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## LINE BLANKETING IN VEGA AND SIRIUS

Grant NSG 5030

Final Report

Principal Investigator  
Dr. Robert L. Kurucz



Prepared for  
National Aeronautics and Space Administration  
Goddard Space Flight Center  
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The Smithsonian Astrophysical Observatory  
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The NASA Technical Officer for this grant is Dr. James E. Kupperian, Code 410, OAO Projects, Projects Directorate, Goddard Space Flight Center, Greenbelt, Maryland 20771.

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## ABSTRACT

Our theoretical model and spectrum calculation for Vega seem to be realistic once we have corrected a few errors in the Kurucz and Peytremann line list. The abundance of carbon is approximately  $-3.8$ , which is  $0.3$  lower than the old solar value and supports Mount and Linsky's newer value. The oxygen abundance is approximately  $-3.5$ . Assuming that Vega has solar abundances, the solar oxygen abundance appears to have been overestimated by  $0.3$  in the log. Other abundances appear to be solar.

For Sirius the calculations do not agree with the observed spectrum. Line opacity is considerably underestimated, notably in third-spectrum iron group lines. Carbon is underabundant relative to Vega by  $0.2$  in the log. Nitrogen is unchanged. Oxygen is enhanced by  $0.3$ . Heavier elements are enhanced by  $1.0$  in the log.

Our tentative calibration yields  $1.3E-10$  ergs/cm<sup>2</sup>/s/nm for each U1 Copernicus count at  $130$  nm.

# LINE BLANKETING IN VEGA AND SIRIUS

## Final Report

### 1. INTRODUCTION

Vega and Sirius are two of the brightest, best observed stars. Vega is the archetypical "normal" star that we would expect to have solar or, because it was formed more recently than the sun, slightly enhanced solar abundances. Its angular diameter and distance are known and it does not suffer from theoretical problems such as convection, so one should be able to calculate realistic theoretical models and spectra. For any model atmosphere program or spectral calculation program to be considered accurate and realistic it must reproduce, at least in a general way, the spectrum and energy distribution of Vega. Furthermore, because photometric systems ultimately are defined relative to Vega, theoretical interpretation of photometry depends on the calculation of a model for Vega.

Once theoretical programs are available to treat normal stars, simple parameter changes should allow the prediction of models for evolved stars and stars of different populations. Sirius is a moderately metallic line star, a binary with a white dwarf companion that presumably transferred matter enriched in heavy elements to Sirius A. The mass, diameter, and distance are known for Sirius, and, because it is easily observed at high resolution, it makes a good test case for checking the effects of abundance changes.

With theoretical programs for computing models and spectra, we are investigating Vega and Sirius over the whole spectral range both to determine the properties of the stars themselves and to test the programs. Copernicus provides a unique opportunity to obtain spectra that show strong resonance lines of many elements and many other lines formed through a range of levels in the atmosphere. Such spectra present a strong test of the stellar atmosphere theory.

## 2. COPERNICUS OBSERVATIONS

Copernicus U1 scans of Vega and Sirius were made during September and November 1974 covering the region 130 to 135 nm with a resolution of approximately 0.0037 nm. We went to Princeton in December 1974 to collect the data.

In Figure 1 we show the scans for both stars normalized as discussed in Section 10. The individual data points for Vega are visible in Figure 8 and for Sirius in Figure 9. Since full scale at 130 nm corresponds to 2400 counts for Sirius and only 575 for Vega, the Vega scan is considerably noisier. The scans were made in small overlapping sections but one piece at 132.9 was not observed in Sirius. The Sirius wavelengths have been incremented by 0.003 nm to align the two spectra approximately, but no other effort has been made to process the data. Wavelengths should be considered uncertain by at least this amount. Although the noise causes some uncertainty, it appears that the same features appear in both spectra, that the stronger features are of similar strength in both stars (e.g., O I at 130.2 and C I at 132.9), but that many features weak in Vega are tremendously increased in Sirius.

### 3. MODEL ATMOSPHERE FOR VEGA

Observations are available for Vega in the visible that allow a reasonably accurate determination of model parameters. A good fit in the visible is important to this analysis because the far ultraviolet falls on the exponential side of the Planck maximum and, thus, is sensitive to small temperature changes. Conversely, the far ultraviolet continuum and line spectrum provide strong tests of the models because they are so sensitive.

We have computed a grid of model atmospheres that include line opacity in the form of statistical distribution functions (Kurucz, in preparation). By comparing these models to the energy distribution determined by Hayes and Latham (1975) we determined parameters  $T_{\text{eff}} = 9400 \pm 200 \text{ K}$  and  $\log g = 4.0 \pm 0.5$ . Then, with Deane Peterson at Stony Brook, we programmed the Vidal, Cooper, Smith theory (Vidal, Cooper, and Smith, 1973) for hydrogen line profiles. By comparing to Peterson's (1969) Balmer line profiles we determined  $\log g = 3.95 \pm 0.05$ . These parameters are consistent with Code's (1975) empirical values,  $9660 \pm 130$ , and  $3.94 \pm 0.08$ . Figures 2 and 3 show the comparisons between the observations and a 9400, 3.95 model. There is a small discrepancy in that the Balmer line cores are narrower than those observed. As discussed in Section 7, Vega has a projected rotational velocity of approximately 25 km/s. Rotationally broadening the theoretical profile would widen the core to match but would leave the central residual intensity too high. Non-LTE effects, which have not been included, presumably would lower the central intensity (Peterson, 1969).

This model was computed assuming solar abundances from Withbroe's compilation (1971). Thus we assumed -3.48 for the log carbon abundance relative to the total. However, as discussed in Section 9, the actual carbon abundance is nearer -3.8. Since the carbon continua are important features in the far ultraviolet, the abundance change reduces the total ultraviolet opacity and decreases the backwarming. This may mean that a slightly hotter model with the new abundances may be more correct. We have not yet determined the magnitude of such a correction.



#### 4. MODEL ATMOSPHERE FOR SIRIUS

In the grid calculation described above, it is a simple matter to compute models at scaled solar abundances, but it is expensive to make changes that require recomputing line opacity. As a moderately metallic line star, Sirius has decidedly nonscaled abundances, with light elements near solar and with metals overabundant by a factor of 10 or so (Kohl, 1964; Latham, 1970). As a first step we tried the approximation of a 10,000,4.3 model with all abundances increased by 0.5 in the log. These parameters are approximately Code's (1975),  $9975 \pm 150$  and  $4.31 \pm 0.04$ . This model agrees fairly well with Peterson's (1969) Balmer line profiles and with the energy distribution given by Latham (1970), corrected to the new calibration of Vega by Hayes and Latham (1975). It would be useful to have new, improved observations of the energy distribution of Sirius.

The initial spectrum calculation with abundances increased by 0.5 in the log was grossly inconsistent with the observations. We were able to improve the fit by changing abundances of various elements. Then we computed a model with abundances C -4.00, N -4.00, O -3.22, and heavier elements 10 times solar, but with line opacity tables computed for abundances 10 times solar. Thus the model is not consistent. We are currently using this model in the spectrum calculations; but, as discussed in Section 9, there remain inconsistencies in the spectrum indicating that the model may need improvement.

## 5. SPECTRUM SYNTHESIS PROGRAM

We have continually improved our spectrum synthesis program during the course of this research. The basic program works as follows. For a given model atmosphere tabulated at 40 depths, we compute number densities and partition functions for all atoms and ions. Then we read the magnetic tape that lists the gf values calculated by Kurucz and Peytremann (1975, hereinafter called KP) and compute a line opacity spectrum at each depth. The expressions for radiative, Stark, and van der Waals broadening are

$$\Gamma_R = \Gamma_{\text{classical}} = 2.223\text{E}13/\lambda^2, \quad \lambda \text{ wavelength in nm} ;$$

$$\Gamma_S = 1.0\text{E}-8 n_{\text{eff}}^5 N_e ;$$

$$\Gamma_W = 4.5\text{E}-9 \langle r^2 \rangle^{4/10} [N_H + 0.42 N_{He} + 0.85 N_{H_2}] (T/10,000)^{3/10} ;$$

where

$$\langle r^2 \rangle = 2.5 n_{\text{eff}}^2 / Z_{\text{eff}}^2 ,$$

$$n_{\text{eff}}^2 = R Z_{\text{eff}}^2 / E_{\text{up}} ,$$

$Z_{\text{eff}}$  is the charge plus 1,  $E_{\text{up}}$  is the upper level energy, and  $R$  is the Rydberg energy. Next, continuum quantities, opacities, source functions, and fluxes, are evaluated at several points in the wavelength interval. Then, the continuum quantities are interpolated to each point in the spectrum, the line opacity added, the source function approximated by

$$[(\kappa + \sigma)S_{\text{cont}} + l S_{\text{line}}]/(\kappa + \sigma + l) ,$$

and the surface flux or intensity computed. Here  $\kappa$  and  $\sigma$  are the continuous absorption and scattering coefficients,  $l$  is the line absorption coefficient,  $S_{\text{cont}}$  is the continuum source function, and  $S_{\text{line}}$  is the line source function, which is assumed to be the Planck function.

The following improvements have been made. We have computed mean square radii for the 4p orbitals of the iron group atoms and ions, and produced an interpolation formula

$$\langle r^2 \rangle = (45 - A + Z)/(Z + 1) ,$$

where  $A$  is the atomic number and  $Z$  is the charge. This expression is used for van der Waals broadening of all iron group atoms, assuming that the strong lines are all resonance lines with a 4p upper state.

There is now provision for additions, deletions, and corrections to the table of gf values and for use of individual "real" radiative, Stark, and van der Waals damping constants for each line.

To resolve the contribution of individual lines to blends, we now compute, in addition to the spectrum, the central intensity for each line in isolation.

We automatically produce spectrum plots with identifications.

## 6. ROTATIONAL BROADENING OF THE THEORETICAL SPECTRUM

In practice, most spectra must be rotationally broadened to compare with observations. We have developed a broadening procedure of direct numerical integration over the stellar disk. This procedure is simple and easily generalized to treat gravity darkening, nonuniform rotation, nonspherical stars, and binaries. In the simple case of uniform rotation, no gravity darkening, and circular projection, we can use symmetry to reduce the evaluation to one quadrant.

The integration is performed by laying a grid of any fineness over the stellar disk and simply adding the intensity at each point. For the calculations reported here we used a spacing of 0.02 times the radius. At each point on the grid we compute the doppler shift and the cosine of the angle of projection. The doppler shift is converted to an integral number of steps in the spectrum (multiples of the point spacing) and the cosine is converted to an integral multiple of 0.01. In general there will be grid points on the disk that have the same values of these integers. All the values are sorted and the multiplicity of each is noted. The multiplicities are added and a normalization factor is determined such that integration of  $I_\nu$  produces  $H_\nu$ . This set of numbers is the rotation operator.

For the work described here we computed the spectrum with a spacing of 0.5 pm at 17 angles and interpolated to 100 cosines from 0.005 to 0.995. These spacings were chosen arbitrarily. Smaller spacings might improve the accuracy of the final spectrum. Fewer angles than 17 are possible. We should point out that computation time is not proportional to the number of angles since the opacity spectrum need be computed only once for any number of angles.

To broaden the spectrum rotationally, we read the intensities  $I_{j\mu}$  one wavelength at a time and distribute each intensity into a flux spectrum  $H$  using the rotation operator. For example, if part of the operator is an 11-step doppler shift for a cosine index  $\mu$  of 37 with a multiplicity of 4, we would add  $4I_{j37}$  to  $H_{j+11}$  and, by

symmetry, to  $H_{j-11}$ . Thus we go through every term of the operator for every wavelength in the spectrum. Once the totals are completed we normalize. If the doppler width of the operator includes many steps,  $N$ , the accuracy is improved by filtering with a  $(1 + N/5)$ -step straight mean. The accuracy of this procedure is better than 1 percent for computing flux from intensity at zero rotation velocity, for the parameters quoted. The accuracy can be improved to any desired limit by increasing the resolution.

## 7. ROTATION OF VEGA AND SIRIUS

These stars have quite significant projected rotational velocities that blend the lines and greatly complicate the analysis. We have been collaborating with Ingemar Furenlid at Kitt Peak and with John Lester at SAO to obtain high-resolution, low-noise spectra in the visible. Through visual examination of 1 Å/nm plates taken by Furenlid, we estimate velocities of 15 to 20 km/s for Sirius and 25 to 30 km/s for Vega. These spectra have not yet been reduced so we have assumed velocities of 15 and 25 km/s in our calculations thus far. The zero velocity and rotationally broadened spectrum for Vega is shown in Figure 4 and for Sirius in Figure 5. The observed Copernicus spectra suggest a velocity somewhat larger than 15 km/s for Sirius and seem consistent with 25 km/s for Vega.

We have also undertaken a project with Wesley Traub, Nathaniel Carleton, and John Lester of SAO to measure a Ba II line profile in Sirius with a high-resolution interferometer. Since the project was begun before we found that Sirius has a high rotation velocity, we had hoped to determine both a rotation velocity and a maximum turbulent velocity. The reductions have not yet been completed, but we provisionally find a rotation velocity of 17 km/s.

## 8. THEORETICAL LINE LIST

One of the aims of this research is to check the available line data for accuracy and completeness and to identify areas where further work is required. Our basic source of these data is the KP line list, which was computed, for sequences up through nickel, by using scaled Thomas-Fermi-Dirac wavefunctions and eigenvectors found through least-squares fits of eigenvalues to observed levels (Kurucz, 1973). Heavier elements and the lightest elements were taken from the literature. The data published by KP represent only a fraction of the lines calculated, those between known levels. There are many lines between predicted levels that cannot be used for spectrum synthesis because the wavelengths are uncertain, but which can be used in computing the statistical distribution functions for the model atmosphere calculations.

We emphasize that spectroscopic analyses of many elements leave considerable room for improvement. There are levels that have not been classified, and so cannot be included in a gf calculation, and there are levels that are misclassified. Most important, many analyses are highly incomplete. Several of the iron group second spectra have not even been observed in the vacuum ultraviolet. We expect such lines account for a number of unidentified features in the Copernicus spectra.

Through examination of Kelly and Palumbo's (1973) line list and the ultraviolet multiplet table (Moore, 1962) we have found one prominent example of the incompleteness of KP. Multiplet 56 of Mn II is not in the list because the upper term has not been classified and so could not be computed. Kelly and Palumbo list a number of weak lines that have not been classified and do not appear in KP.

Thus far we have identified two sorts of errors in the KP line list through the presence of identifiable observed lines where the line list predicts none, and through the presence of a prominent predicted feature where none is observed. Several C II, N III, and Si II transitions involving  $sp^2$ , and several O I, Si II, and S I transitions involving an excited parent, are missing, presumably through programing mistakes. These errors may also occur in other elements that have not yet been checked.

Fortunately, these strong lines appear in the NBS compilations (Wiese, Smith, and Glennon, 1966; Wiese, Smith, and Miles, 1969; Wiese and Glennon, 1972). We have also found a few excited, LS forbidden, C I and N I lines that are computed too strong. Apparently the eigenvector mixing was overestimated.

In general, we assume that laboratory gf values based upon lifetime measurements are more reliable than KP. We are undertaking to replace KP data with such data, especially from the NBS compilations. However, we expect KP to be more accurate than NBS coulomb approximation f values and to give better relative strengths within multiplets than NBS LS multiplets.

We are also undertaking to include radiative and Stark damping constants for the stronger lines. At the present time we are filling in transition arrays and summing A's by hand to get the radiative damping constants. Programs are under development that will produce the radiative damping constants for every transition of an element. The sources used thus far for Stark broadening are Sahal-Brechot and Segre (1971) and Griem (1974). To use Griem's widths we compute

$$\Gamma_s/N_e = 3767 W/\lambda^2$$

with width W at 10,000 or 20,000 K and wavelength  $\lambda$  in A. We have not yet included all Griem's data.

We expect to publish, either as part of this work, or as a separate publication, tables of these revisions.



## 9. COMPARISON OF THE SPECTRA

Figures 6 and 7 show the current theoretical and observed spectra for Vega and Sirius normalized as discussed in Section 10. Figures 8 and 9 are the same plots with identifications for all theoretical lines with zero rotation residual fluxes less than 0.99 in Vega and 0.98 in Sirius. In calculating the spectra the 9400, 3.95 and 10,000,4.3 models described in Sections 3 and 4 were used. In Vega the carbon abundance with reduced from -3.48 to -3.8. A microturbulent velocity of 2 km/s was assumed for the time being.

Since improvements and corrections to the program and line data are an ongoing process, the current plots are the result of a long series of iterations. Except for the abundance changes described in Sections 3 and 4 and below, no attempts have been made to adjust individual lines for a match. The fit is remarkably good for Vega. For Sirius a number of lines match very well but the majority of the lines are grossly underestimated in the calculations. No fourth spectrum or higher lines appear in either the calculations or the observations. In the discussion of individual elements below we assume that the gf values and damping constants are correct. (We use the terms weak and strong to refer to the comparison, calculation relative to observation, not to the strengths of the lines.)

Hydrogen. There is background Lyman  $\alpha$  wing but the Vega data are too noisy and the match in Sirius is not good enough to draw any conclusions at this time.

Helium, Lithium, Beryllium, Boron. There are no lines in this spectral region.

Carbon. The C I resonance lines at 132.9 are computed too strong in Vega but match well in Sirius. The lines around 131.1 from the  $^1D$  lower level are blended in features that are calculated too weak. The continuum in this region arises from the  $^1S$  level. The C II resonance lines at 133.5 are computed with approximately correct cores. The wings are not right in Vega but there may be lines present in

the noise. A C III line at 130.870 does not appear in the spectra. Since C is mainly C II we would expect the C II lines to be more reliable abundance indicators, and the C I lines to be much more sensitive to atmospheric variations. For abundances other than  $-3.8$  in Vega and  $-4.0$  in Sirius the C II lines are discrepant.

Through personal conversations with M. A. J. Sniijders of Goddard, we found that his non-LTE calculations predict increased ionization of C I in Vega and LTE in Sirius. Thus the C I lines would become weaker in Vega without significantly changing the C II lines. The strength of the continuum would also be reduced.

Since we expect Vega to have solar abundances, the solar abundance of C may be overestimated by a factor of 2. Such a result has been found by Mount and Linsky (1975) through analysis of solar molecular features. Sirius is depleted in C by 0.2 in the log relative to Vega.

Nitrogen. There is an isolated N I doublet at 131.967 that is a good match. The blended features at 131.89 and 130.00 are difficult to interpret. N II lines at 134.3, 134.5, and 134.6 do not appear in the predicted spectra, but there are features in the observed spectra. N III lines do not appear. The N abundance is equal and approximately solar in both stars.

Oxygen. The O I resonance lines at 130.2, 130.4, and 130.6 are predicted too strong in Vega and approximately correct in Sirius. We have not yet determined the O abundance in Vega but we guess  $-3.5$ . Since we expect Vega to have solar abundances, we suggest that the solar abundance should be  $-3.5$  instead of  $-3.22$ , which is currently assumed. In Sirius the abundance is approximately  $-3.22$ , a factor of 2 enhanced over Vega.

Fluorine. There are no F I lines in this region. The high excitation F II lines at 132.7, 132.8, 133.2, 133.3, 134.3, and 134.4 do not appear in the calculations, however, in some cases, observed features do correspond. The same situation applies to F III. We can say nothing about the F abundance.

Neon. There are no Ne lines in this region.

Sodium. There are no Na I lines in this region. Na II and III lines do not appear in either spectrum.

Magnesium. There are no Mg I lines in this region. In Vega, the Mg II lines match at 130.67 and 130.82, are too strong at 130.78, and are blended at 130.94. In Sirius, 130.67 matches while 130.78 and 130.82 are slightly strong. Mg III lines do not appear. The Mg abundance is approximately solar in Vega and +1.0 in Sirius.

Aluminum. There are no Al lines in this region.

Silicon. There are no Si I lines in this region.

Si II: 130.08 weak  
130.43 blend, strong  
130.56 blend, good  
130.9 blend, good  
134.68 Vega, slightly strong; Sirius, strong  
134.85 Vega, slightly strong; Sirius, strong  
135.0 strong

Si III: 130.11 slightly strong  
130.33 blend, strong  
131.25 weak?  
134.24 blend  
134.33 blend

The Si abundance in Vega is approximately solar and in Sirius at least +1.0. The models predict the correct ionization.

Phosphorus. The P I line at 130.447 is blended. P II lines at 130.18, 130.46, 130.54, 130.98, and 131.07 are blended in such a way that one can tell the lines are approximately the right strength. Of the P III lines, 133.48 is blended and, in Sirius, blended and strong, 134.43 is blended and strong, 134.49 possibly matches. The wavelengths are discrepant. Other lines do not appear in either star. The P abundance is approximately solar in Vega and +1.0 in Sirius. The models predict the correct ionization.

## Sulfur.

S I:	130.23 blend	131.32 blend, good
	130.28 blend, slightly strong	131.65 slightly strong
	130.31 blend, slightly strong	132.35 slightly strong
	130.34 blend, slightly strong	132.66 blend, slightly strong
	130.58 blend, good	133.37 blend, strong
	131.01 blend, good	

There are no S II lines in this region. S III lines do not appear in the spectra. The sulfur abundance is approximately solar in Vega and +1.0 in Sirius.

Chlorine. The Cl I line at 133.57 is blended. The line at 134.72 is slightly weak. There are no Cl II or III lines in this region. The Cl abundance is approximately solar in Vega and +1.0 in Sirius.

Argon. There are no Ar I lines in this region. There is an Ar II line at 134.72 that does not appear in the predicted spectrum for Vega but does weakly in the predicted spectrum for Sirius. There is an observed feature in both stars at this wavelength that is stronger in Sirius. These lines are highly excited and would be very sensitive to temperature changes. There are no Ar III lines in this region. We can draw no conclusions about the abundance of Ar.

Potassium. There are no K lines in this region.

Calcium. There are no Ca I lines in this region.

Ca II:	130.56 masked
	132.98 blended, strong in both stars
	133.09 match in both
	134.18 slightly weak in both
	134.25 blend, slightly weak in Vega, matches in Sirius

Ca III lines do not appear in the predicted spectra. There is an unidentified feature at 133.74, which is the wavelength of one of the lines. The Ca abundance is approximately solar in Vega and +1.0 in Sirius.

Scandium. There are no Sc I or III lines in this region. Sc II lines have not yet been observed in this region.

Titanium. There are no Ti I lines in this region. Ti II lines have not yet been observed in this region. Ti III 132.75 matches in both stars, 132.98 is blended, and 133.96 is noisy in Vega and matches in Sirius. The Ti abundance is approximately solar in Vega and +1.0 in Sirius.

Vanadium. There are no V I lines in this region. There are six V II lines that are masked, blended, or insignificant. A feature is observed in Sirius at 131.38, but the calculated feature is much weaker. There are a dozen V III lines but they are all masked, blended, or insignificant. We can say nothing about the V abundance.

Chromium. There is no Cr I in this region. Cr II has not yet been observed. The relative strengths of Cr III lines are the same in both stars but many of the lines are very noisy in Vega.

Cr III: 131.15 blended, masked	132.16 blend, weak
131.40 very weak	132.28 weak
131.54 masked	132.84 very weak
131.64 blend, slightly strong	133.15 blend, weak
132.00 very weak	133.77 weak

Either Cr has a greatly enhanced abundance or there is some error in the models that produces the wrong ionization for Cr III.

Manganese. There are no Mn I lines in this region.

Mn II: 130.10 blend, strong in both stars  
130.67 blend  
133.15 blend, weak  
134.43 blend, strong  
134.56 weak

The gf values for multiplet 56 could not be computed by KP but the lines are present in the observed spectra,

- 130.56 masked
- 131.34 masked
- 131.37 present in both stars, stronger in Sirius
- 131.73 may be present in blend
- 131.77 present in Sirius, not apparent in Vega
- 131.80 present in both stars, stronger in Sirius.

The Mn III line at 134.76 is very weak. We can draw no conclusions about the Mn abundance.

Iron. There are no Fe I lines in this region. There are numerous Fe II and Fe III lines. We get the impression that many features observed in Sirius correspond to Fe III lines that are weak in the calculated spectrum. It is possible that this is a coincidence because there are so many lines. In Vega, the noisiness and questions about the normalization level make the comparison difficult for many of the weaker features. In Vega there are a number of Fe II lines that seem to match so we guess that the abundance is approximately solar. In Sirius those lines are predicted slightly weak which may indicate an Fe abundance increase greater than 1.0. There seem to be problems with ionization and Boltzman factors.

Cobalt. There are no Co I lines in this region. The Co II lines at 130.69, 131.18, and 131.81 are weak in both stars. Other lines are masked or blended. The Co III line 132.68 is not seen in Vega and is predicted to be insignificant in Sirius. The Co abundance is greater than solar in Vega and greater than +1.0 in Sirius. The solar Co abundance may be underestimated.

Nickel. There are no Ni I lines in this region. There are numerous Ni II lines. The resonance lines at 130.88, 131.72, 133.52, and 134.58 match. Higher excitation lines are weak but correspond to many features. The Ni III lines are weak. There seems to be some ionization problem. If some way could be found to increase the strength of the weak Ni II and III lines the calculated spectra would fit much better.

Copper. There are no Cu I lines in this region. Cu II lines do not appear in Vega. Two lines, 130.39 and 133.18, are predicted as small in Sirius. No Cu III lines appear in any of the spectra.

Zinc. Zn I lines have not been observed in this region. The Zn II line at 130.6741 was not computed by KP but may be present in the observed spectra. All Zn III lines are insignificant or masked.

Elements heavier than the nickel sequence. Heavier elements were not computed by KP and gf values for lines in this region were not available from the literature so the line list does not predict any heavy lines in this region. An examination of Kelly and Palumbo (1973) and Moore (1962) does not produce any obvious identifications. Detailed searches will be made in the future.

Our overall impression is that there is a temperature problem with the models because resonance lines of lighter elements seem to match in all stages of ionization, while highly excited iron group lines are predicted too weak. Further work is required to determine whether temperature increases will resolve the discrepancy. Temperature changes in Vega cannot be very large because of the good fits with the strong lines and in the visible.

## 10. CALIBRATION OF COPERNICUS IN THE REGION 130 TO 135 nm

We have assumed that the wavelength dependence of the Copernicus sensitivity did not vary in the time between the observations of the two stars so the same relative shape applies to both Sirius and Vega. In plotting the spectra we overlaid the observations on the calculations and determined a relative shape and the number of counts at full scale required to force a match. Currently, the counts are 2400 for Sirius and 575 for Vega at 130 nm. The shape factor that converts from counts to energy is given in this table:

Wavelength	130 nm	131	132	133	134	135
Factor	1	1.0	1.0	1.1	1.1	1.2

The noisiness of the Vega spectrum and the large number of lines in the Sirius spectrum that do not match leave considerable room for subjective fitting. Since there are several places in Vega where the observed spectrum rises above the calculated spectrum, these numbers will probably be revised.

To determine the absolute calibration in  $\text{ergs/cm}^2/\text{s/nm}$  per count in U1, we use the angular diameters measured by Hanbury Brown, Davis, and Allen (1974). The flux at the earth is inversely proportional to the square of the distance,

$$\text{flux} = (R_*/D)^2 4\pi H_\lambda = (\theta/2/206265)^2 4\pi H_\lambda ,$$

where  $\theta$  is the angular diameter of the star in arc seconds. At 130 nm we find

	Sirius	Vega
$\theta$	$0.00589 \pm 16$	$0.00324 \pm 7$ arc sec
$H_\lambda$ , full scale	1.320E8	8.842E7 $\text{ergs/cm}^2/\text{s/ster/nm}$
U1 counts, full scale	2400	575
flux/count	1.41E-10	1.20E-10 $\text{ergs/cm}^2/\text{s/nm/count}$



## 11. FURTHER WORK

We expect to compute one or two more iterations of the Vega spectrum to determine the oxygen abundance and include additional damping constants. We also plan to check for non-LTE effects in C I using  $b$ 's computed by Snijders and another spectrum synthesis program that we have developed to do non-LTE spectra. We need to make another iteration on Sirius with the additional damping constants and we will attempt to identify additional features. This additional research and this final report will be submitted to the Astrophysical Journal Supplement.

We will apply for additional observing time on Copernicus to obtain as much of the spectra of the two stars as possible, hopefully with lower noise in Vega. In fact, we believe that observations of Sirius and Vega are so important that Copernicus should be used to produce atlases for the two stars.

