MICROSEISMS GENERATED OFF THE TEXAS COAST

by

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Dr. Glyn M. Jones

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ABSTRACT

Microseisms that were generated in the Gulf of Mexico were recorded using a seismometer in Hockley, Texas. They were induced by atmospheric disturbances over the Gulf. Their frequency was found using a window length of 204.8 sec. They propagated at a primary frequency of 0.15 cps 0.20 cps and a secondary frequency of 0.33 cps to 0.38 cps. Their behavior for different weather conditions supported the belief that primary microseisms are generated in shallow waters while secondary microseisms may be generated in shallow or deep waters. The secondary microseism was unstable. It would seemingly disappear when it had been present two to three minutes before. Further investigation of this instability should be done using a window of the same length or shorter.

ACKNOWLEDGEMENTS

My special thanks to Dr. G.M. Jones, my Fellows advisor. I feel fortunate to have been able to work under his supervision. The amount of time and work he put into the project was certainly above and beyond the call of duty.

My thanks to Dr. A.F. Gangi for his advice and for providing the equipment which made this research possible.

Mr. Brenton, Meteorology Department, provided the weather maps. His help is also appreciated.

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INTRODUCTION

[1] Earthquakes often bring large destruction with their high energy ground waves. The seismic waves usually have amplitudes large enough to be felt. Much smaller seismic waves occur in the earth which are normally only detected by seismographs. They are called microseisms.

Microseisms are generated from man-made and natural sources. The man-made, or cultural, microseisms include those which are caused by railroad trains, highway traffic, heavy industry, pumps, and mining operations. Winds and atmospheric pressure cells which are passing overland generate them locally. Microseisms whose source are sea waves are the most dominant. They occur when a weather front passes over the sea. The front interacts with the sea waves which induce the seismic activity. This paper is concerned with those microseisms which are generated by sea waves.

The seismograph in College Station, Texas, records microseisms whenever strong cold fronts pass through the area. The seismograph receives signals from a seismometer located in a salt mine 1500 ft below the surface near Hockley, Texas. This town is about forty miles north of Houston (Figure 1). Microseismic activity increases during January and February, when the strongest cold fronts pass.

Our original objective was to find how far out cold fronts must be over the Gulf of Mexico before microseisms start propogating inland and how their frequency and amplitude change as the front gets

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[1] The format used in Geophysics is used in this paper.

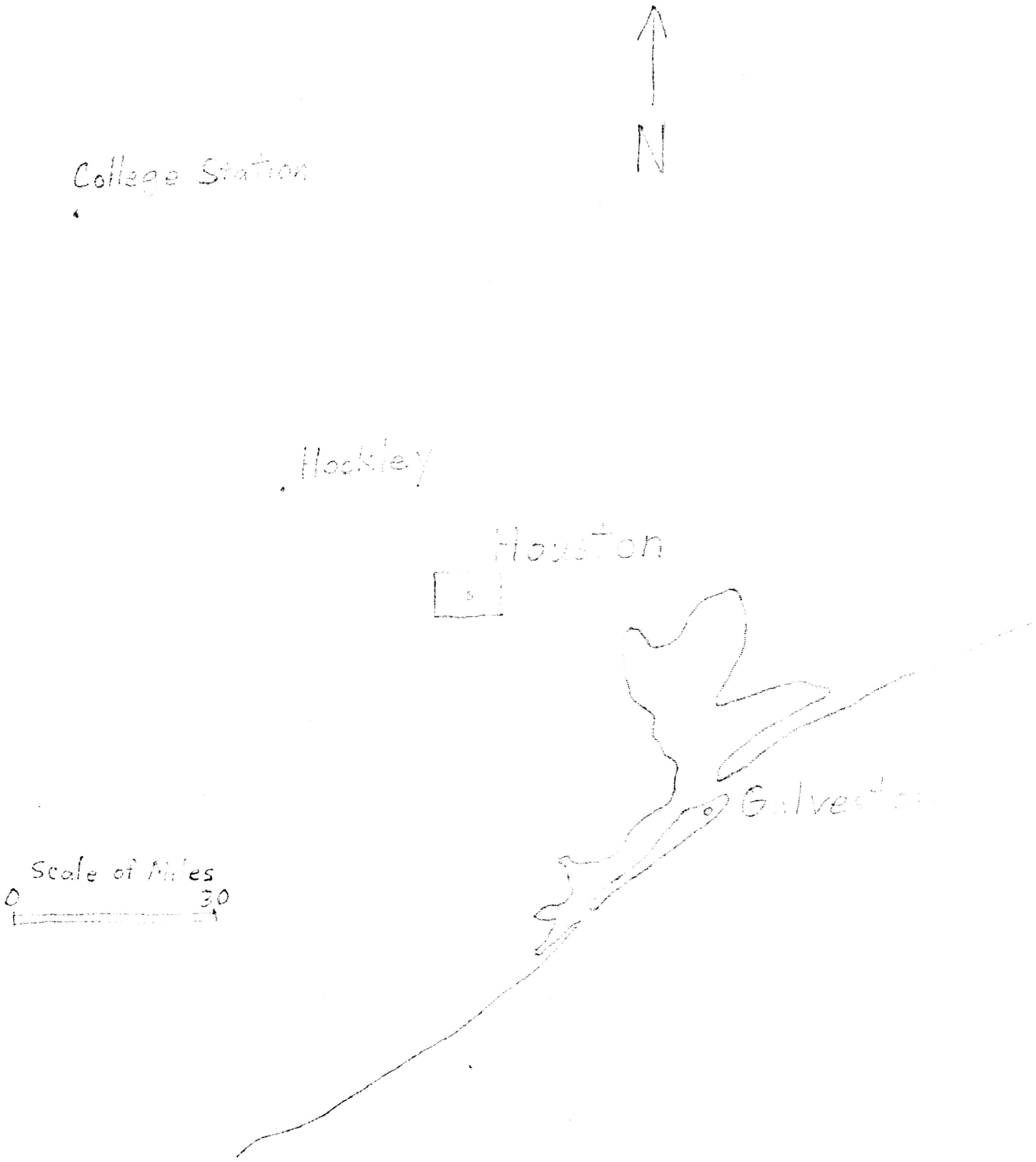


Fig. 1. The Texas Coast. The seismometer was located in Hockley, Texas.

further away. The geography of the upper Texas coast and the usual procession of cold fronts were conducive to this objective. Cold fronts usually come from the northwest, so that they parallel the coast. Therefore, the front would be about the same distance from the coast when microseisms started arriving. Weather maps as well as barometric pressure readings indicated the position of a front. The weather station in Galveston, Texas was prepared to send us continuous barometric pressure readings which indicate more precisely when the cold front passes the beach.

We could analyze the part of the seismogram (recording from the seismograph) that has ever present white noise and the part that has recorded microseisms. Our analysis would involve the frequency spectrum from each part. It shows which frequency of cosine waves compose the original signal and what the amplitude of these cosine waves are. Using the difference between the frequency spectra, we could pick out the time at which the microseisms were first recorded. Then we would find where the cold front was at that time. However, because of difficulties which were later discussed, we were limited to studying the change of the frequency spectra of the microseisms.

GENERATION OF MICROSEISMS

Previous research generally agrees that microseisms are mainly causes by sea waves. Darbyshire and Okeke (1969) pointed out that two conditions must be filled. First, the wave pressure must still be appreciable at the sea bottom. Second, the wave pressure variation must take the form of a progressive wave along the sea bottom with a phase speed equal to that of its ground wave so that resonance occurs.

The microseisms primarily occur at two frequencies. The lower frequency corresponds to the frequency of local sea waves. They are called primary microseisms. The other frequency is about twice that of the sea wave generating them. The microseisms in this frequency mode are secondary.

As early as fifty years ago, Banerji (1930) suspected the existence of parimary microseisms. However, it was only definitely established recently by the work of Oliver (1962) and Haubrich et al. (1963). In both of their studies, they found that the primary microseisms have frequencies of around 0.08cps (cycles per second). However, Bossolasco (1973) found primary microseisms to have frequencies around .18 cps when they were generated in the Mediterranean Sea, an enclosed body of water like the Gulf of Mexico.

These microseisms seem to be generated mainly in shallow water where there may be appreciable pressure variations at the bottom due to wave action. The pressure variation would have energy spread over a wide enough range of frequencies to include the frequency of the ground seismic wave. Hasselmann (1963) suggested that the modulation of sea waves as they approach shallow water allow a wide enough range. As one might expect, the wind velocity affects the amplitude of primary microseisms (Gytinoky, 1973).

Secondary microseisms can be generated in either shallow or deep water. Benard (1941) first observed them. According to the first-order theory of wave motion, the wave pressure disappears at depths greater than half a wavelength. But stationary waves have a second-order term which does not vanish with increasing depth. The interference of two waves with equal frequencies may generate this second-order term if the waves are moving in opposite directions (Longuet-Higgins, 1950). If the two frequencies are not quite equal, a fast moving pressure wave travels along the bottom of the sea. And for the right frequency difference, the speed will equal that of the ground wave. A situation where two waves travel oppositely could be at the eye of a hurricane or the center of some other strong pressure system.

ACCUMULATION AND PROCESSING OF DATA

The accuracy of frequency spectra depend on the equipment recording the data and the data processing. The seismometer and the digital recorder have limiting factors. In processing, these factors become important, as well as inherent problems.

Equipment

As mentioned before, the seismometer in the Hockley salt mine detect the microseims. Its location below the surface contributed to eliminating the noise that would be present otherwise. On the surface, the temperature fluctuates, causing turbulent convection in the air. The convection produces perturbations of the seismometer weight because of the changing buoyancy. The end result is a large background noise in the signal at low frequencies. To avoid this, others have had to heat the air near the top of the seismometer (Haubrich et al., 1963). Heating wasn't necessary in the mine since the temperature remains constant.

