varkappa\xi}{\varkappa} - \frac{1}{\varkappa^2}\right)e^{-i\varkappa\xi}d\xi$$

Multiplying by $\rho \varkappa^3$,

$$\varkappa^3 \frac{\partial}{\partial \varkappa}\left[\frac{1}{\varkappa}\frac{\partial \phi(\varkappa,t)}{\partial \varkappa}\right] = \frac{\rho}{2\pi}\int_{-\infty}^{\infty} R_{11}(\xi,t)(-i\xi)\left(\frac{-i\xi\varkappa}{\varkappa} - \frac{1}{\varkappa^2}\right)\varkappa^3$$

$$\left[\cos \varkappa\xi - i \sin \varkappa\xi\right] d\xi$$

$$= \frac{\rho}{\pi}\int_{0}^{\infty} R_{11}(\xi,t)\varkappa^2\xi^2\left(\frac{\sin \varkappa\xi}{\varkappa\xi} - \cos \varkappa\xi\right) d\xi$$

The result is idential to the term on the right side of equation (34) and hence we have

$$E(\varkappa, t) = \rho \varkappa^3 \frac{\partial}{\partial \varkappa}\left[\frac{1}{\varkappa}\frac{\partial}{\partial \varkappa}\phi(\varkappa,t)\right] \tag{36}$$

for the relationship between the three-dimensional energy spectrum and the measureable one-dimensional energy spectrum. Equation (36) indicates that if $E(\varkappa, t)$ is of the form predicted by the Kolmogoroff hypothesis, that is,

$$E(\varkappa, t) = K \epsilon^{2/3} \varkappa^{-5/3}$$

then $\phi(\varkappa, t)$ is also of this form:

$$\phi(\varkappa, t) = K' \epsilon^{2/3} \varkappa^{-5/3} \tag{37}$$

The rate at which the energy is dissipated by viscosity is determined from the Navier-Stokes equation. Recall that the ith component of the equation at the point $\vec{x}$ is

$$\frac{\partial}{\partial t} U_i(\vec{X},t) = -\frac{\partial}{\partial X_k} U_i(\vec{X},t)U_k(\vec{X},t) - \frac{1}{\rho}\frac{\partial}{\partial X_i}P(\vec{X},t) + \nu\nabla^2 U_i(\vec{X},t) \tag{38}$$

Similarly the jth component at the point $\vec{x}'$ is

$$\frac{\partial}{\partial t} u_j(\vec{x}',t) = -\frac{\partial}{\partial x_k'} u_j(\vec{x}',t) u_k(\vec{x}',t) - \frac{1}{\rho}\frac{\partial}{\partial x_j'} P(\vec{x}',t) + \nu \nabla'^2 u_j(\vec{x}',t) \quad (39)$$

Multiplying the first equation by $u_j(\vec{x}', t)$ and the second by $u_i(\vec{x}, t)$ and adding the results,

$$\begin{aligned} u_j(\vec{x}',t)\frac{\partial}{\partial t} u_i(\vec{x},t) &+ u_i(\vec{x},t)\frac{\partial}{\partial t} u_j(\vec{x}',t) \\ &= u_j(\vec{x}',t)\frac{\partial}{\partial x_k} u_i(\vec{x},t)u_k(\vec{x},t) + u_i(\vec{x},t)\frac{\partial}{\partial x_k'} u_j(\vec{x}',t)u_k(\vec{x}',t) \\ &- \frac{1}{\rho}\left[u_j(\vec{x}',t)\frac{\partial}{\partial x_i} P(\vec{x},t) + u_i(\vec{x},t)\frac{\partial}{\partial x_j'} P(\vec{x}',t)\right] \\ &+ \nu\left[u_j(\vec{x}',t)\nabla^2 u_i(\vec{x},t) + u_i(\vec{x},t)\nabla'^2 u_j(\vec{x}',t)\right] \end{aligned} \quad (40)$$

Since $\vec{x}$ and $\vec{x}'$ are independent variables,

$$\vec{x} = \vec{x}' - \vec{\xi},$$

$$\frac{\partial}{\partial x_k} = -\frac{\partial}{\partial \xi_k},$$

$$\frac{\partial}{\partial x_k'} = \frac{\partial}{\partial \xi_k},$$

and

$$\frac{\partial^2}{\partial x_k^2} = \frac{\partial^2}{\partial x_k'^2} = \frac{\partial^2}{\partial \xi_k^2}.$$

Using these relationships equation (40) becomes

$$\begin{aligned} \frac{\partial}{\partial t} u_j(\vec{x}',t)u_i(\vec{x},t) &= \frac{\partial}{\partial \xi_k}\Big[u_i(\vec{x},t)u_k(\vec{x},t)u_j(\vec{x}',t) \\ &\qquad - u_i(\vec{x},t)u_k(\vec{x}',t)u_j(\vec{x}',t)\Big] \\ &+ \frac{1}{\rho}\left[\frac{\partial}{\partial \xi_i} P(\vec{x},t)u_j(\vec{x}',t) - \frac{\partial}{\partial \xi_j} P(\vec{x}',t)u_i(\vec{x},t)\right] \\ &+ 2\nu\nabla^2 u_j(\vec{x}',t)u_i(\vec{x},t) \end{aligned} \quad (41)$$

The statistical average of this is

$$\frac{\partial}{\partial t} R_{ij}(\vec{\xi},t) = \frac{\partial}{\partial \xi_k}\Big(\text{avg}\left[u_i(\vec{x},t)u_k(\vec{x},t)u_j(\vec{x}',t)\right] - \text{avg}\left[u_i(\vec{x},t)u_k(\vec{x}',t)u_j(\vec{x}',t)\right]\Big)$$
$$+\frac{1}{\rho}\left(\frac{\partial}{\partial \xi_i}\text{avg}\left[p(\vec{x},t)u_j(\vec{x}',t)\right] - \frac{\partial}{\partial \xi_j}\text{avg}\left[p(\vec{x}',t)u_i(\vec{x},t)\right]\right) \quad (42)$$
$$+2\nu\nabla^2 R_{ij}(\vec{\xi},t) .$$

where

$$R_{ij}(\vec{\xi}, t) = \text{avg}\left[u_i(\vec{x}, t)\, u_j(\vec{x}', t)\right]$$

by definition. The order of averaging and differentiation have been interchanged. Multiplying by the metric tensor and contracting indeces and evaluating the result at $\vec{\xi} = 0$ gives

$$\frac{1}{2}\rho\frac{\partial}{\partial t} g_{ij} R_{ij}(0,t) = \frac{\partial}{\partial t}E(t) = \quad . \;.\; . \quad + \frac{1}{2}\rho\, 2\nu g_{ij}\nabla^2 R_{ij}(\vec{\xi},t)\Big|_{\vec{\xi}=0} \quad (43)$$

The last term on the right side of this equation represents the rate of energy dissipation by viscosity:

$$\epsilon(t) = \mu\, g_{ij}\nabla^2 R_{ij}(\vec{\xi},t)\Big|_{\vec{\xi}=0} \quad (44)$$

From equation (11)

$$\nabla^2 R_{ij}(\vec{\xi},t)\Big|_{\vec{\xi}=0} = \int_{-\infty}^{\infty}\Phi_{ij}(\vec{\varkappa},t)\nabla^2 e^{i\vec{\varkappa}\cdot\vec{\xi}}\Big|_{\vec{\xi}=0} d\vec{\varkappa} \quad (45)$$

and thus

$$\epsilon(t) = \mu \int_{-\infty}^{\infty} \varkappa^2 g_{ij} \Phi_{ij}(\vec{\varkappa},t)\, d\vec{\varkappa} = \mu \int_{-\infty}^{\infty} \varkappa^2 E(\varkappa,t)\, d\varkappa \qquad (46)$$

Substituting equation (36) into this,

$$\epsilon(t) = \mu \int_{-\infty}^{\infty} \varkappa^5 \frac{\partial}{\partial \varkappa}\left[\frac{1}{\varkappa}\frac{\partial}{\partial \varkappa}\varphi(\varkappa,t)\right] d\varkappa \qquad (47)$$

Integrating by parts,

$$\epsilon(t) = 5\mu\, \varkappa^3 \frac{\partial}{\partial \varkappa}\varphi(\varkappa,t)\Big|_{-\infty}^{\infty} - 5\mu \int_{-\infty}^{\infty} \varkappa^3 \frac{\partial}{\partial \varkappa}\varphi(\varkappa,t)\, d\varkappa$$

$$= 5\mu \int_{-\infty}^{\infty} \varkappa^3 \frac{\partial}{\partial \varkappa}\varphi(\varkappa,t)\, d\varkappa$$

Integrating by parts again,

$$\epsilon(t) = -15\mu \int_{-\infty}^{\infty} \varkappa^2 \varphi(\varkappa)\, d\varkappa \qquad (48)$$

The quantity $\varkappa^2 \varphi(\varkappa)$ is the one-dimensional energy dissipation spectrum and gives the contribution to the rate of dissipation of energy by viscosity from wave numbers within the interval $\varkappa$ to $\varkappa + d\varkappa$.

Appendix II. Response of Current Meter to Accelerated Flow

Expressions for the resultant driving torque on the impeller of a current meter as a function of the geometry of the current meter, impeller angular velocity, and the velocity of water through the current meter are given by Rubin, Miller and Fox (11), and by Grey (12). Similar expressions are given by Lang (13) for the resultant driving torque on a windmilling propeller. If bearing friction and other torques are assumed negligible the resultant driving torque is of the form

$$k = cu^2 f(J) \tag{1}$$

where

$$J = u/\omega D) \tag{2}$$

and c is a constant of proportionality and is a function only of the geometry of the current meter. When the water velocity and the corresponding angular velocity of the impeller are constant the driving torque is zero so that

$$f(J) = 0;\ J = J_0 = \text{constant.} \tag{3}$$

Hence

$$\omega = \frac{u}{J_o D} = \frac{u}{k} \tag{4}$$

which gives the calibration coefficient for the current meter.

If the water velocity through the current meter consists of a time varying component superimposed on a constant component

$$u = U + u' \tag{5}$$

where u' is assumed small with respect to U so that the lift and drag forces on the impeller blades are approximately linear, then the equation of motion of the impeller can be written as

$$I \frac{d\omega}{dt} = K\ (u, \omega) = c\ u^2 f\ (J) \tag{6}$$

The angular velocity of the impeller also consists of a constant plus a time varying component:

$$\omega = \Omega + \omega' \tag{7}$$

Since u' is assumed small with respect to U, ω' can also be assumed small with respect to Ω and K (u, ω) can therefore be expanded in a Taylor series about the equilibrium value, zero:

$$K(u,\omega) = K(u,\omega)\Big|_{U,\Omega} + \frac{\partial K}{\partial u}\Big|_{U,\Omega} u' + \frac{\partial K}{\partial \omega}\Big|_{U,\Omega} \omega' + \frac{\partial^2 K}{\partial u^2}\Big|_{U,\Omega} u'^2 + \frac{1}{2}\frac{\partial^2 K}{\partial u \partial \omega}\Big|_{U,\Omega} u'\omega' + \frac{\partial^2 K}{\partial \omega^2}\Big|_{U,\Omega} \omega'^2 + \cdots \tag{8}$$

The coefficients of the linear and second order terms in the series are

$$K(u,\omega)\Big|_{U,\Omega} = 0 \tag{9}$$

$$\frac{\partial K(u,\omega)}{\partial u}\Big|_{U,\Omega} = \cancelto{=0}{2cuf(J)\Big|_{U,\Omega}} + cuJ\frac{\partial f(J)}{\partial J}\Big|_{U,\Omega} \tag{10}$$

$$= cUJ_0 \frac{\partial f(J)}{\partial J}\Big|_{J_0} = C_1 U$$

$$\frac{\partial K(u,\omega)}{\partial \omega}\Big|_{U,\Omega} = -cUDJ_0^2 \frac{\partial f(J)}{\partial J}\Big|_{J_0} = -C_2 U \tag{11}$$

$$\left.\frac{\partial^2 K(u,\omega)}{\partial u^2}\right|_{U,\Omega} = 2C\,f(J)\Big|_{J_0} + 4CJ_0\left.\frac{\partial f(J)}{\partial J}\right|_{J_0} + CJ_0^2\left.\frac{\partial^2 f(J)}{\partial J^2}\right|_{J_0} = C_3 \tag{12}$$

$$\frac{1}{2}\left.\frac{\partial^2 K(u,\omega)}{\partial u\,\partial\omega}\right|_{U,\Omega} = \frac{1}{2}\left\{-3CDJ_0^2\left.\frac{\partial f(J)}{\partial J}\right|_{J_0} - DJ_0^3\left.\frac{\partial^2 f(J)}{\partial J^2}\right|_{J_0}\right\} = C_4 \tag{13}$$

$$\left.\frac{\partial^2 K(u,\omega)}{\partial \omega^2}\right|_{U,\Omega} = -CD^2J_0^4\left.\frac{\partial^2 f(J)}{\partial J^2}\right|_{J_0} + 2CD^2J_0^3\left.\frac{\partial f(J)}{\partial J}\right|_{J_0} = C_5 \tag{14}$$

Substituting equations (8) through (14) into equation (6) gives

$$I\frac{d\omega'}{dt} = c_1 U u' - c_2 U\omega' + c_3 u'^2 + c_4 u'\omega' + c_5\omega'^2 \tag{15}$$

If U (and therefore Ω) is zero, then equation (15) becomes

$$I\frac{d\omega'}{dt} = c_3 u'^2 + c_4 u'\omega' + c_5\omega'^2 \tag{16}$$

whereas if

$$\frac{u'}{U} \ll 1$$

then

$$\frac{\omega'}{\Omega} \ll 1$$

and equation (15) becomes

$$I \frac{d\omega'}{dt} = c_1 U u' - c_2 U \omega' \tag{17}$$

neglecting second order and smaller terms. Equation (17), which pertains to the method in which the current meter was used, is a linear first order equation for the time varying component of the impeller angular velocity as a function of the time varying component of the water velocity. The general solution is

$$\omega'(t) = \frac{c_1 U}{I} e^{-\frac{c_2 U}{I} t} \int_0^t u'(t') e^{\frac{c_2 U}{I} t'} dt' \tag{18}$$

From equation (18) the theoretical response time of the current meter can be determined. The response time is defined, for a step function change in water velocity, as the time required for the change in angular velocity of the impeller to achieve $1 - 1/e$ of its final value. If the step function change in water velocity is

$$u'(t) = \begin{cases} 0, & t < 0 \\ u'_f = \text{constant}, & t > 0 \end{cases} \tag{19}$$

then the corresponding motion of the impeller is, from equation (18),

$$\omega'(t) = \begin{cases} 0, & t < 0 \\ \frac{c_1}{c_2} u'_f \left(1 - e^{-\frac{c_2 U}{I} t}\right), & t > 0 \end{cases} \tag{20}$$

From equations (10) and (11)

$$\frac{C_1}{C_2} = \frac{C J_0 \left.\frac{\partial f(J)}{\partial J}\right|_{J_0}}{C D J_0^2 \left.\frac{\partial f(J)}{\partial J}\right|_{J_0}} = \frac{1}{D J_0} = \frac{1}{k} \tag{21}$$

Therefore

$$\omega'(t) = \frac{1}{k} u_f' \left(1 - e^{-\frac{C_2 U}{I} t}\right) = \omega_f' \left(1 - e^{-\frac{C_2 U}{I} t}\right) \tag{22}$$

Examination of this result shows that the response time is given by

$$\tau = \frac{I}{C_2 U} \tag{23}$$

Thus the response time of the current meter is not a constant but is inversely proportional to the mean water velocity. The quantity defined by

$$\lambda = U \tau \tag{24}$$

is, however, a constant for the current meter and is referred to as the response distance.

The response distance in air is considerably larger than in water and consequently more easily measured. The value obtained can be converted to what it should be if it were measured in water. The procedure is similar to that used in calibrating ocean current meters in the wind tunnel (23). The dimensions of each term in equation (17) are ML^2T^{-2} and since the dimensions of and u are T^{-1} and LT^{-1} respectively, the dimensions of the constant c_2 are ML. c_2 is necessarily of the form

$$c_2 = c_2' \rho^A \mu^B L^C \tag{25}$$

where c_2' is a dimensionless constant and A, B and C are to be determined. Substituting the preceding dimensions into this equation,

$$(ML^{-3})^A (ML^{-1} T^{-1})^B L^C = ML,$$

from which

$$A = 1$$
$$B = 0 \tag{26}$$
$$C = 4$$

so that

$$C_2 = C_2' \rho L^4 \tag{27}$$

From equations (23) and (24)

$$\lambda = \frac{I}{C_2}$$

Assuming that I, L and c_2' have the same values in air and in water,

$$\lambda_{air} \rho_{air} = \lambda_{water} \rho_{water} \tag{28}$$

Therefore

$$\lambda_{water} = \lambda_{air} \frac{\rho_{air}}{\rho_{water}} = 1.17 \times 10^{-3} \lambda_{air} \tag{29}$$

The virtual moments of inertia in air and in water have been neglected in the foregoing analysis.

The current meter was mounted in the test section of a closed circuit, single return, low speed wind tunnel (figures 35 and 36). To simulate a step function change in air velocity a small section of screen was suspended immediately in front of the current meter so that it blocked some of the air flowing through the current meter. When the impeller had achieved a constant angular velocity, the screen was quickly removed and the output of the current meter measured as the angular velocity of the impeller increased from its original value to its final value. Initially the period between pulses was measured at intervals of approximately 0.2 sec with an electronic counter connected to a paper tape digital recorder. The interval was determined by the maximum printing rate of the recorder-5 lines/sec. The results, however, were subject to a large amount of scatter which was found to be caused by the variation in angular spacing between adjacent impeller blades-$\pm$10%. To eliminate this the output of the current meter was modified using a Schmidt trigger-binomial counter circuit so that the period per rotation of the impeller could be measured instead of the period between pulses.

Measurements were made as described at six different wind tunnel velocities. The velocity was determined from measurements of dynamic pressure, wet and dry bulb temperatures, and barometric pressure; the dynamic pressure was measured with a pitot static probe connected to a differential micro-manometer.

A calibration of the current meter was also performed in the wind tunnel by measuring the output frequency at various known wind tunnel velocities and using the method described in reference 23 to convert the values measured in air to in-water values.

From equation (22)

$$\omega'_f - \omega'(t) = \omega'_f \; e^{-t/\tau} \qquad (30)$$

This can be written as

$$\ln\left[\frac{1 - T_f/T_o}{1 - T_f/T(t)}\right] = \frac{t}{\tau} \qquad (31)$$

using

$$T(t) = \frac{1}{\omega(t)}$$

$$T_f = \frac{1}{\omega_f} \qquad (32)$$

$$T_o = \frac{1}{\Omega}$$

For each wind tunnel velocity the quantity

$$\ln\left[\frac{1 - T_f/T_o}{1 - T_f/T(t)}\right]$$

was calculated from the recorded data and plotted as a function of time; figure 37 is representative of the results. The response time in air was determined from the slope of the straight line fitted through the points using the least squares method:

$$\tau_{air} = \frac{1}{\text{slope}}$$

The reciprocal of the response time in air was plotted as a function of air velocity (figure 38) and the response distance in air determined from the slope of the straight line through the points. The response distance in water was computed according to equation (29), a value of 0.97 cm resulting.

Appendix III

Computer Programs

```
      PROGRAM TIMELINE
      DIMENSION A(8),J(2500),IB(7)
      CHARACTER A,IB
      EQUIVALENCE (J,A)
      READ(60,120)NR,NT
  120 FORMAT(2I4)
      NOTC=1
      ML=1
      READ(60,40) IB(ML)
   40 FORMAT(O1)
      NBIGSAMP=0
      NSWP=0
      N=3
      CHAN=0.
      BIGCHAN=0.
      TIME=0.
      SW=0.
      SAMP=0.
   11 BUFFER IN (3,1)(J(1),J(2500))
    1 GO TO (1,2,3,4)UNITSTF(3)
    3 K=LENGTHF(3)
      PRINT 10, K
   10 FORMAT(1X,17H EOF ON LV3 AFTER,I5,6H WORDS)
      GO TO 99
    4 K=LENGTHF(3)
      PRINT 20, K
   20 FORMAT(1X,26H PARITY ERROR ON LV3 AFTER,I5,6H WORDS)
      GO TO 11
    2 K=LENGTHF(3)
    5 IF(A(4).EQ.IB(ML))51,6
   51 DO 7 I=N,K
      IF(I.LE.3)9,8
    8 IF(I.GE.K)9,18
   18 IF(J(I).LE.-800)71,9
   71 IF(J(I-1).LE.-800)9,12
   12 IF(J(I+1).LE.-800)14,9
    9 SAMP=SAMP+1.
      TIME=TIME+1./2500.
      GO TO 7
   14 SAMP=SAMP+1.
      TIME=TIME+1./2500.
      CHAN=TIME-CHAN
      SW=SW+1.
      VEL=400./(5.10*CHAN)
      WRITE(61,30)SW,TIME,CHAN,VEL
      WRITE(2,300)CHAN,VEL,TIME,SW
  300 FORMAT(F12.5,F10.5,F12.5,F5.0)
   30 FORMAT(1X,19HSQUARE WAVE CYCLE= ,F5.0,2X,20HTIME TO THIS POINT= ,F
     112.5,2X,13HTIME CHANGE= ,F12.5,2X,10HVELOCITY= ,F10.5)
      CHAN=TIME
      NSWP=NSWP+1
      IF(NSWP.EQ.500)66,7
   66 NBIGSAMP=NBIGSAMP+1
      WRITE(61,80)
   80 FORMAT(1X,///,100(1H*))
      BIGCHAN=TIME-BIGCHAN
      WRITE(61,100)NBIGSAMP,TIME,BIGCHAN
  100 FORMAT(1X,/,1X,20HLARGE SAMPLE NUMBER ,I2,19X,10H AT TIME= ,F12.5,
     18H SECONDS,/,30X,25H TIME SINCE LAST SAMPLE= ,F12.5,8H SECONDS,/,1
     2X,100(1H*),///)
      NSWP=0
```

```
      7 CONTINUE
        GO TO 11
      6 WRITE(59,1000)(A(I),I=1,8)
   1000 FORMAT(1X,6HCODE= ,8O1)
        PAUSE 12345
        GO TO (51,35) SSWTCHF(1)
     35 ML=ML+1
        IF(ML.GT.NR)42,41
     41 READ(60,40)IB(ML)
        NSWP=0
        BIGCHAN=0.
        CHAN=0.
        TIME=0.
        SW=0.
        SAMP=0.
        END FILE 2
        N=3
        NBIGSAMP=0
        WRITE(61,200)ML
    200 FORMAT(1H1,60X,9H RUN NO. ,I1)
        GO TO 5
     99 REWIND 3
        WRITE(61,70)NOTC
     70 FORMAT(1X,19HEND OF TAPE NUMBER ,I1)
        NOTC=NOTC+1
        IF(NOTC.LE.NT)91,999
     91 WRITE(59,60)
     60 FORMAT(1X,20HUNLOAD LV3 AND SAVE.,/,28HMOUNT NEXT TAPE ON SAME UNI
       1T.,/,17HHIT GO WHEN READY)
        PAUSE 1
        GO TO 11
    999 REWIND 3
     42 END FILE 2
        REWIND 2
        END
```



```
          3200 FORTRAN DIAGNOSTIC RESULTS - FOR   TIMELINE

NO ERRORS
EQUIP,2=MTC0F0UU2
EQUIP,3=MTC0F0UU3
LOAD,56
IO ABORT CE UNIT 03
SEQ ERR
```

```
      PROGRAM FITNSUB
      DIMENSION V(452),T(452)
      DIMENSION TIM(500),VEL(500)
      DIMENSION ZA(80)
      COMMON VEL(500),TIM(500)
      VSUM=0.
      Y04=19.61
      JJ=500
      CODE=0.
    1 READ(60,3)(ZA(I),I=1,80)
    3 FORMAT(80R1)
      IF(ZA(2).EQ.0.)80,81
   81 M1=50
      READ(60,13)DMIN,DMAX
   13 FORMAT(2F10.5)
      SX=0.
      SY=0.
      SXX=0.
      SXY=0.
  100 FORMAT(1H1)
      PRINT 100
      WRITE(61,4)(ZA(I),I=1,80)
    4 FORMAT(25X,80R1)
      DO 16 I=1,500
      READ(1,200)VEL(I),TIM(I)
  200 FORMAT(12X,F10.5,F12.5)
      GO TO (1,16)EOFCKF(1)
   16 CONTINUE
      DO 76 J=2,500
      IF(VEL(J).LT.DMIN)22,23
   22 VEL(J)=VEL(J-1)
      GO TO 76
   23 IF(VEL(J).GT.DMAX)24,76
   24 VEL(J)=VEL(J-1)
   76 CONTINUE
      DO 17 I=1,500
      SY=SY+VEL(I)
      SX=SX+TIM(I)
      SXY=SXY+(VEL(I)*TIM(I))
   17 SXX=SXX+(TIM(I)*TIM(I))
      SLOPE=((JJ*SXY)-(SX*SY))/((JJ*SXX)-(SX*SX))
      YINT=((SXY*SX)-(SY*SXX))/((SX*SX)-(JJ*SXX))
      WRITE(61,301)SLOPE,YINT
  301 FORMAT(1X,8HSLOPE = ,F6.3,2X,12HINTERCEPT = ,F8.4)
      DO 18 I=1,500
   18 VEL(I)=VEL(I)-(SLOPE*TIM(I)+YINT)
      CALL SPECTRA (JJ,CODE,M1,Y04)
      GO TO 81
   80 END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR   FITNSUB

NO ERRORS