Since we are undertaking a detailed analysis of both stars in the visible as well as the ultraviolet, we think that detailed discussion of  $f$  values and individual abundances should wait until complementing observations from all spectral regions can be considered together.

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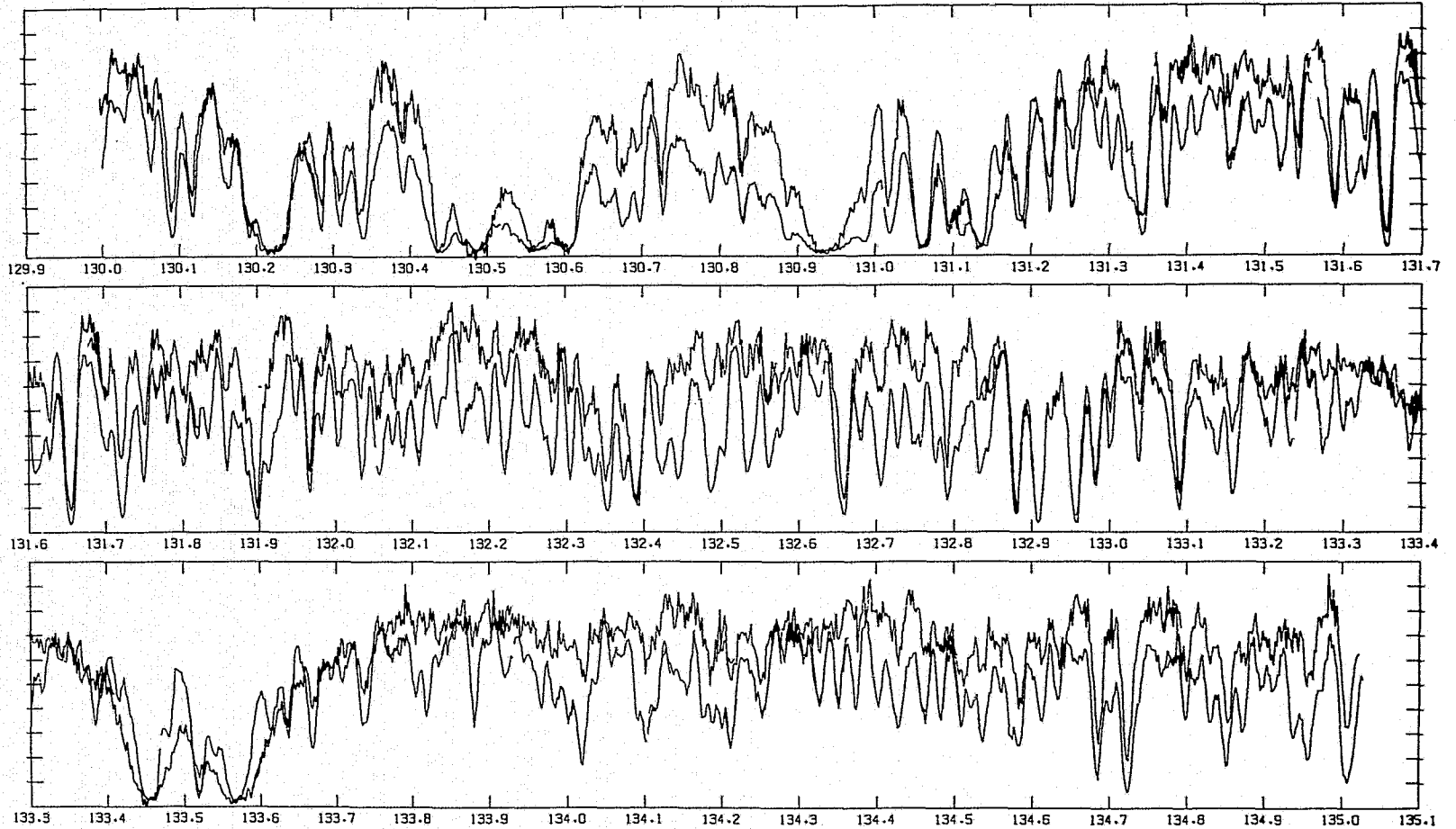


Figure 1. Copernicus UV spectra of Vega and Sirius for the interval 130 to 135 nm. Sirius is the less noisy, generally lower curve. Full scale at 130 nm corresponds to 2400 counts for Sirius and 575 for Vega. Figures 8 and 9 show the individual data points.

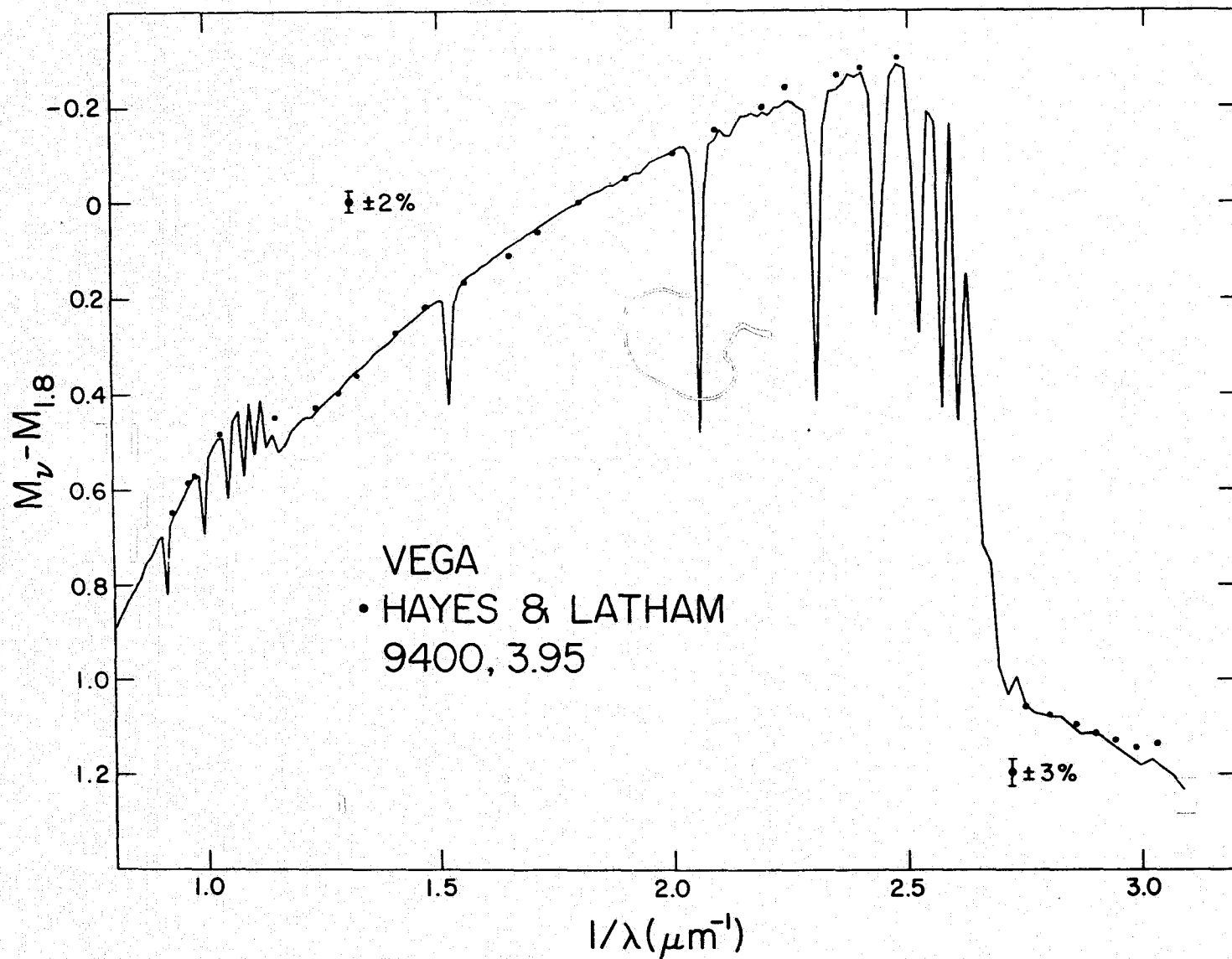


Figure 2. Comparison of the colors of the theoretical model with  $T_{\text{eff}} = 9400$ ,  $\log g = 3.95$  with the new Vega observations of Hayes and Latham (1975). Error bars for the observations are indicated.

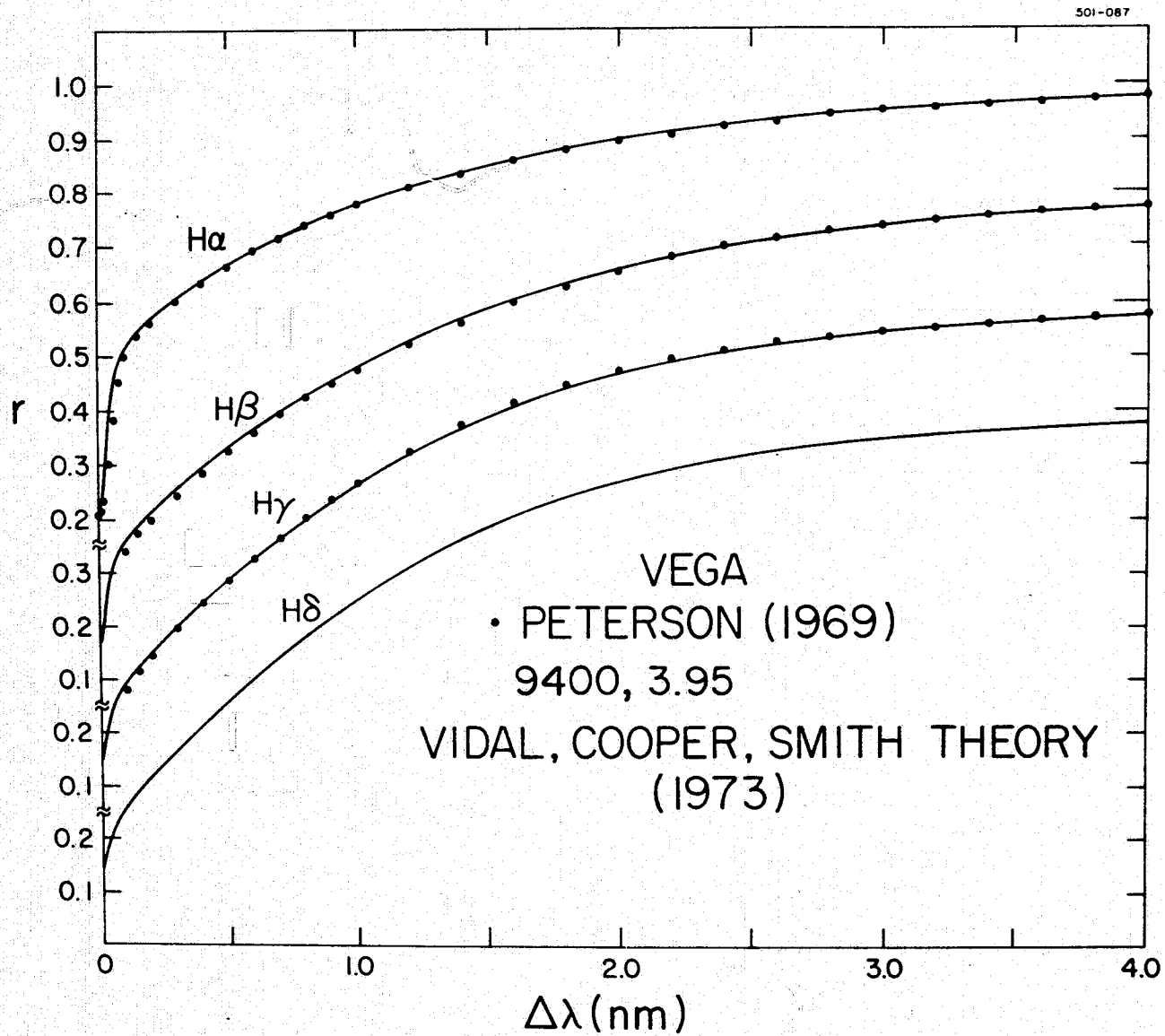


Figure 3. Theoretical Balmer line profiles for the same model compared with the observations of Peterson (1969).

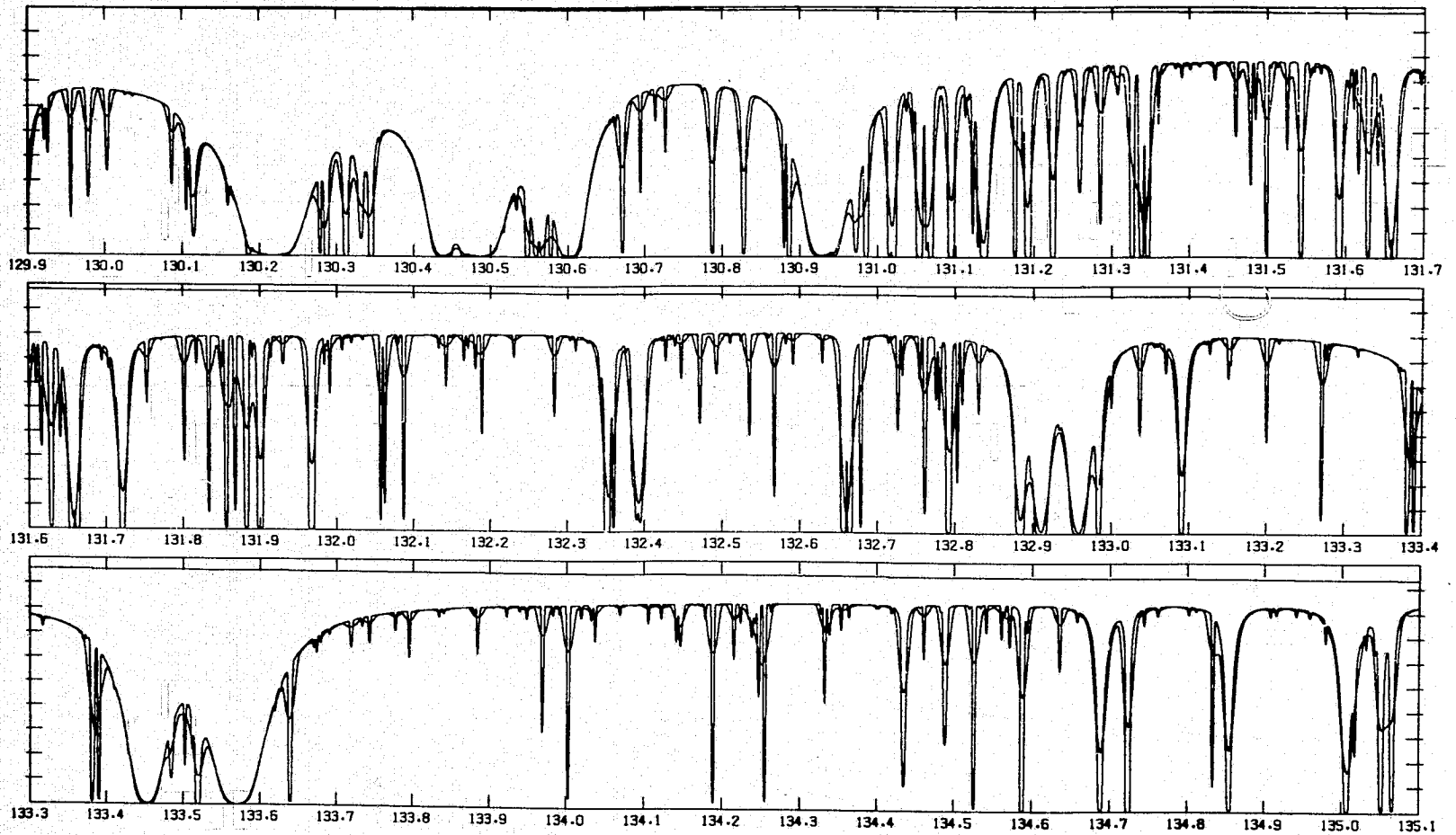


Figure 4. Calculated spectrum for Vega at 0 km/s and rotationally broadened to 25 km/s. The continuum is also shown. Full scale is  $8.842E7$  ergs/cm<sup>2</sup>/s/ster/nm.

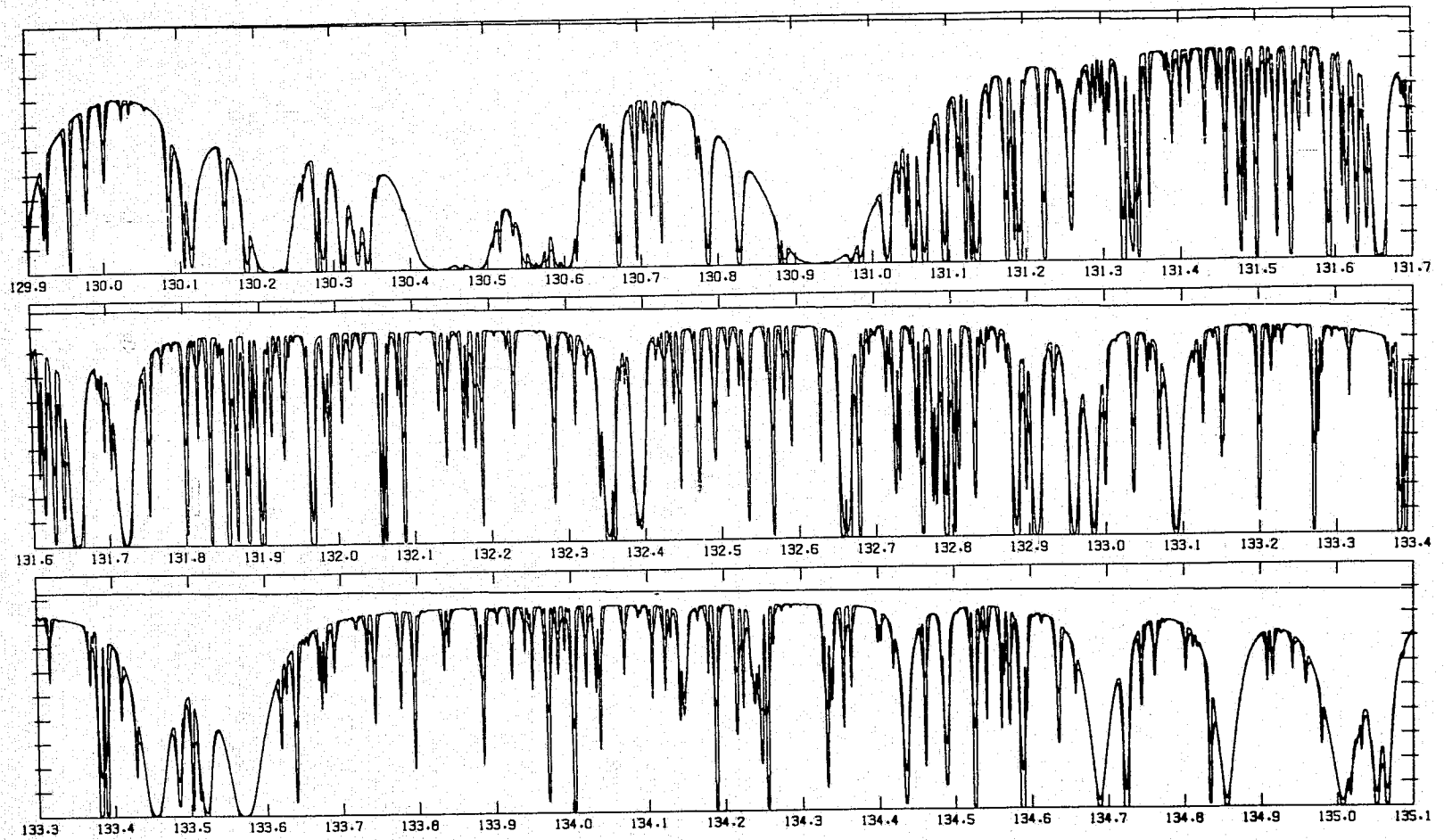


Figure 5. Calculated spectrum for Sirius at 0 km/s and rotationally broadened to 15 km/s. The continuum is also shown. Full scale is  $1.320 \times 10^8$  ergs/cm<sup>2</sup>/s/ster/nm.



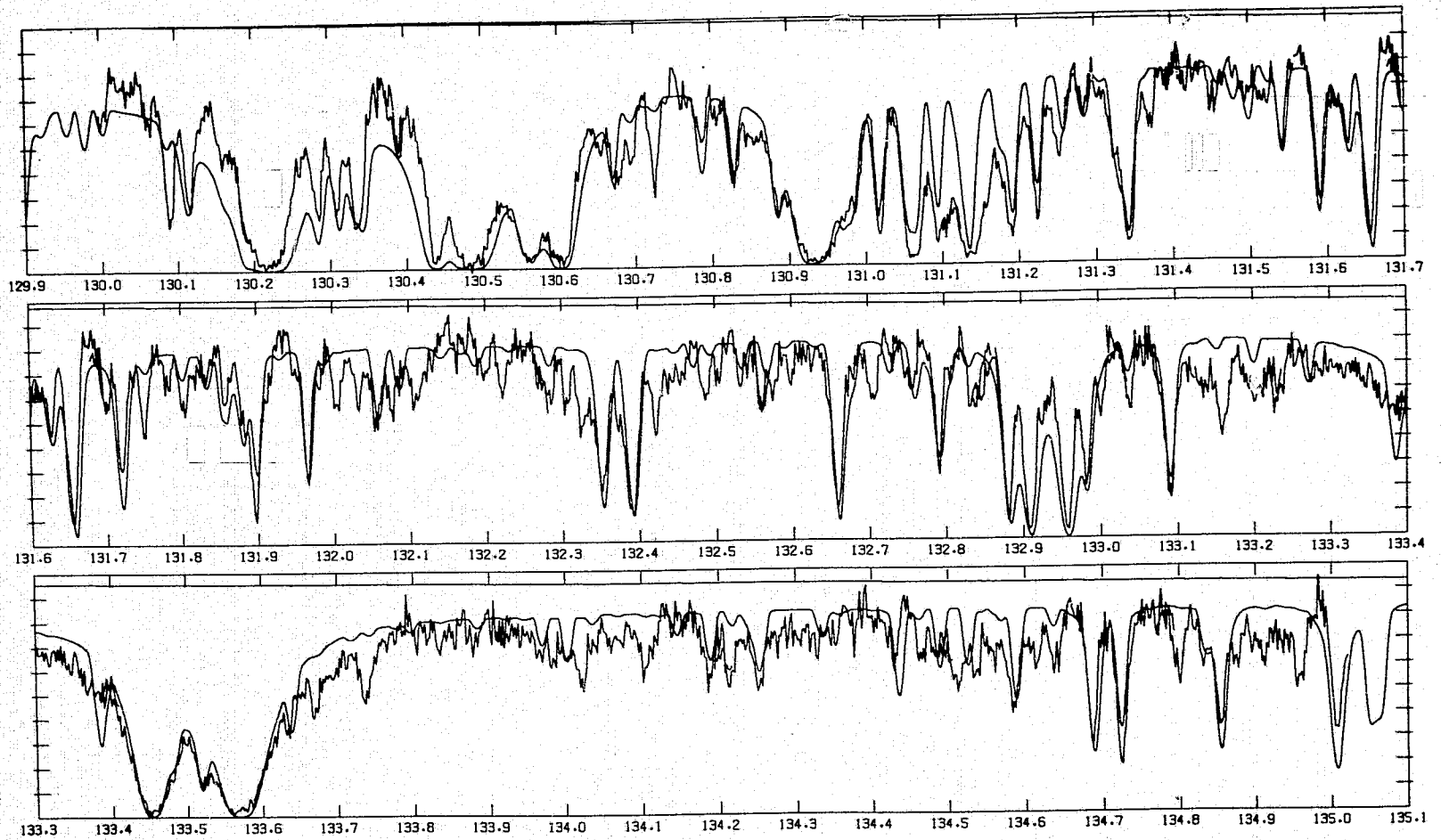


Figure 6. Calculated spectrum for Vega compared to the observations.

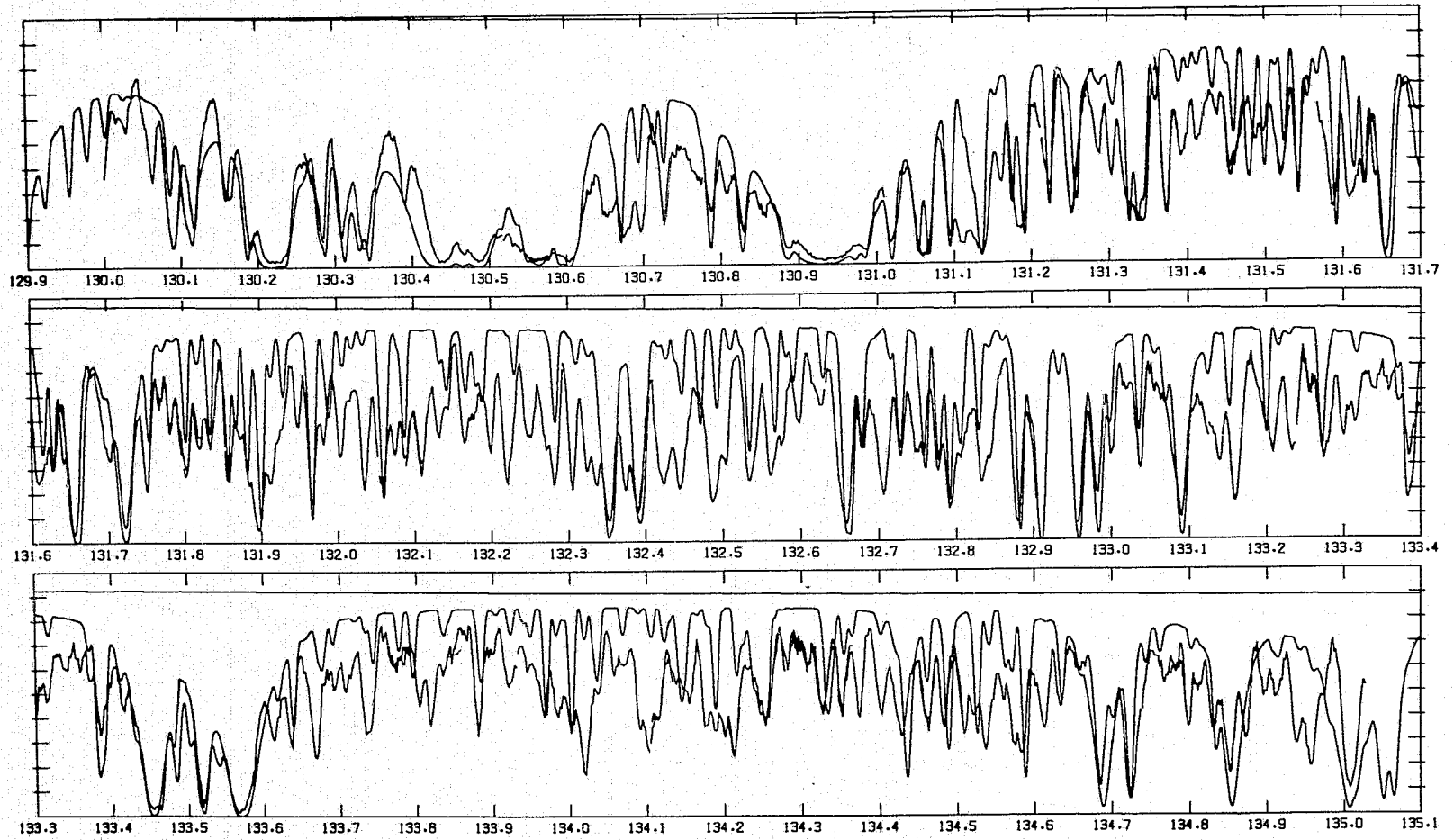
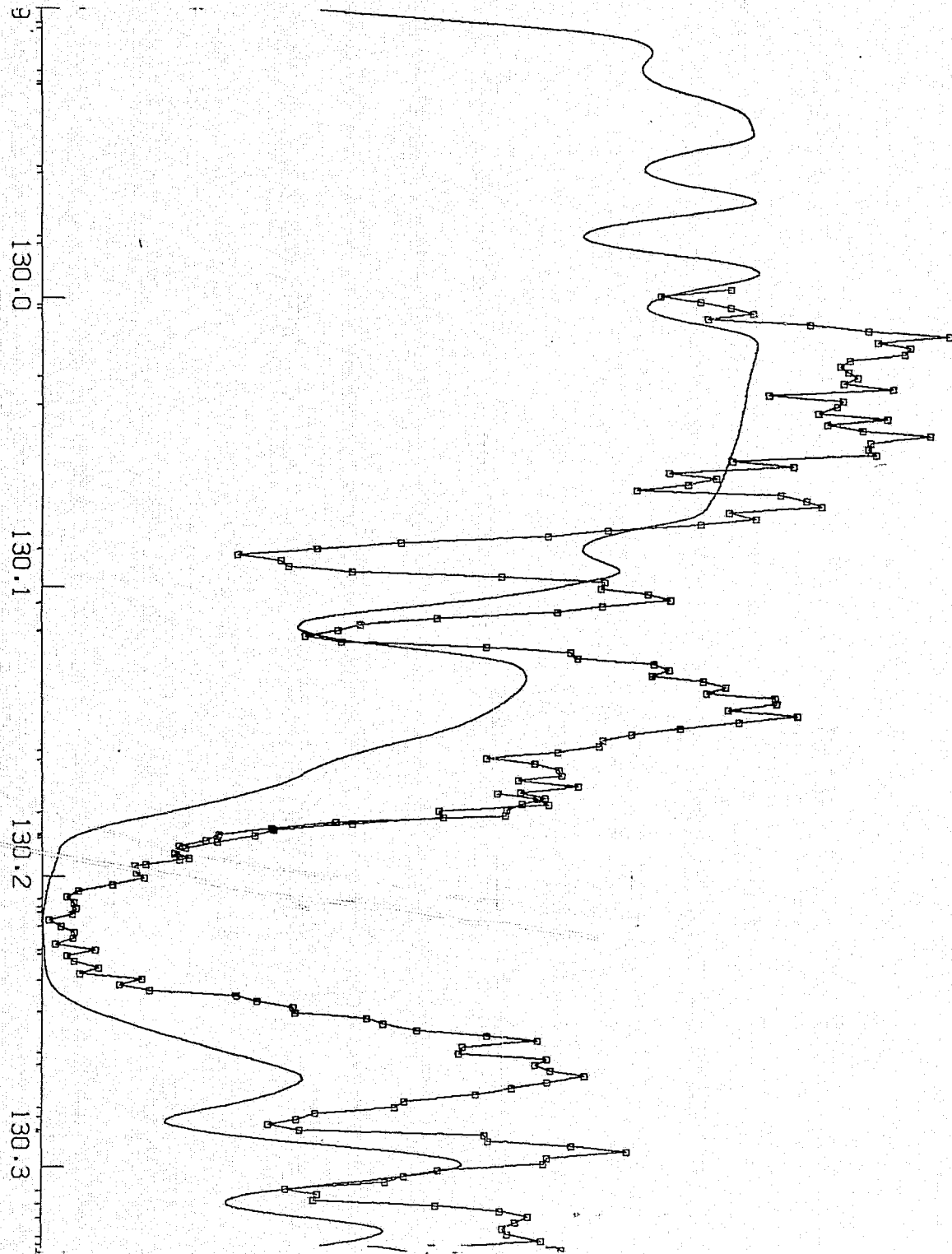


