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AMBIENT SEA NOISE MEASURED FROM 100 TO 2240 METER DEPTHS AT LOC--ETC(U)
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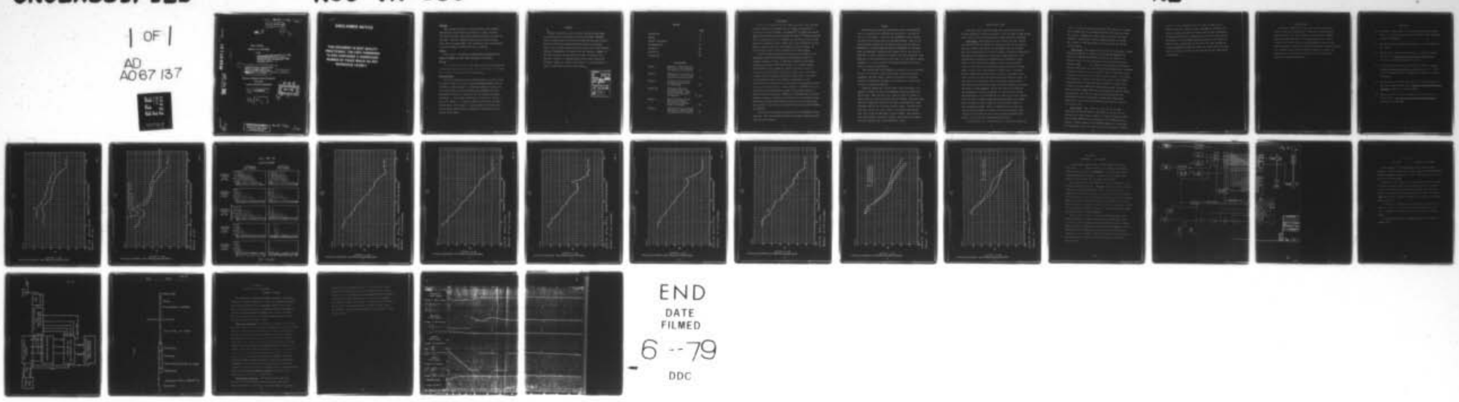

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NAVAL UNDERSEA

RESEARCH AND DEVELOPMENT

CENTER

(6) AMBIENT SEA NOISE MEASURED FROM 100 TO 2240 METER DEPTHS AT LOCATIONS APPROXIMATELY 200 Nautical Miles [redacted] WEST OF SAN DIEGO.

SPATIAL & AMBIENT ANALYSIS BRANCH

CODE 5053

OCEAN SCIENCES DEPARTMENT

(11) Decem[redacted]1971

(12) 32 p.

DISCLAIMER NOTICE

Foreward.

This summary memorandum is being published to make available information on depth dependence of ambient sea noise. The data were recorded in deep - ocean areas approximately 200 n. mi. west of San Diego. They were acquired on three separate cruises during April, June, and August 1971. This research was sponsored jointly by NAVAIRSYSCOM 53301, NAVSHIPSYSCOMS OOV1, and ONR 469.

Problem.

Measure ambient sea noise at various depths and determine the nature of ambient sea noise depth dependence, if possible.

Results.

The limited data reported herein showed decrease in sound pressure spectrum level with increase in depth. Decrease in levels were greater in the higher frequencies for the band analyzed.

Recommendations.

Repeat the experiment with some modifications: to include smaller increments of depth for a more complete noise/depth profile; to use a different station location - - preferably a different oceanic area with significantly different parameters; to rendezvous with other laboratories' measurement systems for both intersystem calibration comparisons and to determine variability in ambient noise spectra - - at the same depths - - at locations widely separated over particular oceanic areas. Measure sound - velocity profiles and combine with data on bottom type and major ship density for developing models to predict ambient noise.

ABSTRACT

Samples of ambient sea noise at depths from 100 to 2240 meters were recorded from a single sensor suspended from NUC's SONODIVER and the spectral level as a function of hydrophone depth was analyzed. These noise data were analyzed from 8 Hz to 5 K Hz in 1/3 octave bands. Within a stable period of sea noise data, with minimal transient effects, 5 integrations of 2 minutes each were averaged. Examples of the noise spectra at various depths are shown. In general, these data show a decrease in sound pressure spectrum level with increase in depth. Signal - to - noise versus depth is the real objective, of course, but this will follow in later reports.

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INTRODUCTION

It has been established that the ambient sea noise level, measured near the surface, may be predicted by the amount of interaction of wind and sea at their interface. See Knudsen[1,2], or Wenz[3], for example. While some measurements made by Perrone[4] and others [5,6] indicate that the level of ambient sea noise is a function of water depth, it is not well known what relationships exist between noise levels measured at or very near the surface, and noise levels measured at various depths. It is the purpose of this study to determine these relationships.

One of the principal problems encountered in this study was the difficulty in obtaining measurements at predetermined depths at a specified location and time. In 1971 this laboratory successfully completed and tested two SONODIVER vehicles and a SPARBUOY vehicle. The SONODIVER vehicle, originally conceived by Gordon M. Wenz, is an unmanned, untethered deep submergence research probe. It employs a velocity regulated buoyancy control system which enables it to hover at a predetermined depth, with vertical acceleration less than 0.05 cm/sec^2, and velocity less than 10 cm/sec, while gathering acoustic sea data. This laboratory has further developed a SPARBUOY vehicle, an untethered, and unmanned surface vehicle for measuring acoustic sea data to depths of 100 meters. SPARBUOY can be deployed from the mother ship for periods up to 5 days and at distances of up to 5 miles, during which time it continuously transmits acoustic data to the mother ship. See appendices I and II for more complete descriptions of the SONODIVER and SPARBUOY.

Simultaneous measurements using SPARBUOY and two SONODIVER vehicles were made. This summary memorandum treats the initial analysis derived from these data sources.

METHODS

Measurements were made from 100 to 2240 meters and intermediate depths incorporating two SONODIVERS and one SPARBUOY. The SPARBUOY sampled at 100 meters at the same time SONODIVER sampled at depth. The depth of the station areas was about 2000 fathoms. Since the set of measurements were made at the same time and at the same location (SONODIVER was launched within 300 meters of SPARBUOY), it is assumed that any variation in sound pressure spectrum level is the result of differences in depth, rather than a change in the noise field that could take place if the measurements were not made at the same time or perhaps equally bad - - at the same time but with great horizontal distances between the sets of measurements.

Data from SPARBUOY and SONODIVER are expressed in dB re 1 dyne/cm^2. The data are processed in 1/3 - octave bands and converted to 1 Hz bandwidth. The 1/3 - octave analysis was performed on board with analysis instrumentation installed in a portable hut. A description of same is shown in appendix III.

While the analysis was limited to 1/3 - octave filtering, it is planned to process the data in much narrower band-widths utilizing an FFT approach. With this capability, signal to noise in addition to noise spectra as a function of depth will be computed. Some preliminary data were acquired for this during the April cruise utilizing several explosions from SUS MK - 61 charges at three ranges. Frequecy versus time plots showing frequencies containing principal energy content were made for 100 and 1000 meter reception depths. These sonograms were analyzed using a 2.8 cycle bandwidth. Explosions were at ranges of 10, 20, and 40 n. mi., at 60 and 800 foot depths.

RESULTS & DISCUSSION

These data, while limited in scope, show consistent indications of depth dependence of ambient sea noise. As the data were acquired during three separate cruises the discussion of results will be so presented.

<u>April cruise</u>. This cruise was on the U.S.N.S. S.P. Lee. Station location was 32° 50' N, 120° 25' W. Ambient sea noise was measured at 100, 300, and 1000 meter depths. No simultaneous pair of sonodiver dives were attempted because of high sea states and equipment difficulties. Simultaneous measurements were made at 100 and 300 meters and at 100 and 1000 meter depths using the SPARBUOY and one SONODIVER vehicle. Figures 1 and 2 show definite decrease in sound pressure spectrum levels for both 300 meter and 1000 meter depths compared to 100 meter depth. There is only slight change in spectrum slope; it appears that the slope begins to fall off more rapidly at frequencies above about 1 K Hz for the 1000 meter depth compared to 100 meter depth. The two spectra for the 100 meter data do not coincide exactly because they were measured at different times, with slight changes in sea states and amount of nearby shipping. The apparent increase in difference between spectral levels for frequencies less than 30 Hz may result from induced noise in the SPARBUOY system. This noise is most probably caused by cable - strumming and/or excessive hydrophone acceleration due to the high sea states (about sea state 4) present during the data acquisition periods. There is a pronounced rise in levels in all the data, from about 40 to 80 Hz. There was considerable heavy shipping in the station area during data acquisition periods which might be the cause of this rather pronounced anomaly.

Although signal - to - noise ratios, as a function of depth, will later be computed in narrow bands using an FFT approach, some results of the signals from the explosions of SUS MK - 61 charges are shown in figure 3. Sonograms were made on these data using a 2.8 cycle bandwidth. Well defined frequency components appear in the data for explosions at 800 foot depth, at receiver depths of both 100 and 1000 meters.

June cruise. This cruise was on the U.S.N.S. De Steiguer. Station location was 32° 10' N, 117° 30' W. The principle objective for use of the SONODIVER and SPARBUOY vehicles on this cruise was to provide a measure of the ambient noise in the vicinity of a large aperture array. . As a result of some mechanical difficulties with that system, time was made available for additional data acquisition on depth dependence of ambient sea noise. Sea state was zero; heavy shipping was present during these data sampling periods. A fortuitous event took place during one data acquisition period. The SONODIVER control mechanism is designed to hold the amount of vertical drift to within 10 cm/sec during its' data sampling period. During one dive, the vehicle slowly descended at about 10 cm/sec from 600 meters to 720 meters. This data was sampled in approximately 30 meter increments to test for variability in levels within these small increments at these depths. No significant variation was observed (figures 4a - 4e).

