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THESIS

NUMERICAL FORECASTING OF
CLEAR AIR TURBULENCE

by

Michael Joseph Ettel

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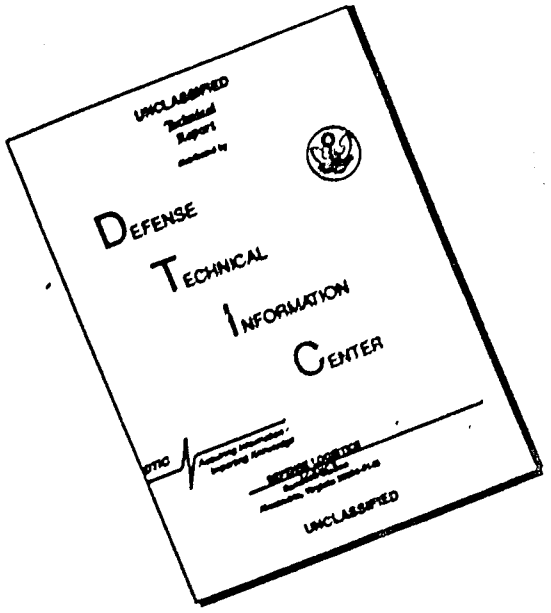

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NUMERICAL FORECASTING OF

CLEAR AIR TURBULENCE

by

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Submitted in partial fulfillment of the
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from the

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ABSTRACT

There is much disagreement as to (a) what causes clear air turbulence (turbulence which is not in or near convective clouds and is above 15,000 feet in altitude) and (b) which meteorological parameters can be used to detect and forecast its occurrence. The approach to this problem has been to relate not one parameter to clear air turbulence but various parameters. By summing these parameters areas can be defined where there is a high probability of encountering clear air turbulence. Each parameter has been based on a statistical study which found a relationship with clear air turbulence. The parameters used were horizontal and vertical shear, curvature, kinetic energy and their derivatives.

The numerical forecasting program proposed here can be extended to the stratosphere when more reliable height and temperature fields are available. This program will have much more significance when intermediate forecast height fields, temperature fields and a grid of much smaller mesh length are available.

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1. INTRODUCTION

The phenomenon of clear air turbulence (henceforth denoted as CAT) appears to consist of random three dimensional eddies that occur in certain confined regions of the atmosphere. This phenomenon was first recognized in the early 1940's as "air pockets", and has gained in importance and depth of study with the development of fast-flying swept wing and delta winged aircraft. It is of prime importance to the aviation industry because it affects the safety and comfort of passengers and crew, as well as operational costs. There have been several cases where loss of control of aircraft, structural damage, passenger and crew injuries (even deaths) have resulted from CAT.

Aircraft manufacturers and the airlines are interested in CAT in order to determine the strength of airframe design so that it can be built to withstand all degrees of turbulence. Planning of supersonic transport aircraft is considering the effects of this unexpected turbulence occurring at any flight level in the atmosphere. Therefore, it becomes an even greater operational problem in the era of future design of SST aircraft as to cost, safety and comfort. CAT Is usually less intense than turbulence encountered in thunderstorms [1]. CAT may be considered at times more dangerous than "thunderstorm turbulence" as it usually occurs with no visible warning.

The various military agencies are deeply concerned with the understanding of CAT and its prediction so they may be better prepared to take it into account operationally in all areas of the world. Scientists are highly interested in CAT because it is a phenomenon of our environment that is not clearly understood. We are faced with the problem of having to rely on mesoscale data while the phenomenon is of a microscale. Because of the great differences in scales involved in the forecasting

problem, isolated patches of CAT (in either space or time) are very difficult to identify. It is the intent of this paper to develop a numerical forecasting system of CAT whereby an empirical approach has been used to accomplish this end.

2. DATA COLLECTION

The nature of clear air turbulence, its physics and its meteorology, are still not completely understood. More mesoscale (2km to 100km horizontal distance) and microscale (less than 2km) studies must be made concerning the causes and generation of CAT. Any improvement in forecasting skill that may be realized by this study will probably result from increased mesoscale input data into the forecast problem. The only mesoscale measurements available operationally at this time which concern the problem are rawinsonde data that give a nearly continuous measurement in the vertical of wind, pressure, temperature and humidity from the surface to above 30km in altitude, and satellite cloud pictures that delineate cloud structures down to a scale of about 1km.

The usual definition of CAT is "atmospheric turbulence which is not in or near convective clouds, including thunderstorms, and is not below 15,000 feet in altitude". (4) Thus, mechanical turbulence induced by rough terrain is excluded. It is realized that this is an extremely arbitrary definition resulting from a desire to simplify pilot reporting procedures.

Turbulence intensities are, at present, designated as light, moderate, severe and extreme. In recent years several definitions of the four categories of turbulence have been proposed. The current definitions in official use were developed by the National Advisory Committee for Aeronautics (NACA) Subcommittee on Meteorological Problems (1957). See Table 1.

There are few quantitative measurements of atmospheric turbulence at any scale. The bulk of the aircraft turbulence data available is based upon the four categories stated in Table 1, (4) , and, consequently is highly subjective and qualitative in nature. Included in the factors that affect the subjective decision of the pilot when reporting turbulence are the wing loading, the aircraft's speed and attitude, the pilot's training, experience, and his psychological reactions (1) .

Objective criteria for turbulence reporting must wait until more measurements are made of the conditions existing in the turbulent eddies, and until cockpit instrumentation includes a gust load or turbulence indicator.

Much time, effort and financial support have been expended in this country by the government, the aircraft industry, and private and public research facilities to investigate the problem of clear air turbulence and to find a good approach leading to a solution to this problem. This research has gone forward in three broad categories: first, research concerning the correlation of CAT with macroscale, mesoscale, and/or microscale atmospheric measurements; second, research into instrumentation for the detection of CAT sufficiently far in advance of the aircraft to allow evasive measures (6) and third, research by military and airline organizations concerning the operational aspects of CAT.

Various projects such as HICAT, ALLCAT, and TOPCAT have been undertaken to study clear air turbulence. The problems encountered were many but the results showed that it was indeed possible, with suitable instrumentation, to find, track and record CAT. The use of constant level ballons and doppler radar to detect CAT has met with some success, but again the lack of detail necessary in CAT studies leaves much to be desired.

Measurements of the microstructure, which contains the perturbations of CAT dimensions (100 to 500 meter wavelength), have been taken by specially instrumented aircraft. Until recently the aircraft itself was used as a sensor to measure atmospheric gusts from the aircraft acceleration data. The Air Force realized the danger of relying solely on the acceleration response of the U-2 aircraft as a measure of turbulence at high altitudes. A full knowledge of the aircraft's response to turbulence over a wide range of wavelengths is required for meaningful interpretation of such data. This procedure usually gives reliable results at short wavelengths up to a few hundred meters. At long wavelengths, this instrumentation becomes less sensitive. Accelerations in longer waves are usually small and can be masked by pilot induced aircraft motions.

A supersonic or hypersonic craft of some radical shape, flying four to ten times the speed of the U-2, will obviously have a somewhat different response to turbulence than the U-2. An aircraft flying at these high speeds would be affected much more by longer turbulence wavelengths and less by the shorter.

As pointed out earlier, the meteorologist has few direct measurements of turbulence intensities and must depend upon the accuracy of the intensities reported by pilots. In our study, we used the Colson monthly turbulence summaries which were obtained from the Air Force 3rd Weather Wing at Offutt AFB, Omaha, Neb. This report suited our needs most closely because the CAT reports were detailed as to location, time, altitude and intensity. In the period used in our study, December 1964 through March 1965, there were no less than 3670 CAT reports. The

reports were located over the United States and extended from about 15,000 feet to over 45,000 feet. The data were collected from military, civilian and private aircraft. They are, as mentioned before, quite subjective.

In the course of this paper three time periods or intervals will be used. It is important to establish at this point which periods were used and for what purpose.

A four month period (December 1964 through March 1965) is used for the research program during which several fields were constructed. Patterns of fields of different meteorological parameters were sometimes similar. Then all but one of them were dropped in our further investigations. In this way only three of the original seven parameters were retained.

The three day period (10 - 12 March, 1965) was used for a verification or correlation study. During this period of time a comparison was made to find out how many times CAT actually occurred in areas where it was predicted.

Finally, 11 February 1965 was arbitrarily chosen from the four month period and used only for illustrating the various fields and parameters used in the research program.

3. THE CLEAR AIR TURBULENCE STUDY

Clear air turbulence (CAT) is a microscale phenomenon (less than 2 kilometers in horizontal extent) but the conditions which are symptomatic of its existence are of synoptic scale. Therefore, synoptic scale parameters may be used to determine areas where CAT could occur, that is forecasting areas where there is a high probability of CAT.

From various reports and their contradications it appears that no single parameter can detect CAT. Certain parameters can detect the possibility of CAT in some synoptic situations but fail in others.

The approach used in this paper was to take statistical studies made by previous investigators and to use the basic parameters which they related to CAT (2,3,5,7,8). If the magnitude of any one parameter becomes large or the sum of various parameters becomes large then there is a high probability of CAT in that area. Therefore, the problem is not one of forecasting actual CAT but rather to forecast areas of high and low probability of encountering CAT. In this way flights may be planned so as to expect least CAT.

The research program consisted of computing the equations shown in Appendix A. These equations were computed using the CDC 1604 digital computer. The program was written utilizing symbolic coded relocatable assembly program (SCRAP). It was necessary to use fixed point fractional numbers in order that Fleet Numerical Weather Facility (FNWF) subroutines could be used. All finite differences were computed using standard FNWF mesh length of 381 kilometers true at 60 degrees north latitude. There are no time derivatives in the program. The research reported here is accomplished using analytical fields. Operational use would employ

forecast fields. Results would naturally not have been as good if forecast fields were used in this research. "Prog 24 hours" printed at the bottom of each field represents the practical forecast interval to be used operationally.

The research program was written to compute CAT in three layers 500 to 300, 300 to 200, and 200 to 100 millibars. Computations were not made for the third layer since 100 millibar fields were not available.

The research program was written to compute on the entire 63 x 63 FNWF grid of the northern hemisphere. A boundary condition of zero was used for the outside rows and columns. The print routines are 22 x 22 extracts of the United States starting at FNWF grid point J008, I018. The latitude and longitude coordinates of the four corners of the printed fields starting with the lower left corner proceeding clockwise are: 9.1N 109.5W, 44.5N 165.5W, 57.7N 3.1E, 13.0N 58.8W.

All printed fields are pure numbers and have no dimensional meaning. All scaled outputs have been shifted to the left end of the register and the first three numbers with sign bit are printed out in decimal. Grid points can take on values from -999 to +999 except those fields which have been made all positive. The decimal point does not appear on the printed fields. Therefore, the printed grid point values are from -999 to +999.

In the research program the capital letters refer to the parameter as computed from the data. The small case letters serving as exponents represent the number of times and direction the register has to be shifted in order to place the significant portion into the first three numbers. Therefore, the two with exponents represent the scaling coefficient. Since the computations were in fixed point fractional all

printouts had to be shifted so as not to exceed one at any grid point in the field. Exceeding one would result in a meaningless value at that particular grid point. In addition the entire field had to be kept large enough so that patterns could exist and not be at or near zero throughout the field. Since these fields are summed they must be small enough so as not to cause the summation field to exceed one at any grid point.

The research program was run for thirty-six days during December 1964 and January, February, and March 1965. The thirty-six days were chosen because they were the most active in CAT reports during the four month period. In other words, there were more reports by pilots encountering CAT on these particular days. In order to show an example of each field printed out by the research program the time 00Z 23 FEB 65 was arbitrarily selected. These fields appear in Appendix C. Each field was produced by an individual term which will be described as follows:

THE FIRST TERM OF THE RESEARCH PROGRAM (APPENDIX A)

The First Term is $\nabla^2 A$ where A is the Laplacian of absolute vorticity. When this term is negative there is a local maximum of absolute vorticity meaning it is larger at that grid point than the average of the surrounding grid points. Therefore, the cyclonic curvature or cyclonic shear or both are relatively large at that grid point. This should correspond to the cold side of the jet especially in troughs. According to Endlich and McLean (1) there is a greater percentage of CAT on the cold side of the jet. Also according to Harrison (2) there is a strong tendency for moderate to severe CAT to be associated with trough lines.

This term was computed for the layer by first calculating the absolute vorticity of the upper and lower level D fields. The Laplacian was then taken of each field and a vertical average made of the upper and lower levels to obtain the Laplacian of vorticity of the layer.

This parameter has depicted most of the CAT associated with the trough over the western United States. The severe CAT near New Orleans is in an area of very large negative numbers. The field is contoured at intervals of 100 with the origin at zero.

THE SECOND TERM

The Second Term is 2^b B where B is the absolute value of the vertical change in the vector thermal wind. One of the parameters which Lake's (7) statistical testing indicated was associated with CAT was the vertical gradient of wind shear. As shown by Richardson (9) the thermal wind shear is proportional to the gradient of static stability.

The u and v components of the thermal wind were computed from the upper and lower level temperature fields. The difference between the upper and lower level values of the u component was found and each difference was squared. This was also done for the v component. The square root of the sum of the squared differences gives the magnitude of the vector difference. According to Endlich and McLean (3) the largest values of the thermal wind shear appear on the warm side of the jet. This was found to be true throughout the four months. The contour interval for this field is 25 and the origin is zero.

THE THIRD TERM

The Third Term is 2^c C where C is one half the geostrophic wind velocity squared. C therefore represents the specific kinetic energy or in other words the kinetic energy per unit mass

Clem (2) found that most cases of moderate to severe CAT were associated with areas of isotach maxima.

This term was computed for the layer by calculating the u and v components of the geostrophic wind at the upper and lower levels. The upper and lower level u components were vertically averaged to obtain an average u component for the layer. The average v component for the layer was obtained by a similar process. The magnitude of the velocity squared is just the sum of the squared components.

In the research program this field is contoured at intervals of 100 with the origin at zero. Contoured at this interval the kinetic energy field clearly depicts the isotach maxima regions. The kinetic energy field in Appendix C shows this field depicting the CAT in the western part of the United States occurring in areas of relatively large wind speeds. The kinetic energy field fails to indicate the severe CAT near New Orleans because it occurs in an area of relatively light winds.

THE FOURTH TERM

The Fourth Term is $\nabla^2 D$ where D is the absolute value of the derivative of the kinetic energy with respect to pressure.

Lake's (7) statistical testing indicated that the gust intensities are related to the vertical gradients of horizontal kinetic energy. This term was computed for the layer by first calculating the velocity squared at the upper and lower levels. The vertical gradient for the layer was then obtained by computing the difference between the upper and lower level values of the velocity squared. The absolute value was taken so as to have all values positive. CAT should be associated with

large values of this field. Large values of this field were found only in areas of large values of kinetic energy. This field was therefore redundant and was eliminated from the CAT forecast program. The contour interval was 100 with the origin at zero.

THE FIFTH TERM

The Fifth Term is 2^e E where E is the absolute value of the Laplacian of kinetic energy. The statistical survey made by Endlich and McLean (3) shows the maximum occurrence of CAT along the edges of the isotach maxima. The Laplacian of kinetic energy shows large horizontal changes in kinetic energy, both positive and negative. Therefore the absolute value of the term is taken in order to give only positive numbers. The contour interval was 25 with the origin at zero.

This term was introduced to depict the areas of large horizontal change in kinetic energy. However, there was no relationship with reported CAT. This field was therefore eliminated from the CAT forecast program.

THE SIXTH TERM

At this point in the research program it was necessary to sum the first five terms due to computer memory space. This term, referred to as KAT1, was the Sixth Term. The contour interval was 250 with the origin at zero. It was found that this term did not supply significantly new information since it was dominated by the kinetic energy and the two associated terms.

THE SEVENTH TERM

The Seventh Term is 2^f F where F is the Jacobian of temperature and omega (component of the wind normal to the pressure surface). This

term was developed by Dr. Moore of Douglas Aircraft and Dr. Krishnamurti (3). The latter was associated at that time with the University of California, Los Angeles and consultant to Douglas Aircraft. The term was developed as the Jacobian of temperature and three dimensional divergence. As shown in their paper this is proportional to the negative of the Jacobian of temperature and omega. This term was computed for the lower level of each layer in the research program. The contour interval for this term was 100 with the origin at zero. In this program no significant relationship was found with large negative or positive numbers over the four month period. This term was therefore eliminated from the CAT forecast program.

THE EIGHTH TERM

The Eighth Term is 2^8 G where G is the absolute value of horizontal divergence. It was computed by taking the derivative of omega with respect to pressure. As previously stated the entrance and exit regions of isotach maxima areas have been found to be associated with CAT. These areas are also associated with horizontal convergence at the entrance and divergence at the exit regions. Therefore the absolute value of the change in omega with pressure represents the convergence and divergence in the layer parallel to the pressure surfaces.

This term was computed by subtracting the lower level omega value from the upper level omega value at each grid point. Areas of convergence and divergence of the height field are quite vividly depicted by the divergence field. No significant relationship was found between the divergence field and the CAT occurrences, therefore, it was eliminated from the CAT forecast program.

THE NINTH TERM

The Ninth Term was KAT2, the summation of all previous terms. No significant relationship was found with CAT occurrences since several terms tended to cancel each other out.

The program then goes into the second layer from 300 to 200 millibars. All terms were computed and scaled the same, except the divergence term. It could not be computed because the 200 millibar omega field was not available.

The third layer from 200 to 100 millibars could not be run for these time periods since the 100 millibar fields were not available. There were very few CAT reports above 200 millibars, therefore, the loss was insignificant.

In all three layers the lower level height field is printed out first. This gives a general impression of the synoptic situation and renders more significance to the patterns developed in the other fields. The contour interval for the 500 millibar field is 60 meters with the origin at 5580 meters. The contour interval for the 300 millibar field is 120 meters with the origin at 9120 meters. The contour interval for the 200 millibar field is 120 meters with the origin at 11,760 meters.

The CAT forecast program appears in Appendix D. The first three terms of the research program are used with minor changes. In the first term "a" is changed to minus one and the contour interval has been changed to 150 to give better defined patterns. The second term has been used unchanged. The third term is unchanged except for the contour interval which was changed to 50 to increase the pattern size. The KAT field itself is the summation of these three terms and gives quite reasonable patterns and pattern sizes.

The pattern area depicting a high probability of CAT would necessarily be larger during a more active CAT period. The most active part of the year was the four month period December 1964, January, February, and March 1965. During these months the most active three day period was the tenth through the twelfth of March 1965. Therefore the KAT fields have quite large pattern sizes in Appendix E since they represent the most active three days of the year. The KAT field patterns were smaller for less active periods. The total area covered by these patterns is much less in the KAT field than in the other three parameter fields.

This is exactly what was attempted in order to obtain optimum size of the forecasted danger areas. If the KAT field patterns are too large, flights will be rerouted unnecessarily. On the other hand, if the KAT field patterns are too small, there is a real danger of CAT occurring outside these areas. Therefore, the restraint of the KAT field patterns is necessary in order to have an operationally useable product.