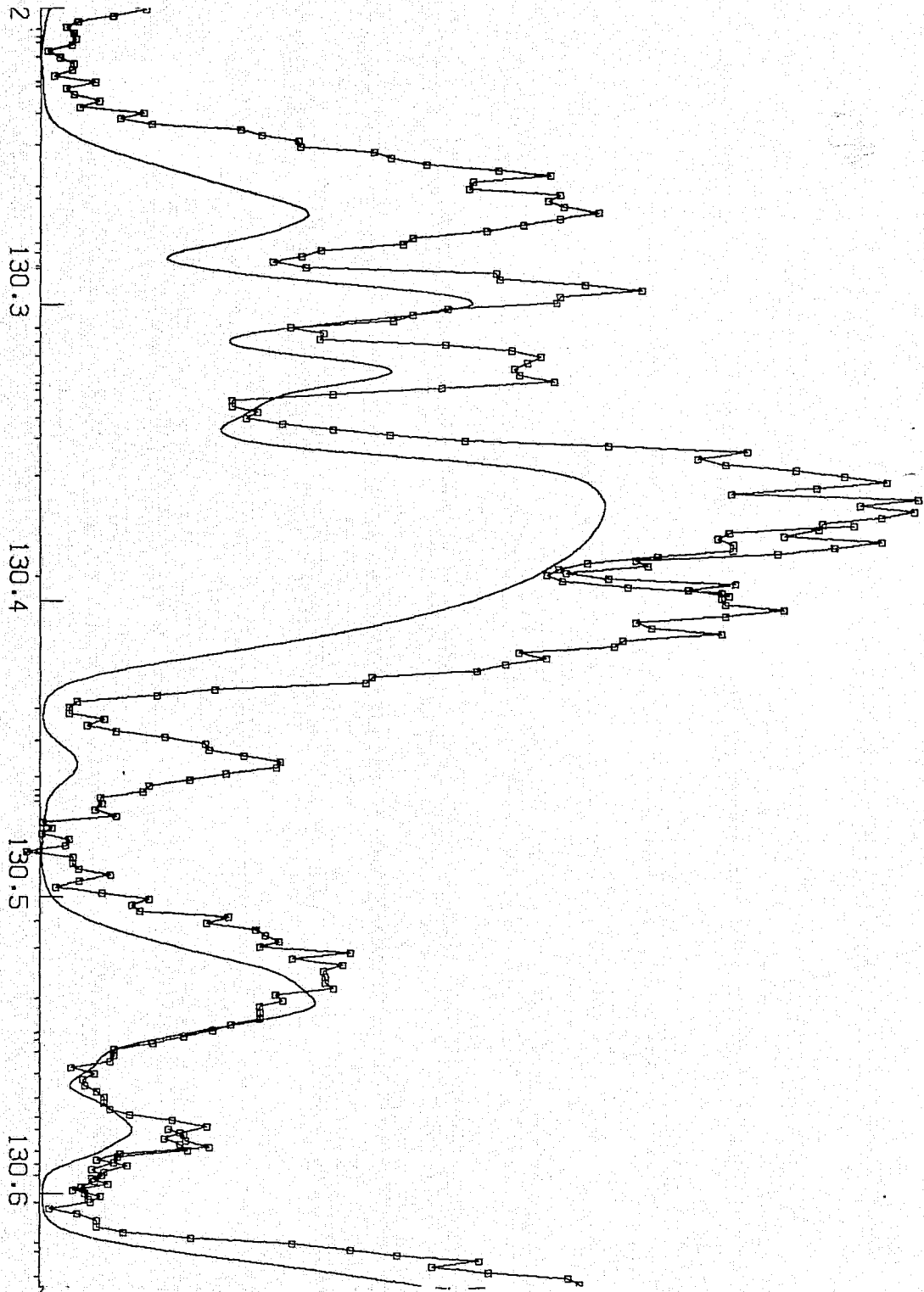
Figure 7. Calculated spectrum for Sirius compared to the observations.

**Figure 8.** Calculated spectrum for Vega compared to the observations with identifications. The labels consist of the last three digits of the wavelength, the symbol for the ion - atomic number plus charge, lower energy level in  $\text{cm}^{-1}$ , and the residual flux in per mil at line center in the unrotated spectrum.



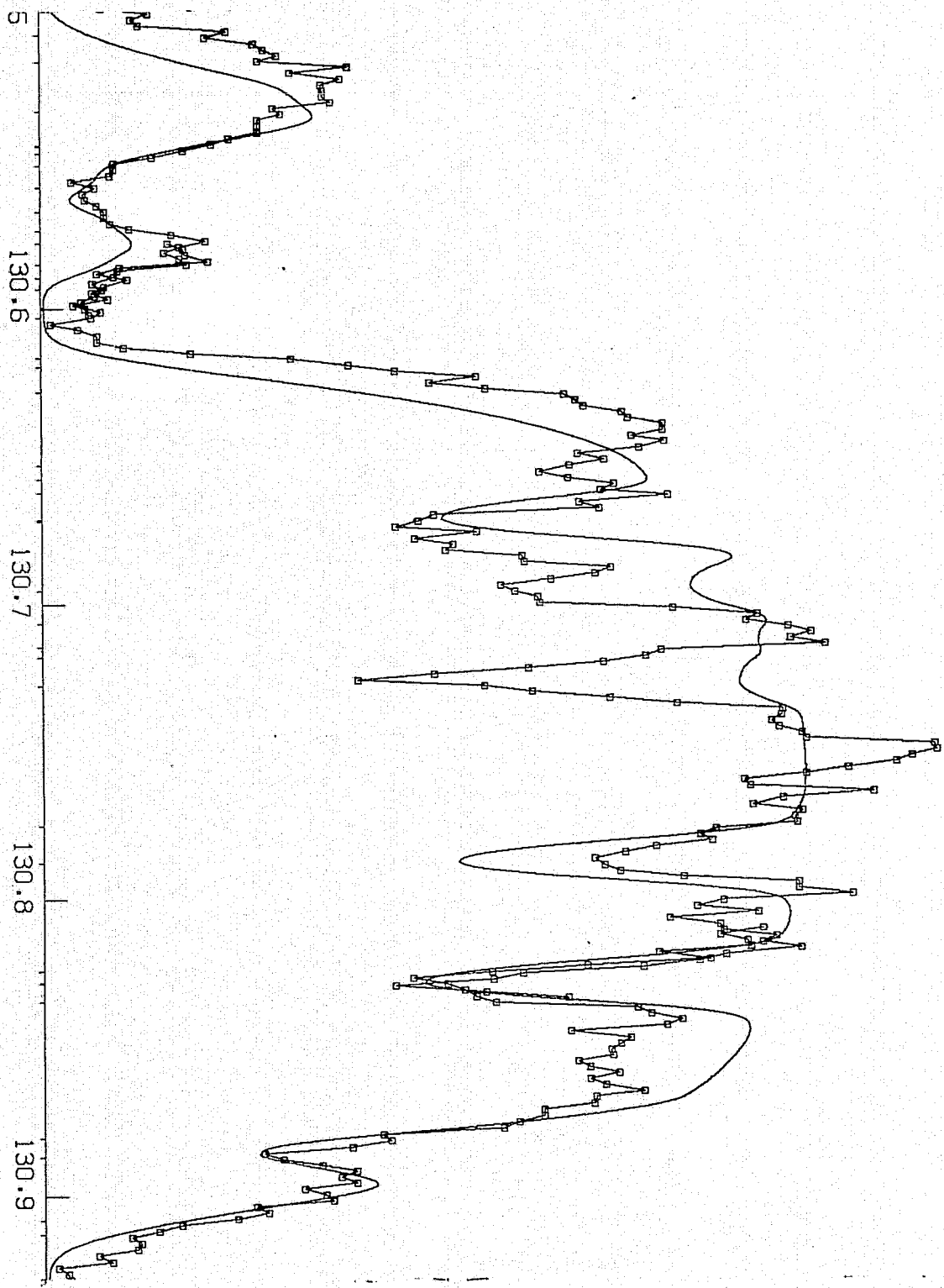
71	23.02	11966	944	52	24.02	17395	976
265	28.01	24788	662	220	28.01	53601	721
				253	23.02	11591	877
567	27.01	3350	222	543	28.01	53037	822
				788	7.01	15316	324
				614	7.01	15316	800
35	7.01	15316	487	21	26.02	93388	980
				268	26.02	70728	984
366	26.01	2430	981				
				866	14.01	76665	455
				55	25.01	29889	347
151	26.01	2430	965	150	14.02	52853	76
582	25.01	29919	966				
595	14.01	76665	613				
				778	25.01	29889	980
859	15.01	0	1	852	26.02	49576	395
				866	26.01	23796	876
75	26.02	89697	932	102	25.01	29951	727
118	26.02	93512	851				
168	6.00	0	0				
248	28.01	29070	920	263	23.02	11769	990
353	16.00	395	0				
				464	28.01	55018	978
603	28.01	54262	954				
643	24.02	20851	988				
792	26.01	15844	9	823	24.02	17272	989
877	16.00	395	0	869	26.02	92523	922
80	28.01	52738	847				
123	16.00	395	0				
172	28.01	52738	925	172	28.01	23108	954
237	28.01	55018	981				
281	28.01	55018	981	261	28.01	53601	868

Figure 8 (Continued)



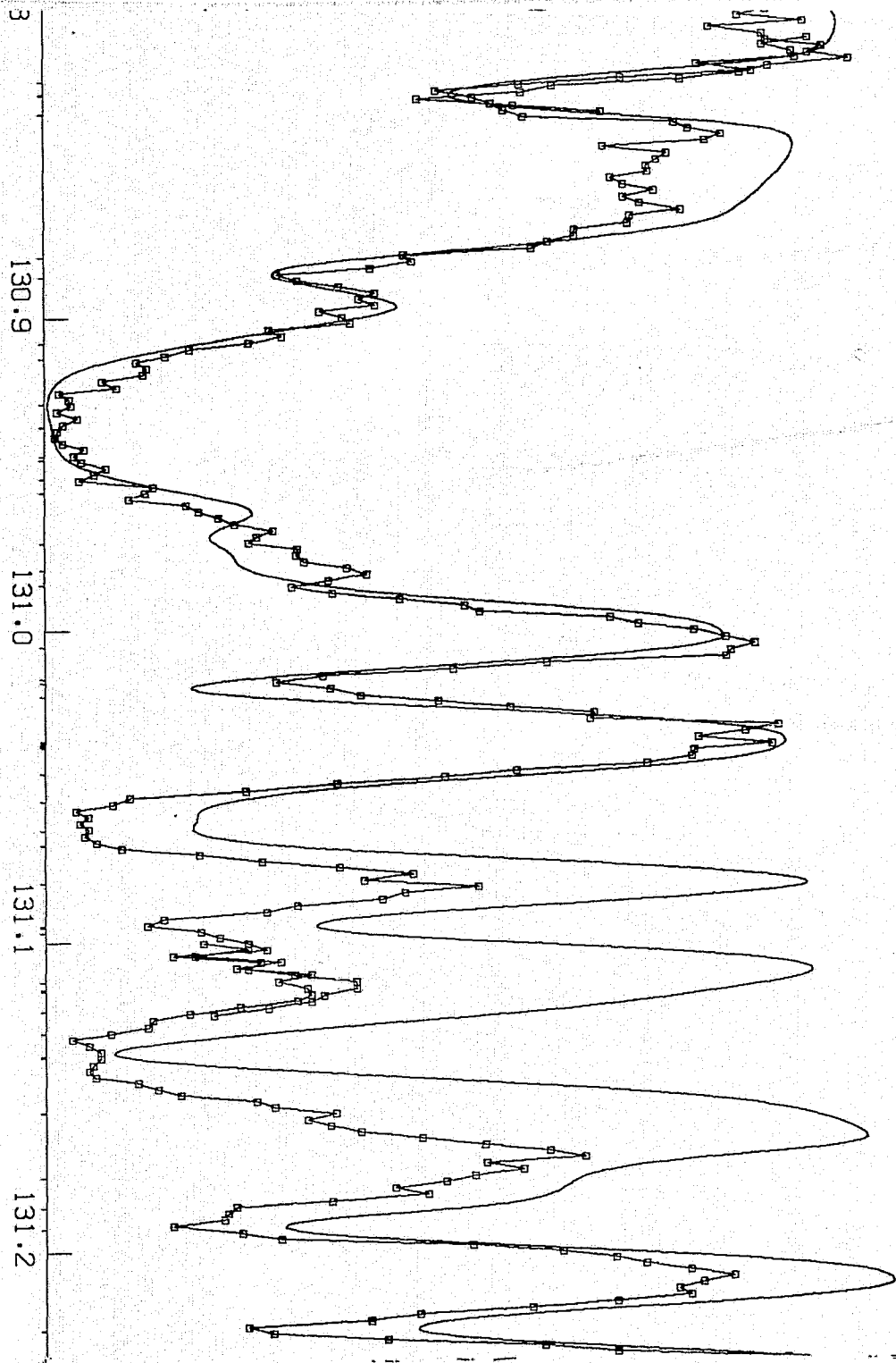
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118	28.02	93512	851				
168	8.00	0	0				
248	28.01	29070	920	263	23.02	11769	990
353	16.00	396	0				
				464	28.01	55018	978
603	28.01	54262	954				
643	24.02	20851	988				
792	26.01	15844	9	823	24.02	17272	989
877	16.00	396	0	869	26.02	92523	922
80	28.01	52738	847				
123	16.00	396	0				
172	28.01	52738	925	172	28.01	23108	954
237	28.01	55018	981	261	28.01	53601	869
285	28.01	57080	989				
320	14.02	53115	71				
448	16.00	0	0	378	26.02	90483	985
				575	26.02	70694	918
914	28.02	61339	982				
366	14.01	0	0				
471	15.00	0	654	475	15.01	164	1
595	28.01	55018	910				
640	20.01	13650	1	657	28.01	32499	986
658	15.01	164	1	677	28.02	62606	901
				857	8.00	158	0
79	24.02	20994	859				
				170	28.01	55018	682
				340	28.02	53703	590
455	28.01	53634	971	453	28.01	55018	985
480	15.01	164	1	457	26.02	90483	982
				520	28.01	29070	989
591	14.01	55325	3				
674	20.01	13710	1	674	20.01	13710	15
				739	25.01	14593	988
				781	26.01	15844	3
				853	26.02	90423	949
				897	16.00	573	0
				937	23.02	28746	752
				28	8.00	226	0
165	25.01	29919	550				
195	23.02	11769	922				
280	28.01	54262	967				

Figure 8 (Continued)



79 24.02	20994 859		
		170 28.01	55018 682
		340 28.02	53703 590
455 28.01	53634 971	453 28.01	55018 986
480 15.01	164 1	457 26.02	90483 982
		520 28.01	29070 989
591 14.01	55325 3		
674 20.01	13710 1	674 20.01	13710 15
		739 25.01	14593 988
		781 26.01	15844 3
		853 26.02	90423 948
		897 16.00	573 0
		937 23.02	28746 752
		28 8.00	226 0
165 25.01	29919 550		
195 23.02	11769 922		
280 28.01	54262 567		
529 28.01	54262 982		
		577 23.02	28746 976
		621 28.01	52738 900
710 25.01	29951 725	714 12.01	35669 21
952 27.01	4028 391		
		63 24.02	20851 974
		145 28.01	54262 811
		180 28.01	53634 988
277 28.01	54262 614		
		748 26.02	70694 956
875 12.01	35669 13		
239 26.02	89783 988		
279 12.01	35760 279	281 12.01	35760 12
		342 26.02	70728 946
801 26.01	2837 57		
		856 28.01	0 0
79 28.01	57420 985		
126 28.01	53601 989		
272 14 01	287 0		

Figure 8 (Continued)



239	26.02	89783	988		
279	12.01	35760	279	281	12.01
				342	26.02
				35760	12
				70726	946

801	26.01	2837	57		
				866	28.01
					0
					0

79	28.01	57420	985		
126	28.01	53601	989		

273	14.01	287	0		
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350	24.02	25725	445		
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443	12.01	35760	8	453	14.01
				55309	4

516	24.02	20994	961		
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558	23.02	11966	974		
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724	14.01	55325	20		
-----	-------	-------	----	--	--

809	26.02	82382	941		
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				857	15.01
				469	1

				51	28.01
				55417	989

155	6.00	10192	5	166	26.01
				212	16.00
				16369	884
				396	0

357	28.01	57420	989	374	6.00
361	28.01	57420	987	370	26.02
370	26.02	89907	982	457	28.01
				51557	763

				541	7.00
				28639	1

537	6.00	10192	41		
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685	15.01	469	0		
-----	-------	-----	---	--	--

804	23.02	11591	979		
-----	-------	-------	-----	--	--

950	7.00	28839	2	944	7.00
				966	26.02
				28838	1
				89907	958

126	27.01	4028	824	149	24.02
-----	-------	------	-----	-----	-------

153	28.01	55417	954		
-----	-------	-------	-----	--	--

				219	26.01
				1872	152

288	26.01	2430	88		
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363	6.00	10192	0	369	26.02
				92523	963

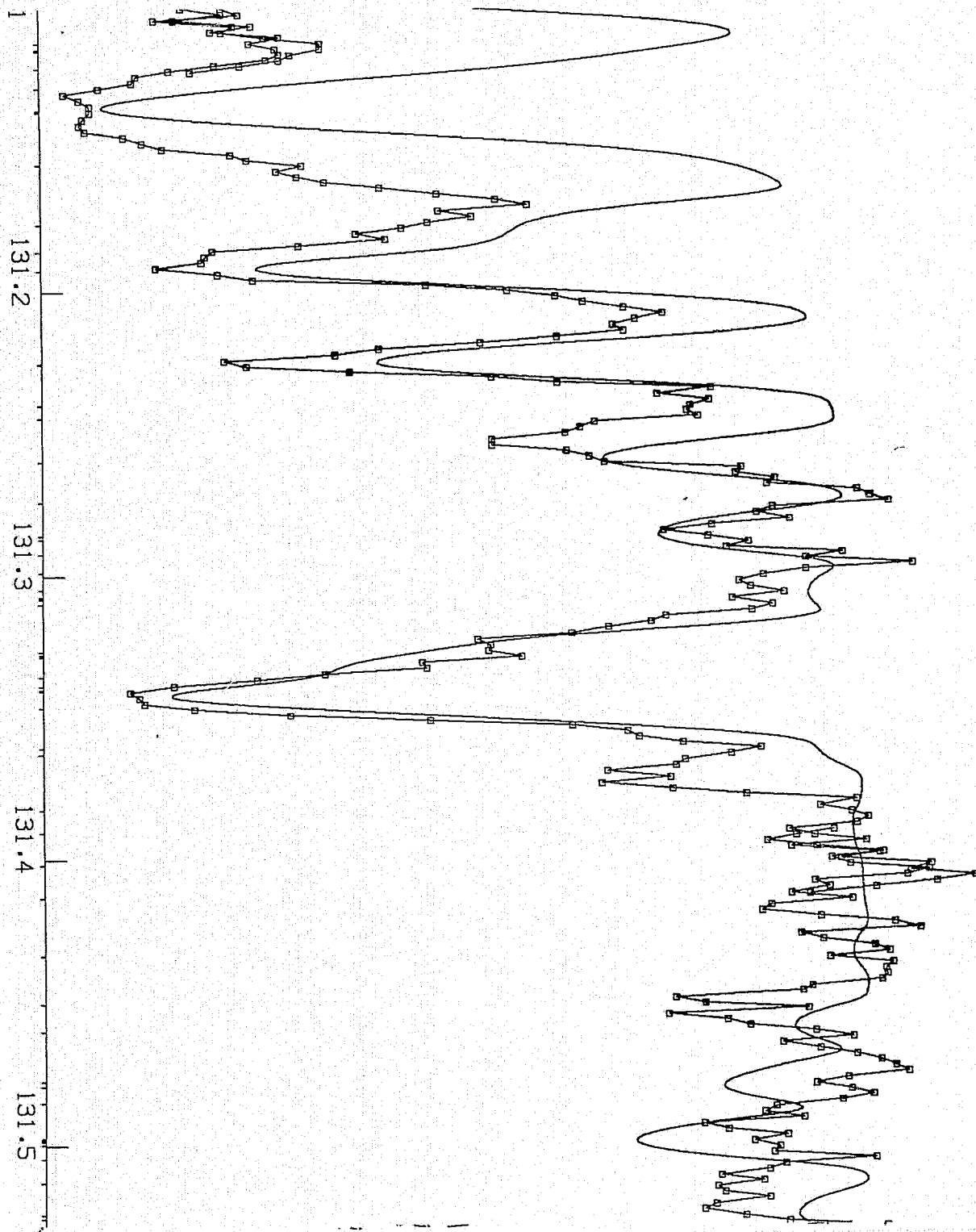
548	24.02	20851	987	546	26.02
				62606	985

758	26.01	16369	4		
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924	6.00	10192	1	856	27.01
				4560	571

247	6.00	10192	2		
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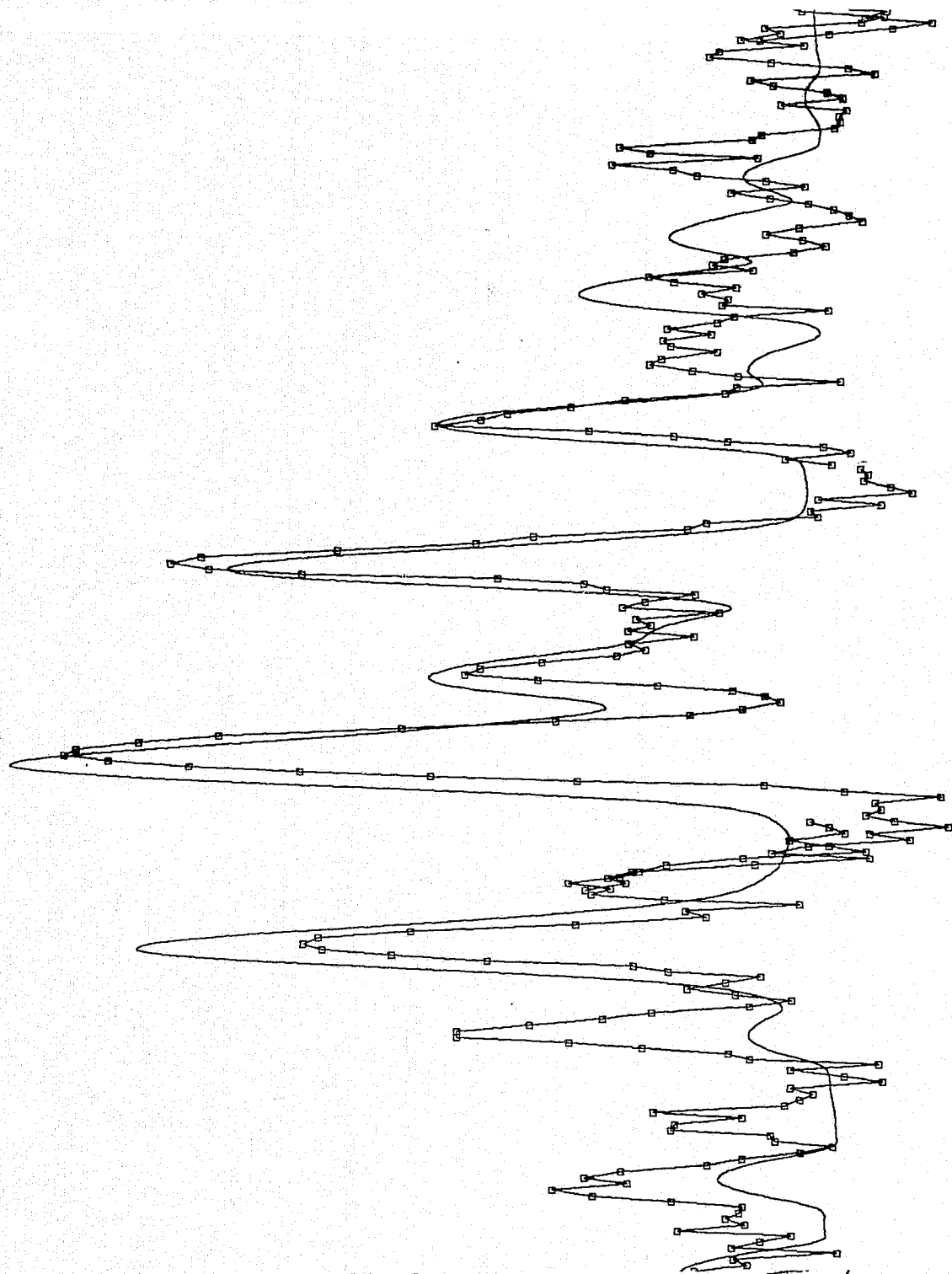
Figure 8 (Continued)



126	27.01	4028	824	149	24.02	20851	979
153	28.01	55417	954	219	26.01	1872	152
288	26.01	2430	88				
363	6.00	10192	0	369	26.02	92523	963
548	24.02	20851	997	546	28.02	62606	985
758	26.01	16369	4				
924	6.00	10192	1	856	27.01	4550	571
247	6.00	10192	2				
392	6.00	10192	870				
440	28.01	54557	980				
591	14.02	62884	323				
				734	23.01	208	981
866	7.00	28839	844	855	6.00	10192	194
921	26.02	70725	973				
46	26.02	63466	908	986	26.02	70728	978
71	7.00	28838	912	78	7.00	28839	912
96	26.02	89783	965				
277	7.00	28838	912	267	16.00	573	1
				283	7.00	28839	912
354	23.02	12187	513	387	6.00	10192	3
398	26.02	63486	979	403	28.01	53365	890
				454	6.00	10192	2
607	26.01	3117	699	629	6.00	10192	970
				823	23.01	106	971
				903	28.01	53365	926
				17	24.02	20994	965
				131	26.02	49576	978
				332	26.02	63425	908
				504	26.02	90423	978
601	26.02	40999	610				
789	26.01	16369	379	771	28.01	53365	733
848	28.01	53365	711				
979	7.00	28839	912	974	7.00	28838	912
995	15.00	0	17	983	23.01	339	925
				45	26.02	63466	970
129	26.02	63425	972				
242	26.02	89907	997	242	26.02	89907	979