August cruise. This cruise was on the U.S.N.S. S.P. Lee. Station location was 32° 38.5' N, 123° 41.5' W. Sea was calm and wind speed was about 8 knots. Little or no change was observed from the 100 meter SPARBUOY sensor during any of the SONODIVER sampling periods. A double launch of two SONODIVER vehicles was accomplished and simultaneous ambient sea noise spectra were obtained. The hover depths of the two SONODIVER vehicles were 650 and 1300 meters. Figure 5 shows the resulting spectra. Although the differences in levels are small, they appear consistent with previous measurements, in that greatest change in spectrum levels are in the higher part of the spectra. A dive to 2240 meters was achieved and the results of these spectra, combined with the 100 meter data, show inconsistent results compared with similar previous data. The spectra, see figure 6, show an increase in level in the lower portion from about 100 Hz to 1.25 K Hz.

RECOMMENDATIONS

Repeat the analysis on these data with a much narrower band - width. Examine the possibility of a relationship existing between these and signal - to - noise profiles and sound velocity profiles and/or propagation loss data for the corresponding areas. Repeat experiments should be planned for uniquely different oceanic areas, with distinctly different sound velocity profiles, bottom characteristics, etc. Said data sample, combined with data reported on herein, may provide clues as to a possible model to be used in prediction of ambient sea noise/depth profiles.

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1. V.O. Knudsen, R.S. Alford, and I.W. Emling, "Survey of Underwater Sound, Report No. 3, Ambient Noise," 6.1 - NDRC - 1848 (September 26, 1944) (PB 31021).

2. V.O. Knudsen, R.S. Alford, and J.W. Emling, J. Marine Research 7, 410 (1948).

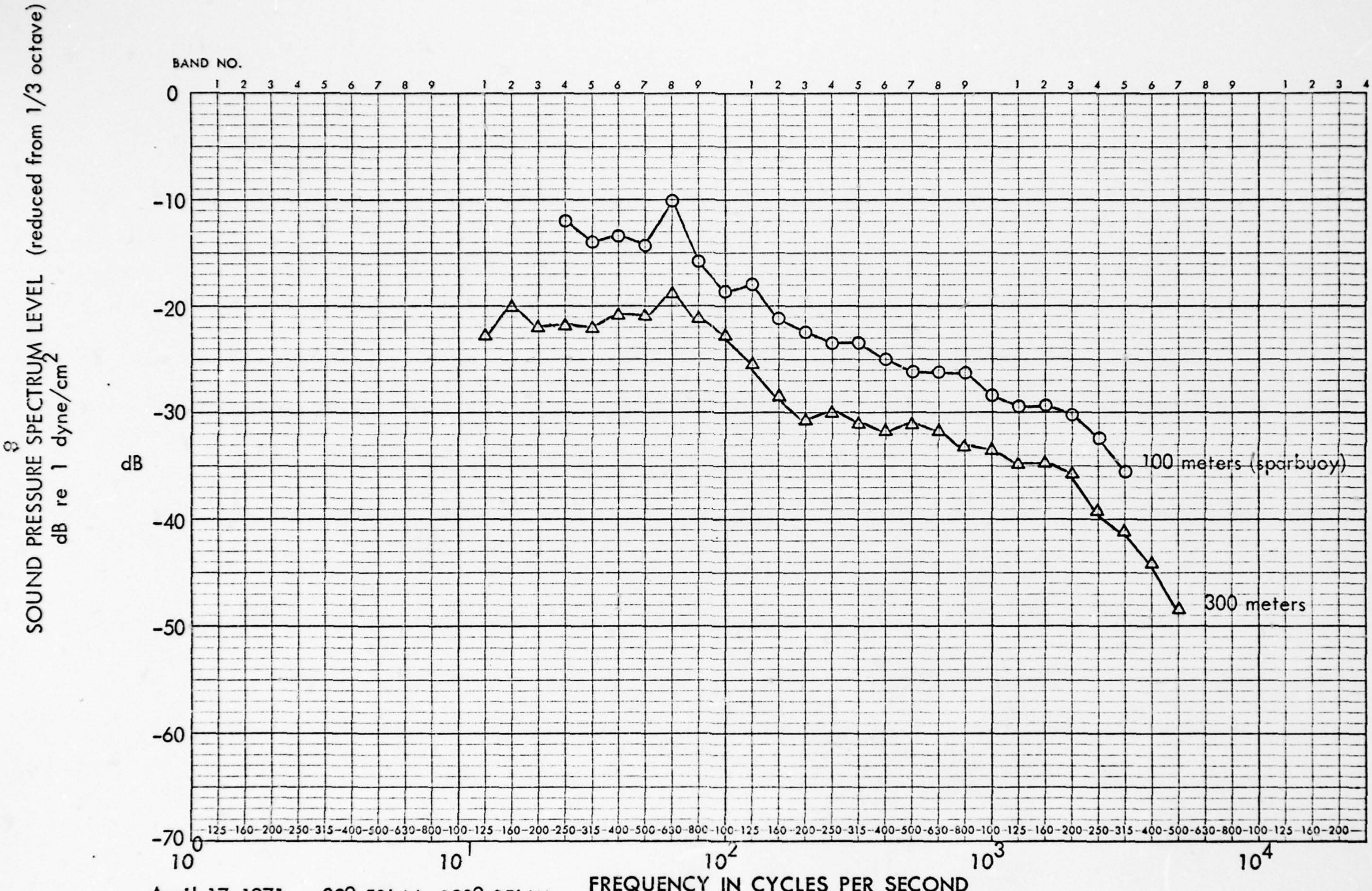
3. Gordon M. Wenz, "Acoustic Ambient Noise in the Ocean; Spectra and Sources", Journal of the Acoustical Society of America, Vol. 34, No. 12, 1936 - 1956, December, 1962

4. A.J. Perrone, USL Technical Memorandum No. 2214-179-69, Ambient Noise Spectrum Levels as a Function of Water Depth, 16 June 1969, U.S. Navy Underwater Sound Laboratory, Fort Trumbull, New London, Connecticut.

5. Lomask, Morton, and Roberto Frassetto, "Acoustic Measurements in Deep Water using the Bathyscaph," Journal of the Acoustical Society of America, Vol. 32, No. 8, August 1960.

6. Arase, E.M., and T. Arase, "Ambient Sea Noise in the Deep and Shallow Ocean," Journal of the Acoustical Society of America, Vol. 42, No. 1, July 1967.

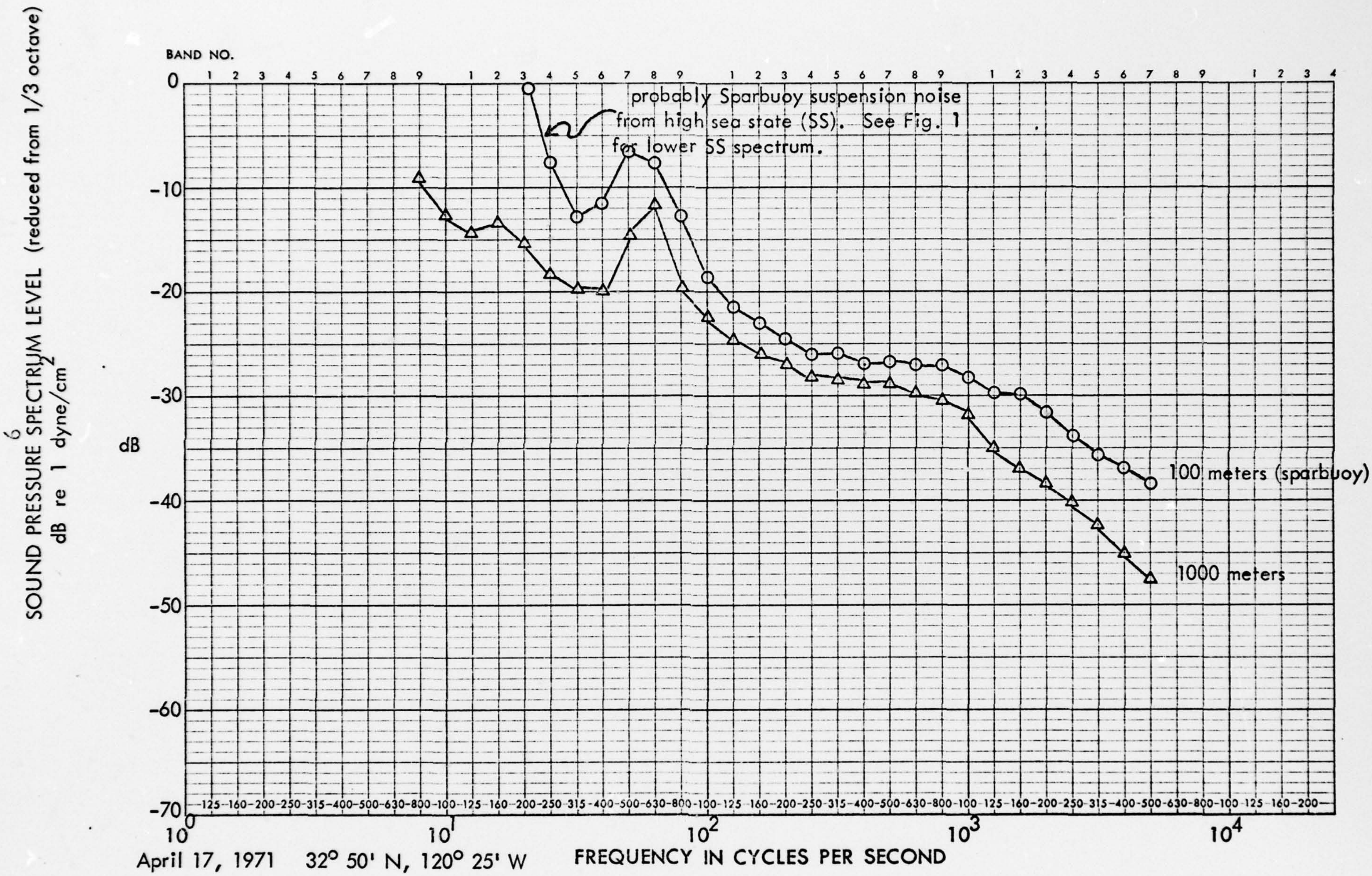
NO. 31.466. WIDE RANGE SOUND ANALYSIS. INSERT BAND NUMBERS AND ADD ZEROS OR EXPONENTS TO FREQUENCY SCALE. CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS. PRINTED IN U.S.A.