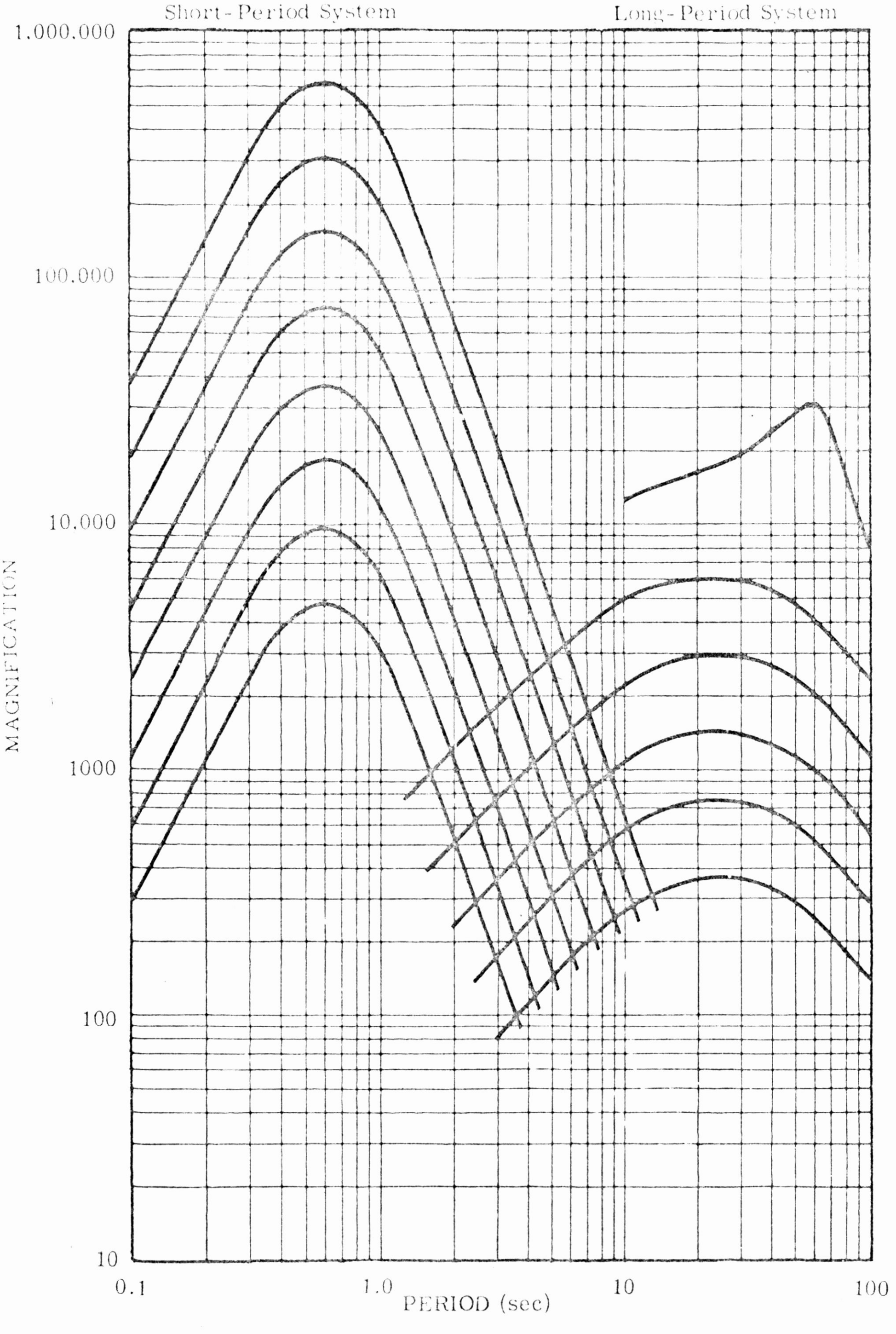
This seismometer has a short period system. Its frequency response shows it has peak sensitivity to waves with a period of .6 sec, or a frequency of about 1.7 cps (Figure 2). A long period seismometer would have been more appropriate for the low frequencies with which we were concerned. However, the Hockley seismometer picked up low frequencies sufficiently.

The seismometer sent electrical signals to the recording terminal of the seismograph in College Station. A digitizer recorded the seismometers measurements digitally on tape while the seismograph recorded them on paper. The digitizer sampled the time signal once every 0.1 sec. The sampling interval limits the frequency in processing the data. The digitizer divided the data into blocks containing values for 1013 samples, 101.3 sec of the signal. At the first of each block, it recorded the time of the first sample in days, hours, minutes, seconds, and milliseconds.

Data Processing

The magnetic tapes contained all the data to be processed. A program recorded the data from the tape onto a computer disc. We could then use available routines to compute the frequency spectra. After the data had gone through some preliminary corrections, the FFTRC subroutine computed the Fourier transform of the time signal from them.

The fourier transform of a function takes a signal in the time domain and transforms it into the frequency domain. The representation of this signal in the frequency domain is the frequency spectra, our e



FREQUENCY RESPONSE OF THE WORLD-WIDE STANDARD SEISMOGRAPH

Fig. 2

(From Simon, R. B., Earthquake Interpretation) device for characterizing the microseisms.

Two limitations were imposed upon the frequencies. A maximum frequency limit occurred because of the sampling interval. This maximum, known as the Nyquist frequency f_N, could be related to sampling interval, t, by:

$$f_N = 1/2t \tag{1}$$

Since the digitizer sampled once every 0.1 sec., the maximum frequency was 5.0 cps. This upper limitation was completely acceptable, since we were concerned with frequencies less than 1.0 cps.

The other limitation was the maximum resolution we could achieve. The resolution, Δf, depended on the length of the time window, T, as:

$$\Delta f = 1/T \tag{2}$$

The time window was just that section of the time signal used in finding the transform. For example, if the whole signal shown in Figure 3 was used, the window length would be eight minutes. One should use the optimum window length. It should be large enough to give as accurate a spectrum as is needed. Theoretically, the window length has no bounds, but the longer the window is, the longer it takes to compute the frequency spectrum. The computer time for an excessively long window would be too costly. Also, if the window length had been very long, we wouldn't have been able to find out how the spectra changed within that time duration.

We found our optimum window length by looking at the spectra calculated from different time durations. We used the same part of the time record (Figure 3) for all the cases, each time starting with the same first sample. First we used 128 data, or a window length of 12.8

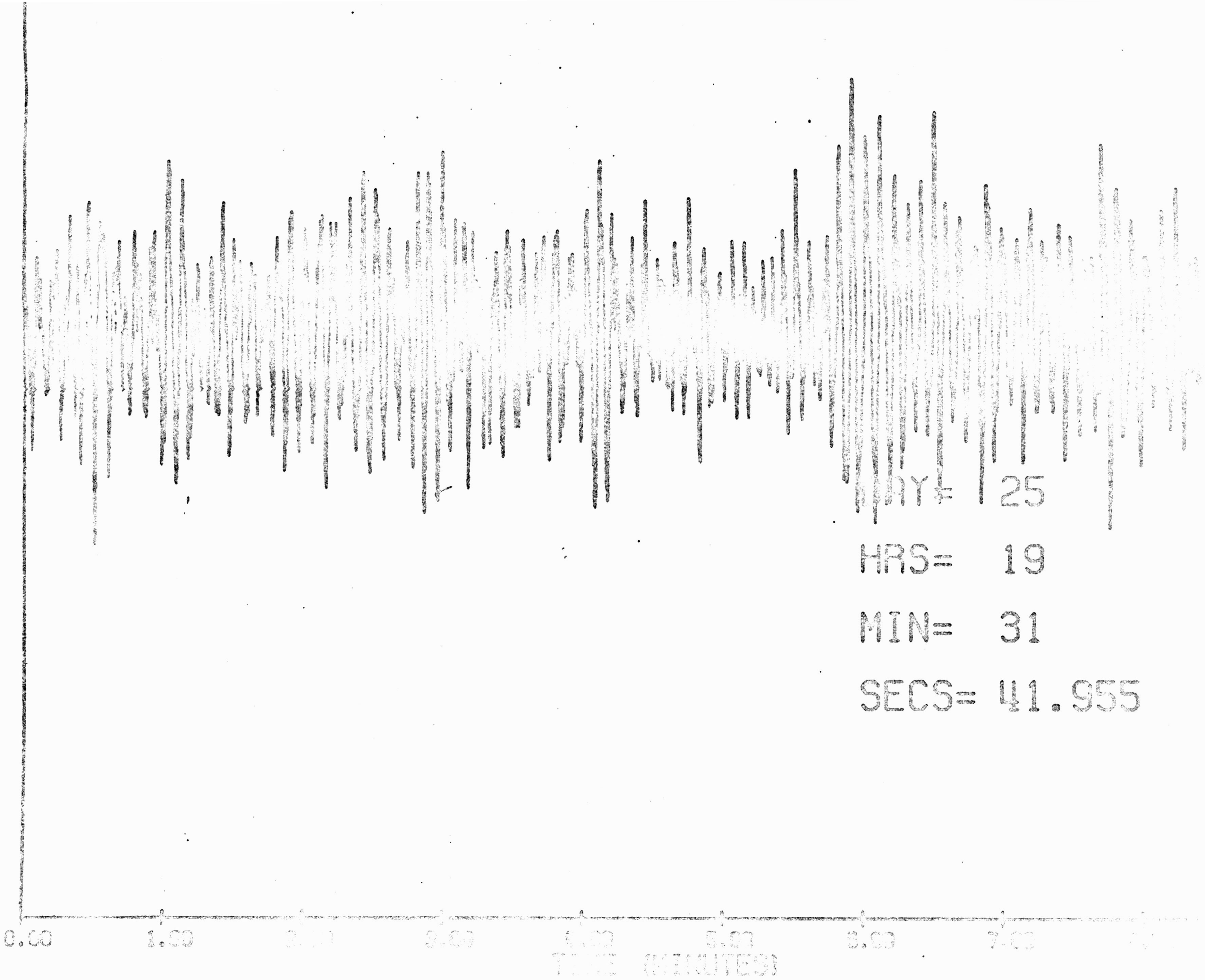


Fig. 3. Time Section Reproduction of the time signal of microseism.

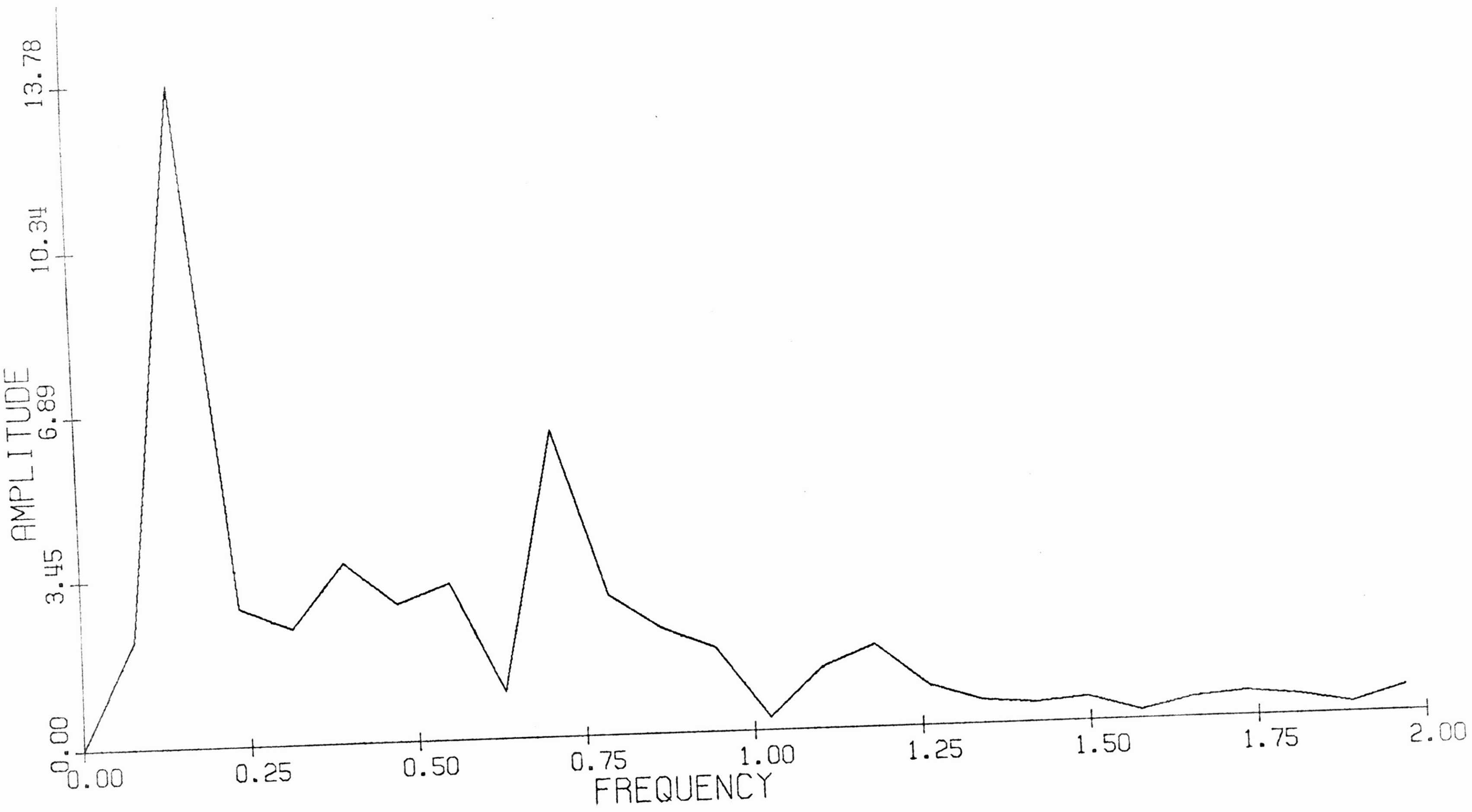


Fig. 4. First Window Spectrum. Frequency Spectrum of 12.8 sec. window length.

