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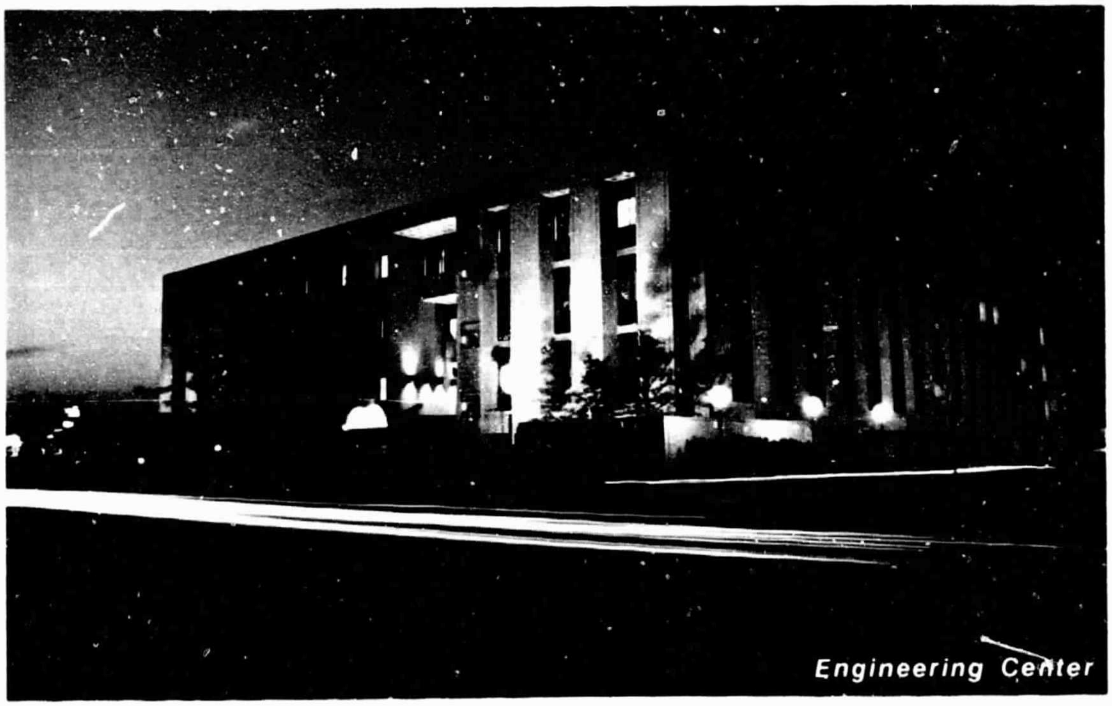

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SEMI-ANNUAL REPORT TO

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THE ROLE OF COHERENT STRUCTURES IN THE GENERATION OF NOISE FOR SUBSONIC JETS

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The objectives of this work were categorized into four main topics:

1. Mean flow field surveys
2. Flow fluctuation amplitude measurements
3. Identification and characterization of the organized structure
4. Acoustic measurements

This report will briefly restate the specific objectives of each topic and the progress to date on each.

1. MEAN FLOW FIELD SURVEYS

Radial and axial distributions of the Pitot and static pressures as well as the local stagnation temperature are to be measured and the axial and radial distributions of the velocity are to be caluclated. In addition, hot-wire anemometry is to be used to directly measure the axial and radial distributions of the mean flow.

All of the measurements for this topic have been performed. Some reduction of the data remains to be done.

2. FLOW FLUCTUATION AMPLITUDE MEASUREMENTS

Radial and axial distributions of the amplitude of the axial and radial flow fluctuations and their product are to be measured for the full spectrum and for individual spectral components.

We have been emphasizing the measurement of the axial flow fluctuations for both the full spectra and for individual spectral components. The data reduction technique for the normal hot-wire probes used to measure the axial flow fluctuations has been our major concern in this topic. We have been trying to get a better estimate of the stagnation temperature fluctuations by directly calibrating the hot-wire probes sensitivity to stagnation temperature variations and by calculating this sensitivity from analytical considerations. We are continuing to work on this in an effort to get consistant results from both measurements. Figure 1 shows profiles of the RMS values of the normal hot-wire voltage fluctuations for the full spectrum (1-20 KHz, St = 0.05 to 1.26) and for selected spectral components (1/10 octave bandpass filtered). Figure 2 shows the RMS value of the axial mass velocity fluctuation level nondimensionalized by the local mean mass velocity. These measurements were made at the radial location of maximum fluctuation level for the 1-20 KHz frequency band.

No measurements have been made to determine the radial flow fluctuations or their product with the axial quantities. This is planned to be the major thrust of the summer.

3. IDENTIFICATION AND CHARACTERIZATION OF THE ORGANIZED STURCTURE

The characterization of the organized structure is to be done for both the axial and radial flow fluctuations and their product in both natural and excited jets. This characterization includes the measurement of spectra at different locations in the flow, axial wavelengths for individual spectral components and azimuthal mode numbers for each spectral component investigated.

Characterization of the organized structure has been done for the axial portion of the flow fluctuations in the natural jet. Spectra have been measured at several different locations in the jet (See Figure 3) and axial wavelengths determined for several different spectral components (See Figure 4). The spectra of the hot-wire fluctuations were made at the radial location of maximum fluctuation level and show the frequency content shifting to the lower frequencies as the flow progresses downstream. Note that the vertical linear scale in each spectrum is the same for all axial locations shown and 20 KHz corresponds to a Strouhal number of 1.26. Figure 4 shows axial wavelengths of the coherent structure in three different high Reynolds number subsonic jets (M = 0.6, 0.7, and 0.8) and for several transonic and supersonic low Reynolds number jets. The low Reynolds number jets were undergoing transition from laminar to turbulent flow. This figure shows that the axial wavelength of the coherent structure varies in the same manner regardless of the Mach number or Reynolds number of the flow for these high speed compressible flows. This is a very important discovery.

Attempts to measure the mode numbers in the natural jet have resulted in only the zero mode being found. However, these measurements do not preclude the existance of higher modes in the jet since the antisymmetric modes may not be locked into one plane of oscillation. This would tend to cancel out the contribution of these modes in our measurements due to the long time period needed to perform the cross correlation measurements at the different azimuthal locations. In order to determine if these higher modes are present it will be necessary to artificially excite the jet and "lock" the modes into one plane of oscillation. This work is currently being pursued.

4. ACOUSTIC MEASUREMENTS

Sound pressure level contours are to be measured in the acoustic field of both the natural and artificially excited jets. When the jet is excited, correlations between the exciter and the microphone signals are to be measured to determine if the organized structure is directly radiating noise.

The sound pressure level contours have been measured for the natural jet (See Figure 5). Problems with electronic noise induced when more than one exciter electrode is operating have delayed these measurements and the other measurements in the jet which require excitation. We are currently working on shielding the exciter circuitry and cables in an effort to reduce or eliminate this electronic interference.

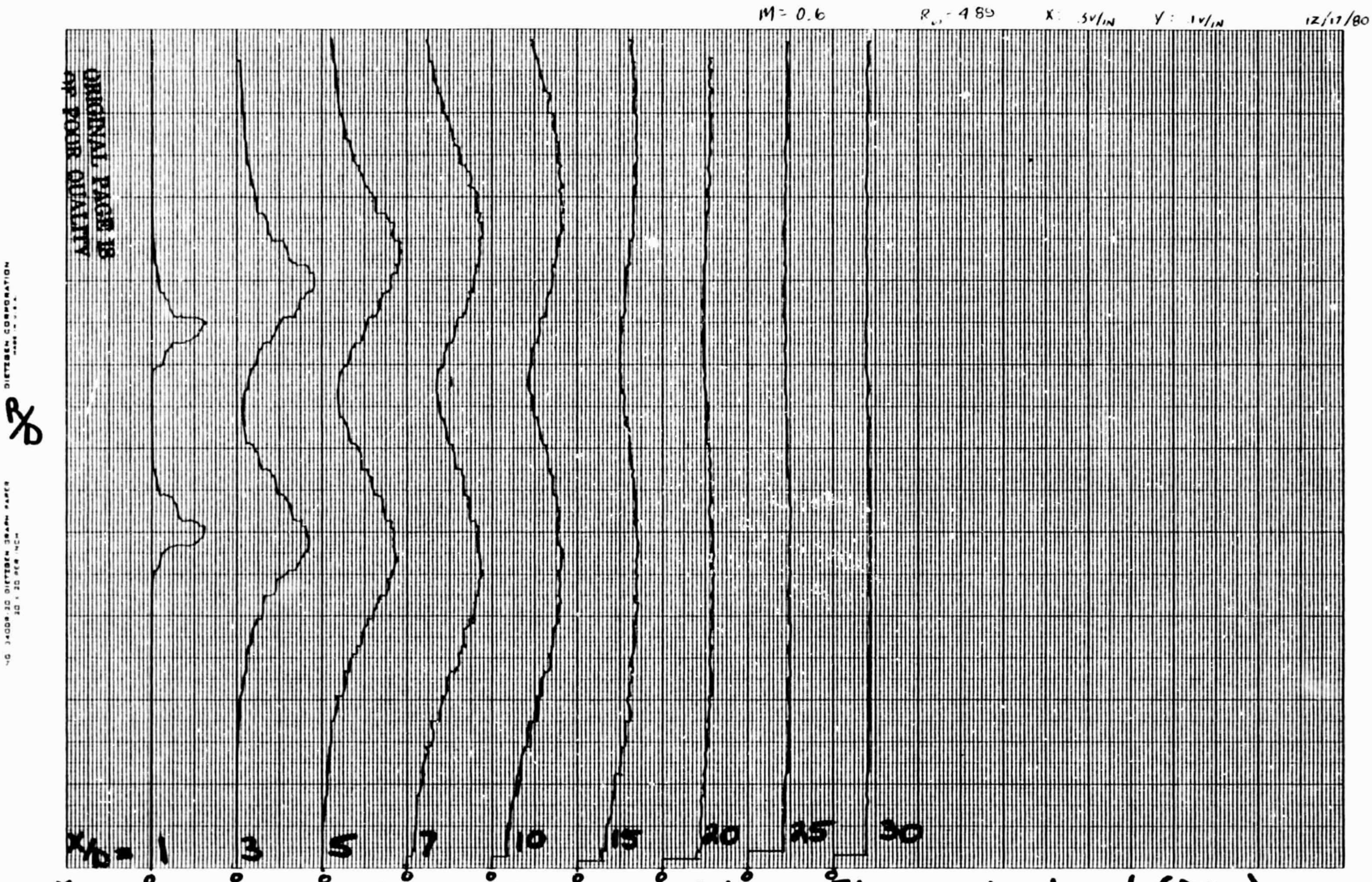


Fig. 1 Hot-wire Voltage Fluctuation Level (RMS)
a) 1-20 KHZ

In summary, we have completed all of the measurements of the mean flow and nearly all of the measurements dealing with the axial flow fluctuations in the natural jet. Radial velocity fluctuation measurements are to be performed this summer. All data concerning the excited jet are pending upon our ability to reduce the electronic interference. It may be necessary to perform the experiments with only one (i.e. a point exciter) electrode.