4. DISCUSSION AND RECOMMENDATION FOR FUTURE STUDIES

The period used in this paper was chosen because of the largest number of reported CAT occurrences. Of the four month period (December 1964, January, February and March 1965) there were scattered periods where a large number of occurrences were reported. This four-month period was used to determine which parameters were best suited for forecasting purposes. The three-day period of 10-12 March 1965 was selected for a correlation study in order to find out how successful our forecast method is. Tables 2, 3, and 4 show the various fields used and the resultant KAT field for the 10th, 11th and 12th of March 1965.

The use of the term "percent correlation" as used in this study does not mean to imply a statistical correlation. The ideal forecast verification makes use of those cases where CAT is forecast, but does not occur, and where CAT is not forecast and does not occur. In our study it was impossible to take those cases quantitatively into account. Therefore, it is to be understood that "correlation" as used in this study was a general comparison of those reported CAT occurrences that fell within the delineated area of high probability of CAT against those that did not. For example, if there were ten reported CAT occurrences for a given layer and time period and six of these reports fell inside or on the line delineating the CAT area and four reports fell outside the area, then for that field, layer and time period we would list it as six occurrences correlated or a sixty percent correlation.

Listed are the names of the fields, the number of occurrences of CAT for each field and the percent correlation by field. Also shown are the number of occurrences and the number of occurrences that correlated by field and CAT intensity.

After combining the Laplacian of Vorticity, Vertical Gradient of Thermal Wind and Kinetic Energy we arrive at the KAT Field which is our end product for the area of high probability of CAT occurrences. Even though a higher correlation may be seen in some fields other than the KAT field, one should realize that these fields encompassed a larger than average area. In such cases one must expect a high correlation.

The high correlation is then not due to the finesse of the forecast method, but rather due to the fact that for most of the USA there was a forecast of high probability for CAT. Theoretically, it would be a good idea to divide the percent correlation (such as we computed) by the size of the area for which CAT was forecasted. We did not follow this idea quantitatively, but only qualitatively. Therefore, one finds that the percent correlation for our ultimate forecast (labeled KAT) is sometimes lower than the percent correlation for one of the three separate forecasting fields.

Table 5 is a summary for the three day period. It shows the total number of CAT occurrences by turbulence category, percent correlation by field and turbulence category, and the three day percent correlation by field.

The results were most encouraging and we feel that our end product was a substantial step in at least the right direction toward forecasting clear air turbulence. Our knowledge of the meso- and micro- structure of flo patterns in the free atmosphere, especially above the tropopause, is still rather poor. A strong need still exists for a well organized and well equipped measurement program, especially at flight levels of the future supersonic transport aircraft. Measurement programs using

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6. APPENDIX A

EQUATIONS

The numbers in parentheses on this and the following pages refer to the page numbers in the text where each item is discussed.

The numbers below each term in the following two equations identify the number of each term (e.g., RAT1 is the sixth term).

THE RESEARCH PROGRAM (p. 15)

$$\underset{6}{RAT1} = \underset{1}{Z^{a}A} - \underset{2}{Z^{b}B} - \underset{3}{Z^{c}C} - \underset{4}{Z^{d}D} - \underset{5}{Z^{e}E} \qquad \underset{9}{RAT2} = \underset{6}{RAT1} - \underset{7}{Z^{f}F} - \underset{8}{Z^{g}G}$$

THE FIRST TERM $Z^{a}A$ (p. 15)

$$a = 0 \qquad A = \nabla^{2}\eta \qquad \eta_{0} = \frac{1}{\delta^{2}}\left[\eta_{1} - \eta_{2} + \eta_{3} + \eta_{4} - 4\eta_{0}\right]$$

$$\nabla^{2}\eta_{0} = \frac{1}{\delta^{2}}\left[\eta_{1} + \eta_{2} + \eta_{3} + \eta_{4} - 4\eta_{0}\right] \qquad \nabla^{2}\eta_{1} = 1/2\left[\nabla^{2}\eta_{0} + \nabla^{2}\eta_{2}\right]$$

THE SECOND TERM $Z^{b}B$ (p. 16)

$$b = 0 \qquad B = \left[\frac{\Delta\vec{V}_{t}}{\Delta P}\right]$$

$$U_{t} = \frac{RT}{fT}\frac{\left[T_{2} - T_{4}\right]}{2d} \qquad V_{t} = \frac{R}{fT}\frac{\left[T_{3} - T_{1}\right]}{2d} \qquad \vec{V}_{t_{0}} = U_{t_{0}}\,i + V_{t_{0}}\,j$$

$$\vec{V}_{t_{1}} = U_{t_{1}}\,i + V_{t_{1}}\,j \qquad \frac{\Delta\vec{V}_{t}}{\Delta P} = \frac{\vec{V}_{t_{1}} - \vec{V}_{t_{0}}}{\Delta P} = \frac{\left[U_{t_{1}}\,i + V_{t_{1}}\right]}{\Delta P} - \frac{\left[U_{t_{0}}\,i + V_{t_{0}}\,j\right]}{\Delta P}$$

$$\frac{\Delta \vec{V}_t}{\Delta P} = \frac{[U_{t_L} - U_{t_u}]}{\Delta P} i + \frac{[V_{t_L} - V_{t_u}]}{\Delta P} j = \frac{\Delta U_t}{\Delta P} i + \frac{\Delta V_t}{\Delta P} j$$

$$\left|\frac{\Delta V_t}{\Delta P}\right| = \left(\frac{\Delta U_t}{\Delta P}\right)^2 + \left(\frac{\Delta V_t}{\Delta P}\right)^2$$

THE THIRD TERM $2^c C$ (p. 16)

$$c = 0 \qquad C = \frac{\bar{\vec{V}}^2}{2}$$

$$U_g = \frac{-g}{f} \frac{[Z_2 - Z_4]}{2d} \qquad V_g = \frac{g}{f} \frac{[Z_3 - Z_1]}{2d}$$

$$\bar{U}_g = \frac{U_{g_u} + U_{g_L}}{2} \qquad \bar{V}_g = \frac{V_{g_u} + V_{g_L}}{2}$$

$$\bar{\vec{V}}_g = \bar{U}_g i + \bar{V}_g j \qquad \bar{\vec{V}}^2_g = (\bar{U}_g)^2 + (\bar{V}_g)^2$$

THE FOURTH TERM $2^d D$ (p. 17)

$$d = 1 \qquad D = \left|\frac{\Delta \frac{\bar{\vec{V}}^2}{2}}{\Delta P}\right|$$

$$\frac{\Delta \bar{\vec{V}}^2}{\Delta P} = \frac{\bar{\vec{V}}^2_L - \bar{\vec{V}}^2_u}{\Delta P} \qquad \left|\frac{\Delta \bar{\vec{V}}^2}{\Delta P}\right| = \sqrt{\left(\frac{\Delta \bar{\vec{V}}^2}{\Delta P}\right)^2}$$

THE FIFTH TERM $2^e E$ (p. 18)

$e = 1 \qquad E = |\nabla^2 \frac{\bar{\vec{v}}^2}{2}|$

$\nabla^2 \bar{\vec{v}}_0^2 = \frac{1}{d^2} [\bar{\vec{v}}_1^2 + \bar{\vec{v}}_2^2 + \bar{\vec{v}}_3^2 + \bar{\vec{v}}_4^2 - 4\bar{\vec{v}}_0^2] \qquad |\nabla^2 \bar{\vec{v}}_0^2| = \sqrt{(\nabla^2 \bar{\vec{v}}_0^2)^2}$

THE SIXTH TERM (p. 18)

$KAT1 = \nabla^2 \eta - |\frac{\Delta \vec{v}_t}{\Delta P}| - \frac{\bar{\vec{v}}^2}{2} - |\frac{\Delta \bar{\vec{v}}^2}{\Delta P}| - |\nabla^2 \frac{\bar{\vec{v}}^2}{2}|$

THE SEVENTH TERM $2^f F$ (p. 18)

$f = 11 \qquad F = J[T,\omega]$

$J[T, \nabla_3 \cdot \vec{v}] = \frac{-1}{\gamma P} J[T,\omega]$

$J[T,\omega] = \frac{1}{4d^2} [(T_3 - T_1)(\omega_2 - \omega_4) - (T_2 - T_4)(\omega_3 - \omega_1)]$

THE EIGHTH TERM $2^g G$ (p. 19)

$g = 13 \qquad G = |\frac{\Delta \omega}{\Delta P}|$

$\frac{\Delta \omega}{\Delta P} = \frac{1}{\Delta P} [\omega_L - \omega_u] \qquad |\frac{\Delta \omega}{\Delta P}| = \frac{1}{\Delta P} \sqrt{(\omega_L - \omega_u)^2}$

THE NINTH TERM (p. 20)

$$KAT2 = KAT1 + 2^{11}\, J[T,\omega] - 2^{13}\left|\frac{\Delta\omega}{\Delta P}\right|$$

PROG KAT PROGRAM (p. 20)

$$KAT = 2^{-1}\,\nabla^2\eta - \left|\frac{\Delta\vec{V}T}{\Delta P}\right| - \frac{\bar{\vec{V}}^2}{2}$$

7. APPENDIX B

THE RESEARCH COMPUTER PROGRAM

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F     00000     50 0 00000                    IDENT   ETTEL MORGAN
                                                      KAT FORECAST
                                                      BEGIN STEERING PROGRAM
                                                      COMPUTES 500 TO 300 MB LAYER
                50 0 00000
                   00600                      ORG     6000
      00600     20 0 02008                    STA     TIME            PUT DATE TIME IN A REGISTER
                50 0 00000
      00601     75 4 00720          START     RTJ     READD2          READS PACKED LOWER LEVEL 0 FIELD INTO
                                                                      FS4
                50 0 00000
      00602     75 4 00726          +         RTJ     UNPCKD2         UNPACKS LOWER LEVEL 0 FIELD INTO FS1
                50 0 00000
      00603     75 4 00746          +         RTJ     READT2          READS LOWER LEVEL TEMPERATURE FIELD
                                                                      INTO FS4
                50 0 00000
      00604     75 4 00754          +         RTJ     UNPCKT2         UNPACKS LOWER LEVEL TEMPERATURE FIELD
                                                                      INTO FS1
                50 0 00000
      00605     75 4 00705          +         RTJ     READ01          READS PACKED UPPER LEVEL 0 FIELD INTO
                                                                      FS4
                50 0 00000
      00606     75 4 00713          +         RTJ     UNPCKD1         UNPACKS UPPER LEVEL 0 FIELD INTO FS0
                50 0 00000
      00607     75 4 00733          +         RTJ     READT1          READS UPPER LEVEL TEMPERATURE FIELD IN
                                                                      TO FS4
                50 0 00000
      00610     75 4 00741          +         RTJ     UNPCKT1         UNPACKS UPPER LEVEL TEMPERATURE FIELD
                                                                      INTO FS2
                50 0 00000
      00611     75 4 00761          +         RTJ     REWIND          REWINDS TU 3 CH 5/6
                50 0 00000
      00612     75 4 00765          +         RTJ     REWIND1
                50 0 00000
      00613     75 4 01447          +         RTJ     PRINT           PRINTS LOWER HEIGHT FIELD
                50 0 00000
      00614     75 4 00771          +         RTJ     SINF            GENERATES SINE FIELD STORS IN FS4
                50 0 00000
      00615     75 4 00774          +         RTJ     VORTIS1         COMPUTES VORTICITY FIELD FROM UPPER
                                                                      LEVEL 0 FIELD STORS IN FS5
                50 0 00000
      00616     75 4 01001          +         RTJ     VORTIS2         COMPUTES VORTICITY FIELD FROM LOWER
                                                                      LEVEL 0 FIELD STORS IN FS6
                50 0 00000
      00617     75 4 01006          +         RTJ     LAPLAC1         COMPUTES LAPLACIAN OF UPPER LEVEL VORT
                                                                      ICITY FIELD STORS IN FS0
                50 0 00000
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00620	75 4 01214	+	RTJ	LAPLAC2	COMPUTES LAPLACIAN OF LOWER LEVEL VORT ICITY FIELD STORS IN FS1
	50 0 00000				
00621	75 4 01222	+	RTJ	HORIZ	COMPUTES AVERAGE VORTICITY BETWEEN UPPER AND LOWER LEVELS STORS IN FS5
	50 0 00000				
00622	75 4 01473	+	RTJ	PRINT1	
	50 0 00000				
00623	75 4 01027	+	RTJ	MHAT	STORS SCALED MAP FACTOR IN FS6
	50 0 00000				
00624	75 4 01035	+	RTJ	UTHM1	COMPUTES U COMPONENT OF THERMAL WIND AT LOWER LEVEL STORS IN FS0
	50 0 00000				
00625	75 4 01053	+	RTJ	UTHM2	COMPUTES U COMPONENT OF THERMAL WIND AT LOWER LEVEL STORS IN FS1
	50 0 00000				
00626	75 4 01071	+	RTJ	DUTHM	COMPUTES U COMPONENT DIFFERANCE BETWEEN UPPER AND LOWER LEVELS STORS IN FS0
	50 0 00000				
00627	75 4 01076	+	RTJ	VTHM1	COMPUTES V COMPONENT OF THERMAL WIND AT LOWER LEVEL STORS IN FS1
	50 0 00000				
00630	75 4 01114	+	RTJ	VTHM2	COMPUTES V COMPONENT OF THERMAL WIND AT UPPER LEVEL STORS IN FS2
	50 0 00000				
00631	75 4 01132	+	RTJ	DVTHM	COMPUTES V COMPONENT DIFFERANCE BETWEEN UPPER AND LOWER LEVELS STORS IN FS1
	50 0 00000				
00632	75 4 01137	+	RTJ	DTHM	COMPUTES VERTICAL GRADIENT OF THERMAL WIND STORS IN FS0
	50 0 00000				
00633	75 4 01517	+	RTJ	PRINT2	
	50 0 00000				
00634	75 4 01147	+	RTJ	KAT1	HORIZ MINUS DTHM STORS IN FS5
	50 0 00000				
00635	75 4 00720	+	RTJ	READD2	SEE ABOVE
	50 0 00000				
00636	75 4 00726	+	RTJ	UNPCKD2	SEE ABOVE
	50 0 00000				
00637	75 4 00705	+	RTJ	READD1	SEE ABOVE
	50 0 00000				
00640	75 4 00713	+	RTJ	UNPCKD1	SEE ABOVE
	50 0 00000				
00641	75 4 00761	+	RTJ	REWIND	REWINDS .U 3 CH 5/6
	50 0 00000				
00642	75 4 00765	+	RTJ	REWIND1	
	50 0 00000				

00643	75 4 00771 50 0 00000	+	RTJ	SINF	SEE ABOVE
00644	75 4 01227 50 0 00000	+	RTJ	MMAT	SEE ABOVE
00645	75 4 01154 50 0 00000	+	RTJ	UGEOS1	COMPUTES U COMPONENT OF GEOSTROPHIC WIND AT UPPER LEVEL STORMS IN FS2
00646	75 4 01172 50 0 00000	+	RTJ	UGEOS2	COMPUTES U COMPONENT OF GEOSTROPHIC WIND AT LOWER LEVEL STORMS IN FS3
00647	75 4 01210 50 0 00000	+	RTJ	UGEOS	COMPUTES AVERAGE U COMPONENT STORMS IN FS2
00650	75 4 01217 50 0 00000	+	RTJ	VGEOS1	COMPUTES V COMPONENT OF GEOSTROPHIC WIND AT UPPER LEVEL STORMS IN FS3
00651	75 4 01235 50 0 00000	+	RTJ	VGEOS2	COMPUTES V COMPONENT OF GEOSTROPHIC WIND AT LOWER LEVEL STORMS IN FS3
00652	75 4 01253 50 0 00000	+	RTJ	VGEOS	COMPUTES AVERAGE V COMPONENT STORMS IN FS0
00653	75 4 01262 50 0 00000	+	RTJ	KINETIC	COMPUTES V SQUARE STORMS IN FS0 COMPUTES V SQ DIFF STORMS IN FS4
00654	75 4 01567 50 0 00000	+	RTJ	PRINT4	
00655	75 4 01613 50 0 00000	+	RTJ	PRINT5	
00656	75 4 01274 50 0 00000	+	RTJ	LAPKIN	COMPUTES LAPLACIAN OF KINETIC ENERGY STORMS IN FS6
00657	75 4 01637 50 0 00000	+	RTJ	PRINT6	
00660	75 4 01306 50 0 00000	+	RTJ	KAT2	STORMS PREVIOUS TERMS IN FS0
00661	75 4 01663 50 0 00000	+	RTJ	PRINT7	
00662	75 4 00746 50 0 00000	+	RTJ	READT2	SEE ABOVE
00663	75 4 00754 50 0 00000	+	RTJ	UNPCKT2	SEE ABOVE.
00664	75 4 00761 50 0 00000	+	RTJ	REWIND	REWINDS TU 3 CH 5/6
00665	75 4 01327 50 0 00000	+	RTJ	READO2	READS OMEGA FIELD INTO FS4
00666	75 4 01335 50 0 00000	+	RTJ	UNPCKO2	UNPACKS LOWER LVL OMEGA INTO FS6

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00667   75 4 00765      +       RTJ     RLWIND1     REWINDS TO2 CH 5/6
        50 1 00000

00670   75 4 01342      +       RTJ     MOORE       COMPUTES THE JACOBIAN OF TEMPERATURE AND
                                                    OMEGA STORS IN FS1
        50 0 00000

00671   75 4 01314      +       RTJ     READ01      READS OMEGA FIELD INTO FS4
        50 1 00000

00672   75 4 01322      +       RTJ     UNPCK01     UNPACKS UPPER LVL OMEGA INTO FS5
        50 0 00000

00673   75 4 00765      +       RTJ     REWIND1
        50 0 00000

00674   75 4 01355      +       RTJ     HORDVG      COMPUTES HORIZONTAL DIVERGENCE STORS FS5
        50 0 00000

00675   75 4 01365      +       RTJ     ABSDIV      COMPUTES ABSCLUTE DIVERG STORS IN FS5
        50 0 00000

00676   75 4 01707      +       RTJ     PRINT8
        50 1 00000

00677   75 4 01543      +       RTJ     PRINT3
        50 0 00000

00700   75 4 01373      +       RTJ     KAT         COMPUTES VORTICITY DIFFERANCE PLUS
                                                    THERMAL WIND DIFFERANCE PLUS KINETIC
                                                    ENERGY DIFFERANCE PLUS THE CHANGE IN
                                                    KINETIC ENERGY PLUS KINETIC ENERGY
                                                    PLUS THE DIVERGENCE
        50 0 00000

00701   75 4 01663      +       RTJ     PRINT7
        50 0 00000

00702   75 4 01400      +       RTJ     LAYER2      COMPUTES 300 TO 200 MB LAYER
        50 0 00000

00703   75 4 01424      +       RTJ     LAYER3      COMPUTES 200 TO 100 MB LAYER
        50 0 00000

00704   76 0 00000      +       SLS                 END OF STEERING PROGRAM USES OFF LINE
                                                    PRINTIN.
        50 0 00000