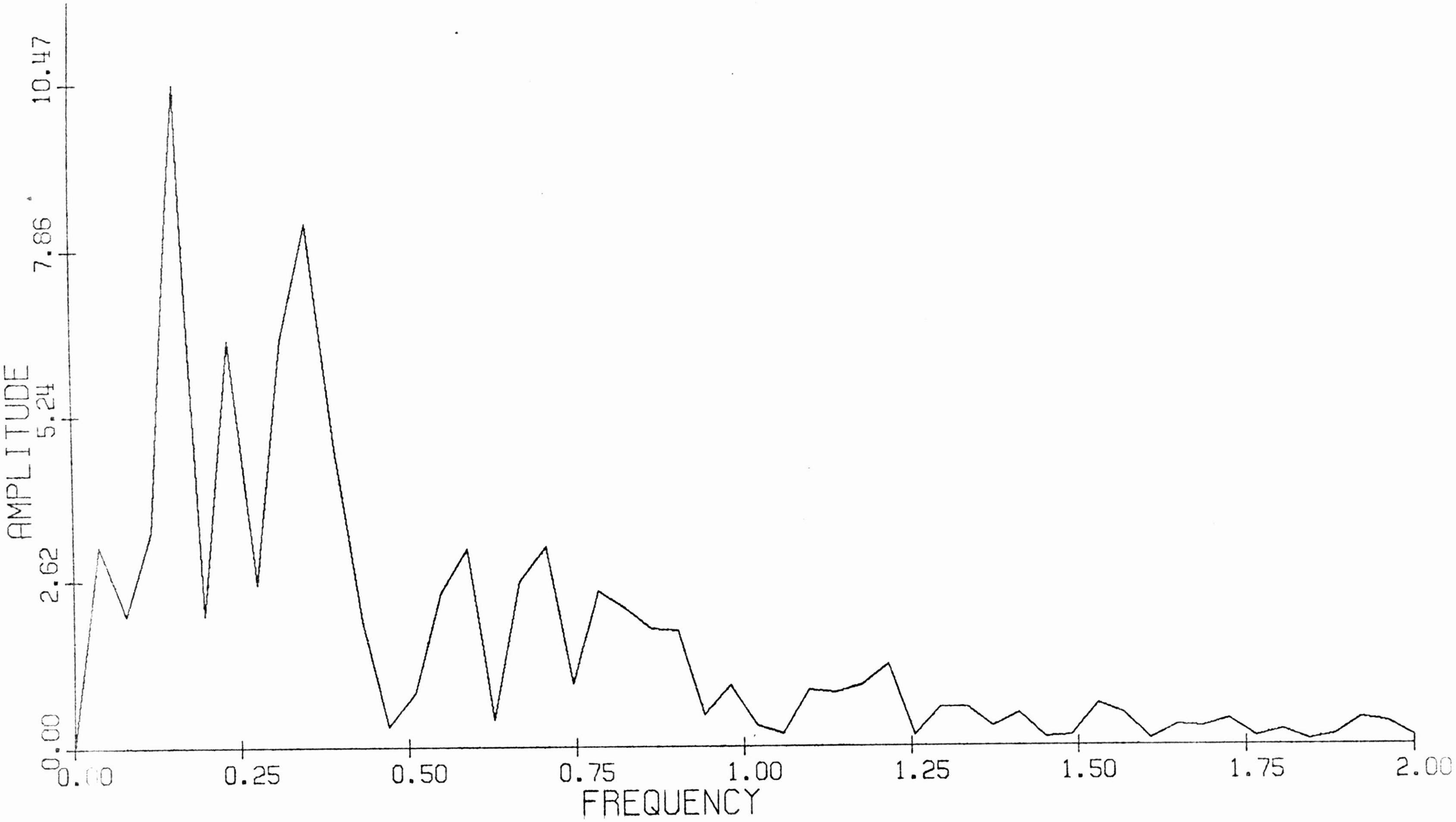


Fig. 5. Second Window Spectrum. Frequency spectrum of 25.6 sec window length.

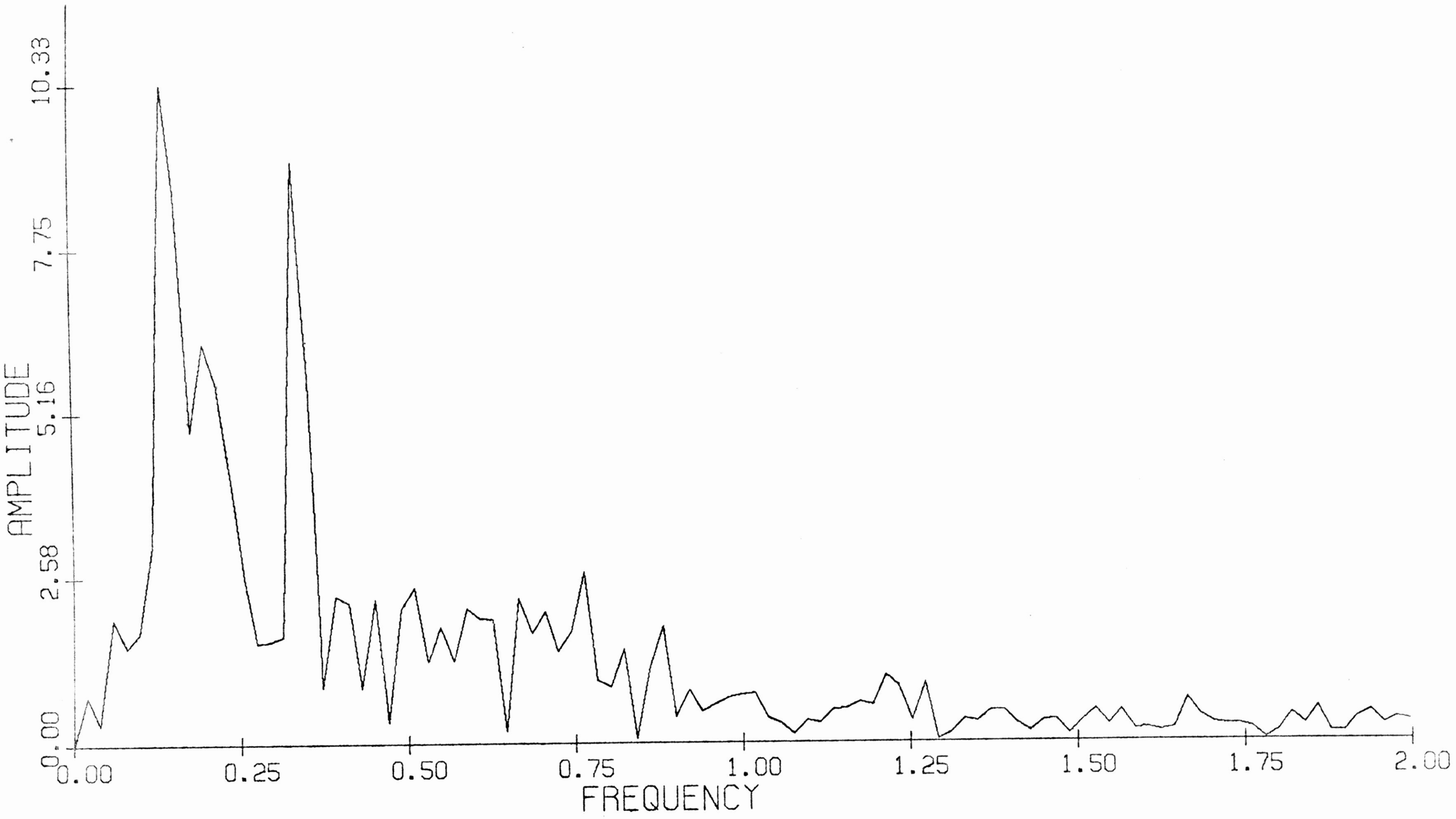


Fig. 6. Third Window Spectrum. Frequency spectrum of 51.2 sec. window length.

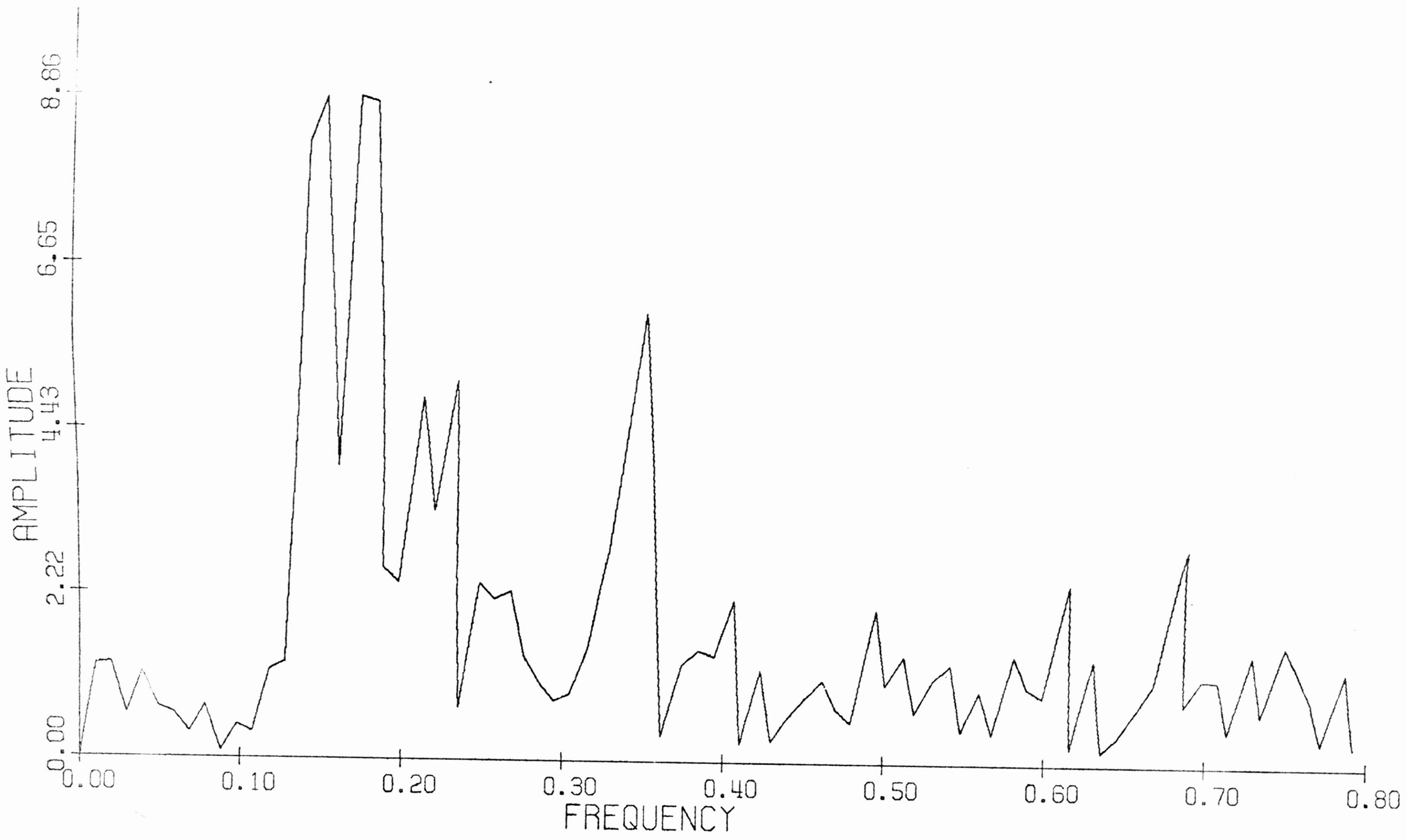


Fig. 7. Fourth Window Spectrum. Frequency spectrum of 102.4 sec. window length.