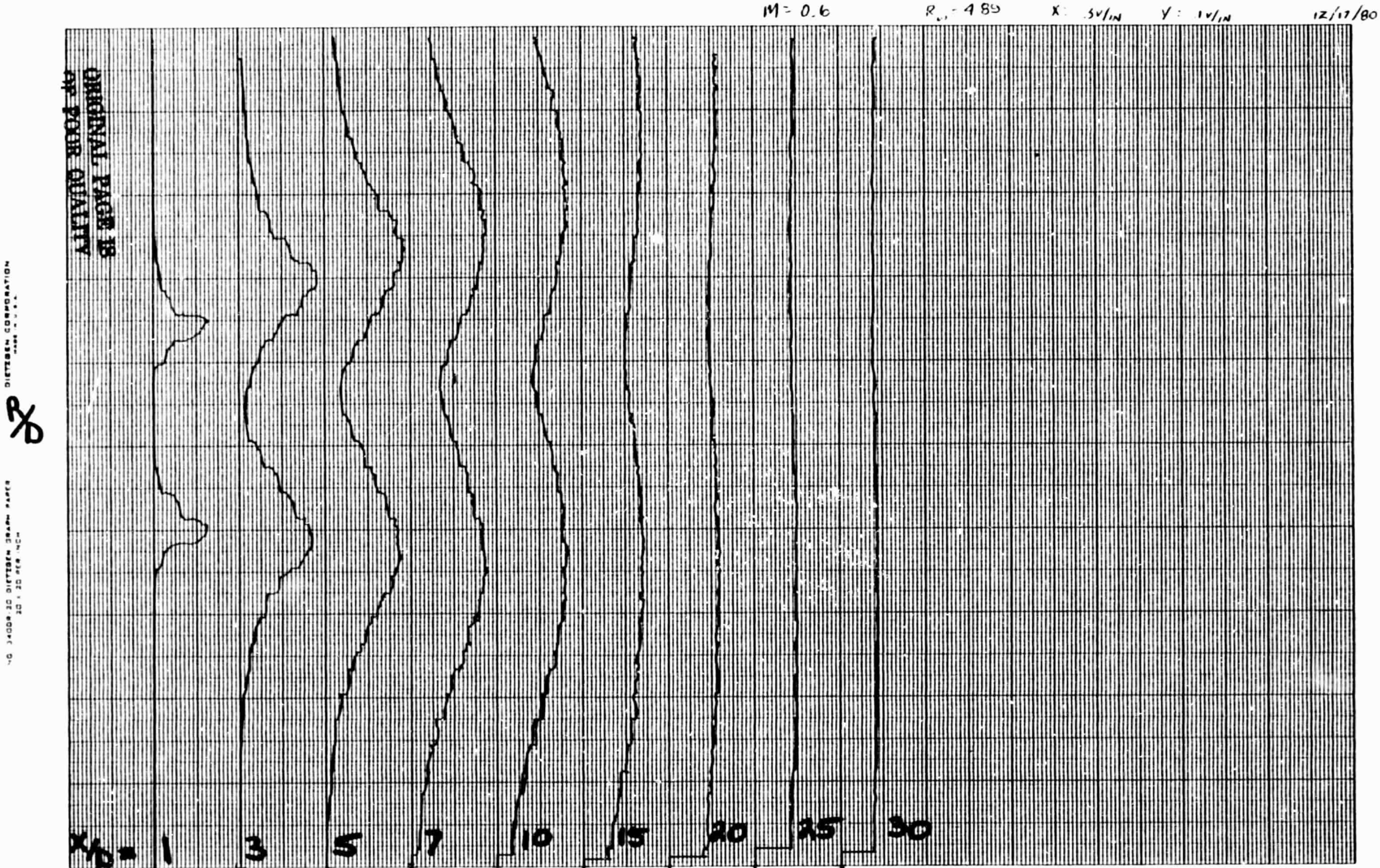


Fig. 1 Hot-wire Voltage Fluctuation Level (RMS)
a) 1-20 KHZ

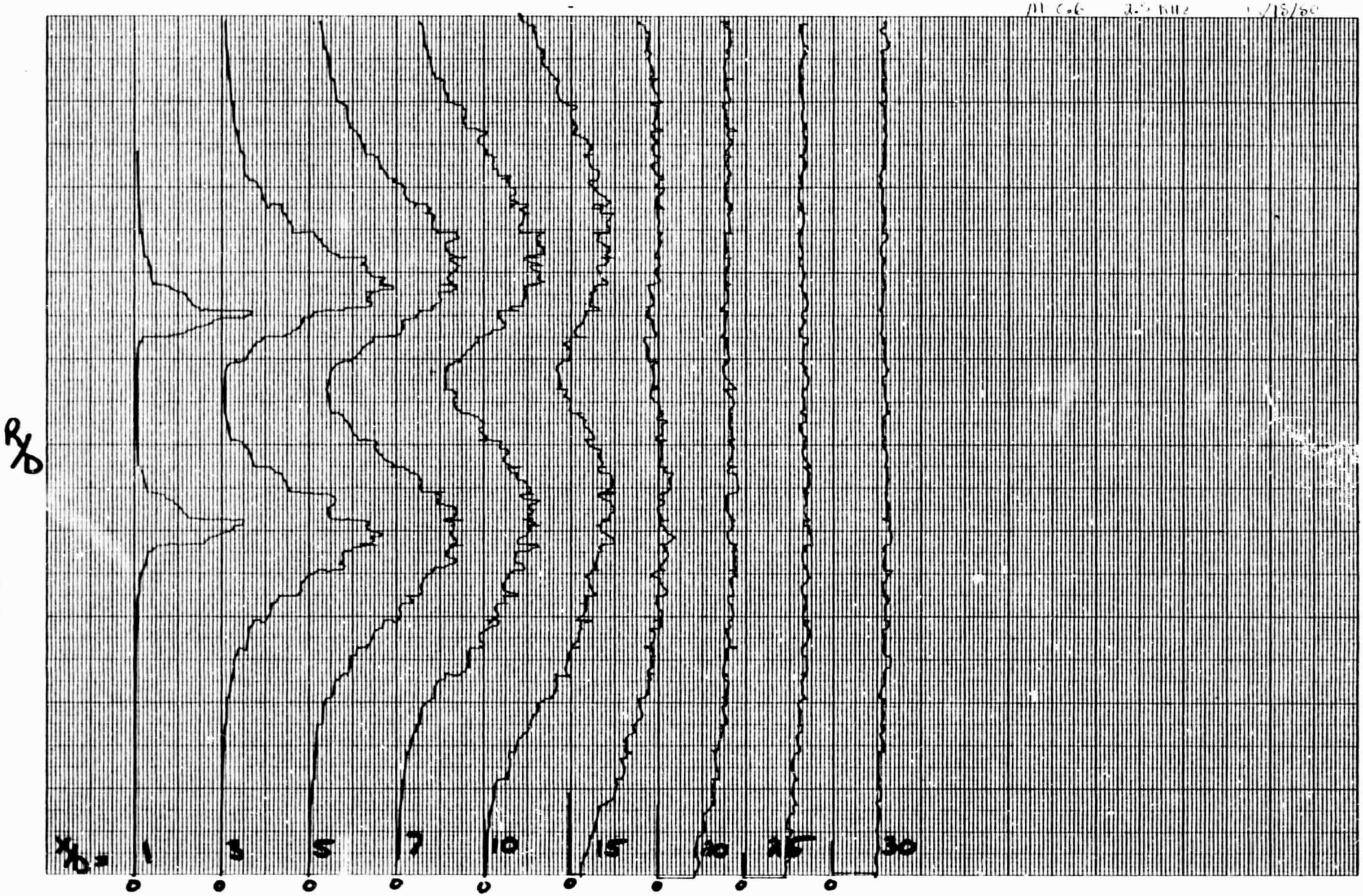


Fig 1 b) 2.5 KHz