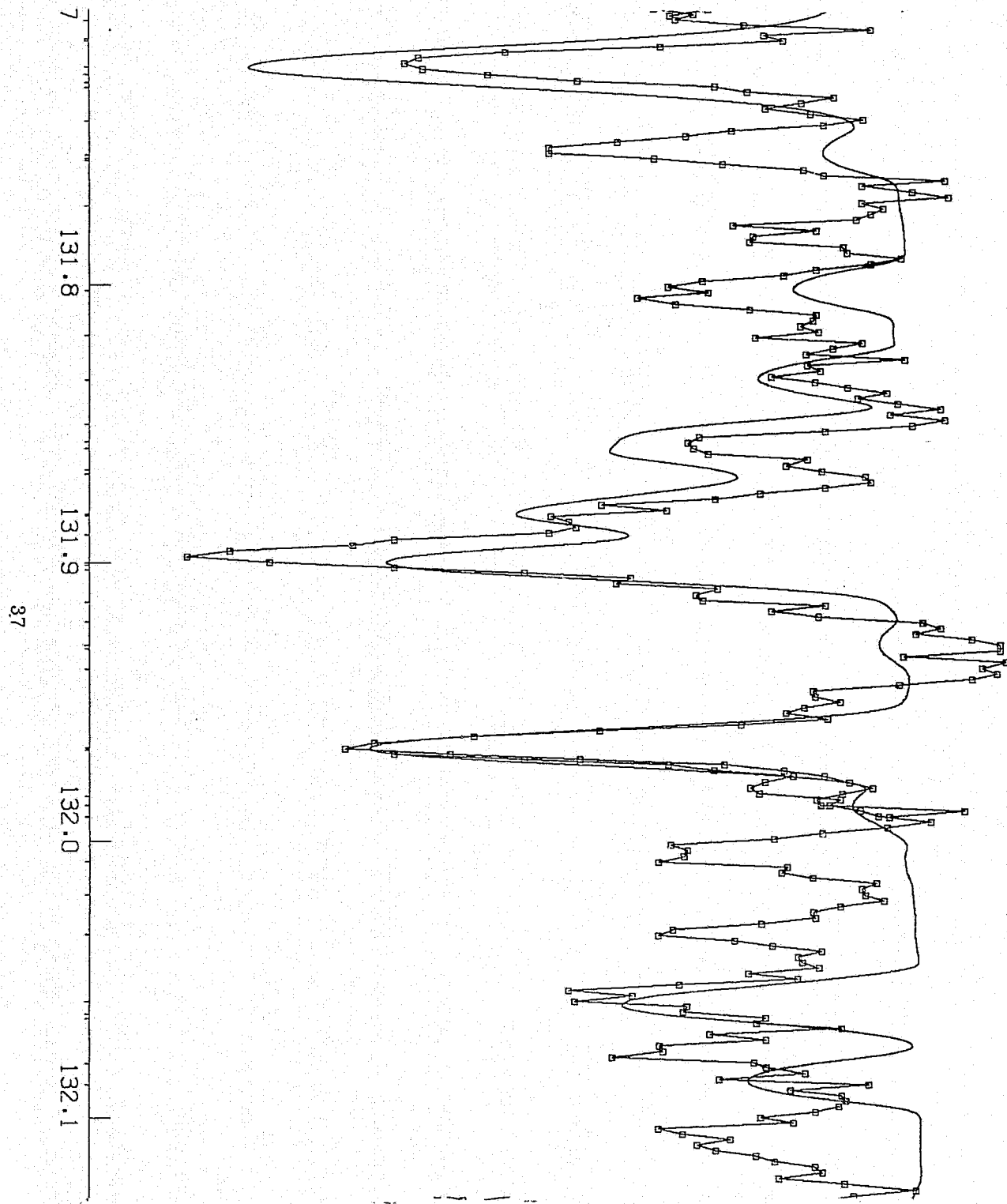
Figure 8 (Continued)





				17 26.02	2055 363		
				131 26.02	49576 978		
				332 26.02	63425 908		
				504 26.02	90423 879		
	601 26.02	40999 610					
	789 26.01	16369 379	771 28.01	53365 733			
	848 28.01	53365 711					
	979 7.00	28839 912	974 7.00	28838 912			
	995 15.00	0 17	983 23.01	335 925			
			45 26.02	63466 970			
	129 26.02	63425 972					
	242 26.02	89907 987	242 26.02	89907 979			
	255 28.01	53365 556					
	419 27.01	4950 734	414 26.02	89697 967			
	436 7.00	28839 12	430 7.00	28838 10			
	559 28.01	55018 945	452 24.02	25725 864			
	590 23.01	208 954	540 26.02	50483 951			
	679 26.02	62410 957					
	842 26.02	63466 986					
	918 6.00	10192 1					
	36 7.00	28839 912					
	120 25.02	68899 988	101 27.01	4560 781			
	157 25.01	38366 890	166 26.02	50412 432			
			291 7.00	28839 6			
	408 24.02	25781 515					
	557 16.00	0 0	501 28.01	54176 951			
	637 16.00	0 2	628 16.00	0 0			
			869 26.02	40999 989			
			905 26.02	89783 988			
	955 28.01	53365 921					
	45 28.01	53496 915					
	114 28.01	55018 976	122 28.01	53496 901			
	244 26.01	7955 986	217 28.01	0 0			
	271 23.02	11966 578	290 26.01	7955 783			
	409 28.01	53365 982					
	545 26.01	20340 988	531 28.01	53496 680			
			552 26.02	40999 668			
	717 26.02	93388 989					
			19 28.01	53496 352			
			180 27.01	5204 851			

Figure 8 (Continued)



45	28.01	53495	915		
114	28.01	55018	976	122	28.01 53496 901
244	26.01	7855	986	217	28.01 0 0
271	23.02	11966	578	290	26.01 7955 783
409	28.01	53365	982		
545	26.01	20340	988	531	28.01 53496 680
				552	26.02 40959 868
717	26.02	93388	989		
				19	28.01 53496 352
				160	27.01 5204 861
				339	26.01 2837 86
				501	7.00 28839 830
564	26.01	20516	7	588	27.01 4950 801
680	15.00	0	98	665	25.01 38542 983
823	7.00	28838	5	830	7.00 28839 912
				899	28.01 24788 910
899	7.00	28838	1		
25	15.00	0	112	6	7.00 28839 2
				141	26.02 49148 894
				211	25.01 38542 987
310	28.01	55018	911	296	26.02 73727 881
				381	24.02 16581 990
677	7.00	28839	1	570	7.00 28838 2
838	27.01	5204	861		
871	26.02	93512	951		
911	26.01	20516	720	914	26.02 82494 971
71	24.02	43285	525		
192	28.01	55018	963		
334	27.01	4560	988	331	26.02 90483 985
				577	26.01 3117 49
638	28.01	56075	987	623	26.01 20340 134
798	28.01	55018	958		
874	26.01	2430	52		

Figure 8 (Continued)

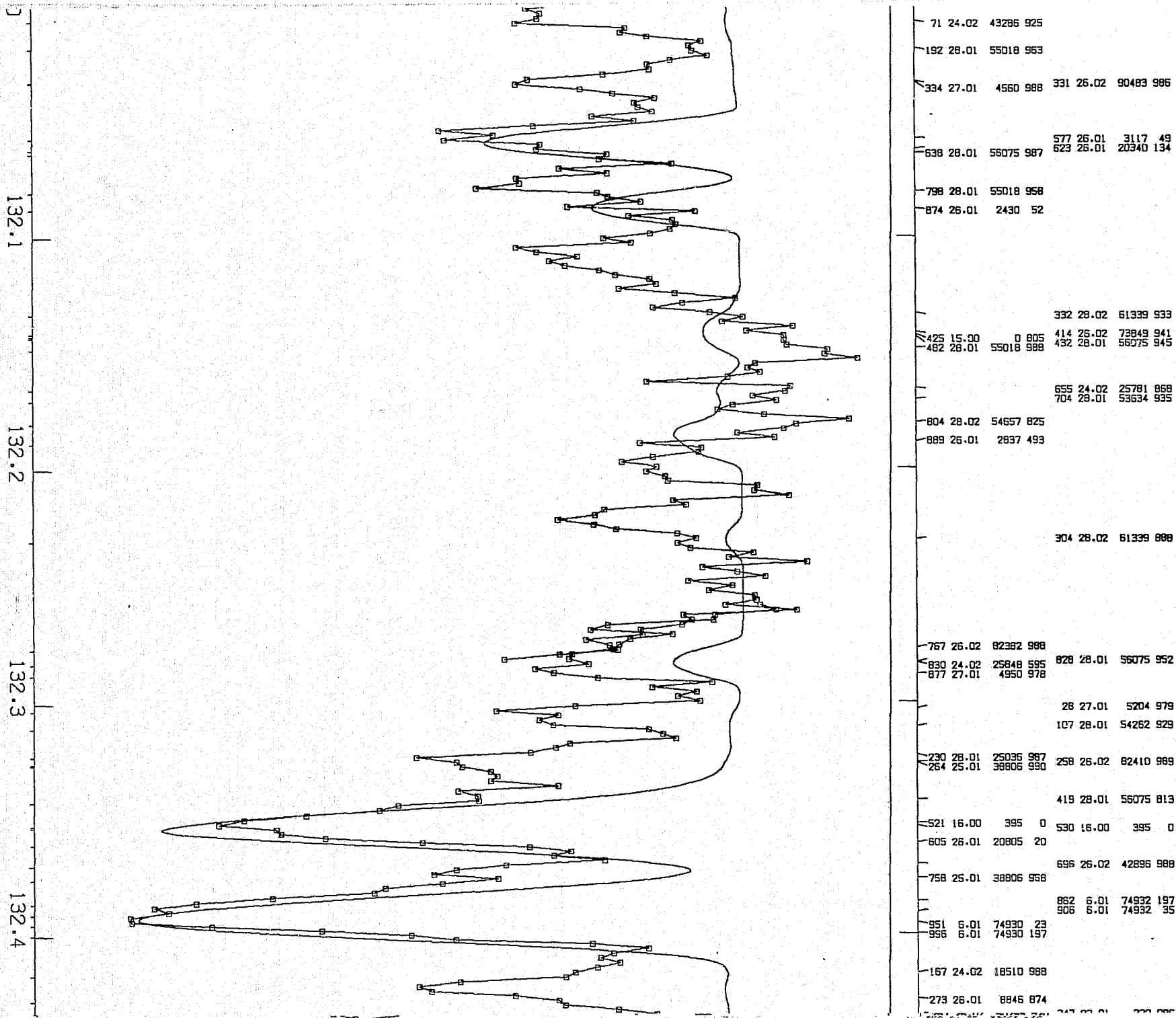


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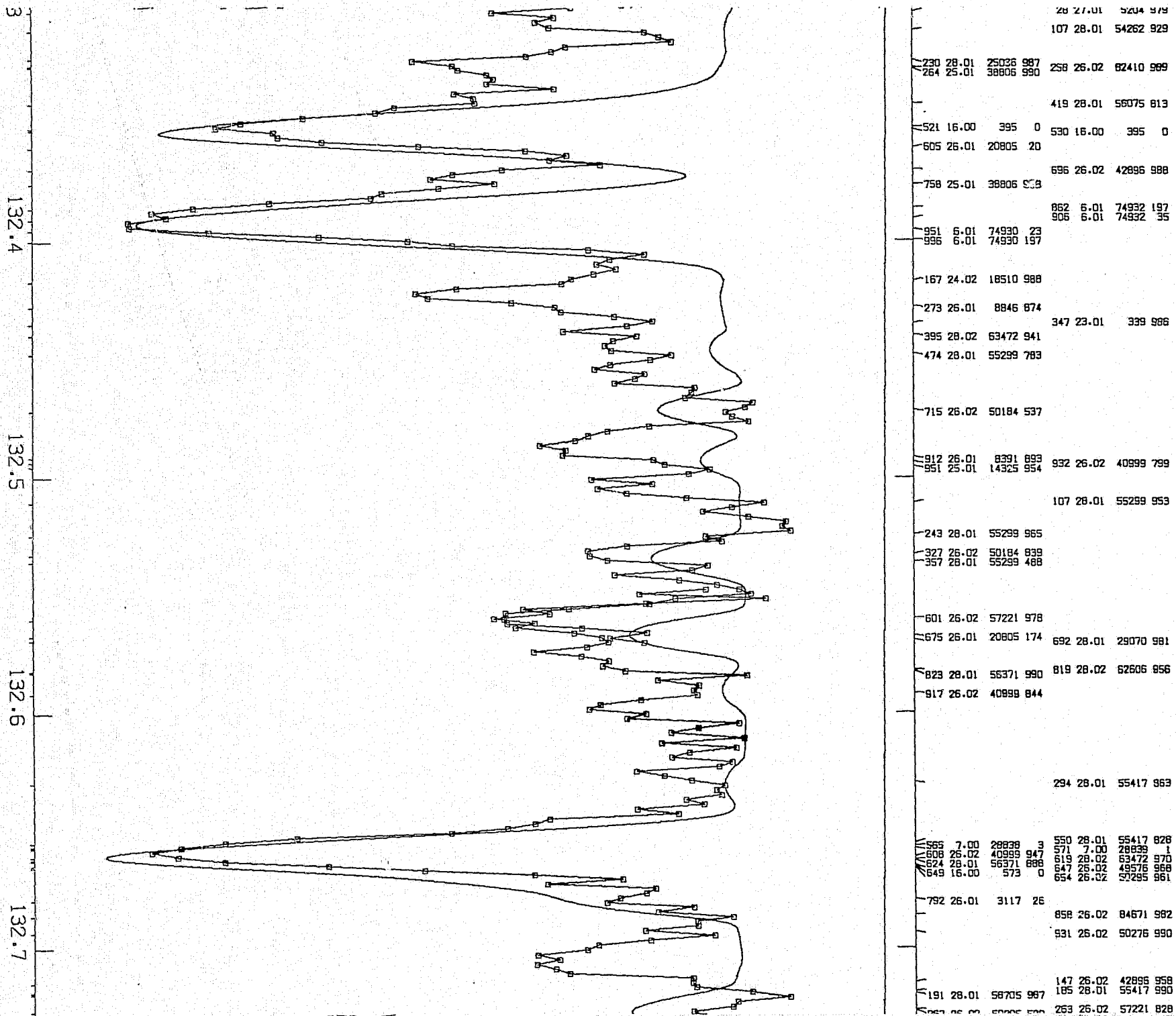
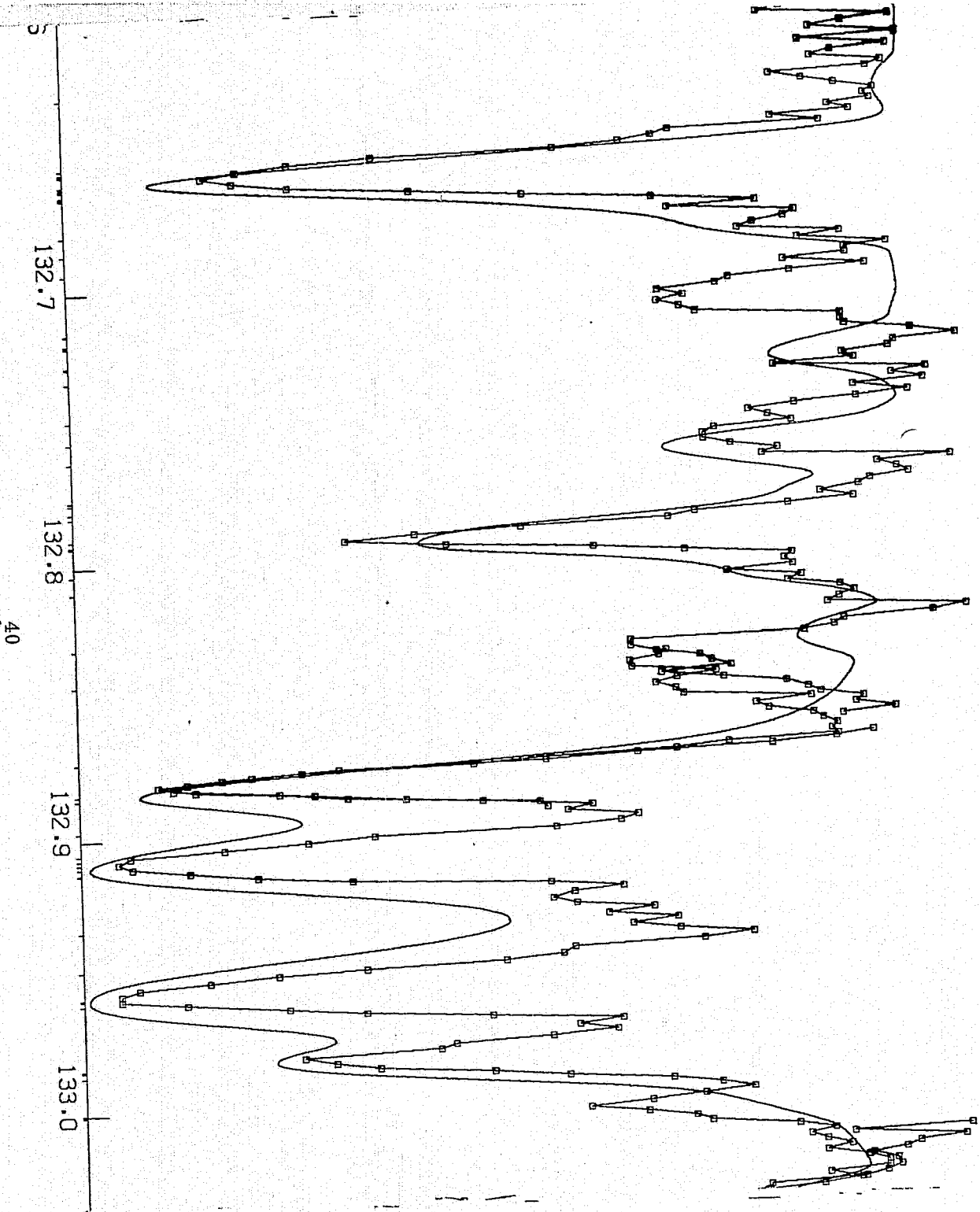
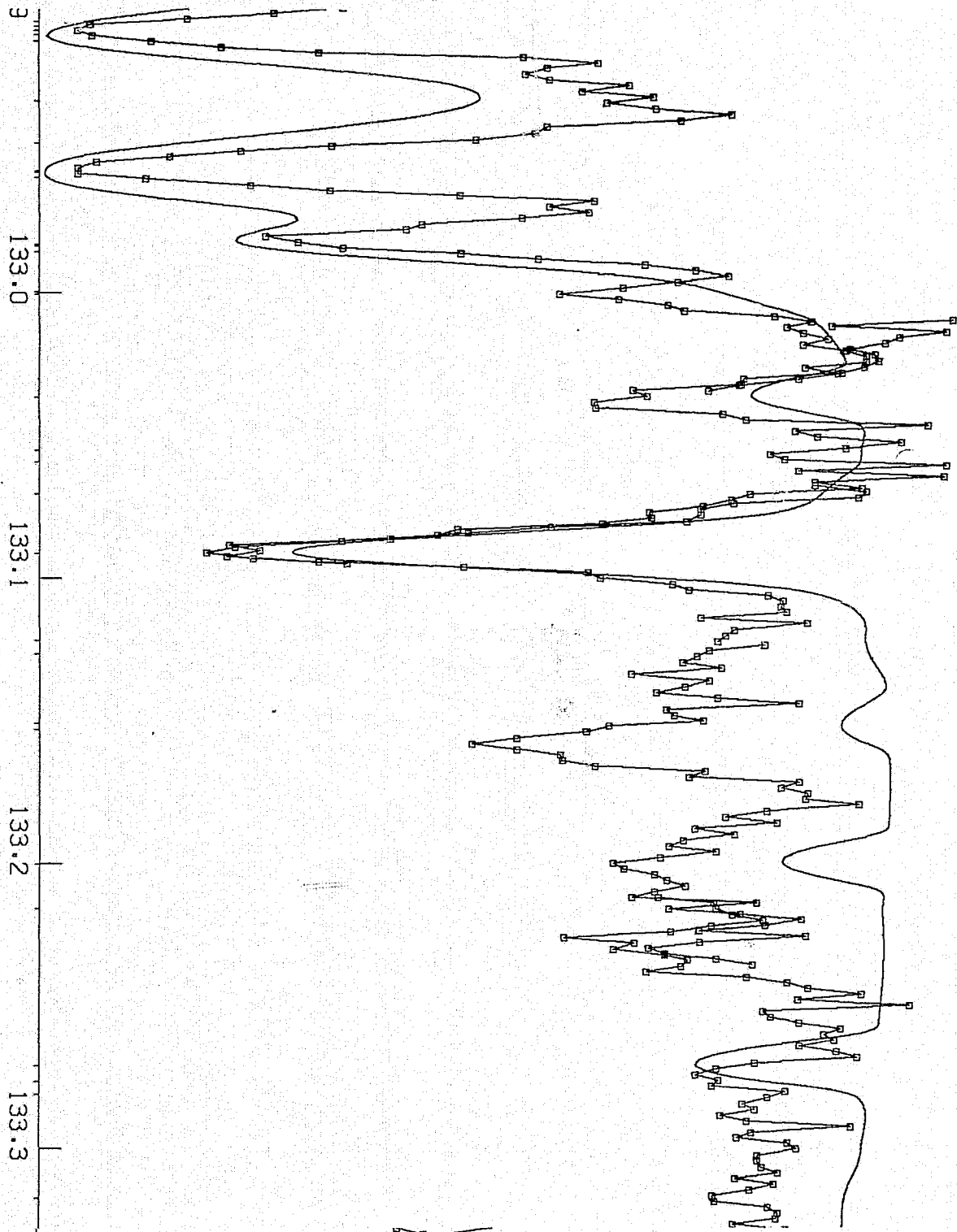


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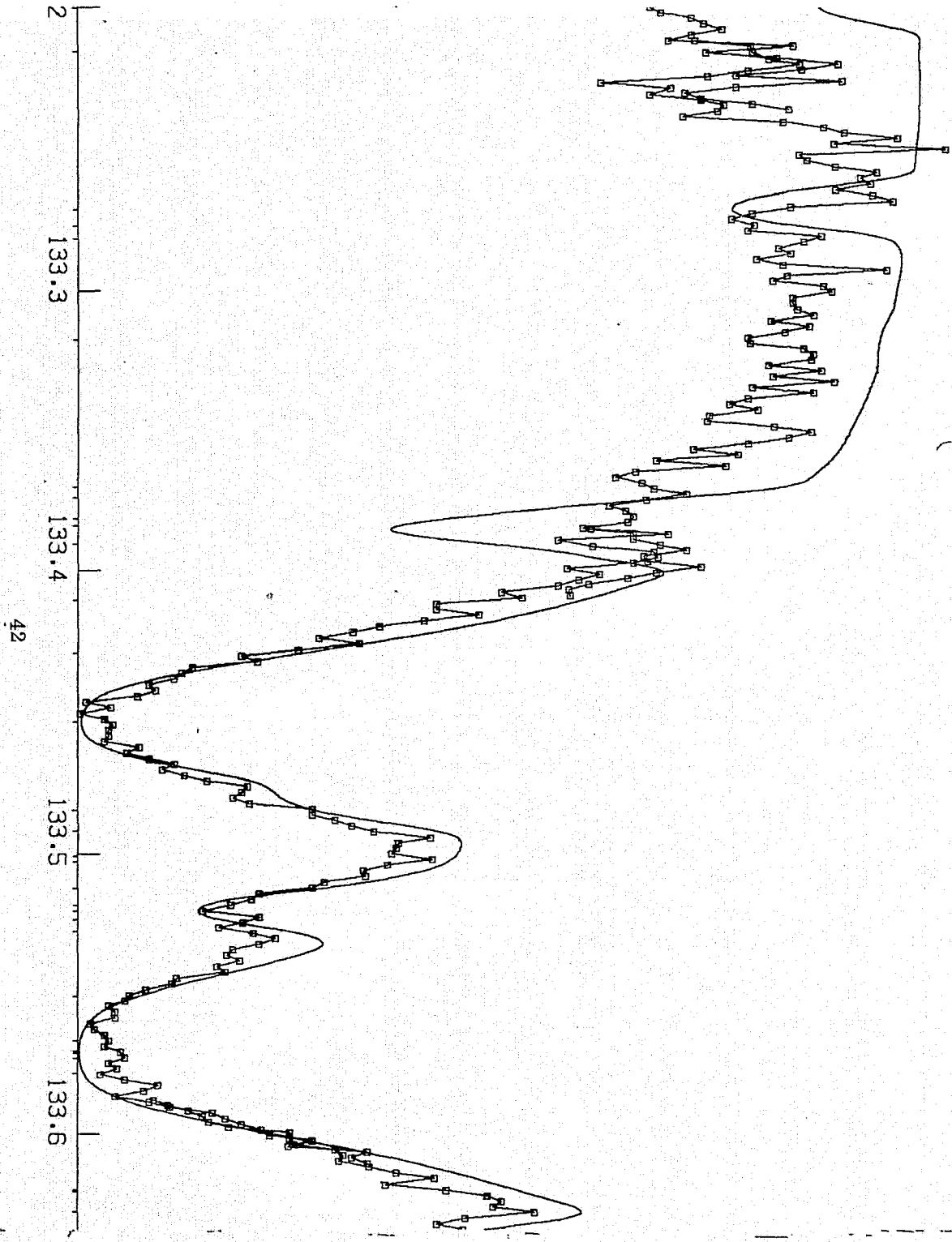
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565 7.00	28838 3	550 28.01	55417 828		
606 26.02	40999 947	571 7.00	28839 1		
624 28.01	56371 888	619 28.02	63472 970		
649 16.00	573 0	647 26.02	48578 968		
		654 26.02	50295 981		
792 25.01	3117 26	858 26.02	84671 982		
		931 28.02	50278 990		
191 28.01	58705 987	147 26.02	42898 958		
267 26.02	50295 820	185 28.01	55417 990		
322 28.01	55417 804	263 26.02	57221 828		
		465 25.01	38366 985		
		545 26.02	49576 779		
		614 22.02	8472 93		
754 28.01	56371 689	764 24.02	18451 989		
797 28.01	55417 970	797 26.01	2430 664		
813 24.02	43286 836				
918 7.00	28838 2	900 23.02	27727 876		
		924 7.00	28839 2		
		28 26.01	2837 262		
		92 28.02	54657 660		
		302 14.01	76665 821		
436 24.02	43321 979				
718 26.02	50412 988				
834 6.00	0 0	849 28.01	52738 937		
868 28.01	56424 786				
84 6.00	16 0	51 23.02	16810 954		
123 6.00	16 0	100 6.00	16 0		
121 26.02	88847 945	70 28.01	54262 879		
		333 26.02	50412 936		
477 28.01	55018 982				
600 6.00	43 0	577 6.00	43 0		
		581 28.01	54262 891		
833 22.02	0 420	838 20.01	13650 1		
839 28.01	58705 983	859 28.01	56424 878		
996 26.01	8680 803	5 26.02	73727 801		

Figure 8 (Continued)