```
      SUBROUTINE SPECTRA(N,CODE,M1,Y04)
      DIMENSION A(102),B(102),C(102),D(102),E(102),F(102)
      COMMON X(500),Y(500)
      PI=3.14159
      SUMX=0.0
      SUMY=0.0
      IF(CODE)11,12,11
   11 DO 5 I=1,N
      SUMX=SUMX+X(I)
    5 SUMY=SUMY+Y(I)
      EN=N
      SUMY=SUMY/EN
      SUMX=SUMX/EN
      WRITE (61,606) M1,N,Y04
      WRITE(61,608) SUMX,SUMY
      WRITE(61,609)
      DO 973 I=1,N
      X(I)=X(I)-SUMX
  973 Y(I)=Y(I)-SUMY
      GO TO 16
   12 DO 4 I=1,N
    4 SUMX=SUMX+X(I)
      EN=N
      SUMX=SUMX/EN
      WRITE(61,606) M1,N,Y04
      WRITE(61,607)SUMX
      WRITE(61,603)
      DO 913 I=1,N
  913 X(I)=X(I)-SUMX
   16 M=M1-1
      M2=M1+1
      DO 22 L=1,M2
      SUM1=0.0
      SUM2=0.0
      SUM3=0.0
      DO 23 I=L,N
      LZ=I-L+1
      SUM1=SUM1+X(LZ)*X(I)
      SUM2=SUM2+X(LZ)
   23 SUM3=SUM3+X(I)
      ZZ=N-L+1
      COEF=1./ZZ
      COEF2=COEF**2
      A(L)=COEF*SUM1-COEF2*SUM2*SUM3
      IF(CODE) 25,24,25
   25 SUM4=0.0
      SUM5=0.0
      SUM6=0.0
      SUM7=0.0
      SUM8=0.0
      DO 26 I=L,N
      LZ=I-L+1
      SUM4=SUM4+Y(LZ)*Y(I)
      SUM5=SUM5+Y(LZ)
      SUM6=SUM6+Y(I)
      SUM7=SUM7+X(LZ)*Y(I)
   26 SUM8=SUM8+Y(LZ)*X(I)
      B(L)=COEF*SUM4-COEF2*SUM5*SUM6
      C(L)=COEF*SUM7-COEF2*SUM2*SUM6
      D(L)=COEF*SUM8-COEF2*SUM5*SUM3
      E(L)=(D(L)+C(L))/2.
```

```
 24 CONTINUE
 22 CONTINUE
    DO 27 K=1,M2
    IF(K-1) 28,28,29
 28 ZM1=M1
    DELT=1./(2.*ZM1)
    GO TO 32
 29 IF(K-M2)31,28,28
 31 ZM1=M1
    DELT=1./ZM1
 32 SUM1=0.0
    SUM2=0.0
    SUM3=0.0
    SUM4=0.0
    EM1=M1
    CAY=K-1
    DO 33 L=2,M2
    EL=L-1
    GUT=(1.+COSF(PI*EL/EM1))*COSF(PI*CAY*EL/EM1)
    SUM1=SUM1+GUT*A(L)
    IF (CODE) 35,33,35
 35 SUM2=SUM2+GUT*B(L)
    SUM3=SUM3+GUT*E(L)
    SUM4=SUM4+(1.+COSF(PI*EL/EM1))*SINF(PI*CAY*EL/EM1)*F(L)
 33 CONTINUE
    X1=DELT*(SUM1+A(1))
    IF(CODE)37,36,37
 37 Y1=DELT*(SUM2+B(1))
    Z=DELT*(SUM3+E(1))
    W=DELT*SUM4
    R=SQRT((Z**2+W**2)/(X1*Y1))
    T=ATANF(W/Z)
    T=T/.0174533
    P=Z/SQRT(X1*Y1)
    Q=W/SQRT(X1*Y1)
    KK=K-1
    XLQ=M1
    XLQP=KK
    FXLP=(2.*XLQ*Y04)/XLQP
    WRITE(61,602)KK,A(K),B(K),E(K),F(K),X1,Y1,Z,W,FXLP,R,T
    WRITE(02,602)KK,A(K),B(K),E(K),F(K),X1,Y1,Z,W,FXLP,R,T
    GO TO 27
 36 KK=K-1
    XLQ=M1
    XLQP=KK
    FXLP=(2.*XLQ*Y04)/XLQP
    FREQ=1./FXLP
    WRITE(61,602)KK,A(K),X1,FXLP,FREQ
    WRITE(02,602)KK,A(K),X1,FXLP,FREQ
 27 CONTINUE
    END FILE 2
    IF(CODE)39,38,39
 39 CC=E(1)/SQRT(A(1)*B(1))
    WRITE(61,3)CC
 38 CONTINUE
609 FORMAT(1X,44HK ACOV U ACOV W COV IN COVOUT SP U SP W   CO, 23H
   1QUA   PER   R   PHI)
608 FORMAT(1X,8HMEAN U =,F6.1,8X,8HMEAN W =,F6.1)
607 FORMAT(1X,8HMEAN U =,F10.5)
602 FORMAT(I3,3F9.3,F8.6,5F6.2,F4.2,F6.2)
606 FORMAT(1X,5HLAGS=, I3,4H  N=,I5,5X,3HDT=,F6.2,3HSEC)
603 FORMAT(36H K    ACOV       SP      PERIOD     F    )
  3 FORMAT(1X,23HCORRELATION COEFFICIENT,F10.3)
    RETURN
    END
```

```
      PROGRAM MOD
      DIMENSION KK(70),A(70),X(70),FXLP(70),FREQ(70),ZA(80),SPK(70)
      DIMENSION SPN(70)
      READ(60,1)NF
    1 FORMAT(I5)
      NFC=0
    9 I=1
      READ(60,2)(ZA(K), K=1,80)
    2 FORMAT(80R1)
      WRITE(61,2)(ZA(K), K=1,80)
      WRITE(61,11)
   11 FORMAT(15X,57H  K     ACOV       SP      PERIOD     FREQ      SPK
     1   SPN)
      READ(3,16)KK(I),A(I),X(I),FXLP(I)
   16 FORMAT(I3,3F9.3)
      I=2
    3 READ(3,4)KK(I),A(I),X(I),FXLP(I),FREQ(I)
    4 FORMAT(I3,3F9.3,F8.6)
      GO TO (5,6) EOFCKF(3)
    6 I=I+1
      GO TO 3
    5 L1=4HINFI
      L2=4HNITY
      IFRQ=000000
      SPK(1)=312.102*X(1)
      SPN(1)=SPK(1)/A(1)
      WRITE(61,13)KK(1),A(1),X(1),L1,L2,IFRQ,SPK(1),SPN(1)
   13 FORMAT(15X,I3,2F9.3,2X,2A4,I8,2F10.3)
      N1=I-1
      DO 7 J=2,N1
      SPK(J)=312.102*X(J)
      SPN(J)=SPK(J)/A(1)
      WRITE(61,10)KK(J),A(J),X(J),FXLP(J),FREQ(J),SPK(J),SPN(J)
    7 WRITE(2,10)KK(J),A(J),X(J),FXLP(J),FREQ(J),SPK(J),SPN(J)
   10 FORMAT(15X,I3,3F9.3,F9.6,2F10.3)
      ENDFILE 2
      NFC=NFC+1
      WRITE(61,15)
   15 FORMAT(1H1)
      IF(NFC.EQ.NF)8,9
    8 REWIND 3
      REWIND 2
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR   MOD

NO ERRORS
LOAD.56
RUN.10

Appendix IV. Analysis of Equally Spaced Data of Finite Length

A. Continuous, Finite Data. The one-dimensional covariance function

$$R(\xi) = \text{avg}\left[u(x)\, u(x+\xi)\right] \tag{1}$$

and the corresponding one-dimensional energy spectrum function

$$\varphi(\varkappa) = \frac{1}{2\pi}\int_{-\infty}^{\infty} R(\xi)\, e^{-i\varkappa\xi}\, d\xi \tag{2}$$

are defined as statistical averages. It is assumed (1, 7) that the statistical average of equation (1) is equivalent to the spatial average giving the autocovariance function

$$R(\xi) = \lim_{L\to\infty} \frac{1}{L-\xi}\int_{-\frac{L-\xi}{2}}^{\frac{L-\xi}{2}} u(x)\, u(x+\xi)\, dx \tag{3}$$

provided the field of turbulence is homogeneous. In practice $R(\xi)$ and $\varphi(\varkappa)$ are estimated from samples of data of finite length; the closest quantity to the autocovariance function that can actually be computed is the apparent autocovariance function

$$R_a(\xi) = \frac{1}{L-\xi}\int_{-\frac{L-\xi}{2}}^{\frac{L-\xi}{2}} u(x)\, u(x+\xi)\, dx \tag{4}$$

where L is the sample length and $|\xi| \leq |\xi_m| \leq L$, ξ_m being the maximum lag at which values of $R_a(\xi)$ are computed. $R_a(\xi)$ is not defined for $|\xi| > |\xi_m|$ and therefore does not possess a Fourier transform. However, if $R_a(\xi)$ is multiplied by a prescribed function of ξ that is zero for $|\xi| > |\xi_m|$ then a modified autocovariance function is obtained which is defined for all values of ξ and having a Fourier transform. Denoting the modifying or lag function by $f(\xi)$, the modified autocovariance function is

$$R_m(\xi) = f(\xi)\, R_a(\xi);\; f(\xi) = 0,\; |\xi| > |\xi_m| \tag{5}$$

The Fourier transform of $R_m(\xi)$ is then

$$\Phi_m(\kappa) = \frac{1}{2\pi}\int_{-\infty}^{\infty} R_m(\xi)\, e^{-i\kappa\xi}\, d\xi \tag{6}$$

If $R_a(\xi)$ were determined for a large number of similar samples, then it could be expected that the average value of $R_a(\xi)$ would be approximately equal to the value of $R(\xi)$ within the interval $-\xi_m \leq \xi \leq \xi_m$ or that

$$\text{avg}\left[R_m(\xi)\right] \simeq f(\xi)\, R(\xi) \tag{7}$$

From equation (5) the average value of $\Phi_m(\kappa)$ (for a large number of samples) is

$$\text{avg}\left[\Phi_m(\kappa)\right] = \frac{1}{2\pi}\int_{-\infty}^{\infty} \text{avg}\left[R_m(\xi)\right] e^{-i\kappa\xi}\, d\xi \tag{8}$$

interchanging the order of integration and averaging; from equation (7),

$$\text{avg}\left[\Phi_m(\kappa)\right] = \frac{1}{2\pi}\int_{-\infty}^{\infty} f(\xi) R(\xi)\, e^{-i\kappa\xi}\, d\xi \tag{9}$$

which expresses the average value of $\Phi_m(\kappa)$ as the Fourier transform of the product $f(\xi)\, R(\xi)$. If the Fourier transform of $f(\xi)$ is $\gamma(\kappa)$ then from the convolution theorem

$$\text{avg}\left[\Phi_m(\kappa)\right] = \int_{-\infty}^{\infty} \Phi(\kappa')\, \gamma(\kappa - \kappa')\, d\kappa' \tag{10}$$

Therefore the average value of $\Phi_m(\kappa)$ is approximately equal to a weighted moving average over wave number of the one-dimensional energy spectrum function $\phi(\varkappa)$; the weighting function is $\gamma(\varkappa)$. A discussion of lag functions and weighting or spectral functions is given in the book by Blackman and Tukey (17). A practical lag function is that denoted as hanning and is given by

$$f_h(\xi) = \begin{cases} \frac{1}{2}\left(1 + \cos\frac{\pi\xi}{\xi_m}\right), & |\xi| < |\xi_m| \\ 0, & |\xi| > |\xi_m| \end{cases} \tag{11}$$

The hanning spectral function, the Fourier transform of $f_h(\xi)$, is

$$\gamma_h(\varkappa) = \frac{1}{2} 2\xi_m \frac{\sin \varkappa\xi_m}{\varkappa\xi_m} + \frac{1}{4}\left\{ 2\xi_m \frac{\sin\left(\varkappa + \frac{1}{2\xi_m}\right)\xi_m}{\left(\varkappa + \frac{1}{2\xi_m}\right)\xi_m} + 2\xi_m \frac{\sin\left(\varkappa - \frac{1}{2\xi_m}\right)\xi_m}{\left(\varkappa - \frac{1}{2\xi_m}\right)\xi_m} \right\} \tag{12}$$

B. Equally Spaced Data. The data from the current meter is not continuous but is equally spaced at intervals of Δx so that values of the autocovariance function can be computed only at lags of $0, \pm\Delta\xi, \pm 2\Delta\xi, \ldots = 0, \pm\Delta x, \pm 2\Delta x, \ldots$ If the data were of infinite length then instead of equation (3) we would have the autocovariance series

$$R(\xi) = R(q\Delta\xi) = R(q\Delta x) = \lim_{N\to\infty} \left\{ \frac{1}{2(N-q)} \sum_{k=-(N-q)}^{N-q} u(k\Delta x)\, u\left[(k+q)\Delta x\right] \right\} \tag{13}$$

If $\phi_a(\varkappa)$ is the Fourier transform of the autocovariance series then

$$R(q\Delta\xi) = \int_{-\pi/\Delta\xi}^{\pi/\Delta\xi} \phi_a(\varkappa)\, e^{i\varkappa q\Delta\xi}\, d\varkappa \tag{14}$$

which is just the expression for the qth coefficient of the Fourier series expansion of the periodic function $\Phi_a(\chi)$ defined in the interval $-\frac{\pi}{\Delta\xi} \leq \chi \leq \frac{\pi}{\Delta\xi}$. Therefore

$$\Phi_a(\chi) = \frac{\Delta\chi}{2\pi}\sum_{q=-\infty}^{\infty} R(q\Delta\xi)\,e^{-i\chi q\Delta\xi} \qquad (15)$$

The $R(q\,\Delta\xi)$ are real and symmetric; hence $\Phi_a(\chi)$ is symmetric and real and equations (14) and (15) reduce to

$$\left.\begin{aligned} R(q\Delta\xi) &= \int_{-\pi/\Delta\xi}^{\pi/\Delta\xi} \Phi_a(\chi)\cos\chi q\Delta\xi\,d\chi \\ \Phi_a(\chi) &= \frac{\Delta\xi}{2\pi}\sum_{q=-\infty}^{\infty} R(q\Delta\xi)\cos\chi q\Delta\xi \end{aligned}\right\} \qquad (16)$$

Since $\Phi_a(\chi)$ is periodic values of $\Phi_a(\chi)$ are not obtained for wave numbers greater than $|\chi_N| = \pi/\Delta\xi$, the Nyquist wave number, although $\Phi(\chi)$ extends to $\pm\infty$.

A second difference exists between $\Phi_a(\chi)$ and $\Phi(\chi)$. The autocovariance series can be considered as the result of sampling $R(\xi)$ at equally spaced values of ξ. For any function of ξ, say $g(\xi)$, the integral

$$\int_{-\infty}^{\infty} g(\xi)\,\delta(\xi - a)\,d\xi$$

where $\delta(\xi - a)$ is the Dirac delta function, generates values of $g(\xi)$ at $\xi = a$. Thus

$$\int_{-\infty}^{\infty} R(\xi)\,\delta(\xi - q\Delta\xi)\,d\xi$$

gives values of $R(\xi)$ at $\xi = q\Delta\xi$ and

$$\int_{-\infty}^{\infty} R(\xi)\cos\varkappa\xi\ \delta(\xi - q\Delta\xi)\,d\xi$$

gives values of the product $R(\xi)\cos\varkappa\xi$ at $\xi = q\Delta\xi$. Thus equation (16b) can be written as

$$\Phi_a(\varkappa) = \frac{\Delta\xi}{2\pi}\sum_{q=-\infty}^{\infty}\int_{-\infty}^{\infty} R(\xi)\cos\varkappa\xi\ \delta(\xi - q\Delta\xi)\,d\xi \tag{17}$$

Changing the order of summation and integration,

$$\Phi_a(\varkappa) = \int_{-\infty}^{\infty} R(\xi)\sum_{q=-\infty}^{\infty}\delta(\xi - q\Delta\xi)\cos\varkappa\xi\,d\xi \tag{18}$$

which expresses $\Phi_a(\varkappa)$ as the Fourier transform of the product

$$2\pi\, R(\xi)\sum_{q=-\infty}^{\infty}\delta(\xi - q\Delta\xi)$$

The transform of $R(\xi)$ is the energy spectrum function $\Phi(\varkappa)$ and that of

$$\sum_{q=-\infty}^{\infty}\delta(\xi - q\Delta\xi)$$

is

$$\frac{1}{\Delta\xi}\sum_{q=-\infty}^{\infty}\delta\left(\frac{\varkappa}{2\pi} - \frac{q}{\Delta\xi}\right)$$

Applying the convolution theorem,

$$\begin{aligned}\Phi_a(\varkappa) &= 2\pi\int_{-\infty}^{\infty}\Phi(\varkappa')\frac{1}{\Delta\xi}\sum_{q=-\infty}^{\infty}\delta\left(\frac{\varkappa-\varkappa'}{2\pi} - \frac{q}{\Delta\xi}\right)d\varkappa' \\ &= \frac{2\pi}{\Delta\xi}\sum_{q=-\infty}^{\infty}\int_{-\infty}^{\infty}\Phi(\varkappa')\,\delta\left(\frac{\varkappa-\varkappa'}{2\pi} - \frac{q}{\Delta\xi}\right)d\varkappa'\end{aligned} \tag{19}$$

changing the order of summation and integration again. Integrating,

$$\varphi_a(\varkappa) = \frac{2\pi}{\Delta\xi} \sum_{q=-\infty}^{\infty} \varphi\left(\frac{\varkappa}{2\pi} - \frac{q}{\Delta\xi}\right)$$

$$= \frac{1}{\Delta\xi} \sum_{q=-\infty}^{\infty} \varphi(\varkappa - 2q\varkappa_N) \tag{20}$$

$$= \frac{1}{\Delta\xi}\left[\varphi(\varkappa) + \varphi(\varkappa - 2\varkappa_N) + \varphi(\varkappa + 2\varkappa_N) + \cdots\right]$$

If $\varphi(\varkappa + 2\varkappa_N)$, $\varphi(\varkappa - 2\varkappa_N)$, etc., are negligible compared to $\varphi(\varkappa)$ then

$$\varphi_a(\varkappa) \simeq \frac{1}{\Delta\xi}\varphi(\varkappa) \tag{21}$$

This requires that

$$\varphi(\varkappa) \simeq 0 \quad \text{for} \quad \varkappa \geq \varkappa_N \tag{22}$$

If condition (22) is not satisfied, the energy spectrum for the equally spaced data is in error at all values of $\varkappa$ (aliasing).

Finite data yields the apparent autocovariance series

$$R_a(q\Delta\xi) = \frac{1}{2(N-q)} \sum_{j=-(N-q)}^{N-q} u(j\Delta\xi)\, u[(j+q)\Delta\xi];$$

$$q = 0, \pm 1, \pm 2, \cdots, \pm m; \tag{23}$$

$$m\Delta\xi = \text{maximum lag}.$$

Values of $R_a(q\Delta\xi)$ are not defined for $q\Delta\xi > m$. As for continuous data the autocovariance series is modified by multiplying by a lag function which is zero for $|q| > m$:

$$R_m(q\Delta\xi) = f(\xi)R_a(q\Delta\xi)\ ; \quad f(\xi) = 0,\ |\xi| > m\Delta\xi \tag{24}$$

Denoting the Fourier transform of the infinite series $R_m(q\Delta\xi)$ by $\phi_{am}(\varkappa)$, we have from equations (16)

$$\left.\begin{aligned} R_m(q\Delta\xi) &= \int_{-\pi/\Delta\xi}^{\pi/\Delta\xi} \phi_{am}(\varkappa)\cos\varkappa q\Delta\xi\, d\varkappa \\ \phi_{am}(\varkappa) &= \frac{\Delta\xi}{2\pi}\sum_{q=-\infty}^{\infty} R_m(q\Delta\xi)\cos\varkappa q\Delta\xi \\ &= \frac{\Delta\xi}{2\pi}\sum_{q=-\infty}^{\infty} R_m(q\Delta\xi)\cos\varkappa q\Delta\xi \end{aligned}\right\} \tag{25}$$

For continuous data the relationship between the computed energy spectrum $\phi_m(\varkappa)$ and the one-dimensional energy spectrum function was found to be

$$\text{avg}\,[\phi_m(\varkappa)] = \int_{-\infty}^{\infty} \phi(\varkappa')\,\gamma(\varkappa-\varkappa')\,d\varkappa' \tag{10}$$

A similar relationship exists for equally spaced finite data. Analgous to equation (7) we have

$$\text{avg}\,[R_m(q\Delta\xi)] = f(q\Delta\xi)R(q\Delta\xi) \tag{26}$$

From equation (25b)

$$\text{avg}\left[\phi_{am}(x)\right] = \frac{\Delta\xi}{2\pi}\sum_{q=-\infty}^{\infty} f(q\Delta\xi)R(q\Delta\xi)\cos xq\Delta\xi \tag{27}$$

As before

$$f(q\Delta\xi)R(q\Delta\xi)\cos xq\Delta\xi = \int_{-\infty}^{\infty} f(\xi)R(\xi)\cos x\xi\,\delta(\xi - q\Delta\xi)\,d\xi \tag{28}$$

and therefore

$$\text{avg}\left[\phi_{am}(x)\right] = \sum_{q=-\infty}^{\infty}\int_{-\infty}^{\infty} f(\xi)R(\xi)\cos x\xi\,\delta(\xi - q\Delta\xi)\,d\xi \tag{29}$$

Following a procedure similar to that prescribed by equations (17), (10), and (19) results in

$$\text{avg}\left[\phi_{am}(x)\right] = \int_{-\infty}^{\infty} \phi_a(x')\gamma(x - x')\,dx' \tag{30}$$

or

$$\text{avg}\left[\phi_{am}(x)\right] = \int_{-\infty}^{\infty} \phi(x')\Gamma(x - x')\,dx' \tag{31}$$

where

$$\Gamma(x) = \frac{1}{\Delta\xi}\sum_{q=-\infty}^{\infty}\gamma(x - 2qx_N) \tag{32}$$

Equation (31) is of the same form as equation (10) and has the same significance.