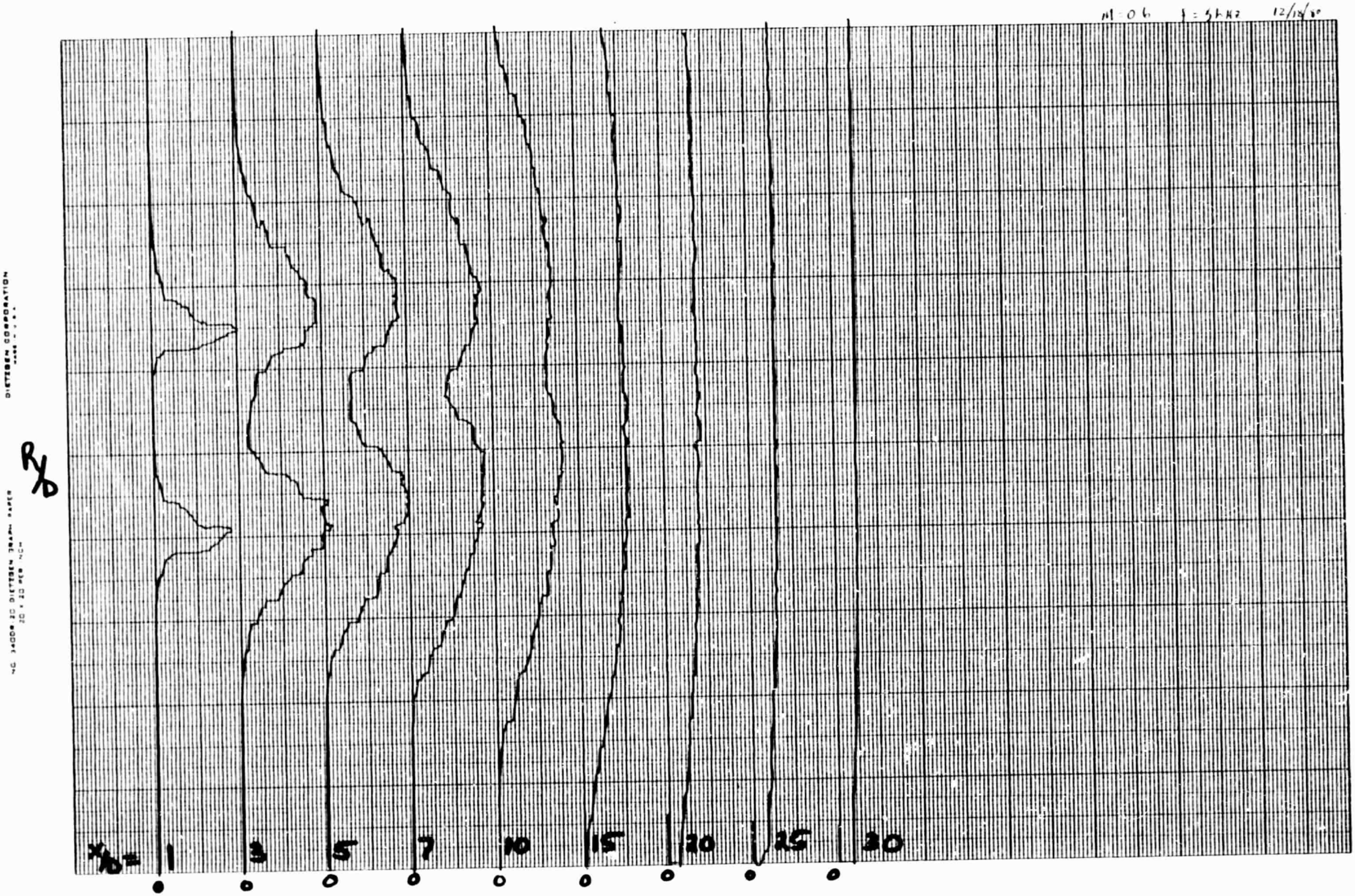


Fig 1. c) 5 KHz

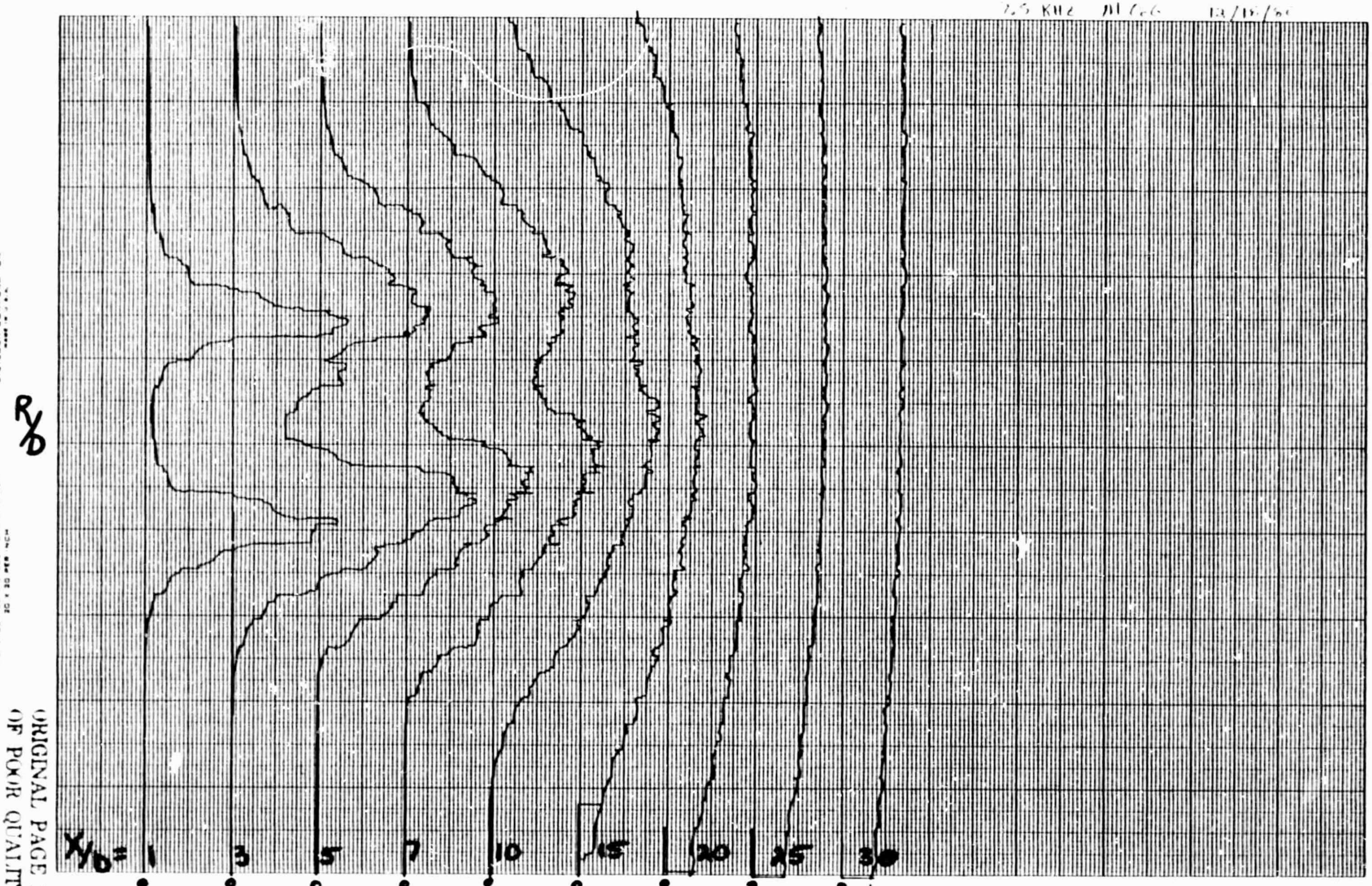


Fig 1 d) 7.5 KHz

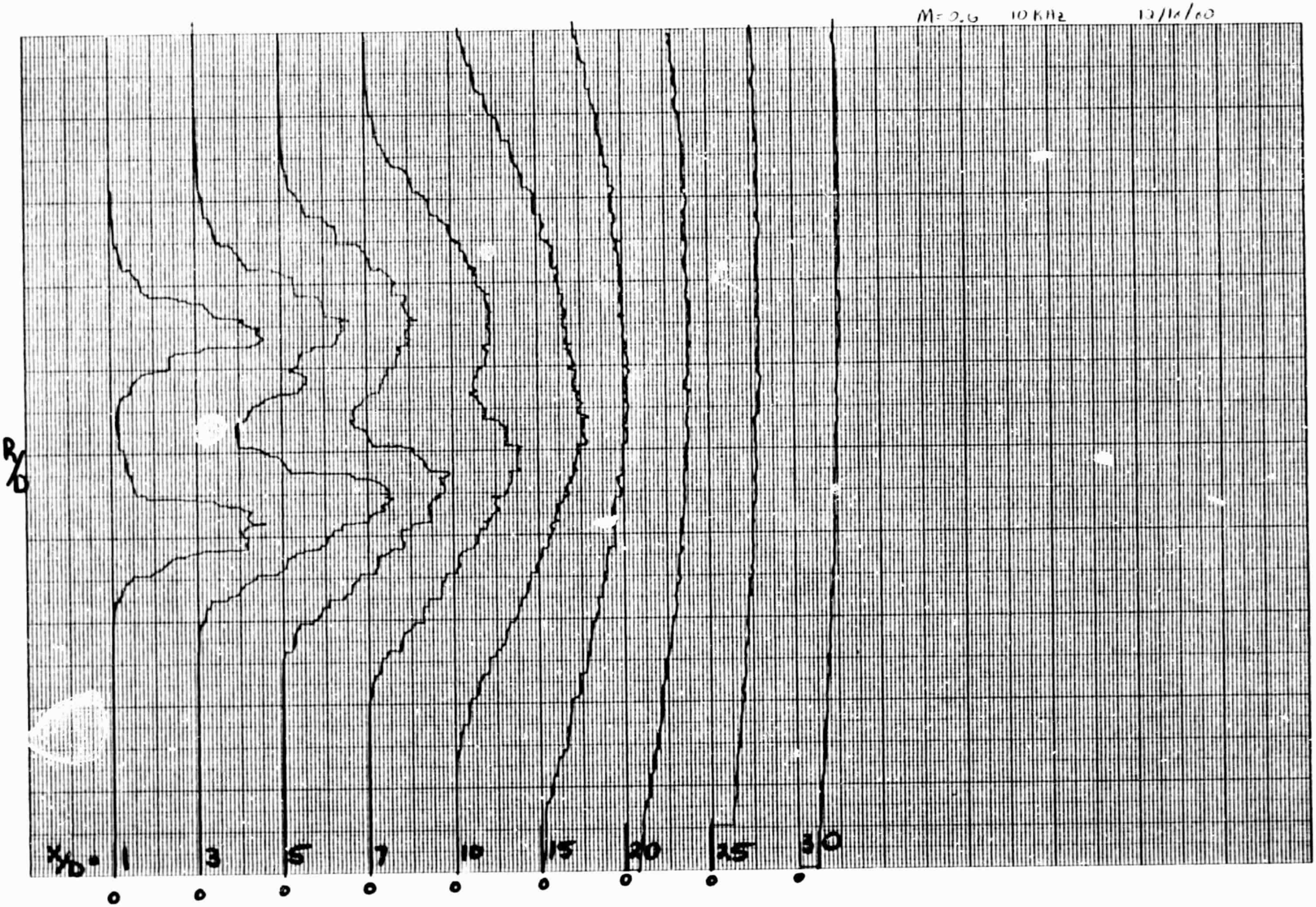