April 17, 1971 32° 50' N, 120° 25' W

1538 Hours Z SS: 4 (est.)

FIG. 1



April 17, 1971 32° 50' N, 120° 25' W

1847 Hours Z SS: 4 (est.)

FIG. 2

SUS MK-61

EXPLOSIONS

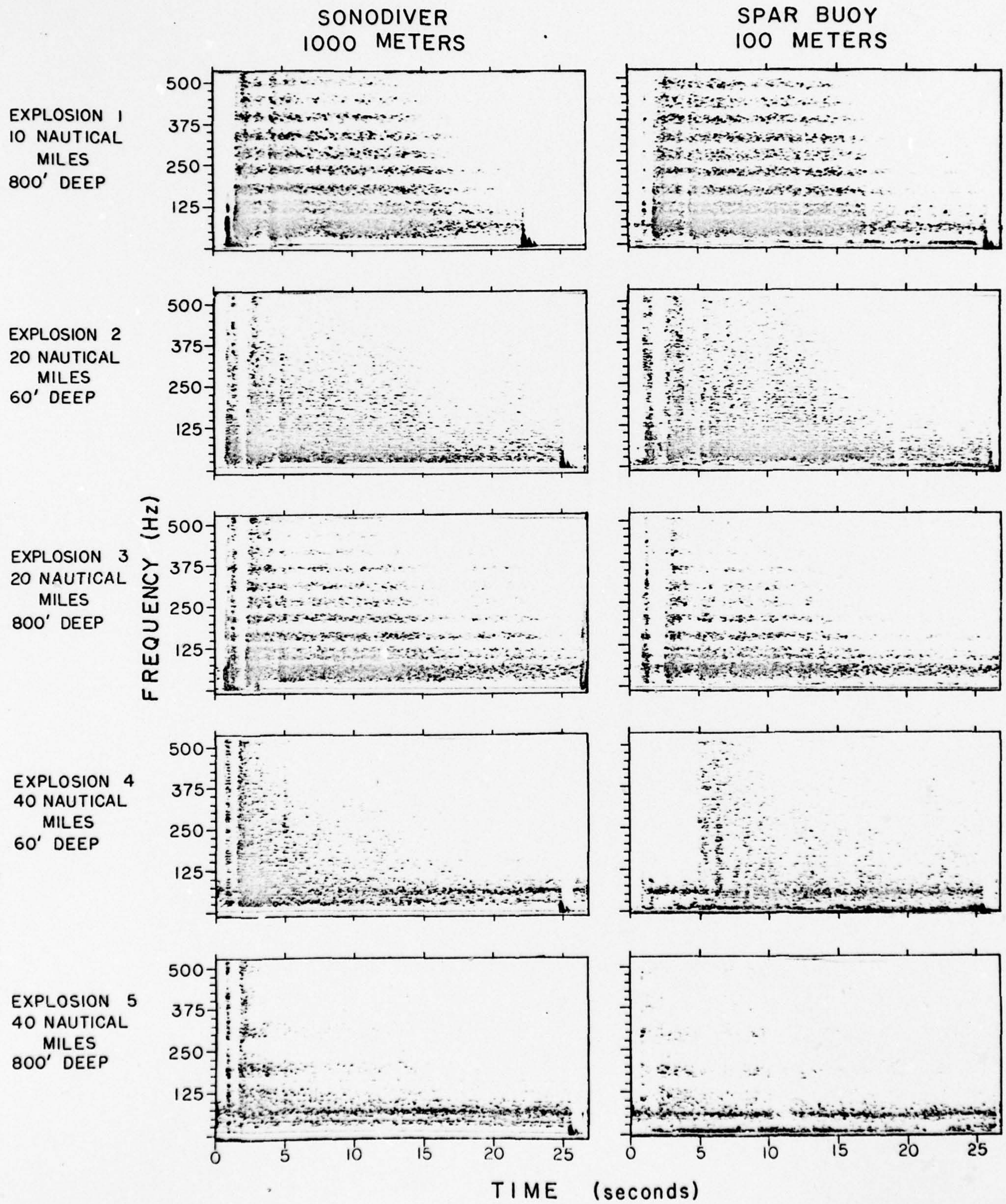
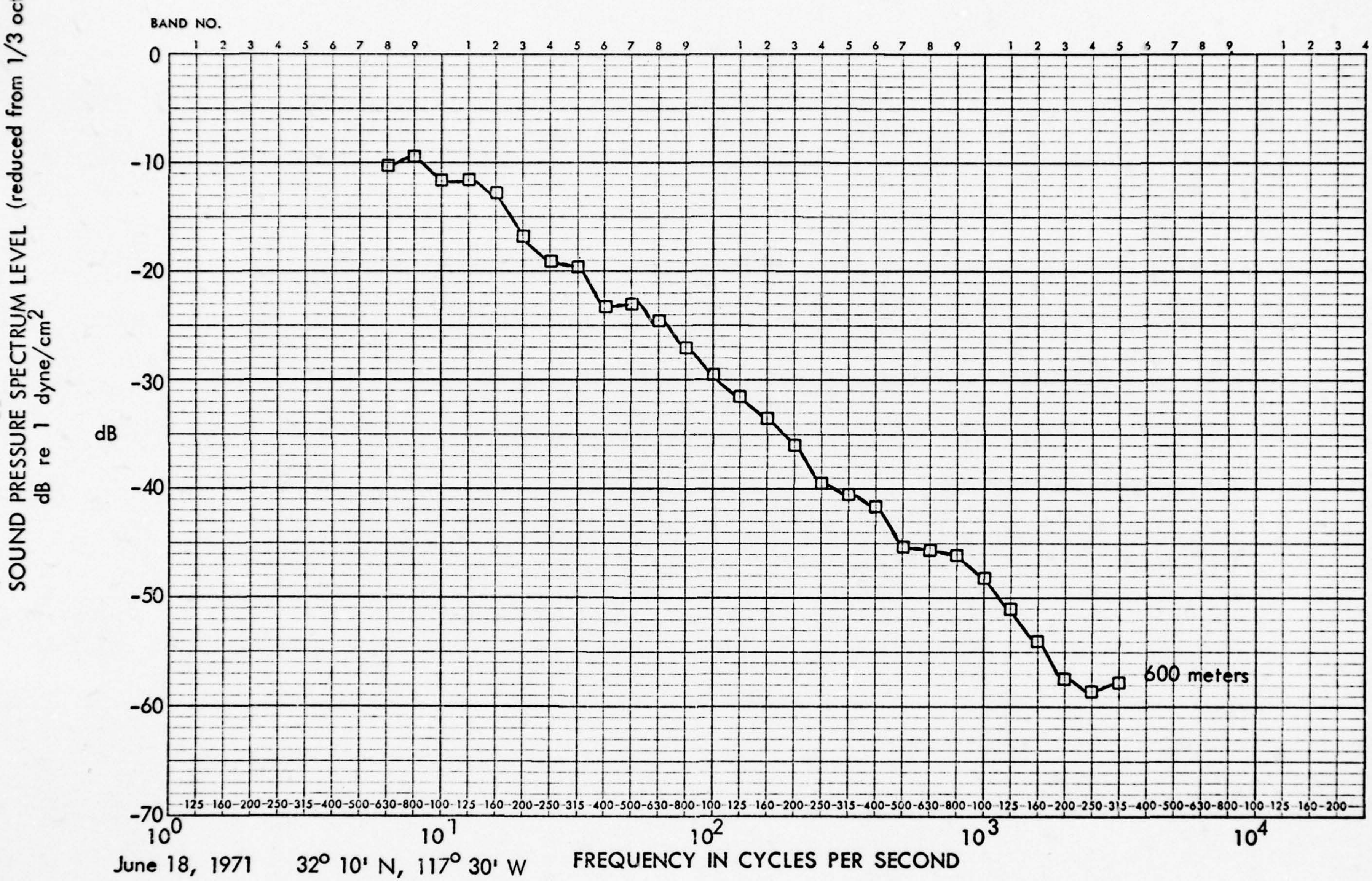