00705   75 0 00000      READ01  SLJ     **
        50 1 00000

00706   12 0 02001      +       LDA     TIME
        14 0 01735              LDC     MAPE1

00707   75 4 04231      +       RTJ     MAG
        00 0 00100              20      0,0

00710   50 0 02414      READ    ENI     MAA
        50 0 01300              LNI     13008

00711   50 0 04215              ENI     FS4
        50 0 02007              ENI     READERR

00712   75 0 00765              SLJ     READ01
        50 1 00000

00713   75 0 00000      UNPCK01 SLJ     **
        50 6 00000              ENI     0,6
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00714   75 4 00716      *       SLJ     **2
        00 0 44215              FS4

00715   00 0 05015              FS2
        00 0 02453              24538

00716   75 4 04715      *       RTJ     WAB
        50 0 00007              7

00717   75 0 00713              SLJ     UNPCKD1
        50 0 00000

00720   75 0 00000      READD2  SLJ     **
        50 0 00000

00721   12 0 02001      *       LDA     TIME
        16 0 01743              LDQ     NAME2

00722   75 4 04231      *       RTJ     MAG
        00 0 00003              0,0

00723   50 0 02014              FNI     MAA
        50 0 01300              FNI     13000

00724   50 0 44215              FNI     FS4
        50 0 02507              FNI     RFAILERR

00725   75 0 00720              SLJ     READD2
        50 0 00000

00726   75 0 00000      UNPCKD2 SLJ     **
        50 0 00000              FNI     0,0

00727   75 0 00731      *       SLJ     **2
        00 0 44215              FS4

00730   00 0 14653              FS1
        00 0 02453              24538

00731   75 4 04715      *       RTJ     WAB
        50 0 00007              7

00732   75 0 00726              SLJ     UNPCKD2
        50 0 00000

00733   75 0 00000      READT1  SLJ     **
        50 0 00000

00734   12 0 02001      *       LDA     TIME
        16 0 01743              LDQ     NAME3

00735   75 4 04231      *       RTJ     MAG
        00 0 00300              0,0

00736   50 0 02014      HIGHT   FNI     MAA
        50 0 01300              FNI     13000

00737   50 0 44215              FNI     FS4
        50 0 02507              FNI     *FADERR

00740   75 0 00733              SLJ     READT1
        50 0 00000

00741   75 0 00300      UNPCKT1 SLJ     **
        50 0 00000              FNI     0,0

00742   75 0 00744      *       SLJ     **2
        00 0 44215              FS4

00743   00 0 24515              FS2
        00 0 02453              24538
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00744   75 4 04715      *          RTJ   MAB
        50 0 00007                 ENI   7

00745   75 0 00741                 SLJ   UNPCKT1
        50 0 00000

00746   75 0 00000      READT2     SLJ   **
        50 0 00000

00747   12 0 02001      *          LDA   TIME
        16 0 01744                 LDQ   NAME4

00750   75 4 04231      *          RTJ   MAC
        00 0 00000                 00    0,0

00751   50 8 02014                 ENI   MAA
        50 0 01300                 ENI   1300B

00752   50 0 44215                 ENI   FS4
        50 0 02007                 ENI   READERR

00753   75 0 00746                 SLJ   READT2
        50 0 00000

00754   75 0 00000      UNPCKT2    SLJ   **
        50 6 00000                 ENI   0,6

00755   75 0 00757      *          SLJ   *+2
        00 0 44215                 00    FS4

00756   00 0 34355                 00    FS3
        00 0 02451                 00    24538

00757   75 4 04715      *          RTJ   MAB
        50 0 00007                 ENI   7

00760   75 0 00754                 SLJ   UNPCKT2
        50 0 00000

00761   75 0 00000      REWIND     SLJ   **
        50 0 00000

00762   75 4 02014      *          RTJ   MAA
        00 0 11306                 00    11306B

00763   75 0 00761      *          SLJ   REWIND
        50 0 00000

00764   75 0 02013      *          SLJ   WINDERR
        50 0 00000

00765   75 0 00000      REWIND1    SLJ   **
        50 0 00000

00766   75 4 02014      *          RTJ   MAA
        00 0 11206                 00    11206B

00767   75 0 00765      *          SLJ   REWIND1
        50 0 00000

00770   75 0 02013      *          SLJ   WINDERR
        50 0 00000

00771   75 0 00000      SINF       SLJ   **
        50 0 00000

00772   75 4 04535      *          RTJ   SAI
        50 0 44215                 ENI   FS4

00773   75 0 00771      *          SLJ   SINF
        50 0 00000
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00774   75 0 00000   VORTIS1  SLJ     **
        50 0 00000

00775   75 4 04611   *        RTJ     SAR
        50 0 44215            ENI     FS4

00776   50 0 05015            ENI     FS0
        50 0 54055            ENI     FS5

00777   50 0 02011            ENI     VORTER1
        50 0 04451            ENI     SAH

01000   75 0 00774            SLJ     VORTIS1
        50 0 00000

01001   75 0 00000   VORTIS2  SLJ     **
        50 0 00000

01002   75 4 04611   *        RTJ     SAR
        50 0 44215            ENI     FS4

01003   50 0 14655            ENI     FS1
        50 0 63715            ENI     FS6

01004   50 0 02012            ENI     VORTER2
        50 0 04451            ENI     SAH

01005   75 0 01001            SLJ     VORTIS2
        50 0 00000

01006   75 0 00000   LAPLAC1  SLJ     **
        50 0 00000

01007   75 4 04423   *        RTJ     SAD
        00 0 05015            00      FS0

01010   00 0 54055            00      FS5
        00 0 02004            00      LAPERR1

01011   75 4 04451   *        RTJ     SAH
        50 0 04447            ENI     SAD+248

01012   50 0 04435            ENI     SAD+128
        50 0 04435            ENI     SAD+128

01013   75 0 01006            SLJ     LAPLAC1
        50 0 00000

01014   75 0 00000   LAPLAC2  SLJ     **
        50 0 00000

01015   75 4 04423   *        RTJ     SAD
        00 0 14655            00      FS1

01016   00 0 63715            00      FS6
        00 0 02005            00      LAPERR2

01017   75 4 04451   *        RTJ     SAH
        50 0 04447            ENI     SAD+248

01020   50 0 04435            ENI     SAD+128
        50 0 04435            ENI     SAD+128

01021   75 0 01014            SLJ     LAPLAC2
        50 0 00000

01022   75 0 00000   HORIZ    SLJ     **
        50 4 00000            ENI     0,4

01023   12 4 05015   LOOP1    LDA     FS0,4
        14 4 14655            ADD     FS1,4
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01024  20 4 54055          STA   FS5,4
       50 0 00005

01025  54 4 07600          ISK   7600B,4
       75 1 01023          SLJ   LOOP1

01026  75 0 01027          SLJ   HORIZ
       50 0 00000

01027  75 0 00000    MHAT  SLJ   **
       50 0 00000

01030  75 4 04570    *     RTJ   SAJ
       00 0 02502          00    MATERR

01031  50 0 44215          ENI   FS4
       50 0 63715          ENI   FS6

01032  75 4 04451    *     RTJ   SAH
       00 0 04577          00    SAJ+7R

01033  50 0 04577          ENI   SAJ+7R
       50 0 04577          ENI   SAJ+7R

01034  75 0 01027          SLJ   MHAT
       50 0 00000

01035  75 0 00000    LTHP1 SLJ   **
       50 0 00000

01036  75 4 04451    DIF1  RTJ   SAH
       00 0 01041          00    OUTS101

01037  50 0 01043    *     ENI   INSID1
       50 0 01043          ENI   INSID1

01040  75 0 01035    *     SLJ   UTHM1
       50 0 00000

01041  10 0 00000    OUTS1D1 ENA 0
       20 2 05315          STA   FS0,2

01042  75 0 01036          SLJ   DIF1
       50 0 00000

01043  12 2 44215    INSID1 LDA  FS4,2
       01 0 00001          ARS   1

01044  14 0 01733          ADD   CONST1
       20 0 01775          STA   LOCAT1

01045  66 0 01775          MUF   LOCAT1
       20 0 01775          STA   LOCAT1

01046  12 3 24515          LDA   FS2,3
       15 1 24515          SUB   FS2,1

01047  20 0 01776          STA   LOCAT2
       12 0 01734          LDA   CONST2

01050  26 2 63715          MUF   FS6,2
       26 0 01776          MUF   LOCAT2

01051  27 3 01775          DVF   LOCAT1
       27 2 24515          DVF   FS2,2

01052  20 2 05315          STA   FS0,2
       75 0 01036          SLJ   DIF1

01053  75 0 00000    UTHP2 SLJ   **
       50 0 00000
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01054   75 4 04451   DIF2    RTJ   SAH
        00 0 01057           00    OUTSID2

01055   50 0 01061   *       ENI   INSID2
        50 0 01061           ENI   INSID2

01056   75 0 01053   *       SLJ   UTHM2
        50 0 00000

01057   10 0 00000   OUTSID2 ENA   0
        20 2 14655           STA   FS1,2

01060   75 0 01054           SLJ   DIF2
        50 0 00000

01061   12 2 44215   INSID2  LDA   FS4,2
        01 0 00001           ARS   1

01062   14 0 01733           ADD   CONST1
        20 0 01775           STA   LOCAT1

01063   26 0 01775           MUF   LOCAT1
        20 0 01775           STA   LOCAT1

01064   12 3 34355           LDA   FS3,3
        15 1 34355           SUB   FS3,1

01065   20 0 01776           STA   LOCAT2
        12 0 01734           LDA   CONST2

01066   26 2 63715           MUF   FS6,2
        26 0 01776           MUF   LOCAT2

01067   27 0 01775           OVF   LOCAT1
        27 2 34355           OVF   FS3,2

01070   20 2 14655           STA   FS1,2
        75 0 01054           SLJ   DIF2

01071   75 0 00000   DUTHM   SLJ   **
        50 4 00000           ENI   0,4

01072   12 4 05015   LOOP4   LDA   FS0,4
        15 4 14655           SUB   FS1,4

01073   20 4 05015           STA   FS0,4
        50 0 00000

01074   54 4 07600   *       ISK   76008,4
        75 0 01072           SLJ   LOOP4

01075   75 0 01071           SLJ   DUTHM
        50 0 00000

01076   75 0 00000   VTHM1   SLJ   **
        50 0 00000

01077   75 4 04451   DIF3    RTJ   SAH
        00 0 01102           00    OUTSID3

01100   50 0 01104   *       ENI   INSID3
        50 0 01104           ENI   INSID3

01101   75 0 01076   *       SLJ   VTHM1
        50 0 00000

01102   10 0 00000   OUTSID3 ENA   0
        20 2 14655           STA   FS1,2

01103   75 0 01077           SLJ   DIF3
        50 0 00000
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01104   12 2 44215          INSID3  LDA   FS4,2
        01 0 00001                  ARS   1

01105   14 1 01734                  ADD   CONST1
        20 1 01775                  STA   LOCAT1

01106   26 0 01775                  MUF   LOCAT1
        20 0 01775                  STA   LOCAT1

01107   12 2 24516                  LDA   FS2+1,2
        15 2 24514                  SUB   FS2-1,2

01110   20 0 01776                  STA   LOCAT2
        12 0 01734                  LDA   CONST2

01111   26 2 63715                  MUF   FS6,2
        26 0 01776                  MUF   LOCAT2

01112   27 0 01775                  DVF   LOCAT1
        27 2 24515                  DVF   FS2,2

01113   20 2 14655                  STA   FS1,2
        75 0 01077                  SLJ   DIF3

01114   75 0 00000          VTHM2   SLJ   **
        50 4 00000                  ENI   0,4

01115   75 4 04451          DIF4    RTJ   S&M
        00 0 01120                  00    OUTSID4

01116   50 0 01122          *       ENI   INSID4
        50 0 01122                  ENI   INSID4

01117   75 0 01114          *       SLJ   VTHM2
        50 0 00000

01120   10 0 00000          OUTSID4 ENA   0
        20 2 24515                  STA   FS2,2

01121   75 0 01115                  SLJ   DIF4
        50 0 00000

01122   12 2 44215          INSID4  LDA   FS4,2
        01 0 00001                  ARS   1

01123   14 0 01733                  ADD   CONST1
        20 0 01775                  STA   LOCAT1

01124   26 0 01775                  MUF   LOCAT1
        20 0 01775                  STA   LOCAT1

01125   12 2 34456                  LDA   FS3+1,2
        15 2 34454                  SUB   FS3-1,2

01126   20 0 01776                  STA   LOCAT2
        12 0 01734                  LDA   CONST2

01127   26 2 63715                  MUF   FS6,2
        26 0 01776                  MUF   LOCAT2

01130   27 0 01775                  DVF   LOCAT1
        27 2 34455                  DVF   FS3,2

01131   20 2 24515                  STA   FS2,2
        75 0 01115                  SLJ   DIF4

01132   75 0 00000          DVTHM   SLJ   **
        50 4 00000                  ENI   0,4

01133   12 4 24515          LOOP7   LDA   FS2,4
        15 4 14655                  SUB   FS1,4
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01134   20 4 14655          STA   FS1,4
        50 0 00000

01135   54 4 07600    *     ISK   76000,4
        75 0 01133          SLJ   LOOP7

01136   75 0 01132          SLJ   DVTHM
        50 0 00000

01137   75 0 00000    DTHM  SLJ   **
        50 4 00000          ENI   0,4

01140   12 4 05015    LOOP8 LDA   FS0,4
        26 4 05015          MUF   FS0,4

01141   20 4 05015          STA   FS0,4
        12 4 14655          LDA   FS1,4

01142   26 4 14655          MUF   FS1,4
        14 4 05015          ADD   FS0,4

01143   75 4 04666    *     RTJ   VAB
        00 0 02010          00    SQERR

01144   20 4 05015    *     STA   FS0,4
        50 0 00000

01145   54 4 07600    *     ISK   76000,4
        75 0 01140          SLJ   LOOP8

01146   75 0 01137          SLJ   DTHM
        50 0 00000

01147   75 0 00000    KAT1  SLJ   **
        50 4 00000          ENI   0,4

01150   12 4 54055    LOOP9 LDA   FS5,4
        15 4 05015          SUB   FS0,4

01151   20 4 54055          STA   FS5,4
        50 0 00000

01152   54 4 07600    *     ISK   76000,4
        75 0 01150          SLJ   LOOP9

01153   75 0 01147          SLJ   KAT1
        50 0 00000

01154   75 0 00000    UGEOS1 SLJ  **
        50 0 00000

01155   75 4 04451    DIF5  RTJ   SAH
        00 0 01160          00    OUTSID5

01156   50 0 01162    *     ENI   INSID5
        50 0 01162          ENI   INSID5

01157   75 0 01154    *     SLJ   UGEOS1
        50 0 00000

01160   10 0 00000    OUTSID5 ENA 0
        20 2 24515          STA   FS2,2

01161   75 0 01155          SLJ   DIF5
        50 0 00000

01162   12 2 44215    INSID5 LDA  FS4,2
        01 0 00001          ARS   1

01163   16 0 01733          ADD   CONST1
        20 0 01775          STA   LOCAT1
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01164   26 0 01775          MUF   LOCAT1
        20 1 01775          STA   LOCAT1

01165   12 3 05015          LDA   FS0,3
        15 1 05015          SUB   FS0,1

01166   20 0 01776          STA   LOCAT2
        12 0 01734          LDA   CONST2

01167   26 2 63715          MUF   FS6,2
        26 3 01776          MUF   LOCAT2

01170   27 0 01775          DVF   LOCAT1
        20 2 24515          STA   FS2,2

01171   75 0 01155          SLJ   DIF5
        50 0 00000

01172   75 0 00000  UGEOS2   SLJ   **
        50 0 00000

01173   75 4 04451  DIF6    RTJ   SAN
        00 0 01176          DO    OUTSID6

01174   50 0 01200  *       ENI   INSID6
        50 0 01200          ENI   INSID6

01175   75 0 01172  *       SLJ   UGEOS2
        50 0 00000

01176   10 0 00000  OUTSID6 ENA   0
        20 2 34355          STA   FS3,2

01177   75 0 01173          SLJ   DIF6
        50 0 00000

01200   12 2 44215  INSID6  LDA   FS4,2
        01 0 00001          ARS   1

01201   14 0 01733          ADD   CONST1
        20 0 01775          STA   LOCAT1

01202   26 0 01775          MUF   LOCAT1
        20 0 01775          STA   LOCAT1

01203   12 3 14655          LDA   FS1,3
        15 1 14655          SUB   FS1,1

01204   20 0 01776          STA   LOCAT2
        12 0 01734          LDA   CONST2

01205   26 2 63715          MUF   FS6,2
        26 3 01776          MUF   LOCAT2

01206   27 0 01775          DVF   LOCAT1
        20 2 34355          STA   FS3,2

01207   75 0 01173          SLJ   DIF6
        50 0 00000

01210   75 0 00000  UGEOS    SLJ   **
        50 4 00000          ENI   0,4

01211   12 4 24515  LOOP10  LDA   FS2,4
        05 0 00003          ALS   3

01212   20 0 01775          STA   LOCAT1
        12 4 34355          LDA   FS3,4

01213   05 0 00003          ALS   3
        14 0 01775          ADD   LOCAT1
```

```
01214   20 4 24515          STA   FS2,*
        50 0 00000
01215   54 4 07600    *     ISK   7600B,*
        75 0 01211          SLJ   LOOP10
01216   75 0 01210          SLJ   UGEOS
        50 0 00000
01217   75 0 00000    VGEOS1  SLJ   **
        50 0 00000
01220   75 4 04451    DIF7    RTJ   SAH
        00 0 01223          00    OUTSID7
01221   50 0 01225    *     ENI   INSID7
        50 0 01225          ENI   INSID7
01222   75 0 01217    *     SLJ   VGEOS1
        50 0 00000
01223   10 0 00000    OUTSID7 ENA   0
        20 2 34355          STA   FS3,2
01224   75 0 01220          SLJ   DIF7
        50 0 00000
01225   12 2 44215    INSID7  LDA   FS4,2
        01 0 00001          ARS   1
01226   14 0 01733          ADD   CONST1
        20 0 01775          STA   LOCAT1
01227   26 0 01775          MUF   LOCAT1
        20 0 01775          STA   LOCAT1
01230   12 2 05016          LDA   FS0+1,2
        15 2 05014          SUB   FS0-1,2
01231   20 0 01776          STA   LOCAT2
        12 0 01734          LDA   CONST2
01232   26 2 63715          MUF   FS6,2
        26 0 01776          MUF   LOCAT2
01233   27 0 01775          DVF   LOCAT1
        20 2 34355          STA   FS3,2
01234   75 0 01220          SLJ   DIF7
        50 0 00000
01235   75 0 00000    VGEOS2  SLJ   **
        50 0 00000
01236   75 4 04451    DIF8    RTJ   SAH
        00 0 01241          00    OUTSID8
01237   50 0 01243    *     ENI   INSID8
        50 0 01243          ENI   INSID8
01240   75 0 01235    *     SLJ   VGEOS2
        50 0 00000
01241   10 0 00000    OUTSID8 ENA   0
        20 2 05015          STA   FS0,2
01242   75 0 01236          SLJ   DIF8
        50 0 00000
01243   12 2 44215    INSID8  LDA   FS4,2
        01 0 00001          ARS   1
```