Fig 1 e) 10 KHz

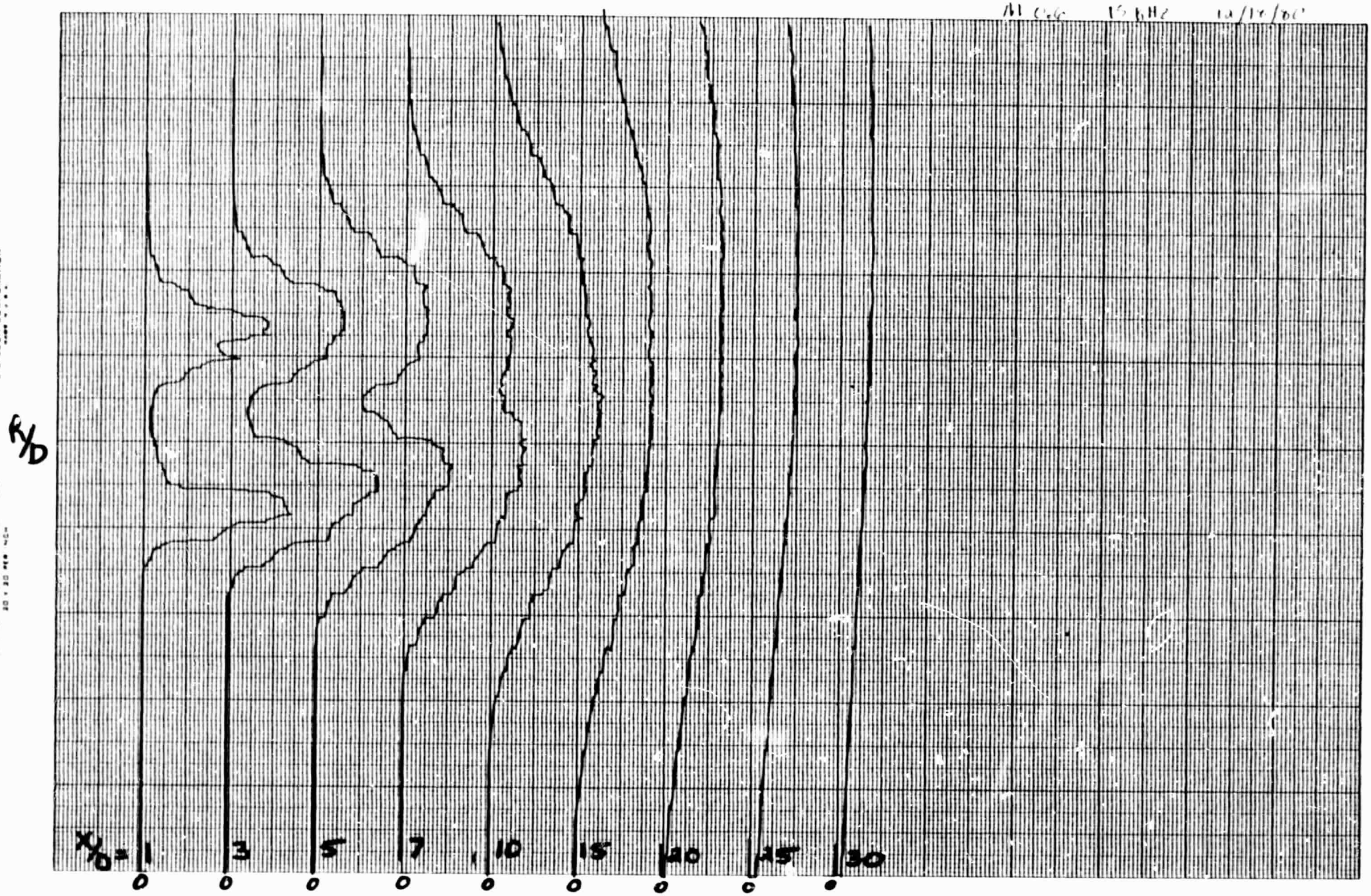


Fig 1 f) 15 KHz

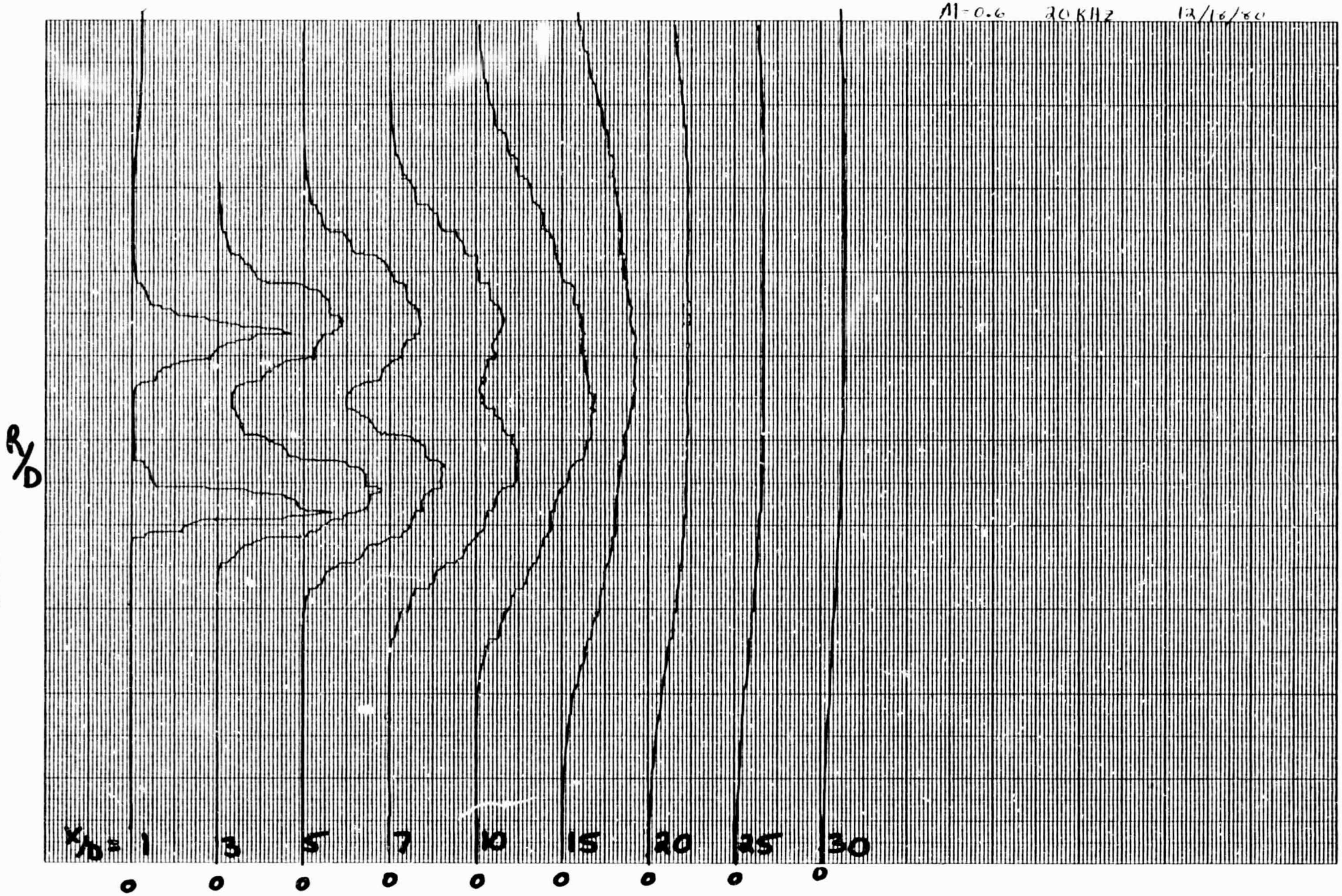


Fig 1 g) 20 KHz

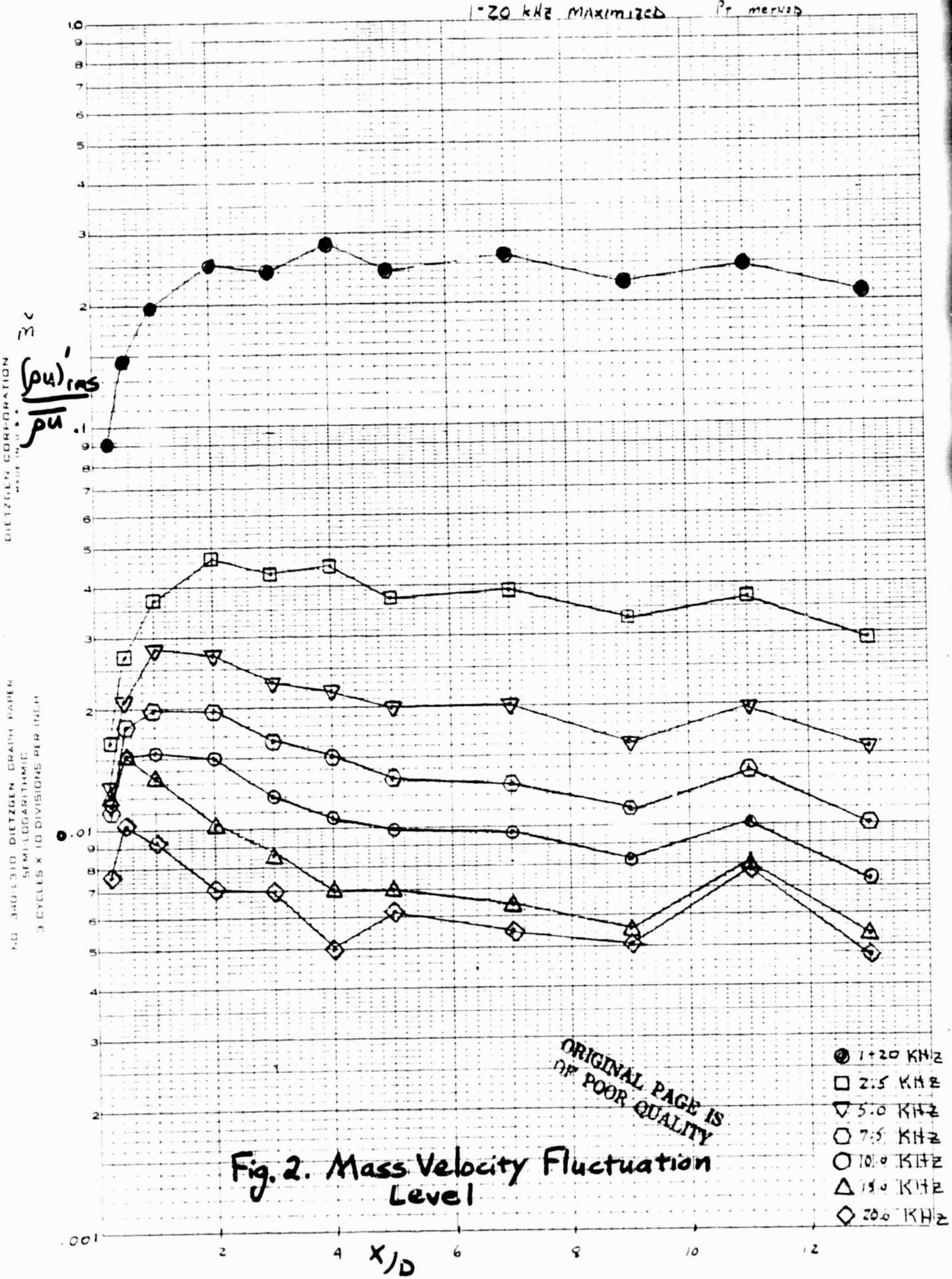