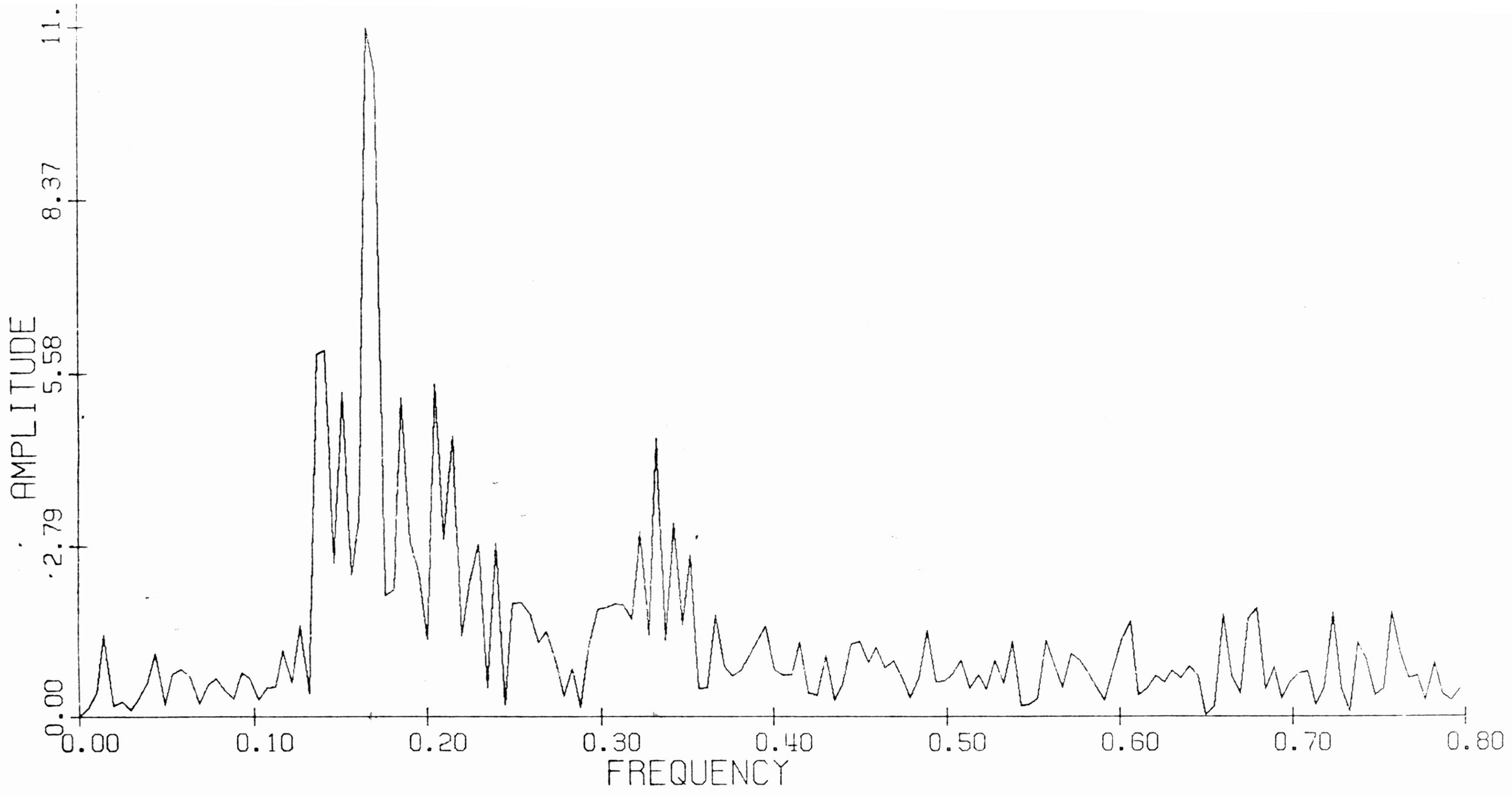


Fig. 8. Fifth Window Spectrum. Frequency spectrum of 204.8 sec window length. It has distincitve primary (0.17 cps) and secondary (0.33 cps). Started January 25, 1980, 5:31:42 pm (GMT)

seconds, to run through our Fourier transform program which computed the spectrum (Figure 4). Then we doubled the window length, reran the program, and compared that spectrum (Figure 5) withthe first. We repeated this procedure until there wasn't much difference between a spectrum from a certain length and the spectrum from twice that length (Figures 6-8). The main peaks were at about the same values for window lengths of 102.4 seconds and 204.8 seconds (Figures 7 and 8). But the resolution was much better for the longer window so we used it.

Complications

This research was a real lesson in technical limitations and the importance of equipment. We had some trouble with the recording equipment. The digitizer had a sticking register. It always magnetized a certain byte. This introduced an error in some of the headings and sampled data. While technicians were trying to find and correct the problem, some strong cold fronts passed through the area. We missed recording data for them.

The problem couldn't be corrected without a new register. We were unable to attain a new register in time, so the error created by the digitizer was corrected by a subroutine in the processing. The machine was recording when one notably strong cold front did pass through. Armed with our programs to work around the digitizer's error, we were hopeful of fulfilling our original objectives. However, we couldn't record the data onto the disc because the tape was defective. Being unable to work around this difficulty, we decided to use previously recorded tapes. One had some weak microseisms on it, but the digitizer started recording on it after the microseismic activity had already started. Therefore, we could not carry out our original objective of finding when microseisms start.

VARIATION OF THE SPECTRA

We found the frequency spectra for several different times. We did find that most records contained primary and secondary microseisms. We looked at how the spectra changed over long time intervals and over short time intervals.

Change with Weather Movement

The data that we used for finding the window length were actually a record of microseisms. They were apparently induced by a low pressure center accompanied by a trough (an elongated area of relatively low atmospheric pressure, somewhat like a weak front). The trough was moving offshore at 6:00 p.m. (GMT), January 25, 1980 (Figure 9). The microseisms at 7:30 p.m. of the same day had showed a large primary frequency amplitude at 0.165 cps and a smaller secondary peak at 0.335 cps (Figure 8). Six hours later, there was double peak centered around 0.17 cps with an amplitude about one unit smaller than before (Figure 10). At the frequency of the secondary microseism, there was more of a rise just above the noise than a peak. However, the tallest part of the rise was at 0.34 cps. Then five minutes later, the secondary peaks became clearer, but appeared to have shifted to 0.375 cps (Figure 11). The primary microseism had a smear of frequency peaks from 0.14 cps to 0.21 cps, with their amplitudes decreasing as frequency increases. On the same day, January 26, at 9:20 p.m., the frequency peaks were smaller and more evenly distributed (Figure 12). The main peak for the

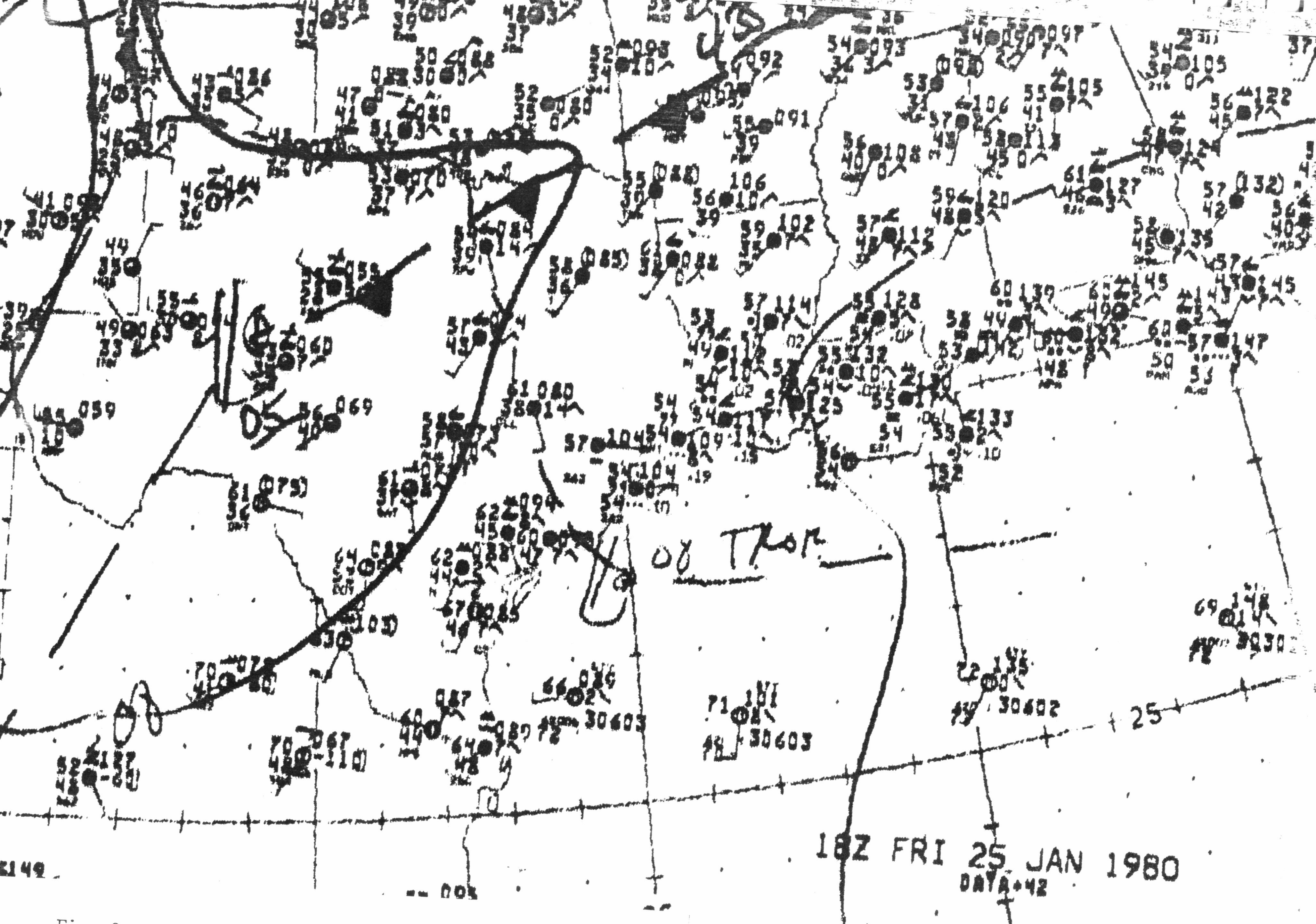


Fig. 9. Weather conditions on Friday, January 25, 1980.