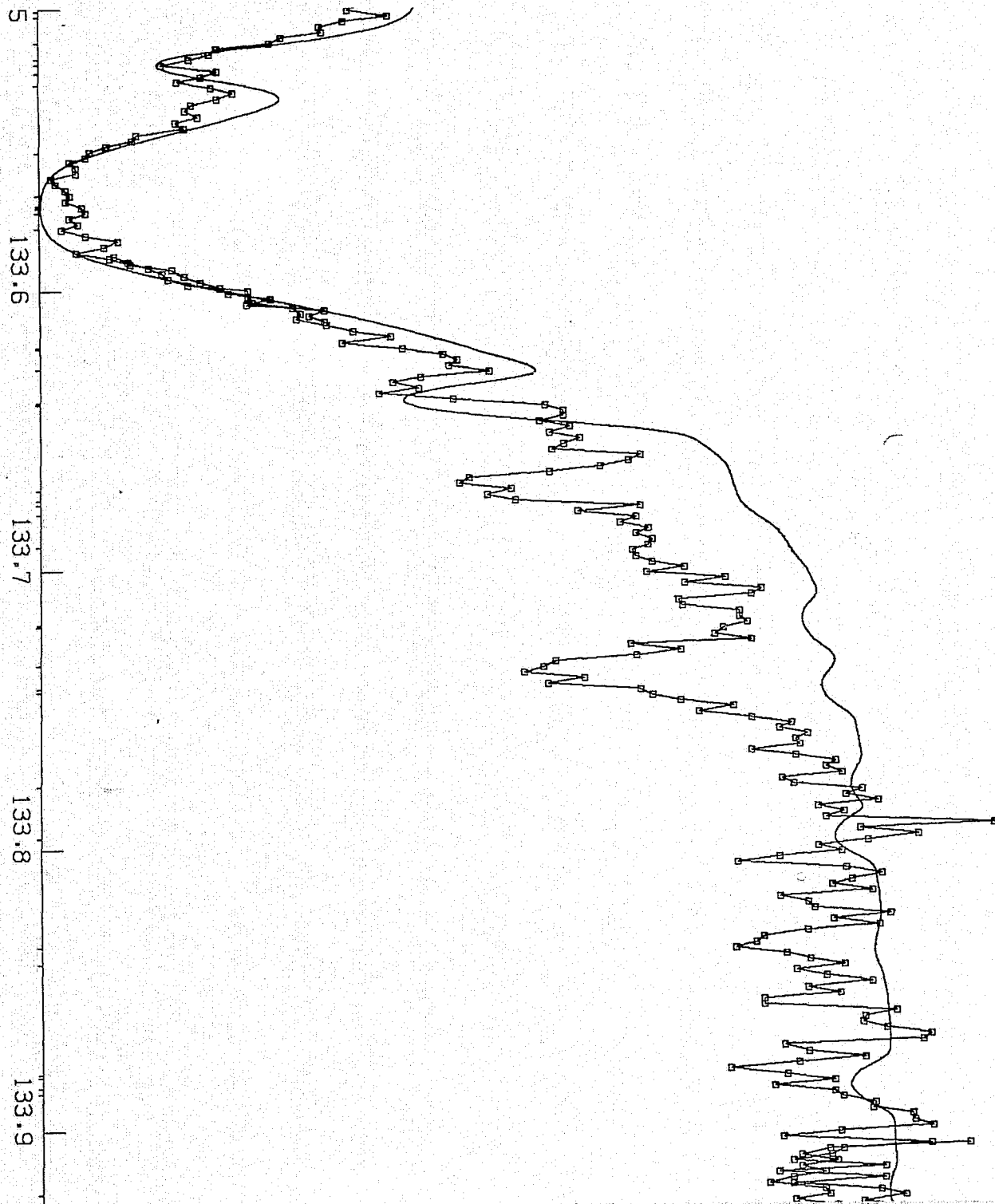
84	6.00	16	0	51	23.02	16810	954
123	6.00	16	0	100	6.00	16	0
121	26.02	86847	845	70	28.01	54262	878
						333	26.02 50412 936
477	28.01	55018	982				
600	6.00	43	0	577	6.00	43	0
				581	28.01	54262	891
833	22.02	0	420	838	20.01	13650	1
839	28.01	58705	989	859	28.01	55424	878
996	26.01	8680	803	5	26.02	73727	901
363	26.02	50276	505				
						549	28.01 54262 977
590	25.01	38542	980			701	26.02 50295 849
912	20.01	13710	1	912	20.01	13710	7
						218	24.02 43304 978
						266	28.01 55018 926
						506	25.01 14325 793
						530	24.02 43321 651
2	23.02	16977	452				
157	26.02	73849	975				
712	26.01	18360	68				
767	28.01	54262	912			812	28.01 58705 972
						172	28.01 54262 952

Figure 8 (Continued)



157	26.02	73849	975		
712	26.01	18360	68		
767	28.01	54262	912		
				812	28.01 58705 972
				172	28.01 54262 952
				701	26.02 73935 949
				739	25.01 14593 989
839	26.01	21308	150	814	16.00 0 4
				903	26.01 18360 15
				103	28.01 56075 929
				281	28.01 54557 789
				532	6.01 0 0
844	15.02		0 179		
917	28.02		55952 970		
7	28.02		55406 980	27	26.01 2837 348
122	23.02		16810 495		
201	28.01		1506 0	182	7.00 28839 615
231	26.02		70725 914		
273	25.01		38806 975		
				508	28.02 82277 988
701	28.01		56075 967	663	6.01 63 0
726	17.00		0 0	708	6.01 63 0
				702	28.01 54557 570
				782	28.01 54557 795
196	26.02		63425 937	202	28.01 54557 899
273	25.01		14593 941		

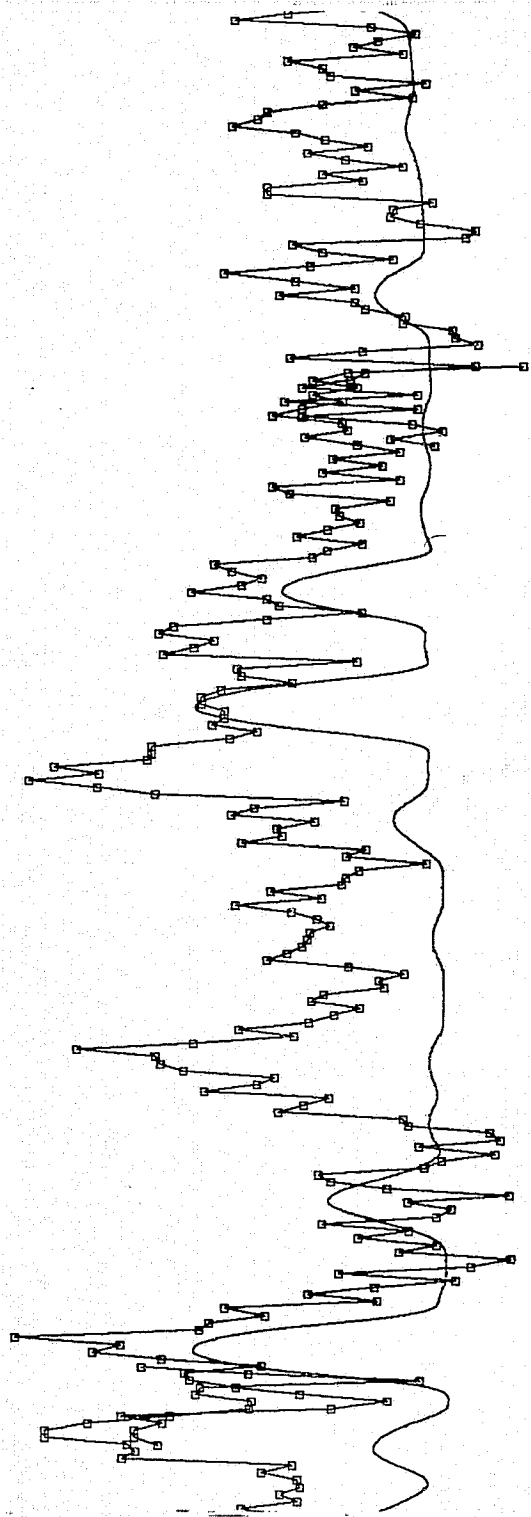
Figure 8 (Continued)



122	23.02	16810	495	27	26.01	2837	346
201	28.01	1506	0	182	7.00	28839	615
231	26.02	70725	914				
273	25.01	38806	975				
				508	28.02	82277	988
701	28.01	58075	967	653	6.01	63	0
726	17.00	0	0	708	6.01	63	0
				702	28.01	54557	570
				782	28.01	54557	795
196	26.02	63425	937	202	28.01	54557	899
273	25.01	14593	941				
394	7.00	28838	371	401	7.00	28839	14
760	28.01	25036	985	708	26.01	21251	939
793	26.02	73849	931	743	26.01	21430	899
911	28.02	82172	960				
191	7.00	28838	912	199	7.00	28839	912
				338	26.01	21581	957
435	26.02	50184	848	422	25.01	14325	987
				773	24.02	43304	900
956	28.01	54557	827	960	28.01	56075	895
				347	26.02	50184	959
407	28.01	57080	977				
797	26.02	63494	976	807	26.02	63494	986
843	28.01	23108	763	867	28.01	56075	947
				223	28.01	57080	952

Figure 8 (Continued)



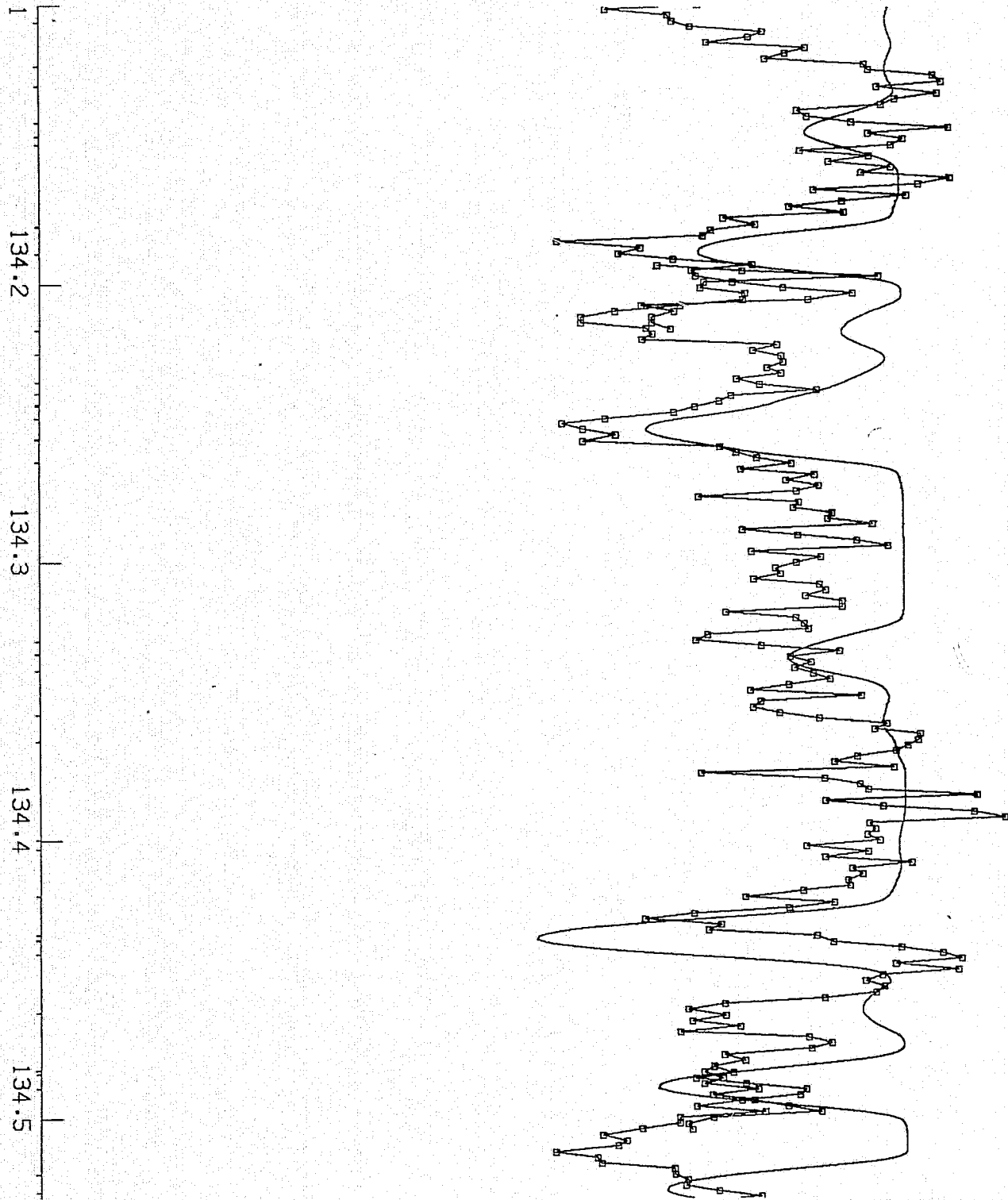


497 28.01	57080 977	347 26.02	50184 959
797 26.02	63494 976	607 26.02	63494 986
643 28.01	23108 763	867 28.01	56075 947
		223 28.01	57080 952
395 28.01	56371 973		
490 28.01	56075 938	451 26.01	21581 989
		693 22.02	8472 360
		823 26.02	63466 950
912 26.01	21430 956		
9 28.01	53365 849	28 26.01	3117 43
194 28.01	56075 973	189 26.02	63486 958
326 26.02	50295 924	296 26.02	83646 987
		375 28.01	57080 829
		695 26.02	63466 948
62 26.01	21711 918	61 26.02	63486 986
		223 26.02	50295 932
		295 28.02	56308 986
470 14.02	142944 777	421 28.02	55406 810
		500 14.02	142948 920
792 26.01	21711 928		
		890 20.01	0 27
161 28.02	55406 723		
247 28.01	53365 910		
		349 14.02	142944 972

Figure 8 (Continued)

3  
133.9  
134.0  
134.1  
134.2

.44

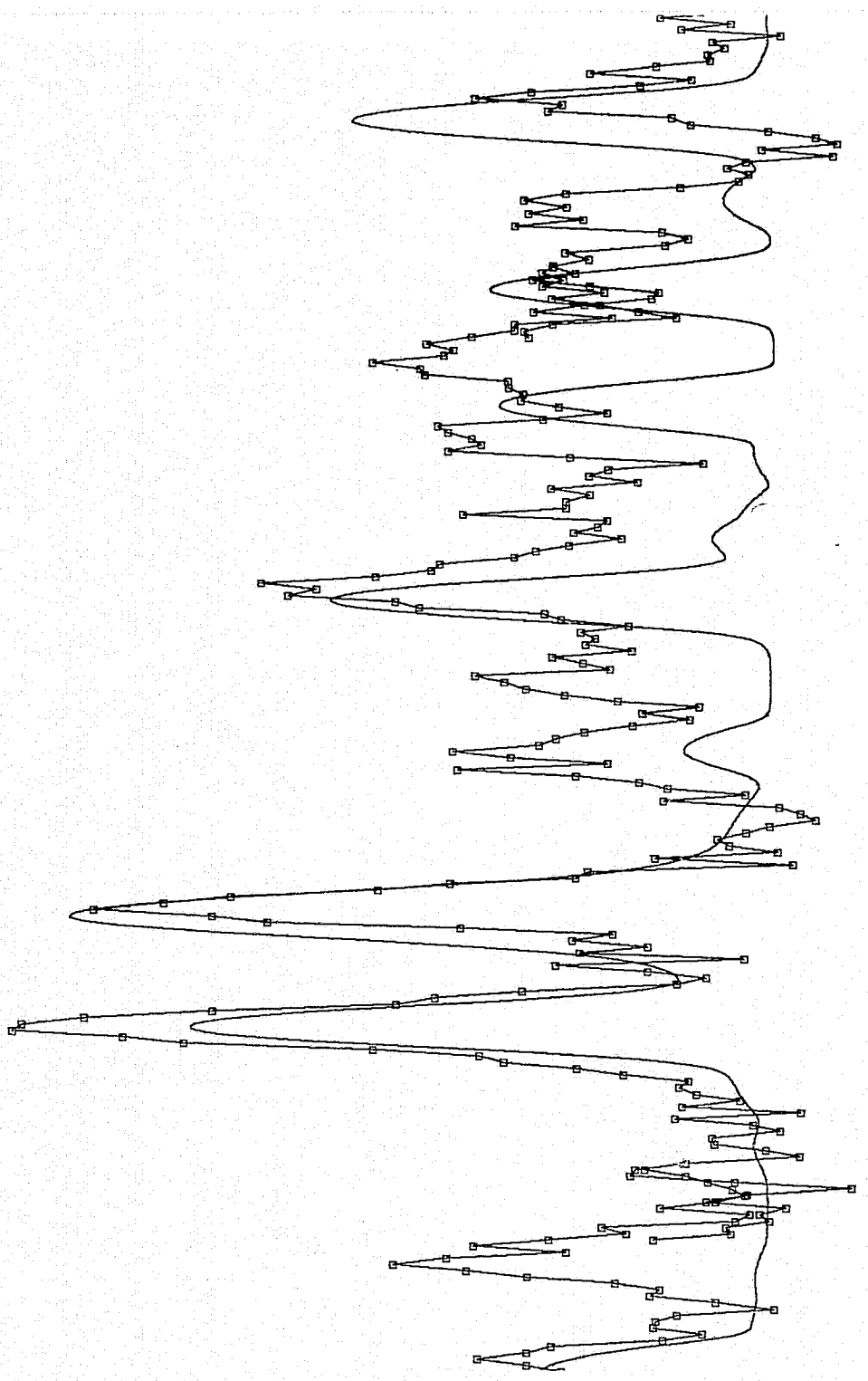


62	26.01	21711	918	61	26.02	63486	986
				223	26.02	50295	932
				295	28.02	56308	988
				421	28.02	55406	810
470	14.02	142944	777	500	14.02	142946	820
				792	26.01	21711	928
				890	20.01	0	27
161	28.02	55406	723				
247	28.01	53365	910				
				349	14.02	142944	922
				389	14.02	142946	825
430	14.02	142948	923	433	26.02	50412	958
478	26.02	57221	535				
551	25.01	14593	884	554	20.01	0	39
633	26.01	21581	962				
				283	28.01	56371	953
				330	26.01	18886	691
				332	26.02	50412	708
390	14.02	142948	860	390	14.02	142946	924
				546	28.01	56371	877
644	28.01	55417	936				
997	26.02	43148	983	29	26.02	84159	984
197	28.01	56371	968				
				353	25.01	32787	517
407	28.01	25036	984	357	15.02	559	156
				617	28.01	53496	737
836	28.02	62606	986	825	28.01	56371	982
890	15.02	559	310				
197	26.02	63425	983				
				262	26.01	18360	11

Figure 8 (Continued)

134.5  
134.6  
134.7  
134.8

46



				29 26.02	84159 984
197	28.01	56371	968		
353	25.01	32787	517	337 28.01	56371 983
407	28.01	25036	984	357 15.02	559 156
				617 28.01	53496 737
836	28.02	62606	996	825 28.01	56371 982
890	15.02	559	310		
197	26.02	63425	983		
				262 26.01	18960 11
				341 28.01	57420 985
				416 28.01	23795 853
608	25.01	32856	834		
642	25.01	32858	972	649 26.02	70725 963
716	26.02	70728	793		
878	28.01	0	0		
944	26.02	63466	941	937 25.01	14781 925
358	26.02	70694	674	334 28.01	55018 965
				578 25.02	68899 940
884	14.01	42932	4		
				987 26.02	70728 957
240	17.00	0	0		
446	23.02	28746	913		
644	28.01	55299	986	618 25.02	68892 952
				19 26.02	87901 959
114	25.01	14901	980		
				335 28.01	82108 117

Figure 8 (Continued)

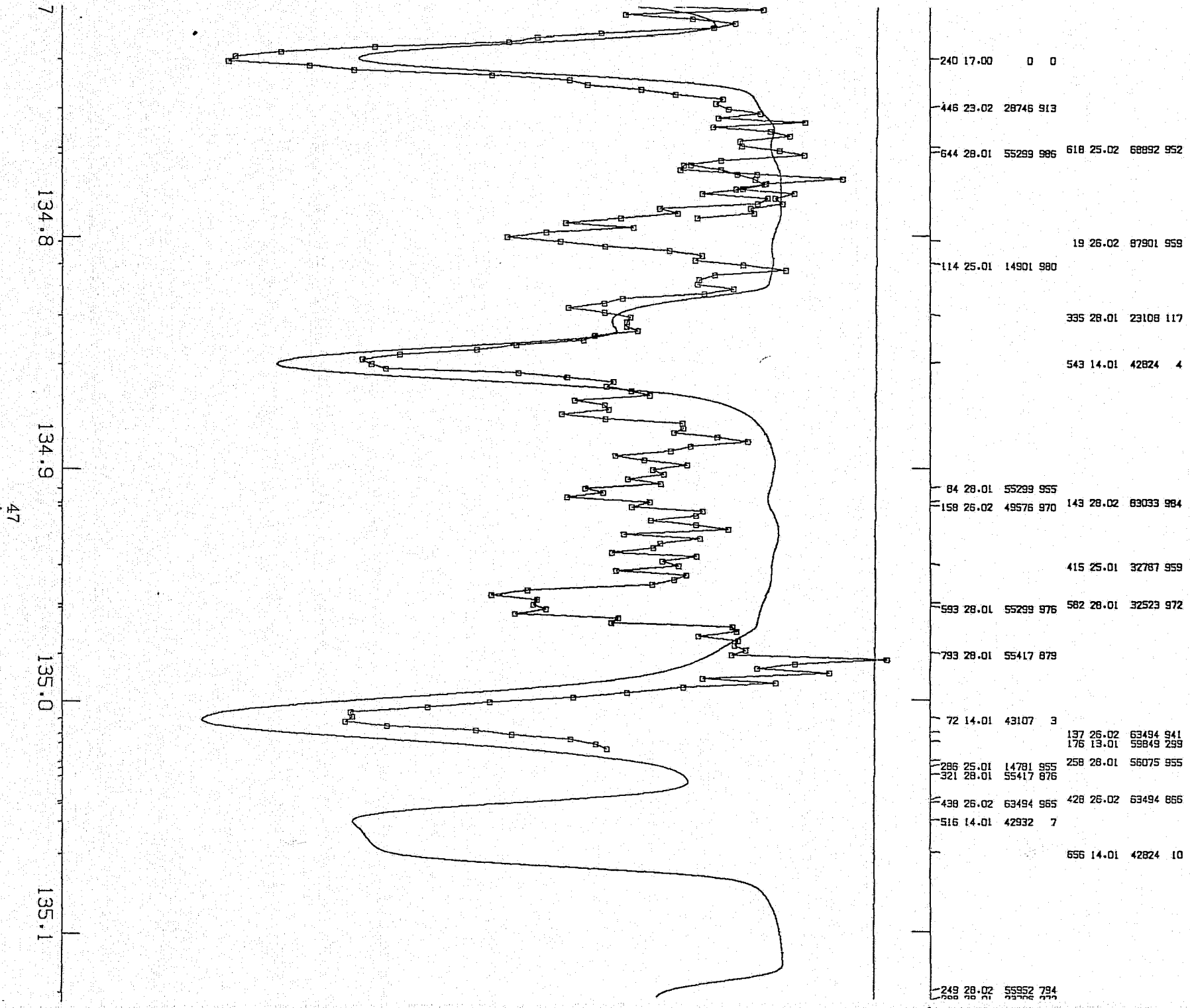
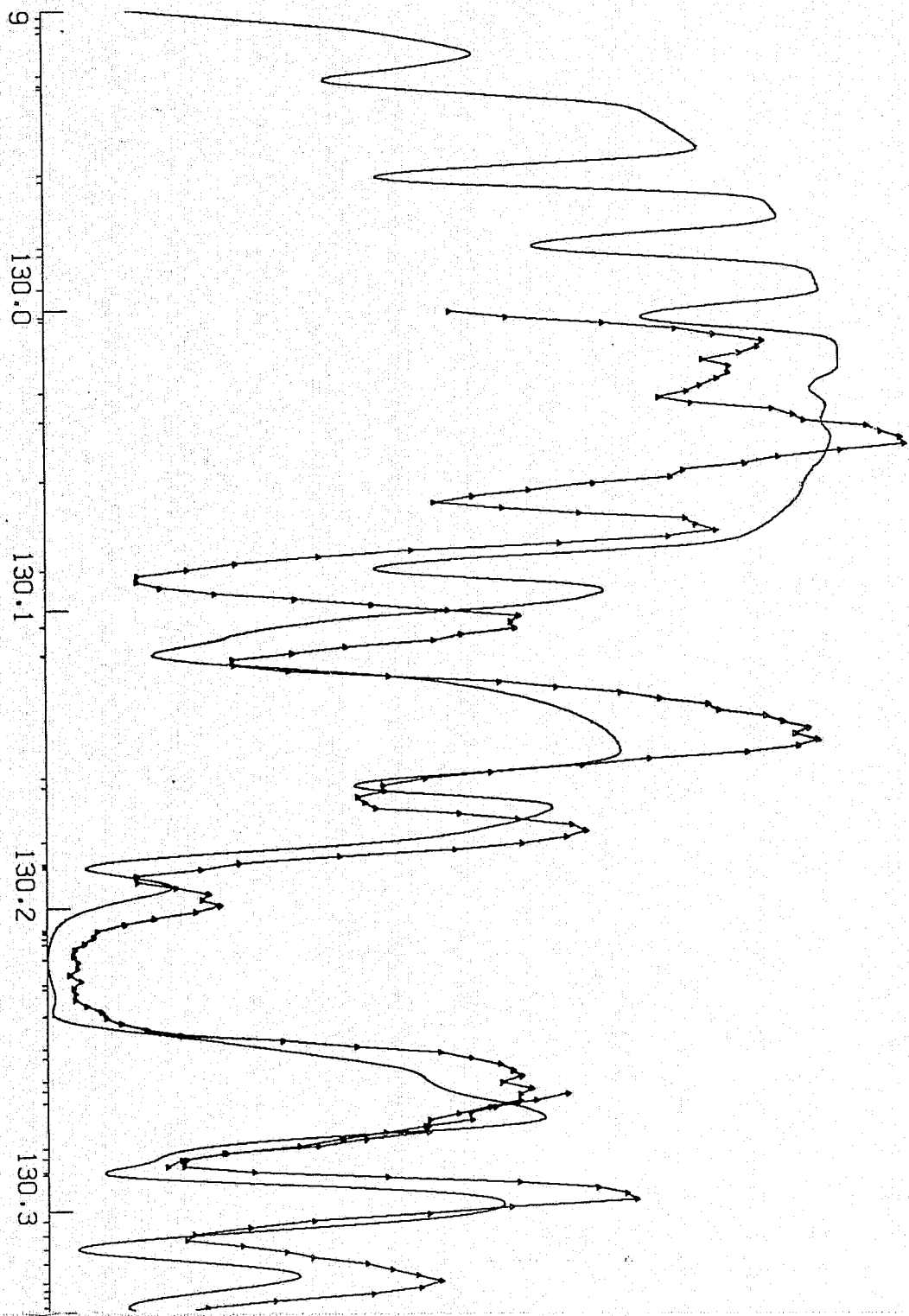


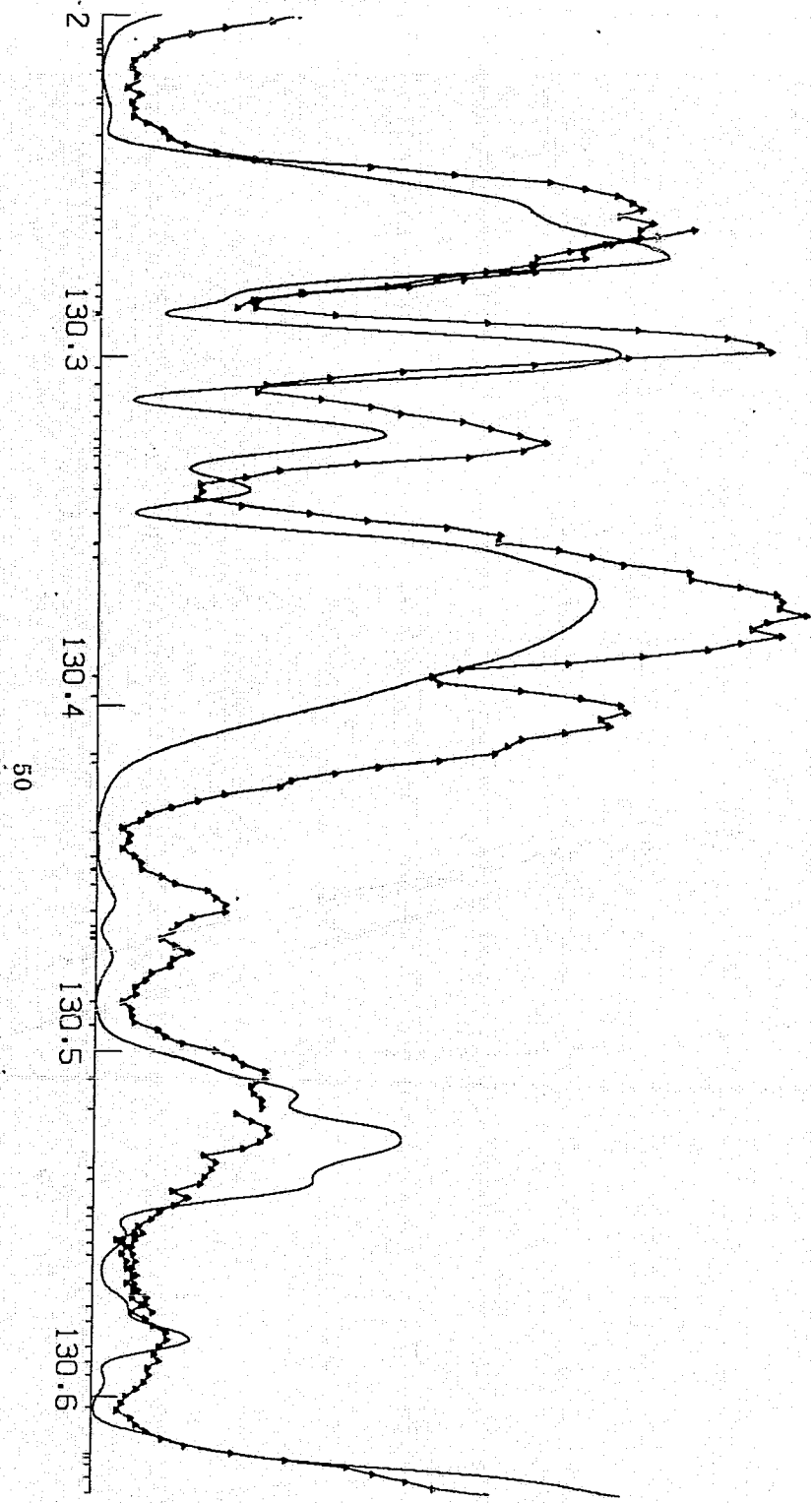
Figure 8 (Continued)

Figure 9. Calculated spectrum for Sirius compared to the observations with identifications. See Figure 8 for an explanation.