Fig. 2. Mass Velocity Fluctuation Level

Fig 3. Hot-wire Spectra

a) $x/D = 1$

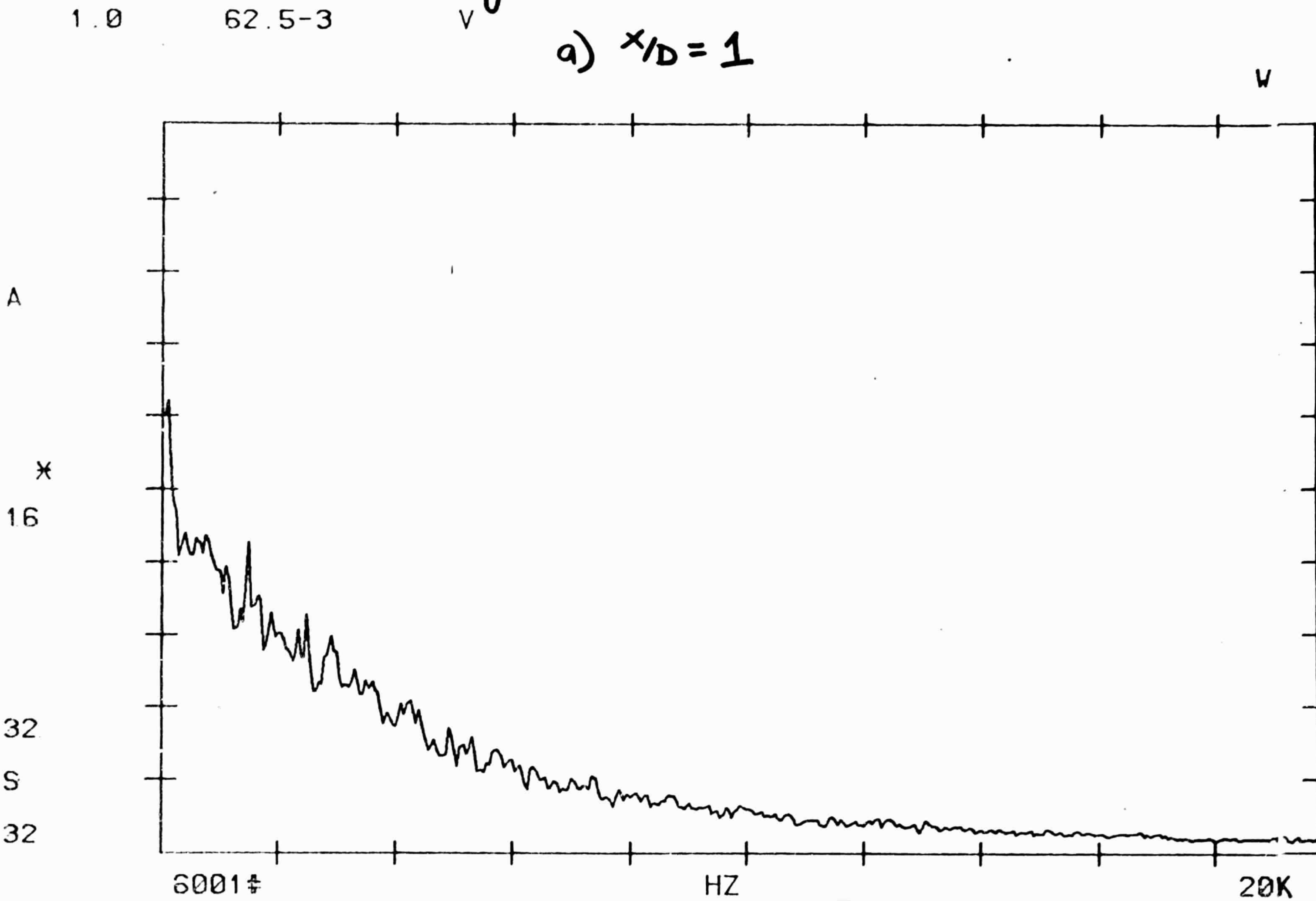


Fig 3 b) x/D = 3