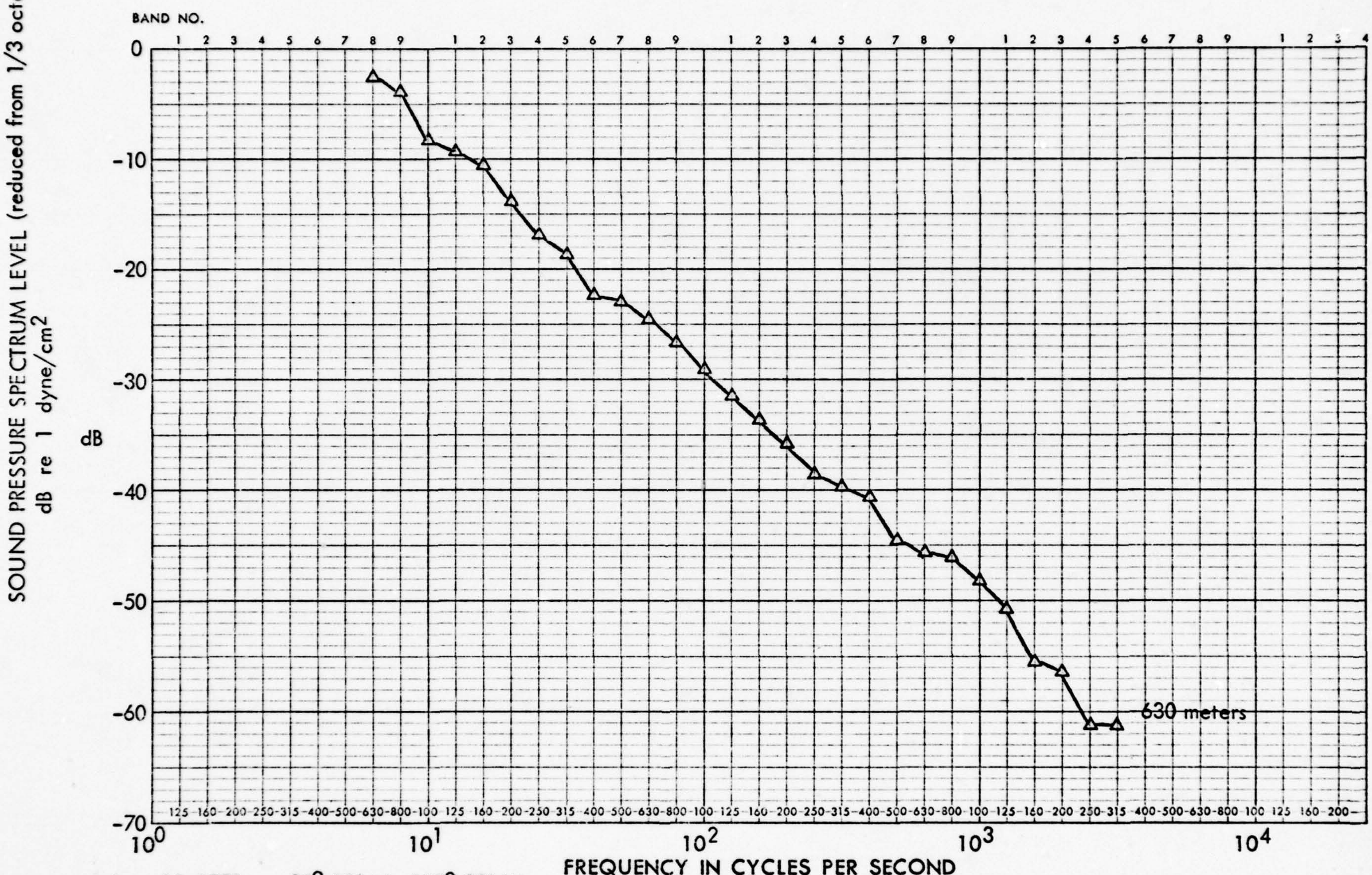
FIG. 3



June 18, 1971 32° 10' N, 117° 30' W

1604 Hours Z SS: 0 (est.) heavy shipping

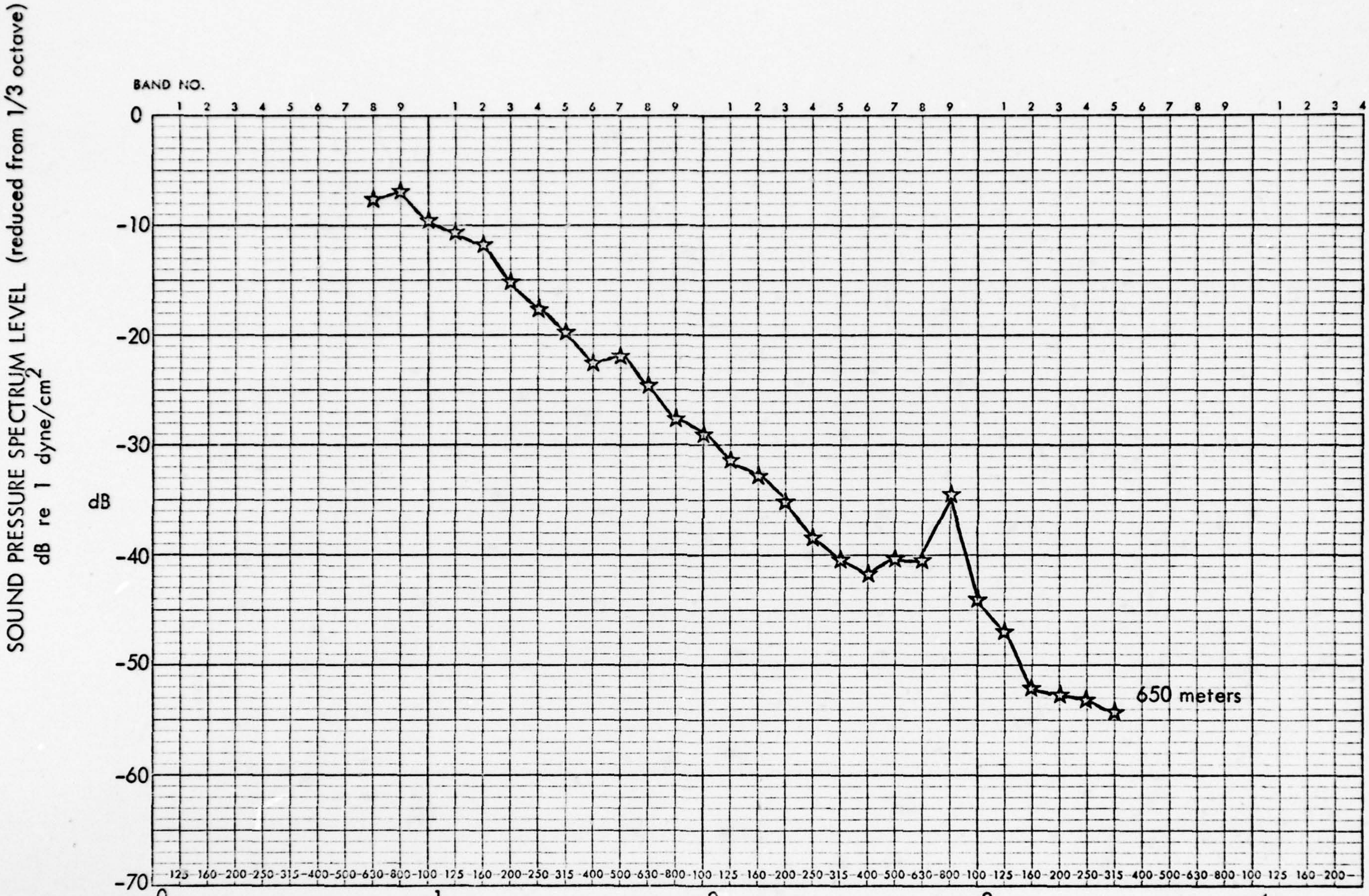
FIG. 4a



June 18, 1971   32° 10' N, 117° 30' W

1608 Hours Z   SS: 0 (est.) heavy shipping

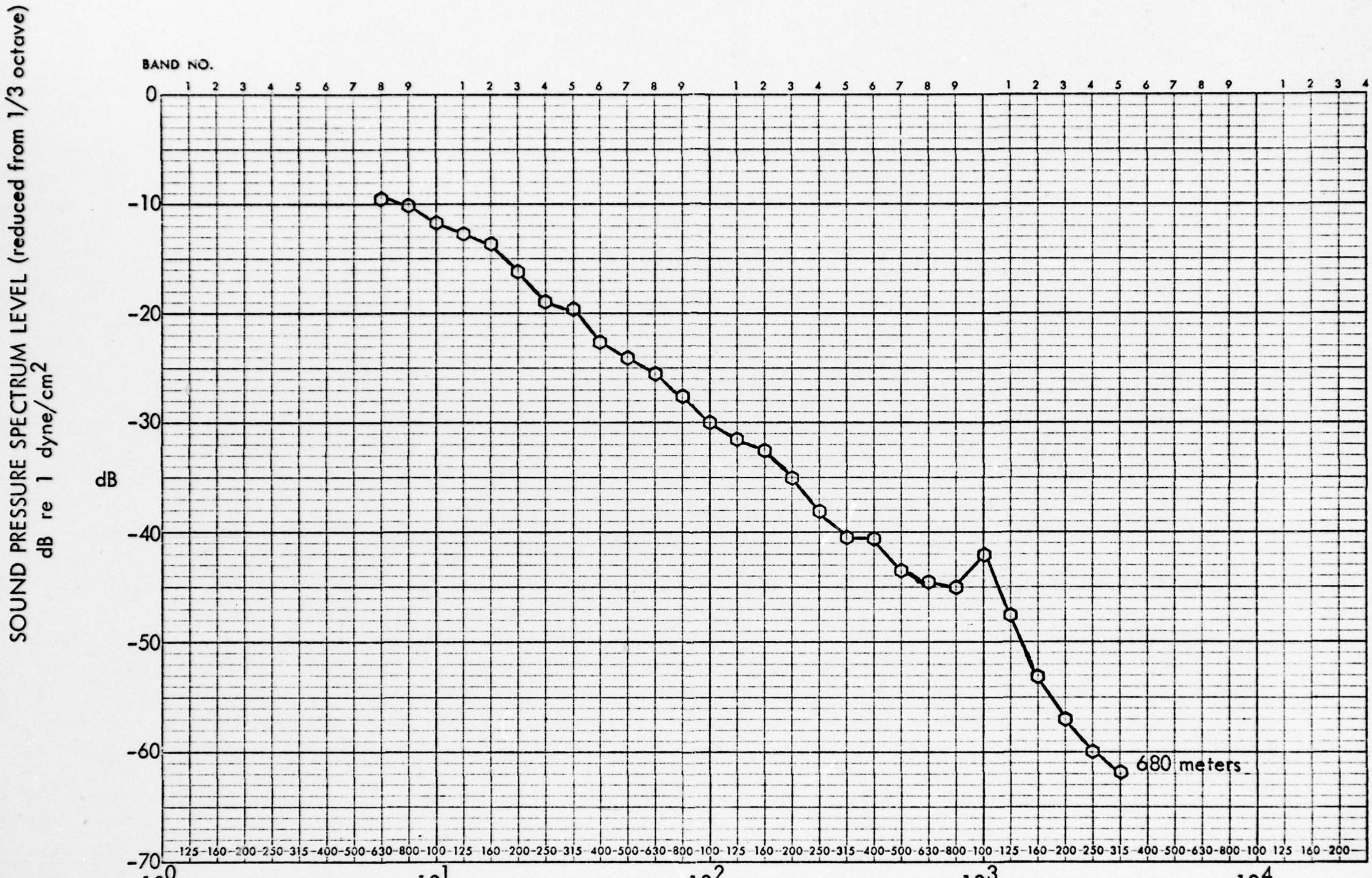
FIG. 4b



June 18, 1971 32° 10' N, 117° 30' W

1612 Hours Z SS: 0 (est.) heavy shipping

