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MICROPROCESSES. PART I. MIDWATER THERMAL STRUCTURE. PART II. SURFACE WAVES AND NEAR SURFACE EFFECTS. PART III.

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Scripps Institution of Oceanography

Prepared for:

Office of Naval Research
Advanced Research Projects Agency

14 August 1973

AD 766151

SCRIPPS INSTITUTION OF OCEANOGRAPHY
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Technical Progress Report

June 30, 1973

Sponsored by
ADVANCED RESEARCH PROJECTS AGENCY
ARPA Order Number 2185
Program Code 2E20

Administered by the OFFICE OF NAVAL RESEARCH
Contract N00014-69-A-0200-6039
Contract Effective Date: April 1, 1972
Contract Expiration Date: December 31, 1973
Total Contract Amount $1,303,600.00

SIO Reference Number 73-20

AOEL Report #41

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) The Regents of the University of California University of California, San Diego La Jolla, California 92037	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP Not applicable
3. REPORT TITLE Technical Progress Report Advanced Ocean Engineering Laboratory	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) January 1, 1973 to June 30, 1973	
5. AUTHOR(S) (First name, middle initial, last name) Charles S. Cox and Michael C. Gregg - Part I James L. Cairns and Gordon O. Williams - Part II Frank H. Champagne, Carl A. Friehe and Carl H. Gibson - Part III	
6. REPORT DATE August 14, 1973	7a. TOTAL NO. OF PAGES 29 7b. NO. OF REFS None
8a. CONTRACT OR GRANT NO. N00014-69-A-0200-6039 b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) SIO Reference No. 73-20 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AOEL Report No. 41
10. DISTRIBUTION STATEMENT Distribution of this document is unlimited	
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency c/o Office of Naval Research Arlington, Virginia 22217

13. ABSTRACT

This semi-annual report reflects the technical status of internal/surface wave interaction and microstructure projects conducted within the Advanced Ocean Engineering Laboratory at the Scripps Institution of Oceanography. These projects are: (1) Thermal Microstructure - to examine in detail the structure and dynamics of temperature and salinity and (2) Atmospheric Boundary Layer - to provide an understanding of the interaction between atmospheric boundary effects and surface waves.

DD FORM 1 NOV 65 1473 (PAGE 1)
0102-014-6600

Unclassified
Security Classification

Unclassified
Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Microprocesses						
Midwater Thermal Structure						
Freely Floating Instrumented Capsule						
Buoyancy Control System						
Surface Waves and Near Surface Effects						
Sonic Anemometer						
Wave Height Measuring Circuit						
Inertial Navigation System						
Data Recording Systems						
Capillary Wave Probe Array						

DD FORM 1 NOV 65 1473 (BACK)
(PAGE 2)

Unclassified
Security Classification

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ADVANCED OCEAN ENGINEERING LABORATORY

TECHNICAL PROGRESS REPORT

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Part I

Microprocesses

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ONR Contract N00014-69-A-0200-6039

Part I

Microprocesses

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I. Project Summary

This report summarizes the work undertaken between 1 January 1973 and 1 July 1973, and should be considered as a supplement to the previous report.

II. Technical Report

Our major efforts have been: (a) a continuing development of computer programs for batch processing of data ashore; (b) completion of a sea-going mini-computer system to digitize the FM records produced by the free-fall microstructure recorders and to perform preliminary analysis of the data; and (c) a program of microstructure measurements adjacent to Pinkel's internal wave array.

Beginning on 15 June 1973, a full-time programmer was hired to develop a system of programs on the Burroughs 6700 for the batch processing of microstructure data. A portable remote terminal was purchased to aid him in this task. To date a pre-existing program for spectral analysis of the records has been rewritten, providing lower costs per job and the ability to include more spectra in a given job. A program to deconvolve the data for instrument response and to produce a finished tape for analysis is running and is currently being debugged.

A portable van to house the mini-computer system was purchased and outfitted with RF shielding, work tables, an air conditioner and an electronics rack. The system, consisting of a DATA GENERAL NOVA JUMBO computer, TANDBERG FM tape deck, Kennedy 9-track tape deck, and DATA GENERAL DISK went to sea on the R/V THOMAS WASHINGTON during June 1973, and performed satisfactorily. All of the data tapes were digitized at sea and the data read to determine actual depths and temperatures of the drops. Spectra were taken, indicating that most of the data were of high quality, but the absolute levels were uncertain since the program had not been previously debugged.

During 4 days in early June 1973, microstructure observations were taken within a few hundred yards of FLIP while the internal wave array was in operation. In addition to the "nose" and "wing" temperature gradient measurements which have been reported earlier, an additional temperature gradient was observed from a "mini-wing" mounted below the vehicle. The smaller radius of the helical path followed by this probe should permit a determination of the degree of isotropy of the temperature fluctuations to scales of 2 or 3 centimeters. The normal wing measurements could make this determination only to scales of 10 to 20 centimeters. In addition, 2 STD patterns were run about FLIP. The data will be used to assess the influence of intrusive features in the water on the FLIP internal wave measurements.

Part II

Midwater Thermal Structure

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This experiment conducted by
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under the guidance of Drs. Munk and Snodgrass

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Part II

Midwater Thermal Structure

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I. Project Summary

Equipment development and at-sea testing of a freely floating instrumented capsule with associated equipment have been essentially completed.

Preliminary examination of data gathered in June in connection with the simultaneous OWEX experiments indicates all equipment functioned properly.

II. Purpose

The purpose of this project is to examine in detail the history of oceanic thermal structure within $\simeq$ 100 meter vertical segments of the water column. The observations are made from a freely floating instrumented capsule described previously.

III. Accomplishments

During the period under consideration three sea trips were made to the Southern California offshore area. These trips are summarized as follows:

1) April - During the first week in April engineering checks of the entire capsule-shipboard system were made in the San Diego Trough. Many new or modified items or equipment were included in this evaluation. The principal equipment tests were of:

- a) a new shipboard portable laboratory and associated equipment,
- b) new shipboard acoustic equipment for capsule tracking, command, and interrogation,
- c) a new hydraulic capsule buoyancy control,
- d) a compass system to monitor azimuthal orientation of capsule sensors, and
- e) equipment for at-sea reading, plotting and preliminary analysis of capsule-generated computer tapes.

These sea tests were largely successful, and suggested the need for only minor modifications. The buoyancy control system was not fully tested due to a faulty electrical cable.

2) April - During the third week in April a one-day capsule drop was made in the area south of San Clemente Island to verify proper operation of the buoyancy control system. All capsule and shipboard systems worked well on this trip. A 13-hour record of thermal microstructure was obtained at a depth of $\sim$750 meters.

3) June - During the interval 1 to 18 June we obtained data with the midwater capsule in connection with other simultaneous OWCX experiments in an area approximately 300 miles SW of San Diego. Three capsule drops, each of one-day duration, were made to examine spatial and temporal variations of thermal microstructure, including interactions with internal waves. These were to depths of approximately 950 m, 600 m, and 500 m.

A fourth thermal structure record, of 6 days duration was measured at a depth of 750 m, to examine the background internal wave spectrum and the coherence of waves in the vertical direction. A preliminary examination of data from these drops indicates that all of the measurements were made successfully.

IV. Future Plans

The equipment development portion of the program is essentially completed. Our immediate plans are to analyze and report on the data gathered in April and June. The choice of future observations to be made with the midwater capsule will depend heavily on understanding gained from these data.