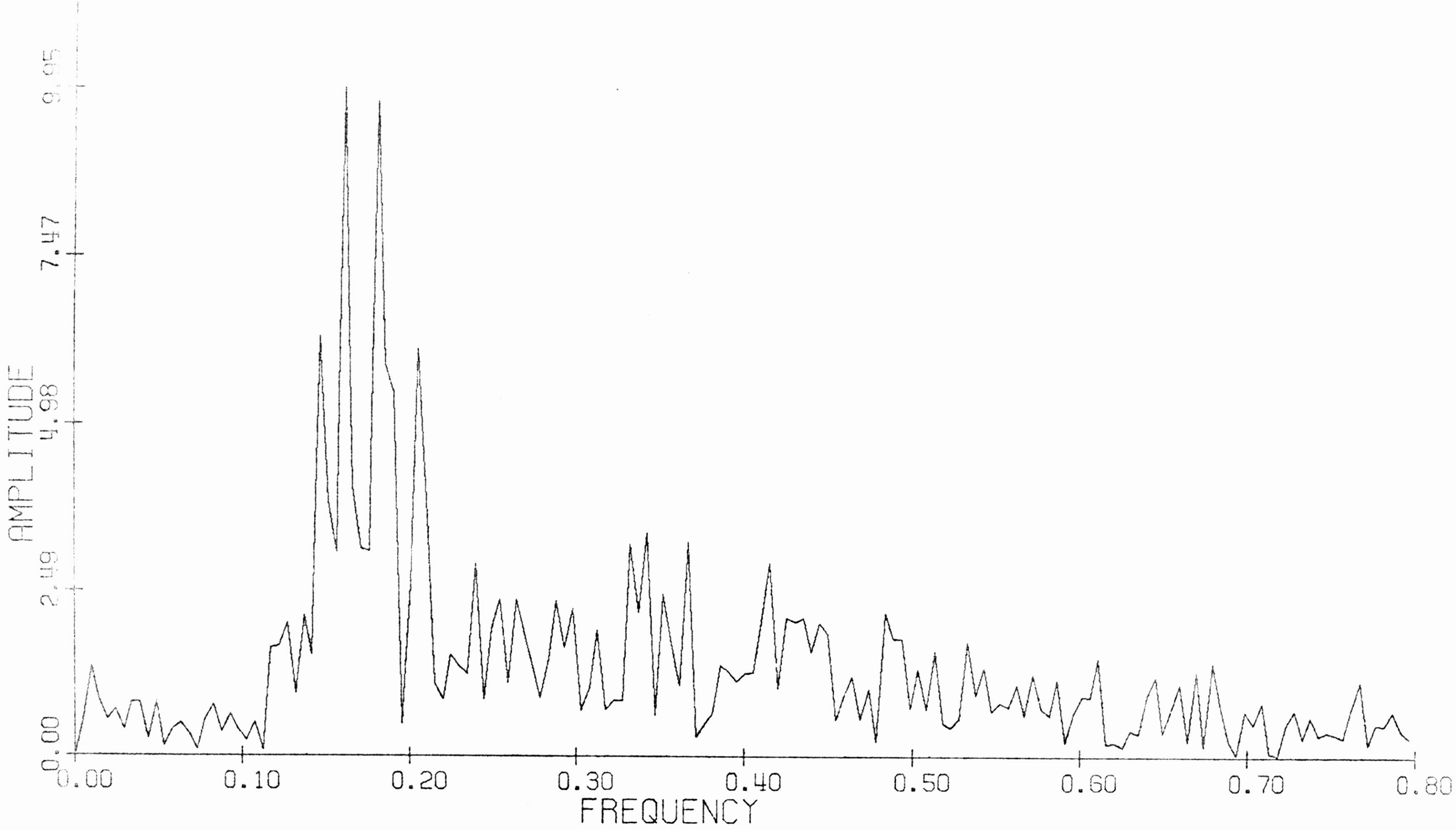


Fig. 10. Spectrum for January 26, 12:15 a.m.

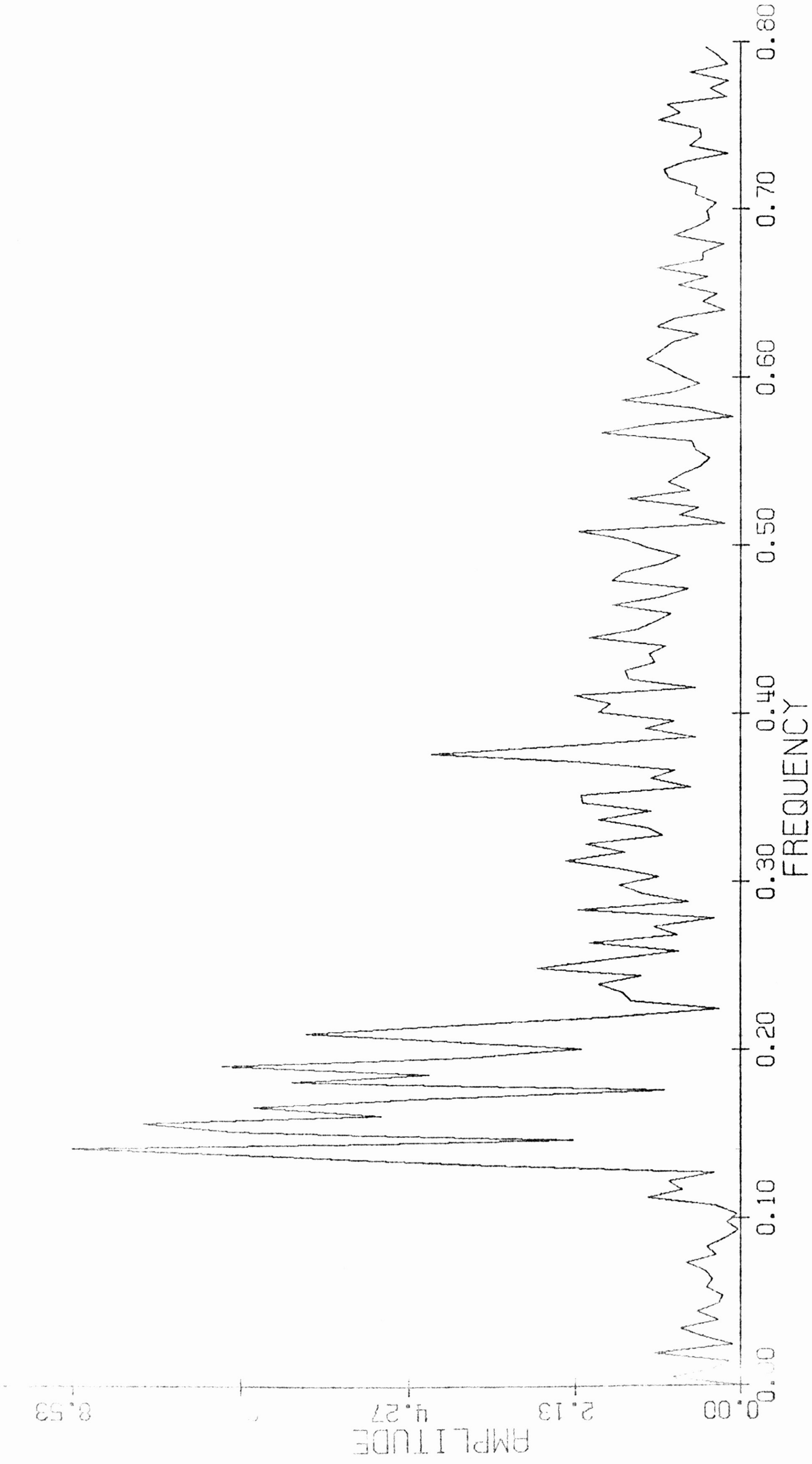


Fig. 11. Spectrum for January 26, 12:20 a.m.

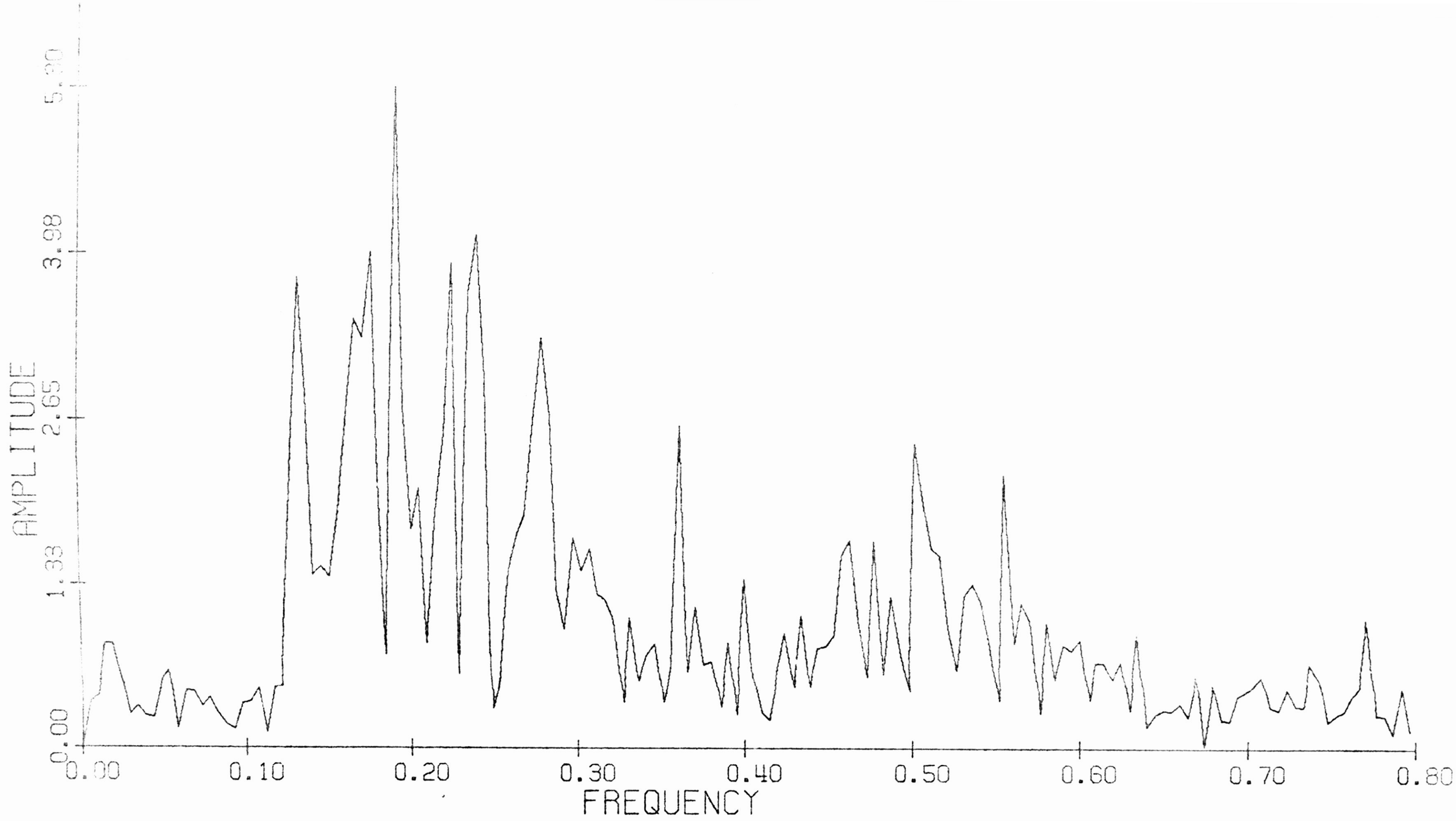


Fig. 12. Spectrum for January 26, 9:20 p.m.