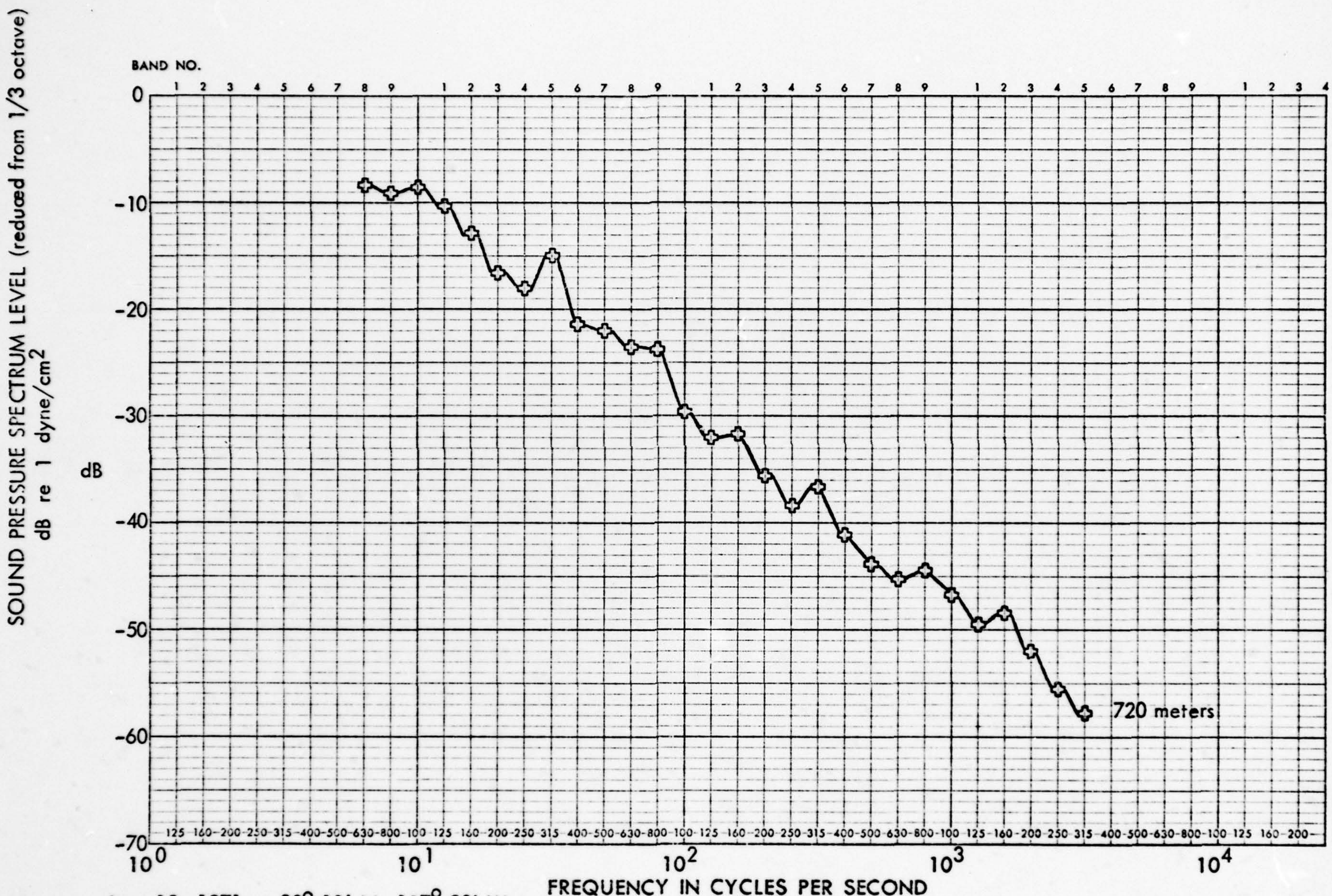
FIG. 4c



June 18, 1971 32° 10' N, 117° 30' W

1616 Hours Z SS: 0 (est.) heavy shipping

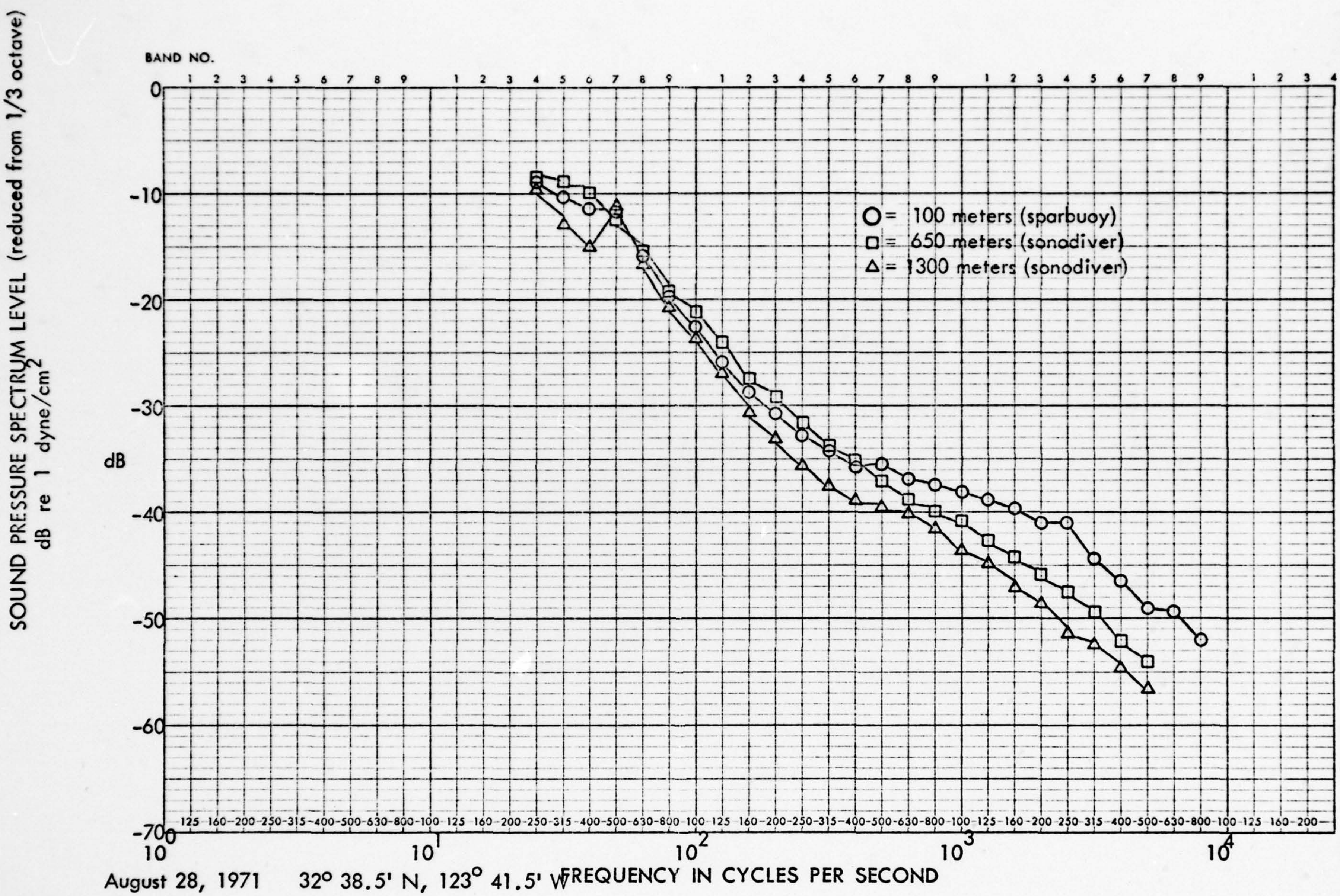
FIG. 4d



June 18, 1971 32° 10' N, 117° 30' W

1620 Hours Z SS: 0 (est.) heavy shipping

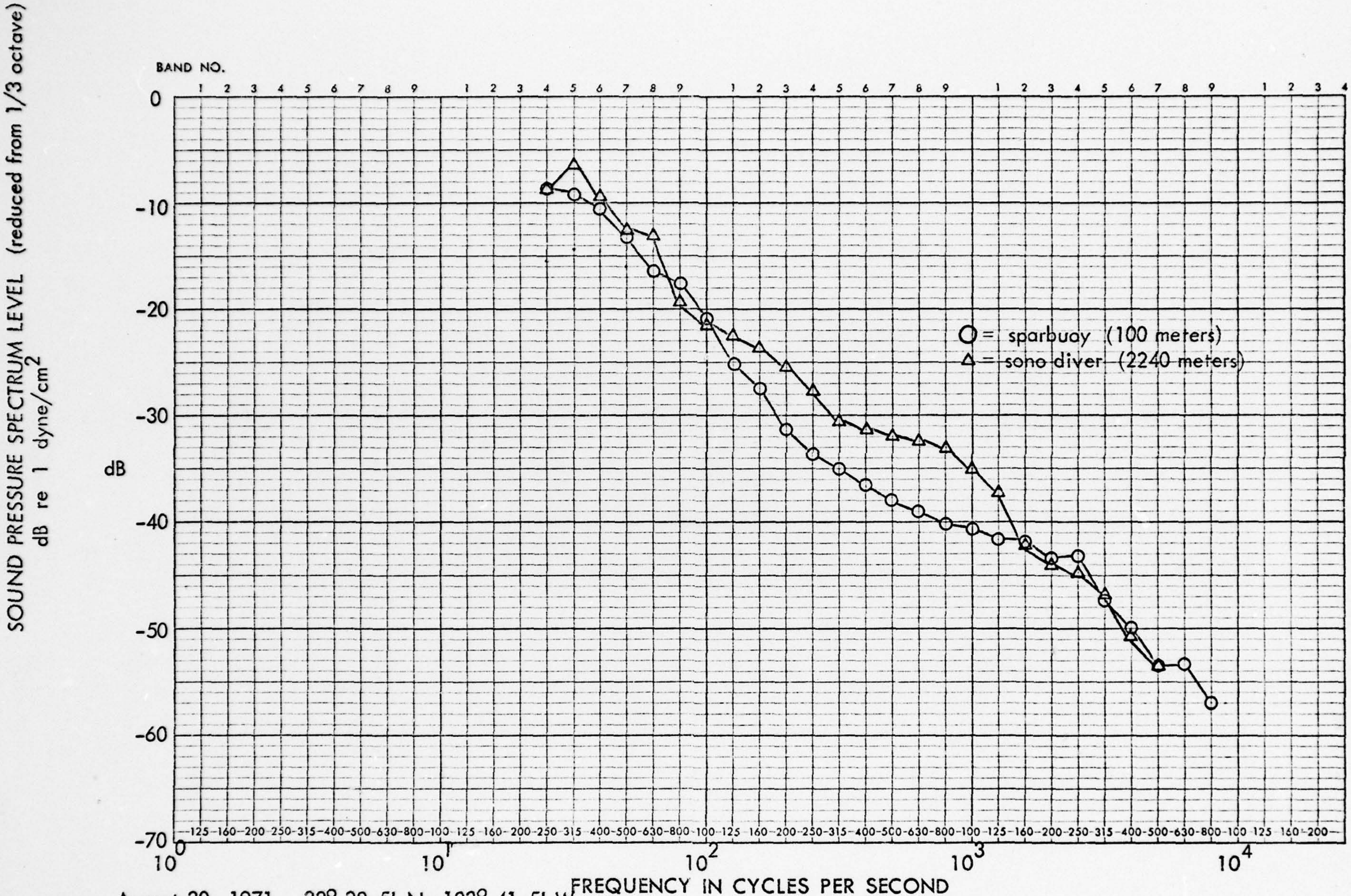
FIG. 4e



August 28, 1971 32° 38.5' N, 123° 41.5' W

1750 Hours Z SS: 1

FIG. 5



August 30, 1971 32° 38.5' N, 123° 41.5' W