C. <u>Equations for Computing</u>. With a change in indexing, equation (23) is

$$R_a(q\Delta\xi) = \frac{1}{N-q}\sum_{k=1}^{N-q} u_k u_{k+q} \qquad q = 0, \pm 1, \pm 2, \cdots, \pm m \tag{33}$$

Modifying the apparent autocovariance series according to hanning, equation (11) gives

$$R_m(q\Delta\xi) = \begin{cases} R_a(q\Delta\xi)\,\frac{1}{2}\left(1+\cos\frac{\pi q}{m}\right), & |q| < m \\ 0, & |q| > m \end{cases} \tag{34}$$

The energy spectrum is, from equation (25b),

$$\varphi_{am}(\kappa) = \frac{\Delta\xi}{2\pi}\sum_{q=-m}^{m} R_m(q\Delta\xi)\cos\kappa q\Delta\xi \tag{35}$$

Since $R_m(q\Delta\xi) = R_m(-q\Delta\xi)$ and $R_m(m\Delta\xi) = o$, this can be written as

$$\varphi_{am}(\kappa) = \frac{\Delta\xi}{2\pi}\left[R_m(0) + 2\sum_{q=1}^{m-1} R_m(q\Delta\xi)\cos\kappa q\Delta\xi\right] \tag{36}$$

and if the energy spectrum is referred to positive wave numbers only,

$$2\varphi_{2m}(\mathcal{H}) = \frac{\Delta\xi}{\pi}\sigma(\mathcal{H})\left[R_m(0) + 2\sum_{q=1}^{m-1} R_m(q\Delta\xi)\cos\mathcal{H}q\Delta\xi\right] \tag{37}$$

where $\sigma(\mathcal{H}) = 1/2$ when $\mathcal{H} = 0$, 1 for all other values of $\mathcal{H}$. The usual procedure is to compute $\varphi_{2m}(\mathcal{H})$ at values of $\mathcal{H}$ equally spaced at intervals of $\Delta\mathcal{H} = \frac{\pi}{m\Delta\xi}$. Then

$$2\varphi_{2m}(\ell\Delta\mathcal{H}) = \frac{\Delta\xi}{\pi}\sigma_{\ell 0}\left[R_m(0) + 2\sum_{q=1}^{m-1} R_m(q\Delta\xi)\cos\frac{\ell\pi q}{m}\right] \tag{38}$$

RUN 1 CHANNEL 7

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	300.525	123.074	INFINITY	0	38411.642	127.815
1	275.056	135.528	1961.000	.000510	42298.560	140.749
2	270.622	13.171	980.500	.001020	4110.695	13.678
3	274.441	1.928	653.667	.001530	601.733	2.002
4	274.580	1.693	490.250	.002040	528.389	1.758
5	266.900	1.095	392.200	.002550	341.752	1.137
6	265.260	1.144	326.833	.003060	357.045	1.188
7	263.554	1.069	280.143	.003570	333.637	1.110
8	261.599	.832	245.125	.004080	259.669	.864
9	259.949	.521	217.889	.004589	162.605	.541
10	258.247	.358	196.100	.005099	111.733	.372
11	256.538	.336	178.273	.005609	104.866	.349
12	254.150	.385	163.417	.006119	120.159	.400
13	252.837	.327	150.846	.006629	102.057	.340
14	250.637	.289	140.071	.007139	90.197	.300
15	248.305	.278	130.733	.007649	86.764	.289
16	245.971	.296	122.563	.008159	92.382	.307
17	243.215	.349	115.353	.008669	108.924	.362
18	240.190	.430	108.944	.009179	134.204	.447
19	237.002	.521	103.211	.009689	162.605	.541
20	234.364	.561	98.050	.010199	175.089	.583
21	231.972	.594	93.381	.010709	185.389	.617
22	229.746	.692	89.136	.011219	215.975	.719
23	226.727	.767	85.261	.011729	239.382	.797
24	224.725	.785	81.708	.012239	245.000	.815
25	222.213	.799	78.440	.012749	249.369	.830
26	220.043	.805	75.423	.013259	251.242	.836
27	216.901	.833	72.630	.013768	259.981	.865
28	214.231	.868	70.036	.014278	270.905	.901
29	211.388	.831	67.621	.014788	259.357	.863
30	208.350	.774	65.367	.015298	241.567	.804
31	206.169	.727	63.258	.015808	226.898	.755
32	203.066	.656	61.281	.016318	204.739	.681
33	200.353	.574	59.424	.016828	179.147	.596
34	196.975	.507	57.676	.017338	158.236	.527
35	194.932	.464	56.029	.017848	144.815	.482
36	191.556	.426	54.472	.018358	132.955	.442
37	188.789	.398	53.000	.018868	124.217	.413
38	185.401	.372	51.605	.019378	116.102	.386
39	183.535	.333	50.282	.019888	103.930	.346
40	180.900	.303	49.025	.020398	94.567	.315
41	178.580	.305	47.829	.020908	95.191	.317
42	176.143	.328	46.690	.021418	102.369	.341
43	173.567	.342	45.605	.021928	106.739	.355
44	170.339	.361	44.568	.022438	112.669	.375
45	167.264	.436	43.578	.022947	136.076	.453
46	164.609	.477	42.630	.023457	148.873	.495
47	161.081	.436	41.723	.023967	136.076	.453
48	159.044	.446	40.854	.024477	139.197	.463
49	155.670	.472	40.020	.024987	147.312	.490
50	153.159	.231	39.220	.025497	72.096	.240

Appendix V

Numerical Tabulation of Results

RUN 1 CHANNEL 7

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	57.033	22.153	INFINITY	0	6913.996	121.228
1	53.860	25.526	1961.000	.000510	7966.716	139.686
2	53.519	3.910	980.500	.001020	1220.319	21.397
3	52.497	.975	653.667	.001530	304.299	5.335
4	51.520	.592	490.250	.002040	184.764	3.240
5	50.831	.355	392.200	.002550	110.796	1.943
6	49.971	.324	326.833	.003060	101.121	1.773
7	49.332	.199	280.143	.003570	62.108	1.089
8	48.802	.167	245.125	.004080	52.121	.914
9	48.309	.207	217.889	.004589	64.605	1.133
10	47.443	.192	196.100	.005099	59.924	1.051
11	46.857	.135	178.273	.005609	42.134	.739
12	46.060	.111	163.417	.006119	34.643	.607
13	45.016	.092	150.846	.006629	28.713	.503
14	44.535	.064	140.071	.007139	19.975	.350
15	43.851	.049	130.733	.007649	15.293	.268
16	43.286	.053	122.563	.008159	16.541	.290
17	42.407	.049	115.353	.008669	15.293	.268
18	41.831	.044	108.944	.009179	13.732	.241
19	41.519	.061	103.211	.009689	19.038	.334
20	40.589	.074	98.050	.010199	23.096	.405
21	40.065	.059	93.381	.010709	18.414	.323
22	39.086	.042	89.136	.011219	13.108	.230
23	38.814	.041	85.261	.011729	12.796	.224
24	37.607	.044	81.708	.012239	13.732	.241
25	37.287	.052	78.440	.012749	16.229	.285
26	36.467	.070	75.423	.013259	21.847	.383
27	35.751	.066	72.630	.013768	20.599	.361
28	35.308	.032	70.036	.014278	9.987	.175
29	34.774	.023	67.621	.014788	7.178	.126
30	34.694	.037	65.367	.015298	11.548	.202
31	34.049	.045	63.258	.015808	14.045	.246
32	33.372	.057	61.281	.016318	17.790	.312
33	32.937	.057	59.424	.016828	17.790	.312
34	32.283	.060	57.676	.017338	18.726	.328
35	31.613	.073	56.029	.017848	22.783	.399
36	30.825	.074	54.472	.018358	23.096	.405
37	30.270	.064	53.000	.018868	19.975	.350
38	29.556	.056	51.605	.019378	17.478	.306
39	28.593	.063	50.282	.019888	19.662	.345
40	28.329	.058	49.025	.020398	18.102	.317
41	27.466	.043	47.829	.020908	13.420	.235
42	26.855	.072	46.690	.021418	22.471	.394
43	26.254	.105	45.605	.021928	32.771	.575
44	25.797	.085	44.568	.022438	26.529	.465
45	24.910	.049	43.578	.022947	15.293	.268
46	24.534	.043	42.630	.023457	13.420	.235
47	23.856	.070	41.723	.023967	21.847	.383
48	23.303	.079	40.854	.024477	24.656	.432
49	22.798	.056	40.020	.024987	17.478	.306
50	21.778	.022	39.220	.025497	6.866	.120

RUN 1 CHANNEL 7

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	94.965	36.966	INFINITY	0	11537.163	121.489
1	91.629	42.411	1961.000	.000510	13236.558	139.384
2	90.403	6.820	980.500	.001020	2128.536	22.414
3	89.044	2.579	653.667	.001530	804.911	8.476
4	87.114	1.418	490.250	.002040	442.561	4.660
5	85.955	.542	392.200	.002550	169.159	1.781
6	84.375	.485	326.833	.003060	151.369	1.594
7	82.669	.346	280.143	.003570	107.987	1.137
8	81.231	.293	245.125	.004080	91.446	.963
9	79.410	.210	217.889	.004589	65.541	.690
10	78.517	.198	196.100	.005099	61.796	.651
11	77.082	.173	178.273	.005609	53.994	.569
12	75.574	.121	163.417	.006119	37.764	.398
13	74.056	.075	150.846	.006629	23.408	.246
14	72.516	.074	140.071	.007139	23.096	.243
15	71.332	.097	130.733	.007649	30.274	.319
16	70.168	.102	122.563	.008159	31.834	.335
17	69.441	.110	115.353	.008669	34.331	.362
18	67.984	.123	108.944	.009179	38.389	.404
19	66.989	.100	103.211	.009689	31.210	.329
20	66.211	.067	98.050	.010199	20.911	.220
21	65.287	.038	93.381	.010709	11.860	.125
22	64.470	.025	89.136	.011219	7.803	.082
23	63.572	.047	85.261	.011729	14.669	.154
24	62.993	.065	81.708	.012239	20.287	.214
25	62.617	.047	78.440	.012749	14.669	.154
26	62.017	.036	75.423	.013259	11.236	.118
27	61.462	.053	72.630	.013768	16.541	.174
28	60.843	.063	70.036	.014278	19.662	.207
29	60.146	.066	67.621	.014788	20.599	.217
30	59.573	.074	65.367	.015298	23.096	.243
31	58.524	.054	63.258	.015808	16.854	.177
32	57.968	.043	61.281	.016318	13.420	.141
33	57.310	.052	59.424	.016828	16.229	.171
34	56.516	.053	57.676	.017338	16.541	.174
35	55.166	.073	56.029	.017848	22.783	.240
36	54.299	.086	54.472	.018358	26.841	.283
37	53.346	.078	53.000	.018868	24.344	.256
38	51.813	.076	51.605	.019378	23.720	.250
39	50.819	.080	50.282	.019888	24.968	.263
40	49.225	.094	49.025	.020398	29.338	.309
41	47.222	.087	47.829	.020908	27.153	.286
42	45.733	.052	46.690	.021418	16.229	.171
43	43.885	.035	45.605	.021928	10.924	.115
44	42.048	.027	44.568	.022438	8.427	.089
45	40.351	.026	43.578	.022947	8.115	.085
46	38.602	.044	42.630	.023457	13.732	.145
47	37.029	.057	41.723	.023967	17.790	.187
48	34.997	.051	40.854	.024477	15.917	.168
49	33.185	.048	40.020	.024987	14.981	.158
50	31.481	.026	39.220	.025497	8.115	.085

RUN 1 CHANNEL 7

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	92.103	31.822	INFINITY	0	9931.710	107.833
1	88.326	40.558	1961.000	.000510	12658.233	137.436
2	87.197	10.125	980.500	.001020	3160.033	34.310
3	85.488	2.524	653.667	.001530	787.745	8.553
4	83.581	1.675	490.250	.002040	522.771	5.676
5	81.378	.832	392.200	.002550	259.669	2.819
6	79.317	.529	326.833	.003060	165.102	1.793
7	77.268	.465	280.143	.003570	145.127	1.576
8	75.103	.334	245.125	.004080	104.242	1.132
9	73.346	.225	217.889	.004589	70.223	.762
10	71.629	.212	196.100	.005099	66.166	.718
11	69.959	.141	178.273	.005609	44.006	.478
12	67.702	.083	163.417	.006119	25.904	.281
13	66.009	.073	150.846	.006629	22.783	.247
14	63.975	.065	140.071	.007139	20.287	.220
15	62.338	.065	130.733	.007649	20.287	.220
16	60.418	.073	122.563	.008159	22.783	.247
17	58.754	.075	115.353	.008669	23.408	.254
18	57.203	.093	108.944	.009179	29.025	.315
19	55.268	.097	103.211	.009689	30.274	.329
20	53.882	.071	98.050	.010199	22.159	.241
21	52.320	.066	93.381	.010709	20.599	.224
22	50.562	.070	89.136	.011219	21.847	.237
23	49.084	.050	85.261	.011729	15.605	.169
24	47.651	.047	81.708	.012239	14.669	.159
25	45.818	.063	78.440	.012749	19.662	.213
26	44.571	.063	75.423	.013259	19.662	.213
27	43.201	.067	72.630	.013768	20.911	.227
28	41.490	.082	70.036	.014278	25.592	.278
29	39.794	.090	67.621	.014788	28.089	.305
30	38.054	.085	65.367	.015298	26.529	.288
31	36.305	.059	63.258	.015808	18.414	.200
32	34.562	.050	61.281	.016318	15.605	.169
33	32.533	.072	59.424	.016828	22.471	.244
34	30.599	.078	57.676	.017338	24.344	.264
35	28.825	.057	56.029	.017848	17.790	.193
36	27.748	.045	54.472	.018358	14.045	.152
37	26.201	.059	53.000	.018868	18.414	.200
38	24.978	.077	51.605	.019378	24.032	.261
39	23.684	.077	50.282	.019888	24.032	.261
40	22.596	.062	49.025	.020398	19.350	.210
41	21.360	.054	47.829	.020908	16.854	.183
42	20.076	.054	46.690	.021418	16.854	.183
43	19.247	.053	45.605	.021928	16.541	.180
44	17.746	.076	44.568	.022438	23.720	.258
45	17.015	.091	43.578	.022947	28.401	.308
46	15.667	.090	42.630	.023457	28.089	.305
47	14.725	.082	41.723	.023967	25.592	.278
48	13.686	.061	40.854	.024477	19.038	.207
49	12.648	.055	40.020	.024987	17.166	.186
50	11.593	.030	39.220	.025497	9.363	.102

RUN 1 CHANNEL 7

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	18.907	3.965	INFINITY	0	1237.484	65.451
1	15.545	5.775	1961.000	.000510	1802.389	95.329
2	14.966	2.553	980.500	.001020	796.796	42.143
3	13.843	1.323	653.667	.001530	412.911	21.839
4	12.820	.864	490.250	.002040	269.656	14.262
5	11.811	.505	392.200	.002550	157.612	8.336
6	10.919	.302	326.833	.003060	94.255	4.985
7	10.446	.239	280.143	.003570	74.592	3.945
8	9.783	.327	245.125	.004080	102.057	5.398
9	9.418	.279	217.889	.004589	87.076	4.606
10	8.719	.174	196.100	.005099	54.306	2.872
11	8.415	.142	178.273	.005609	44.318	2.344
12	7.932	.126	163.417	.006119	39.325	2.080
13	7.095	.082	150.846	.006629	25.592	1.354
14	6.504	.068	140.071	.007139	21.223	1.122
15	6.106	.063	130.733	.007649	19.662	1.040
16	5.909	.059	122.563	.008159	18.414	.974
17	5.462	.063	115.353	.008669	19.662	1.040
18	5.127	.070	108.944	.009179	21.847	1.156
19	4.792	.076	103.211	.009689	23.720	1.255
20	5.018	.059	98.050	.010199	18.414	.974
21	5.024	.027	93.381	.010709	8.427	.446
22	4.740	.028	89.136	.011219	8.739	.462
23	4.587	.059	85.261	.011729	18.414	.974
24	4.772	.081	81.708	.012239	25.280	1.337
25	4.374	.088	78.440	.012749	27.465	1.453
26	4.187	.071	75.423	.013259	22.159	1.172
27	3.723	.043	72.630	.013768	13.420	.710
28	3.513	.053	70.036	.014278	16.541	.875
29	2.806	.066	67.621	.014788	20.599	1.089
30	2.963	.052	65.367	.015298	16.229	.858
31	2.631	.044	63.258	.015808	13.732	.726
32	2.689	.054	61.281	.016318	16.854	.891
33	2.550	.071	59.424	.016828	22.159	1.172
34	2.550	.072	57.676	.017338	22.471	1.189
35	2.849	.057	56.029	.017848	17.790	.941
36	2.254	.051	54.472	.018358	15.917	.842
37	2.159	.055	53.000	.018868	17.166	.908
38	1.702	.053	51.605	.019378	16.541	.875
39	1.582	.054	50.282	.019888	16.854	.891
40	1.045	.062	49.025	.020398	19.350	1.023
41	.673	.058	47.829	.020908	18.102	.957
42	.468	.068	46.690	.021418	21.223	1.122
43	-0.177	.092	45.605	.021928	28.713	1.519
44	-0.625	.077	44.568	.022438	24.032	1.271
45	-1.535	.072	43.578	.022947	22.471	1.189
46	-2.013	.084	42.630	.023457	26.217	1.387
47	-2.698	.060	41.723	.023967	18.726	.990
48	-3.300	.043	40.854	.024477	13.420	.710
49	-3.734	.061	40.020	.024987	19.038	1.007
50	-4.193	.038	39.220	.025497	11.860	.627

RUN 1 CHANNEL 7

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	82.157	27.736	INFINITY	0	8656.461	105.365
1	71.276	32.661	1961.000	.000510	10193.563	124.074
2	69.293	5.769	980.500	.001020	1800.516	21.916
3	67.173	1.547	653.667	.001530	482.822	5.877
4	65.625	1.301	490.250	.002040	406.045	4.942
5	64.305	1.225	392.200	.002550	382.325	4.654
6	63.415	.958	326.833	.003060	298.994	3.639
7	62.543	.535	280.143	.003570	166.975	2.032
8	61.377	.443	245.125	.004080	138.261	1.683
9	59.522	.420	217.889	.004589	131.083	1.596
10	57.705	.332	196.100	.005099	103.618	1.261
11	56.976	.320	178.273	.005609	99.873	1.216
12	56.537	.314	163.417	.006119	98.000	1.193
13	56.945	.418	150.846	.006629	130.459	1.588
14	56.438	.584	140.071	.007139	182.268	2.219
15	54.986	.482	130.733	.007649	150.433	1.831
16	54.161	.286	122.563	.008159	89.261	1.086
17	53.102	.201	115.353	.008669	62.733	.764
18	52.394	.186	108.944	.009179	58.051	.707
19	51.401	.189	103.211	.009689	58.987	.718
20	51.235	.166	98.050	.010199	51.809	.631
21	50.952	.192	93.381	.010709	59.924	.729
22	48.772	.237	89.136	.011219	73.968	.900
23	47.848	.268	85.261	.011729	83.643	1.018
24	45.810	.265	81.708	.012239	82.707	1.007
25	44.375	.210	78.440	.012749	65.541	.798
26	44.238	.189	75.423	.013259	58.987	.718
27	42.933	.199	72.630	.013768	62.108	.756
28	42.108	.202	70.036	.014278	63.045	.767
29	41.091	.228	67.621	.014788	71.159	.866
30	40.037	.240	65.367	.015298	74.904	.912
31	38.812	.188	63.258	.015808	58.675	.714
32	38.519	.155	61.281	.016318	48.376	.589
33	38.041	.172	59.424	.016828	53.682	.653
34	38.061	.217	57.676	.017338	67.726	.824
35	37.454	.224	56.029	.017848	69.911	.851
36	36.376	.173	54.472	.018358	53.994	.657
37	36.345	.195	53.000	.018868	60.860	.741
38	33.960	.250	51.605	.019378	78.025	.950
39	32.984	.221	50.282	.019888	68.975	.840
40	31.976	.166	49.025	.020398	51.809	.631
41	31.773	.146	47.829	.020908	45.567	.555
42	31.448	.174	46.690	.021418	54.306	.661
43	31.030	.238	45.605	.021928	74.280	.904
44	29.782	.224	44.568	.022438	69.911	.851
45	28.377	.187	43.578	.022947	58.363	.710
46	28.838	.210	42.630	.023457	65.541	.798
47	28.194	.210	41.723	.023967	65.541	.798
48	27.184	.202	40.854	.024477	63.045	.767
49	26.785	.204	40.020	.024987	63.669	.775
50	27.415	.099	39.220	.025497	30.898	.376