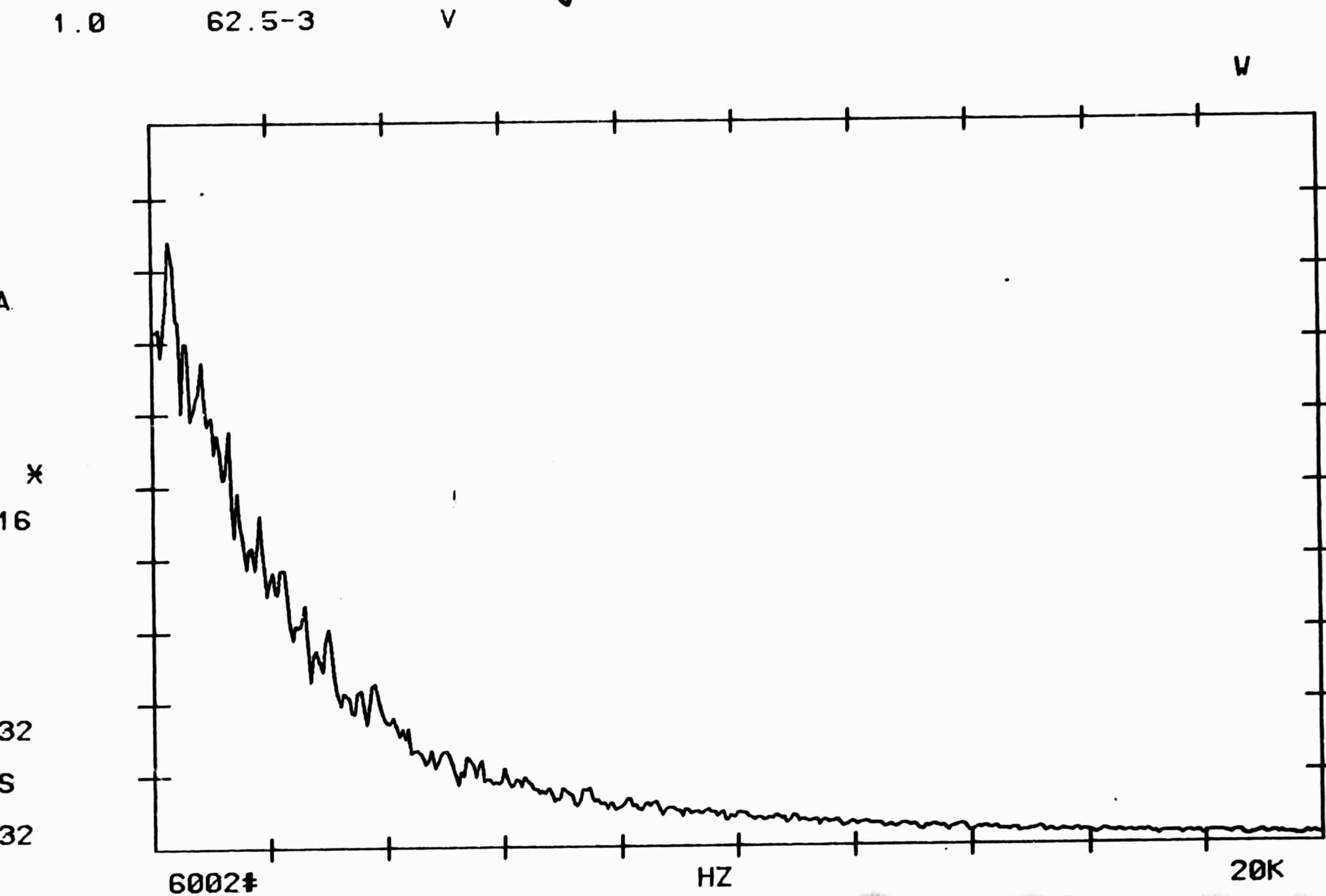


Fig. 3. c) $x/D = 5$

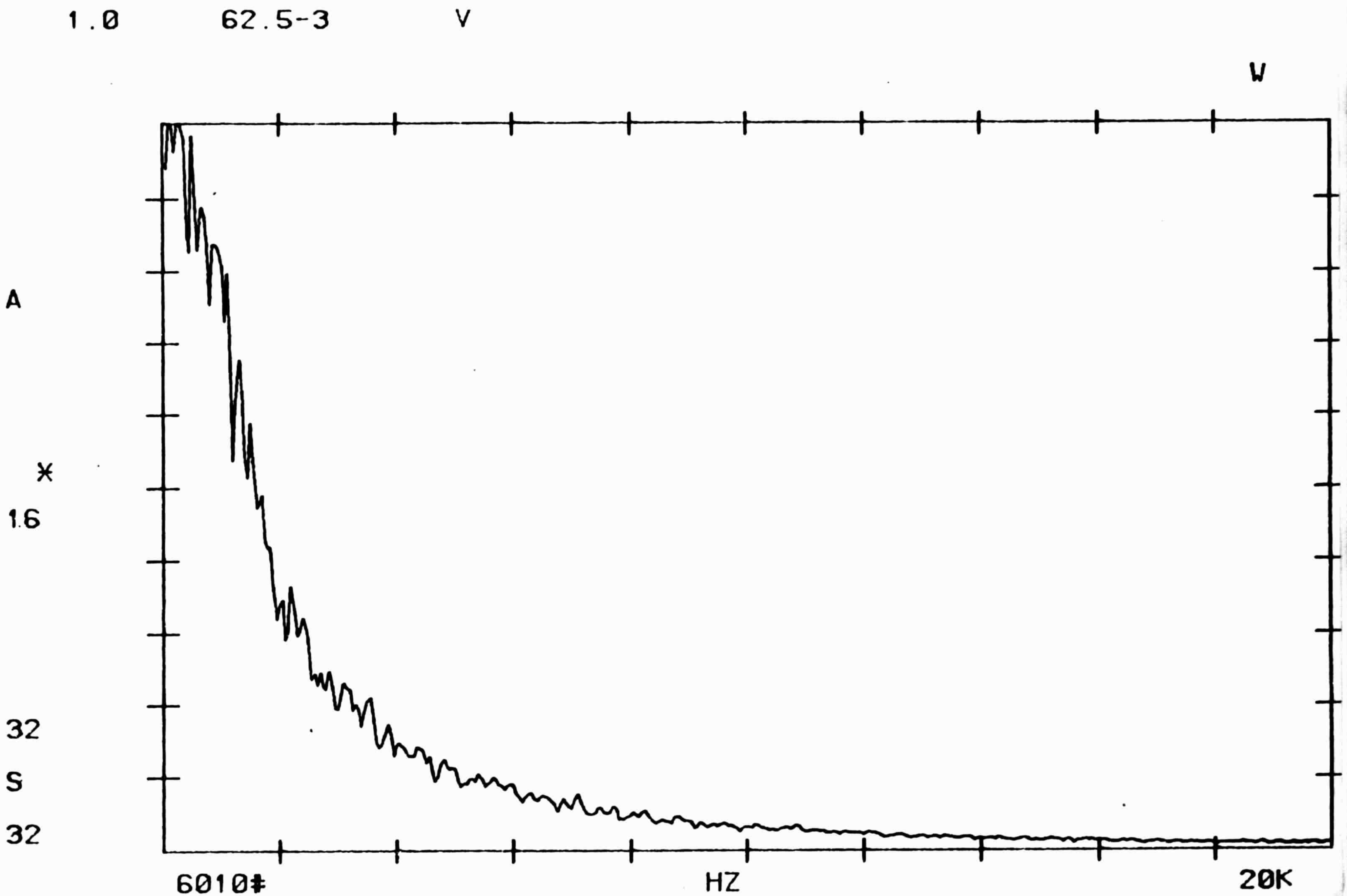


Fig. 3. d) $x_{10}=7$

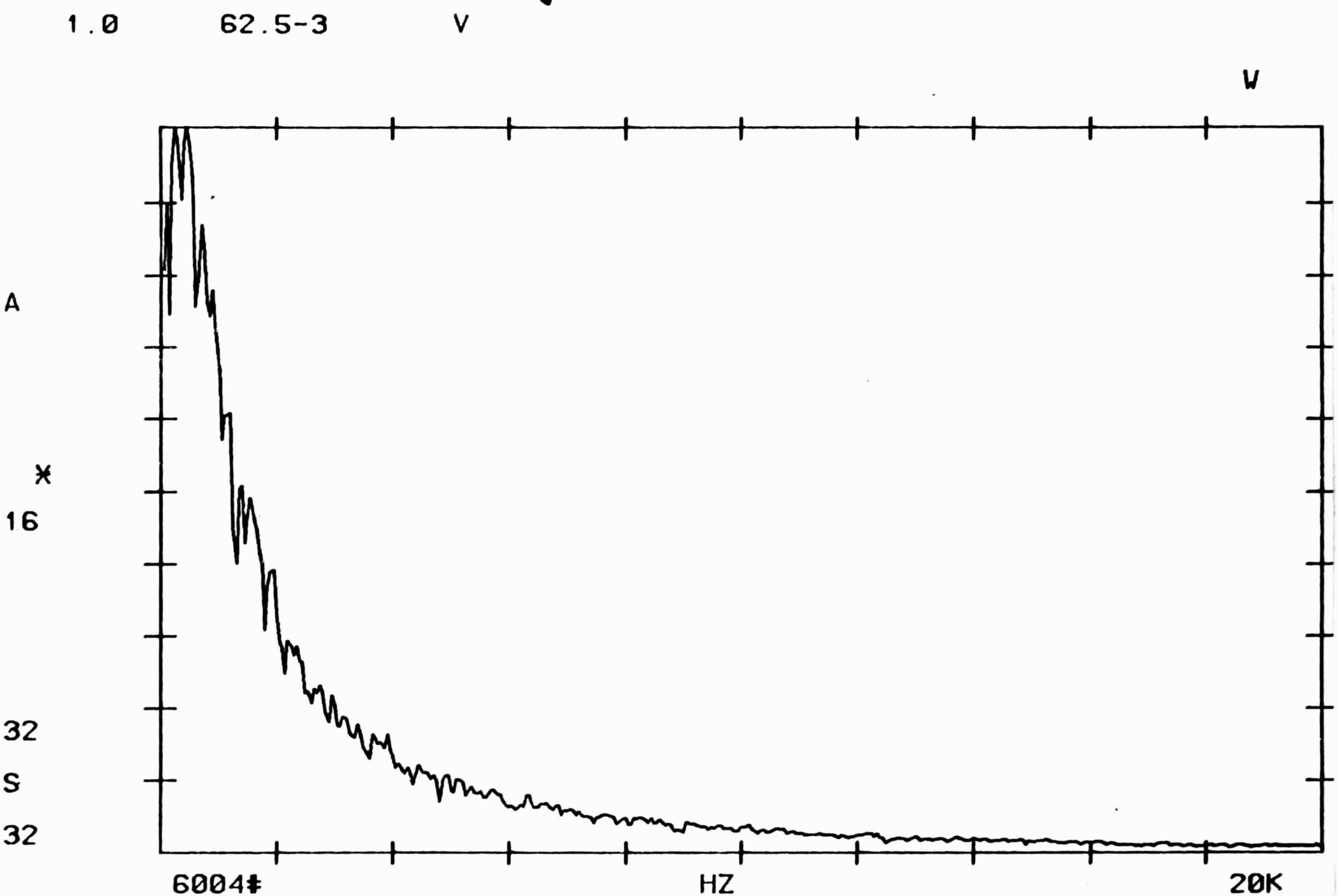