Part III

Surface Waves and Near Surface Effects

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Part III

Surface Waves and Near Surface Effects

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I. Project Summary

The organization, preparation and completion of the ocean field experiment OWAX, in conjunction with R. Davis and C Paulson, was our primary research effort during the contract period January 1 to June 30, 1973. Most of the measurements proposed in the experiment plan given in the last technical report were obtained. Preliminary analysis of some of the recorded data indicates that, in general, high-quality measurements were obtained of the desired variables - the turbulent wind field, surface waves, motion of the research platform FLIP, fine-scale air temperature and humidity fluctuations, etc. A prototype internal wave measuring device developed by R. Pinkel was deployed for field tests and also used to provide indication of internal waves for simultaneous recording with the other variables. Detailed data analysis on various aspects of the atmospheric boundary layer-open ocean wave problem is proceeding.

II. Major Instrumentation Developed and Acquired

Several important major instrument systems that were utilized in the field experiment are described in this section.

a) Three-component sonic anemometer. This device provides simultaneous resolution of the turbulent velocity vector (in the air) over a bandwidth from D. C. to about 10 Hz. It does not require calibration in the field, and is our primary absolute velocity measuring instrument. The sonic anemometer array was purchased from EG & G, Inc., while the readout circuitry was designed by Mr. T. Deaton of our staff and the unit was constructed in our shop at a considerable savings over the EG & G price. The entire sonic anemometer system was thoroughly tested in the UCSD-AMES low speed wind tunnel, and worked very well in the field experiment.

b) Wave height measuring circuit. A six-channel A. C. carrier wave height measuring circuit was designed by T. Deaton and constructed for use with the resistance-wire wave height technique used by R. Davis. The circuit has a bandwidth of D. C. to 200 Hz and has an equivalent input noise of about 0.2 mm wave height over that bandwidth.

c) Litton Inertial Navigation System. Through ARPA, a Litton Industries LTN-51 Inertial Navigation System was acquired to measure all components of FLIP's motions. Such measurements are needed to correct other data, primarily the turbulent velocity component and surface wave height data.

d) Data recording systems. Data was recorded on both analog and digital systems for maximum flexibility and reliability. A 14-channel Honeywell FM laboratory instrumentation analog tape recorder with two multiplexed channels was used to record up to 21 signals simultaneously. A Texas Instruments Model 980 computer system was used to record up to 32 channels on digital tape. Some on-line calculations were performed with the TI-980 on the FLIP.

III. Experiments

Several experiments were performed during the OWAX cruise and are described briefly in this section. Approximately 40 hours of data were obtained. Instrument locations on the port boom of FLIP are shown in Figure 1. The Litton Inertial Navigation System was located in the Electronics Laboratory.

Experiment 1: FLIP motion. Measurements were made of all 6 components of FLIP's motion (three components of the acceleration and the three angles, pitch, roll, azimuth) with the Litton platform. Three wave height sensor outputs (operated with R. Davis wave height bridge for this experiment) and wind speed and direction were also measured.

Experiment 2: Surface effects: Measurements were made of the turbulent wind field, surface waves air temperature and humidity fluctuations from the instrument "package" suspended 3 m below the end of the port boom. The outputs from a vertical gyro located on the package as well as the inertial platform outputs were simultaneously recorded and these will be referred to as boom and FLIP motion.

Experiment 3: Surface effects, capillary waves, internal waves, FLIP and boom motion: In addition to the basic atmospheric measurements made from the package, R. Davis and L. Regier's capillary wave probe array was deployed. Also, two temperature signals from R. Pinkel's internal wave device positioned in the thermocline region were recorded.

Experiment 4: Fine-scale velocity, temperature, and humidity measurements: velocity (hot-film anemometer), temperature and humidity probes were deployed to obtain fine-scale measurements in the atmospheric boundary layer in addition to the basic package and boom and FLIP motion measurements. Temperature and humidity instruments were also deployed on the high vertical mast on FLIP.

Experiment 5: Capillary wave measurements: The Davis-Regier capillary wave array was deployed and data obtained simultaneously R. Pinkel's internal wave signals, surface waves, turbulent velocity field and FLIP and boom motion.

Experiment 6: Capillary wave, air temperature and sea surface temperature: To the arrangement described in Experiment 5 was added a thermistor to measure fluctuating air temperature and the signal from the Oregon State University (C. Paulson) sea surface temperature radiometer.

Experiment 7: FLIP motion: Measurement of FLIP motion with Litton system, boom gyro, and Honeywell gyroscopes for comparison.

Experiment 7.1, 7.2, 7.3: Temperature Structure: Three temperature probes were placed at three heights to provide data on structure of the atmospheric temperature field.

Experiment 8: Fine scale velocity measurements: A 2-channel hot-film x-array anemometer system was used to provide fine scale velocity measurements, in addition to basic package and boom and FLIP motion measurements. Data was recorded during a developing storm with high winds and occasional light rain.

Approximately 15 XBT soundings were obtained. Routine environmental data was logged by the O.S.U. group.

IV. Preliminary Analysis

Preliminary analysis of many of the recorded data tapes has been made with our laboratory computing system to verify the quality of the data, obtain some preliminary results, and identify those areas requiring detailed analysis.

Some aspects of the motion of FLIP as measured with the Litton Inertial Navigation Unit have been analyzed. For Experiment 1 the following results were obtained:

rms vertical (z) acceleration	= 1.86 cm/sec^2
rms horizontal (x^1,y^1) accelerations	= 1.02, 6.9 cm/sec^2 (2 axes)
rms pitch	= 0.335 deg
rms roll	= 0.321 deg
rms wave height	= 0.8 meter

Power spectra of the motion variables were obtained, and are shown in Figures 2, 3, 4, 5, 6. Figure 7 shows the power spectra from one of the R. Davis' wave probes. The response of the FLIP as measured with the Litton system appears reasonable. From the vertical acceleration spectrum, the vertical displacement spectrum was obtained (not including very low frequency accelerometer drift contributions, per suggestion of R. Davis), and is shown in Figure 8. The rms vertical displacement thus calculated was found to be 23 cm, and the rms vertical velocity was 10 cm/sec. Therefore this component of the motion will have to be taken into account when analyzing measured vertical velocities, waves, etc.

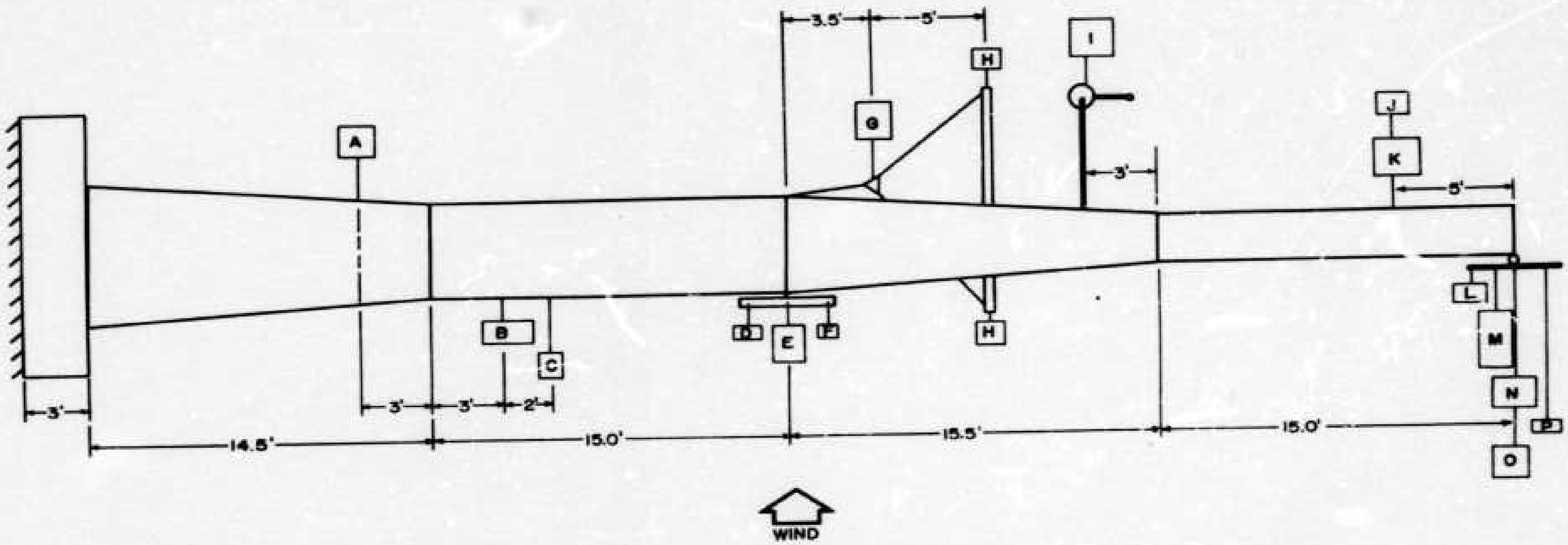
Figures 9 and 10 show the power spectra of the u and w velocity components as measured by the sonic anemometer. The peaks in the w component spectrum occur at 0.05 and 0.1 Hz which corresponds with two of the peaks in the vertical displacement and wave height spectra.