RUN 1 CHANNEL 7

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	40.603	10.224	INFINITY	0	3190.931	78.589
1	36.194	14.701	1961.000	.000510	4588.212	113.002
2	35.308	5.928	980.500	.001020	1850.141	45.567
3	33.344	2.277	653.667	.001530	710.656	17.503
4	31.735	1.382	490.250	.002040	431.325	10.623
5	30.203	.901	392.200	.002550	281.204	6.926
6	28.727	.542	326.833	.003060	169.159	4.166
7	27.524	.380	280.143	.003570	118.599	2.921
8	26.564	.286	245.125	.004080	89.261	2.198
9	24.383	.191	217.889	.004589	59.611	1.468
10	23.591	.228	196.100	.005099	71.159	1.753
11	21.816	.265	178.273	.005609	82.707	2.037
12	20.878	.184	163.417	.006119	57.427	1.414
13	19.989	.141	150.846	.006629	44.006	1.084
14	19.001	.162	140.071	.007139	50.561	1.245
15	18.092	.152	130.733	.007649	47.440	1.168
16	17.185	.120	122.563	.008159	37.452	.922
17	16.458	.066	115.353	.008669	20.599	.507
18	15.795	.041	108.944	.009179	12.796	.315
19	15.173	.054	103.211	.009689	16.854	.415
20	14.377	.068	98.050	.010199	21.223	.523
21	13.323	.072	93.381	.010709	22.471	.553
22	12.524	.066	89.136	.011219	20.599	.507
23	11.646	.077	85.261	.011729	24.032	.592
24	11.038	.079	81.708	.012239	24.656	.607
25	10.753	.065	78.440	.012749	20.287	.500
26	10.061	.079	75.423	.013259	24.656	.607
27	9.808	.088	72.630	.013768	27.465	.676
28	8.516	.075	70.036	.014278	23.408	.577
29	8.274	.070	67.621	.014788	21.847	.538
30	7.417	.078	65.367	.015298	24.344	.600
31	6.329	.068	63.258	.015808	21.223	.523
32	5.930	.048	61.281	.016318	14.981	.369
33	5.283	.045	59.424	.016828	14.045	.346
34	5.165	.045	57.676	.017338	14.045	.346
35	4.907	.049	56.029	.017848	15.293	.377
36	4.560	.064	54.472	.018358	19.975	.492
37	4.879	.098	53.000	.018868	30.586	.753
38	4.101	.110	51.605	.019378	34.331	.846
39	3.947	.097	50.282	.019888	30.274	.746
40	3.233	.126	49.025	.020398	39.325	.969
41	2.886	.125	47.829	.020908	39.013	.961
42	3.104	.067	46.690	.021418	20.911	.515
43	2.787	.053	45.605	.021928	16.541	.407
44	2.370	.063	44.568	.022438	19.662	.484
45	2.148	.057	43.578	.022947	17.790	.438
46	1.705	.058	42.630	.023457	18.102	.446
47	1.241	.081	41.723	.023967	25.280	.623
48	.271	.118	40.854	.024477	36.828	.907
49	.265	.128	40.020	.024987	39.949	.984
50	-0.271	.059	39.220	.025497	18.414	.454

RUN 1 CHANNEL 7

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	15.693	3.496	INFINITY	0	1091.109	69.528
1	13.229	5.504	1961.000	.000510	1717.809	109.463
2	13.371	2.675	980.500	.001020	834.873	53.200
3	12.730	.946	653.667	.001530	295.248	18.814
4	11.912	.464	490.250	.002040	144.815	9.228
5	11.666	.285	392.200	.002550	88.949	5.668
6	10.775	.181	326.833	.003060	56.490	3.600
7	10.284	.143	280.143	.003570	44.631	2.844
8	9.669	.110	245.125	.004080	34.331	2.188
9	9.156	.085	217.889	.004589	26.529	1.690
10	8.686	.071	196.100	.005099	22.159	1.412
11	8.029	.061	178.273	.005609	19.038	1.213
12	7.654	.049	163.417	.006119	15.293	.975
13	7.114	.034	150.846	.006629	10.611	.676
14	6.483	.026	140.071	.007139	8.115	.517
15	6.134	.035	130.733	.007649	10.924	.696
16	5.518	.045	122.563	.008159	14.045	.895
17	5.279	.041	115.353	.008669	12.796	.815
18	4.904	.035	108.944	.009179	10.924	.696
19	4.354	.031	103.211	.009689	9.675	.617
20	3.981	.028	98.050	.010199	8.739	.557
21	3.657	.031	93.381	.010709	9.675	.617
22	3.179	.037	89.136	.011219	11.548	.736
23	3.025	.041	85.261	.011729	12.796	.815
24	2.619	.033	81.708	.012239	10.299	.656
25	2.300	.021	78.440	.012749	6.554	.418
26	2.231	.024	75.423	.013259	7.490	.477
27	1.679	.027	72.630	.013768	8.427	.537
28	1.528	.026	70.036	.014278	8.115	.517
29	1.198	.028	67.621	.014788	8.739	.557
30	1.037	.032	65.367	.015298	9.987	.636
31	.836	.035	63.258	.015808	10.924	.696
32	.495	.035	61.281	.016318	10.924	.696
33	.495	.046	59.424	.016828	14.357	.915
34	.149	.057	57.676	.017338	17.790	1.134
35	.071	.051	56.029	.017848	15.917	1.014
36	-0.070	.040	54.472	.018358	12.484	.796
37	-0.204	.039	53.000	.018868	12.172	.776
38	-0.101	.060	51.605	.019378	18.726	1.193
39	-0.252	.087	50.282	.019888	27.153	1.730
40	-0.364	.079	49.025	.020398	24.656	1.571
41	-0.244	.068	47.829	.020908	21.223	1.352
42	-0.264	.074	46.690	.021418	23.096	1.472
43	-0.304	.067	45.605	.021928	20.911	1.332
44	-0.286	.048	44.568	.022438	14.981	.955
45	-0.360	.048	43.578	.022947	14.981	.955
46	-0.005	.056	42.630	.023457	17.478	1.114
47	-0.296	.052	41.723	.023967	16.229	1.034
48	.031	.045	40.854	.024477	14.045	.895
49	.138	.039	40.020	.024987	12.172	.776
50	.126	.019	39.220	.025497	5.930	.378

RUN 2 CHANNEL 7

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	23025.710	168.668	INFINITY	0	52641.620	2.286
1	-110.084	375.622	1961.000	.000510	117232.377	5.091
2	-122.883	425.686	980.500	.001020	132857.452	5.770
3	-173.876	448.754	653.667	.001530	140057.021	6.083
4	-246.009	464.773	490.250	.002040	145056.583	6.300
5	-255.962	473.296	392.200	.002550	147716.628	6.415
6	-266.275	479.996	326.833	.003060	149807.712	6.506
7	-273.635	483.976	280.143	.003570	151049.878	6.560
8	-205.602	483.831	245.125	.004080	151004.623	6.558
9	-174.188	477.432	217.889	.004589	149007.482	6.471
10	-146.869	471.169	196.100	.005099	147052.787	6.386
11	-137.320	471.080	178.273	.005609	147025.010	6.385
12	-118.374	469.499	163.417	.006119	146531.577	6.364
13	-102.134	464.373	150.846	.006629	144931.742	6.294
14	-86.637	461.621	140.071	.007139	144072.837	6.257
15	-90.471	460.554	130.733	.007649	143739.825	6.243
16	-87.159	459.275	122.563	.008159	143340.646	6.225
17	-64.043	460.526	115.353	.008669	143731.086	6.242
18	-78.621	461.943	108.944	.009179	144173.334	6.261
19	-91.444	460.609	103.211	.009689	143756.990	6.243
20	-101.077	460.299	98.050	.010199	143660.238	6.239
21	-78.139	462.491	93.381	.010709	144344.366	6.269
22	-75.292	463.797	89.136	.011219	144751.971	6.287
23	-61.925	463.251	85.261	.011729	144581.564	6.279
24	-52.422	462.132	81.708	.012239	144232.321	6.264
25	-49.473	460.871	78.440	.012749	143838.761	6.247
26	-46.074	459.481	75.423	.013259	143404.939	6.228
27	-48.309	459.326	72.630	.013768	143356.563	6.226
28	-30.975	461.443	70.036	.014278	144017.283	6.255
29	-72.414	461.876	67.621	.014788	144152.423	6.260
30	-75.144	460.781	65.367	.015298	143810.672	6.246
31	-78.276	461.165	63.258	.015808	143930.519	6.251
32	-56.057	461.861	61.281	.016318	144147.742	6.260
33	-46.627	463.024	59.424	.016828	144510.716	6.276
34	-49.576	463.809	57.676	.017338	144755.717	6.287
35	-39.403	464.298	56.029	.017848	144908.334	6.293
36	-57.083	464.922	54.472	.018358	145103.086	6.302
37	-66.496	464.304	53.000	.018868	144910.207	6.293
38	-71.197	463.859	51.605	.019378	144771.322	6.287
39	-55.295	463.859	50.282	.019888	144771.322	6.287
40	-86.081	463.404	49.025	.020398	144629.315	6.281
41	-80.498	462.658	47.829	.020908	144396.487	6.271
42	-63.788	462.702	46.690	.021418	144410.220	6.272
43	-85.487	462.892	45.605	.021928	144469.519	6.274
44	-75.124	461.059	44.568	.022438	143897.436	6.249
45	-65.006	460.438	43.578	.022947	143703.621	6.241
46	-54.906	462.337	42.630	.023457	144296.302	6.267
47	-58.946	463.128	41.723	.023967	144543.175	6.277
48	-62.037	462.896	40.854	.024477	144470.767	6.274
49	-80.379	463.051	40.020	.024987	144519.143	6.276
50	-87.018	231.614	39.220	.025497	72287.193	3.139

RUN 2 CHANNEL 7

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	60.956	19.261	INFINITY	0	6011.397	98.619
1	58.142	21.911	1961.000	.000510	6838.467	112.187
2	56.146	3.370	980.500	.001020	1051.784	17.255
3	52.403	3.085	653.667	.001530	962.835	15.796
4	48.811	4.586	490.250	.002040	1431.300	23.481
5	44.792	3.376	392.200	.002550	1053.656	17.286
6	41.268	1.480	326.833	.003060	461.911	7.578
7	38.434	.689	280.143	.003570	215.038	3.528
8	35.917	.597	245.125	.004080	186.325	3.057
9	34.035	.388	217.889	.004589	121.096	1.987
10	32.581	.311	196.100	.005099	97.064	1.592
11	31.601	.233	178.273	.005609	72.720	1.193
12	31.321	.122	163.417	.006119	38.076	.625
13	31.221	.101	150.846	.006629	31.522	.517
14	31.967	.094	140.071	.007139	29.338	.481
15	32.713	.061	130.733	.007649	19.038	.312
16	33.879	.031	122.563	.008159	9.675	.159
17	35.126	.022	115.353	.008669	6.866	.113
18	36.443	.030	108.944	.009179	9.363	.154
19	37.724	.037	103.211	.009689	11.548	.189
20	38.842	.036	98.050	.010199	11.236	.184
21	39.650	.029	93.381	.010709	9.051	.148
22	39.925	.029	89.136	.011219	9.051	.148
23	39.854	.037	85.261	.011729	11.548	.189
24	39.266	.039	81.708	.012239	12.172	.200
25	38.818	.034	78.440	.012749	10.611	.174
26	37.556	.032	75.423	.013259	9.987	.164
27	36.632	.040	72.630	.013768	12.484	.205
28	34.724	.038	70.036	.014278	11.860	.195
29	33.543	.030	67.621	.014788	9.363	.154
30	31.489	.029	65.367	.015298	9.051	.148
31	29.988	.028	63.258	.015808	8.739	.143
32	28.377	.024	61.281	.016318	7.490	.123
33	27.422	.026	59.424	.016828	8.115	.133
34	26.374	.032	57.676	.017338	9.987	.164
35	26.017	.027	56.029	.017848	8.427	.138
36	25.599	.025	54.472	.018358	7.803	.128
37	25.294	.027	53.000	.018868	8.427	.138
38	24.920	.020	51.605	.019378	6.242	.102
39	24.258	.021	50.282	.019888	6.554	.108
40	23.459	.039	49.025	.020398	12.172	.200
41	22.382	.053	47.829	.020908	16.541	.271
42	21.127	.055	46.690	.021418	17.166	.282
43	19.968	.054	45.605	.021928	16.854	.276
44	18.853	.066	44.568	.022438	20.599	.338
45	17.712	.062	43.578	.022947	19.350	.317
46	16.696	.030	42.630	.023457	9.363	.154
47	16.214	.038	41.723	.023967	11.860	.195
48	15.324	.079	40.854	.024477	24.656	.404
49	15.227	.070	40.020	.024987	21.847	.358
50	14.752	.022	39.220	.025497	6.866	.113

RUN 2 CHANNEL 7

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	67.445	17.370	INFINITY	0	5421.212	80.380
1	63.328	22.607	1961.000	.000510	7055.690	104.614
2	59.762	8.455	980.500	.001020	2638.822	39.126
3	55.636	5.732	653.667	.001530	1788.969	26.525
4	51.969	3.970	490.250	.002040	1239.045	18.371
5	48.356	2.018	392.200	.002550	629.822	9.338
6	45.296	.833	326.833	.003060	259.981	3.855
7	42.673	.554	280.143	.003570	172.905	2.564
8	40.602	.548	245.125	.004080	171.032	2.536
9	38.192	.739	217.889	.004589	230.643	3.420
10	35.756	.904	196.100	.005099	282.140	4.183
11	32.950	.569	178.273	.005609	177.586	2.633
12	30.153	.249	163.417	.006119	77.713	1.152
13	28.056	.208	150.846	.006629	64.917	.963
14	25.683	.185	140.071	.007139	57.739	.856
15	24.485	.168	130.733	.007649	52.433	.777
16	23.715	.149	122.563	.008159	46.503	.689
17	23.755	.106	115.353	.008669	33.083	.491
18	24.281	.078	108.944	.009179	24.344	.361
19	25.052	.095	103.211	.009689	29.650	.440
20	25.420	.122	98.050	.010199	38.076	.565
21	25.471	.117	93.381	.010709	36.516	.541
22	24.797	.096	89.136	.011219	29.962	.444
23	24.454	.087	85.261	.011729	27.153	.403
24	24.108	.094	81.708	.012239	29.338	.435
25	23.838	.090	78.440	.012749	28.089	.416
26	23.589	.061	75.423	.013259	19.038	.282
27	23.623	.054	72.630	.013768	16.854	.250
28	23.895	.057	70.036	.014278	17.790	.264
29	23.751	.061	67.621	.014788	19.038	.282
30	23.521	.063	65.367	.015298	19.662	.292
31	22.550	.053	63.258	.015808	16.541	.245
32	21.602	.055	61.281	.016318	17.166	.255
33	20.251	.052	59.424	.016828	16.229	.241
34	19.498	.037	57.676	.017338	11.548	.171
35	18.586	.034	56.029	.017848	10.611	.157
36	18.861	.041	54.472	.018358	12.796	.190
37	18.901	.054	53.000	.018868	16.854	.250
38	19.204	.068	51.605	.019378	21.223	.315
39	19.410	.071	50.282	.019888	22.159	.329
40	19.616	.056	49.025	.020398	17.478	.259
41	19.134	.041	47.829	.020908	12.796	.190
42	18.206	.032	46.690	.021418	9.987	.148
43	17.922	.035	45.605	.021928	10.924	.162
44	17.173	.045	44.568	.022438	14.045	.208
45	16.736	.043	43.578	.022947	13.420	.199
46	16.402	.062	42.630	.023457	19.350	.287
47	17.061	.088	41.723	.023967	27.465	.407
48	17.333	.066	40.854	.024477	20.599	.305
49	17.637	.049	40.020	.024987	15.293	.227
50	17.745	.026	39.220	.025497	8.115	.120

RUN 2 CHANNEL 7

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	65.037	16.734	INFINITY	0	5222.715	80.304
1	60.721	24.537	1961.000	.000510	7658.047	117.749
2	57.910	9.313	980.500	.001020	2906.606	44.692
3	54.017	2.632	653.667	.001530	821.452	12.631
4	50.433	2.019	490.250	.002040	630.134	9.689
5	47.046	1.717	392.200	.002550	535.879	8.240
6	44.965	1.135	326.833	.003060	354.236	5.447
7	43.226	.735	280.143	.003570	229.395	3.527
8	41.932	.970	245.125	.004080	302.739	4.655
9	41.105	1.030	217.889	.004589	321.465	4.943
10	39.973	.702	196.100	.005099	219.096	3.369
11	38.630	.395	178.273	.005609	123.280	1.896
12	36.703	.304	163.417	.006119	94.879	1.459
13	35.033	.209	150.846	.006629	65.229	1.003
14	32.814	.135	140.071	.007139	42.134	.648
15	31.387	.102	130.733	.007649	31.834	.489
16	29.713	.104	122.563	.008159	32.459	.499
17	28.618	.110	115.353	.008669	34.331	.528
18	27.280	.082	108.944	.009179	25.592	.394
19	26.703	.082	103.211	.009689	25.592	.394
20	25.687	.100	98.050	.010199	31.210	.480
21	24.563	.071	93.381	.010709	22.159	.341
22	23.311	.045	89.136	.011219	14.045	.216
23	21.757	.057	85.261	.011729	17.790	.274
24	19.726	.064	81.708	.012239	19.975	.307
25	17.770	.062	78.440	.012749	19.350	.298
26	15.413	.057	75.423	.013259	17.790	.274
27	12.725	.062	72.630	.013768	19.350	.298
28	11.313	.068	70.036	.014278	21.223	.326
29	9.894	.058	67.621	.014788	18.102	.278
30	8.691	.071	65.367	.015298	22.159	.341
31	7.854	.094	63.258	.015808	29.338	.451
32	6.953	.085	61.281	.016318	26.529	.408
33	6.233	.052	59.424	.016828	16.229	.250
34	5.535	.049	57.676	.017338	15.293	.235
35	4.768	.070	56.029	.017848	21.847	.336
36	3.490	.063	54.472	.018358	19.662	.302
37	2.255	.044	53.000	.018868	13.732	.211
38	1.004	.048	51.605	.019378	14.981	.230
39	.283	.061	50.282	.019888	19.038	.293
40	-0.746	.056	49.025	.020398	17.478	.269
41	-1.817	.050	47.829	.020908	15.605	.240
42	-3.248	.055	46.690	.021418	17.166	.264
43	-4.349	.054	45.605	.021928	16.854	.259
44	-6.393	.050	44.568	.022438	15.605	.240
45	-8.271	.069	43.578	.022947	21.535	.331
46	-9.875	.104	42.630	.023457	32.459	.499
47	-11.580	.106	41.723	.023967	33.083	.509
48	-13.459	.084	40.854	.024477	26.217	.403
49	-14.531	.059	40.020	.024987	18.414	.283
50	-15.641	.022	39.220	.025497	6.866	.106

RUN 2 CHANNEL 7

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	52.492	17.139	INFINITY	0	5349.116	101.903
1	48.830	21.416	1961.000	.000510	6683.976	127.333
2	47.257	5.332	980.500	.001020	1664.128	31.703
3	45.395	1.559	653.667	.001530	486.567	9.269
4	43.622	.721	490.250	.002040	225.026	4.287
5	41.914	.556	392.200	.002550	173.529	3.306
6	40.640	.775	326.833	.003060	241.879	4.608
7	39.988	.731	280.143	.003570	228.147	4.346
8	39.397	.510	245.125	.004080	159.172	3.032
9	38.569	.410	217.889	.004589	127.962	2.438
10	37.977	.300	196.100	.005099	93.631	1.784
11	37.465	.218	178.273	.005609	68.038	1.296
12	36.828	.194	163.417	.006119	60.548	1.153
13	35.870	.161	150.846	.006629	50.248	.957
14	35.155	.137	140.071	.007139	42.758	.815
15	34.081	.111	130.733	.007649	34.643	.660
16	32.999	.089	122.563	.008159	27.777	.529
17	31.666	.062	115.353	.008669	19.350	.369
18	30.517	.061	108.944	.009179	19.038	.363
19	29.399	.075	103.211	.009689	23.408	.446
20	28.205	.067	98.050	.010199	20.911	.398
21	27.513	.048	93.381	.010709	14.981	.285
22	26.224	.058	89.136	.011219	18.102	.345
23	25.576	.076	85.261	.011729	23.720	.452
24	24.688	.077	81.708	.012239	24.032	.458
25	24.118	.079	78.440	.012749	24.656	.470
26	23.797	.093	75.423	.013259	29.025	.553
27	23.108	.093	72.630	.013768	29.025	.553
28	22.678	.073	70.036	.014278	22.783	.434
29	22.230	.069	67.621	.014788	21.535	.410
30	22.109	.057	65.367	.015298	17.790	.339
31	21.780	.043	63.258	.015808	13.420	.256
32	21.157	.052	61.281	.016318	16.229	.309
33	20.477	.055	59.424	.016828	17.166	.327
34	20.021	.060	57.676	.017338	18.726	.357
35	19.157	.061	56.029	.017848	19.038	.363
36	18.247	.051	54.472	.018358	15.917	.303
37	17.745	.056	53.000	.018868	17.478	.333
38	16.835	.072	51.605	.019378	22.471	.428
39	16.274	.066	50.282	.019888	20.599	.392
40	15.885	.048	49.025	.020398	14.981	.285
41	15.931	.049	47.829	.020908	15.293	.291
42	15.497	.069	46.690	.021418	21.535	.410
43	15.632	.083	45.605	.021928	25.904	.493
44	15.679	.065	44.568	.022438	20.287	.386
45	15.278	.040	43.578	.022947	12.484	.238
46	14.493	.049	42.630	.023457	15.293	.291
47	13.869	.062	41.723	.023967	19.350	.369
48	12.873	.066	40.854	.024477	20.599	.392
49	11.915	.067	40.020	.024987	20.911	.398
50	10.820	.031	39.220	.025497	9.675	.184

RUN 3 CHANNEL 7

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	303.990	79.564	INFINITY	0	24832.084	81.687
1	221.302	98.955	1961.000	.000510	30884.053	101.596
2	214.516	25.143	980.500	.001020	7847.181	25.814
3	207.931	9.890	653.667	.001530	3086.689	10.154
4	203.815	6.582	490.250	.002040	2054.255	6.758
5	197.667	4.223	392.200	.002550	1318.007	4.336
6	192.792	3.027	326.833	.003060	944.733	3.108
7	188.031	2.492	280.143	.003570	777.758	2.558
8	182.003	2.525	245.125	.004080	788.058	2.592
9	177.707	2.435	217.889	.004589	759.968	2.500
10	172.431	2.279	196.100	.005099	711.280	2.340
11	167.305	2.192	178.273	.005609	684.128	2.250
12	161.846	2.100	163.417	.006119	655.414	2.156
13	157.030	2.045	150.846	.006629	638.249	2.100
14	152.772	1.935	140.071	.007139	603.917	1.987
15	148.466	1.775	130.733	.007649	553.981	1.822
16	145.645	1.791	122.563	.008159	558.975	1.839
17	141.891	1.916	115.353	.008669	597.987	1.967
18	138.502	1.864	108.944	.009179	581.758	1.914
19	135.271	1.767	103.211	.009689	551.484	1.814
20	132.738	1.778	98.050	.010199	554.917	1.825
21	129.567	1.776	93.381	.010709	554.293	1.823
22	127.243	1.713	89.136	.011219	534.631	1.759
23	125.384	1.667	85.261	.011729	520.274	1.711
24	121.781	1.688	81.708	.012239	526.828	1.733
25	118.657	1.688	78.440	.012749	526.828	1.733
26	114.540	1.669	75.423	.013259	520.898	1.714
27	112.508	1.652	72.630	.013768	515.593	1.696
28	109.229	1.624	70.036	.014278	506.854	1.667
29	107.416	1.664	67.621	.014788	519.338	1.708
30	103.740	1.703	65.367	.015298	531.510	1.748
31	100.923	1.651	63.258	.015808	515.280	1.695
32	97.408	1.599	61.281	.016318	499.051	1.642
33	96.033	1.562	59.424	.016828	487.503	1.604
34	93.782	1.546	57.676	.017338	482.510	1.587
35	91.570	1.556	56.029	.017848	485.631	1.598
36	89.209	1.545	54.472	.018358	482.198	1.586
37	86.945	1.525	53.000	.018868	475.956	1.566
38	83.946	1.508	51.605	.019378	470.650	1.548
39	80.770	1.517	50.282	.019888	473.459	1.557
40	79.220	1.539	49.025	.020398	480.325	1.580
41	76.317	1.550	47.829	.020908	483.758	1.591
42	73.526	1.575	46.690	.021418	491.561	1.617
43	71.153	1.615	45.605	.021928	504.045	1.658
44	69.192	1.680	44.568	.022438	524.331	1.725
45	67.916	1.684	43.578	.022947	525.580	1.729
46	67.131	1.586	42.630	.023457	494.994	1.628
47	66.045	1.575	41.723	.023967	491.561	1.617
48	65.040	1.649	40.854	.024477	514.656	1.693
49	62.478	1.624	40.020	.024987	506.854	1.667
50	61.056	.786	39.220	.025497	245.312	.807