```
01244   14 3 01733          ADD     CONST1
        20 3 01775          STA     LOCAT1

01245   26 3 01775          MUF     LOCAT1
        20 3 01775          STA     LOCAT1

01246   12 2 14656          LDA     FS1+1,2
        15 2 14654          SUB     FS1-1,2

01247   20 3 01776          STA     LOCAT2
        12 3 01734          LDA     CONST2

01250   26 2 63715          MUF     FS0,2
        26 3 01776          MUF     LOCAT2

01251   27 3 01775          DVF     LOCAT1
        20 2 05015          STA     FS0,2

01252   75 3 01336          SLJ     DIFR
        50 0 00000

01253   75 3 00000  VGEOS    SLJ     **
        50 4 00000          ENI     0,4

01254   12 4 54355  LOOP11  LDA     FS3,4
        55 0 00003          ALS     3

01255   20 3 01775          STA     LOCAT1
        12 4 05015          LDA     FS0,4

01256   05 3 00003          ALS     3
        14 3 01775          ADD     LOCAT1

01257   20 4 05015          STA     FS0,4
        50 0 00000

01260   54 4 07600  *       ISK     76000,4
        75 3 01254          SLJ     LOOP11

01261   75 3 01253          SLJ     VGEOS
        50 3 00000

01262   75 3 00000  KINETIC  SLJ     **
        50 4 00000          ENI     0,4

01263   12 4 24515  LOOP12  LDA     FS2,4
        26 4 24515          MUF     FS2,4

01264   20 3 01775          STA     LOCAT1
        12 4 05015          LDA     FS0,4

01265   26 4 05015          MUF     FS0,4
        20 3 01776          STA     LOCAT2

01266   14 3 01775          ADD     LOCAT1
        01 3 00001          ARS     1

01267   20 4 05015          STA     FS0,4
        12 3 01775          LDA     LOCAT1

01270   15 3 01776          SUB     LOCAT2
        20 4 44215          STA     FS4,4

01271   26 4 44215          MUF     FS4,4
        20 4 44215          STA     FS4,4

01272   54 4 07600  *       ISK     76000,4
        75 3 01263          SLJ     LOOP12

01273   75 3 01262          SLJ     KINETIC
        50 3 00000
```

```
01274  75 0 00000        LAPKIN   SLJ     **
       50 0 00000

01275  75 4 04423        *        RTJ     SAD
       00 0 63715                 00      FS6

01276  00 0 05315                 00      FS0
       00 0 02006                 00      LAPERR3

01277  75 4 04451        *        RTJ     SAH
       50 0 04447                 ENI     SAD+24B

01300  50 0 04435                 ENI     SAD+12B
       50 0 04435                 ENI     SAD+12B

01301  50 4 00000                 ENI     0,4
       50 0 00000

01302  12 4 63715        ABS      LDA     FS6,4
       26 4 63715                 MUF     FS6,4

01303  20 4 63715                 STA     FS6,4
       50 0 00000

01304  54 4 07600        *        ISK     7600B,4
       75 0 01302                 SLJ     ABS

01305  75 0 01274                 SLJ     LAPKIN
       50 0 00000

01306  75 0 00000        KAT2     SLJ     **
       50 4 00000                 ENI     0,4

01307  12 4 54055        LOOP13   LDA     FS5,4
       15 4 05015                 SUB     FS0,4

01310  15 4 63715                 SUB     FS6,4
       15 4 44215                 SUB     FS4,4

01311  20 4 05315                 STA     FS0,4
       50 0 00000

01312  54 4 07600        *        ISK     7600B,4
       75 0 01307                 SLJ     LOOP13

01313  75 0 01306                 SLJ     KAT2
       50 0 00000

01314  75 0 00000        READ01   SLJ     **
       50 0 00000

01315  12 0 02001        *        LDA     TIME
       16 0 01751                 LDQ     NAMES

01316  75 4 04231        *        RTJ     MAG
       00 0 00000                 00      0,0

01317  50 0 02014                 ENI     MAA
       50 0 01200                 ENI     1200B

01320  50 0 44215                 ENI     FS4
       50 0 02007                 ENI     READERR

01321  75 0 01314                 SLJ     READ01
       50 0 00000

01322  75 0 00000        UNPCK01  SLJ     **
       50 6 00000                 ENI     0,6

01323  75 0 01325        *        SLJ     *+2
       00 0 44215                 00      FS4
```

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01324   00 0 54055          00      FS5
        00 0 02453          00      2453B

01325   75 4 06715    *     RTJ     MAB
        50 0 00007          FNI     7

01326   75 0 01322          SLJ     UNPCK01
        50 0 00004

01327   75 0 00000    READ02  SLJ     **
        50 0 00000

01330   12 0 02301    *     LDA     TIME
        16 0 01754          LDQ     NAME6

01331   75 4 04231    *     RTJ     MAG
        00 0 00000          00      0,0

01332   50 0 02014          ENI     M4A
        50 0 01200          ENI     1200B

01333   50 0 44215          ENI     FS4
        50 0 02007          ENI     READERR

01334   75 0 01327          SLJ     READ02
        50 0 00000

01335   75 0 00000    UNPCK02 SLJ     **
        50 6 00000          ENI     0,6

01336   75 0 01340    *     SLJ     *+2
        00 0 44215          00      FS4

01337   00 0 63715          00      FS6
        00 0 02453          00      2453B

01340   75 4 04715    *     RTJ     MAB
        50 0 00007          FNI     7

01341   75 0 01335          SLJ     UNPCK02
        50 0 00000

01342   75 0 00000    MOORE   SLJ     **
        50 0 00000

01343   75 4 04371    *     RTJ     SAB
        00 0 14655          00      FS1

01344   00 0 34355          00      FSJ
        00 0 63715          00      FS6

01345   00 0 00000    *     00      0
        00 0 02003          00      JACERR

01346   75 4 04451          RTJ     SAH
        50 0 04420          ENI     SAB+27B

01347   50 0 04406    *     ENI     SAB+15B
        50 0 04406          ENI     SAB+15B

01350   50 4 00000          ENI     0,4
        50 0 00000

01351   12 4 14555    SHIFT   LDA     FS1,4
        05 0 00015          ALS     13

01352   20 4 14655          STA     FS1,4
        50 0 00000

01353   54 4 07600    *     ISK     76000,4
        75 0 01351          SLJ     SHIFT
```

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01354   75 4 01142          SLJ     MORDVC
        50 4 00000

01355   75 0 00000  MORDVC   SLJ     **
        50 4 00000          ENI     0,4

01356   12 4 54355  LOOP15  LDA     FSS,4
        01 0 00001          ARS     1

01357   20 4 01775          STA     LOCAT1
        12 4 54715          LDA     FS0,4

01360   01 0 00001          ARS     1
        20 0 01776          STA     LOCAT2

01361   12 0 01775          LDA     LOCAT1
        14 0 01776          SUB     LOCAT2

01362   20 4 54055          STA     FSS,4
        50 0 00000

01363   54 4 07600  *       ISK     7600B,4
        75 0 01356          SLJ     LOOP15

01364   75 0 01355          SLJ     MORDVC
        50 0 00000

01365   75 4 00000  ABSDIV  SLJ     **
        50 4 00000          ENI     0,4

01366   12 4 54055  LOOP17  LDA     FSS,4
        26 4 54055          PUP     FSS,4

01367   05 0 00016          ALS     14
        50 0 00000

01370   20 4 54055  *       STA     FSS,4
        50 0 00000

01371   54 4 07600  *       ISK     7600B,4
        75 0 01366          SLJ     LOOP17

01372   75 0 01365          SLJ     ABSDIV
        50 0 00000

01373   75 4 00000  KAT     SLJ     **
        50 4 00000          ENI     0,4

01374   12 4 05015  LOOP16  LDA     FSS,4
        14 4 54055          SUB     FSS,4

01375   14 4 14655          SUM     FS1,4
        20 4 05015          STA     FS0,4

01376   54 4 07600  *       ISK     7600B,4
        75 0 01374          SLJ     LOOP16

01377   75 0 01373          SLJ     KAT
        50 0 00000

01400   75 0 00000  LAYER2  SLJ     **
        12 0 01757          LDA     COUNT

01401   05 0 00001          ALS     1
        20 0 01757          STA     COUNT

01402   22 1 01400          AJPM    LAYER2
        12 0 01736          LDA     NAME1A

01403   20 0 01735          STA     NAME1
        12 0 01741          LDA     NAME2A
```

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C1404   20 3 01740          STA   NAME2
        12 3 01744          LDA   NAME3A

C1405   20 3 01743          STA   NAME3
        12 3 01747          LDA   NAME4A

C1406   20 3 01746          STA   NAME4
        12 3 01755          LDA   NAME6A

01407   20 0 01754          STA   NAME6
        12 0 01761          LDA   LEVEL2

C1410   20 0 01471          STA   TITLE+3
        20 0 01515          STA   TITLE1+3

C1411   20 0 01541          STA   TITLE2+3
        20 0 01565          STA   TITLE3+3

C1412   20 0 01611          STA   TITLE4+3
        20 0 01635          STA   TITLE5+3

C1413   20 0 01661          STA   TITLE6+3
        20 0 01705          STA   TITLE7+3

01414   20 0 01731          STA   TITLE8+3
        12 0 01763          LDA   A2

C1415   20 0 01461          STA   A1
        12 0 01765          LDA   B2

01416   20 0 01462          STA   B1
        12 0 01767          LDA   C2

C1417   20 0 01464          STA   C1
        12 0 01771          LDA   D2

C1420   20 0 01463          STA   D1
        12 0 01773          LDA   E2

01421   61 0 01460          SAL   E1
        12 0 01777          LDA   TAPUNIT

01422   61 0 00710          SAL   HIGHD
        61 0 00736          SAL   HIGHT

C1423   75 0 00601          SLJ   START
        50 0 00000

01424   75 0 00000  LAYER3   SLJ   **
        12 0 01760          LDA   COUNT1

01425   05 0 00001          ALS   1
        20 0 01760          STA   COUNT1

C1426   22 0 01424          AJPM  LAYER3
        12 0 01737          LDA   NAME1B

01427   20 0 01735          STA   NAME1
        12 0 01742          LDA   NAME2B

C1430   20 0 01740          STA   NAME2
        12 0 01745          LDA   NAME3B

01431   20 0 01743          STA   NAME3
        12 0 01750          LDA   NAME4B

01432   20 0 01746          STA   NAME4
        12 0 01753          LDA   NAME5B

01433   20 0 01751          STA   NAME5
        12 0 01756          LDA   NAME6B
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01434   20 1 01754          STA   NAME6
        12 0 01767          LDA   LEVEL3

01435   20 0 01471          STA   TITLE+3
        20 0 01515          STA   TITLE1+3

01436   20 0 01541          STA   TITLE2+3
        20 0 01565          STA   TITLE3+3

01437   20 0 01611          STA   TITLE4+3
        20 0 01635          STA   TITLE5+3

01440   20 0 01661          STA   TITLE6+3
        20 0 01705          STA   TITLE7+3

01441   20 0 01731          STA   TITLE8+3
        12 0 01764          LDA   A3

01442   20 0 01461          STA   A1
        12 0 01766          LDA   B3

01443   20 0 01462          STA   B1
        12 0 01770          LDA   C3

01444   20 0 01464          STA   C1
        12 0 01772          LDA   D3

01445   20 0 01463          STA   D1
        12 0 01774          LDA   E3

01446   61 0 01460          SAL   E1
        75 0 00601          SLJ   START

01447   75 0 00000  PRINT   SLJ   **
        10 0 00012          FNA   10

01450   20 0 00017          STA   17B
        50 0 00000

01451   75 0 01455  *       SLJ   *+4
        00 0 00000          00    0

01452   00 0 14655          00    FS1
        00 0 63715          00    FS6

01453   00 0 00047          00    39
        00 0 00035          00    29

01454   00 0 00022          00    18
        00 0 00010          00    8

01455   75 4 04745  *       RTJ   MAE
        00 0 00000          00    0

01456   75 4 02524  *       RTJ   MAC
        00 0 63715          00    FS6,0

01457   75 0 01447  *       SLJ   PRINT
        77 7 63715          77    FS6,7

01460   10 0 02000  E1      10    TAU
        00 0 00004          00    4

01461   13 1 11710  A1      OCT   1311171047640243
        47 6 40243

01462   02 4 76132  B1      OCT   0247613261070664
        61 3 70664

01463   00 1 42600  D1      OCT   0014260000000000
        00 0 00000
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01464	61 1 56400 00 1 03000	G1	ECT	013560000000000
01465	20 2 00166 00 2 00026		ECT	22 22
01466	20 4 34626 65 5 12043	TITLE	HOLL	4, LOWER LEVEL Z FIELD LAYER 1
01467	65 2 56543 20 3 12466	TITLE	HOLL	4, LOWER LEVEL Z FIELD LAYER 1
01470	71 6 54364 20 7 02323	TITLE	HOLL	4, LOWER LEVEL Z FIELD LAYER 1
01471	43 6 13365 01 2 00127	TITLE	HOLL	4, LOWER LEVEL Z FIELD LAYER 1
01472	75 0 01447 50 0 00309		SLJ	PRINT
01473	75 0 00000 10 0 00012	PRINT	SLJ ENA	** 10
01474	60 1 00017 50 0 00017		STA	178
01475	75 0 01501 00 0 00000	*	SLJ 00	**4 0
01476	00 0 54355 00 0 63715		00 00	FS5 FS6
01477	00 0 00047 00 0 00035		00 00	39 29
01500	00 0 00022 00 0 00010		00 00	18 8
01501	75 4 04745 00 0 00000	*	RTJ 00	MAE 0
01502	75 4 02544 00 0 63715	*	RTJ 00	MAC FS6,0
01503	75 0 01473 77 7 63715		SLJ 77	PRINT1 FS6,7
01504	10 0 02000 00 0 00001		10 00	TSX 1
01505	00 0 00000 00 0 00000		ECT	0
01506	20 0 00400 00 0 00000		FEC	50-1847
01507	20 0 00000 00 0 00000		ECT	0
01510	43 1 46314 60 1 46314		FEC	10-1847
01511	20 0 00026 00 0 00026		20 00	22 22
01512	20 4 36147 43 4 16371	TITLE1	HOLL	4, LAPLACIAN OF VORTICITY LAYER 1
01513	61 4 52466 66 0 02546	TITLE1	HOLL	4, LAPLACIAN OF VORTICITY LAYER 1

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01514   51 2 37163          TITLE1   BCD   4, LAPLACIAN OF VORTICITY LAYER 1
        71 2 33020

01515   43 6 13045          TITLE1   BCD   4, LAPLACIAN OF VORTICITY LAYER 1
        51 2 00120

01516   75 0 01473                   SLJ   PRINT1
        50 0 00000

01517   75 0 00000          PRINT2   SLJ   **
        10 0 00012                   ENA   10

01520   20 0 00017                   STA   17B
        50 0 00000

01521   75 0 01525          *        SLJ   *+4
        00 0 00000                   00    0

01522   00 0 05015                   00    FS0
        00 0 63715                   00    FS6

01522   00 0 05015                   CO    FS0

01523   00 0 00047                   00    39
        00 0 00035                   00    29

01524   00 0 00022                   00    18
        00 0 00010                   00    8

01525   75 4 04745          SKIP     RTJ   WAE
        00 0 00000                   00    0

01526   75 4 02524          *        RTJ   MAC
        00 0 63715                   00    FS6,0

01527   75 0 01517                   SLJ   PRINT2
        77 7 63715                   77    FS6,7

01530   10 0 02000                   10    TAU
        00 0 00001                   00    1

01531   00 0 00000                   OCT   0
        00 0 00000

01532   20 0 00000                   DEC   50-1047
        00 0 00000

01533   00 0 00000                   OCT   0
        00 0 00000

01534   00 6 31463                   DEC   250-3847
        14 6 31463

01535   00 0 00026                   00    22
        00 0 00026                   00    22

01536   20 2 56551          TITLE2   BCD   4, VERT GRAD OF VT        LAYER 1
        23 2 06751

01537   61 6 42046          TITLE2   BCD   4, VERT GRAD OF VT        LAYER 1
        66 2 02523

01540   20 2 02020          TITLE2   BCD   4, VERT GRAD OF VT        LAYER 1
        20 2 02020

01541   43 6 13045          TITLE2   BCD   4, VERT GRAD OF VT        LAYER 1
        51 2 00120

01542   75 0 01517                   SLJ   PRINT2
        50 0 00000

01543   75 0 00000          PRINT3   SLJ   **
        10 0 00012                   ENA   10
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01544	[illegible]			STA	17B
01545	75 4 01551 00 0 00000	*		SLJ 00	*** 0
01546	[illegible]			[illegible] 00	FSS FS6
01547	60 0 00047 00 0 00035			00 00	39 29
01550	00 0 00022 00 0 00015			00 00	18 8
01551	75 4 04745 00 0 00000	*		RTJ 00	WAL 0
01552	75 4 02324 00 0 63715	*		RTJ 00	MAC FSG,0
01553	75 0 01543 77 7 63715			SLJ 77	PRINT3 FS6,7
01554	10 1 02401 00 0 00001			10 00	TAU 1
01555	[illegible]			CCT	0
01556	20 0 00000 00 0 00000			DEC	50-1847
01557	00 0 00000 00 0 00000			CCT	0
01560	03 1 46314 03 1 46314			DEC	10-1847
01561	00 0 00026 00 0 00026			00 00	22 22
01562	20 6 12565 51 6 16765	TITLE4		BCD	4, AVERAGE DIVERGENCE LAYER 1
01563	20 6 47125 65 6 16765	TITLE4		BCD	4, AVERAGE DIVERGENCE LAYER 1
01564	45 6 36520 20 0 00000	TITLE4		BCD	4, AVERAGE DIVERGENCE LAYER 1
01565	[illegible]	TITLE4		BCD	4, AVERAGE DIVERGENCE LAYER 1
01566	75 0 01543 50 0 00000			SLJ	PRINT3
01567	75 1 00000 10 0 00012	PRINT4		SLJ FNA	** 10
01570	20 [illegible]			STA	17B
01571	75 1 01573 70 1 00000	*		SLJ 00	*** 0
01572	[illegible]			[illegible] 00	FSS FS6
01573	[illegible]			00 00	39 29

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01574   00 0 00022          *         RTJ     MAE
        00 0 00010                    00      8

01575   75 4 04745          *         RTJ     MAE
        00 0 00000                    00      0

01576   75 4 02524          *         RTJ     MAC
        00 0 63715                    00      FS6,0

01577   75 0 01567                    SLJ     PRINT4
        77 7 63715                    77      FS6,7

01600   10 0 02000                    10      TAU
        00 0 00001                    00      1

01601   00 0 00000                    OCT     0
        00 0 00000

01602   20 0 00000                    DEC     50-1847
        00 0 00000

01603   00 0 00000                    OCT     0
        00 0 00000

01604   03 1 46314                    DEC     10-1847
        63 1 46314

01605   00 0 00026                    DD      22
        00 0 00026                    DD      22

01606   20 4 27145          TITLE4    BCD     4, KINETIC ENERGY       LAYER 1
        65 2 37163

01607   20 4 54565          TITLE4    BCD     4, KINETIC ENERGY       LAYER 1
        51 6 73020

01610   20 2 02020          TITLE4    BCD     4, KINETIC ENERGY       LAYER 1
        20 2 02020

01611   43 6 13065          TITLE4    BCD     4, KINETIC ENERGY       LAYER 1
        51 2 00120

01612   75 0 01547                    SLJ     PRINT4
        50 0 00000

01613   75 0 00000          PRINTS    SLJ     **
        10 0 00012                    ENA     10

01614   20 0 00017                    STA     17B
        50 0 00000

01615   75 0 01621          *         SLJ     *+4
        00 0 00000                    00      0

01616   00 0 44215                    00      FS4
        00 0 63715                    00      FS6

01617   00 0 00047                    00      39
        00 0 00035                    00      29

01620   00 0 00022                    00      18
        00 0 00010                    00      8

01621   75 4 04745          *         RTJ     MAE
        00 0 00000                    00      0

01622   75 4 02524          *         RTJ     MAC
        00 0 63715                    00      FS6,0

01623   75 0 01613                    SLJ     PRINTS
        77 7 63715                    77      FS6,7
```

```
01624   10 1 02000      TAU     10
        00 0 00001              1

01625   00 0 00000      OCT     0
        00 0 00000

01626   20 0 00100      DEC     90-1847
        00 0 00103

01627   00 0 00000      OCT     0
        00 0 00000

01630   03 1 46314      DEC     10-1847
        03 1 46314

01631   00 0 00026      GO      22
        00 0 00026      GO      22

01632   20 4 27145  TITLE4  BCD     4, KINT ENERGY DIFF     LAYER 1
        23 2 06545

01633   65 5 16730  TITLE5  BCD     4, KINT ENERGY DIFF     LAYER 1
        20 6 47166

01634   66 2 02020  TITLE6  BCD     4, KINT ENERGY DIFF     LAYER 1
        20 2 02020

01635   43 6 13365  TITLE7  BCD     4, KINT ENERGY DIFF     LAYER 1
        51 2 00120

01636   75 0 01613      SLJ     PRINT5

01637   75 0 00000  PRINT6  SLJ     **
        10 0 00012      FNA     10

01640   20 0 00017      STA     17B
        50 0 00000

01641   75 0 01645  *       SLJ     *+4
        00 0 00000      00      0

01642   00 0 63715      GO      FS6
        00 0 14455      GO      FS1

01643   00 0 00047      GO      39
        00 0 00035      GO      29

01644   00 0 00022      GO      18
        00 0 00010      GO      8

01645   75 4 04745  *       RTJ     WAE
        00 0 00000      00      0

01646   75 4 02524  *       RTJ     WAC
        00 0 14655      00      FS1,0

01647   75 0 01637      SLJ     PRINT6
        77 7 14655      77      FS1,*

01650   10 0 02000      10      TAU
        00 0 00001      00      1

01651   00 0 00000      OCT     0
        00 0 00000

01652   20 0 00000      DEC     50-1847
        00 0 00000

01653   00 0 00000      OCT     0
        00 0 00000
```