1845 Hours Z SS: 1

FIG. 6

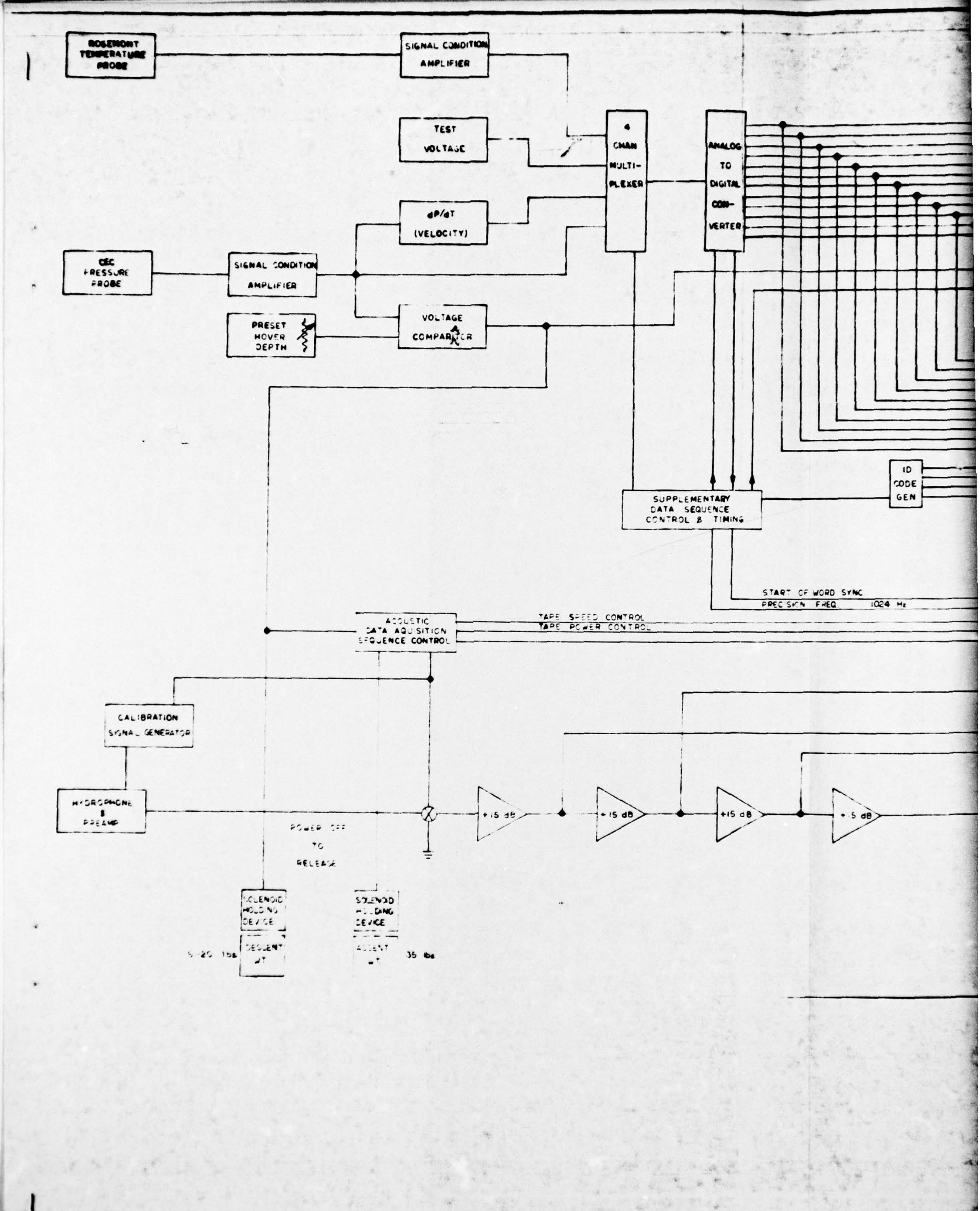
APPENDIX I

SONODIVER - J. C. Brown

A system block diagram of the SONODIVER vehicle is shown in Figure A-1. . The SONODIVER is a deep diving, ocean ambient noise research vehicle. It is untethered and is free to drift with deep ocean currents to provide an extremely stable platform from which to measure ambient sea noise from 8 Hz to 5 K Hz.