RUN 3 CHANNEL 7

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	45.984	15.403	INFINITY	0	4807.307	104.543
1	43.379	20.068	1961.000	.000510	6263.263	136.205
2	42.742	5.239	980.500	.001020	1635.102	35.558
3	41.905	1.074	653.667	.001530	335.198	7.289
4	40.648	.676	490.250	.002040	210.981	4.588
5	39.980	.358	392.200	.002550	111.733	2.430
6	38.693	.368	326.833	.003060	114.854	2.498
7	37.864	.328	280.143	.003570	102.369	2.226
8	36.790	.216	245.125	.004080	67.414	1.466
9	36.102	.132	217.889	.004589	41.197	.896
10	35.445	.109	196.100	.005099	34.019	.740
11	34.339	.099	178.273	.005609	30.898	.672
12	33.684	.089	163.417	.006119	27.777	.604
13	32.814	.062	150.846	.006629	19.350	.421
14	31.704	.035	140.071	.007139	10.924	.238
15	30.726	.039	130.733	.007649	12.172	.265
16	29.992	.064	122.563	.008159	19.975	.434
17	29.087	.072	115.353	.008669	22.471	.489
18	27.767	.066	108.944	.009179	20.599	.448
19	26.874	.054	103.211	.009689	16.854	.367
20	25.617	.047	98.050	.010199	14.669	.319
21	24.683	.049	93.381	.010709	15.293	.333
22	23.708	.047	89.136	.011219	14.669	.319
23	22.953	.053	85.261	.011729	16.541	.360
24	22.124	.054	81.708	.012239	16.854	.367
25	21.314	.043	78.440	.012749	13.420	.292
26	20.513	.028	75.423	.013259	8.739	.190
27	19.541	.018	72.630	.013768	5.618	.122
28	18.800	.029	70.036	.014278	9.051	.197
29	18.067	.042	67.621	.014788	13.108	.285
30	16.966	.056	65.367	.015298	17.478	.380
31	16.274	.072	63.258	.015808	22.471	.489
32	15.229	.060	61.281	.016318	18.726	.407
33	14.302	.036	59.424	.016828	11.236	.244
34	13.169	.037	57.676	.017338	11.548	.251
35	12.346	.041	56.029	.017848	12.796	.278
36	11.333	.044	54.472	.018358	13.732	.299
37	10.270	.054	53.000	.018868	16.854	.367
38	9.825	.058	51.605	.019378	18.102	.394
39	8.604	.065	50.282	.019888	20.287	.441
40	7.821	.063	49.025	.020398	19.662	.428
41	7.036	.071	47.829	.020908	22.159	.482
42	6.272	.085	46.690	.021418	26.529	.577
43	5.805	.063	45.605	.021928	19.662	.428
44	4.862	.040	44.568	.022438	12.484	.271
45	4.103	.036	43.578	.022947	11.236	.244
46	3.856	.031	42.630	.023457	9.675	.210
47	3.290	.037	41.723	.023967	11.548	.251
48	2.915	.040	40.854	.024477	12.484	.271
49	2.482	.026	40.020	.024987	8.115	.176
50	2.049	.009	39.220	.025497	2.809	.061

RUN 3 CHANNEL 7

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	31.589	8.297	INFINITY	0	2589.510	81.975
1	28.574	11.670	1961.000	.000510	3642.230	115.301
2	28.034	4.799	980.500	.001020	1497.777	47.415
3	26.628	1.892	653.667	.001530	590.497	18.693
4	25.526	.799	490.250	.002040	249.369	7.894
5	24.347	.592	392.200	.002550	184.764	5.849
6	23.109	.387	326.833	.003060	120.783	3.824
7	22.243	.247	280.143	.003570	77.089	2.440
8	21.147	.212	245.125	.004080	66.166	2.095
9	20.394	.194	217.889	.004589	60.548	1.917
10	19.299	.183	196.100	.005099	57.115	1.808
11	18.265	.152	178.273	.005609	47.440	1.502
12	17.173	.124	163.417	.006119	38.701	1.225
13	16.469	.085	150.846	.006629	26.529	.840
14	15.244	.053	140.071	.007139	16.541	.524
15	14.519	.051	130.733	.007649	15.917	.504
16	13.950	.064	122.563	.008159	19.975	.632
17	12.995	.061	115.353	.008669	19.038	.603
18	12.635	.050	108.944	.009179	15.605	.494
19	11.791	.040	103.211	.009689	12.484	.395
20	11.039	.048	98.050	.010199	14.981	.474
21	10.354	.062	93.381	.010709	19.350	.613
22	9.583	.060	89.136	.011219	18.726	.593
23	9.348	.054	85.261	.011729	16.854	.534
24	8.539	.046	81.708	.012239	14.357	.454
25	8.130	.051	78.440	.012749	15.917	.504
26	7.519	.050	75.423	.013259	15.605	.494
27	7.080	.035	72.630	.013768	10.924	.346
28	6.905	.033	70.036	.014278	10.299	.326
29	6.359	.040	67.621	.014788	12.484	.395
30	6.427	.049	65.367	.015298	15.293	.484
31	6.125	.058	63.258	.015808	18.102	.573
32	6.221	.059	61.281	.016318	18.414	.583
33	5.960	.050	59.424	.016828	15.605	.494
34	6.155	.034	57.676	.017338	10.611	.336
35	6.093	.030	56.029	.017848	9.363	.296
36	6.182	.033	54.472	.018358	10.299	.326
37	6.328	.042	53.000	.018868	13.108	.415
38	6.439	.065	51.605	.019378	20.287	.642
39	6.819	.076	50.282	.019888	23.720	.751
40	6.684	.063	49.025	.020398	19.662	.622
41	6.627	.038	47.829	.020908	11.860	.375
42	6.758	.039	46.690	.021418	12.172	.385
43	6.797	.081	45.605	.021928	25.280	.800
44	6.616	.095	44.568	.022438	29.650	.939
45	6.165	.072	43.578	.022947	22.471	.711
46	6.021	.070	42.630	.023457	21.847	.692
47	5.735	.072	41.723	.023967	22.471	.711
48	5.709	.056	40.854	.024477	17.478	.553
49	5.201	.049	40.020	.024987	15.293	.484
50	5.117	.026	39.220	.025497	8.115	.257

RUN 3 CHANNEL 7

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	33.165	10.161	INFINITY	0	3171.268	95.621
1	29.679	12.594	1961.000	.000510	3930.613	118.517
2	28.991	3.316	980.500	.001020	1034.930	31.205
3	27.770	1.486	653.667	.001530	463.784	13.984
4	26.424	.981	490.250	.002040	306.172	9.232
5	25.845	.646	392.200	.002550	201.618	6.079
6	24.713	.384	326.833	.003060	119.847	3.614
7	24.340	.181	280.143	.003570	56.490	1.703
8	23.348	.158	245.125	.004080	49.312	1.487
9	22.493	.176	217.889	.004589	54.930	1.656
10	21.528	.182	196.100	.005099	56.803	1.713
11	20.625	.212	178.273	.005609	66.166	1.995
12	19.879	.185	163.417	.006119	57.739	1.741
13	19.272	.136	150.846	.006629	42.446	1.280
14	18.926	.117	140.071	.007139	36.516	1.101
15	18.254	.098	130.733	.007649	30.586	.922
16	18.154	.085	122.563	.008159	26.529	.800
17	18.145	.073	115.353	.008669	22.783	.687
18	17.437	.063	108.944	.009179	19.662	.593
19	17.456	.050	103.211	.009689	15.605	.471
20	16.976	.041	98.050	.010199	12.796	.386
21	16.450	.051	93.381	.010709	15.917	.480
22	16.181	.067	89.136	.011219	20.911	.631
23	15.809	.058	85.261	.011729	18.102	.546
24	15.532	.049	81.708	.012239	15.293	.461
25	14.951	.064	78.440	.012749	19.975	.602
26	14.561	.059	75.423	.013259	18.414	.555
27	14.595	.040	72.630	.013768	12.484	.376
28	13.994	.040	70.036	.014278	12.484	.376
29	13.337	.068	67.621	.014788	21.223	.640
30	13.451	.084	65.367	.015298	26.217	.790
31	13.015	.054	63.258	.015808	16.854	.508
32	12.798	.035	61.281	.016318	10.924	.329
33	12.961	.045	59.424	.016828	14.045	.423
34	12.443	.047	57.676	.017338	14.669	.442
35	12.586	.052	56.029	.017848	16.229	.489
36	12.441	.089	54.472	.018358	27.777	.838
37	11.813	.094	53.000	.018868	29.338	.885
38	11.716	.050	51.605	.019378	15.605	.471
39	10.956	.056	50.282	.019888	17.478	.527
40	11.000	.086	49.025	.020398	26.841	.809
41	10.461	.095	47.829	.020908	29.650	.894
42	10.148	.108	46.690	.021418	33.707	1.016
43	10.376	.093	45.605	.021928	29.025	.875
44	10.163	.070	44.568	.022438	21.847	.659
45	9.908	.064	43.578	.022947	19.975	.602
46	9.675	.059	42.630	.023457	18.414	.555
47	9.663	.058	41.723	.023967	18.102	.546
48	9.231	.049	40.854	.024477	15.293	.461
49	9.371	.039	40.020	.024987	12.172	.367
50	9.534	.019	39.220	.025497	5.930	.179

RUN 3 CHANNEL 7

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	38.695	6.316	INFINITY	0	1971.236	50.943
1	34.358	10.051	1961.000	.000510	3136.937	81.068
2	31.996	6.857	980.500	.001020	2140.083	55.306
3	29.091	4.978	653.667	.001530	1553.644	40.151
4	26.110	2.553	490.250	.002040	796.796	20.592
5	23.607	1.308	392.200	.002550	408.229	10.550
6	21.282	.958	326.833	.003060	298.994	7.727
7	18.639	.668	280.143	.003570	208.484	5.388
8	16.505	.562	245.125	.004080	175.401	4.533
9	14.805	.447	217.889	.004589	139.510	3.605
10	12.486	.355	196.100	.005099	110.796	2.863
11	11.144	.263	178.273	.005609	82.083	2.121
12	9.672	.225	163.417	.006119	70.223	1.815
13	7.691	.202	150.846	.006629	63.045	1.629
14	6.762	.165	140.071	.007139	51.497	1.331
15	5.442	.141	130.733	.007649	44.006	1.137
16	4.450	.142	122.563	.008159	44.318	1.145
17	3.960	.137	115.353	.008669	42.758	1.105
18	3.122	.128	108.944	.009179	39.949	1.032
19	2.510	.116	103.211	.009689	36.204	.936
20	2.546	.085	98.050	.010199	26.529	.686
21	2.473	.078	93.381	.010709	24.344	.629
22	2.118	.078	89.136	.011219	24.344	.629
23	2.624	.065	85.261	.011729	20.287	.524
24	2.598	.080	81.708	.012239	24.968	.645
25	2.778	.086	78.440	.012749	26.841	.694
26	2.946	.057	75.423	.013259	17.790	.460
27	3.407	.044	72.630	.013768	13.732	.355
28	3.890	.056	70.036	.014278	17.478	.452
29	4.200	.063	67.621	.014788	19.662	.508
30	4.719	.058	65.367	.015298	18.102	.468
31	5.194	.043	63.258	.015808	13.420	.347
32	5.743	.046	61.281	.016318	14.357	.371
33	6.037	.093	59.424	.016828	29.025	.750
34	5.963	.128	57.676	.017338	39.949	1.032
35	6.251	.126	56.029	.017848	39.325	1.016
36	6.626	.095	54.472	.018358	29.650	.766
37	6.660	.054	53.000	.018868	16.854	.436
38	6.262	.038	51.605	.019378	11.860	.306
39	6.117	.045	50.282	.019888	14.045	.363
40	5.513	.051	49.025	.020398	15.917	.411
41	5.089	.055	47.829	.020908	17.166	.444
42	4.342	.071	46.690	.021418	22.159	.573
43	3.306	.092	45.605	.021928	28.713	.742
44	2.002	.085	44.568	.022438	26.529	.686
45	1.085	.062	43.578	.022947	19.350	.500
46	.023	.058	42.630	.023457	18.102	.468
47	-1.058	.065	41.723	.023967	20.287	.524
48	-1.278	.071	40.854	.024477	22.159	.573
49	-1.698	.066	40.020	.024987	20.599	.532
50	-2.137	.028	39.220	.025497	8.739	.226

RUN 3 CHANNEL 7

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	39.987	9.937	INFINITY	0	3101.358	77.559
1	36.539	15.993	1961.000	.000510	4991.447	124.827
2	35.472	6.745	980.500	.001020	2105.128	52.645
3	34.046	1.369	653.667	.001530	427.268	10.685
4	32.623	.989	490.250	.002040	308.669	7.719
5	31.474	.562	392.200	.002550	175.401	4.386
6	30.195	.499	326.833	.003060	155.739	3.895
7	29.078	.450	280.143	.003570	140.446	3.512
8	27.827	.304	245.125	.004080	94.879	2.373
9	26.464	.173	217.889	.004589	53.994	1.350
10	24.953	.117	196.100	.005099	36.516	.913
11	24.275	.099	178.273	.005609	30.898	.773
12	23.282	.128	163.417	.006119	39.949	.999
13	22.521	.152	150.846	.006629	47.440	1.186
14	21.204	.167	140.071	.007139	52.121	1.303
15	20.271	.157	130.733	.007649	49.000	1.225
16	18.842	.102	122.563	.008159	31.834	.796
17	17.249	.068	115.353	.008669	21.223	.531
18	16.009	.069	108.944	.009179	21.535	.539
19	14.750	.061	103.211	.009689	19.038	.476
20	13.445	.056	98.050	.010199	17.478	.437
21	12.596	.050	93.381	.010709	15.605	.390
22	11.141	.045	89.136	.011219	14.045	.351
23	9.863	.062	85.261	.011729	19.350	.484
24	9.031	.079	81.708	.012239	24.656	.617
25	7.723	.079	78.440	.012749	24.656	.617
26	6.740	.073	75.423	.013259	22.783	.570
27	5.692	.063	72.630	.013768	19.662	.492
28	4.388	.054	70.036	.014278	16.854	.421
29	3.210	.047	67.621	.014788	14.669	.367
30	1.960	.038	65.367	.015298	11.860	.297
31	.531	.039	63.258	.015808	12.172	.304
32	-0.539	.059	61.281	.016318	18.414	.461
33	-1.956	.079	59.424	.016828	24.656	.617
34	-3.062	.069	57.676	.017338	21.535	.539
35	-4.671	.047	56.029	.017848	14.669	.367
36	-5.982	.048	54.472	.018358	14.981	.375
37	-7.171	.078	53.000	.018868	24.344	.609
38	-8.110	.090	51.605	.019378	28.089	.702
39	-9.116	.063	50.282	.019888	19.662	.492
40	-9.988	.049	49.025	.020398	15.293	.382
41	-11.207	.053	47.829	.020908	16.541	.414
42	-11.877	.055	46.690	.021418	17.166	.429
43	-13.013	.060	45.605	.021928	18.726	.468
44	-13.794	.068	44.568	.022438	21.223	.531
45	-14.516	.074	43.578	.022947	23.096	.578
46	-15.453	.079	42.630	.023457	24.656	.617
47	-16.278	.079	41.723	.023967	24.656	.617
48	-17.018	.053	40.854	.024477	16.541	.414
49	-17.690	.035	40.020	.024987	10.924	.273
50	-18.076	.019	39.220	.025497	5.930	.148

RUN 4 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	580.722	140.659	INFINITY	0	43899.955	75.595
1	425.453	190.388	1961.000	.000510	59420.476	102.322
2	417.278	64.985	980.500	.001020	20281.948	34.925
3	397.437	20.456	653.667	.001530	6384.359	10.994
4	386.383	8.184	490.250	.002040	2554.243	4.398
5	382.037	6.190	392.200	.002550	1931.911	3.327
6	371.823	5.317	326.833	.003060	1659.446	2.858
7	368.276	4.685	280.143	.003570	1462.198	2.518
8	349.748	5.503	245.125	.004080	1717.497	2.958
9	339.557	4.844	217.889	.004589	1511.822	2.603
10	327.577	3.422	196.100	.005099	1068.013	1.839
11	317.346	4.116	178.273	.005609	1284.612	2.212
12	305.108	5.207	163.417	.006119	1625.115	2.798
13	291.994	4.168	150.846	.006629	1300.841	2.240
14	280.112	3.371	140.071	.007139	1052.096	1.812
15	267.800	4.375	130.733	.007649	1365.446	2.351
16	255.765	4.552	122.563	.008159	1420.688	2.446
17	242.141	3.329	115.353	.008669	1038.988	1.789
18	229.762	3.118	108.944	.009179	973.134	1.676
19	217.116	3.639	103.211	.009689	1135.739	1.956
20	209.448	3.254	98.050	.010199	1015.580	1.749
21	194.945	2.635	93.381	.010709	822.389	1.416
22	186.104	2.577	89.136	.011219	804.287	1.385
23	174.723	2.584	85.261	.011729	806.472	1.389
24	180.388	2.638	81.708	.012239	823.325	1.418
25	168.875	2.969	78.440	.012749	926.631	1.596
26	160.672	2.945	75.423	.013259	919.140	1.583
27	152.115	2.619	72.630	.013768	817.395	1.408
28	128.755	2.818	70.036	.014278	879.503	1.514
29	124.792	3.163	67.621	.014788	987.179	1.700
30	117.235	2.976	65.367	.015298	928.816	1.599
31	129.854	2.652	63.258	.015808	827.695	1.425
32	124.780	2.721	61.281	.016318	849.230	1.462
33	122.588	2.921	59.424	.016828	911.650	1.570
34	118.739	2.832	57.676	.017338	883.873	1.522
35	114.898	2.648	56.029	.017848	826.446	1.423
36	112.554	2.675	54.472	.018358	834.873	1.438
37	109.362	2.933	53.000	.018868	915.395	1.576
38	105.294	3.086	51.605	.019378	963.147	1.659
39	104.340	2.842	50.282	.019888	886.994	1.527
40	98.096	2.991	49.025	.020398	933.497	1.607
41	95.887	3.678	47.829	.020908	1147.911	1.977
42	92.577	3.602	46.690	.021418	1124.191	1.936
43	89.880	3.049	45.605	.021928	951.599	1.639
44	85.553	3.356	44.568	.022438	1047.414	1.804
45	82.557	3.822	43.578	.022947	1192.854	2.054
46	78.106	3.311	42.630	.023457	1033.370	1.779
47	77.195	2.680	41.723	.023967	836.433	1.440
48	71.679	2.842	40.854	.024477	886.994	1.527
49	70.243	2.978	40.020	.024987	929.440	1.600
50	67.778	1.420	39.220	.025497	443.185	.763

RUN 4 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	13.724	4.053	INFINITY	0	1264.949	92.171
1	11.609	4.908	1961.000	.000510	1531.797	111.614
2	11.388	.941	980.500	.001020	293.688	21.400
3	10.814	.515	653.667	.001530	160.733	11.712
4	10.384	.706	490.250	.002040	220.344	16.055
5	9.830	.394	392.200	.002550	122.968	8.960
6	9.369	.185	326.833	.003060	57.739	4.207
7	8.922	.124	280.143	.003570	38.701	2.820
8	8.513	.098	245.125	.004080	30.586	2.229
9	8.317	.086	217.889	.004589	26.841	1.956
10	7.937	.093	196.100	.005099	29.025	2.115
11	7.650	.078	178.273	.005609	24.344	1.774
12	7.590	.044	163.417	.006119	13.732	1.001
13	7.317	.039	150.846	.006629	12.172	.887
14	7.266	.046	140.071	.007139	14.357	1.046
15	7.337	.047	130.733	.007649	14.669	1.069
16	7.158	.045	122.563	.008159	14.045	1.023
17	7.415	.039	115.353	.008669	12.172	.887
18	7.309	.025	108.944	.009179	7.803	.569
19	7.705	.036	103.211	.009689	11.236	.819
20	7.664	.057	98.050	.010199	17.790	1.296
21	7.632	.043	93.381	.010709	13.420	.978
22	7.542	.033	89.136	.011219	10.299	.750
23	7.465	.039	85.261	.011729	12.172	.887
24	7.473	.039	81.708	.012239	12.172	.887
25	7.365	.040	78.440	.012749	12.484	.910
26	7.234	.040	75.423	.013259	12.484	.910
27	6.963	.036	72.630	.013768	11.236	.819
28	6.736	.027	70.036	.014278	8.427	.614
29	6.499	.028	67.621	.014788	8.739	.637
30	6.288	.037	65.367	.015298	11.548	.841
31	5.748	.037	63.258	.015808	11.548	.841
32	5.225	.041	61.281	.016318	12.796	.932
33	4.785	.046	59.424	.016828	14.357	1.046
34	4.653	.043	57.676	.017338	13.420	.978
35	4.152	.044	56.029	.017848	13.732	1.001
36	3.961	.039	54.472	.018358	12.172	.887
37	3.508	.027	53.000	.018868	8.427	.614
38	3.079	.022	51.605	.019378	6.866	.500
39	2.990	.025	50.282	.019888	7.803	.569
40	2.672	.037	49.025	.020398	11.548	.841
41	2.323	.057	47.829	.020908	17.790	1.296
42	1.845	.056	46.690	.021418	17.478	1.274
43	1.805	.043	45.605	.021928	13.420	.978
44	1.699	.035	44.568	.022438	10.924	.796
45	1.510	.032	43.578	.022947	9.987	.728
46	1.613	.050	42.630	.023457	15.605	1.137
47	1.187	.061	41.723	.023967	19.038	1.387
48	1.462	.050	40.854	.024477	15.605	1.137
49	1.249	.039	40.020	.024987	12.172	.887
50	1.216	.019	39.220	.025497	5.930	.432