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01654    14 4 31463                    DEC     25D-1847
01655    30 3 10026                    DEC     22
01656    67 2 07145    TITLE6  BCD     4, CHNG IN KINETIC ENERGY LAYER 1
01657    65 2 37163    TITLE6  BCD     4, CHNG IN KINETIC ENERGY LAYER 1
01660    51 6 73120    TITLE6  BCD     4, CHNG IN KINETIC ENERGY LAYER 1
01661    51 2 50120    TITLE6  BCD     4, CHNG IN KINETIC ENERGY LAYER 1
01662    50 3 00305                    PRINTA
01663    10 0 00312    PRINT7  SLJ     *S
                                       LJ
01664    50 0 00300                    STA     178
01665    00 3 00000    *               SLJ     *+4
                                       LJ      0
01666    30 3 63715                    FS0     FS6
01667    00 3 00035                    39      29
01670    00 3 00310                    18      8
01671    00 0 00000    *               RTJ     MAE
                                       00      0
01672    00 0 63715    *               RTJ     MAC
                                       00      FS6,0
01673    77 7 63715                    SLJ     PRINT7
                                       77      FS6,7
01674    00 3 00001                    TAU     1
01675    00 3 00300                    OCT     0
01676    00 0 00000                    DEC     50-1847
01677    30 3 00000                    OCT     0
01700    00 0 00000                    DEC     25D-1847
01701    00 0 00026                    22      22
01702    67 2 04261    TITLE7  BCD     4, PROG KAT FIELD          LAYER 1
01703    65 4 36420    TITLE7  BCD     4, PROG KAT FIELD          LAYER 1
```

```
01704   20 0 02120
        20 2 02420
01705   43 6 13065
        51 2 00120
01706   75 0 01663
        50 0 00000
01707   75 0 00000
        10 0 00012
01710   20 0 00017
        50 0 00000
01711   75 0 01715
        00 0 00000
01712   00 0 14455
        00 0 63715
01713   00 0 00007
        00 0 00055
01714   00 0 00022
        00 0 00010
01715   75 4 04746
        00 0 00000
01716   75 4 02524
        00 0 63715
01717   75 0 01707
        77 7 63715
01720   10 0 02300
        00 0 00001
01721   00 0 00000
        00 0 00000
01722   20 0 00300
        00 0 00000
01723   00 0 00000
        00 0 00003
01724   23 1 46314
        63 1 44314
01725   00 0 00026
        00 0 00026
01726   20 6 16425
        65 6 32046
01727   66 2 04644
        05 6 76120
01730   62 3 02723
        65 4 44720
01731   43 6 13065
        51 2 00120
01732   75 0 01707
        50 0 00000
01733   20 0 00300
        00 0 00000

TITLE7  BCD     4, PROG KAT FIELC          LAYER 1
TITLE7  BCD     4, PROG KAT FIELD          LAYER 1
        SLJ     PRINT7
PRINT8  SLJ     **
        ENA     15
        STA     178
*       SLJ     ***4
        00      0
        00      ESI
        00      FS6
        00      39
        00      29
        00      1H
        00      9
*       RTJ     MAC
        00      0
        RTJ     MAC
        00      FS6,0
        SLJ     PRINT8
        77      FS6,7
        10      TAU
        00      1
        OCT     0
        DEC     50-1847
        OCT     0
        DEC     10-1847
        00      22
        00      22
TITLE8  BCD     4, ADVEC OF OMEGA BY TEMP LAYER 1
TITLE8  BCD     4, ADVEC OF OMEGA BY TEMP LAYER 1
TITLE8  BCD     4, ADVEC OF OMEGA BY TEMP LAYER 1
TITLE8  BCD     4, ADVEC OF OMEGA BY TEMP LAYER 1
        SLJ     PRINT8
CONST1  DEC     50-1847
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01734   05 5 11512          CONST2   DEC   17637D-5847
        62 5 77555

01735   64 2 02003          NAME1    OCT   6420200312122020
        12 1 22020

01736   64 2 02002          NAME1A   OCT   6420200212122020
        12 1 22020

01737   64 2 02001          NAME1B   OCT   6420200112122020
        12 1 22020

01740   64 2 02005          NAME2    OCT   6420200512122020
        12 1 22020

01741   64 2 02003          NAME2A   OCT   6420200312122020
        12 1 22020

01742   64 2 02002          NAME2B   OCT   6420200212122020
        12 1 22020

01743   23 2 02003          NAME3    OCT   2320200312122020
        12 1 22020

01744   23 2 02002          NAME3A   OCT   2320200212122020
        12 1 22020

01745   23 2 02001          NAME3B   OCT   2320200112122020
        12 1 22020

01746   23 2 02005          NAME4    OCT   2320200512122020
        12 1 22020

01747   23 2 02003          NAME4A   OCT   2320200312122020
        12 1 22020

01750   23 2 02002          NAME4B   OCT   2320200212122020
        12 1 22020

01751   46 4 46720          NAME5    OCT   4644672003121220
        03 1 21220

01752   46 4 46720          NAME5A   OCT   4644672002121220
        02 1 21220

01753   46 4 46720          NAME5B   OCT   4644672001121220
        01 1 21220

01754   46 4 46720          NAME6    OCT   4644672005121220
        05 1 21220

01755   46 4 46720          NAME6A   OCT   4644672003121220
        03 1 21220

01756   46 4 46720          NAME6B   OCT   4644672002121220
        02 1 21220

01757   17 7 77777          COUNT    OCT   1777777777777777
        77 7 77777

01760   17 7 77777          COUNT1   OCT   1777777777777777
        77 7 77777

01761   43 6 13065          LEVEL2   OCT   4361306551200220
        51 2 00220

01762   43 6 13065          LEVEL3   OCT   4361306551200320
        51 2 00320

01763   07 2 47764          A2       OCT   0724776415014743
        15 0 14743
```

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01764   11 3 33231          A3      OCT   1133323141120344
        41 1 20344

01765   01 0 30675          B2      OCT   0103067572026573
        72 0 26573

01766   01 0 30675          B3      OCT   0103067572026573
        72 0 26573

01767   02 7 34000          C2      OCT   0273400000000000
        00 0 00000

01770   02 7 34000          C3      OCT   0273400000000000
        00 0 00000

01771   77 0 12577          D2      OCT   7701257777777777
        77 7 77777

01772   77 3 02377          D3      OCT   7730237777777777
        77 7 77777

01773   00 0 00000          E2      OCT   2
        00 0 00002

01774   00 0 00000          E3      OCT   2
        00 0 00002

01775       01776           LOCAT1  BSS   1

01776       01777           LOCAT2  BSS   1

01777   00 0 00000          TAPUNIT OCT   50001200
        50 0 01200

02000   00 0 00000          TAU     DEC   24
        00 0 00030

02001   12 1 21205          TIME    OCT   1212120512010605
        12 0 10605

02002   76 0 01027          MATERR  SLS   MMAT
        50 0 00000

02003   76 0 01342          JACERR  SLS   MOORE
        50 0 00000

02004   76 0 01006          LAPERR1 SLS   LAPLAC1
        50 0 00000

02005   76 0 01014          LAPERR2 SLS   LAPLAC2
        50 0 00000

02006   76 0 01274          LAPERR3 SLS   LAPKIN
        50 0 00000

02007   76 0 00705          READERR SLS   READ01
        50 0 00000

02010   76 0 01137          SQERR   SLS   DTHM
        50 0 00000

02011   76 0 00774          VORTER1 SLS   VORTIS1
        50 0 00000

02012   76 0 01001          VORTER2 SLS   VORTIS2
        50 0 00000

02013   76 0 00761          WINDERR SLS   REWIND
        50 0 00000
```
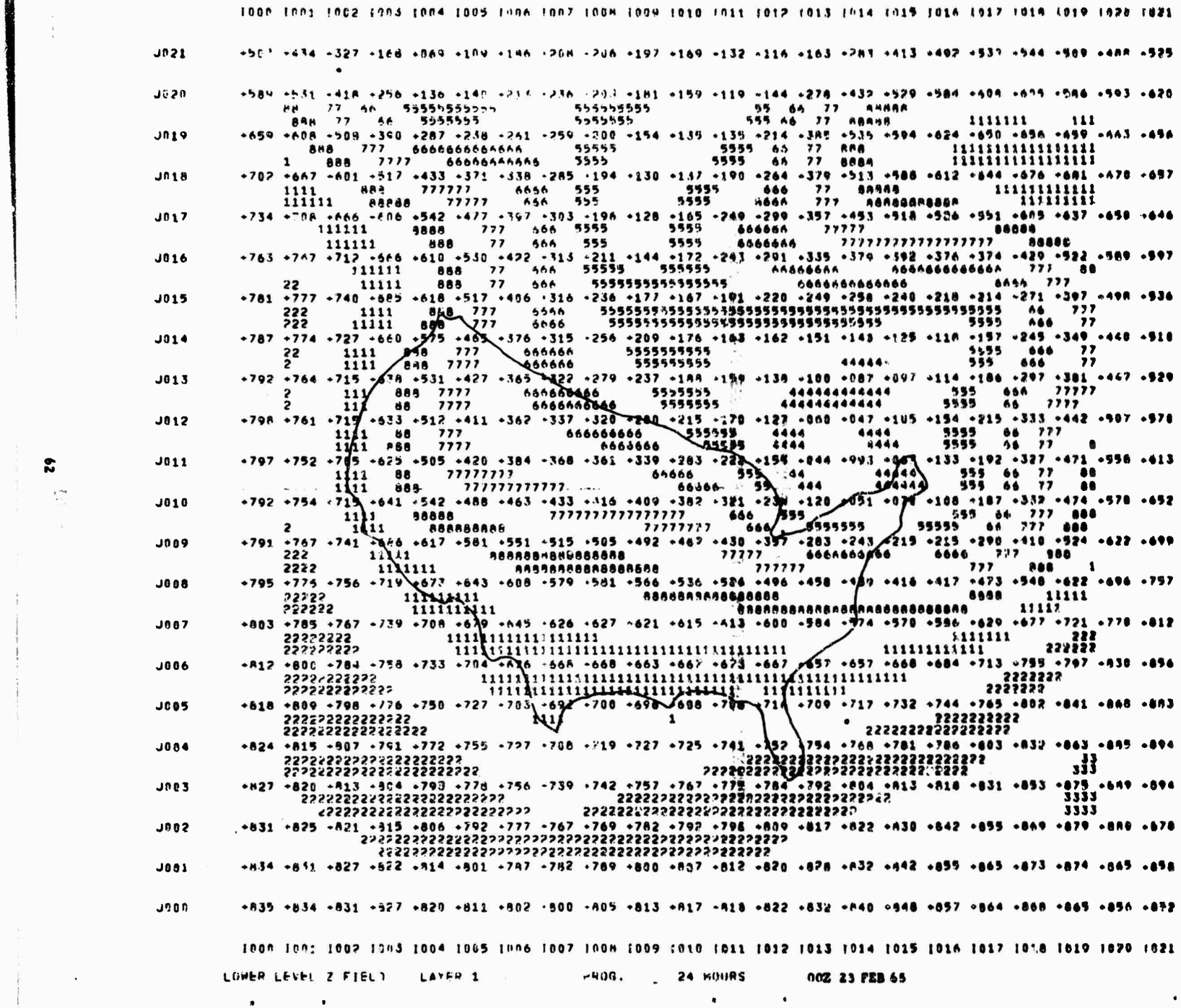

02014	02524	MAA	LIB	MAA
02524	04231	MAC	LIB	MAC
04231	04371	MAG	LIB	MAG
04371	04423	SAB	LIB	SAB
04423	04451	SAD	LIB	SAD
04451	04535	SAH	LIB	SAH
04535	04570	SAI	LIB	SAI
04570	04611	SAJ	LIB	SAJ
04611	04666	SAR	LIB	SAR
04666	04715	VAB	LIB	VAB
04715	04745	WAB	LIB	WAB
04745	05015	WAE	LIB	WAE
05015	14655	FS0	BSS	4000
14655	24515	FS1	BSS	4000
24515	34355	FS2	BSS	4000
34355	44215	FS3	BSS	4000
44215	54055	FS4	BSS	4000
54055	63715	FS5	BSS	4000
63715	73555	FS6	BSS	4000
73555	00000		END	