Fig. 3. c) x/D = 10

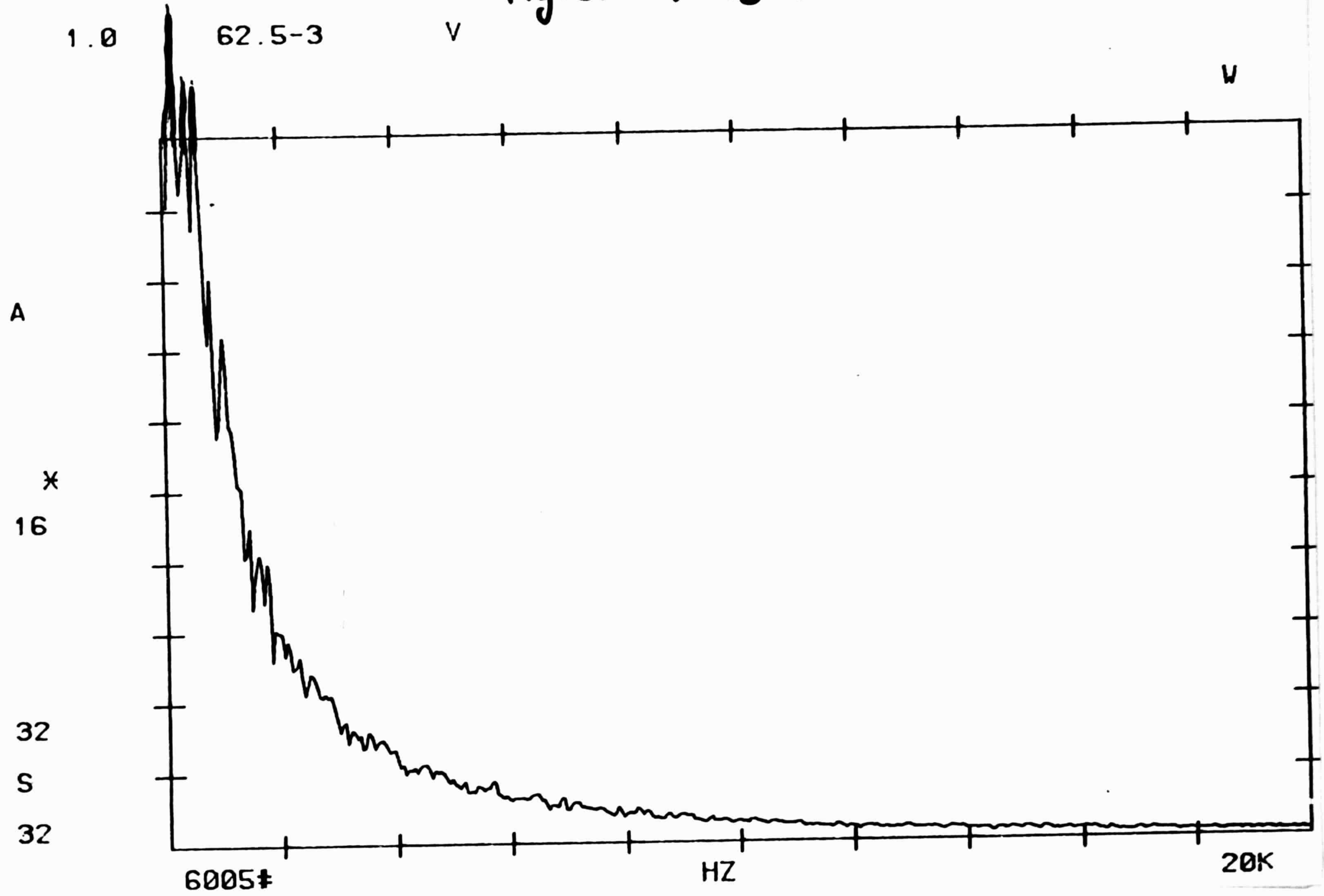


Fig. 3. f) X/D = 15

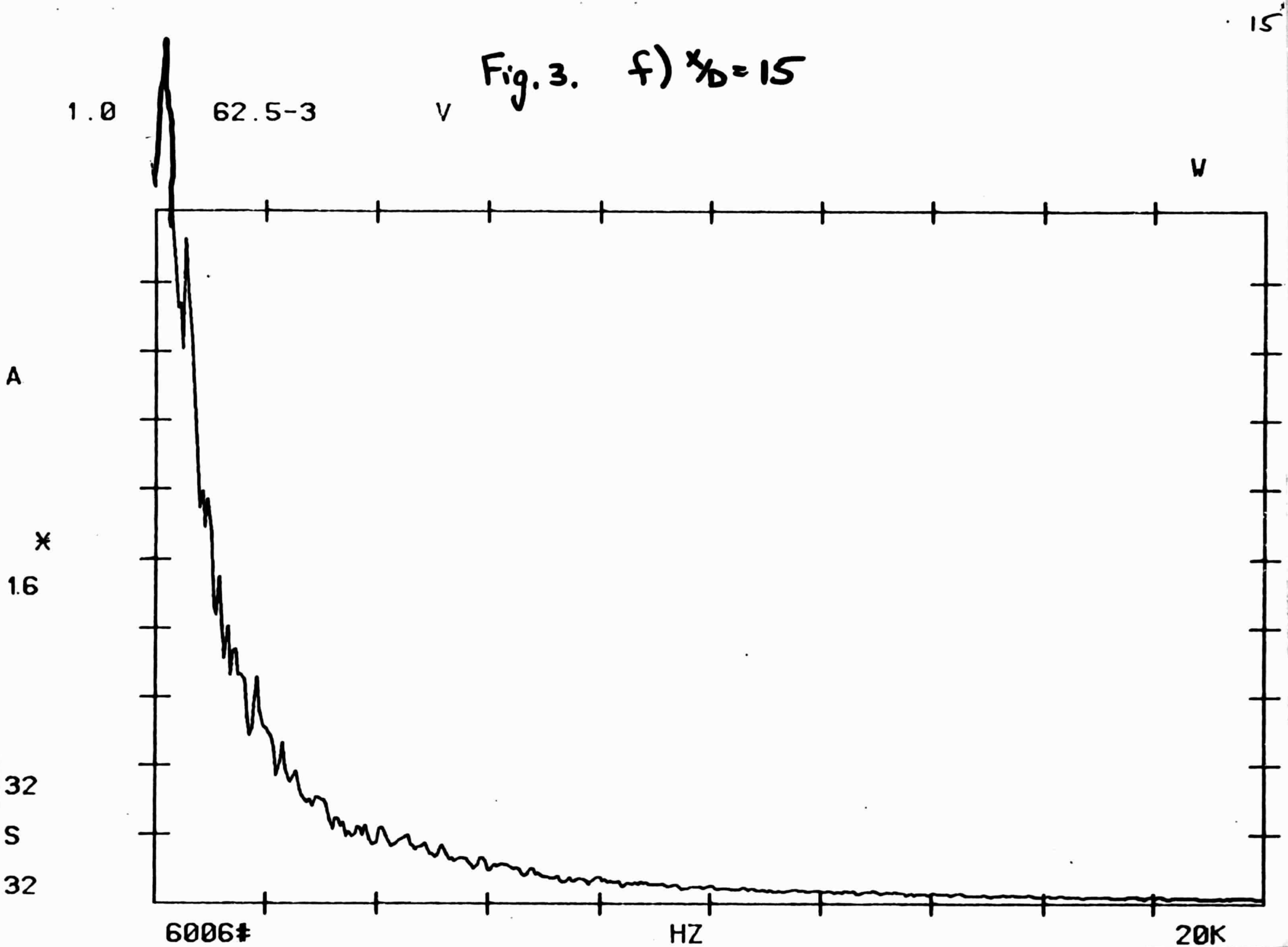
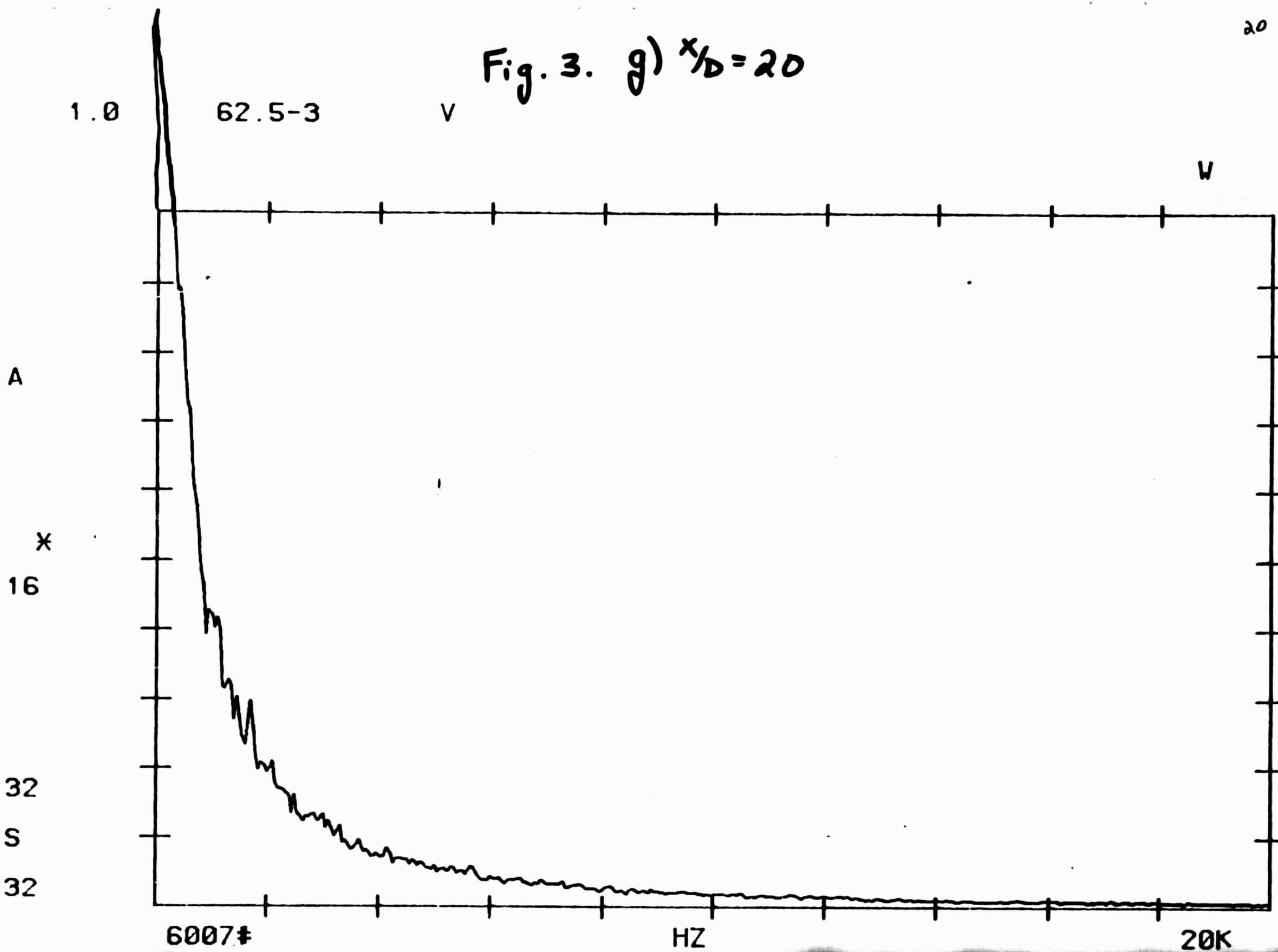