RUN 4 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	247.241	87.726	INFINITY	0	27379.460	110.740
1	241.461	107.231	1961.000	.000510	33467.010	135.362
2	235.473	24.299	980.500	.001020	7583.766	30.674
3	228.284	7.720	653.667	.001530	2409.427	9.745
4	221.576	4.562	490.250	.002040	1423.809	5.759
5	215.016	3.365	392.200	.002550	1050.223	4.248
6	209.574	2.375	326.833	.003060	741.242	2.998
7	204.754	1.216	280.143	.003570	379.516	1.535
8	199.733	1.296	245.125	.004080	404.484	1.636
9	195.424	1.284	217.889	.004589	400.739	1.621
10	191.259	.882	196.100	.005099	275.274	1.113
11	186.218	.651	178.273	.005609	203.178	.822
12	181.669	.592	163.417	.006119	184.764	.747
13	177.183	.453	150.846	.006629	141.382	.572
14	173.014	.294	140.071	.007139	91.758	.371
15	169.116	.213	130.733	.007649	66.478	.269
16	165.690	.199	122.563	.008159	62.108	.251
17	161.926	.183	115.353	.008669	57.115	.231
18	158.451	.180	108.944	.009179	56.178	.227
19	154.993	.178	103.211	.009689	55.554	.225
20	151.614	.153	98.050	.010199	47.752	.193
21	148.477	.104	93.381	.010709	32.459	.131
22	144.990	.089	89.136	.011219	27.777	.112
23	141.012	.110	85.261	.011729	34.331	.139
24	137.113	.089	81.708	.012239	27.777	.112
25	132.790	.062	78.440	.012749	19.350	.078
26	128.854	.077	75.423	.013259	24.032	.097
27	124.342	.090	72.630	.013768	28.089	.114
28	120.914	.089	70.036	.014278	27.777	.112
29	117.869	.093	67.621	.014788	29.025	.117
30	116.182	.110	65.367	.015298	34.331	.139
31	114.263	.098	63.258	.015808	30.586	.124
32	112.494	.088	61.281	.016318	27.465	.111
33	111.244	.080	59.424	.016828	24.968	.101
34	109.832	.039	57.676	.017338	12.172	.049
35	107.474	.027	56.029	.017848	8.427	.034
36	105.610	.040	54.472	.018358	12.484	.050
37	102.728	.039	53.000	.018868	12.172	.049
38	99.779	.057	51.605	.019378	17.790	.072
39	96.933	.068	50.282	.019888	21.223	.086
40	93.304	.054	49.025	.020398	16.854	.068
41	89.678	.066	47.829	.020908	20.599	.083
42	86.502	.087	46.690	.021418	27.153	.110
43	83.437	.084	45.605	.021928	26.217	.106
44	79.916	.067	44.568	.022438	20.911	.085
45	76.535	.058	43.578	.022947	18.102	.073
46	73.621	.070	42.630	.023457	21.847	.088
47	70.153	.069	41.723	.023967	21.535	.087
48	66.146	.055	40.854	.024477	17.166	.069
49	62.979	.080	40.020	.024987	24.968	.101
50	59.848	.054	39.220	.025497	16.854	.068

RUN 4 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	295.575	101.045	INFINITY	0	31536.347	106.695
1	289.260	130.282	1961.000	.000510	40661.273	137.567
2	282.631	35.287	980.500	.001020	11013.143	37.260
3	275.683	8.889	653.667	.001530	2774.275	9.386
4	268.228	4.603	490.250	.002040	1436.606	4.860
5	261.091	2.756	392.200	.002550	860.153	2.910
6	254.968	1.873	326.833	.003060	584.567	1.978
7	248.465	1.787	280.143	.003570	557.726	1.887
8	242.246	1.466	245.125	.004080	457.542	1.548
9	235.745	1.035	217.889	.004589	323.026	1.093
10	229.647	.938	196.100	.005099	292.752	.990
11	224.352	.661	178.273	.005609	206.299	.698
12	218.352	.289	163.417	.006119	90.197	.305
13	211.558	.248	150.846	.006629	77.401	.262
14	204.404	.390	140.071	.007139	121.720	.412
15	197.270	.446	130.733	.007649	139.197	.471
16	190.031	.377	122.563	.008159	117.662	.398
17	183.699	.260	115.353	.008669	81.147	.275
18	178.525	.159	108.944	.009179	49.624	.168
19	172.544	.128	103.211	.009689	39.949	.135
20	166.639	.115	98.050	.010199	35.892	.121
21	160.730	.089	93.381	.010709	27.777	.094
22	154.441	.104	89.136	.011219	32.459	.110
23	148.664	.128	85.261	.011729	39.949	.135
24	143.088	.106	81.708	.012239	33.083	.112
25	138.195	.095	78.440	.012749	29.650	.100
26	134.156	.141	75.423	.013259	44.006	.149
27	129.056	.167	72.630	.013768	52.121	.176
28	123.766	.120	70.036	.014278	37.452	.127
29	119.090	.084	67.621	.014788	26.217	.089
30	113.583	.079	65.367	.015298	24.656	.083
31	108.015	.077	63.258	.015808	24.032	.081
32	102.747	.092	61.281	.016318	28.713	.097
33	97.696	.108	59.424	.016828	33.707	.114
34	94.310	.133	57.676	.017338	41.510	.140
35	90.515	.113	56.029	.017848	35.268	.119
36	87.615	.058	54.472	.018358	18.102	.061
37	85.174	.067	53.000	.018868	20.911	.071
38	82.665	.100	51.605	.019378	31.210	.106
39	80.256	.076	50.282	.019888	23.720	.080
40	78.304	.043	49.025	.020398	13.420	.045
41	76.202	.043	47.829	.020908	13.420	.045
42	73.488	.041	46.690	.021418	12.796	.043
43	71.784	.044	45.605	.021928	13.732	.046
44	69.900	.066	44.568	.022438	20.599	.070
45	68.379	.064	43.578	.022947	19.975	.068
46	67.311	.062	42.630	.023457	19.350	.065
47	67.197	.069	41.723	.023967	21.535	.073
48	66.718	.063	40.854	.024477	19.662	.067
49	66.873	.068	40.020	.024987	21.223	.072
50	65.786	.038	39.220	.025497	11.860	.040

RUN 4 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	44.424	11.009	INFINITY	0	3435.931	77.344
1	40.910	15.520	1961.000	.000510	4843.823	109.036
2	38.744	6.346	980.500	.001020	1980.599	44.584
3	35.741	2.688	653.667	.001530	838.930	18.885
4	32.989	1.293	490.250	.002040	403.548	9.084
5	31.003	.973	392.200	.002550	303.675	6.836
6	29.351	1.054	326.833	.003060	328.956	7.405
7	27.880	.841	280.143	.003570	262.478	5.908
8	26.865	.620	245.125	.004080	193.503	4.356
9	25.992	.604	217.889	.004589	188.510	4.243
10	25.109	.478	196.100	.005099	149.185	3.358
11	24.246	.288	178.273	.005609	89.885	2.023
12	23.159	.212	163.417	.006119	66.166	1.489
13	22.094	.217	150.846	.006629	67.726	1.525
14	20.946	.185	140.071	.007139	57.739	1.300
15	19.715	.109	130.733	.007649	34.019	.766
16	18.779	.103	122.563	.008159	32.147	.724
17	17.325	.114	115.353	.008669	35.580	.801
18	16.489	.092	108.944	.009179	28.713	.646
19	15.402	.082	103.211	.009689	25.592	.576
20	14.501	.079	98.050	.010199	24.656	.555
21	13.807	.056	93.381	.010709	17.478	.393
22	12.871	.049	89.136	.011219	15.293	.344
23	12.046	.052	85.261	.011729	16.229	.365
24	10.990	.043	81.708	.012239	13.420	.302
25	10.360	.037	78.440	.012749	11.548	.260
26	9.608	.040	75.423	.013259	12.484	.281
27	9.516	.041	72.630	.013768	12.796	.288
28	9.396	.038	70.036	.014278	11.860	.267
29	9.766	.036	67.621	.014788	11.236	.253
30	9.914	.041	65.367	.015298	12.796	.288
31	9.751	.049	63.258	.015808	15.293	.344
32	9.386	.055	61.281	.016318	17.166	.386
33	9.068	.057	59.424	.016828	17.790	.400
34	8.675	.053	57.676	.017338	16.541	.372
35	8.486	.047	56.029	.017848	14.669	.330
36	7.906	.056	54.472	.018358	17.478	.393
37	7.338	.071	53.000	.018868	22.159	.499
38	6.736	.069	51.605	.019378	21.535	.485
39	6.341	.061	50.282	.019888	19.038	.429
40	6.046	.051	49.025	.020398	15.917	.358
41	6.019	.038	47.829	.020908	11.860	.267
42	5.911	.041	46.690	.021418	12.796	.288
43	6.053	.063	45.605	.021928	19.662	.443
44	6.000	.075	44.568	.022438	23.408	.527
45	5.955	.062	43.578	.022947	19.350	.436
46	5.478	.042	42.630	.023457	13.108	.295
47	4.747	.042	41.723	.023967	13.108	.295
48	4.127	.061	40.854	.024477	19.038	.429
49	3.375	.062	40.020	.024987	19.350	.436
50	2.838	.026	39.220	.025497	8.115	.183

RUN 4 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	43.487	12.509	INFINITY	0	3904.084	89.776
1	40.095	15.991	1961.000	.000510	4990.823	114.766
2	38.101	4.426	980.500	.001020	1381.363	31.765
3	35.054	1.494	653.667	.001530	466.280	10.722
4	32.635	1.249	490.250	.002040	389.815	8.964
5	30.440	1.277	392.200	.002550	398.554	9.165
6	28.989	.964	326.833	.003060	300.866	6.919
7	28.072	.920	280.143	.003570	287.134	6.603
8	27.569	.915	245.125	.004080	285.573	6.567
9	26.951	.497	217.889	.004589	155.115	3.567
10	26.459	.254	196.100	.005099	79.274	1.823
11	26.381	.362	178.273	.005609	112.981	2.598
12	25.809	.322	163.417	.006119	100.497	2.311
13	25.566	.185	150.846	.006629	57.739	1.328
14	25.160	.171	140.071	.007139	53.369	1.227
15	24.694	.115	130.733	.007649	35.892	.825
16	24.085	.067	122.563	.008159	20.911	.481
17	23.120	.084	115.353	.008669	26.217	.603
18	22.217	.073	108.944	.009179	22.783	.524
19	21.095	.056	103.211	.009689	17.478	.402
20	20.541	.057	98.050	.010199	17.790	.409
21	19.796	.052	93.381	.010709	16.229	.373
22	19.451	.038	89.136	.011219	11.860	.273
23	19.147	.040	85.261	.011729	12.484	.287
24	18.780	.067	81.708	.012239	20.911	.481
25	18.637	.065	78.440	.012749	20.287	.466
26	17.618	.046	75.423	.013259	14.357	.330
27	16.747	.057	72.630	.013768	17.790	.409
28	15.671	.058	70.036	.014278	18.102	.416
29	14.381	.043	67.621	.014788	13.420	.309
30	12.868	.033	65.367	.015298	10.299	.237
31	11.806	.033	63.258	.015808	10.299	.237
32	11.650	.034	61.281	.016318	10.611	.244
33	11.834	.029	59.424	.016828	9.051	.208
34	12.415	.035	57.676	.017338	10.924	.251
35	12.752	.054	56.029	.017848	16.854	.388
36	12.947	.057	54.472	.018358	17.790	.409
37	12.871	.051	53.000	.018868	15.917	.366
38	12.145	.050	51.605	.019378	15.605	.359
39	11.872	.051	50.282	.019888	15.917	.366
40	11.760	.053	49.025	.020398	16.541	.380
41	11.878	.040	47.829	.020908	12.484	.287
42	11.619	.024	46.690	.021418	7.490	.172
43	11.386	.045	45.605	.021928	14.045	.323
44	10.911	.077	44.568	.022438	24.032	.553
45	10.575	.076	43.578	.022947	23.720	.545
46	9.668	.066	42.630	.023457	20.599	.474
47	9.165	.061	41.723	.023967	19.038	.438
48	8.652	.064	40.854	.024477	19.975	.459
49	8.544	.066	40.020	.024987	20.599	.474
50	8.457	.031	39.220	.025497	9.675	.222

RUN 5 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	129.340	23.161	INFINITY	0	7228.594	55.888
1	60.022	28.203	1961.000	.000510	8802.213	68.055
2	59.730	7.440	980.500	.001020	2322.039	17.953
3	57.518	3.789	653.667	.001530	1182.554	9.143
4	56.099	2.288	490.250	.002040	714.089	5.521
5	55.386	1.902	392.200	.002550	593.618	4.590
6	54.228	1.776	326.833	.003060	554.293	4.286
7	52.697	1.552	280.143	.003570	484.382	3.745
8	51.876	1.564	245.125	.004080	488.128	3.774
9	49.618	1.492	217.889	.004589	465.656	3.600
10	48.082	1.333	196.100	.005099	416.032	3.217
11	47.110	1.350	178.273	.005609	421.338	3.258
12	45.592	1.607	163.417	.006119	501.548	3.878
13	44.597	1.652	150.846	.006629	515.593	3.986
14	44.034	1.408	140.071	.007139	439.440	3.398
15	42.657	1.364	130.733	.007649	425.707	3.291
16	42.434	1.494	122.563	.008159	466.280	3.605
17	40.453	1.402	115.353	.008669	437.567	3.383
18	39.319	1.310	108.944	.009179	408.854	3.161
19	37.825	1.430	103.211	.009689	446.306	3.451
20	36.902	1.407	98.050	.010199	439.128	3.395
21	36.611	1.273	93.381	.010709	397.306	3.072
22	36.039	1.319	89.136	.011219	411.663	3.183
23	35.586	1.373	85.261	.011729	428.516	3.313
24	35.660	1.366	81.708	.012239	426.331	3.296
25	35.055	1.352	78.440	.012749	421.962	3.262
26	34.409	1.333	75.423	.013259	416.032	3.217
27	31.731	1.363	72.630	.013768	425.395	3.289
28	31.237	1.345	70.036	.014278	419.777	3.246
29	31.130	1.319	67.621	.014788	411.663	3.183
30	32.710	1.330	65.367	.015298	415.096	3.209
31	33.750	1.315	63.258	.015808	410.414	3.173
32	32.536	1.324	61.281	.016318	413.223	3.195
33	32.511	1.344	59.424	.016828	419.465	3.243
34	31.112	1.342	57.676	.017338	418.841	3.238
35	31.643	1.382	56.029	.017848	431.325	3.335
36	32.463	1.433	54.472	.018358	447.242	3.458
37	32.381	1.433	53.000	.018868	447.242	3.458
38	30.821	1.444	51.605	.019378	450.675	3.484
39	30.784	1.430	50.282	.019888	446.306	3.451
40	30.741	1.346	49.025	.020398	420.089	3.248
41	30.125	1.323	47.829	.020908	412.911	3.192
42	28.669	1.398	46.690	.021418	436.319	3.373
43	27.610	1.426	45.605	.021928	445.057	3.441
44	27.421	1.382	44.568	.022438	431.325	3.335
45	26.282	1.394	43.578	.022947	435.070	3.364
46	25.131	1.405	42.630	.023457	438.503	3.390
47	24.880	1.362	41.723	.023967	425.083	3.287
48	24.351	1.382	40.854	.024477	431.325	3.335
49	24.419	1.445	40.020	.024987	450.987	3.487
50	23.297	.733	39.220	.025497	228.771	1.769

RUN 5 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	52.790	16.636	INFINITY	0	5192.129	98.354
1	49.278	21.112	1961.000	.000510	6589.097	124.817
2	48.008	5.898	980.500	.001020	1840.778	34.870
3	46.117	2.249	653.667	.001530	701.917	13.296
4	44.558	1.292	490.250	.002040	403.236	7.638
5	42.685	.757	392.200	.002550	236.261	4.475
6	41.390	.582	326.833	.003060	181.643	3.441
7	39.724	.508	280.143	.003570	158.548	3.003
8	38.950	.378	245.125	.004080	117.975	2.235
9	37.533	.291	217.889	.004589	90.822	1.720
10	36.481	.270	196.100	.005099	84.268	1.596
11	35.491	.221	178.273	.005609	68.975	1.307
12	34.491	.116	163.417	.006119	36.204	.686
13	33.202	.096	150.846	.006629	29.962	.568
14	32.090	.116	140.071	.007139	36.204	.686
15	31.083	.106	130.733	.007649	33.083	.627
16	30.217	.086	122.563	.008159	26.841	.508
17	29.130	.065	115.353	.008669	20.287	.384
18	28.276	.080	108.944	.009179	24.968	.473
19	27.524	.088	103.211	.009689	27.465	.520
20	27.008	.064	98.050	.010199	19.975	.378
21	25.861	.054	93.381	.010709	16.854	.319
22	25.223	.061	89.136	.011219	19.038	.361
23	24.396	.063	85.261	.011729	19.662	.372
24	23.623	.068	81.708	.012239	21.223	.402
25	23.182	.082	78.440	.012749	25.592	.485
26	22.792	.091	75.423	.013259	28.401	.538
27	22.648	.059	72.630	.013768	18.414	.349
28	21.974	.032	70.036	.014278	9.987	.189
29	21.175	.046	67.621	.014788	14.357	.272
30	20.746	.052	65.367	.015298	16.229	.307
31	20.056	.048	63.258	.015808	14.981	.284
32	19.332	.055	61.281	.016318	17.166	.325
33	18.556	.053	59.424	.016828	16.541	.313
34	18.123	.058	57.676	.017338	18.102	.343
35	17.669	.071	56.029	.017848	22.159	.420
36	17.100	.073	54.472	.018358	22.783	.432
37	17.017	.067	53.000	.018868	20.911	.396
38	16.624	.051	51.605	.019378	15.917	.302
39	15.673	.050	50.282	.019888	15.605	.296
40	15.450	.064	49.025	.020398	19.975	.378
41	14.902	.047	47.829	.020908	14.669	.278
42	15.068	.029	46.690	.021418	9.051	.171
43	14.739	.038	45.605	.021928	11.860	.225
44	15.152	.050	44.568	.022438	15.605	.296
45	15.035	.060	43.578	.022947	18.726	.355
46	15.474	.058	42.630	.023457	18.102	.343
47	15.045	.064	41.723	.023967	19.975	.378
48	14.810	.080	40.854	.024477	24.968	.473
49	14.059	.098	40.020	.024987	30.586	.579
50	14.228	.057	39.220	.025497	17.790	.337

RUN 5 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	70.090	23.697	INFINITY	0	7395.881	105.520
1	63.091	28.939	1961.000	.000510	9031.920	128.862
2	61.498	6.108	980.500	.001020	1906.319	27.198
3	59.402	1.500	653.667	.001530	468.153	6.679
4	58.606	.948	490.250	.002040	295.873	4.221
5	57.371	.612	392.200	.002550	191.006	2.725
6	55.989	.602	326.833	.003060	187.885	2.681
7	53.166	.586	280.143	.003570	182.892	2.609
8	53.948	.510	245.125	.004080	159.172	2.271
9	53.850	.401	217.889	.004589	125.153	1.786
10	52.919	.401	196.100	.005099	125.153	1.786
11	51.602	.424	178.273	.005609	132.331	1.888
12	50.282	.246	163.417	.006119	76.777	1.095
13	48.755	.088	150.846	.006629	27.465	.392
14	47.825	.083	140.071	.007139	25.904	.370
15	47.067	.098	130.733	.007649	30.586	.436
16	45.732	.121	122.563	.008159	37.764	.539
17	44.662	.142	115.353	.008669	44.318	.632
18	43.947	.175	108.944	.009179	54.618	.779
19	42.790	.258	103.211	.009689	80.522	1.149
20	41.651	.305	98.050	.010199	95.191	1.358
21	40.129	.282	93.381	.010709	88.013	1.256
22	38.675	.250	89.136	.011219	78.025	1.113
23	37.939	.191	85.261	.011729	59.611	.850
24	37.137	.142	81.708	.012239	44.318	.632
25	36.552	.128	78.440	.012749	39.949	.570
26	35.844	.108	75.423	.013259	33.707	.481
27	35.341	.073	72.630	.013768	22.783	.325
28	33.844	.041	70.036	.014278	12.796	.183
29	32.960	.042	67.621	.014788	13.108	.187
30	31.757	.056	65.367	.015298	17.478	.249
31	30.738	.072	63.258	.015808	22.471	.321
32	29.501	.108	61.281	.016318	33.707	.481
33	28.706	.158	59.424	.016828	49.312	.704
34	27.950	.188	57.676	.017338	58.675	.837
35	27.580	.170	56.029	.017848	53.057	.757
36	26.963	.147	54.472	.018358	45.879	.655
37	25.611	.141	53.000	.018868	44.006	.628
38	24.685	.126	51.605	.019378	39.325	.561
39	23.093	.121	50.282	.019888	37.764	.539
40	22.744	.108	49.025	.020398	33.707	.481
41	21.904	.086	47.829	.020908	26.841	.383
42	21.040	.075	46.690	.021418	23.408	.334
43	20.662	.070	45.605	.021928	21.847	.312
44	20.406	.097	44.568	.022438	30.274	.432
45	20.287	.120	43.578	.022947	37.452	.534
46	19.871	.116	42.630	.023457	36.204	.517
47	18.723	.149	41.723	.023967	46.503	.663
48	18.510	.192	40.854	.024477	59.924	.855
49	17.815	.195	40.020	.024987	60.860	.868
50	17.054	.095	39.220	.025497	29.650	.423

RUN 5 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	75.815	24.753	INFINITY	0	7725.461	101.899
1	72.146	31.878	1961.000	.000510	9949.188	131.230
2	70.755	9.000	980.500	.001020	2808.918	37.050
3	68.991	3.235	653.667	.001530	1009.650	13.317
4	67.187	1.688	490.250	.002040	526.828	6.949
5	64.850	.562	392.200	.002550	175.401	2.314
6	62.970	.460	326.833	.003060	143.567	1.894
7	61.569	.434	280.143	.003570	135.452	1.787
8	59.220	.403	245.125	.004080	125.777	1.659
9	57.588	.336	217.889	.004589	104.866	1.383
10	55.800	.197	196.100	.005099	61.484	.811
11	53.961	.108	178.273	.005609	33.707	.445
12	51.854	.129	163.417	.006119	40.261	.531
13	50.246	.162	150.846	.006629	50.561	.667
14	48.410	.144	140.071	.007139	44.943	.593
15	46.588	.084	130.733	.007649	26.217	.346
16	44.767	.048	122.563	.008159	14.981	.198
17	42.767	.062	115.353	.008669	19.350	.255
18	41.209	.076	108.944	.009179	23.720	.313
19	39.837	.075	103.211	.009689	23.408	.309
20	39.047	.073	98.050	.010199	22.783	.301
21	37.817	.065	93.381	.010709	20.287	.268
22	37.456	.061	89.136	.011219	19.038	.251
23	36.357	.056	85.261	.011729	17.478	.231
24	35.378	.050	81.708	.012239	15.605	.206
25	34.293	.061	78.440	.012749	19.038	.251
26	33.449	.086	75.423	.013259	26.841	.354
27	32.812	.095	72.630	.013768	29.650	.391
28	31.575	.084	70.036	.014278	26.217	.346
29	31.221	.087	67.621	.014788	27.153	.358
30	30.190	.104	65.367	.015298	32.459	.428
31	29.217	.097	63.258	.015808	30.274	.399
32	28.208	.063	61.281	.016318	19.662	.259
33	27.152	.046	59.424	.016828	14.357	.189
34	25.945	.042	57.676	.017338	13.108	.173
35	24.725	.037	56.029	.017848	11.548	.152
36	23.230	.037	54.472	.018358	11.548	.152
37	21.839	.047	53.000	.018868	14.669	.193
38	20.370	.046	51.605	.019378	14.357	.189
39	19.060	.038	50.282	.019888	11.860	.156
40	17.960	.062	49.025	.020398	19.350	.255
41	16.461	.074	47.829	.020908	23.096	.305
42	15.576	.057	46.690	.021418	17.790	.235
43	14.091	.055	45.605	.021928	17.166	.226
44	13.221	.087	44.568	.022438	27.153	.358
45	12.484	.112	43.578	.022947	34.955	.461
46	11.418	.081	42.630	.023457	25.280	.333
47	10.768	.048	41.723	.023967	14.981	.198
48	10.247	.049	40.854	.024477	15.293	.202
49	9.946	.054	40.020	.024987	16.854	.222
50	9.349	.028	39.220	.025497	8.739	.115