8. APPENDIX C

PRINTED FIELDS FROM THE RESEARCH PROGRAM FOR OOZ 23 FEB 65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J020
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J014
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J008
J007
J006
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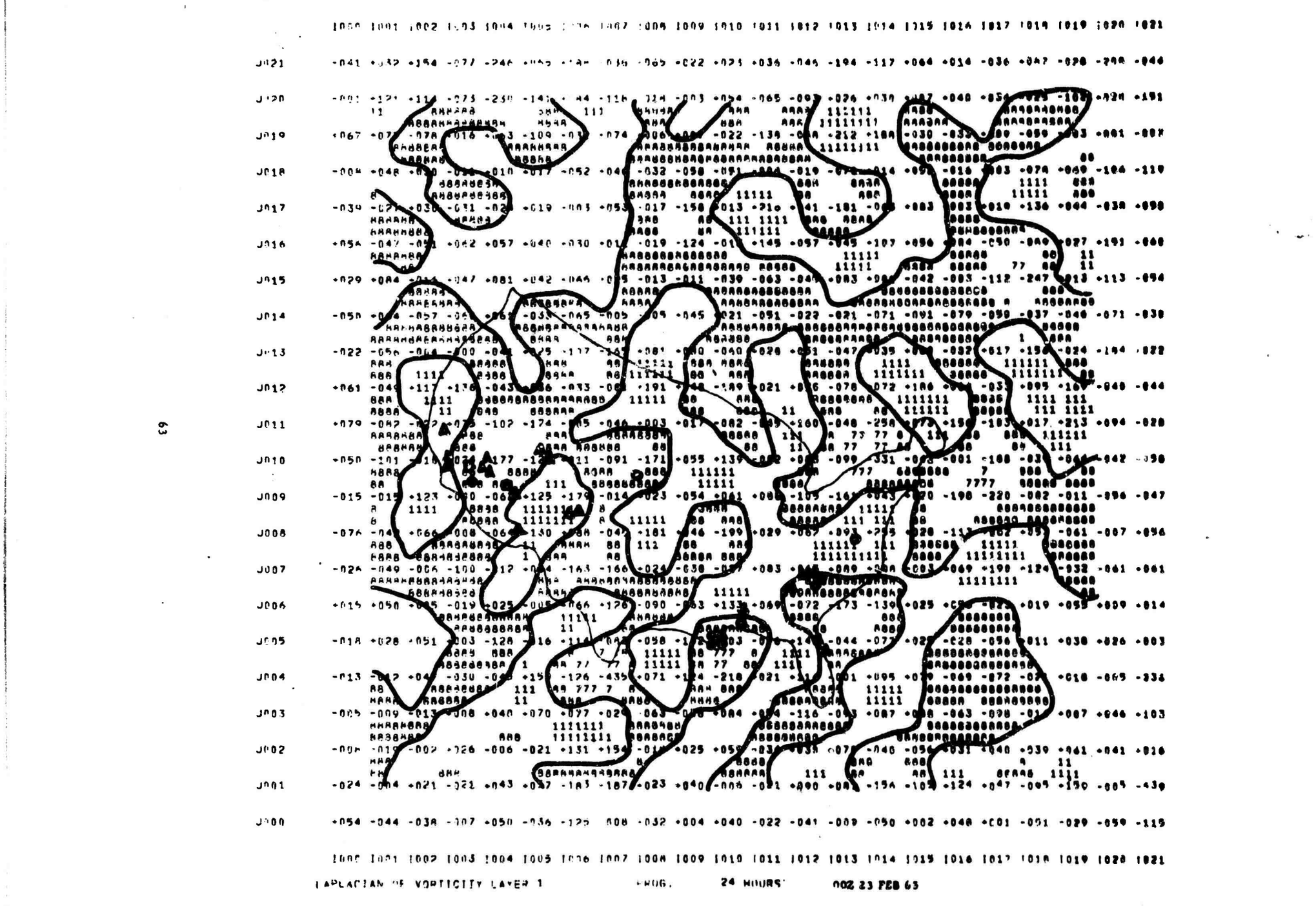
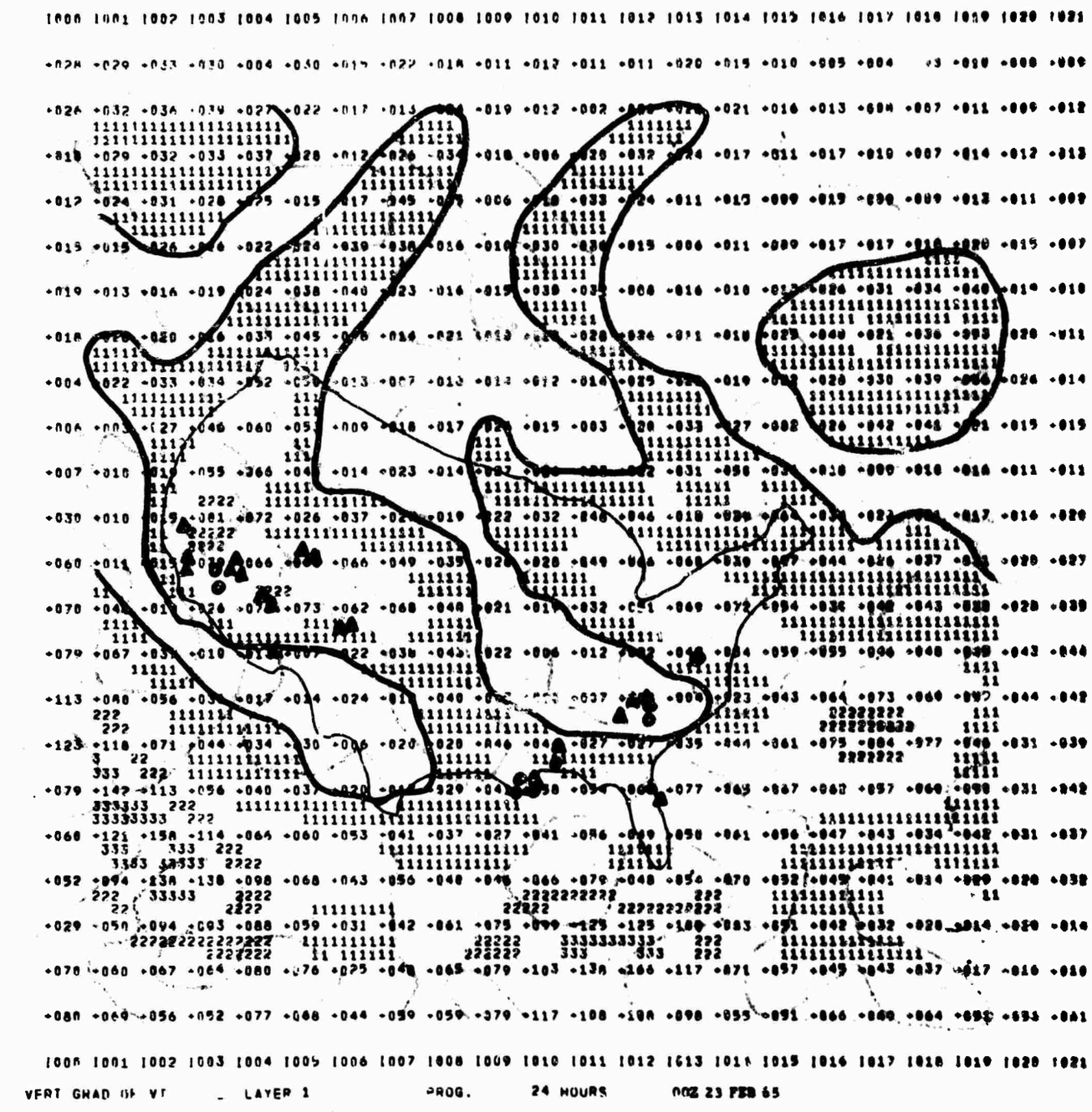
J001
J000
I000 I001 I002 I003 I004 I005 I006 I007 I008 I009 I010 I011 I012 I013 I014 I015 I016 I017 I018 I019 I020 I021
LOWER LEVEL Z FIELD LAYER 1 +HOG. 24 HOURS 00Z 23 FEB 65


LAPLACIAN OF VORTICITY LAYER 1
PROG. 24 HOURS
00Z 23 FEB 63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J021
J020
J019
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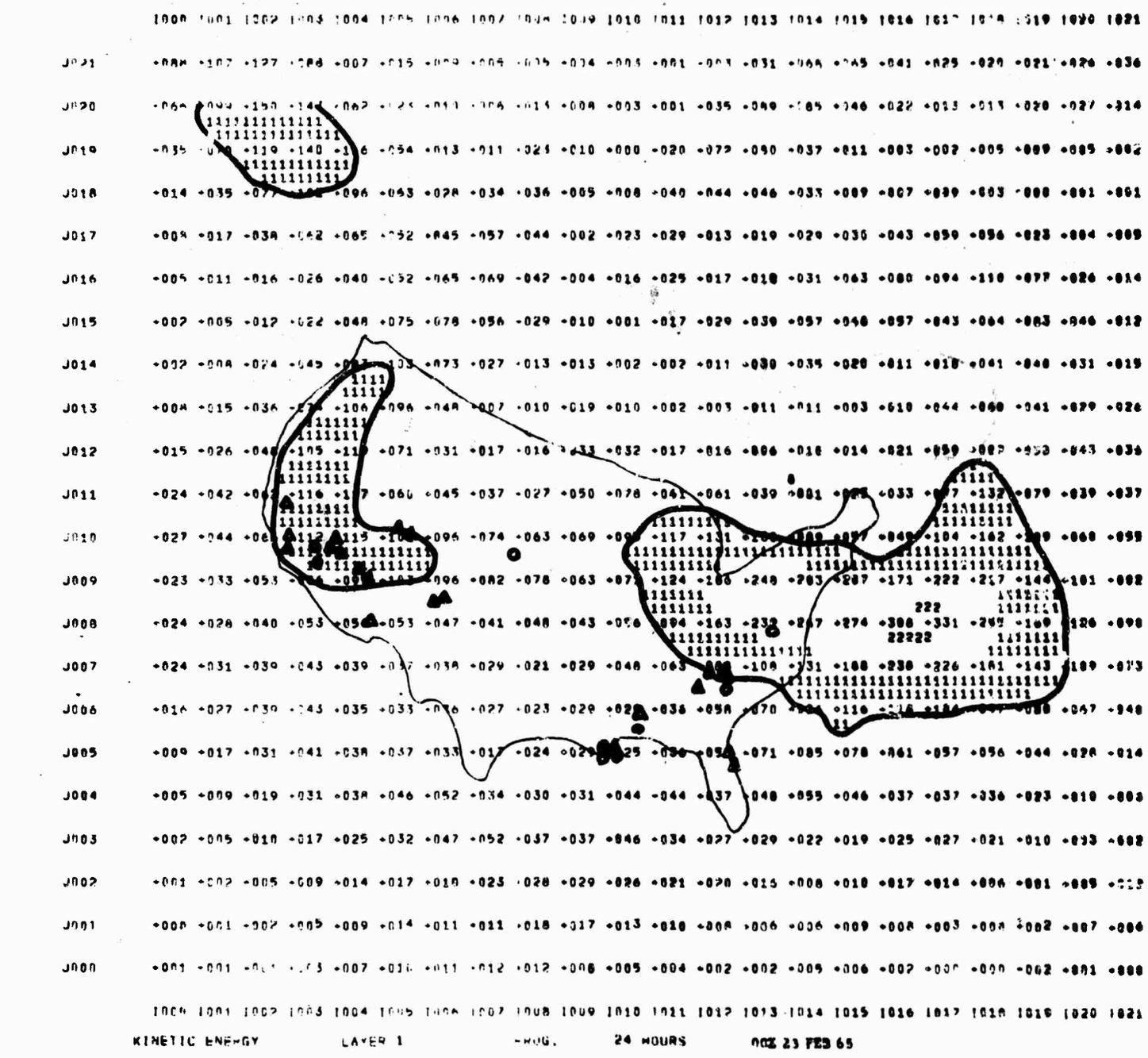
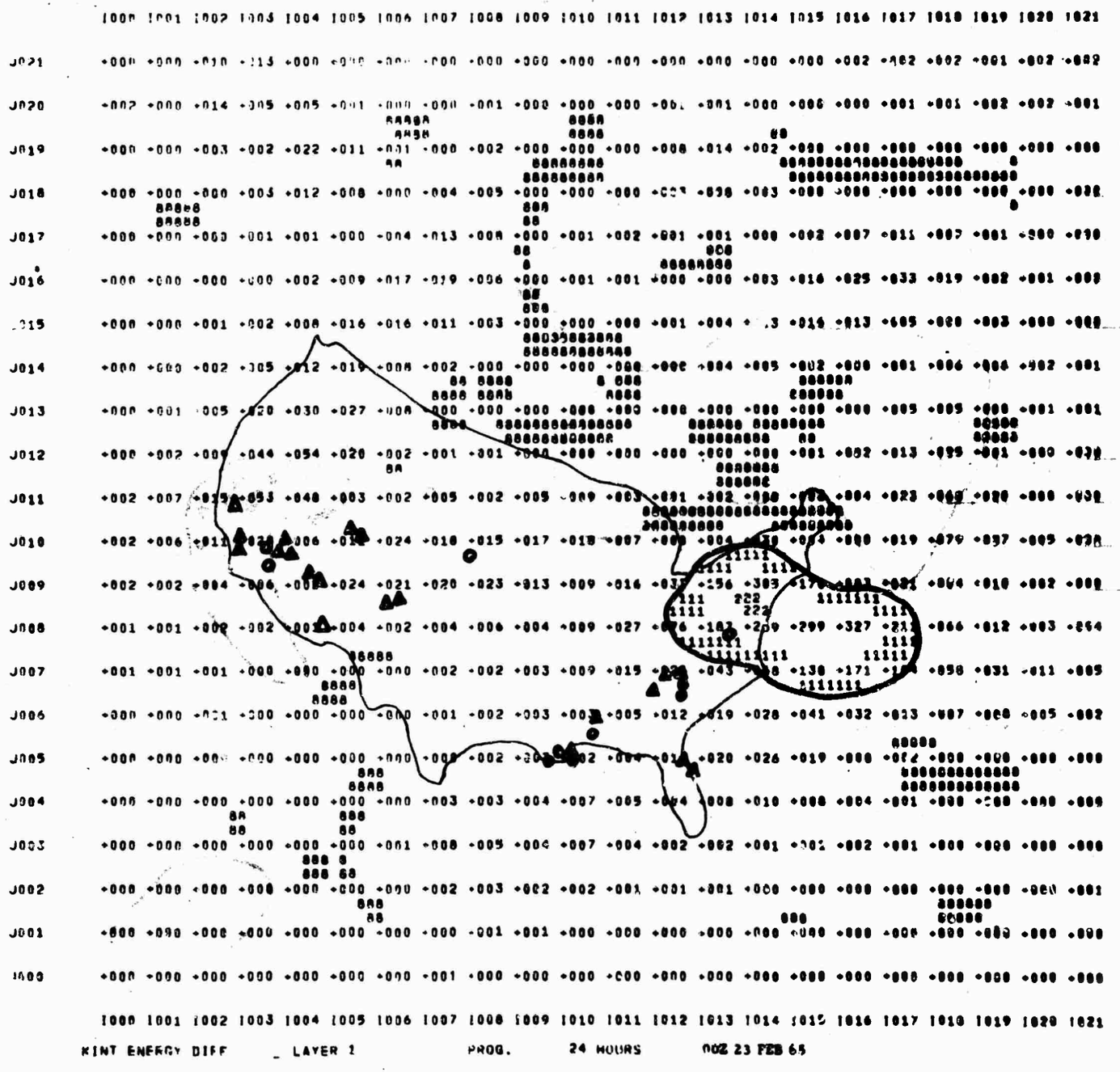
J015
J014
J013
J012
J011
J010
J009
J008
J007
J006
J005
J004
J003
J002
J001
J000
I000 I001 I002 I003 I004 I005 I006 I007 I008 I009 I010 I011 I012 I013 I014 I015 I016 I017 I018 I019 I020 I021
VERT GRAD 06 VT - LAYER 1 PROG. 24 HOURS 00Z 23 FEB 65


KINETIC ENERGY LAYER 1 PROG. 24 HOURS 00Z 23 FEB 65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J020
J019
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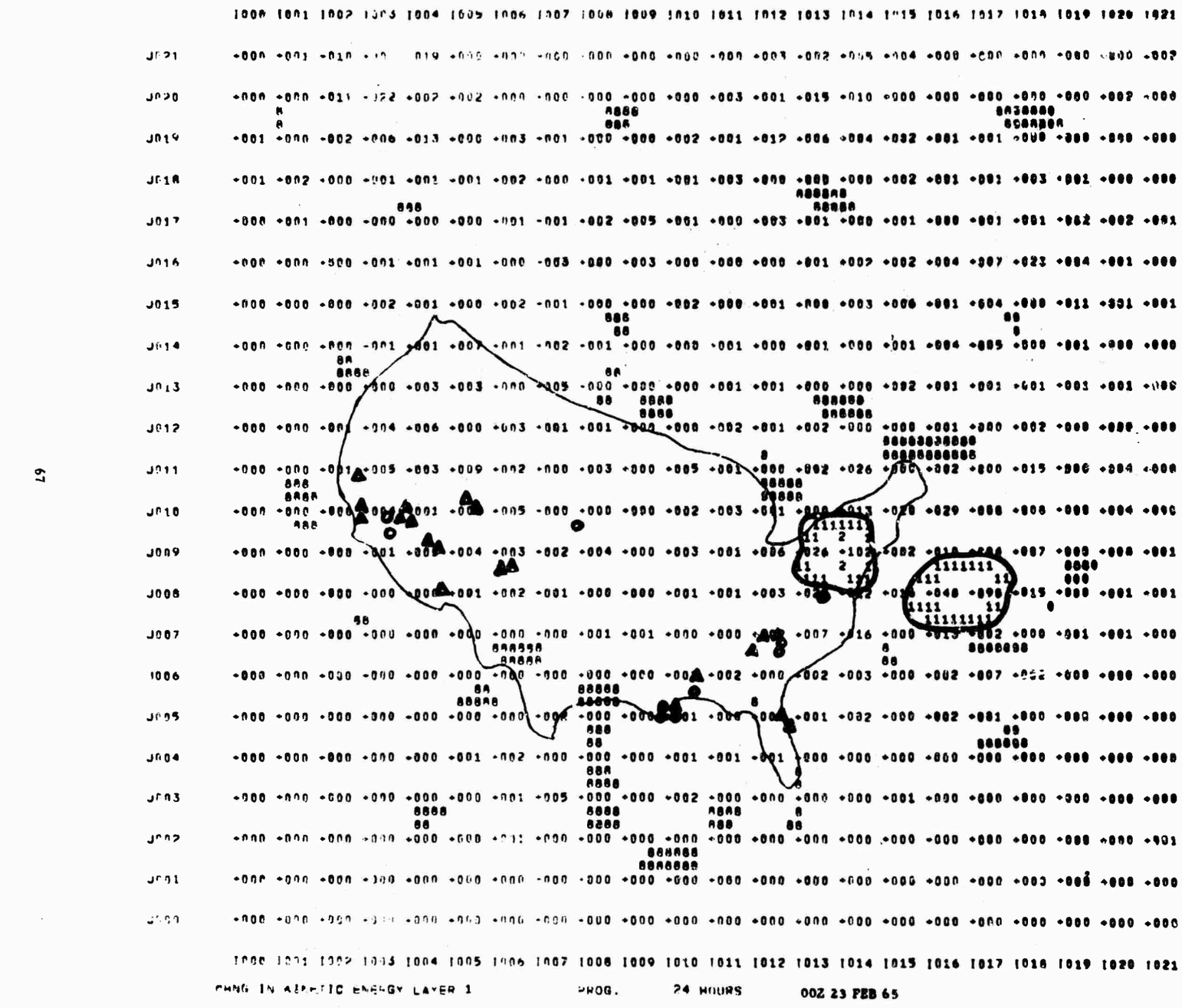
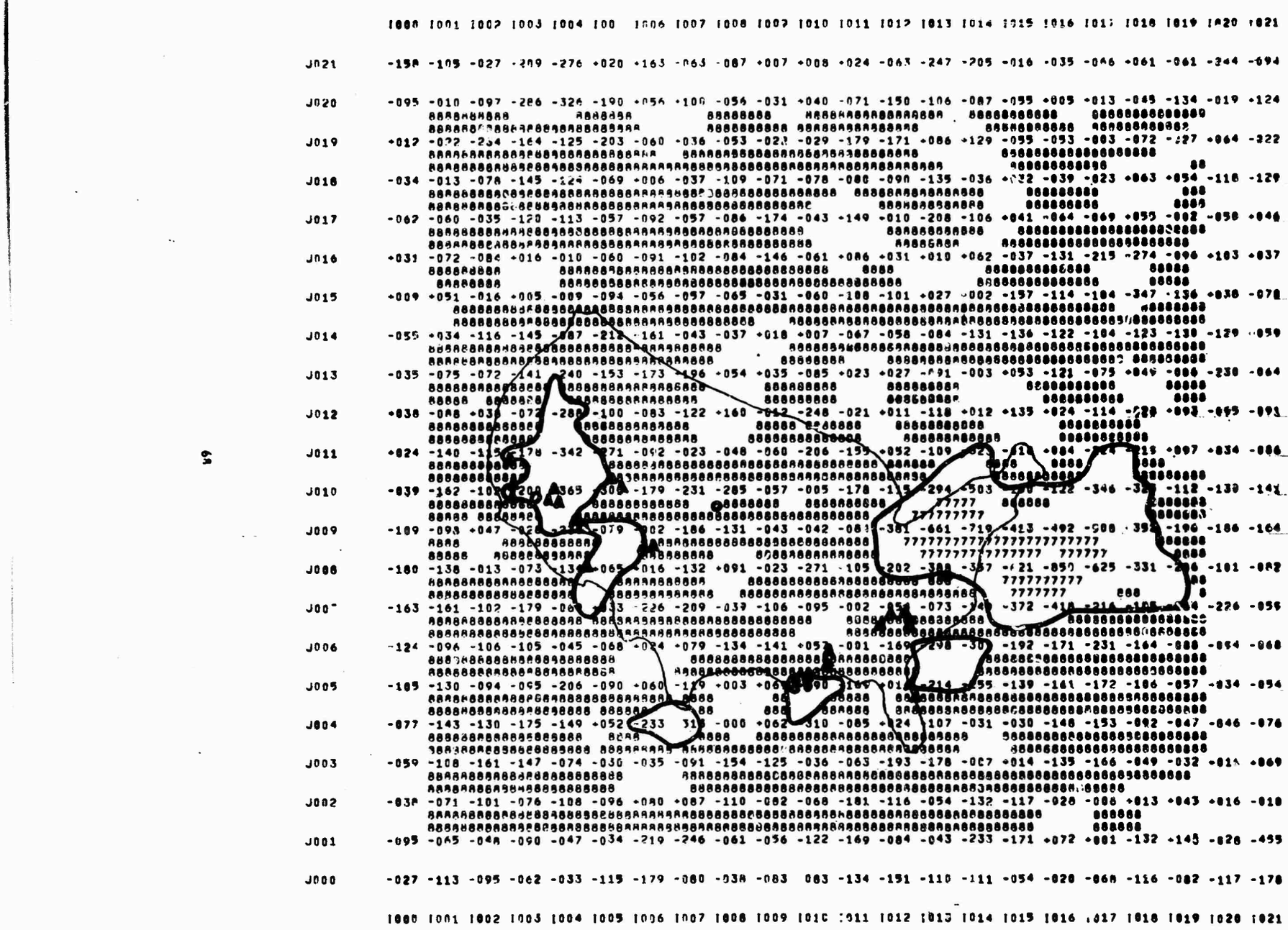
J002
J001
J000
I000 I001 I002 I003 I004 I005 I006 I007 I008 I009 I010 I011 I012 I013 I014 I015 I016 I017 I018 I019 I020 I021
KINT ENERGY DIFF _ LAYER 1 PROG. 24 HOURS 00Z 23 FEB 65