Fig. 3. g) x/D = 20



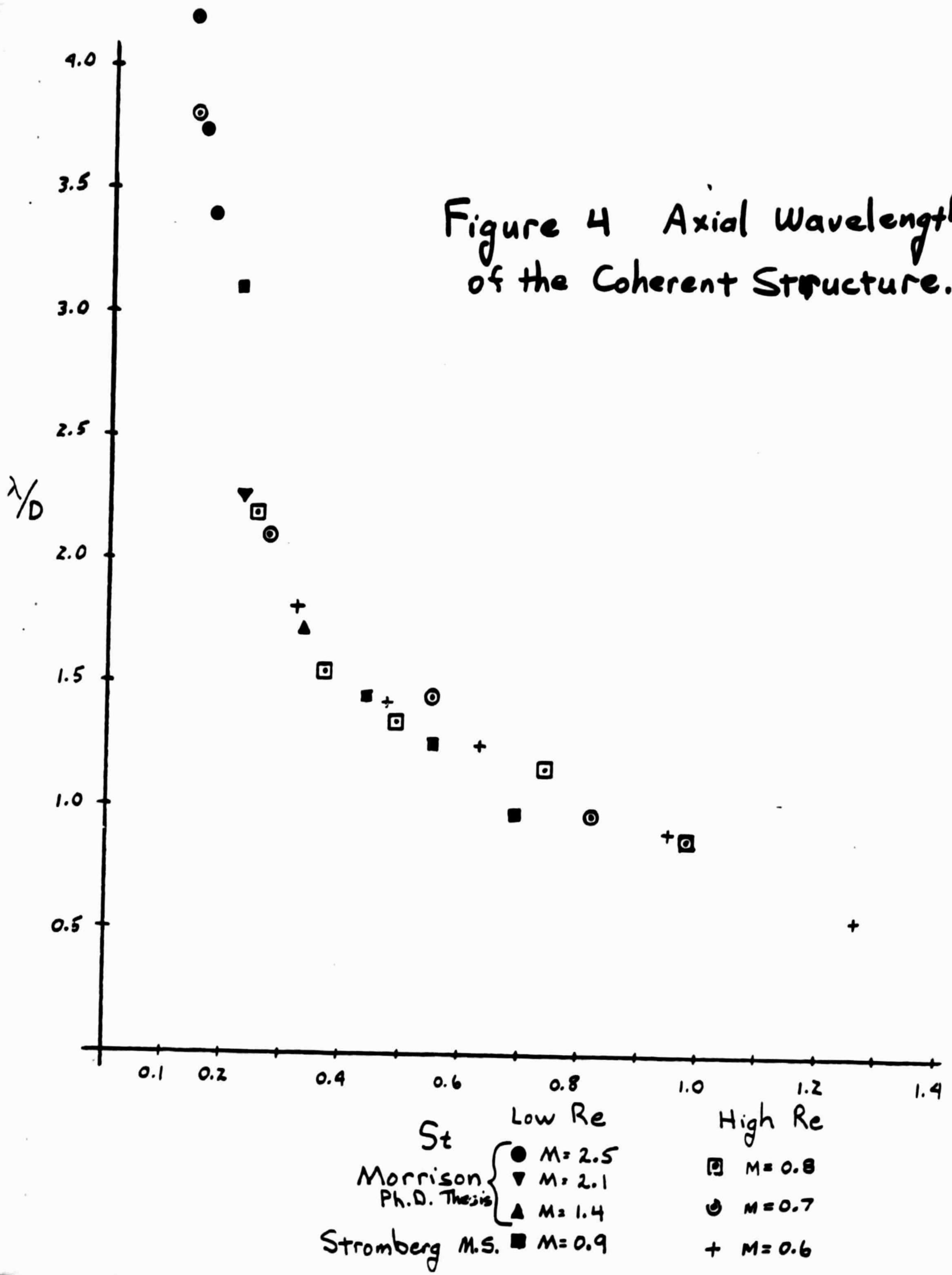
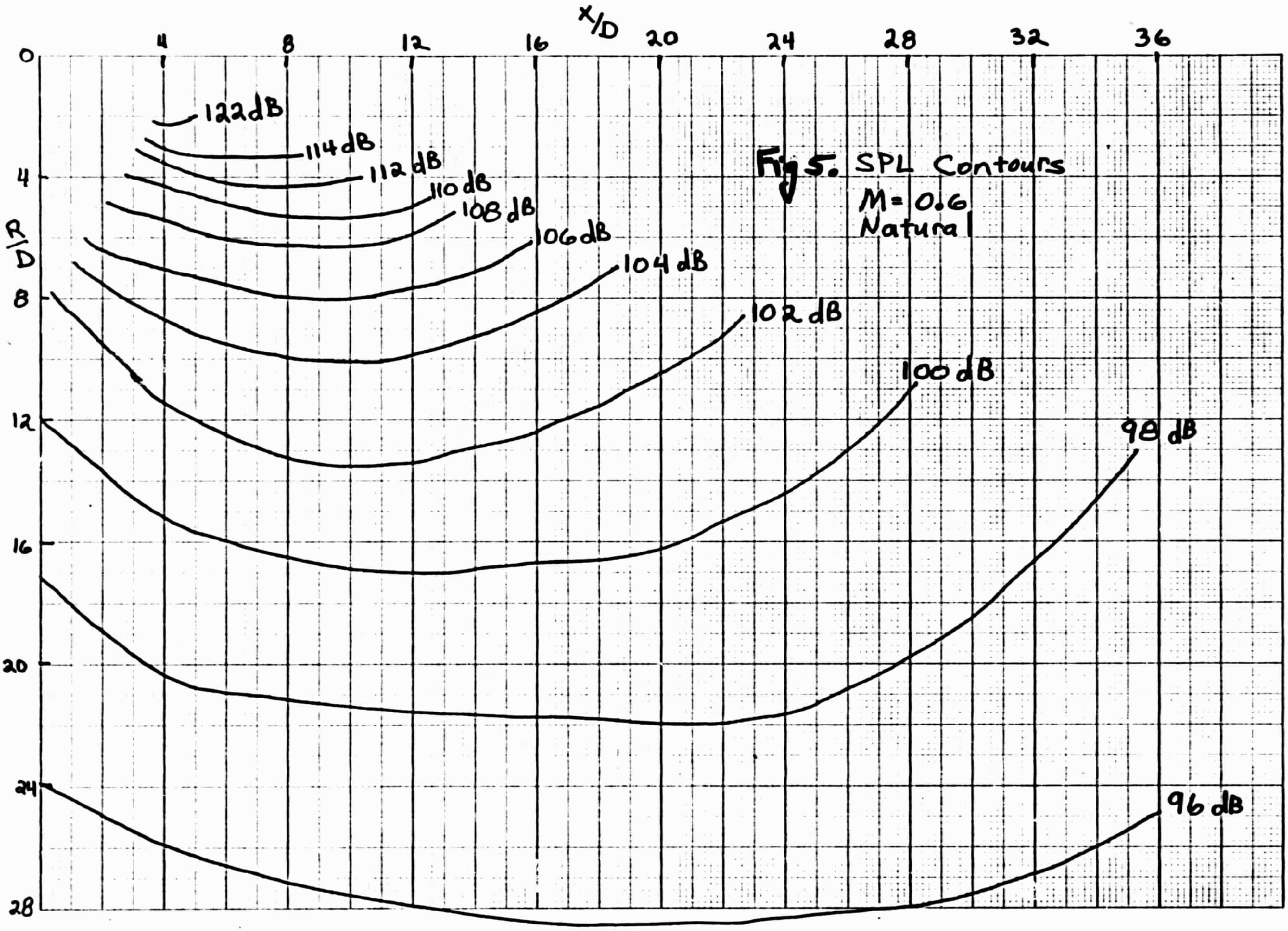
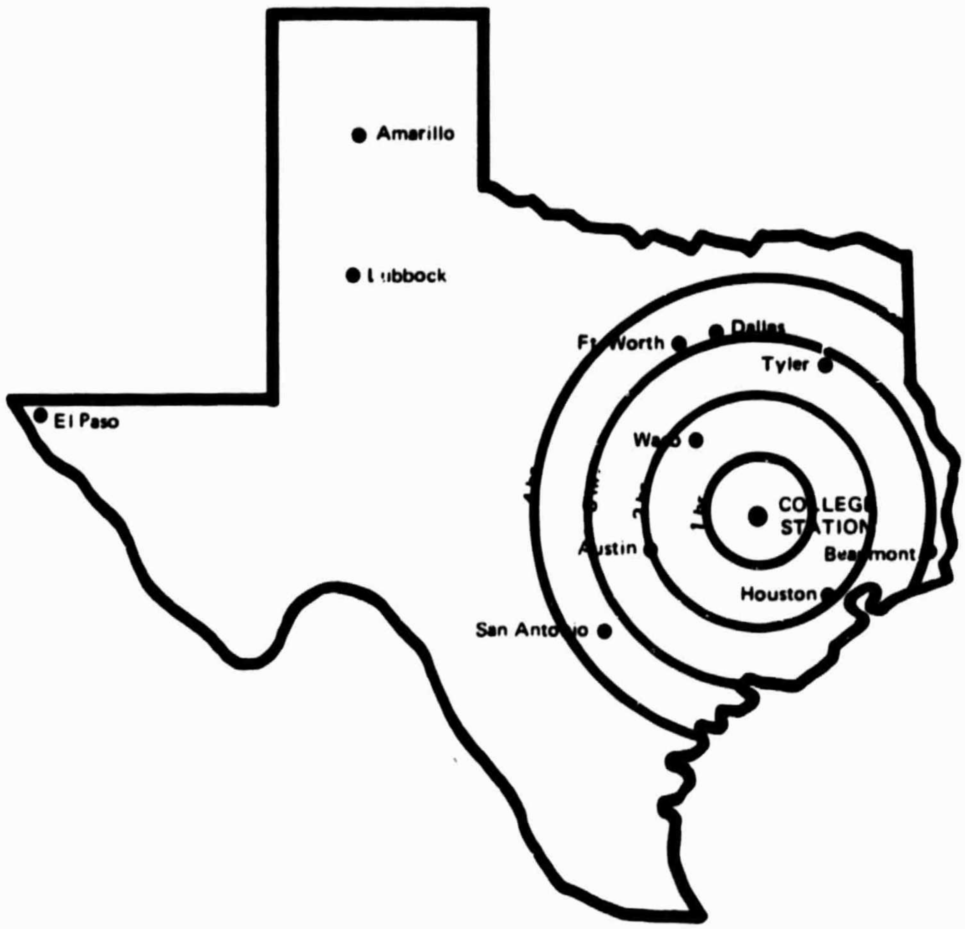


Figure 4 Axial Wavelength of the Coherent Structure.


x/D
4
8
12
16
20
24
28
32
36
R/D
0
4
8
12
16
20
24
28
122dB
114dB
112dB
110dB
108dB
106dB
104dB
102dB
100dB
98dB
96dB
Fig 5. SPL Contours
M = 0.6
Natural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