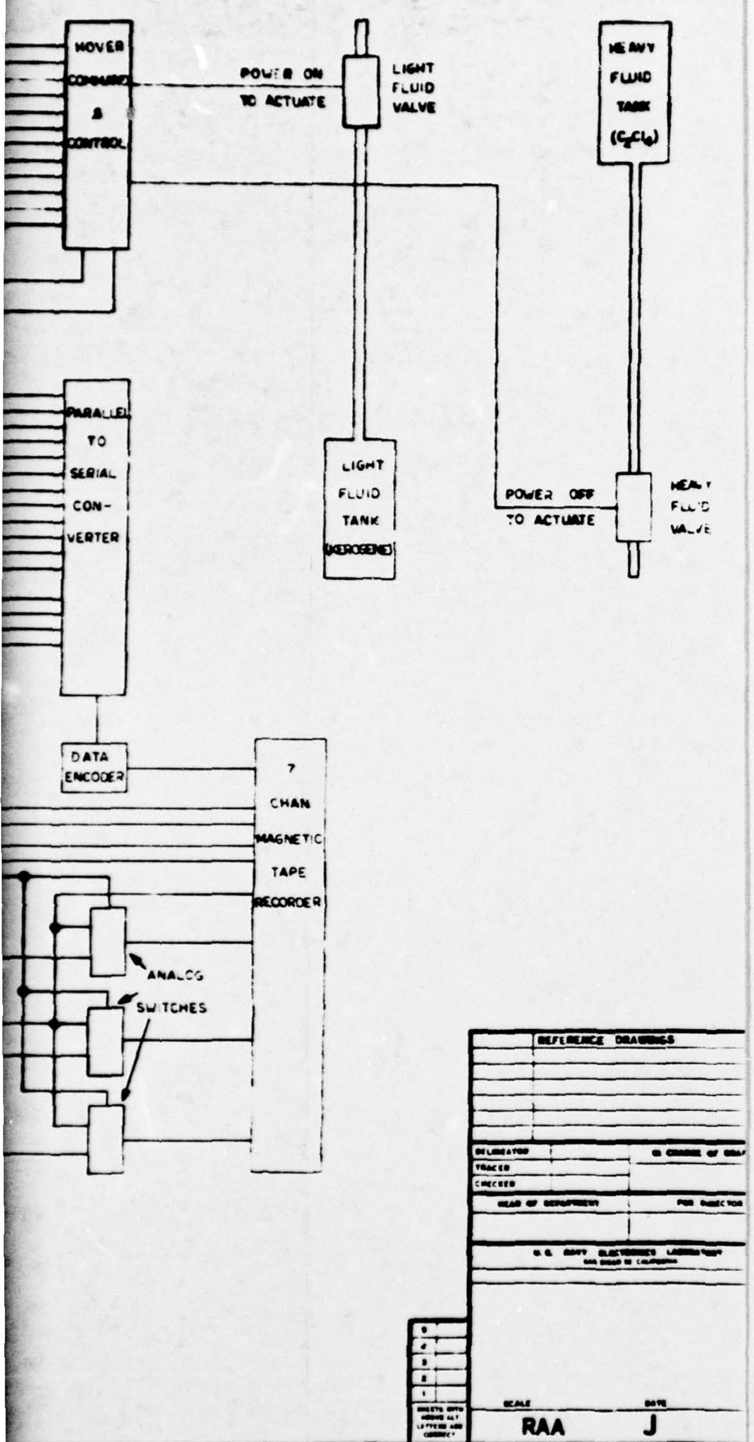
The acoustic portion of SONODIVER consists of a hydrophone manufactured by ITC Santa Barbara. A balanced output preamplifier provides a high frequency preamplifier that provides a high frequency pre - emphasis above 1 K Hz at 6 dB/octave. The preamplifier is manufactured by Marine Resources Inc. of Northridge California and with the hydrophone forms a unit that is suspended 35 feet below SONODIVER after reaching the preset depth. The signal is then amplified by a four stage amplifier to a maximum gain of 60 dB. Each stage has a gain of 15 dB, the output of which is recorded on magnetic tape.

After the descent phase and a preset delay (adjustable in 1 or 10 min increments to a maximum of 90 minutes) a calibration period is initiated. The calibration period consists of 4 minutes of system noise, 4 minutes of random noise, and 4 minutes of multitones. At the completion of the calibration period a twenty minute acoustic data acquisition period is begun. When the acquisition period is completed the vehicle is commanded to surface for recovery and preliminary data reduction.



ROSEMONT TEMPERATURE PROBE
SIGNAL CONDITION AMPLIFIER
TEST VOLTAGE
4 CHAN MULTI-PLEXER
ANALOG TO DIGITAL CON-VERTER
dP/dT (VELOCITY)
CEC PRESSURE PROBE
SIGNAL CONDITION AMPLIFIER
PRESET HOVER DEPTH
VOLTAGE COMPARATOR
ID CODE GEN
SUPPLEMENTARY DATA SEQUENCE CONTROL & TIMING
START OF WORD SYNC
PRECISION FREQ 1024 Hz
ACOUSTIC DATA AQUISITION SEQUENCE CONTROL
TAPE SPEED CONTROL
TAPE POWER CONTROL
CALIBRATION SIGNAL GENERATOR
HYDROPHONE & PREAMP
+15 dB
+15 dB
+15 dB
+15 dB
POWER OFF TO RELEASE
SOLENOID HOLDING DEVICE
SOLENOID HOLDING DEVICE
DESCENT WT
ASCENT WT
35 lbs

Fig. A-1


HOVER COMMAND & CONTROL
POWER ON TO ACTUATE
LIGHT FLUID VALVE
HEAVY FLUID TANK (C_2Cl_4)
PARALLEL TO SERIAL CON- VERTER
LIGHT FLUID TANK (KEROSENE)
POWER OFF TO ACTUATE
DATA ENCODER
7 CHAN MAGNETIC TAPE RECORDER
ANALOG SWITCHES
REFERENCE DRAWINGS
SCALE
RAA
J

APPENDIX II

SPARBUOY - Melquiades A. Calderon

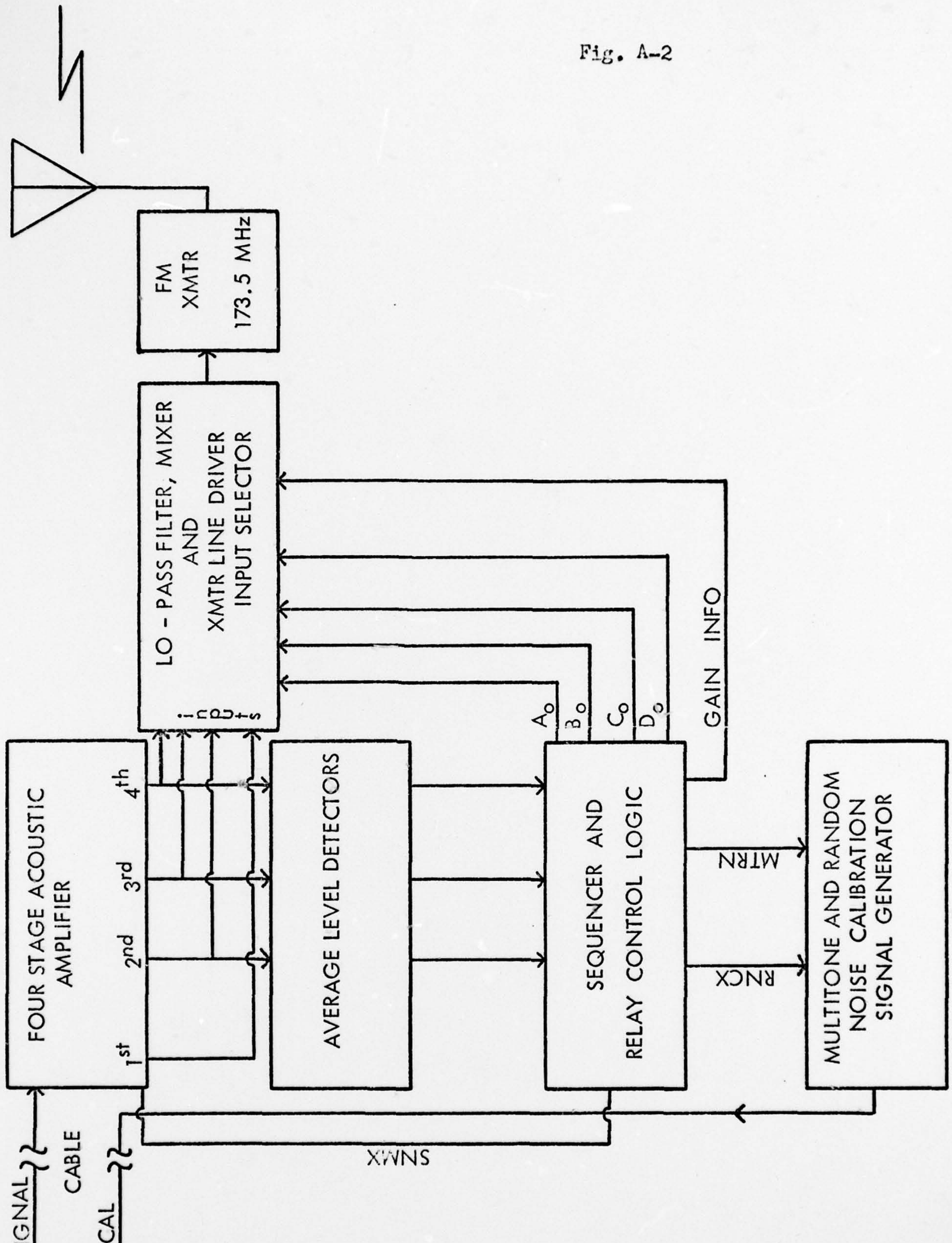
A block diagram of the SPARBUOY along with a drawing of the vehicle are shown in Figs A-2 and A-3 respectively. The system consists of an ITC hydrophone and 400 feet of cable. The hydrophone is the same type used in the SONODIVER.