It is tempting to attribute the peaks in the u component spectra to wave-induced motion in the wind velocity field, but more analysis of possible effects caused by FLIP's motion must be undertaken before such conclusions can be drawn. Figures 11 and 12 show humidity and temperature spectra, respectively. The humidity spectrum displays better agreement with a - 5/3 slope (solid straight lines on plots) than does the temperature spectrum.

Figure 1

PORT BOOM CONFIGURATION FOR OWAX

- TOP VIEW -



|A| O.S.U Float

|B| Internal Wave Probe

|C| O.S.U. "Fish"

|D| Vane

|E| EG & G Dew Point

|F| Cup

|G| Capillary Wave Array

|H| Wave Wire

|I| O.S.U. Radiometers

|J| Wave Wire

|K| O.S.U. Barnes Radiometer

|L| Lyman-α Humidiometer

|M| Hot Wire / Thermistor

|N| EG&G Sonic Anemometer / Gyro

|O| Wave Wire

|P| Cup

A(Z) POWER SPECTRUM

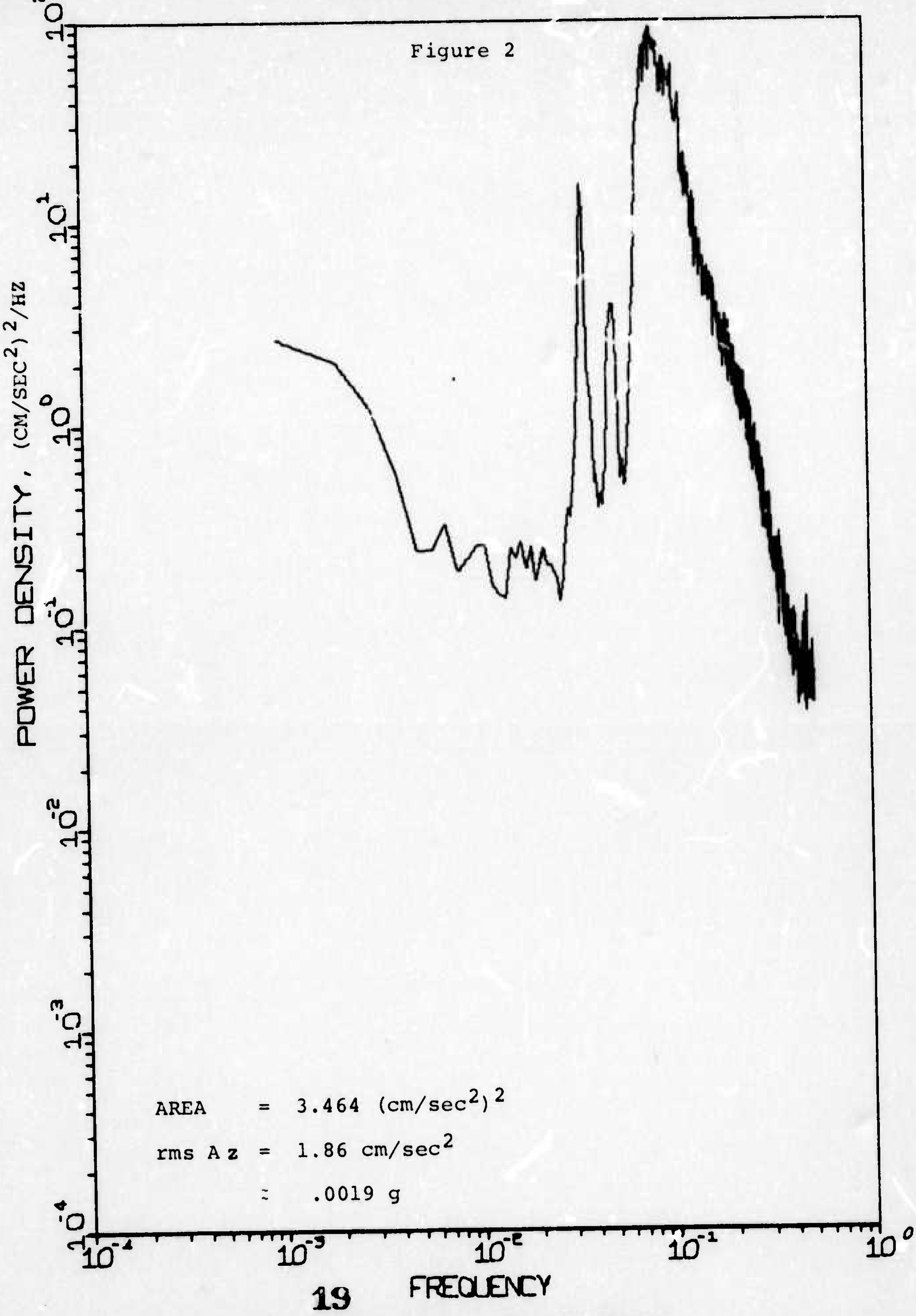


Figure 2

RECORDS 941 - 971 OF OWAX D1

SF = 1.0188 CAL 422.2973

SPECTRUM OF A(X')