CHNG IN ARCTIC ENERGY LAYER 1 PROG. 24 HOURS 00Z 23 FEB 65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J020 -095 -010 -097 -286 -324 -190 +056 +100 -056 -031 +040 -071 -150 -106 -087 -055 +005 +013 -045 -134 -019 +124
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J010 -039 -162 -101 -208 -365 -308 -179 -231 -285 -057 -005 -178 -115 -294 -503 -290 -122 -346 -321 -112 -138 -141
J009 -109 -098 +047 -126 -288 -079 -002 -186 -131 -043 -042 -081 -381 -661 -719 -413 -492 -508 -391 -196 -186 -164
J008 -180 -138 -013 -073 -134 -065 -016 -132 +091 -023 -271 -105 -202 -388 -387 -421 -850 -625 -331 -206 -101 -082
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J005 -105 -130 -094 -065 -206 -090 +060 -119 +003 +067 -090 -166 -014 -214 -255 -139 -141 -172 -106 -057 -034 -054
J004 -077 -143 -130 -175 -149 +052 -233 -315 -000 +062 -310 -085 +124 -107 -031 -030 -148 -153 -092 -047 -046 -076
J003 -059 -108 -161 -147 -074 -030 -035 -091 -154 -125 -036 -063 -193 -178 -067 +014 -135 -166 -049 -032 -015 +069
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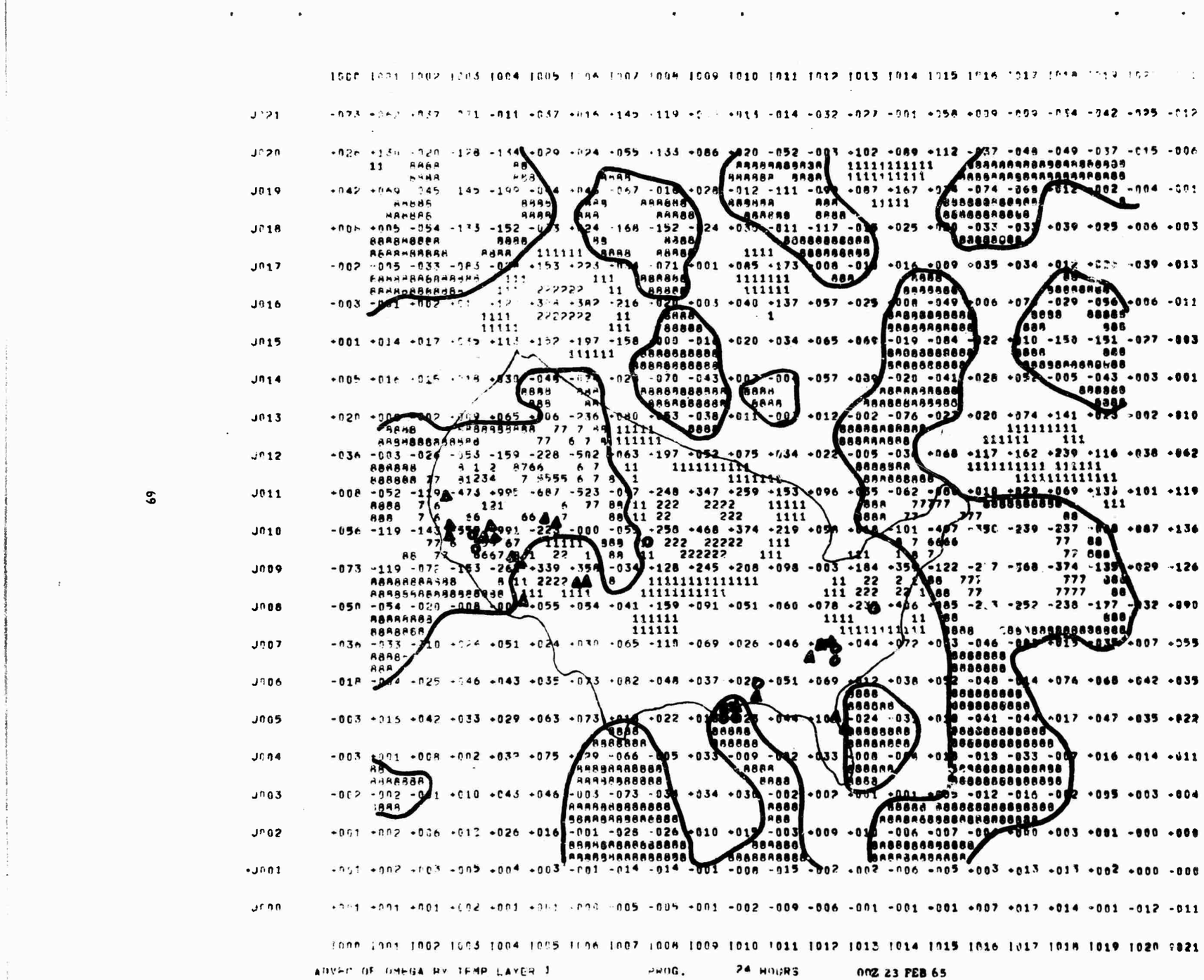
PROG MAT FIELD LAYER 1 PROG. 24 HOURS 00Z 23 FEB 65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J020
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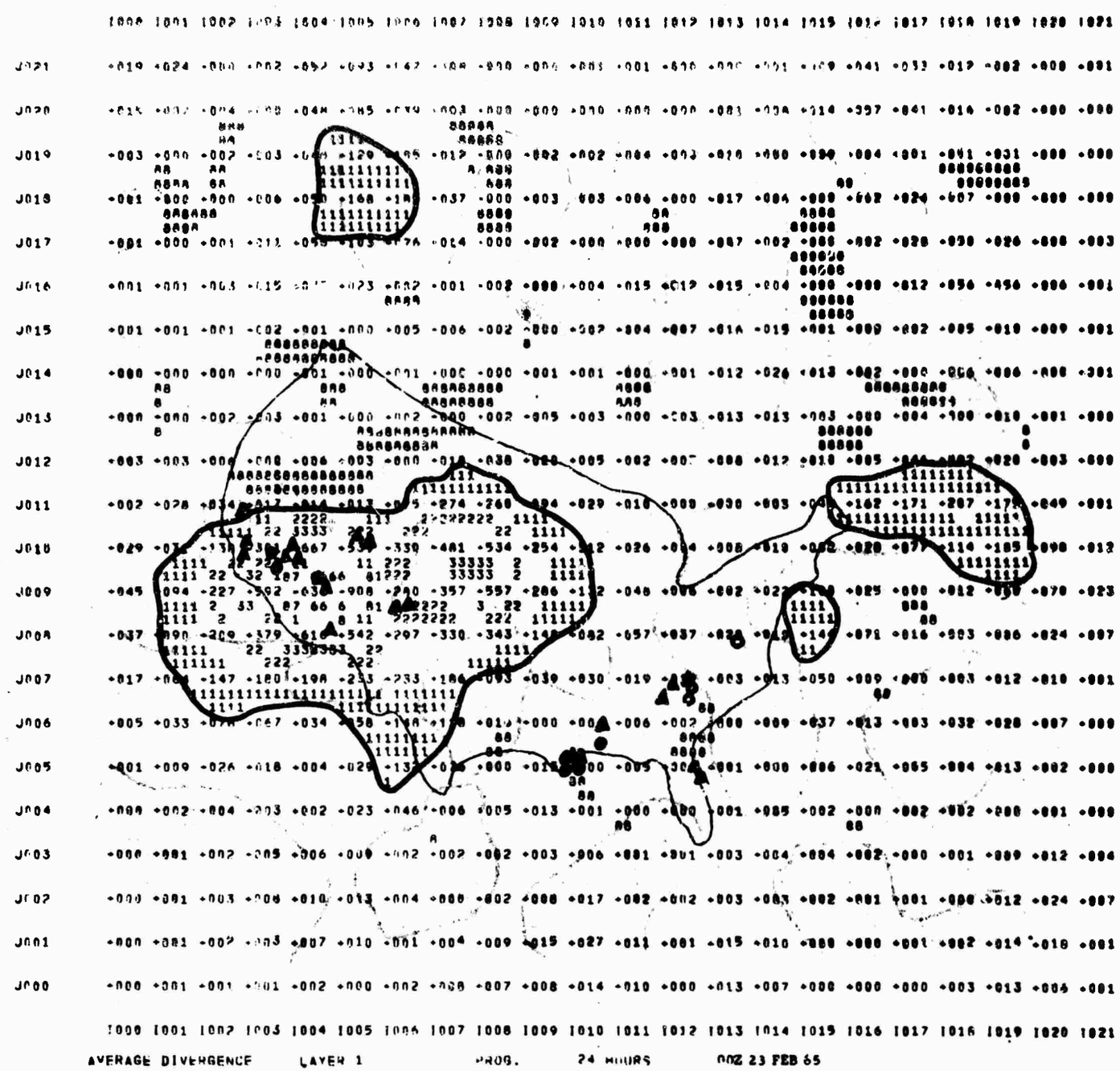
J017
J016
J015
J014
J013
J012
J011
J010
J009
J008
J007
J006
J005
J004
J003
J002
J001
J000
I000 I001 I002 I003 I004 I005 I006 I007 I008 I009 I010 I011 I012 I013 I014 I015 I016 I017 I018 I019 I020 I021
ABVER OF OMEGA BY TEMP LAYER J
PROG.
24 HOURS
00Z 23 FEB 65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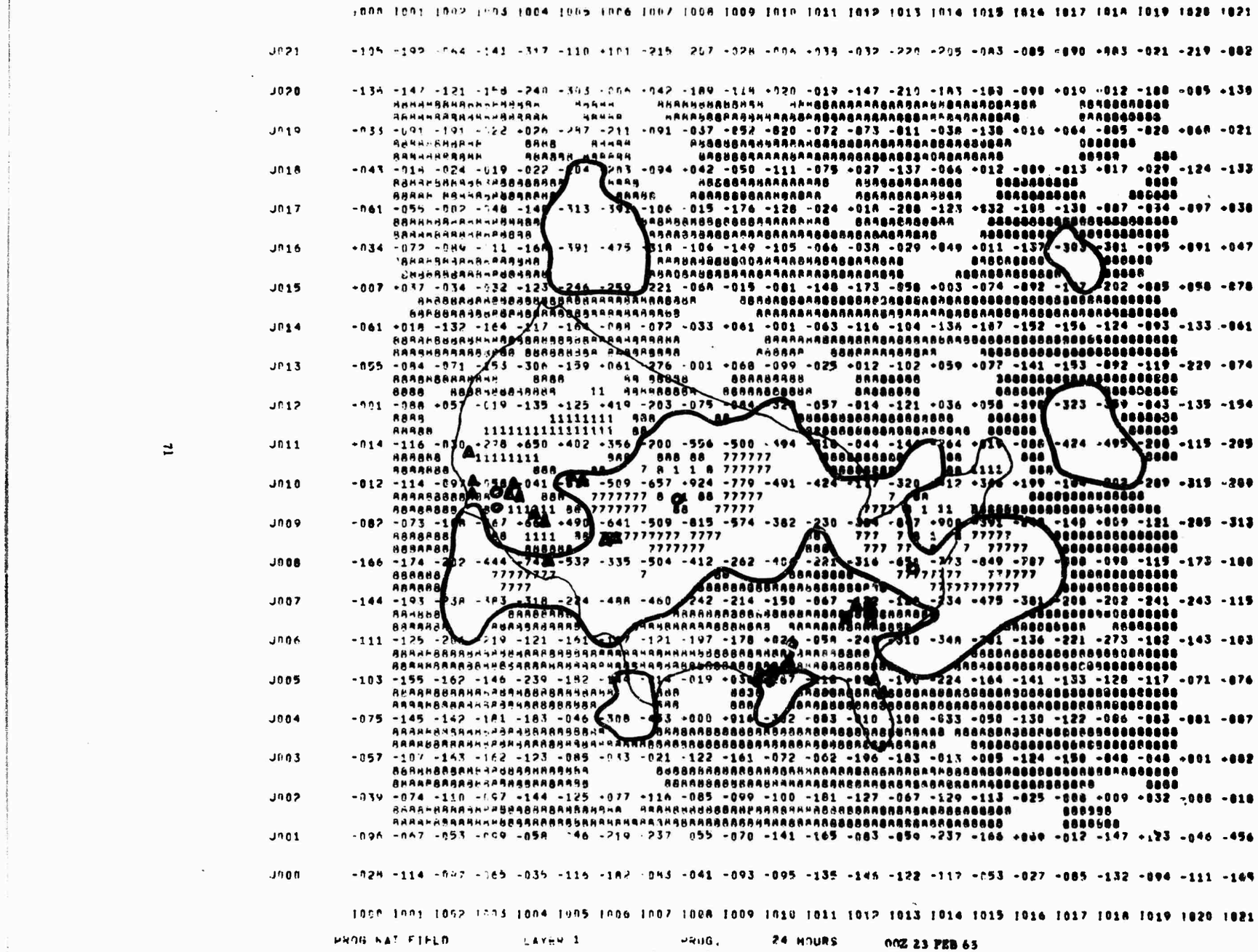
J020
J019
J018
J017
J016
J015
J014
J013
J012
J011
J010
J009
J008
J007
J006
J005
J004
J003
J002
J001
J000
I000 I001 I002 I003 I004 I005 I006 I007 I008 I009 I010 I011 I012 I013 I014 I015 I016 I017 I018 I019 I020 I021
AVERAGE DIVERGENCE LAYER 1 PROG. 24 HOURS 00Z 23 FEB 65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J019 -031 -091 -191 -122 +026 -297 -211 -091 -037 -052 -020 -072 -073 -011 -038 -138 +016 +064 -085 -028 +068 -021
J018 -043 -018 -024 -019 -022 -104 -203 -094 +042 -050 -111 -075 +027 -137 -066 +012 -089 -013 +017 +029 -124 -133
J017 -061 -055 -002 -048 -148 -313 -391 -106 -015 -176 -128 -024 +018 -208 -123 +032 -108 -138 -087 -034 -097 +038
J016 +034 -072 -086 -111 -164 -391 -475 -018 -106 -149 -105 -066 -038 -029 +049 +011 -137 -305 -301 -095 +091 +047
J015 +007 +037 -034 -032 -123 -244 -259 -221 -068 -015 -081 -148 -173 -058 +003 -074 -092 -197 -202 -085 -058 -078
J014 -061 +018 -132 -164 -217 -164 -088 -072 -033 +061 -001 -063 -116 -104 -134 -187 -152 -156 -124 -093 -133 -061
J013 -055 -084 -071 -153 -306 -159 +061 -276 -001 +068 -099 -025 +012 -102 +059 +077 -141 -153 -092 -119 -229 -074
J012 -001 -088 +057 -019 -135 +125 +419 -203 -075 -044 -321 -057 -014 -121 +036 +058 -398 -323 -359 -043 -135 -154
J011 +014 -116 -010 +228 +650 +402 +356 -200 -556 -500 -494 -110 -044 -141 -264 +010 -086 -424 -495 -208 -115 -209
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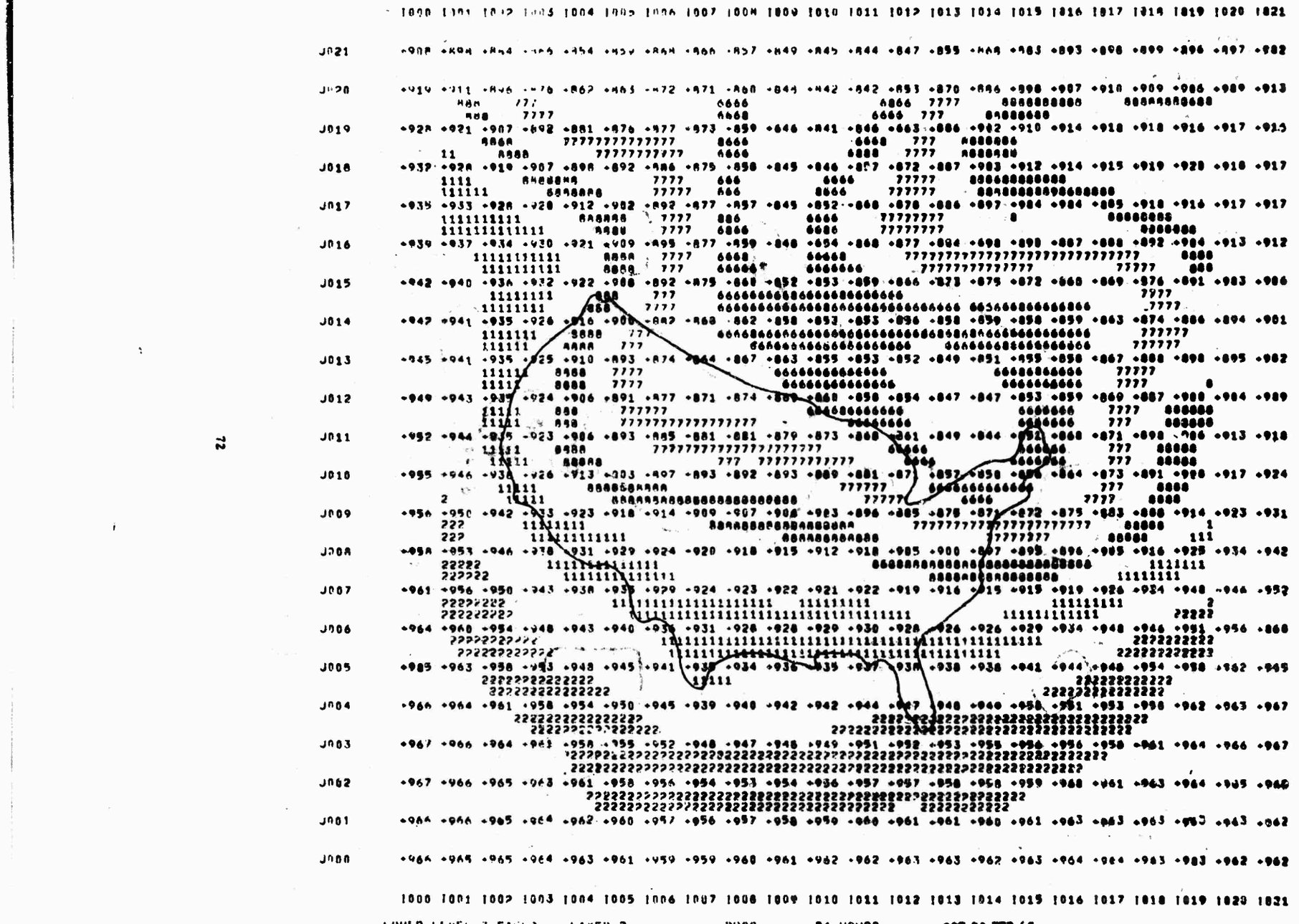
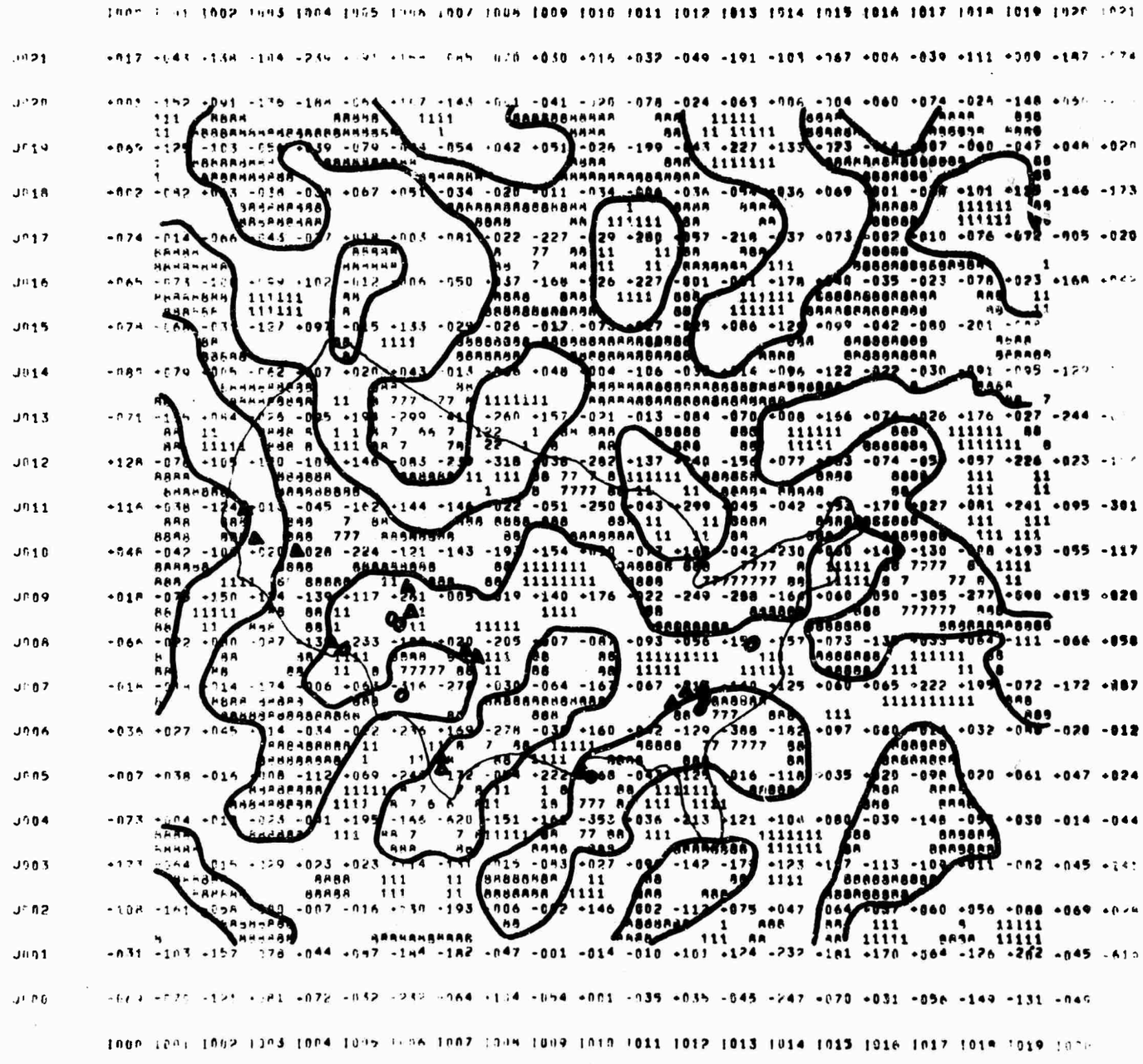
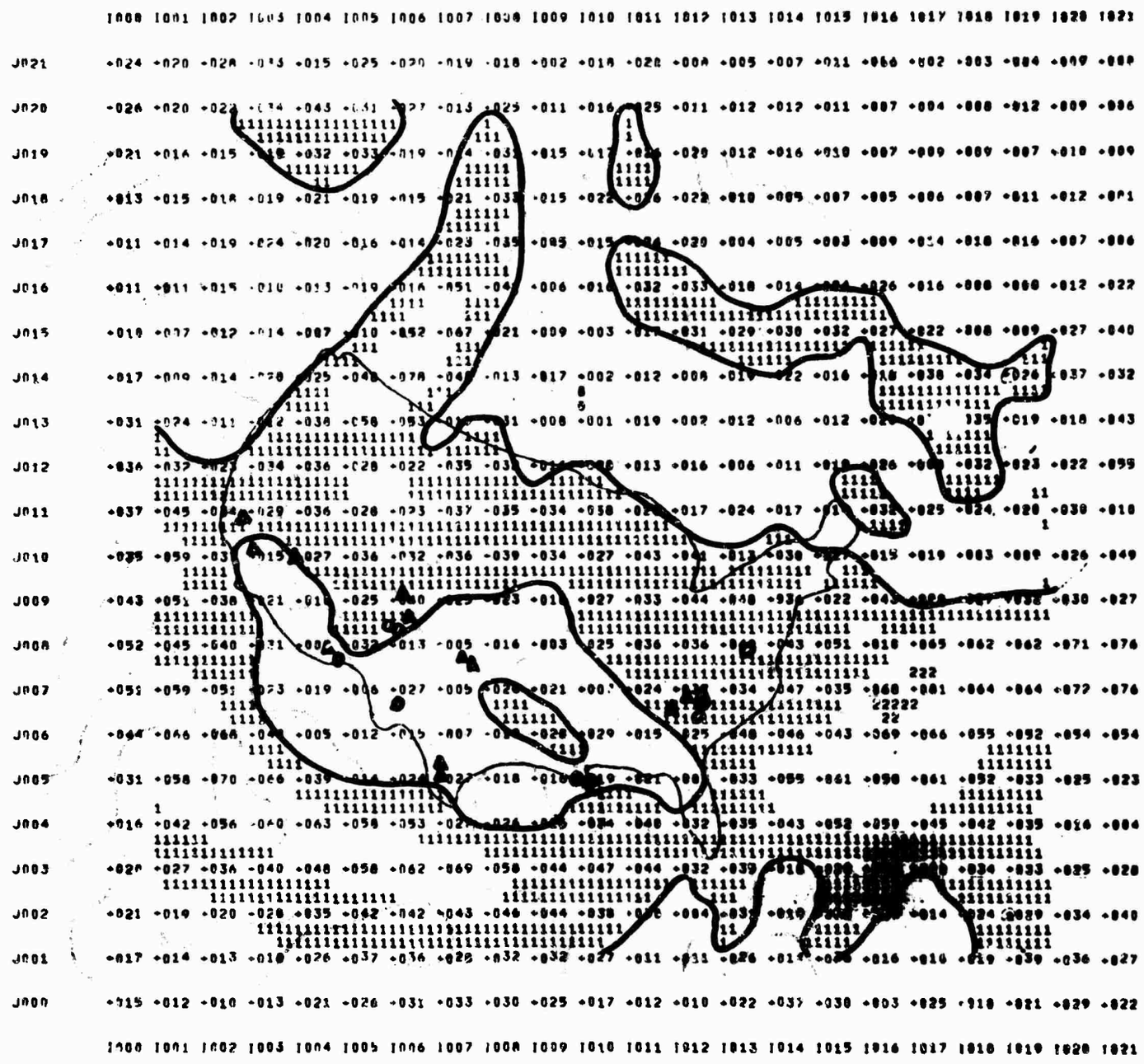
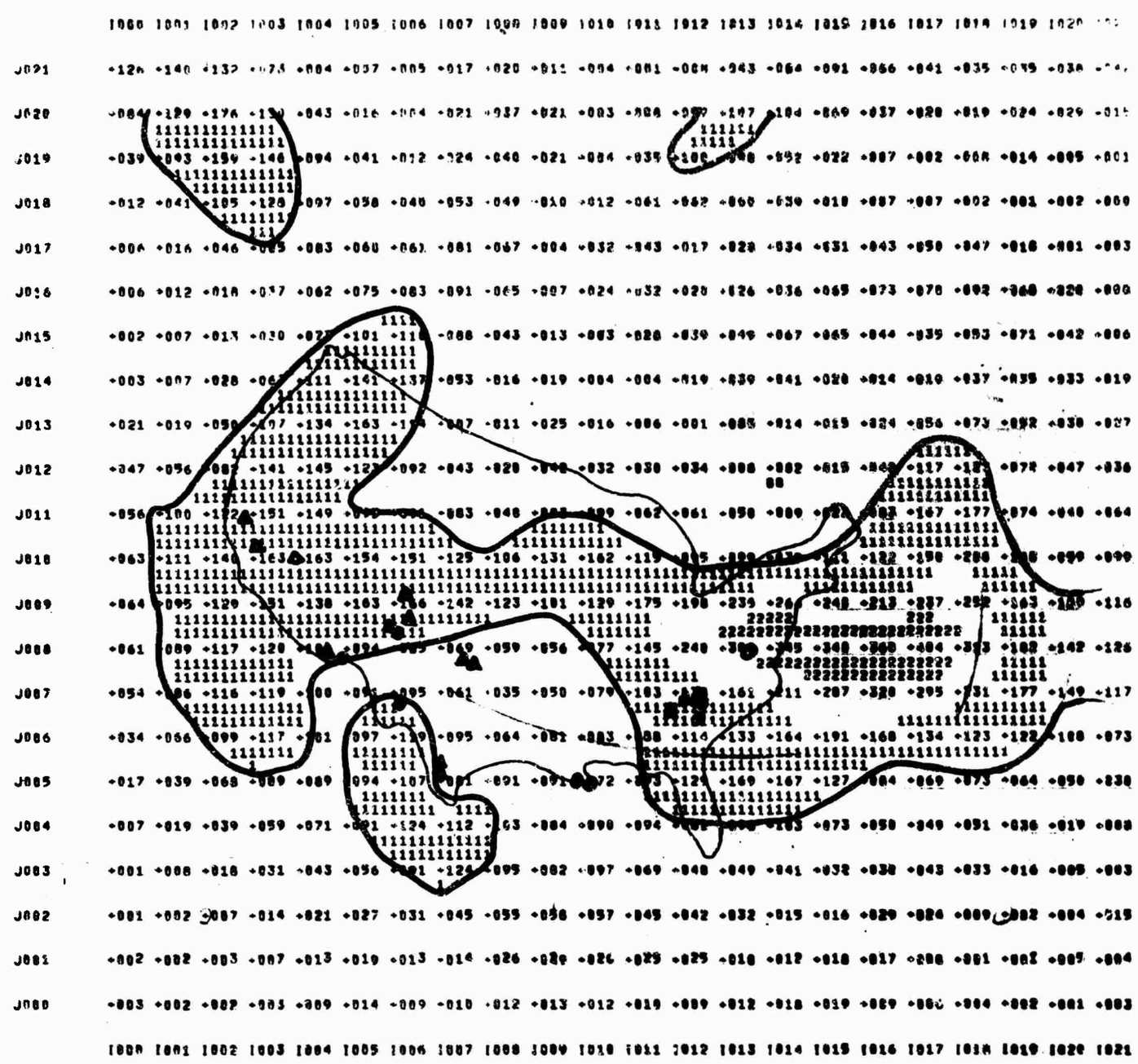
J007 -144 -193 -238 -183 -318 -224 -488 -460 -242 -214 -150 -067 -128 -126 -234 -479 -381 -208 -202 -241 -243 -115
J006 -111 -125 -200 -219 -121 -161 -197 -121 -197 -178 -024 -059 -240 -210 -348 -291 -136 -221 -273 -182 -143 -183
J005 -103 -155 -162 -146 -239 -182 -174 -116 -019 +030 -067 -110 -094 -196 -224 -164 -141 -133 -128 -117 -071 -076
J004 -075 -145 -142 -181 -183 -046 -308 -053 +000 +014 -342 -083 -110 -108 -033 -050 -130 -122 -086 -083 -081 -087
J003 -057 -107 -143 -162 -123 -085 -033 -021 -122 -161 -072 -062 -196 -183 -013 +005 -124 -150 -048 -048 +001 +002
J002 -039 -074 -110 -097 -144 -125 +077 +116 -085 -099 -100 -181 -127 -067 -129 -113 -025 -008 +009 +032 -008 -010
J001 -096 -047 -053 -059 -058 -146 -219 -237 -055 -070 -141 -165 -083 -050 -237 -166 +009 -012 -147 +123 -046 -456
J000 -028 -114 -097 -165 -035 -116 -182 -043 -041 -093 -095 -135 -146 -122 -117 -053 -027 -085 -132 -094 -111 -169
I000 I001 I002 I003 I004 I005 I006 I007 I008 I009 I010 I011 I012 I013 I014 I015 I016 I017 I018 I019 I020 I021
PROG NAT FIELD LAYER 1 PROG. 24 HOURS 00Z 23 FEB 65