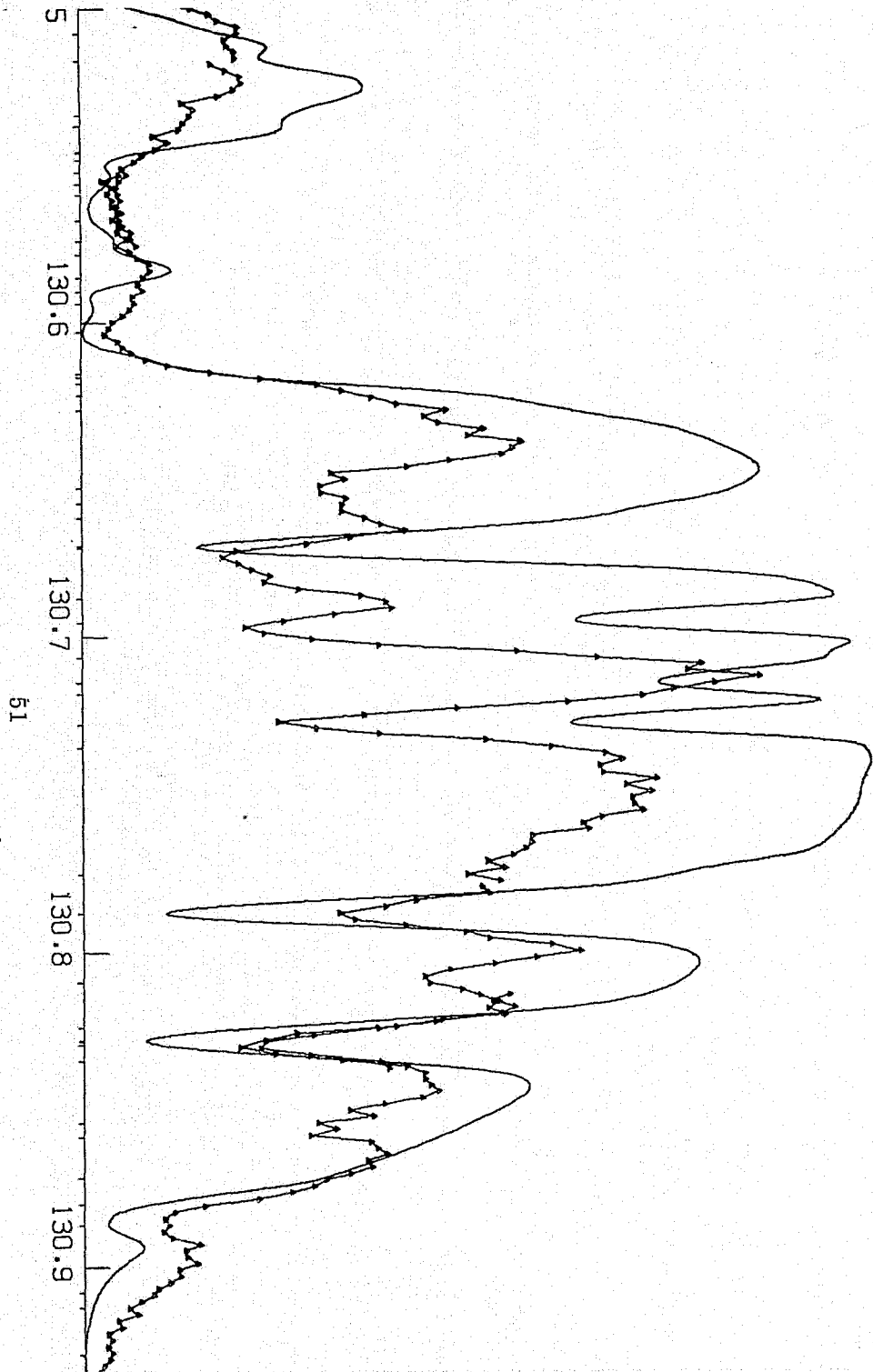
71	23.02	11966	613	22	24.02	20702	480
				52	24.02	17395	778
265	28.01	24788	128	220	28.01	53601	177
				253	23.02	11591	413
567	27.01	3950	12	543	28.01	53037	289
				788	7.01	15316	298
				814	7.01	15316	790
929	26.02	73727	978				
35	7.01	15316	462	21	26.02	93388	794
				268	26.02	70728	820
366	26.01	2430	920				
565	26.02	70725	946				
				866	14.01	76665	105
				55	25.01	29889	22
151	26.01	2430	863	160	14.02	52853	21
562	25.01	29919	834				
595	14.01	76665	165				
				778	25.01	29889	898
859	15.01	0	0	852	26.02	49576	138
				866	28.01	23796	461
75	26.02	89697	617	83	26.02	83237	932
102	25.01	29951	213	118	26.02	93512	475
168	8.00	0	0				
248	28.01	28070	586	283	23.02	11789	890
353	16.00	396	0				
				484	28.01	55018	828
				493	28.01	29593	935
603	28.01	54252	888	572	26.02	63425	978
643	24.02	20851	871				
792	26.01	15844	3	823	24.02	17272	880
877	16.00	396	0	869	26.02	92523	554
31	26.01	53037	933				
80	28.01	52738	334				
123	16.00	396	0				
172	28.01	52738	556	172	28.01	23108	800
237	28.01	55018	850				
285	28.01	57060	903	261	28.01	53601	380
320	14.02	53115	19				

Figure 9 (Continued)



75	26.02	89697	617	89	26.02	83237	932
102	25.01	29951	213	118	26.02	93512	475
168	8.00	0	0				
248	26.01	29070	586	263	23.02	11769	890
353	16.00	396	0				
				464	28.01	55018	828
				493	28.01	29599	935
603	28.01	54262	688	572	26.02	63425	978
643	24.02	20851	871				
792	26.01	15844	3	823	24.02	17272	880
877	16.00	396	0	859	26.02	92523	594
91	28.01	53097	933				
80	28.01	52738	334				
129	16.00	396	0				
172	28.01	52738	555	172	28.01	23108	800
237	28.01	55018	850	261	28.01	53601	380
285	28.01	57080	903				
320	14.02	53115	19				
448	16.00	0	0	378	25.02	90483	827
536	26.02	89783	894	535	30.02	141327	962
				575	26.02	70694	571
914	28.02	61339	811				
				972	29.01	69867	972
165	26.02	70728	568	138	26.02	83358	973
366	14.01	0	0				
437	26.02	90423	964				
471	15.00	0	467				
517	24.02	20702	964	475	15.01	164	0
595	28.01	55018	499				
640	20.01	13650	1	657	28.01	32499	903
658	15.01	164	0	672	28.01	57420	949
677	26.02	62606	549				
857	8.00	158	0				
923	28.01	57420	936				
79	24.02	20994	403	82	28.01	58493	960
				170	28.01	55018	153
				340	28.02	53703	258
				371	25.01	29919	953
455	28.01	53634	785	453	28.01	55018	887
480	15.01	164	0	457	25.02	80486	810
557	29.01	71919	921	520	28.01	29070	927
591	14.01	55325	1				
674	20.01	13710	0	674	20.01	13710	4
				739	25.01	14593	947
				781	26.01	15844	1
				853	26.02	90423	664
				897	16.00	573	0
				937	23.02	28746	276
				28	8.00	226	0
165	25.01	29919	71				
166	25.02	11769	932	174	28.01	52738	950
232	28.01	52738	334				
332	28.01	52738	334				

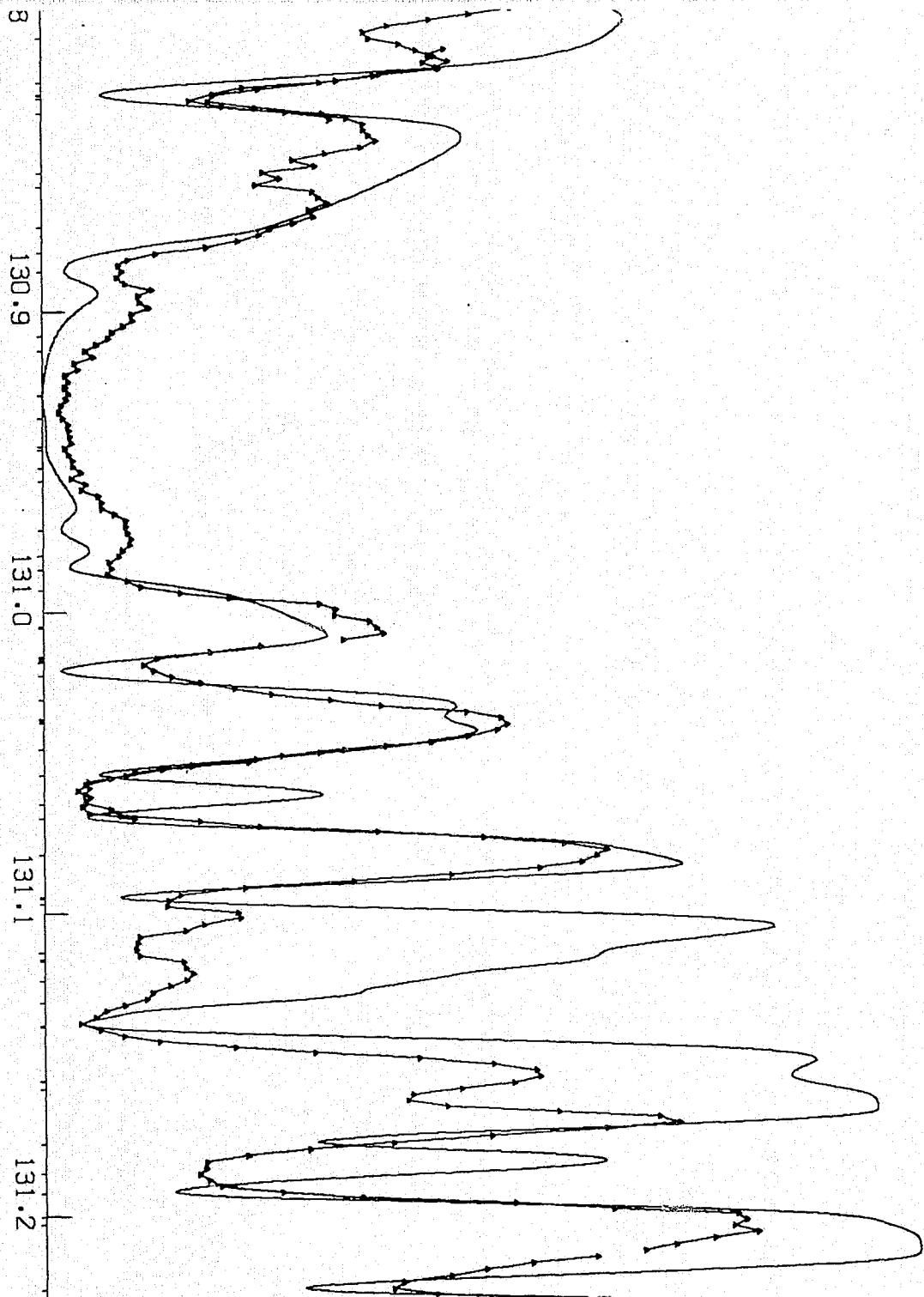
Figure 9 (Continued)



79	24.02	20994	403	82	28.01	58483	880
				170	28.01	55018	153
				340	28.02	53703	258
				371	25.01	29919	953
455	28.01	53634	785	453	28.01	55018	887
480	15.01	164	0	457	26.02	90483	810
557	29.01	71919	921	520	28.01	29070	927
581	14.01	55325	1				
674	20.01	13710	0	674	20.01	13710	4
				738	25.01	14593	947
				781	26.01	15844	1
				853	26.02	90423	664
				897	16.00	573	0
				937	23.02	28746	276
				28	8.00	226	0
165	25.01	29919	71	174	28.01	52738	960
195	23.02	11769	532				
232	28.01	52738	939				
280	28.01	54262	760				
529	28.01	54262	857	577	23.02	28746	777
				621	28.01	52738	468
710	25.01	29951	210	714	12.01	35669	5
875	26.02	90483	974				
952	27.01	4026	35				
				63	24.02	20851	768
				145	28.01	54262	275
				180	28.01	53634	903
277	28.01	54262	119	350	30.02	137866	958
				748	26.02	70694	684
875	12.01	35669	4				
				93	26.01	2837	971
239	26.02	89783	853	279	12.01	35760	18
278	26.02	70725	950	292	29.01	68447	953
281	12.01	35760	4				
342	26.02	70728	648				
				541	26.02	63425	966
				587	24.02	20702	978
716	28.01	58705	954				
801	26.01	2837	5	866	28.01	0	0
79	28.01	57420	874				
126	28.01	53501	911				
273	14.01	287	0				

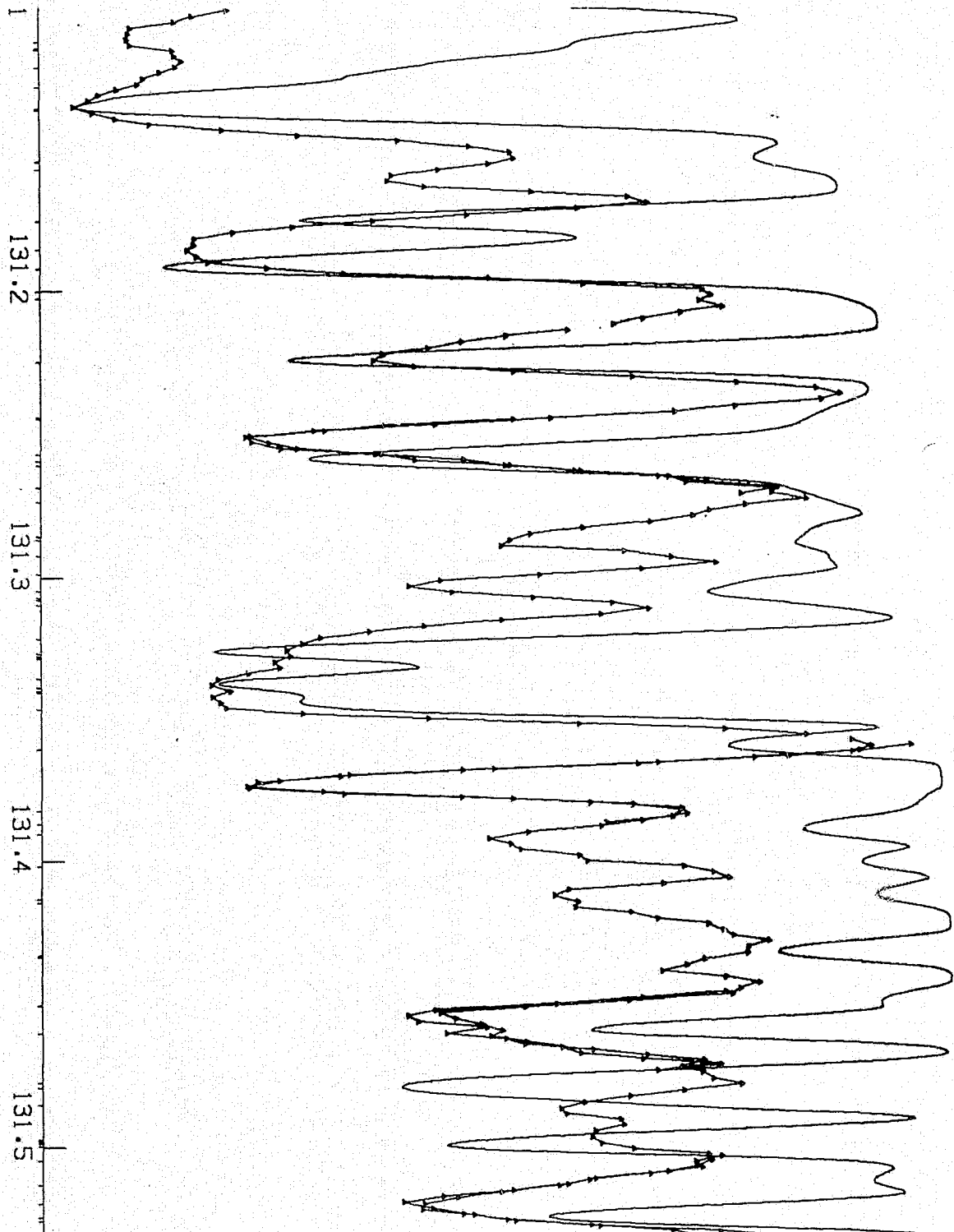
Figure 9 (Continued)





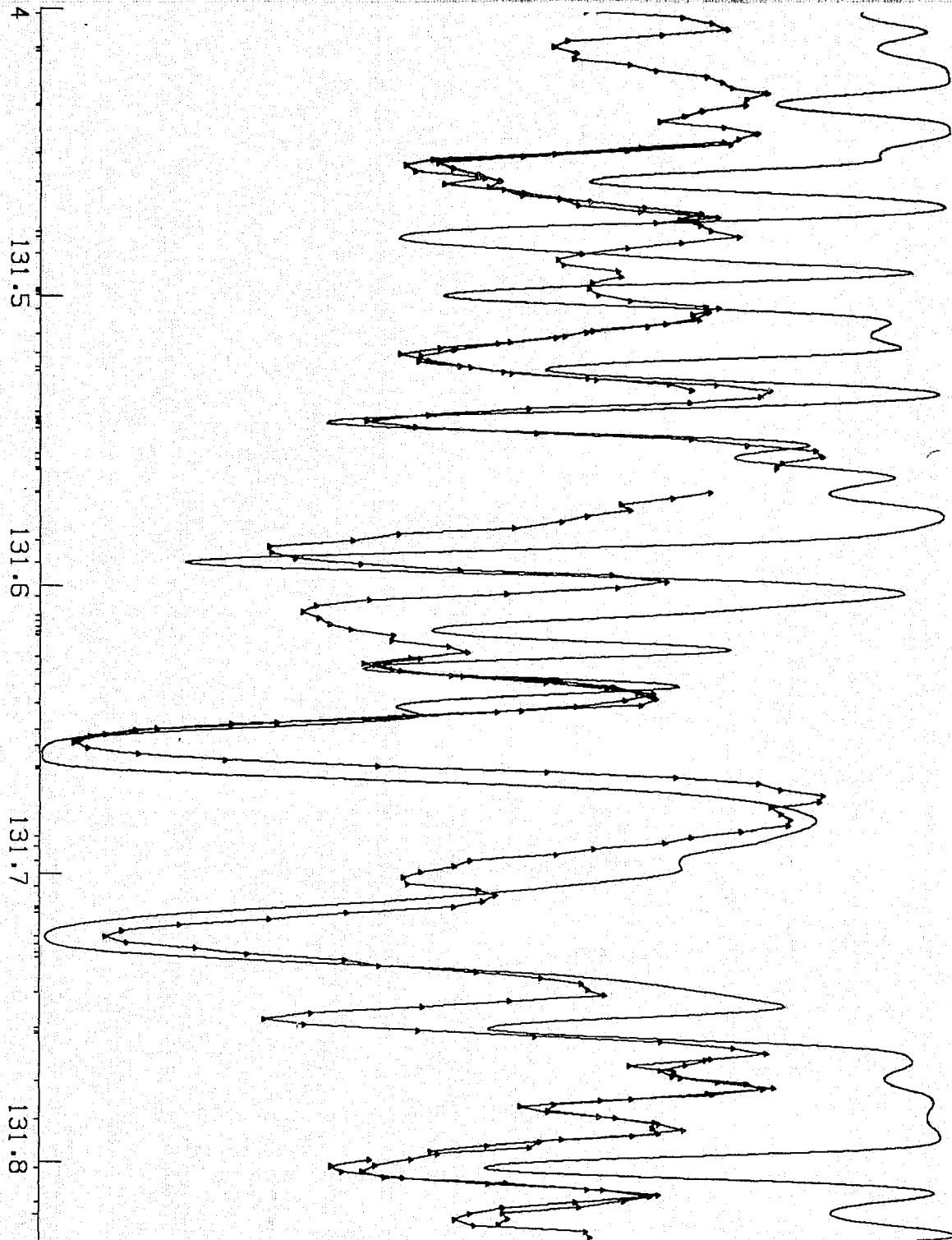
				93	26.01	2837	971
239	26.02	89783	853				
278	26.02	70725	960	279	12.01	35780	18
281	12.01	35780	4	292	29.01	68447	953
342	26.02	70728	648				
				541	26.02	63425	965
				587	24.02	20702	978
716	28.01	58705	954				
801	26.01	2837	5				
				866	28.01	0	0
79	28.01	57420	874				
126	28.01	53601	911				
273	14.01	287	0				
350	24.02	25725	125				
443	12.01	35780	3	453	14.01	55309	2
516	24.02	20994	694				
558	23.02	11866	773				
724	14.01	55325	6				
809	26.02	82382	638				
				857	15.01	469	0
923	26.02	63486	951				
45	26.02	63494	970	51	28.01	55417	908
155	6.00	10192	182	148	26.01	15844	964
166	26.01	16369	174	161	25.01	33147	974
				212	16.00	396	0
357	28.01	57420	904	291	26.02	82410	932
370	26.02	89907	607	361	28.01	57420	758
				370	26.02	89907	810
				457	28.01	51557	216
				541	7.00	28839	1
637	6.00	10192	605				
685	15.01	469	0				
804	23.02	11591	806				
950	7.00	28839	3	944	7.00	28838	1
				966	26.02	89907	695
126	27.01	4028	439	149	24.02	20851	804
153	28.01	55417	691	219	26.01	1872	9
288	26.01	2430	6				
363	6.00	10192	1	369	26.02	92523	718
548	24.02	20851	864	546	28.02	62606	830
				574	28.01	54557	976
758	26.01	16369	2				
924	6.00	10192	2	856	27.01	4560	109
2	24.02	20702	943	26	24.02	18581	917
247	6.00	10192	5				

Figure 9 (Continued)



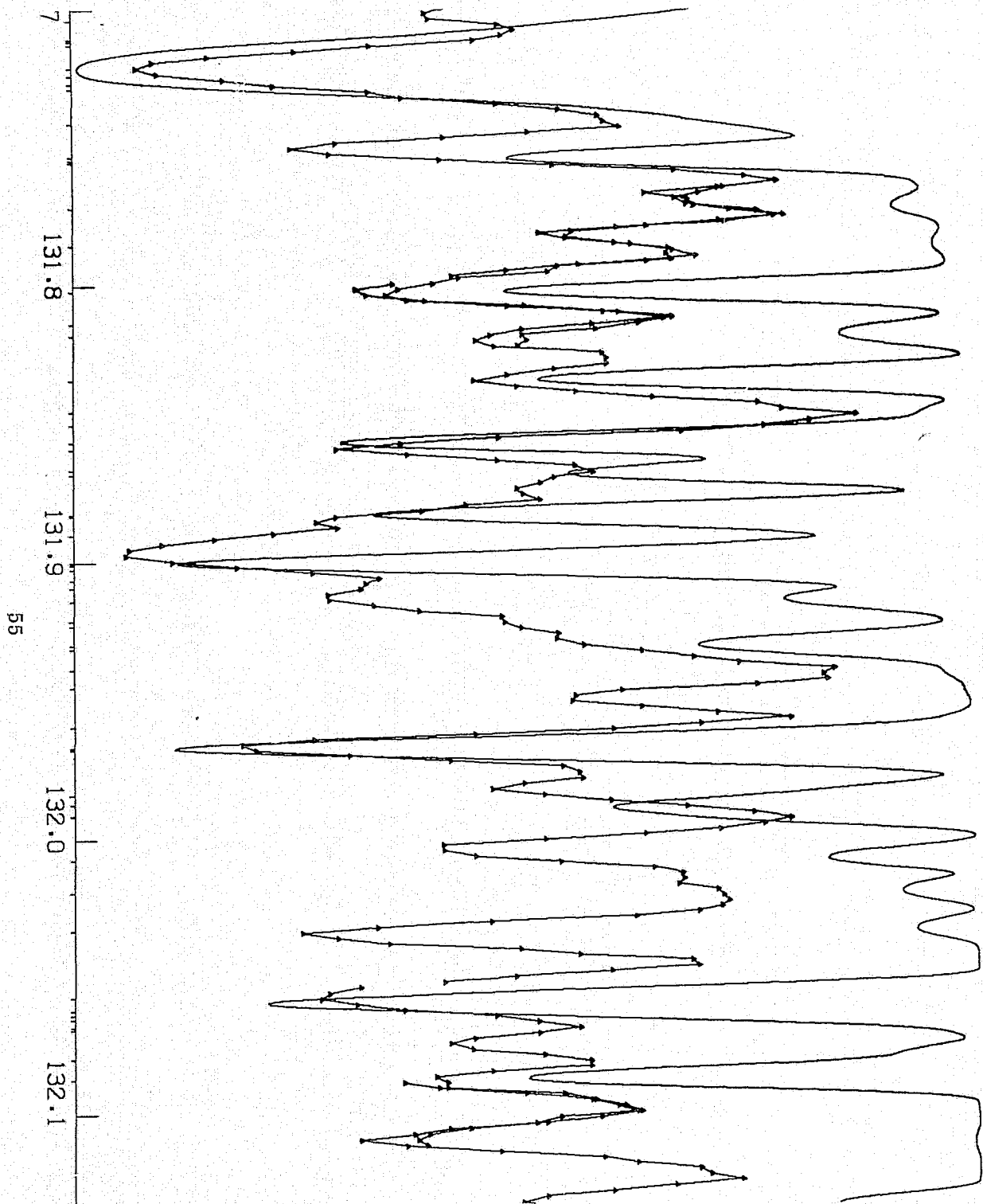
126	27.01	4028	439	149	24.02	20851	804
153	28.01	55417	691				
288	26.01	2430	6	219	26.01	1872	9
363	6.00	10192	1	369	26.02	92523	718
548	24.02	20851	864	545	28.02	62606	830
				574	28.01	54557	976
758	26.01	16369	2				
824	6.00	10192	2	856	27.01	4580	109
2	24.02	20702	543	28	24.02	19801	817
247	6.00	10182	5				
440	28.01	54557	921	445	26.02	63486	848
569	26.02	63494	898				
581	14.02	82884	131	606	23.01	36	875
683	26.02	82382	958	734	23.01	208	838
735	28.01	58493	944				
866	7.00	28839	935	855	5.00	10192	789
921	26.02	70725	760				
45	26.02	63466	549	986	26.02	70728	785
71	7.00	28838	955				
95	26.02	69783	726	78	7.00	28839	965
277	7.00	28838	965	217	28.01	58493	973
				267	16.00	573	0
				283	7.00	28839	965
354	23.02	12187	114	387	6.00	10192	45
398	26.02	63486	790	403	28.01	53365	439
				464	6.00	10192	11
607	26.01	3117	247				
				823	23.01	106	906
				868	23.02	11769	927
				903	28.01	53365	561
				17	24.02	20994	716
144	29.01	70841	979	131	26.02	49576	784
333	28.01	68730	926	332	26.02	63425	591
				604	26.02	60423	781
801	26.02	40989	296				
788	26.01	16369	29	771	28.01	53365	181
848	28.01	53365	174				
879	7.00	28839	965	874	7.00	28838	965
995	15.00	0	6	883	23.01	339	771
				45	26.02	63466	743
129	26.02	63425	752				
193	26.02	82382	950				
242	26.02	89907	846	242	26.02	89907	795
255	28.01	53365	98				