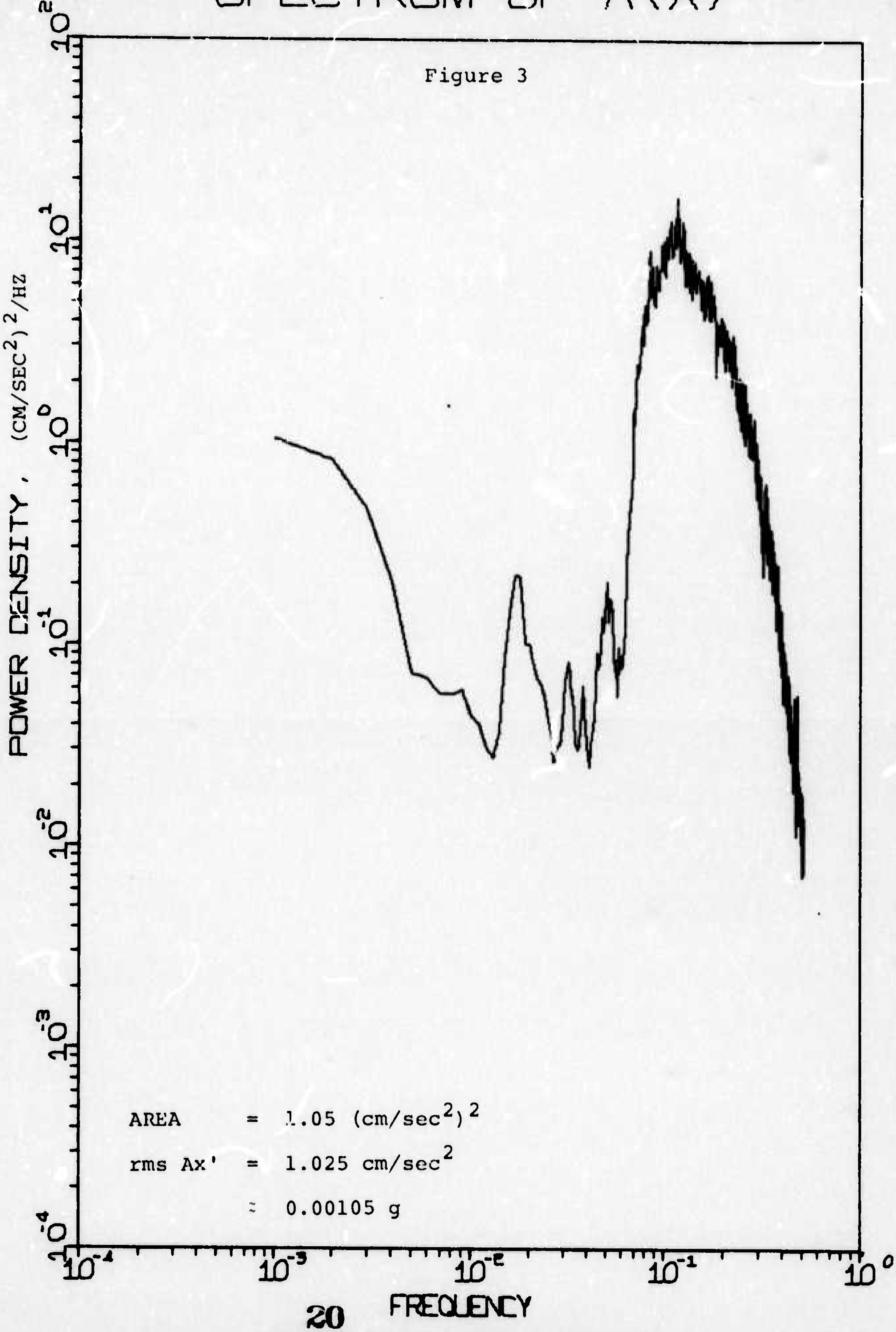


Figure 3

RECORDS 910 TO 940 OF OWAX 01

SF = 1.0188 CAL = 751.3148

A(Y') POWER SPECTRUM

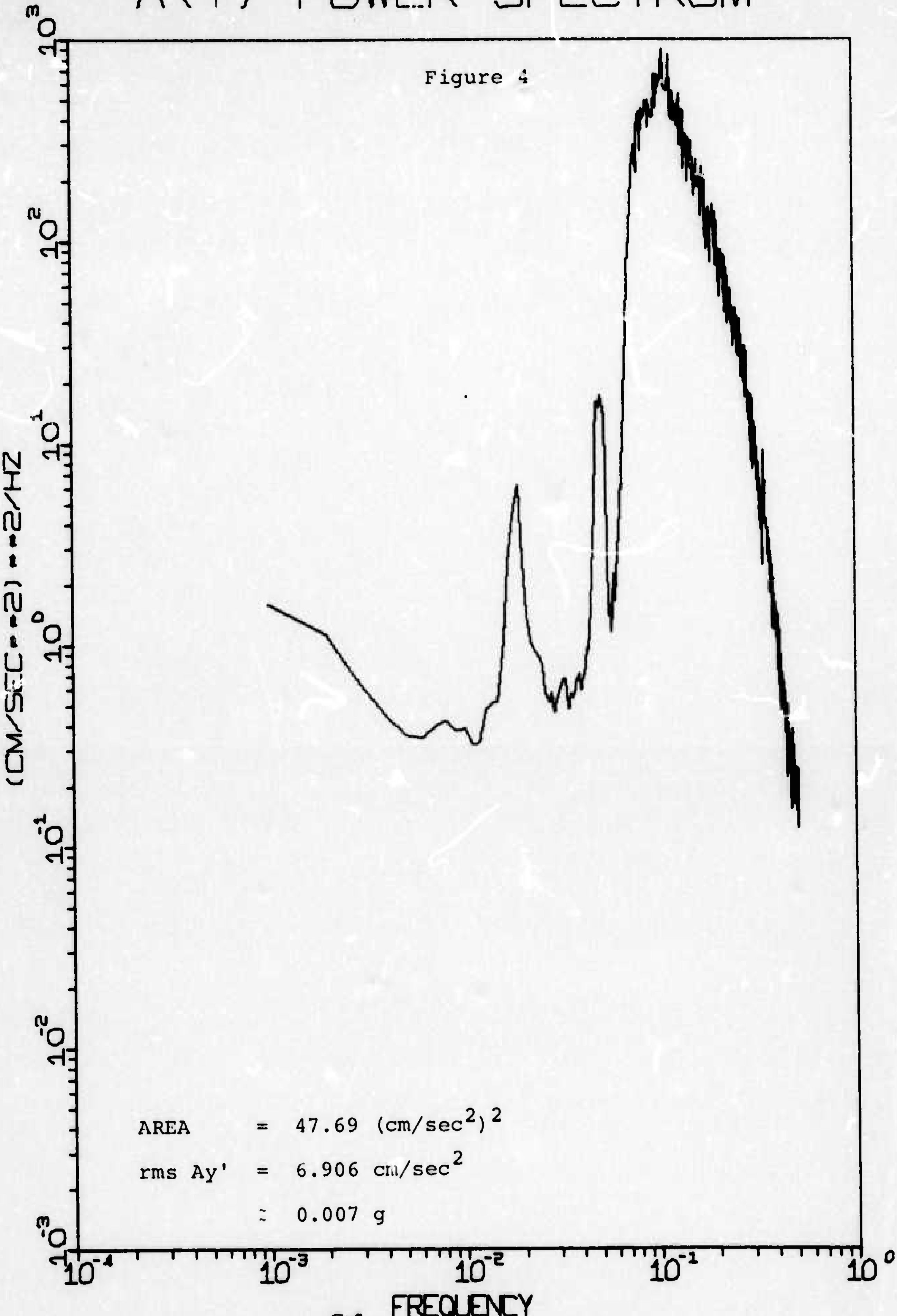
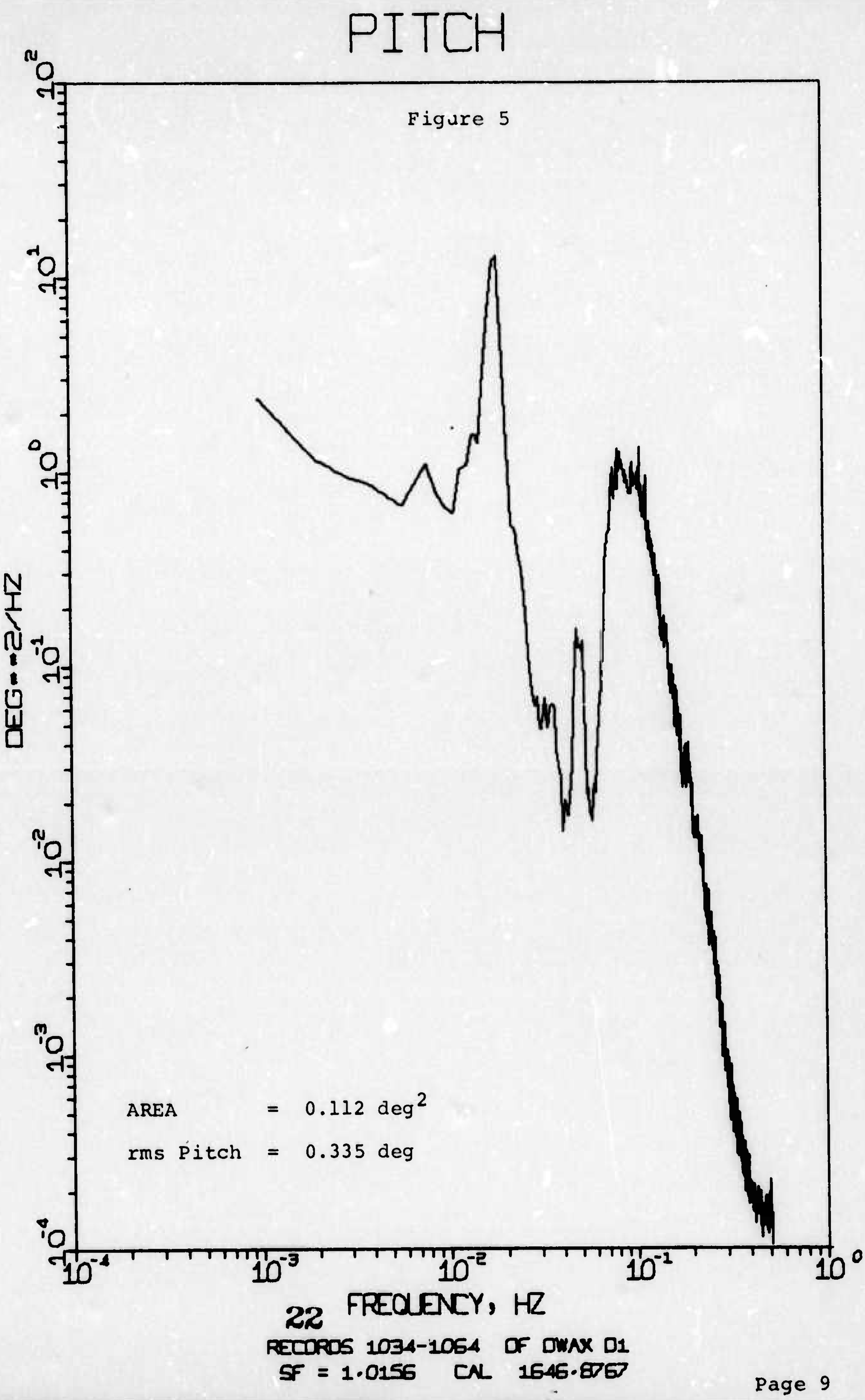
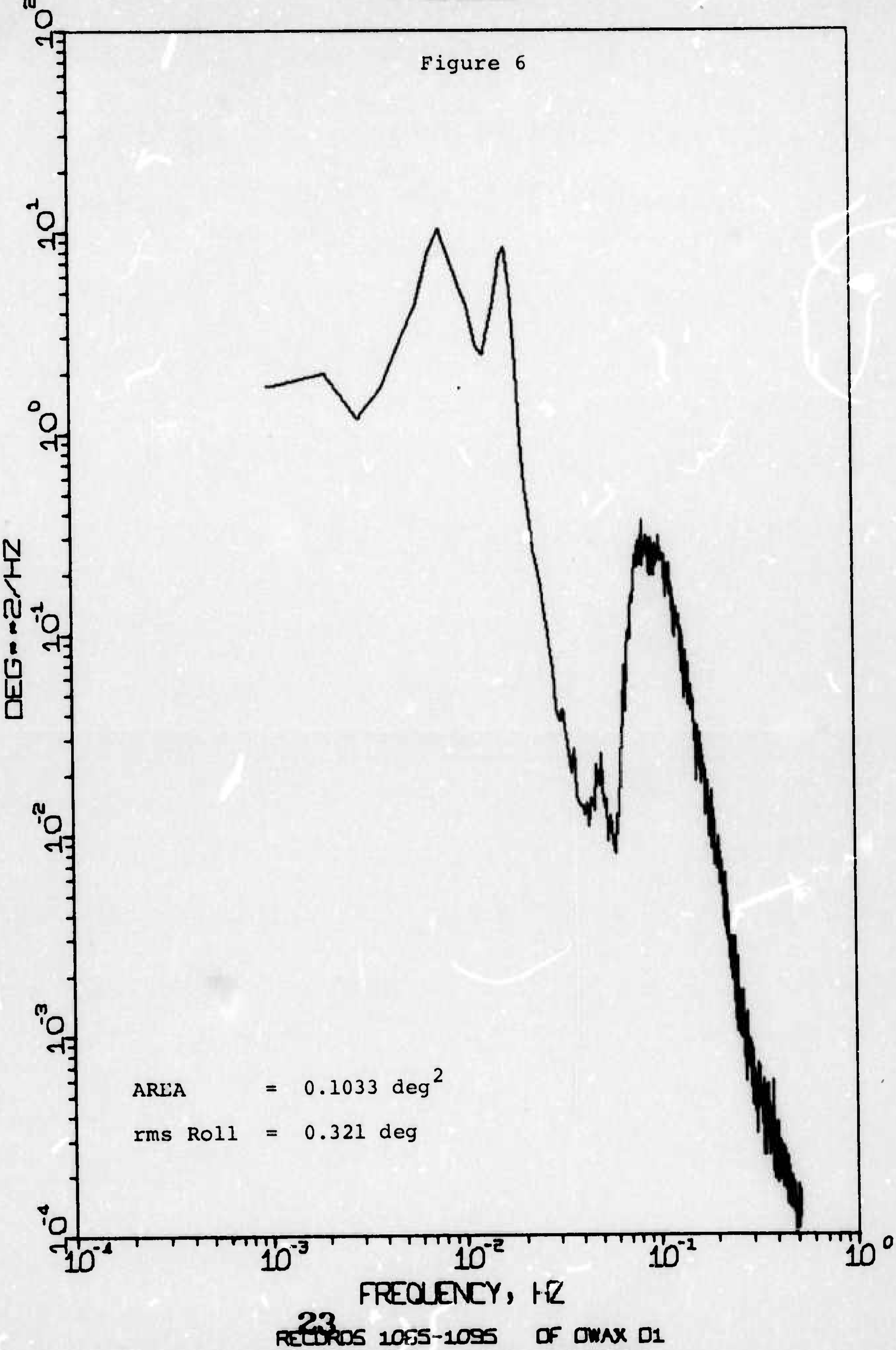


Figure 4

RECORDS 972-1002 OF OWAX D1
SF = 1.0219 CAL 765.1109


PITCH
Figure 5
DEG**2/HZ
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
AREA = 0.112 deg^2
rms Pitch = 0.335 deg
10^{-4}
10^{-3}
10^{-2}
10^{-1}
10^{0}
FREQUENCY, HZ
RECORDS 1034-1064 OF OWAX 01
SF = 1.0156 CAL 1646.8767