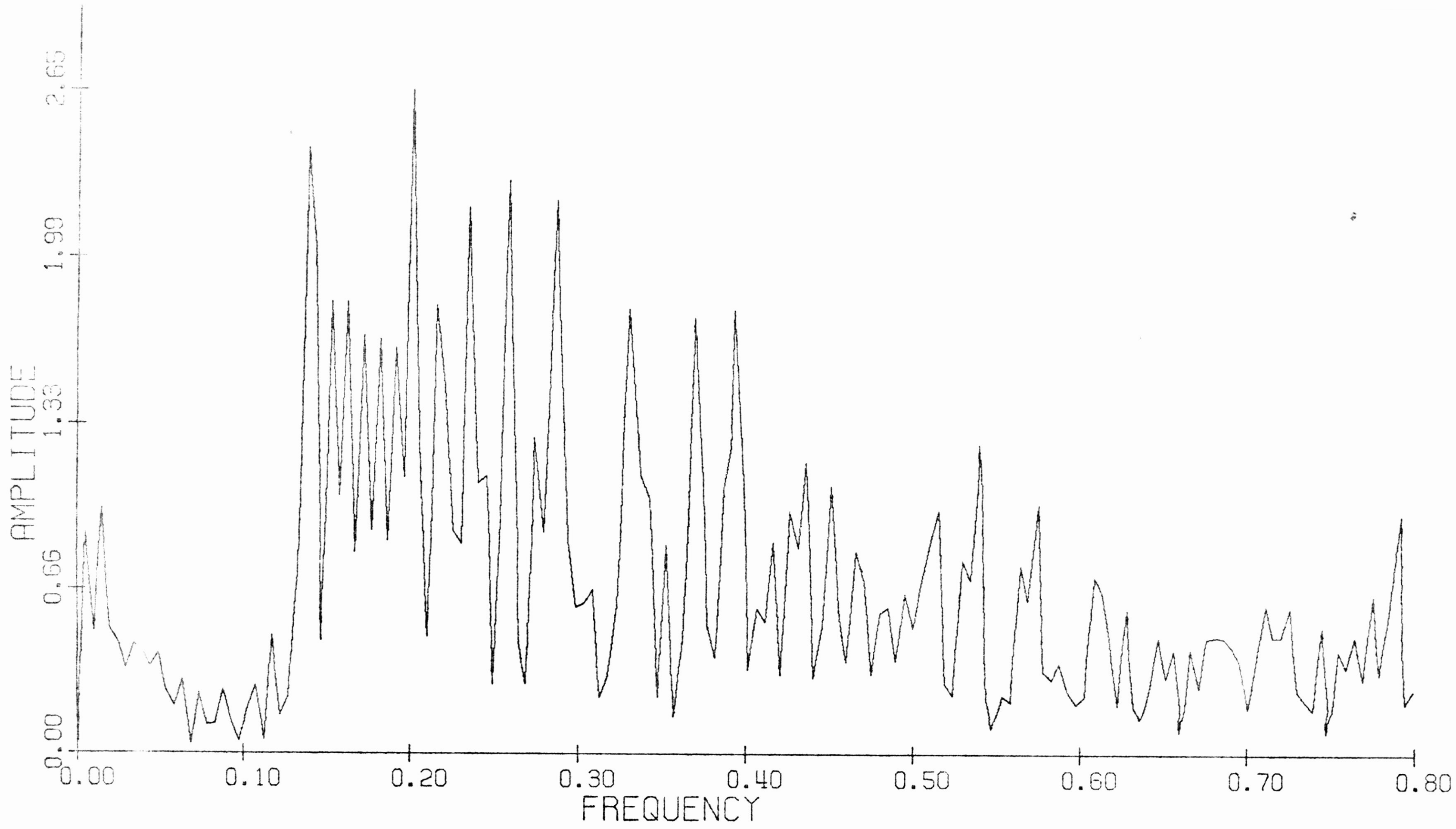


Fig. 13. Spectrum for January 28, 1980.

primary occurred at 0.19 cps and the secondary appeared to be at 0.365 cps. By January 28, 6:05 p.m., all atmospheric disturbances had moved out of the Gulf. The frequency peaks of the microseisms were too small and spread out to note anything (Figure 13). It appeared to be mainly "white" noise in the signal.

Out spectra indicated that primary microseisms generated in the Gulf were between 0.15 cps and 0.20 cps. The secondary microseisms were between 0.33 cps and 0.38 cps. The possibility was considered that what appeared to be prinary microseisms were actually secondary microseisms since much of the literature found the primary microseism to have a frequency of 0.08 cps. What should have been our primary microseism may have been lost because of our short period seismometer. However, much of the previous research was done near the open ocean, not near an enclosed body of water like the Gulf of Mexico. Since the Mediterranean Sea is more like the Gulf and primary microseisms propagated there at 0.18 cps, we felt safe in assuming that our primary frequency was in the correct range.

The frequency spectrum was found for another seismic record taken at 5:30 p.m. (GMT), February 25, 1980 (Figure 14). The only peak was at 0.32 cps. It was different from the other records in that only the secondary frequency was present. There was a cold front about 500 miles off the coast at the time (Figure 15). Apparently, the weather system was too far from the coast to increase ocean wave activity near the shore, where the water was more shallow. Since primary microseisms are found in shallow water, none were formed. However, secondary microseisms can be generated in deep water, so according to theory, they

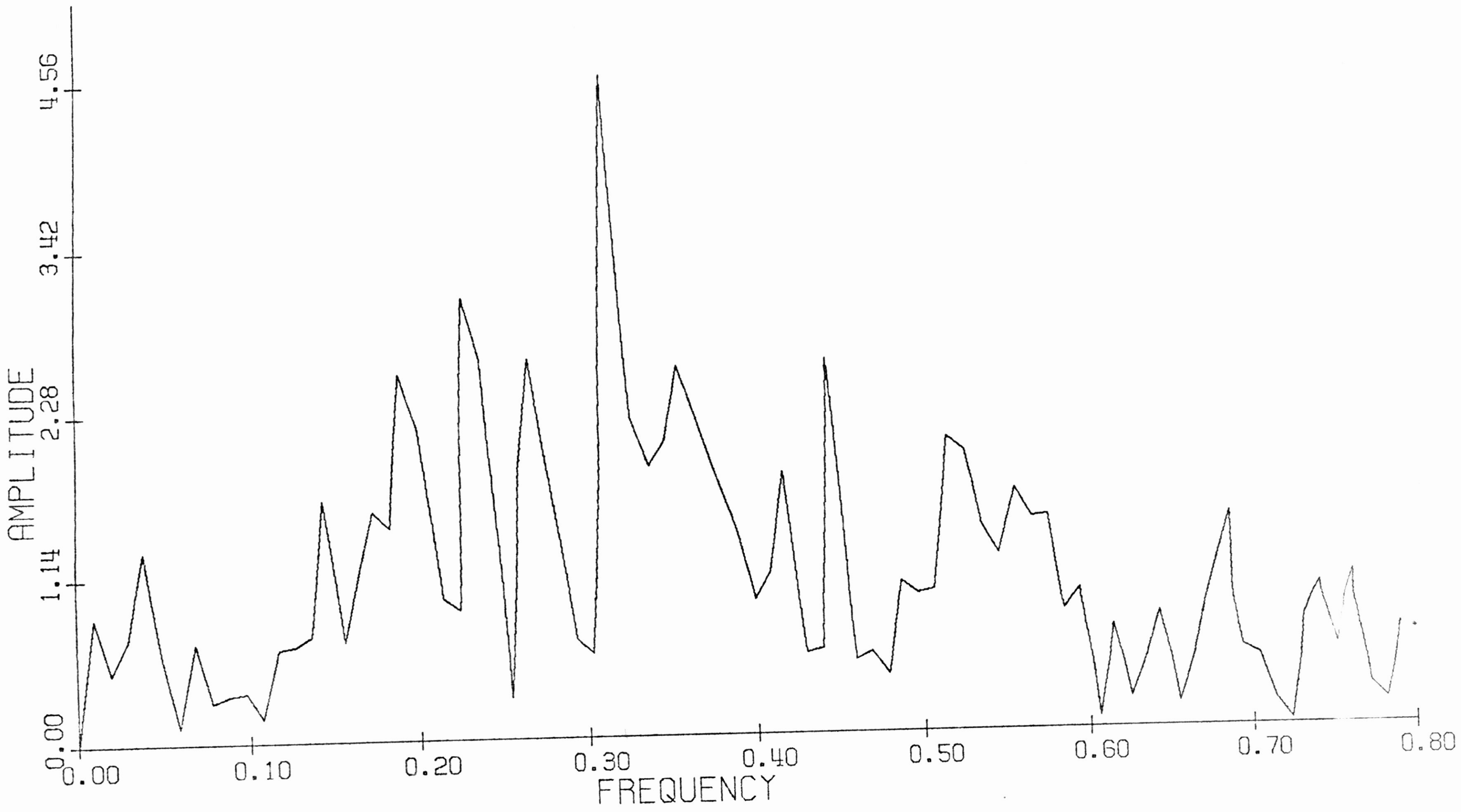


Fig. 14. Spectrum for February 25, 1980.

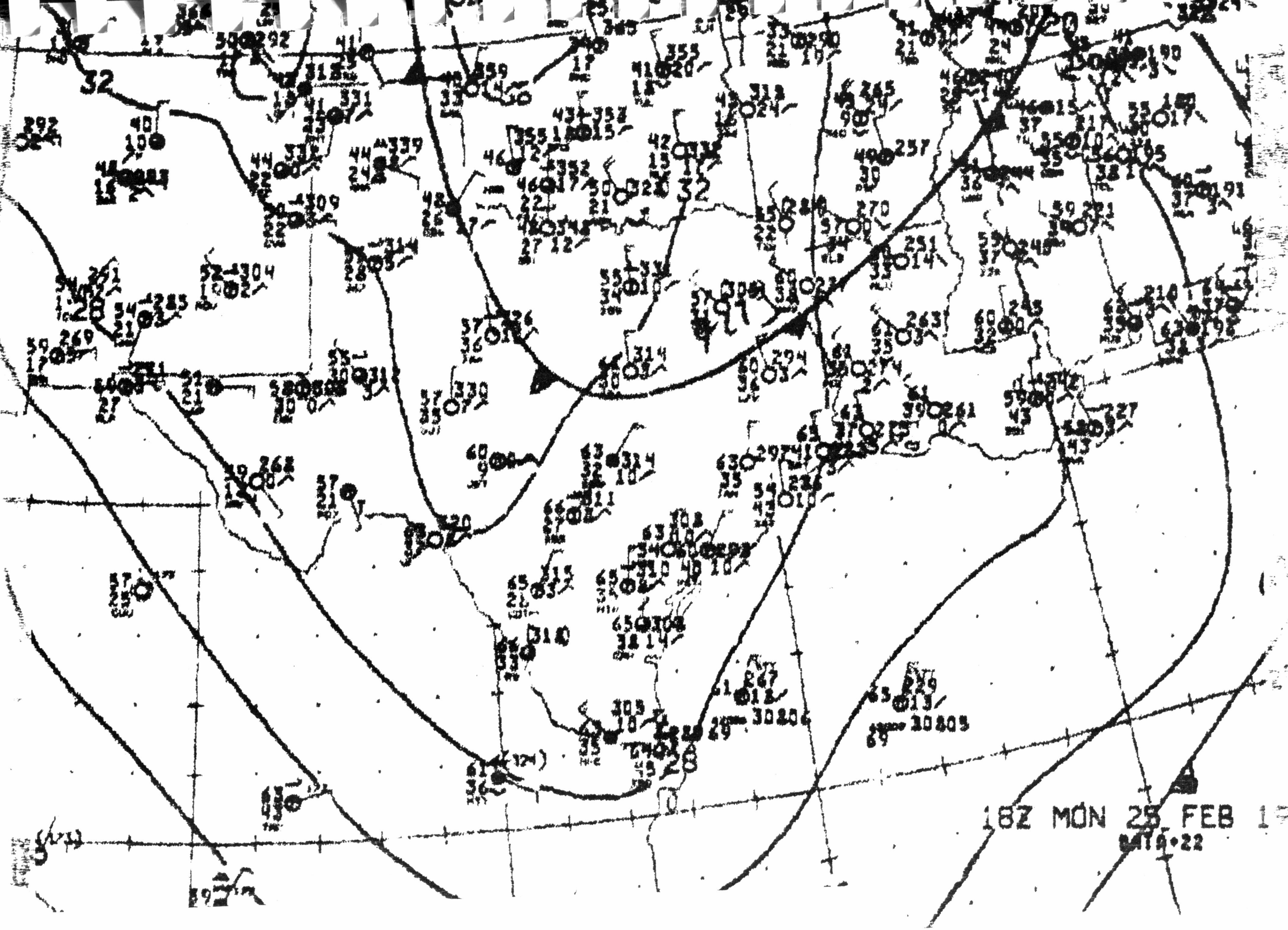


Fig. 15. Weather conditions on Monday, February 25, 1980.

must have formed near the cold front and propagated 500 miles to shore. The spectrum of this record supported the established theories.