RUN 5 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	108.676	36.081	INFINITY	0	11260.952	103.619
1	99.869	45.264	1961.000	.000510	14126.985	129.992
2	96.879	10.510	980.500	.001020	3280.192	30.183
3	94.075	2.489	653.667	.001530	776.822	7.148
4	91.707	1.821	490.250	.002040	568.338	5.230
5	89.242	1.415	392.200	.002550	441.624	4.064
6	86.961	1.022	326.833	.003060	318.968	2.935
7	85.212	.630	280.143	.003570	196.624	1.809
8	82.996	.781	245.125	.004080	243.752	2.243
9	82.248	.667	217.889	.004589	208.172	1.916
10	80.228	.512	196.100	.005099	159.796	1.470
11	78.433	.503	178.273	.005609	156.987	1.445
12	76.660	.327	163.417	.006119	102.057	.939
13	74.945	.192	150.846	.006629	59.924	.551
14	73.054	.260	140.071	.007139	81.147	.747
15	71.038	.341	130.733	.007649	106.427	.979
16	69.042	.267	122.563	.008159	83.331	.767
17	67.562	.170	115.353	.008669	53.057	.488
18	66.236	.205	108.944	.009179	63.981	.589
19	65.094	.228	103.211	.009689	71.159	.655
20	63.507	.232	98.050	.010199	72.408	.666
21	61.391	.252	93.381	.010709	78.650	.724
22	59.207	.234	89.136	.011219	73.032	.672
23	57.382	.191	85.261	.011729	59.611	.549
24	55.124	.179	81.708	.012239	55.866	.514
25	53.926	.168	78.440	.012749	52.433	.482
26	51.945	.153	75.423	.013259	47.752	.439
27	50.077	.159	72.630	.013768	49.624	.457
28	47.486	.162	70.036	.014278	50.561	.465
29	45.285	.158	67.621	.014788	49.312	.454
30	42.689	.174	65.367	.015298	54.306	.500
31	41.312	.193	63.258	.015808	60.236	.554
32	40.726	.180	61.281	.016318	56.178	.517
33	39.727	.152	59.424	.016828	47.440	.437
34	38.688	.160	57.676	.017338	49.936	.459
35	37.678	.160	56.029	.017848	49.936	.459
36	36.150	.129	54.472	.018358	40.261	.370
37	35.247	.113	53.000	.018868	35.268	.325
38	33.115	.112	51.605	.019378	34.955	.322
39	30.966	.116	50.282	.019888	36.204	.333
40	28.396	.145	49.025	.020398	45.255	.416
41	25.770	.157	47.829	.020908	49.000	.451
42	23.633	.149	46.690	.021418	46.503	.428
43	21.643	.178	45.605	.021928	55.554	.511
44	20.759	.192	44.568	.022438	59.924	.551
45	18.809	.177	43.578	.022947	55.242	.508
46	17.601	.153	42.630	.023457	47.752	.439
47	15.522	.149	41.723	.023967	46.503	.428
48	11.873	.155	40.854	.024477	48.376	.445
49	9.960	.118	40.020	.024987	36.828	.339
50	8.324	.042	39.220	.025497	13.108	.121

RUN 5 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	94.222	19.248	INFINITY	0	6007.339	63.757
1	89.060	33.828	1961.000	.000510	10557.786	112.052
2	84.236	18.137	980.500	.001020	5660.594	60.077
3	77.646	5.871	653.667	.001530	1832.351	19.447
4	72.510	4.212	490.250	.002040	1314.574	13.952
5	67.790	2.610	392.200	.002550	814.586	8.645
6	64.190	1.207	326.833	.003060	376.707	3.998
7	60.483	1.101	280.143	.003570	343.624	3.647
8	57.251	1.251	245.125	.004080	390.440	4.144
9	53.603	1.033	217.889	.004589	322.401	3.422
10	49.528	.621	196.100	.005099	193.815	2.057
11	45.750	.591	178.273	.005609	184.452	1.958
12	42.434	.725	163.417	.006119	226.274	2.401
13	38.891	.541	150.846	.006629	168.847	1.792
14	35.720	.292	140.071	.007139	91.134	.967
15	32.775	.255	130.733	.007649	79.586	.845
16	29.915	.246	122.563	.008159	76.777	.815
17	27.454	.191	115.353	.008669	59.611	.633
18	24.838	.149	108.944	.009179	46.503	.494
19	21.841	.109	103.211	.009689	34.019	.361
20	19.851	.080	98.050	.010199	24.968	.265
21	18.111	.078	93.381	.010709	24.344	.258
22	16.748	.095	89.136	.011219	29.650	.315
23	15.139	.118	85.261	.011729	36.828	.391
24	13.227	.098	81.708	.012239	30.586	.325
25	10.625	.056	78.440	.012749	17.478	.185
26	7.390	.048	75.423	.013259	14.981	.159
27	3.399	.052	72.630	.013768	16.229	.172
28	-0.442	.044	70.036	.014278	13.732	.146
29	-3.819	.042	67.621	.014788	13.108	.139
30	-6.425	.037	65.367	.015298	11.548	.123
31	-8.710	.032	63.258	.015808	9.987	.106
32	-10.908	.047	61.281	.016318	14.669	.156
33	-12.731	.070	59.424	.016828	21.847	.232
34	-14.952	.077	57.676	.017338	24.032	.255
35	-17.222	.070	56.029	.017848	21.847	.232
36	-19.305	.051	54.472	.018358	15.917	.169
37	-20.598	.034	53.000	.018868	10.611	.113
38	-21.598	.038	51.605	.019378	11.860	.126
39	-22.321	.052	50.282	.019888	16.229	.172
40	-22.692	.060	49.025	.020398	18.726	.199
41	-23.094	.054	47.829	.020908	16.854	.179
42	-22.930	.055	46.690	.021418	17.166	.182
43	-23.027	.059	45.605	.021928	18.414	.195
44	-22.801	.063	44.568	.022438	19.662	.209
45	-22.454	.081	43.578	.022947	25.280	.268
46	-22.247	.086	42.630	.023457	26.841	.285
47	-21.412	.079	41.723	.023967	24.656	.262
48	-21.002	.087	40.854	.024477	27.153	.288
49	-19.808	.104	40.020	.024987	32.459	.344
50	-18.598	.057	39.220	.025497	17.790	.189

RUN 6 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	1877.371	99.790	INFINITY	0	31144.659	16.590
1	225.899	137.462	1961.000	.000510	42902.165	22.852
2	221.217	58.839	980.500	.001020	18363.770	9.782
3	220.191	38.526	653.667	.001530	12024.042	6.405
4	212.092	35.182	490.250	.002040	10980.373	5.849
5	209.635	34.550	392.200	.002550	10783.124	5.744
6	207.077	33.641	326.833	.003060	10499.423	5.593
7	204.889	33.717	280.143	.003570	10523.143	5.605
8	197.752	33.341	245.125	.004080	10405.793	5.543
9	194.185	33.187	217.889	.004589	10357.729	5.517
10	187.790	33.493	196.100	.005099	10453.232	5.568
11	184.036	33.521	178.273	.005609	10461.971	5.573
12	178.290	33.321	163.417	.006119	10399.551	5.539
13	174.605	33.327	150.846	.006629	10401.423	5.540
14	168.594	33.229	140.071	.007139	10370.837	5.524
15	165.184	33.311	130.733	.007649	10396.430	5.538
16	159.270	33.396	122.563	.008159	10422.958	5.552
17	153.068	33.048	115.353	.008669	10314.347	5.494
18	152.540	32.894	108.944	.009179	10266.283	5.468
19	146.681	32.878	103.211	.009689	10261.290	5.466
20	140.670	32.890	98.050	.010199	10265.035	5.468
21	134.873	33.007	93.381	.010709	10301.551	5.487
22	131.341	32.923	89.136	.011219	10275.334	5.473
23	125.234	32.799	85.261	.011729	10236.633	5.453
24	122.121	32.866	81.708	.012239	10257.544	5.464
25	118.996	32.916	78.440	.012749	10273.149	5.472
26	116.068	32.974	75.423	.013259	10291.251	5.482
27	107.216	33.217	72.630	.013768	10367.092	5.522
28	110.377	33.231	70.036	.014278	10371.462	5.524
29	101.665	33.022	67.621	.014788	10306.232	5.490
30	99.047	32.986	65.367	.015298	10294.997	5.484
31	97.881	33.155	63.258	.015808	10347.742	5.512
32	89.122	33.395	61.281	.016318	10422.646	5.552
33	92.736	33.297	59.424	.016828	10392.060	5.535
34	81.190	33.005	57.676	.017338	10300.927	5.487
35	83.501	33.059	56.029	.017848	10317.780	5.496
36	81.120	33.122	54.472	.018358	10337.442	5.506
37	85.801	32.956	53.000	.018868	10285.634	5.479
38	84.319	32.998	51.605	.019378	10298.742	5.486
39	83.199	33.273	50.282	.019888	10384.570	5.531
40	85.415	33.087	49.025	.020398	10326.519	5.501
41	82.337	32.705	47.829	.020908	10207.296	5.437
42	85.174	33.050	46.690	.021418	10314.971	5.494
43	90.097	33.150	45.605	.021928	10346.181	5.511
44	90.608	32.852	44.568	.022438	10253.175	5.461
45	95.426	33.131	43.578	.022947	10340.251	5.508
46	90.539	33.210	42.630	.023457	10364.907	5.521
47	96.243	32.728	41.723	.023967	10214.474	5.441
48	94.176	32.617	40.854	.024477	10179.831	5.422
49	95.831	32.743	40.020	.024987	10219.156	5.443
50	94.093	16.351	39.220	.025497	5103.180	2.718

RUN 6 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	116.506	41.715	INFINITY	0	13019.335	111.748
1	112.403	47.768	1961.000	.000510	14908.488	127.963
2	109.672	6.615	980.500	.001020	2064.555	17.721
3	105.794	3.235	653.667	.001530	1009.650	8.666
4	100.887	5.882	490.250	.002040	1835.784	15.757
5	96.105	4.623	392.200	.002550	1442.848	12.384
6	91.298	1.641	326.833	.003060	512.159	4.396
7	87.161	.581	280.143	.003570	181.331	1.556
8	84.028	.719	245.125	.004080	224.401	1.926
9	81.291	.628	217.889	.004589	196.000	1.682
10	79.321	.376	196.100	.005099	117.350	1.007
11	77.780	.202	178.273	.005609	63.045	.541
12	76.771	.124	163.417	.006119	38.701	.332
13	76.518	.068	150.846	.006629	21.223	.182
14	76.643	.066	140.071	.007139	20.599	.177
15	77.158	.082	130.733	.007649	25.592	.220
16	78.370	.071	122.563	.008159	22.159	.190
17	79.240	.039	115.353	.008669	12.172	.104
18	81.331	.040	108.944	.009179	12.484	.107
19	83.037	.052	103.211	.009689	16.229	.139
20	84.057	.072	98.050	.010199	22.471	.193
21	84.260	.102	93.381	.010709	31.834	.273
22	84.448	.095	89.136	.011219	29.650	.254
23	83.528	.048	85.261	.011729	14.981	.129
24	82.097	.032	81.708	.012239	9.987	.086
25	79.387	.075	78.440	.012749	23.408	.201
26	76.545	.092	75.423	.013259	28.713	.246
27	73.639	.061	72.630	.013768	19.038	.163
28	69.839	.045	70.036	.014278	14.045	.121
29	66.330	.045	67.621	.014788	14.045	.121
30	63.216	.060	65.367	.015298	18.726	.161
31	60.482	.072	63.258	.015808	22.471	.193
32	58.441	.069	61.281	.016318	21.535	.185
33	56.262	.067	59.424	.016828	20.911	.179
34	54.588	.056	57.676	.017338	17.478	.150
35	53.514	.045	56.029	.017848	14.045	.121
36	52.536	.070	54.472	.018358	21.847	.188
37	51.652	.104	53.000	.018868	32.459	.279
38	51.224	.094	51.605	.019378	29.338	.252
39	50.749	.067	50.282	.019888	20.911	.179
40	50.282	.066	49.025	.020398	20.599	.177
41	49.593	.063	47.829	.020908	19.662	.169
42	49.400	.051	46.690	.021418	15.917	.137
43	48.848	.053	45.605	.021928	16.541	.142
44	47.973	.068	44.568	.022438	21.223	.182
45	46.829	.072	43.578	.022947	22.471	.193
46	45.655	.052	42.630	.023457	16.229	.139
47	44.195	.035	41.723	.023967	10.924	.094
48	42.130	.040	40.854	.024477	12.484	.107
49	40.232	.066	40.020	.024987	20.599	.177
50	37.931	.043	39.220	.025497	13.420	.115

RUN 6 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	52.140	9.304	INFINITY	0	2903.797	55.692
1	46.234	13.723	1961.000	.000510	4282.976	82.144
2	41.731	5.619	980.500	.001020	1753.701	33.634
3	35.583	2.697	653.667	.001530	841.739	16.144
4	30.254	3.939	490.250	.002040	1229.370	23.578
5	25.737	4.775	392.200	.002550	1490.287	28.582
6	21.987	3.241	326.833	.003060	1011.523	19.400
7	18.944	1.295	280.143	.003570	404.172	7.752
8	16.757	.686	245.125	.004080	214.102	4.106
9	14.879	.743	217.889	.004589	231.892	4.447
10	12.981	.758	196.100	.005099	236.573	4.537
11	12.283	.532	178.273	.005609	166.038	3.184
12	12.325	.551	163.417	.006119	171.968	3.298
13	13.263	.586	150.846	.006629	182.892	3.508
14	14.786	.351	140.071	.007139	109.548	2.101
15	16.806	.190	130.733	.007649	59.299	1.137
16	18.339	.174	122.563	.008159	54.306	1.042
17	19.407	.125	115.353	.008669	39.013	.748
18	19.793	.125	108.944	.009179	39.013	.748
19	19.598	.159	103.211	.009689	49.624	.952
20	19.588	.128	98.050	.010199	39.949	.766
21	18.507	.094	93.381	.010709	29.338	.563
22	16.871	.091	89.136	.011219	28.401	.545
23	14.644	.111	85.261	.011729	34.643	.664
24	12.021	.118	81.708	.012239	36.828	.706
25	9.211	.090	78.440	.012749	28.089	.539
26	6.906	.077	75.423	.013259	24.032	.461
27	4.408	.066	72.630	.013768	20.599	.395
28	3.379	.048	70.036	.014278	14.981	.287
29	2.668	.054	67.621	.014788	16.854	.323
30	3.281	.061	65.367	.015298	19.038	.365
31	2.947	.060	63.258	.015808	18.726	.359
32	2.796	.058	61.281	.016318	18.102	.347
33	2.206	.078	59.424	.016828	24.344	.467
34	1.593	.098	57.676	.017338	30.586	.587
35	1.377	.092	56.029	.017848	28.713	.551
36	1.900	.084	54.472	.018358	26.217	.503
37	2.492	.068	53.000	.018868	21.223	.407
38	3.168	.068	51.605	.019378	21.223	.407
39	2.792	.090	50.282	.019888	28.089	.539
40	2.123	.088	49.025	.020398	27.465	.527
41	1.538	.068	47.829	.020908	21.223	.407
42	.606	.072	46.690	.021418	22.471	.431
43	-1.280	.089	45.605	.021928	27.777	.533
44	-2.696	.089	44.568	.022438	27.777	.533
45	-4.518	.096	43.578	.022947	29.962	.575
46	-6.152	.115	42.630	.023457	35.892	.688
47	-7.568	.105	41.723	.023967	32.771	.629
48	-8.262	.070	40.854	.024477	21.847	.419
49	-8.841	.082	40.020	.024987	25.592	.491
50	-8.371	.055	39.220	.025497	17.166	.329

RUN 6 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	37.038	7.614	INFINITY	0	2376.345	64.160
1	32.442	11.551	1961.000	.000510	3605.090	97.335
2	30.662	5.854	980.500	.001020	1827.045	49.329
3	28.038	2.830	653.667	.001530	883.249	23.847
4	25.398	1.295	490.250	.002040	404.172	10.912
5	23.364	.732	392.200	.002550	228.459	6.168
6	21.492	.839	326.833	.003060	261.854	7.070
7	20.535	.918	280.143	.003570	286.510	7.736
8	19.370	.731	245.125	.004080	228.147	6.160
9	18.866	.571	217.889	.004589	178.210	4.812
10	18.120	.459	196.100	.005099	143.255	3.868
11	17.077	.315	178.273	.005609	98.312	2.654
12	16.360	.195	163.417	.006119	60.860	1.643
13	15.105	.129	150.846	.006629	40.261	1.087
14	13.772	.141	140.071	.007139	44.006	1.188
15	12.484	.156	130.733	.007649	48.688	1.315
16	11.133	.120	122.563	.008159	37.452	1.011
17	9.769	.075	115.353	.008669	23.408	.632
18	8.799	.057	108.944	.009179	17.790	.480
19	8.363	.074	103.211	.009689	23.096	.624
20	7.555	.105	98.050	.010199	32.771	.885
21	6.630	.097	93.381	.010709	30.274	.817
22	5.713	.064	89.136	.011219	19.975	.539
23	5.571	.054	85.261	.011729	16.854	.455
24	5.326	.071	81.708	.012239	22.159	.598
25	5.299	.088	78.440	.012749	27.465	.742
26	5.305	.082	75.423	.013259	25.592	.691
27	5.422	.064	72.630	.013768	19.975	.539
28	5.164	.052	70.036	.014278	16.229	.438
29	5.494	.057	67.621	.014788	17.790	.480
30	5.022	.088	65.367	.015298	27.465	.742
31	4.909	.096	63.258	.015808	29.962	.809
32	4.660	.081	61.281	.016318	25.280	.683
33	4.364	.080	59.424	.016828	24.968	.674
34	4.204	.074	57.676	.017338	23.096	.624
35	3.525	.067	56.029	.017848	20.911	.565
36	3.486	.056	54.472	.018358	17.478	.472
37	3.031	.059	53.000	.018868	18.414	.497
38	2.710	.081	51.605	.019378	25.280	.683
39	3.143	.082	50.282	.019888	25.592	.691
40	2.833	.082	49.025	.020398	25.592	.691
41	2.985	.109	47.829	.020908	34.019	.918
42	2.855	.108	46.690	.021418	33.707	.910
43	3.065	.095	45.605	.021928	29.650	.801
44	2.622	.100	44.568	.022438	31.210	.843
45	2.606	.079	43.578	.022947	24.656	.666
46	2.415	.063	42.630	.023457	19.662	.531
47	2.028	.073	41.723	.023967	22.783	.615
48	2.058	.082	40.854	.024477	25.592	.691
49	1.550	.068	40.020	.024987	21.223	.573
50	1.629	.025	39.220	.025497	7.803	.211

RUN 6 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	29.185	6.161	INFINITY	0	1922.860	65.885
1	25.956	9.870	1961.000	.000510	3080.447	105.549
2	23.900	4.609	980.500	.001020	1438.478	49.288
3	21.735	1.249	653.667	.001530	389.815	13.357
4	19.487	.500	490.250	.002040	156.051	5.347
5	17.639	.388	392.200	.002550	121.096	4.149
6	16.275	.588	326.833	.003060	183.516	6.288
7	15.745	.898	280.143	.003570	280.268	9.603
8	16.115	1.059	245.125	.004080	330.516	11.325
9	16.570	.839	217.889	.004589	261.854	8.972
10	16.779	.508	196.100	.005099	158.548	5.433
11	16.961	.254	178.273	.005609	79.274	2.716
12	16.271	.116	163.417	.006119	36.204	1.240
13	15.215	.076	150.846	.006629	23.720	.813
14	13.682	.069	140.071	.007139	21.535	.738
15	12.107	.073	130.733	.007649	22.783	.781
16	10.319	.069	122.563	.008159	21.535	.738
17	9.128	.065	115.353	.008669	20.287	.695
18	7.988	.067	108.944	.009179	20.911	.716
19	7.134	.072	103.211	.009689	22.471	.770
20	6.777	.075	98.050	.010199	23.408	.802
21	6.209	.079	93.381	.010709	24.656	.845
22	5.733	.072	89.136	.011219	22.471	.770
23	5.307	.072	85.261	.011729	22.471	.770
24	4.749	.082	81.708	.012239	25.592	.877
25	4.306	.072	78.440	.012749	22.471	.770
26	3.464	.062	75.423	.013259	19.350	.663
27	2.919	.058	72.630	.013768	18.102	.620
28	2.184	.055	70.036	.014278	17.166	.588
29	1.623	.057	67.621	.014788	17.790	.610
30	.913	.042	65.367	.015298	13.108	.449
31	.423	.035	63.258	.015808	10.924	.374
32	.009	.041	61.281	.016318	12.796	.438
33	-0.396	.047	59.424	.016828	14.669	.503
34	-0.661	.063	57.676	.017338	19.662	.674
35	-0.942	.071	56.029	.017848	22.159	.759
36	-1.377	.061	54.472	.018358	19.038	.652
37	-1.288	.052	53.000	.018868	16.229	.556
38	-1.585	.047	51.605	.019378	14.669	.503
39	-2.160	.048	50.282	.019888	14.981	.513
40	-2.561	.057	49.025	.020398	17.790	.610
41	-2.950	.047	47.829	.020908	14.669	.503
42	-3.489	.030	46.690	.021418	9.363	.321
43	-4.280	.033	45.605	.021928	10.299	.353
44	-4.676	.047	44.568	.022438	14.669	.503
45	-4.959	.055	43.578	.022947	17.166	.588
46	-5.117	.051	42.630	.023457	15.917	.545
47	-5.287	.049	41.723	.023967	15.293	.524
48	-5.427	.049	40.854	.024477	15.293	.524
49	-5.547	.035	40.020	.024987	10.924	.374
50	-5.168	.012	39.220	.025497	3.745	.128