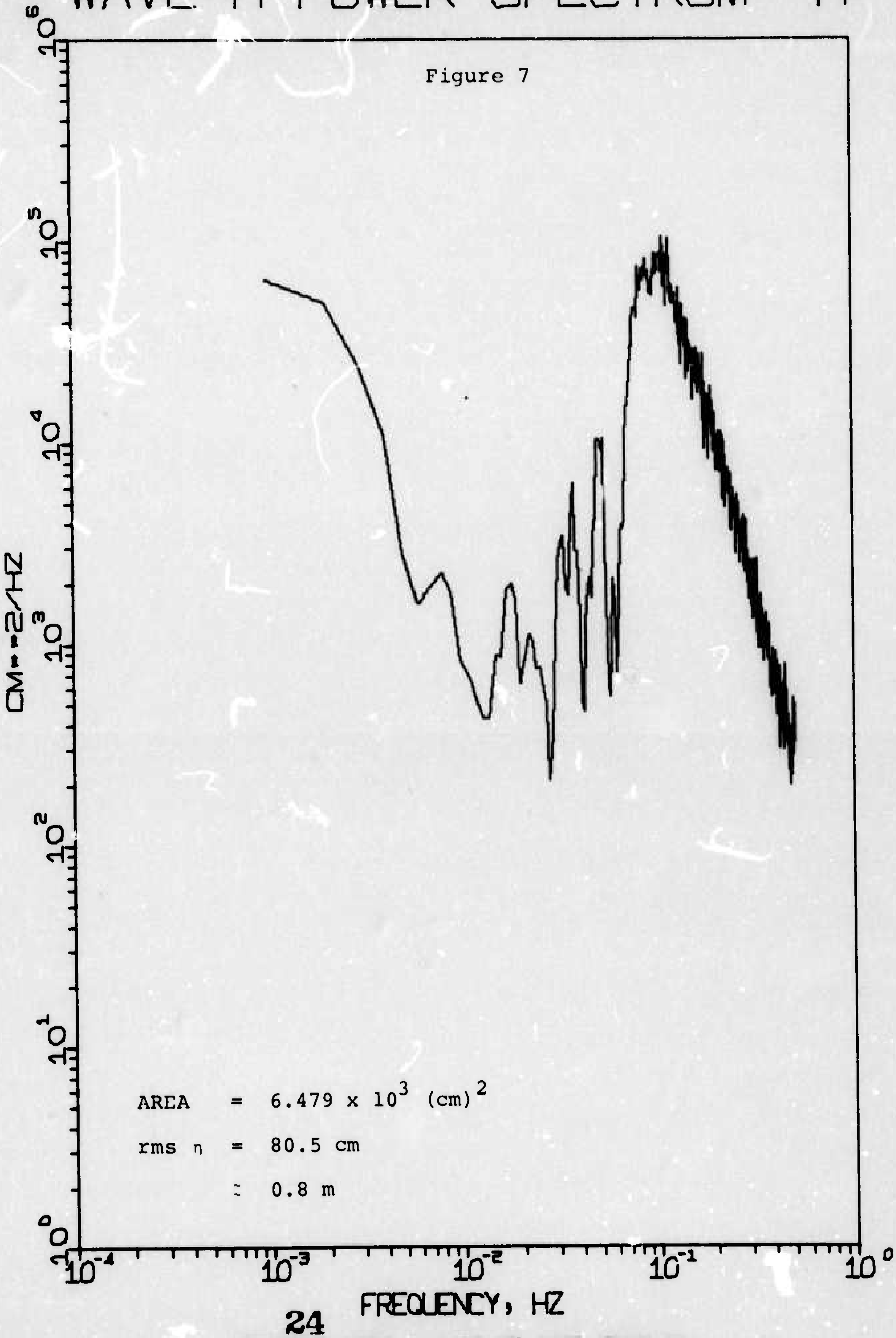
ROLL



RECORDS 1065-1095 OF OWAX D1

SF = 1.0219 CAL 1784.4397

WAVE H POWER SPECTRUM H



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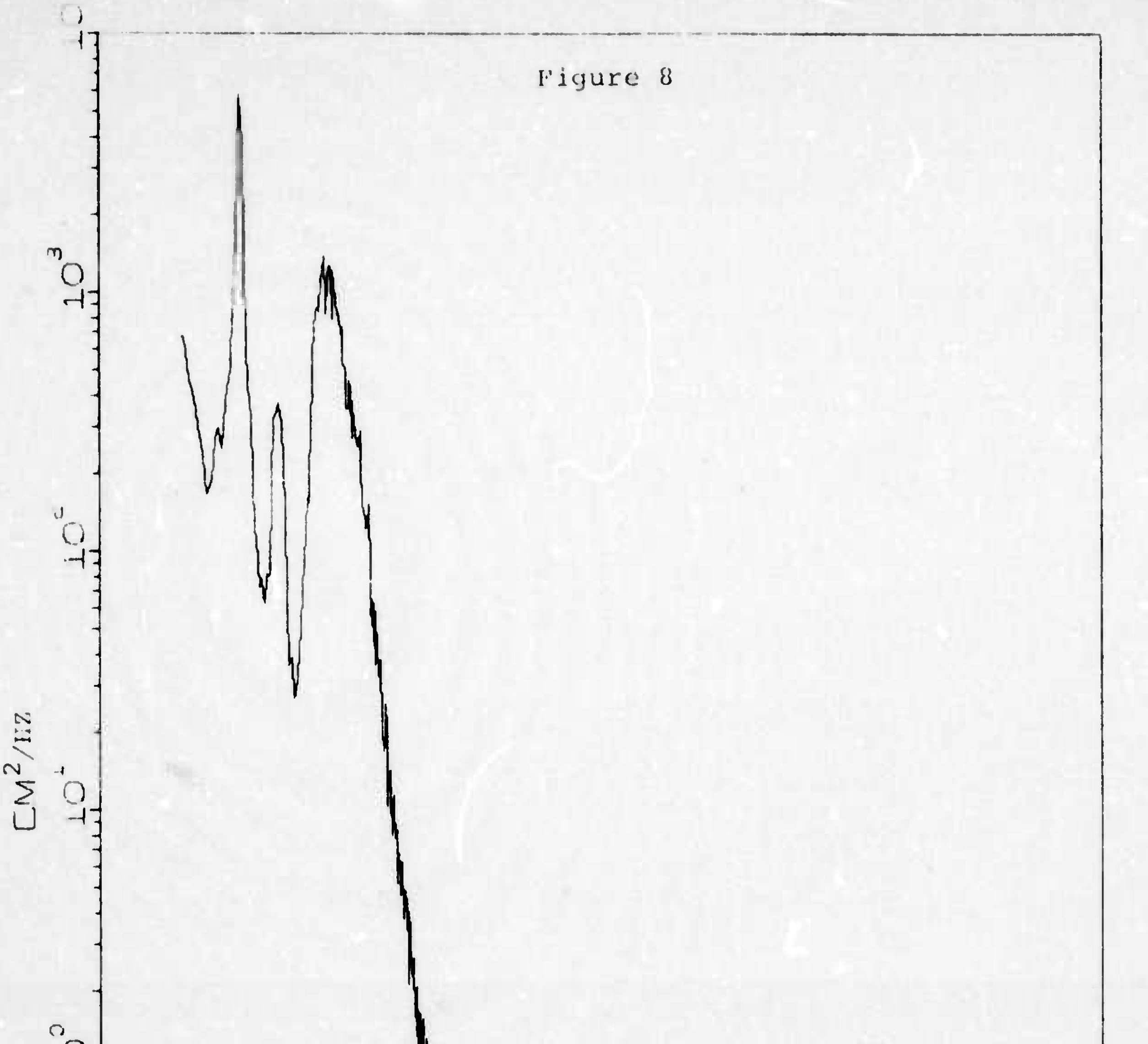
RECORDS 1096 - 1125 OF TAPE OWAX D1