Intermittency of Secondary Microseisms

We were puzzled by the rapid change of the secondary microseism from the time it was recorded at 12:15 a.m. to the time it was recorded at 12:20 a.m. on January 26, 1980 (Figures 10 and 11). It did not have a much more significant amplitude than the noise at the earlier time. But five minutes later it showed up clearly.

We analyzed some more of the tape that we had used in determining window length (Figure 3). We took sequential blocks 204.8 sec in length and found their spectra. The blocks overlapped 2.2 sec. The first spectra in the sequence showed the only good secondary peak at 0.33 cps (Figure 8). The second had a rise above the noise between 0.30 and 0.40 cps but no dominant peak (Figure 16). The third didn't even show much of a rise in the secondary frequency range (Figure 17). However, there appeared to be a recurring character to it. A double peak was repeated starting at 0.20 cps and went to 0.10 cps. The fourth and final spectra showed the secondary peak was above the noise, but that was a result of the amplitude of the noise dropping more than the amplitude of the secondary peak (Figure 18). The peaks were centered around 0.34 cps.

CONCLUSION

The amplitude of the primary microseism was large when a weather system was near the coast and decreased as the front continued over the ocean, as would be expected. The shift in the primary and secondary

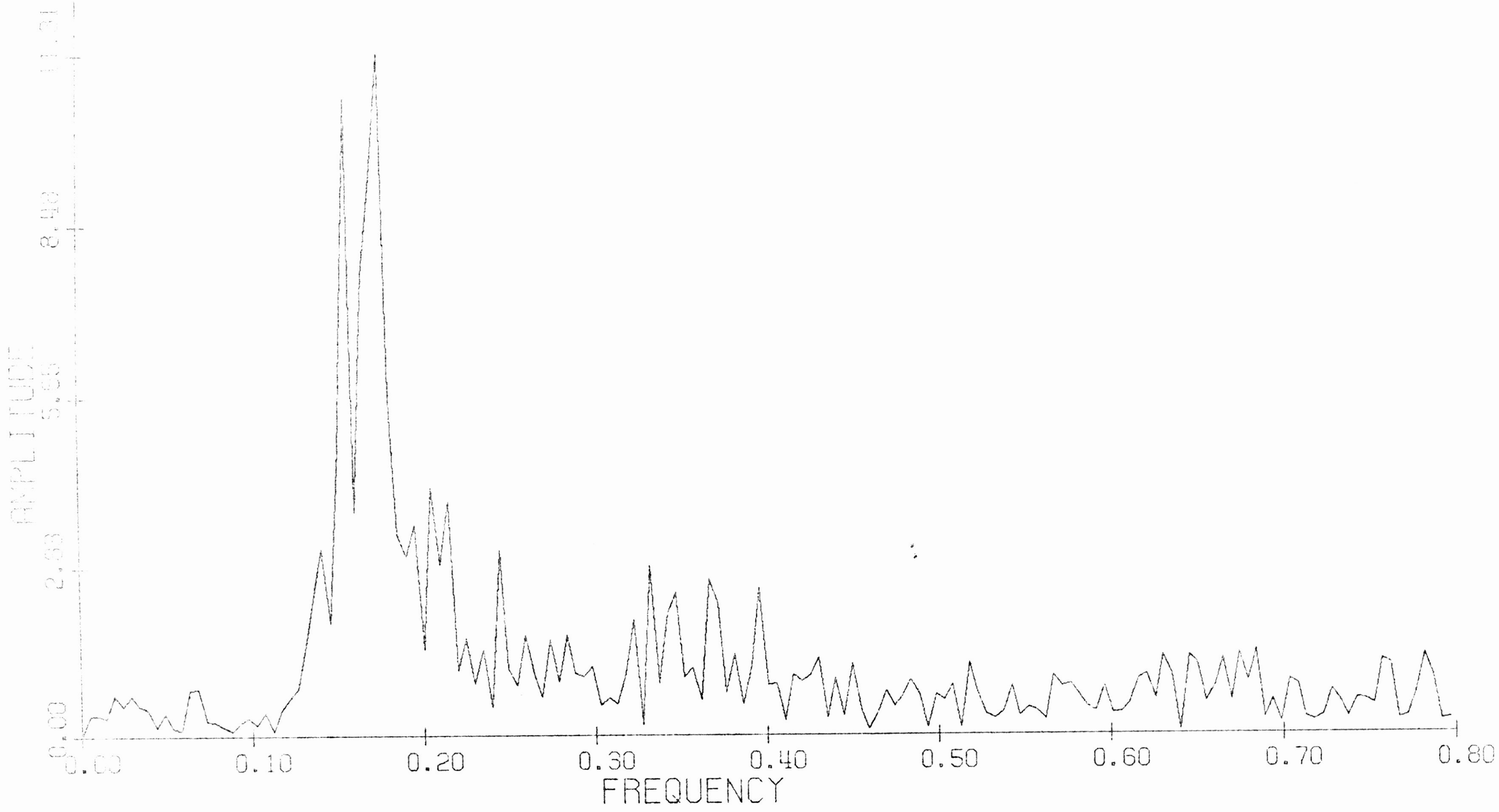


Fig. 16. Second Sequential Spectrum. Started at 7:35:04.pm, January 25, 1980.