Figure 9 (Continued)



			17 24.02	20994 716
144 29.01	70841 979	131 26.02	49576 784	
333 29.01	68730 928	332 28.02	63425 551	
		504 28.02	90423 791	
601 26.02	40999 236			
789 26.01	16369 29	771 28.01	53365 191	
848 28.01	53365 174			
979 7.00	28839 965	974 7.00	28839 965	
995 15.00	0 6	983 23.01	339 771	
		45 26.02	63466 743	
129 26.02	63425 752			
193 26.02	82382 950			
242 26.02	89907 946	242 26.02	89907 795	
255 28.01	53365 98			
397 26.02	63486 952	414 26.02	89697 845	
416 27.01	4950 273	430 7.00	28839 55	
436 7.00	28839 75	452 24.02	25725 421	
559 28.01	55018 643	540 26.02	90483 674	
590 23.01	208 854	597 24.02	20702 969	
673 28.01	53496 929	679 26.02	82410 692	
842 26.02	63466 845			
918 6.00	10192 2			
36 7.00	28839 965			
120 25.02	68899 861	101 27.01	4580 351	
157 25.01	38366 942	139 25.01	38366 965	
169 25.01	38366 948	166 26.02	50412 157	
246 28.01	54282 957			
		291 7.00	28839 15	
		344 26.01	8391 977	
408 24.02	25781 154			
557 16.00	0 0	501 28.01	54176 674	
637 16.00	0 1	628 16.00	0 0	
		869 26.02	40999 875	
		905 26.02	65783 854	
955 28.01	53365 544			
45 28.01	53496 518			
114 28.01	55018 819	122 28.01	53496 474	
134 26.02	82494 931	217 28.01	0 0	
244 26.01	7955 940	290 26.01	7955 352	
271 23.02	11966 141			
409 28.01	53365 862			
545 26.01	20340 938	531 28.01	53496 154	
		552 26.02	40999 460	
717 26.02	93388 865			
		851 28.02	62606 953	
		19 28.01	53496 49	
		136 24.02	18510 967	
		180 27.01	5204 522	

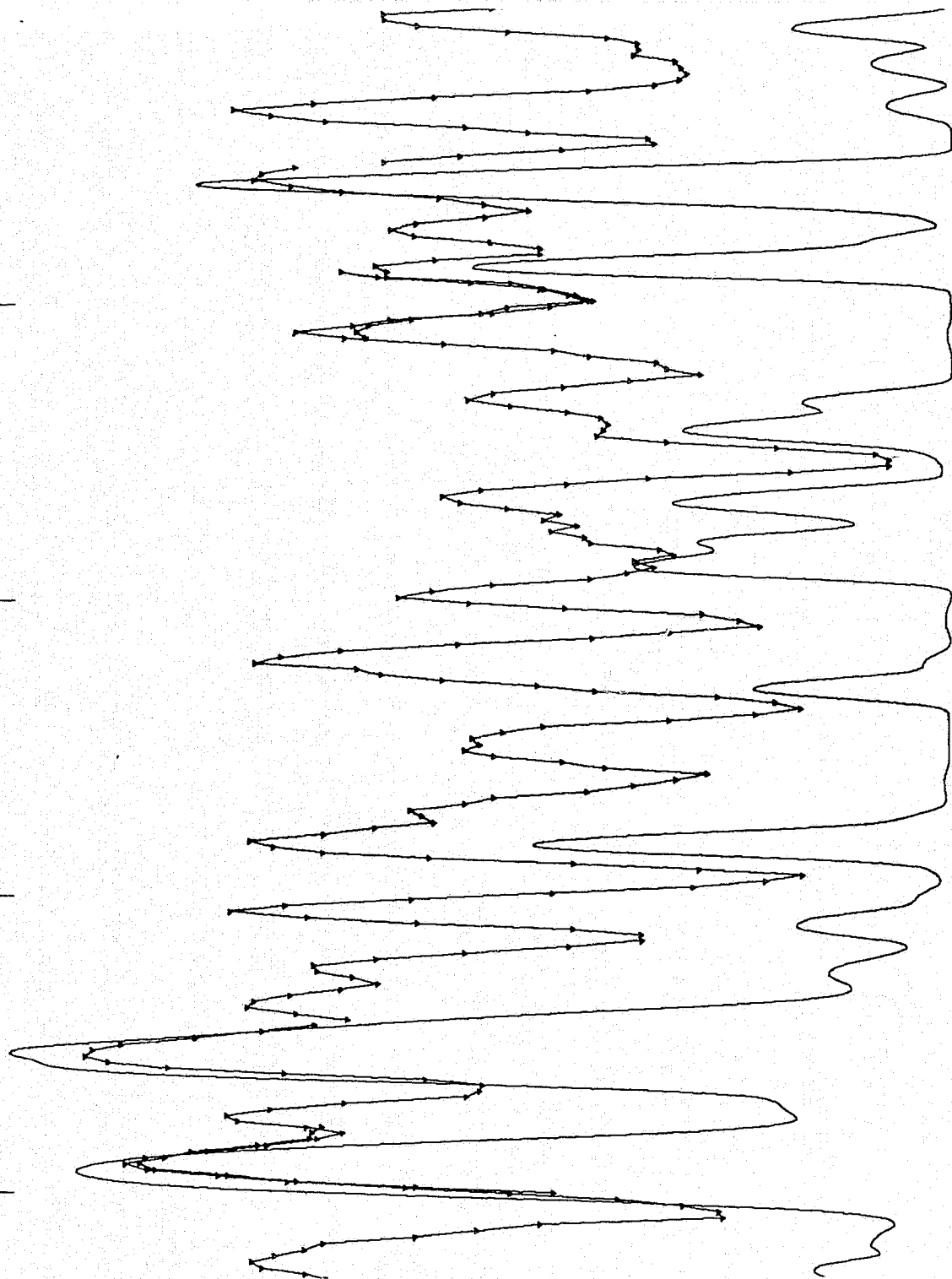
Figure 9 (Continued)



45	28.01	53496	518				
114	28.01	55018	819	122	28.01	53496	474
134	26.02	82494	931				
244	26.01	7955	940	217	28.01	0	0
271	23.02	11966	141	290	26.01	7955	352
409	28.01	53365	862				
545	26.01	20340	938	531	28.01	53496	154
				552	26.02	40999	480
717	26.02	93388	865				
				851	28.02	82606	953
				18	28.01	53496	48
				136	24.02	18510	987
				180	27.01	8204	522
				339	28.01	2837	7
				454	26.02	82410	923
				501	7.00	28839	828
564	26.01	20516	3	588	27.01	4950	388
680	15.00	0	22	665	25.01	38542	907
823	7.00	28838	9	830	7.00	28839	965
				899	28.01	24788	567
999	7.00	28839	2	6	7.00	28839	4
25	15.00	0	26	64	26.02	89907	969
				92	30.02	140654	820
				141	26.02	49148	512
228	25.01	38542	972	211	25.01	38542	927
310	28.01	55018	503	296	26.02	73727	509
				381	24.02	18581	893
447	26.02	42896	967				
592	28.02	63472	906				
677	7.00	28839	2	670	7.00	28838	3
838	27.01	5204	523				
871	26.02	93512	676				
911	26.01	20516	202	914	26.02	82494	753
71	24.02	43286	568				
192	28.01	55018	740				
334	27.01	4560	949	331	26.02	90483	844
				577	26.01	3117	5
638	28.01	56075	897	623	26.01	20340	11
681	29.01	70841	932	655	26.01	16359	960
				692	24.02	25725	954
798	28.01	55018	712				
874	26.01	2430	5				

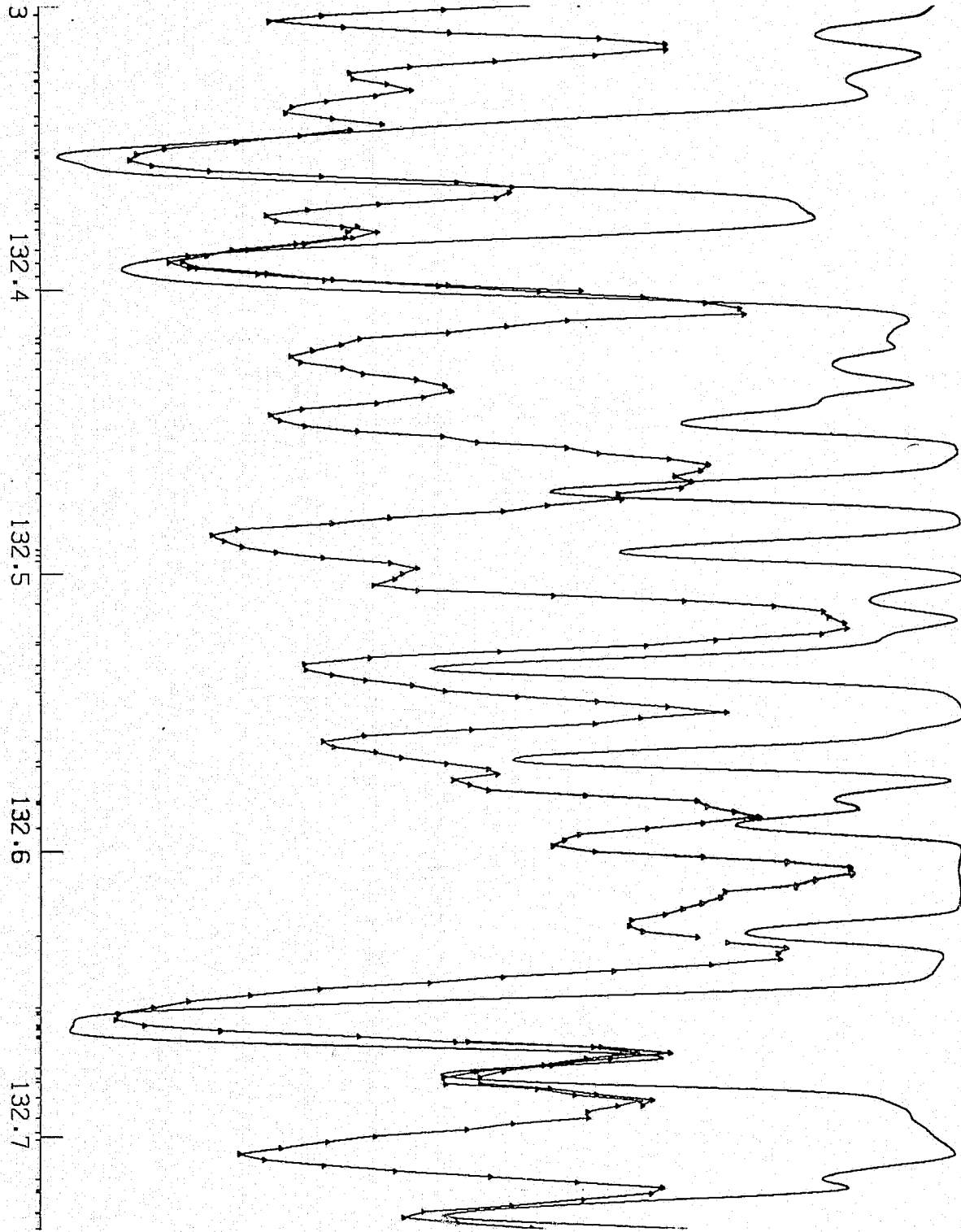
Figure 9 (Continued)

132.1  
132.2  
132.3  
132.4



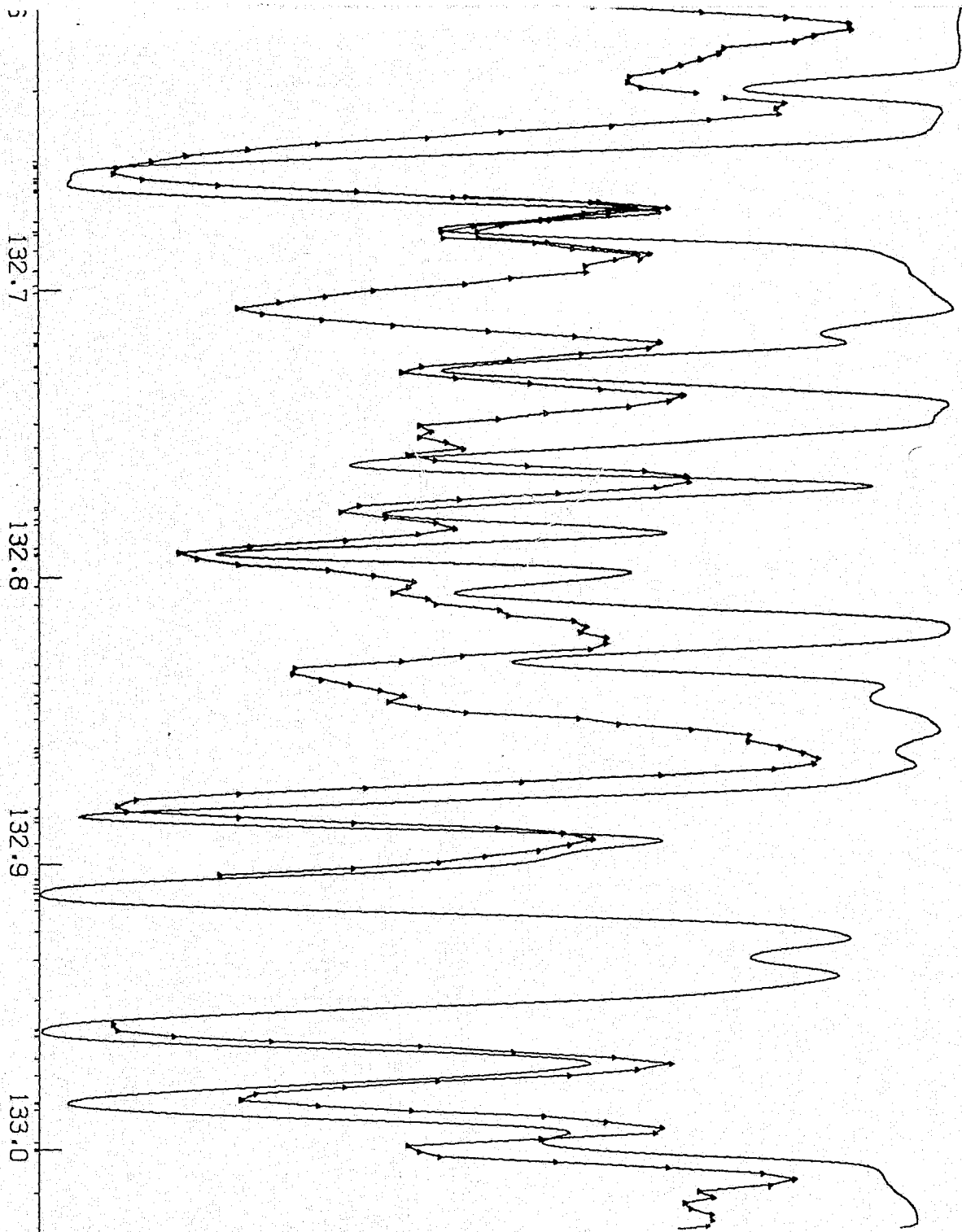
71	24.02	43286	568		
192	28.01	55018	740		
334	27.01	4560	949	331	26.02 90483 844
638	28.01	56075	897	577	26.01 3117 5
681	29.01	70841	932	623	26.01 20340 11
				655	26.01 16369 960
				692	24.02 25725 954
798	28.01	55018	712		
874	26.01	2430	5		
				332	28.02 61339 622
425	15.00	0	677	414	26.02 73849 639
482	28.01	55018	904	432	28.01 56075 644
563	26.02	84369	980		
				655	24.02 25781 428
				704	28.01 53634 601
791	29.01	70841	965	804	28.02 54657 443
889	26.01	2837	76		
				65	23.01 208 979
				221	25.02 68892 916
				304	28.02 61339 530
767	26.02	82382	861		
830	24.02	25848	193	828	28.01 56075 675
877	27.01	4950	906		
				28	27.01 5204 910
				107	28.01 54262 575
230	28.01	25036	919	258	26.02 82410 869
264	25.01	38806	845	304	26.02 83161 971
				387	26.02 57221 956
				419	28.01 56075 282
521	16.00	395	0	501	30.02 142483 963
605	26.01	20805	5	530	16.00 395 0
711	28.01	56075	979	696	26.02 42896 865
758	25.01	38806	832	789	29.01 73101 977
				862	6.01 74932 212
				906	6.01 74932 58
951	6.01	74930	43		
996	6.01	74930	212		
167	24.02	18510	875	183	25.01 34910 955
				218	28.01 55299 928

Figure 9 (Continued)



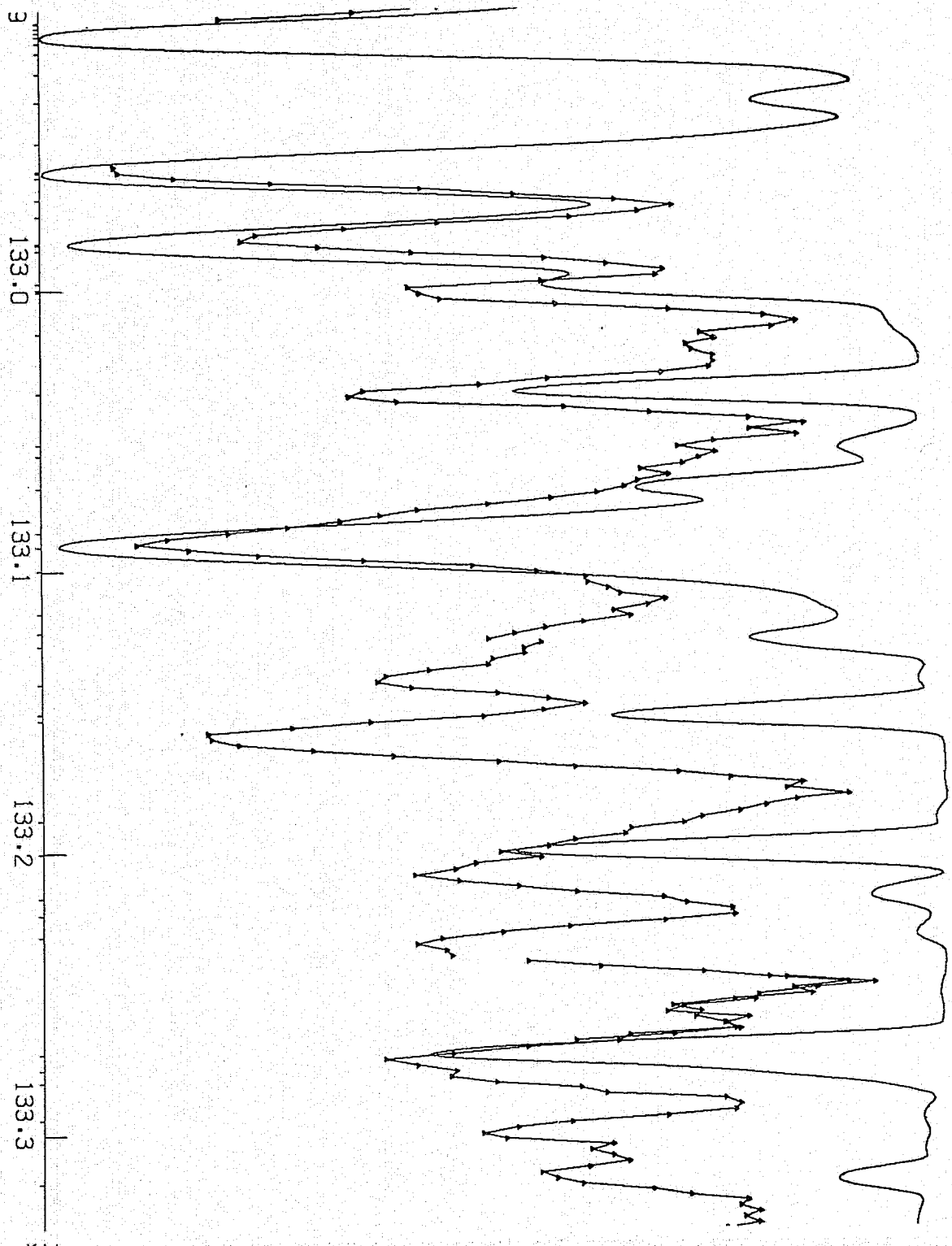
				28 27.01	5204 910
				107 28.01	54262 575
230	28.01	25036 919	258 26.02	82410 869	
264	25.01	38806 945	304 26.02	83181 971	
			387 26.02	57221 956	
			419 28.01	58075 282	
521	16.00	395 0	501 30.02	142483 963	
			530 16.00	395 0	
605	26.01	20805 5			
711	28.01	58075 979	696 26.02	42896 665	
758	25.01	38806 832	789 29.01	73101 977	
			862 6.01	74932 212	
			906 6.01	74932 58	
951	6.01	74930 43			
996	6.01	74930 212			
167	24.02	18510 875	183 25.01	34910 955	
			218 26.01	55299 928	
273	26.01	8846 551			
			347 23.01	339 952	
395	28.02	63472 644			
474	28.01	55299 244			
843	26.02	83237 936			
715	26.02	50184 208			
912	26.01	8391 607	932 26.02	40999 377	
951	25.01	14325 819			
			107 28.01	55299 685	
243	28.01	55299 751	251 29.01	73101 977	
327	26.02	50184 431			
357	28.01	55299 81			
			423 24.02	18581 970	
601	26.02	57221 787			
675	26.01	20805 13	692 28.01	29070 882	
823	28.01	58371 918	818 28.02	82606 893	
			830 28.02	83138 838	
817	26.02	40599 428			
			294 28.01	55417 371	
585	7.00	28838 9	550 28.01	55417 306	
608	26.02	40999 644	571 7.00	28839 3	
624	28.01	56371 434	619 28.02	63472 751	
649	16.00	573 0	647 26.02	49578 735	
			654 26.02	50295 698	
757	28.01	56424 966			
792	26.01	3117 5	805 27.02	55729 960	
			858 26.02	84671 818	
			931 26.02	50276 885	
9	23.02	12187 965	985 14.02	159069 972	
191	28.01	58705 893	147 26.02	42896 684	
			185 28.01	55417 921	
267	26.02	50295 200	263 26.02	57221 425	
322	28.01	55417 971			

Figure 9 (Continued)



				294 28.01	55417 371
565	7.00	29836	9	550 28.01	55417 306
566	26.02	40399	644	571 7.00	26839 3
574	28.01	56371	434	619 28.02	63472 751
649	16.00	573	0	647 26.02	49576 735
				654 26.02	50295 698
757	28.01	56424	966		
792	26.01	3117	5	805 27.02	55729 960
				858 26.02	84671 818
9	23.02	12187	965	931 26.02	50276 885
				985 14.02	159069 972
191	28.01	59705	893	147 26.02	42896 684
				185 28.01	55417 921
267	26.02	50295	200	263 26.02	57221 425
322	28.01	55417	271		
				465 25.01	38366 917
				545 26.02	49576 367
				614 22.02	8472 11
754	28.01	56371	164	764 24.02	18451 889
797	28.01	55417	781	797 26.01	2430 210
813	24.02	43286	405		
918	7.00	29836	4	900 23.02	27727 436
				924 7.00	26839 7
				28 26.01	2837 18
				92 28.02	54657 308
				302 14.01	76665 176
367	30.02	141327	908		
408	29.01	73353	932	491 26.02	82410 941
436	24.02	43321	799		
595	26.02	93512	971	610 26.02	42896 895
627	28.01	56371	967		
718	26.02	50412	866		
805	24.02	18510	961		
834	6.00	0	0	849 28.01	52738 608
923	28.01	59705	945		
968	28.01	56424	248		
49	28.01	58493	945	51 23.02	16810 659
84	6.00	16	0	100 6.00	16 0
123	6.00	16	0	70 29.01	54262 411
121	26.02	85847	658	158 26.02	50483 926
233	28.01	56424	961		
				333 26.02	50412 61*
477	28.01	55018	858		
600	6.00	43	0	577 6.00	43 0
				581 28.01	54262 444
678	29.01	73353	975		
				738 28.02	82172 679
833	22.02	0	52	836 26.02	63494 974
858	28.01	13650	0	839 28.01	58705 864
859	28.01	56424	408		
996	26.01	8680	387	974 25.02	82494 891
				5 26.02	73727 546
151	26.02	83237	973		

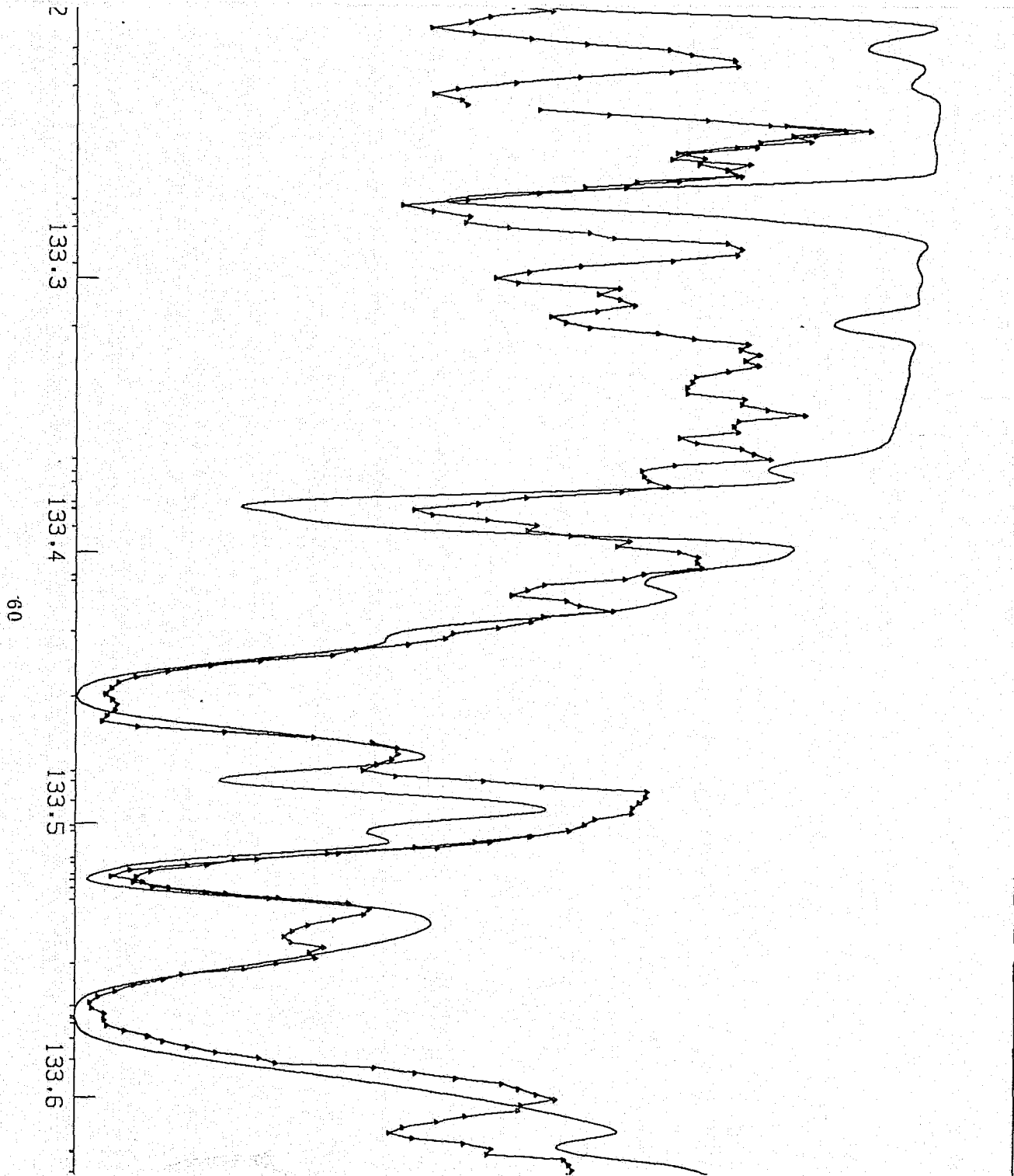
Figure 9 (Continued)