SF = 1.0125 CAL = 19.6618

DISPLACEMENT Z SPECTRUM



VELOCITY SPECTRUM INTEGRATED

OWAX TAPE D1 RECS 941-971 WITH FIRST 5 CARDS TAKEN OUT

U - SONIC SPECTRUM
OWAX EXPERIMENT 3 7-25-73

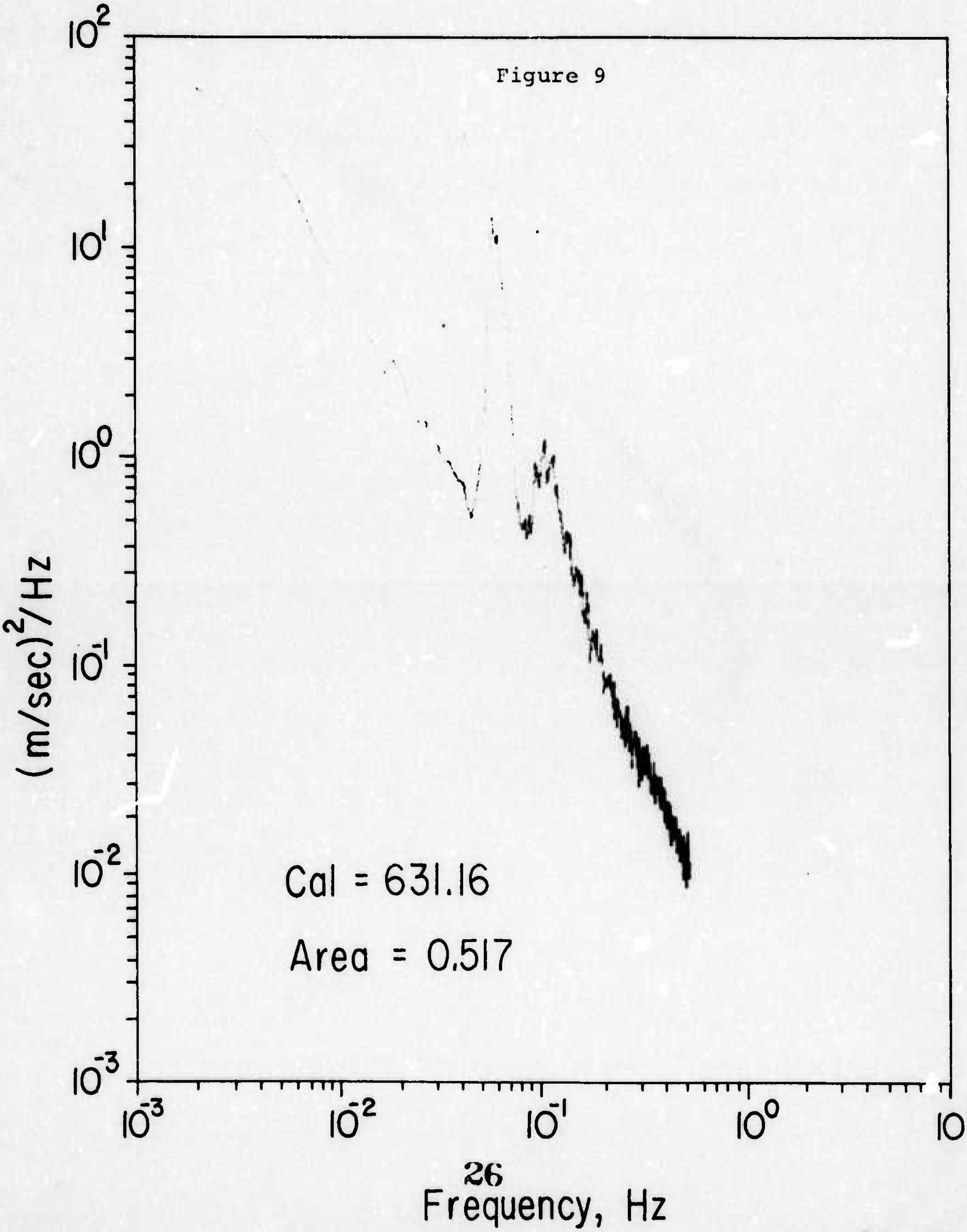
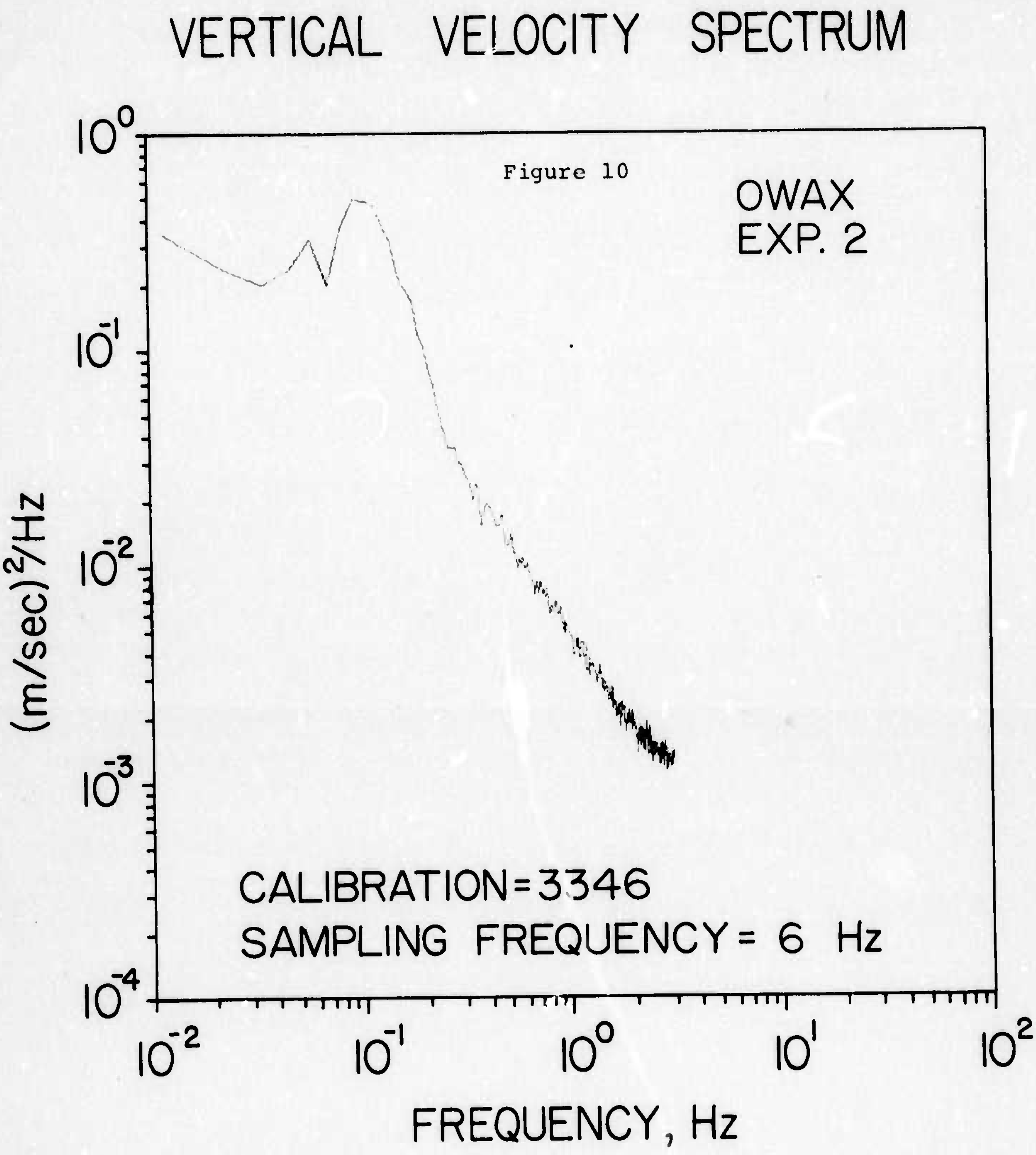