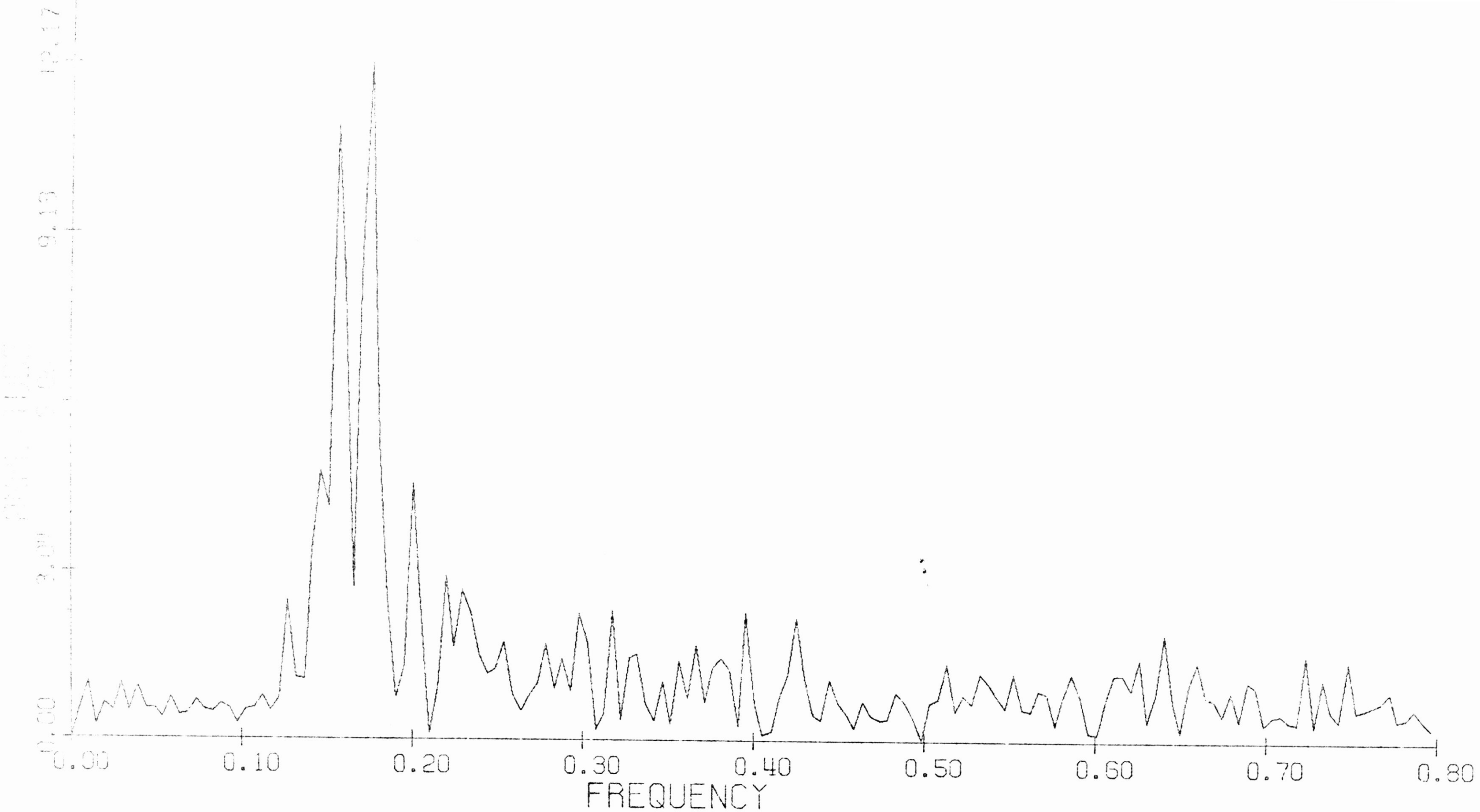


Fig. 17. Third Sequential Spectrum. Started at 7:38:26 pm, January 25, 1980

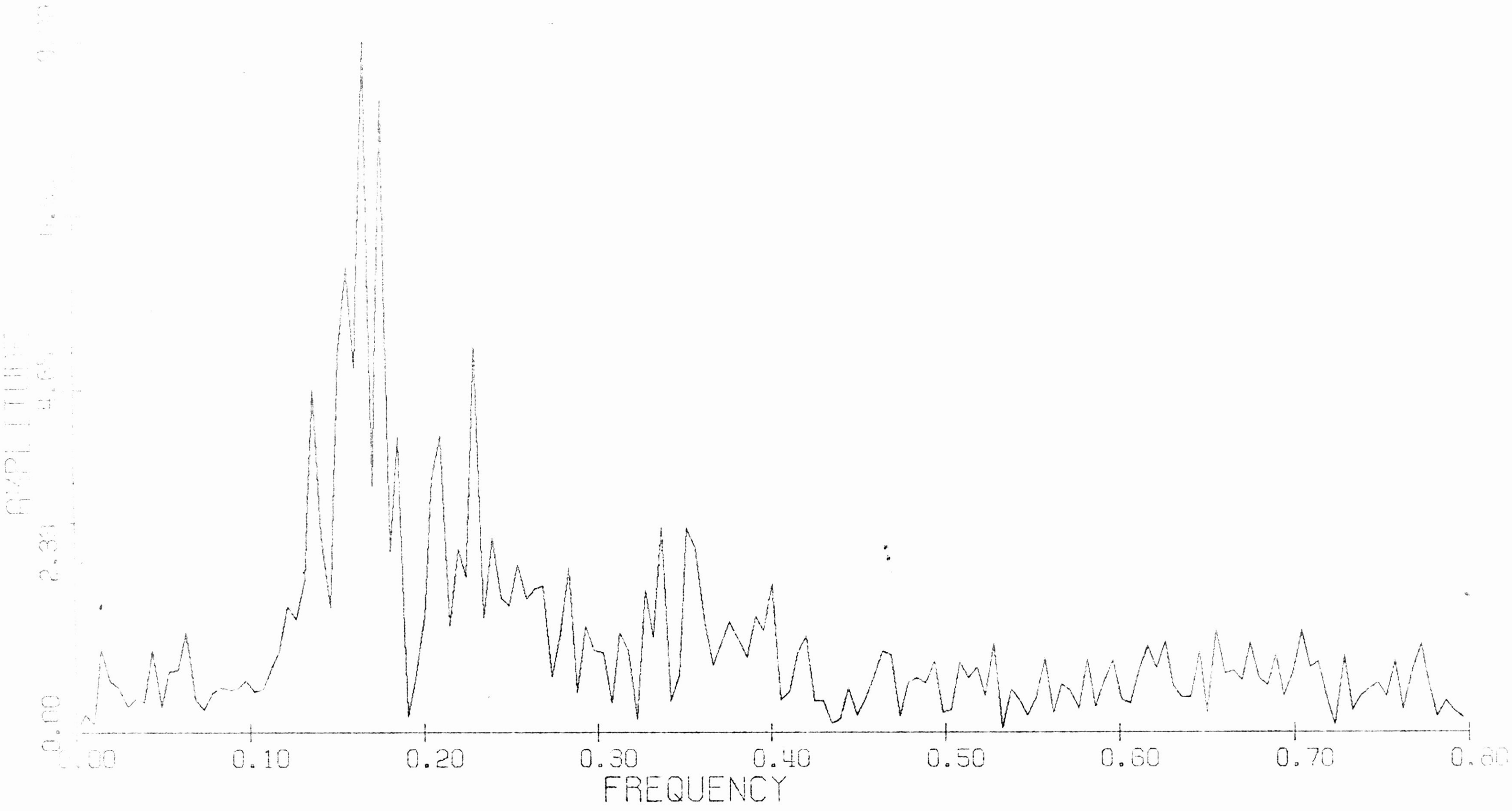


Fig. 18. Fourth Sequential Spectrum. Started at 7:41:48 pm, January 25, 1980

frequencies from time to time may have been from change in the sea's bottom. The sea floor at one plane may have had a different ground frequency than the floor at another place.

The instability of the secondary microseism needs further investigation. Spectra should be taken of relatively short time durations (less than five minutes) instead of using an hour's worth of a record as others have used. Spectra produced from such a long duration may average out any discontinuity of the secondary microseism's presence.

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APPENDIX

```
IMSL ROUTINE NAME    - FFTRC

PURPOSE              - COMPUTE THE FAST FOURIER TRANSFORM OF A
                         REAL VALUED SEQUENCE

USAGE                - CALL FFTRC (A,N,X,IWK,WK)

ARGUMENTS   A        - INPUT REAL VECTOR OF LENGTH N WHICH
                         CONTAINS THE DATA TO BE TRANSFORMED.
            N        - INPUT NUMBER OF DATA POINTS TO BE TRANSFORMED.
                          N MUST BE A POSITIVE EVEN INTEGER.
            X        - OUTPUT COMPLEX VECTOR OF LENGTH N/2+1
                         CONTAINING THE FIRST N/2+1 COEFFICIENTS OF
                         THE FOURIER TRANSFORM. THE REMAINING
                         COEFFICIENTS MAY BE DETERMINED BY
                           X(N+2-I) = CONJG(X(I)), FOR I=2,...,N/2.
            IWK      - INTEGER WORK VECTOR.
                         IF N IS A POWER OF 2, THEN IWK SHOULD BE OF
                         LENGTH M WHERE N=2**M.
                         OTHERWISE, IWK SHOULD BE OF LENGTH
                         6*(N/2)+150.
                         (SEE PROGRAMMING NOTES FOR FURTHER DETAILS)
            WK       - REAL WORK VECTOR OF LENGTH 6*(N/2)+150.
                         WK IS NOT USED IF N IS A POWER OF 2.
                         (SEE PROGRAMMING NOTES FOR FURTHER DETAILS)

PRECISION/HARDWARE   - SINGLE AND DOUBLE/H32
                     - SINGLE/H36,H48,H60

REQD. IMSL ROUTINES  - FFTCC,FFT2C

NOTATION             - INFORMATION ON SPECIAL NOTATION AND
                         CONVENTIONS IS AVAILABLE IN THE MANUAL
                         INTRODUCTION OR THROUGH IMSL ROUTINE UHELP

REMARKS  1.  FFTRC COMPUTES THE FOURIER TRANSFORM, X, ACCORDING
             TO THE FOLLOWING FORMULA;

               X(K+1) = SUM FROM J = 0 TO N-1 OF
                        A(J+1)*CEXP((0.0,(2.0*PI*J*K)/N))
               FOR K=0,1,...,N/2 AND PI=3.1415...

             THE USER CAN COMPUTE THE REMAINING X VALUES BY
             PERFORMING THE FOLLOWING STEPS;

                  ND2 = N/2
                  DO 10 I=2,ND2
                     X(N+2-I) = CONJG(X(I))
               10 CONTINUE
         2.  FFTRC CAN BE USED TO COMPUTE

               X(K+1) = (1/N)*SUM FROM J = 0 TO N-1 OF
                        A(J+1)*CEXP((0.0,(-2.0*PI*J*K)/N))
               FOR K=0,1,...,N/2 AND PI=3.1415...
```

BY PERFORMING THE FOLLOWING STEPS;

```
                CALL FFTRC (A,N,X,IWK,WK)
                ND2P1 = N/2+1
                DO 10 I=1,ND2P1
                   X(I) = CONJG(X(I))/N
             10 CONTINUE
```

Algorithm

FFTRC computes the fast Fourier transform (FFT) of a real vector of length N where N is any positive even integer.

The output vector X is defined mathematically as

$$X_{k+1} = \sum_{j=0}^{N-1} A_{j+1} e^{2\pi ijk/N} \quad \text{where } k=0,\ldots,N-1 \text{ and } i=\text{SQRT}(-1)$$

FFTRC factors N into its prime factors and applies Cooley-Tukey techniques for each prime factor. FFTRC computes the first N/2+1 coefficients. The remaining coefficients may be determined by X(N+2-I)= CONJG(X(I)) for I=2,...,N/2.

See reference:

Singleton, Richard C., "On computing the fast Fourier transform", Comm. ACM, 10(10)1967, 647-654.

Programming Notes

1. The number 6*(N/2)+150 is an upper bound on the number of words of work vector storage required when N is not a power of two. The actual requirement may be much less than this. To compute this, see programming note number one in the documentation for IMSL subroutine FFTCC substituting N/2 for N when it appears in that note.

2. Some environments allow the equivalencing of different variable types. In those environments, when N is not a power of two, work vectors IWK and WK may share the same storage locations. For example, assume N=100, then each of the work vectors should be dimensioned 61. I.e.,

```
                    DIMENSION  IWK(61),WK(61)
```

   An equivalence statement may be used to cause them to share the same storage locations. I.e.,

```
                    EQUIVALENCE   (IWK(1),WK(1)).
```

   Then FFTRC is called as follows:

```
                    CALL FFTRC (A,N,X,IWK,WK)
```

Example 1

This example computes the Fourier transform of a real valued sequence of length 6.

Input:

```
INTEGER   N,IWK(35)
REAL      A(6),WK(35)
COMPLEX   X(4)
N     =  6
A(1)  =  2.0
A(2)  =  1.0
A(3)  =  3.0
A(4)  =  1.0
A(5)  =  4.0
A(6)  =  0.0
CALL FFTRC (A,N,X,IWK,WK)
    :
END
```

Output:

```
X(1)  =   (11.0,0.0)
X(2)  =   (-2.0,0.0)
X(3)  =   (-1.0,1.732)
X(4)  =   (7.0,0.0)
```

Example 2

This example computes the Fourier transform of a real valued sequence of length 8.

Input:

```
INTEGER   N,IWK(3)
REAL      A(8),WK(1)
COMPLEX   X(5)
N     =  8
A(1)  =  1.0
A(2)  =  4.0
A(3)  =  3.0
A(4)  =  1.0
A(5)  =  2.0
A(6)  =  3.0
A(7)  =  2.0
A(8)  =  4.0
CALL FFTRC (A,N,X,IWK,WK)
    :
END
```

Output:

```
X(1)  =   (20.0,0.0)
X(2)  =   (1.828,-.4142)
X(3)  =   (-2.0,2.0)
X(4)  =   (-3.828,-2.414)
X(5)  =   (-4.0,0.0)
```

CONT SCAN MODE (NORMAL OPERATION)

BEGINNING OF TAPE OR INTER RECORD GAP

9 TRACK	SCANS			DAYS			HRS		MIN		SEC		MSEC			CHANNELS SELECTED		HEADER CONSTANTS				BLANK	1ST. SAMPLE		2ND SAMPLE		N SAMPLE
PARITY	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X
0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	2^7	0	2^7	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	2^6	0	2^6	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	2^5	0	2^5	0
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	2^4	0	2^4	0
4	800	80	8	0	80	8	0	8	0	8	0	8	800	80	8	80	8	8000	800	80	8	0	2^{11}	2^3	2^{11}	2^3	2^{11}
5	400	40	4	0	40	4	0	4	40	4	40	4	400	40	4	40	4	4000	400	40	4	0	2^{10}	2^2	2^{10}	2^2	2^{10}
6	200	20	2	200	20	2	20	2	20	2	20	2	200	20	2	20	2	2000	200	20	2	0	2^9	2^1	2^9	2^1	2^9
7	100	10	1	100	10	1	10	1	10	1	10	1	100	10	1	10	1	1000	100	10	1	0	2^8	2^0	2^8	2^0	2^8
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	2047

ETC

10^2 10^1 10^0

TAPE CHARACTER (BYTES)

TAPE MOTION

E3

2A3, 3A2, A3, A2

page 3-5

#2047 #2048

4. 2° IS THE LSB.

3. DATA FORMAT NOT PHYSICAL DATA LOCATION ON TAPE (EBCDIC CODING).

2. 1013 A/D SAMPLES PER RECORD.

1. 2048 CHARACTERS PER RECORD.

NOTES:

ITEM NO	ELECT DES	QTY REQ'D	DESCRIPTION	VENDOR
PARTS LIST				

NEXT ASSY	USED ON
APPLICATION	

DO NOT SCALE THIS DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES BREAK SHARP EDGES .015 MAX

TOLERANCES			
FRACT ± 1/64	XX ± .010	XXX ± .005	ANGLES ± 0°30'

MAT'L

FINISH

CONTRACT		
DRAWN BY		3/12/72
CHECKER		
DESIGNER	D. Jones	3/20/72
PROJECT ENGINEER		
APPROVAL		
OTHER APPROVAL		

KINEMETRICS, INC.

TAPE FORMAT

DIGITAL CLOCK WITH THRES

IN THE NORMAL SCANNING M

SIZE	CODE IDENT NO	
A		102033
SCALE	WEIGHT	SHEET OF