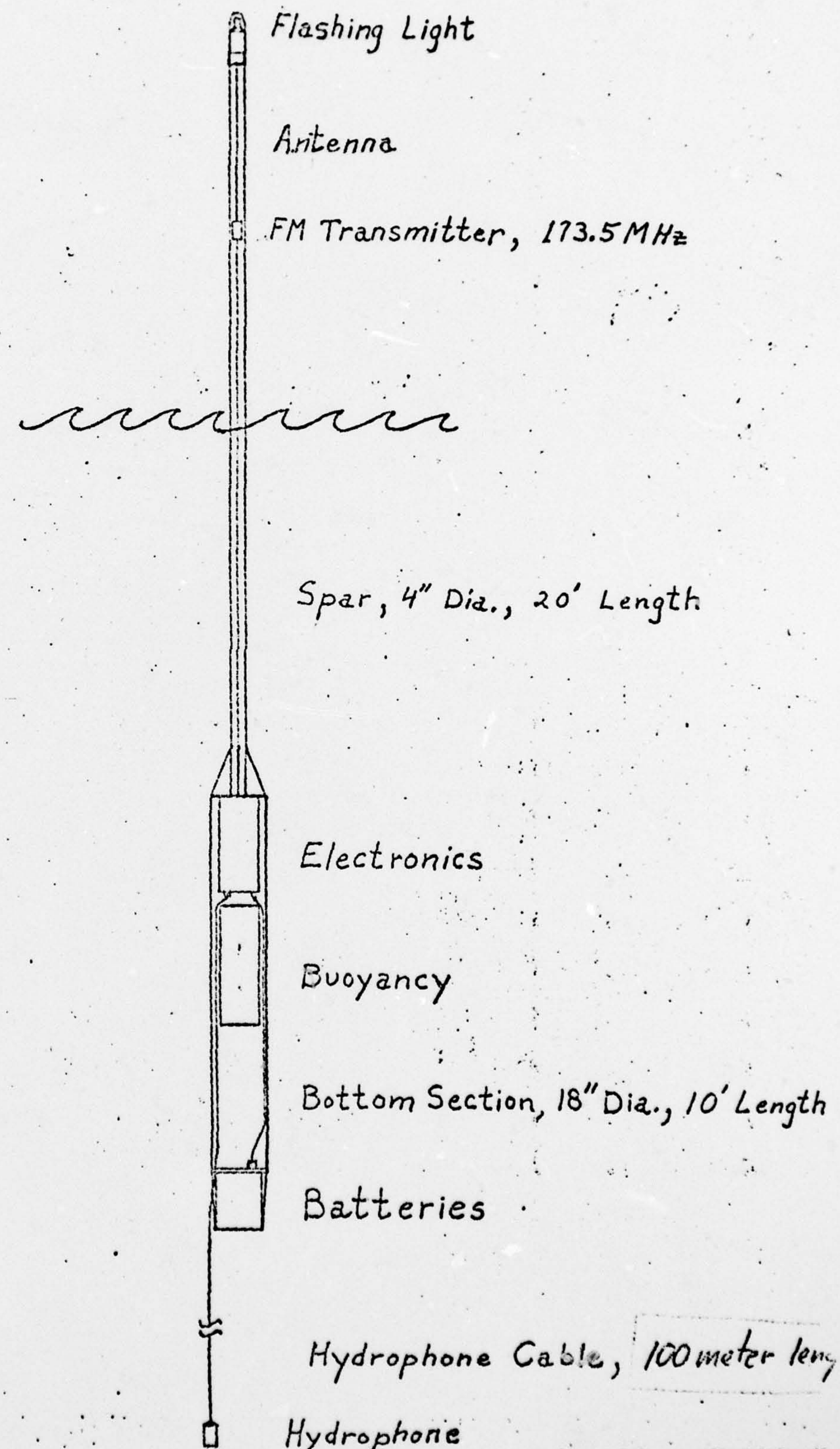
A four stage amplifier (each stage 15 dB gain) is used to amplify the hydrophone signal. Three average level detectors and some logic are used to control relays which select the output of a particular stage. This output is then low-pass filtered and summed with another signal which carries the gain information, i.e., identifies the output stage transmitted.

A multitone and random noise generator supply calibration signal which are applied to the input of the hydrophone amplifier and are used to calculate the absolute levels of the acoustic ambient noise signal.

A sequencer provides for a calibration sequence of 10 minutes every 2 hours.

Fig. A-2


FM
XMTR
173.5 MHz
LO - PASS FILTER, MIXER
AND
XMTR LINE DRIVER
INPUT SELECTOR
inputs
FOUR STAGE ACOUSTIC
AMPLIFIER
1st
2nd
3rd
4th
AVERAGE LEVEL DETECTORS
Ao
Bo
Co
Do
GAIN INFO
SEQUENCER AND
RELAY CONTROL LOGIC
MTRN
RNCX
MULTITONE AND RANDOM
NOISE CALIBRATION
SIGNAL GENERATOR
SNMX
SIGNAL
CABLE
CAL
Hydrophone
and
Preamp


Flashing Light
Antenna
FM Transmitter, 173.5 MHz
Spar, 4" Dia., 20' Length
Electronics
Buoyancy
Bottom Section, 18" Dia., 10' Length
Batteries
Hydrophone Cable, 100 meter leng
Hydrophone

APPENDIX III

SONODIVER SHIPBOARD PROCESSOR

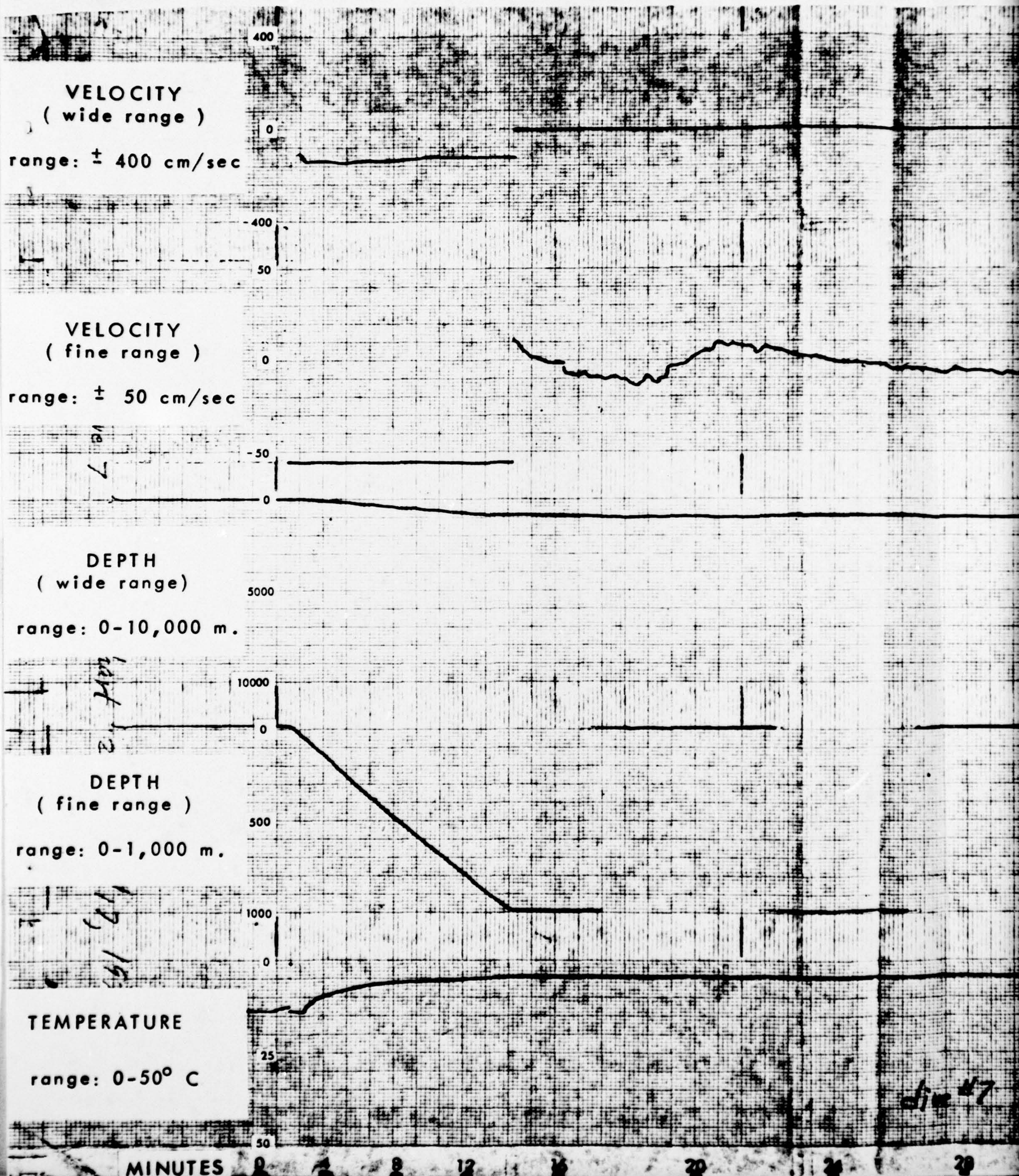
Carroll W. Marshall

The purpose of the shipboard sonodiver processor is to recover, format, and analyze the acoustic and status data measured and recorded on a 7 track magnetic tape by the sonodiver vehicle during a dive. It is significant to note that a preliminary analysis of the data can be made for evaluation within 15 minutes after a dive is completed. If for any reason the data is sub-standard another dive can be made at the same location to gather new data.

Status Data Processing. The status data parameters of the vehicle (velocity, temperature, and depth) are recorded during a dive on magnetic tape in a serialized pulse code format at the rate of two parameters per second. A sixteen bit word is required to define each parameter. The Sonodiver Processor accepts each parameter word of the recorded status data, in the format of serialized PCM, converts it to a digital number, displays the number on a visual numeric read out display, and records it on an incremental digital tape in a format that is acceptable to a digital computer. This same digital number is converted to an analog voltage and recorded on a strip chart recorder. The result of the strip chart recording operation is a plot of each parameter as a function of time for the duration of the entire dive. This plot of parameters gives, at a glance, a detailed analysis of vehicle behavior during a dive. Figure A-4 shows an example of this display for a 1000 meter dive made during the April cruise.

Acoustic Data Processing. The acoustic ambient noise data from one of the four channels recorded on magnetic tape by the Sonodiver vehicle is presented to the processor where it is spectrum analyzed into thirty 1/3 octave bands in the region from 5 Hz to 5000 Hz. The RMS level of each band is computed for a specified period of time and converted to a digital number (0 - 60 dB) which is recorded on a digital recorder in the format that is acceptable to a digital computer. In addition, an analog voltage representing the RMS levels of the 30 bands for the specified period of time are generated, displayed on an oscilloscope, and recorded on a hard copy bar graph.

1


400
VELOCITY
(wide range)
0
range: ± 400 cm/sec
-400
50
VELOCITY
(fine range)
0
range: ± 50 cm/sec
-50
0
DEPTH
(wide range)
5000
range: 0-10,000 m.
10000
0
DEPTH
(fine range)
500
range: 0-1,000 m.
1000
0
TEMPERATURE
25
range: 0-50° C
50
MINUTES 0 4 8 12 16 20 24 28

2