49	28.01	58493	945	51	23.02	16810	858
124	6.00	16	0	100	6.00	16	0
123	6.00	16	0	70	28.01	54282	411
121	26.02	86847	958	158	26.02	80483	826
233	28.01	56424	961				
				333	26.02	50412	614
477	28.01	55018	858				
500	6.00	43	0	577	6.00	43	0
581	28.01	54282	444				
678	29.01	73353	975	738	28.02	82172	879
833	22.02	0	52	836	26.02	63494	874
838	20.01	13650	0	839	28.01	58705	864
859	28.01	56424	408	974	26.02	82494	881
996	26.01	6680	387	5	26.02	73727	546
151	26.02	83237	973				
363	26.02	50276	194				
590	25.01	38542	889	549	28.01	54262	822
				701	26.02	50295	445
859	25.01	14325	975				
912	20.01	13710	0	912	20.01	13710	4
997	26.02	69836	976				
				149	26.02	84369	903
				218	24.02	43304	788
				266	28.01	55018	560
402	28.02	86646	954				
				506	25.01	14325	387
				530	24.02	43321	441
884	29.01	71493	960				
2	23.02	16977	101				
157	26.02	73849	772	216	29.01	71493	939
				295	26.02	83358	901
712	26.01	18360	8	767	28.01	54262	510
766	23.02	12187	928	812	28.01	58705	790
				945	28.01	54262	954
				172	28.01	54262	678

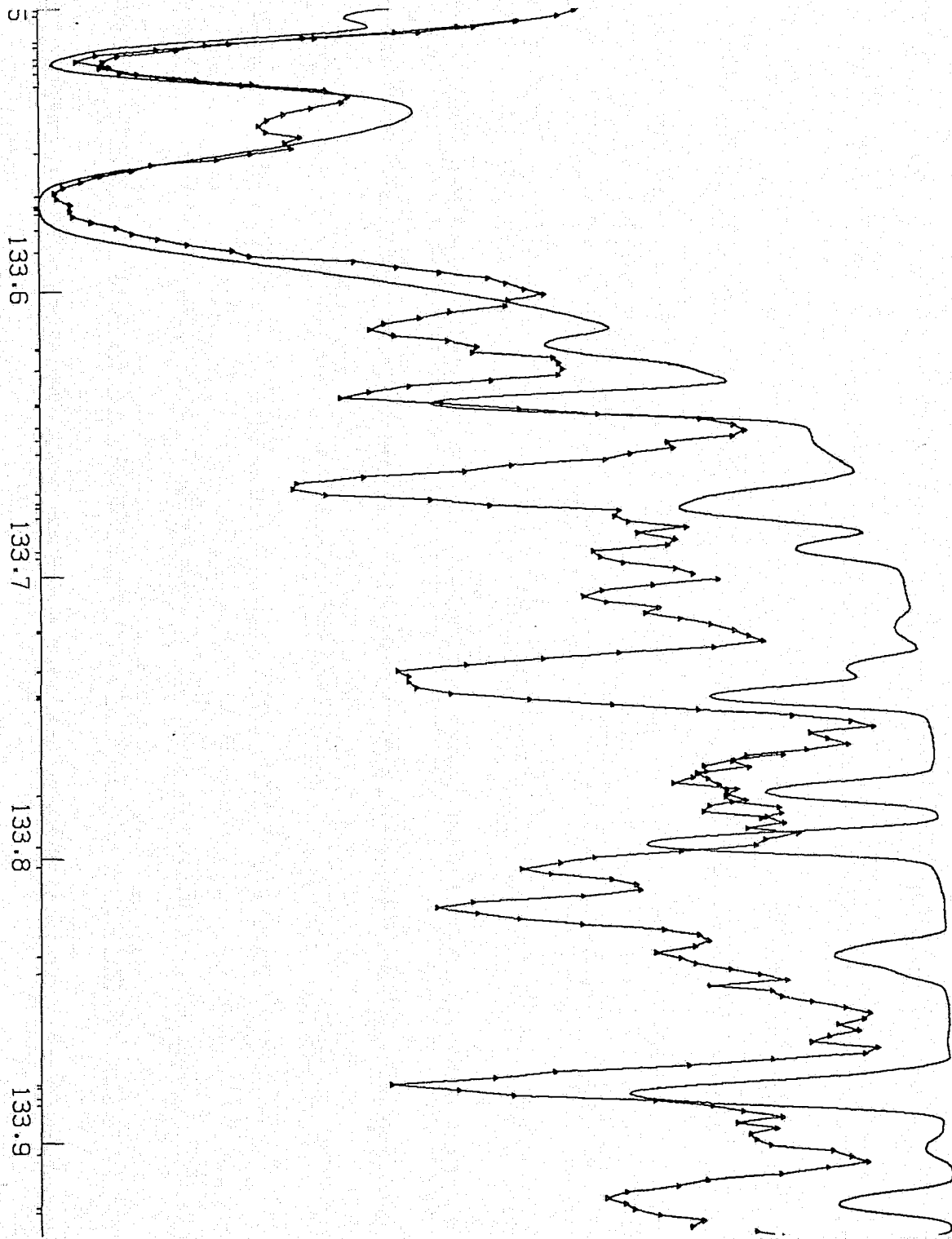
Figure 9 (Continued)





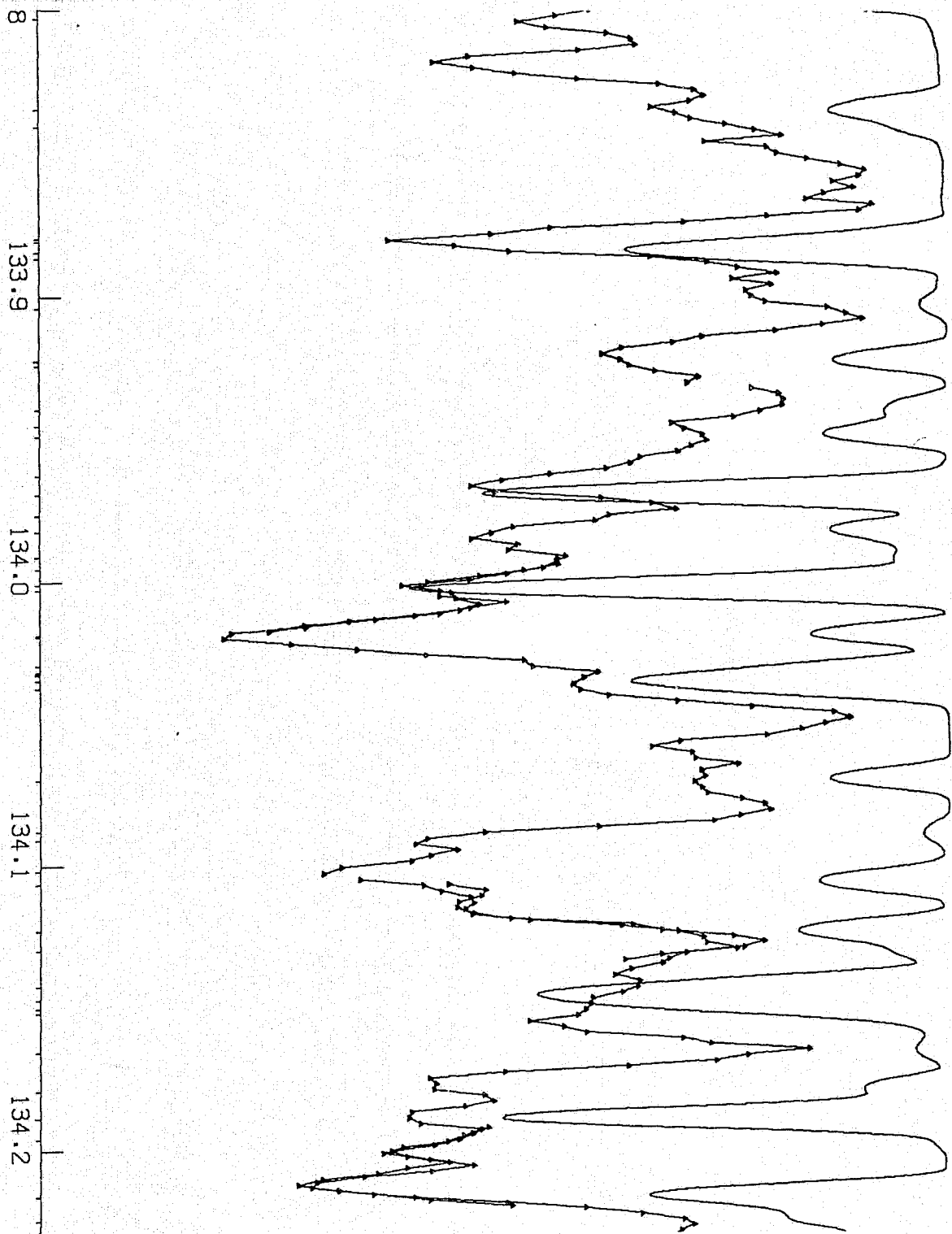
157	26.02	73849	772			
				216	29.01	71493 939
				295	26.02	83358 901
712	25.01	18360	8			
766	23.02	12187	928	767	28.01	54262 510
				812	28.01	58705 790
				945	28.01	54262 954
				172	28.01	54262 678
				553	28.02	82172 934
				701	26.02	73935 666
				739	25.01	14593 931
836	23.02	11966	972	814	15.00	0 4
				839	26.01	21308 12
				903	26.01	18360 5
84	28.02	82277	919	103	28.01	56075 574
				291	28.01	54557 252
				532	6.01	0 0
807	28.01	54557	955			
844	15.02	0	47			
917	28.02	55952	748			
7	28.02	55406	799	27	26.01	2837 30
122	23.02	16810	117	140	26.02	83358 990
201	28.01	1506	0	182	7.00	28839 823
231	26.02	70725	573			
273	25.01	38806	664			
				508	28.02	82277 855
701	28.01	56075	758	663	6.01	63 0
726	17.00	0	0	708	6.01	63 0
				702	28.01	54557 108
				782	28.01	54557 260
				659	26.02	57221 920
196	26.02	63425	625	202	28.01	54557 469
273	25.01	14593	773			

Figure 9 (Continued)



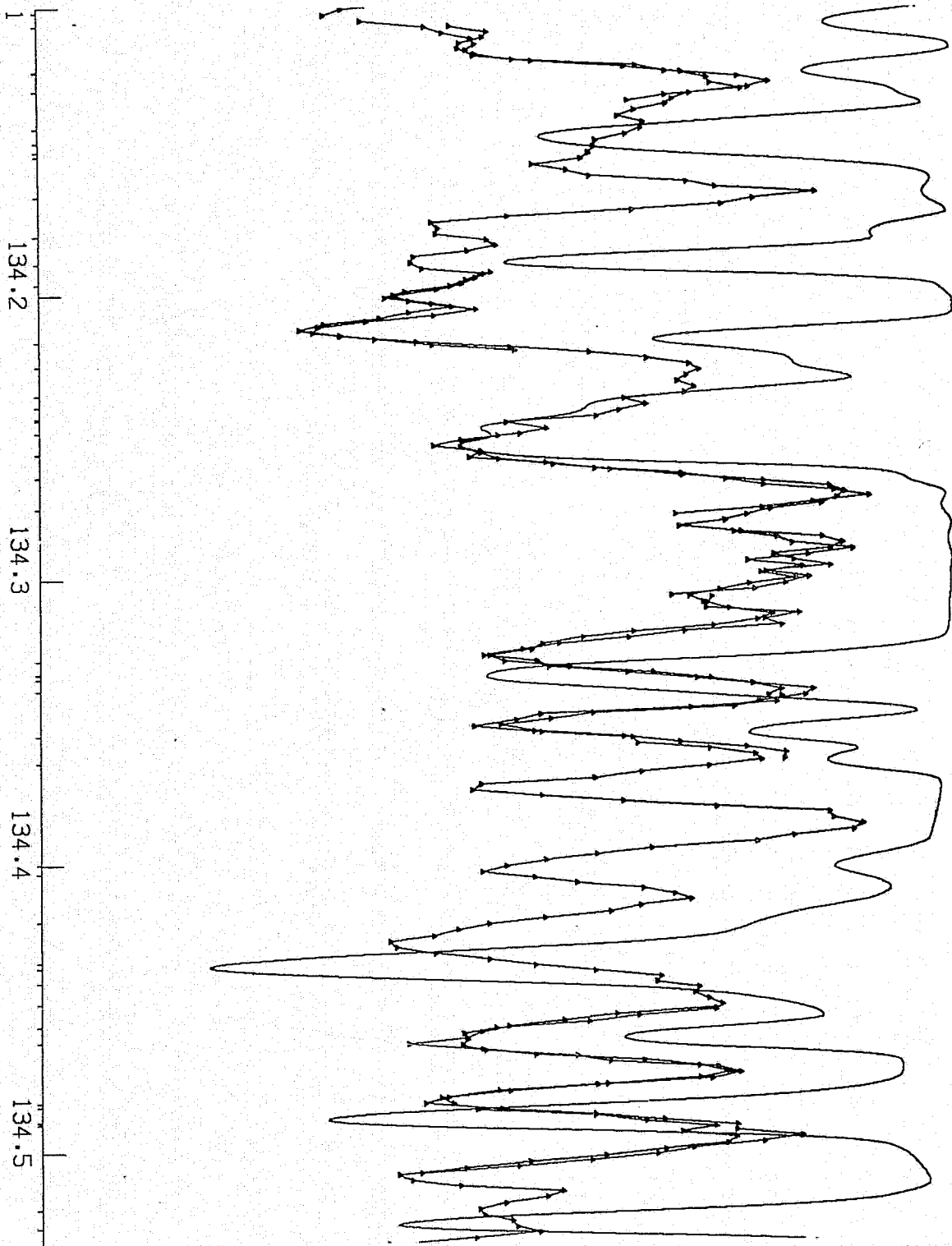
122	23.02	16810	117	140	26.02	83358	980
201	28.01	1506	0	182	7.00	28839	823
231	26.02	70725	573				
273	25.01	38805	864				
				508	28.02	82277	855
701	28.01	56075	798	663	6.01	83	0
726	17.00	0	0	708	6.01	63	0
				702	28.01	54557	108
				782	28.01	54557	280
				859	28.02	57221	920
196	26.02	63425	625	202	28.01	54557	489
273	25.01	14593	773				
394	7.00	28838	667	401	7.00	28839	91
476	28.01	55018	978				
521	26.02	84671	948				
569	28.01	55417	936				
760	28.01	25036	908	708	26.01	21251	714
783	26.02	73849	613	743	26.01	21430	567
911	28.02	82172	713	933	26.02	63466	933
191	7.00	28838	964	199	7.00	28839	964
338	26.01	21581	788	333	26.02	92523	882
429	26.02	83646	966	422	25.01	14325	944
				435	26.02	50184	446
				773	24.02	43304	512
956	28.01	54557	306	960	28.01	56075	455
30	25.01	14325	975				
407	28.01	57080	823	347	26.02	50184	651
797	26.02	63494	778	807	26.02	63494	844
843	28.01	23108	242	857	28.01	56075	651
38	28.02	82172	916				
241	26.02	50184	915	223	28.01	57080	673

Figure 9 (Continued)



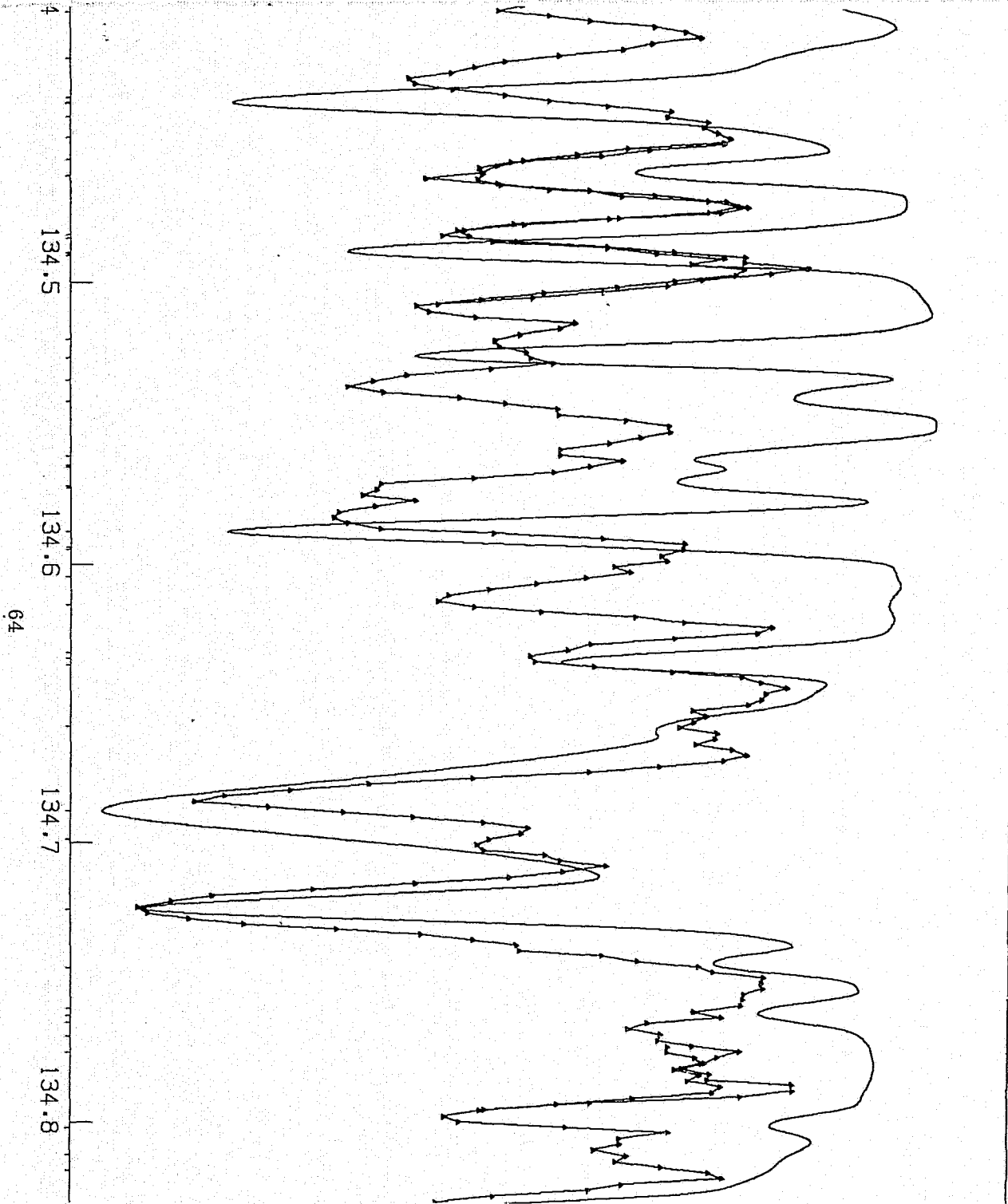
30	25.01	14325	975		
407	28.01	57080	823	347	26.02 50184 691
797	26.02	63494	778	807	26.02 63494 844
843	28.01	23108	242	857	28.01 58075 651
38	28.02	82172	916		
241	26.02	50184	915	223	28.01 57080 673
395	28.01	56371	794		
490	28.01	58075	609	451	26.01 21581 941
				628	25.01 14781 961
767	29.01	71919	953	693	22.02 8472 49
				823	26.02 63466 663
912	26.01	21430	782		
954	26.02	63425	973		
9	28.01	53365	546	28	26.01 3117 6
194	28.01	56075	797	189	26.02 63485 692
319	26.02	63494	927	295	26.02 63546 848
347	28.01	56424	568	326	26.02 50295 581
				375	28.01 57080 311
				695	26.02 63466 657
879	26.02	50276	949	909	29.01 71919 961
62	26.01	21711	632	16	26.02 84159 950
				51	26.02 63486 841
226	28.01	32523	946	223	26.02 50295 603
				295	28.02 56308 839
470	14.02	142944	450	421	28.02 55406 433
515	26.02	50412	917	500	14.02 142946 635
				654	26.02 77102 923
792	26.01	21711	667		
961	28.01	56424	948	890	20.01 0 6
161	28.02	55406	358		
247	28.01	53365	505		

Figure 9 (Continued)



62	26.01	21711	632	16	26.02	84159	950
				61	26.02	63486	841
226	28.01	32523	946	223	26.02	50295	603
				295	28.02	56308	839
470	14.02	142944	450	421	28.02	55406	433
515	26.02	50412	917	500	14.02	142946	635
				654	26.02	77102	923
792	26.01	21711	667				
961	28.01	56424	948	890	20.01	0	6
161	28.02	55406	358				
247	28.01	53365	505				
				349	14.02	142944	638
430	14.02	142948	541	369	14.02	142946	458
478	26.02	57221	217	433	26.02	50412	688
551	25.01	14593	598	554	20.01	0	7
633	26.01	21581	808				
				746	26.02	113635	967
283	28.01	56371	682				
330	26.01	18885	178	332	26.02	50412	316
346	30.02	145243	973	390	14.02	142946	642
390	14.02	142948	539				
546	14.02	175336	980	546	28.01	56371	406
844	28.01	55417	603				
997	26.02	49148	820	29	26.02	84159	826
197	28.01	56371	765				
353	25.01	32787	61	337	28.01	56371	853
407	28.01	25036	898	357	15.02	559	39
482	26.02	113635	976				
561	24.02	25725	907	617	28.01	53496	202
836	28.02	62606	839	825	28.01	56371	857
890	15.02	559	107	899	15.02	173813	974
197	26.02	63425	818				
				262	26.01	18360	4

Figure 9 (Continued)



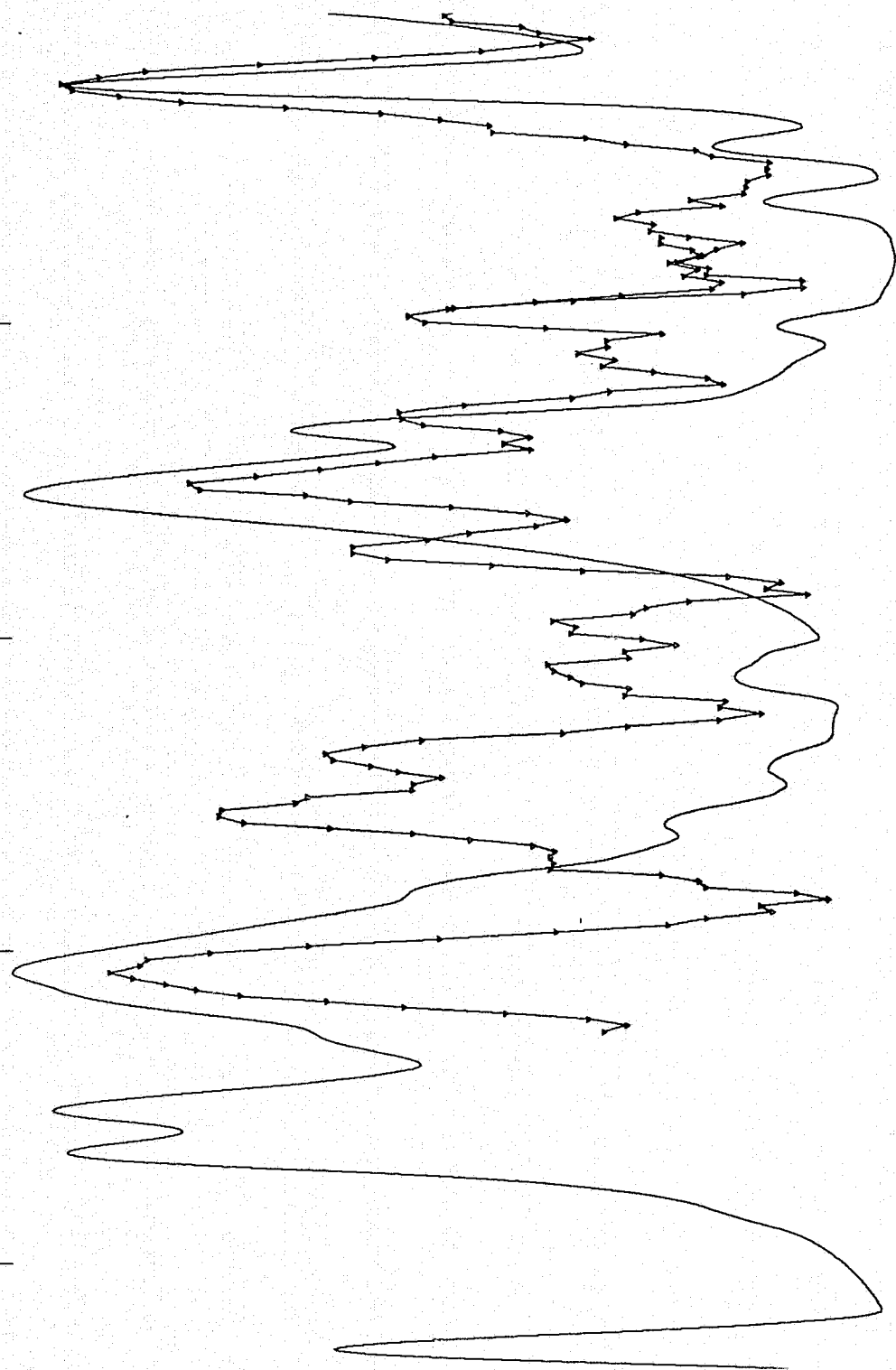
64

197	28.01	56371	765				
353	25.01	32787	61	337	28.01	56371	863
407	28.01	25036	898	357	15.02	559	39
482	26.02	113635	976				
561	24.02	25725	907				
				617	28.01	53496	202
836	28.02	62606	839	825	28.01	56371	857
890	15.02	559	107	899	15.02	173813	974
197	26.02	63425	818				
				262	26.01	18360	4
				341	28.01	57420	879
				416	28.01	23796	433
608	25.01	32856	394				
642	25.01	32858	854	649	26.02	70725	716
716	26.02	70728	406	723	24.02	20994	972
878	28.01	0	0				
944	26.02	63466	636	937	25.01	14781	720
42	18.61	144709	977				
				142	28.01	56424	956
313	26.02	63496	909				
358	26.02	70594	310	334	28.01	55018	747
				578	25.02	68899	629
884	14.01	42932	2				
				987	26.02	70728	693
240	17.00	0	0				
446	23.02	28746	522				
593	28.02	62606	954	618	25.02	68892	667
644	28.01	55299	885	691	28.02	83033	944
				749	25.02	68899	977
				19	26.02	87901	705
114	25.01	14901	916				
				170	28.01	55299	951

Figure 9 (Continued)

7  
134.8  
134.9  
135.0  
135.1

65



240	17.00	0	0		
446	23.02	28746	522		
593	28.02	62605	954	618	25.02 68892 667
644	28.01	55299	865	691	28.02 83033 944
				749	25.02 68899 977
				19	26.02 87901 705
114	25.01	14901	916	170	28.01 55299 951
				335	28.01 23108 13
				418	28.01 56075 941
				543	14.01 42824 2
				629	14.02 176487 958
				703	28.02 82826 959
751	18.01	132481	923		
84	28.01	55299	692	143	28.02 83033 830
158	26.02	49576	742	165	28.01 55299 929
				264	26.02 70728 973
				415	25.01 32787 798
589	28.01	55299	812	582	28.01 32523 823
783	28.01	55417	413		
72	14.01	43107	1	137	26.02 63494 637
				176	13.01 59849 51
				229	26.02 63466 882
282	24.02	25781	940	258	28.01 56075 690
293	26.02	84571	961	286	25.01 14781 820
				321	28.01 55417 485
438	26.02	63494	721	428	26.02 63494 485
486	26.02	84359	952		
516	14.01	42532	3		
570	26.02	83646	935	556	14.01 42824 4
868	28.02	82826	916	864	24.02 57422 976
249	28.02	55952	421		
288	28.01	23796	25		
317	28.02	55952	735		

Figure 9 (Continued)