Figure 9


VERTICAL VELOCITY SPECTRUM
Figure 10
OWAX
EXP. 2
(m/sec)²/Hz
CALIBRATION=3346
SAMPLING FREQUENCY = 6 Hz
FREQUENCY, Hz

HUMIDITY SPECTRUM

OWAX EXPERIMENT 3 7-25-73

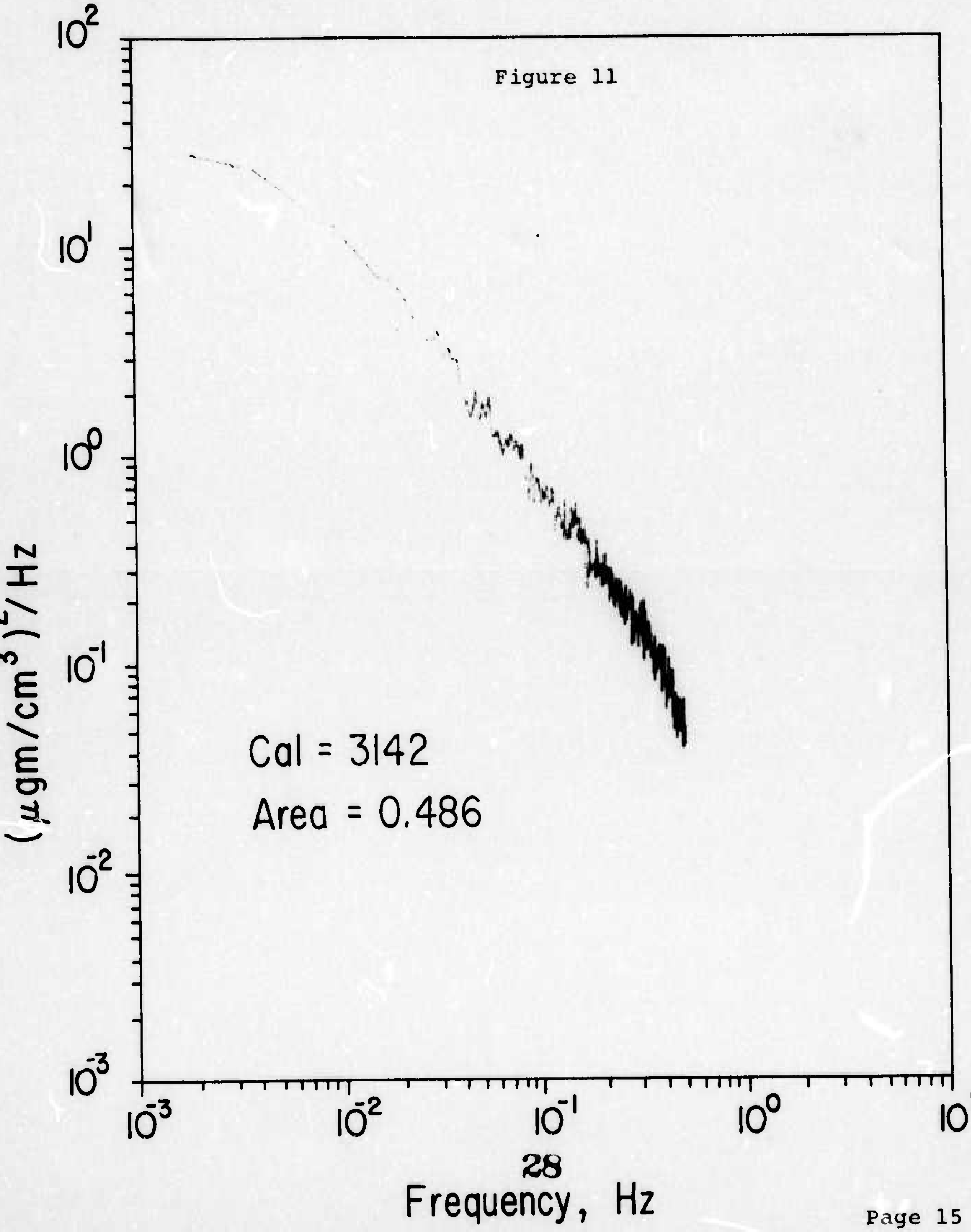
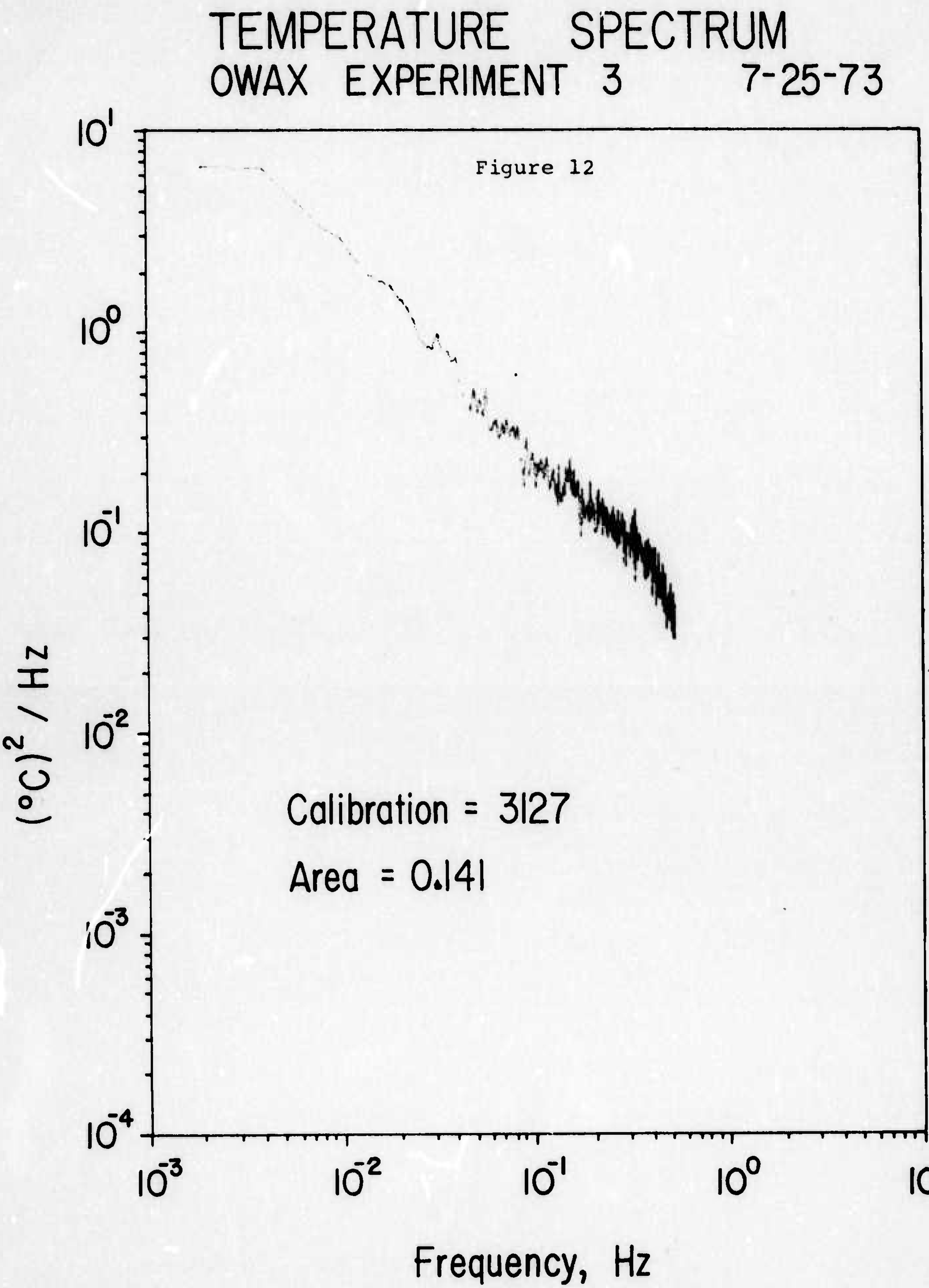


Figure 11


TEMPERATURE SPECTRUM
OWAX EXPERIMENT 3 7-25-73
Figure 12
$(°C)^2$ / Hz
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
Calibration = 3127
Area = 0.141
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
Frequency, Hz