RUN 6 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	42.185	12.354	INFINITY	0	3855.708	91.400
1	38.261	15.673	1961.000	.000510	4891.575	115.955
2	36.272	4.288	980.500	.001020	1338.293	31.724
3	33.877	1.565	653.667	.001530	488.440	11.579
4	31.775	.990	490.250	.002040	308.981	7.324
5	30.257	.791	392.200	.002550	246.873	5.852
6	29.152	.728	326.833	.003060	227.210	5.386
7	28.501	.677	280.143	.003570	211.293	5.009
8	27.817	.704	245.125	.004080	219.720	5.208
9	27.542	.631	217.889	.004589	196.936	4.668
10	26.752	.432	196.100	.005099	134.828	3.196
11	26.961	.245	178.273	.005609	76.465	1.813
12	26.354	.171	163.417	.006119	53.369	1.265
13	25.739	.190	150.846	.006629	59.299	1.406
14	24.388	.190	140.071	.007139	59.299	1.406
15	23.449	.155	130.733	.007649	48.376	1.147
16	22.562	.150	122.563	.008159	46.815	1.110
17	21.669	.158	115.353	.008669	49.312	1.169
18	21.090	.106	108.944	.009179	33.083	.784
19	20.711	.055	103.211	.009689	17.166	.407
20	19.995	.050	98.050	.010199	15.605	.370
21	19.742	.051	93.381	.010709	15.917	.377
22	19.480	.066	89.136	.011219	20.599	.488
23	18.823	.077	85.261	.011729	24.032	.570
24	18.224	.070	81.708	.012239	21.847	.518
25	17.198	.081	78.440	.012749	25.280	.599
26	16.573	.086	75.423	.013259	26.841	.636
27	16.061	.067	72.630	.013768	20.911	.496
28	15.677	.050	70.036	.014278	15.605	.370
29	15.382	.043	67.621	.014788	13.420	.318
30	15.047	.048	65.367	.015298	14.981	.355
31	14.692	.059	63.258	.015808	18.414	.437
32	14.108	.076	61.281	.016318	23.720	.562
33	13.708	.074	59.424	.016828	23.096	.547
34	13.678	.059	57.676	.017338	18.414	.437
35	13.463	.059	56.029	.017848	18.414	.437
36	13.032	.066	54.472	.018358	20.599	.488
37	12.578	.077	53.000	.018868	24.032	.570
38	12.014	.073	51.605	.019378	22.783	.540
39	11.806	.048	50.282	.019888	14.981	.355
40	11.481	.037	49.025	.020398	11.548	.274
41	10.833	.049	47.829	.020908	15.293	.363
42	10.320	.062	46.690	.021418	19.350	.459
43	10.113	.067	45.605	.021928	20.911	.496
44	9.665	.076	44.568	.022438	23.720	.562
45	9.550	.091	43.578	.022947	28.401	.673
46	9.498	.095	42.630	.023457	29.650	.703
47	9.472	.077	41.723	.023967	24.032	.570
48	9.022	.050	40.854	.024477	15.605	.370
49	8.555	.033	40.020	.024987	10.299	.244
50	8.940	.013	39.220	.025497	4.057	.096

RUN 7 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	338.568	127.427	INFINITY	0	39770.222	117.466
1	332.549	153.046	1961.000	.000510	47765.963	141.082
2	327.417	31.154	980.500	.001020	9723.226	28.719
3	320.714	8.349	653.667	.001530	2605.740	7.696
4	314.339	4.499	490.250	.002040	1404.147	4.147
5	307.956	3.040	392.200	.002550	948.790	2.802
6	301.303	2.044	326.833	.003060	637.936	1.884
7	295.412	1.334	280.143	.003570	416.344	1.230
8	289.034	1.071	245.125	.004080	334.261	.987
9	283.300	.833	217.889	.004589	259.981	.768
10	277.804	.744	196.100	.005099	232.204	.686
11	272.710	.544	178.273	.005609	169.783	.501
12	266.242	.306	163.417	.006119	95.503	.282
13	261.082	.232	150.846	.006629	72.408	.214
14	255.159	.279	140.071	.007139	87.076	.257
15	249.783	.281	130.733	.007649	87.701	.259
16	244.417	.241	122.563	.008159	75.217	.222
17	238.817	.181	115.353	.008669	56.490	.167
18	234.448	.161	108.944	.009179	50.248	.148
19	229.262	.193	103.211	.009689	60.236	.178
20	224.731	.175	98.050	.010199	54.618	.161
21	219.138	.131	93.381	.010709	40.885	.121
22	213.590	.095	89.136	.011219	29.650	.088
23	208.144	.065	85.261	.011729	20.287	.060
24	203.395	.075	81.708	.012239	23.408	.069
25	198.442	.094	78.440	.012749	29.338	.087
26	193.985	.103	75.423	.013259	32.147	.095
27	189.678	.097	72.630	.013768	30.274	.089
28	185.193	.100	70.036	.014278	31.210	.092
29	180.854	.108	67.621	.014788	33.707	.100
30	176.770	.083	65.367	.015298	25.904	.077
31	172.834	.058	63.258	.015808	18.102	.053
32	169.076	.050	61.281	.016318	15.605	.046
33	165.543	.050	59.424	.016828	15.605	.046
34	162.392	.054	57.676	.017338	16.854	.050
35	159.867	.041	56.029	.017848	12.796	.038
36	157.416	.053	54.472	.018358	16.541	.049
37	154.751	.092	53.000	.018868	28.713	.085
38	152.562	.106	51.605	.019378	33.083	.098
39	149.061	.106	50.282	.019888	33.083	.098
40	146.886	.086	49.025	.020398	26.841	.079
41	144.270	.052	47.829	.020908	16.229	.048
42	141.552	.053	46.690	.021418	16.541	.049
43	138.260	.074	45.605	.021928	23.096	.068
44	135.033	.121	44.568	.022438	37.764	.112
45	132.145	.153	43.578	.022947	47.752	.141
46	129.343	.121	42.630	.023457	37.764	.112
47	126.823	.078	41.723	.023967	24.344	.072
48	123.871	.049	40.854	.024477	15.293	.045
49	120.969	.052	40.020	.024987	16.229	.048
50	117.571	.035	39.220	.025497	10.924	.032

RUN 7 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	23.076	5.829	INFINITY	0	1819.243	78.837
1	20.518	8.740	1961.000	.000510	2727.771	118.208
2	20.080	3.547	980.500	.001020	1107.026	47.973
3	19.222	1.093	653.667	.001530	341.127	14.783
4	18.344	.680	490.250	.002040	212.229	9.197
5	17.598	.362	392.200	.002550	112.981	4.896
6	16.939	.215	326.833	.003060	67.102	2.908
7	16.379	.148	280.143	.003570	46.191	2.002
8	15.748	.138	245.125	.004080	43.070	1.866
9	14.917	.137	217.889	.004589	42.758	1.853
10	14.148	.145	196.100	.005099	45.255	1.961
11	13.334	.129	178.273	.005609	40.261	1.745
12	12.690	.095	163.417	.006119	29.650	1.285
13	11.895	.092	150.846	.006629	28.713	1.244
14	11.354	.088	140.071	.007139	27.465	1.190
15	10.440	.060	130.733	.007649	18.726	.811
16	10.313	.046	122.563	.008159	14.357	.622
17	9.496	.054	115.353	.008669	16.854	.730
18	9.088	.046	108.944	.009179	14.357	.622
19	8.592	.028	103.211	.009689	8.739	.379
20	8.154	.030	98.050	.010199	9.363	.406
21	7.532	.032	93.381	.010709	9.987	.433
22	7.268	.037	89.136	.011219	11.548	.500
23	6.556	.047	85.261	.011729	14.669	.636
24	6.234	.045	81.708	.012239	14.045	.609
25	5.315	.047	78.440	.012749	14.669	.636
26	5.170	.054	75.423	.013259	16.854	.730
27	4.649	.043	72.630	.013768	13.420	.582
28	4.188	.029	70.036	.014278	9.051	.392
29	3.792	.042	67.621	.014788	13.108	.568
30	3.281	.055	65.367	.015298	17.166	.744
31	2.679	.051	63.258	.015808	15.917	.690
32	2.010	.044	61.281	.016318	13.732	.595
33	1.595	.038	59.424	.016828	11.860	.514
34	1.371	.037	57.676	.017338	11.548	.500
35	.876	.042	56.029	.017848	13.108	.568
36	.411	.050	54.472	.018358	15.605	.676
37	-0.040	.064	53.000	.018868	19.975	.866
38	-0.338	.061	51.605	.019378	19.038	.825
39	-0.932	.040	50.282	.019888	12.484	.541
40	-1.172	.032	49.025	.020398	9.987	.433
41	-1.748	.049	47.829	.020908	15.293	.663
42	-2.222	.065	46.690	.021418	20.287	.879
43	-2.456	.056	45.605	.021928	17.478	.757
44	-2.713	.052	44.568	.022438	16.229	.703
45	-2.933	.057	43.578	.022947	17.790	.771
46	-3.514	.043	42.630	.023457	13.420	.582
47	-3.800	.024	41.723	.023967	7.490	.325
48	-4.032	.027	40.854	.024477	8.427	.365
49	-4.536	.066	40.020	.024987	20.599	.893
50	-4.777	.047	39.220	.025497	14.669	.636

RUN 7 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	49.560	18.490	INFINITY	0	5770.766	116.440
1	46.092	20.961	1961.000	.000510	6541.970	132.001
2	45.649	3.361	980.500	.001020	1048.975	21.166
3	44.563	1.426	653.667	.001530	445.057	8.980
4	43.275	.858	490.250	.002040	267.784	5.403
5	42.569	.569	392.200	.002550	177.586	3.583
6	41.474	.396	326.833	.003060	123.592	2.494
7	40.510	.301	280.143	.003570	93.943	1.896
8	39.802	.271	245.125	.004080	84.580	1.707
9	38.981	.177	217.889	.004589	55.242	1.115
10	38.489	.095	196.100	.005099	29.650	.598
11	37.623	.108	178.273	.005609	33.707	.680
12	37.020	.112	163.417	.006119	34.955	.705
13	36.684	.099	150.846	.006629	30.898	.623
14	36.078	.108	140.071	.007139	33.707	.680
15	35.773	.076	130.733	.007649	23.720	.479
16	35.168	.044	122.563	.008159	13.732	.277
17	34.409	.046	115.353	.008669	14.357	.290
18	33.918	.065	108.944	.009179	20.287	.409
19	33.477	.076	103.211	.009689	23.720	.479
20	33.089	.079	98.050	.010199	24.656	.497
21	33.000	.064	93.381	.010709	19.975	.403
22	32.407	.051	89.136	.011219	15.917	.321
23	32.357	.056	85.261	.011729	17.478	.353
24	31.800	.045	81.708	.012239	14.045	.283
25	31.545	.040	78.440	.012749	12.484	.252
26	31.416	.048	75.423	.013259	14.981	.302
27	30.915	.046	72.630	.013768	14.357	.290
28	30.487	.043	70.036	.014278	13.420	.271
29	30.108	.045	67.621	.014788	14.045	.283
30	29.821	.059	65.367	.015298	18.414	.372
31	29.289	.066	63.258	.015808	20.599	.416
32	29.258	.061	61.281	.016318	19.038	.384
33	29.138	.059	59.424	.016828	18.414	.372
34	29.072	.068	57.676	.017338	21.223	.428
35	29.381	.062	56.029	.017848	19.350	.390
36	28.618	.048	54.472	.018358	14.981	.302
37	28.646	.079	53.000	.018868	24.656	.497
38	28.230	.100	51.605	.019378	31.210	.630
39	27.842	.099	50.282	.019888	30.898	.623
40	27.839	.093	49.025	.020398	29.025	.586
41	27.194	.063	47.829	.020908	19.662	.397
42	27.282	.064	46.690	.021418	19.975	.403
43	27.542	.079	45.605	.021928	24.656	.497
44	26.953	.060	44.568	.022438	18.726	.378
45	26.637	.049	43.578	.022947	15.293	.309
46	26.063	.062	42.630	.023457	19.350	.390
47	25.573	.071	41.723	.023967	22.159	.447
48	24.996	.073	40.854	.024477	22.783	.460
49	24.665	.063	40.020	.024987	19.662	.397
50	23.943	.027	39.220	.025497	8.427	.170

RUN 7 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	49.294	15.756	INFINITY	0	4917.479	99.758
1	45.658	20.532	1961.000	.000510	6408.078	129.997
2	45.165	5.749	980.500	.001020	1794.274	36.399
3	43.584	1.581	653.667	.001530	493.433	10.010
4	42.177	.859	490.250	.002040	268.096	5.439
5	41.330	.611	392.200	.002550	190.694	3.869
6	39.811	.520	326.833	.003060	162.293	3.292
7	39.020	.272	280.143	.003570	84.892	1.722
8	37.944	.225	245.125	.004080	70.223	1.425
9	36.737	.180	217.889	.004589	56.178	1.140
10	35.523	.139	196.100	.005099	43.382	.880
11	34.703	.196	178.273	.005609	61.172	1.241
12	33.474	.196	163.417	.006119	61.172	1.241
13	32.365	.104	150.846	.006629	32.459	.658
14	31.493	.071	140.071	.007139	22.159	.450
15	30.894	.085	130.733	.007649	26.529	.538
16	29.753	.095	122.563	.008159	29.650	.601
17	28.951	.074	115.353	.008669	23.096	.469
18	28.115	.050	108.944	.009179	15.605	.317
19	27.012	.058	103.211	.009689	18.102	.367
20	25.875	.068	98.050	.010199	21.223	.431
21	24.582	.057	93.381	.010709	17.790	.361
22	23.604	.042	89.136	.011219	13.108	.266
23	22.800	.044	85.261	.011729	13.732	.279
24	22.051	.047	81.708	.012239	14.669	.298
25	21.101	.051	78.440	.012749	15.917	.323
26	20.642	.073	75.423	.013259	22.783	.462
27	19.151	.082	72.630	.013768	25.592	.519
28	18.292	.052	70.036	.014278	16.229	.329
29	17.633	.029	67.621	.014788	9.051	.184
30	16.897	.030	65.367	.015298	9.363	.190
31	16.494	.029	63.258	.015808	9.051	.184
32	15.866	.030	61.281	.016318	9.363	.190
33	15.681	.044	59.424	.016828	13.732	.279
34	15.360	.067	57.676	.017338	20.911	.424
35	14.570	.079	56.029	.017848	24.656	.500
36	14.011	.064	54.472	.018358	19.975	.405
37	13.077	.058	53.000	.018868	18.102	.367
38	12.057	.087	51.605	.019378	27.153	.551
39	10.973	.097	50.282	.019888	30.274	.614
40	10.108	.082	49.025	.020398	25.592	.519
41	9.180	.087	47.829	.020908	27.153	.551
42	8.463	.097	46.690	.021418	30.274	.614
43	7.556	.080	45.605	.021928	24.968	.507
44	6.653	.073	44.568	.022438	22.783	.462
45	5.726	.091	43.578	.022947	28.401	.576
46	4.611	.094	42.630	.023457	29.338	.595
47	4.057	.076	41.723	.023967	23.720	.481
48	3.591	.053	40.854	.024477	16.541	.336
49	3.180	.051	40.020	.024987	15.917	.323
50	2.642	.029	39.220	.025497	9.051	.184

RUN 7 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	40.218	8.378	INFINITY	0	2614.791	65.015
1	36.378	13.555	1961.000	.000510	4230.543	105.190
2	35.075	7.221	980.500	.001020	2253.689	56.037
3	32.707	3.271	653.667	.001530	1020.886	25.384
4	30.736	1.832	490.250	.002040	571.771	14.217
5	28.922	.920	392.200	.002550	287.134	7.139
6	26.533	.512	326.833	.003060	159.796	3.973
7	25.351	.381	280.143	.003570	118.911	2.957
8	23.436	.367	245.125	.004080	114.541	2.848
9	21.857	.427	217.889	.004589	133.268	3.314
10	20.402	.398	196.100	.005099	124.217	3.089
11	19.022	.212	178.273	.005609	66.166	1.645
12	17.158	.103	163.417	.006119	32.147	.799
13	15.378	.089	150.846	.006629	27.777	.691
14	13.696	.126	140.071	.007139	39.325	.978
15	12.326	.125	130.733	.007649	39.013	.970
16	11.154	.058	122.563	.008159	18.102	.450
17	10.290	.077	115.353	.008669	24.032	.598
18	9.487	.140	108.944	.009179	43.694	1.086
19	9.093	.096	103.211	.009689	29.962	.745
20	8.315	.042	98.050	.010199	13.108	.326
21	8.385	.050	93.381	.010709	15.605	.388
22	7.480	.062	89.136	.011219	19.350	.481
23	6.555	.065	85.261	.011729	20.287	.504
24	5.441	.063	81.708	.012239	19.662	.489
25	4.694	.064	78.440	.012749	19.975	.497
26	4.493	.072	75.423	.013259	22.471	.559
27	4.174	.081	72.630	.013768	25.280	.629
28	4.032	.077	70.036	.014278	24.032	.598
29	3.092	.059	67.621	.014788	18.414	.458
30	2.638	.040	65.367	.015298	12.484	.310
31	1.918	.036	63.258	.015808	11.236	.279
32	1.787	.037	61.281	.016318	11.548	.287
33	1.375	.037	59.424	.016828	11.548	.287
34	.577	.034	57.676	.017338	10.611	.264
35	-0.208	.030	56.029	.017848	9.363	.233
36	-1.014	.047	54.472	.018358	14.669	.365
37	-1.422	.068	53.000	.018868	21.223	.528
38	-1.350	.073	51.605	.019378	22.783	.566
39	-1.530	.078	50.282	.019888	24.344	.605
40	-1.750	.075	49.025	.020398	23.408	.582
41	-2.059	.077	47.829	.020908	24.032	.598
42	-2.682	.105	46.690	.021418	32.771	.815
43	-2.990	.116	45.605	.021928	36.204	.900
44	-3.538	.086	44.568	.022438	26.841	.667
45	-4.161	.064	43.578	.022947	19.975	.497
46	-5.031	.082	42.630	.023457	25.592	.636
47	-5.066	.091	41.723	.023967	28.401	.706
48	-4.954	.063	40.854	.024477	19.662	.489
49	-4.660	.039	40.020	.024987	12.172	.303
50	-4.759	.017	39.220	.025497	5.306	.132

RUN 7 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	50.632	12.569	INFINITY	0	3922.810	77.477
1	47.104	19.922	1961.000	.000510	6217.696	122.802
2	46.196	9.416	980.500	.001020	2938.752	58.041
3	44.214	2.782	653.667	.001530	868.268	17.149
4	42.442	1.054	490.250	.002040	328.956	6.497
5	41.051	.569	392.200	.002550	177.586	3.507
6	39.363	.453	326.833	.003060	141.382	2.792
7	37.691	.363	280.143	.003570	113.293	2.238
8	36.020	.260	245.125	.004080	81.147	1.603
9	34.177	.232	217.889	.004589	72.408	1.430
10	32.239	.215	196.100	.005099	67.102	1.325
11	30.660	.164	178.273	.005609	51.185	1.011
12	28.545	.143	163.417	.006119	44.631	.881
13	27.029	.147	150.846	.006629	45.879	.906
14	24.889	.114	140.071	.007139	35.580	.703
15	23.160	.104	130.733	.007649	32.459	.641
16	21.256	.112	122.563	.008159	34.955	.690
17	19.774	.085	115.353	.008669	26.529	.524
18	17.779	.071	108.944	.009179	22.159	.438
19	16.341	.069	103.211	.009689	21.535	.425
20	14.548	.049	98.050	.010199	15.293	.302
21	13.199	.045	93.381	.010709	14.045	.277
22	11.643	.055	89.136	.011219	17.166	.339
23	10.246	.057	85.261	.011729	17.790	.351
24	9.075	.052	81.708	.012239	16.229	.321
25	7.662	.044	78.440	.012749	13.732	.271
26	6.773	.042	75.423	.013259	13.108	.259
27	5.613	.040	72.630	.013768	12.484	.247
28	4.716	.036	70.036	.014278	11.236	.222
29	3.794	.050	67.621	.014788	15.605	.308
30	3.305	.051	65.367	.015298	15.917	.314
31	2.418	.040	63.258	.015808	12.484	.247
32	1.795	.042	61.281	.016318	13.108	.259
33	.564	.044	59.424	.016828	13.732	.271
34	-0.059	.051	57.676	.017338	15.917	.314
35	-0.882	.064	56.029	.017848	19.975	.395
36	-1.600	.067	54.472	.018358	20.911	.413
37	-1.484	.083	53.000	.018868	25.904	.512
38	-2.355	.089	51.605	.019378	27.777	.549
39	-2.769	.062	50.282	.019888	19.350	.382
40	-3.191	.064	49.025	.020398	19.975	.395
41	-3.648	.069	47.829	.020908	21.535	.425
42	-3.764	.063	46.690	.021418	19.662	.388
43	-4.146	.068	45.605	.021928	21.223	.419
44	-4.127	.056	44.568	.022438	17.478	.345
45	-4.139	.065	43.578	.022947	20.287	.401
46	-4.526	.104	42.630	.023457	32.459	.641
47	-4.060	.105	41.723	.023967	32.771	.647
48	-4.089	.067	40.854	.024477	20.911	.413
49	-3.550	.043	40.020	.024987	13.420	.265
50	-3.040	.019	39.220	.025497	5.930	.117

RUN 7 CHANNEL 10

K	ACOV	SP	PERIOD	FREQ	SPK	SPN
0	78.386	22.896	INFINITY	0	7145.887	91.163
1	74.422	32.642	1961.000	.000510	10187.633	129.968
2	72.158	11.567	980.500	.001020	3610.084	46.055
3	69.486	2.465	653.667	.001530	769.331	9.815
4	66.705	1.207	490.250	.002040	376.707	4.806
5	64.506	.986	392.200	.002550	307.733	3.926
6	62.187	.937	326.833	.003060	292.440	3.731
7	60.125	.972	280.143	.003570	303.363	3.870
8	58.496	.645	245.125	.004080	201.306	2.568
9	56.608	.343	217.889	.004589	107.051	1.366
10	55.307	.385	196.100	.005099	120.159	1.533
11	53.667	.350	178.273	.005609	109.236	1.394
12	52.318	.165	163.417	.006119	51.497	.657
13	50.172	.095	150.846	.006629	29.650	.378
14	47.779	.127	140.071	.007139	39.637	.506
15	45.799	.167	130.733	.007649	52.121	.665
16	43.746	.160	122.563	.008159	49.936	.637
17	41.586	.125	115.353	.008669	39.013	.498
18	39.043	.110	108.944	.009179	34.331	.438
19	36.835	.107	103.211	.009689	33.395	.426
20	34.567	.085	98.050	.010199	26.529	.338
21	31.893	.054	93.381	.010709	16.854	.215
22	29.112	.049	89.136	.011219	15.293	.195
23	27.043	.060	85.261	.011729	18.726	.239
24	25.680	.092	81.708	.012239	28.713	.366
25	23.774	.113	78.440	.012749	35.268	.450
26	22.821	.072	75.423	.013259	22.471	.287
27	21.235	.035	72.630	.013768	10.924	.139
28	19.688	.034	70.036	.014278	10.611	.135
29	17.804	.056	67.621	.014788	17.478	.223
30	15.687	.070	65.367	.015298	21.847	.279
31	13.800	.058	63.258	.015808	18.102	.231
32	11.970	.056	61.281	.016318	17.478	.223
33	9.939	.062	59.424	.016828	19.350	.247
34	8.736	.070	57.676	.017338	21.847	.279
35	7.516	.069	56.029	.017848	21.535	.275
36	6.961	.048	54.472	.018358	14.981	.191
37	6.394	.063	53.000	.018868	19.662	.251
38	5.707	.089	51.605	.019378	27.777	.354
39	5.140	.080	50.282	.019888	24.968	.319
40	5.091	.073	49.025	.020398	22.783	.291
41	4.098	.084	47.829	.020908	26.217	.334
42	3.381	.081	46.690	.021418	25.280	.323
43	3.311	.048	45.605	.021928	14.981	.191
44	2.837	.029	44.568	.022438	9.051	.115
45	2.873	.037	43.578	.022947	11.548	.147
46	2.602	.055	42.630	.023457	17.166	.219
47	2.426	.061	41.723	.023967	19.038	.243
48	2.578	.050	40.854	.024477	15.605	.199
49	2.105	.062	40.020	.024987	19.350	.247
50	2.418	.040	39.220	.025497	12.484	.159