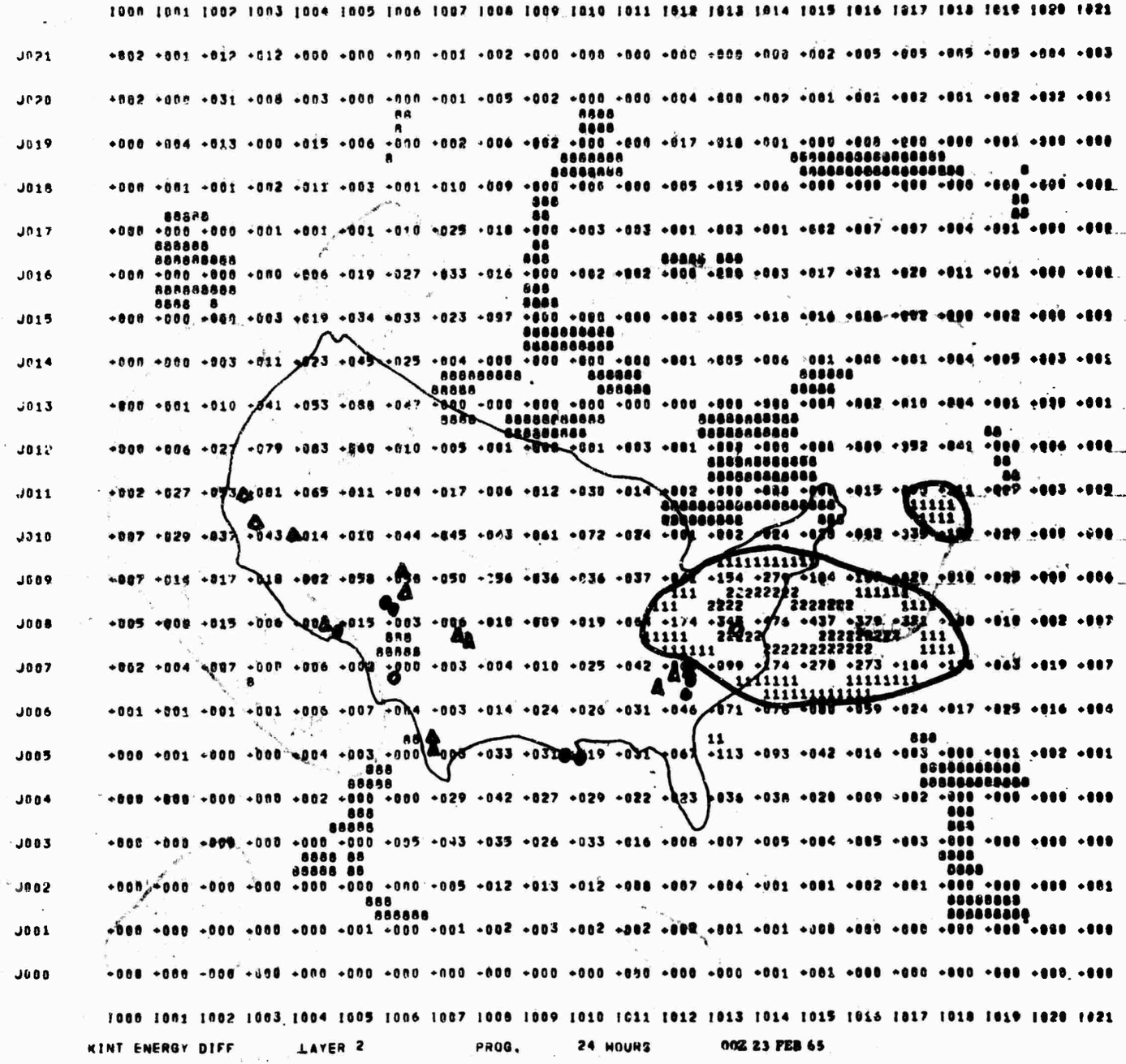
LOWER LEVEL 7 FIELD LAYER 2 PROG. 24 HOURS 00Z 23 FEB 69


LAPLACIAN OF VORTICITY LAYER
24 HOURS
00Z 23 FEB 65

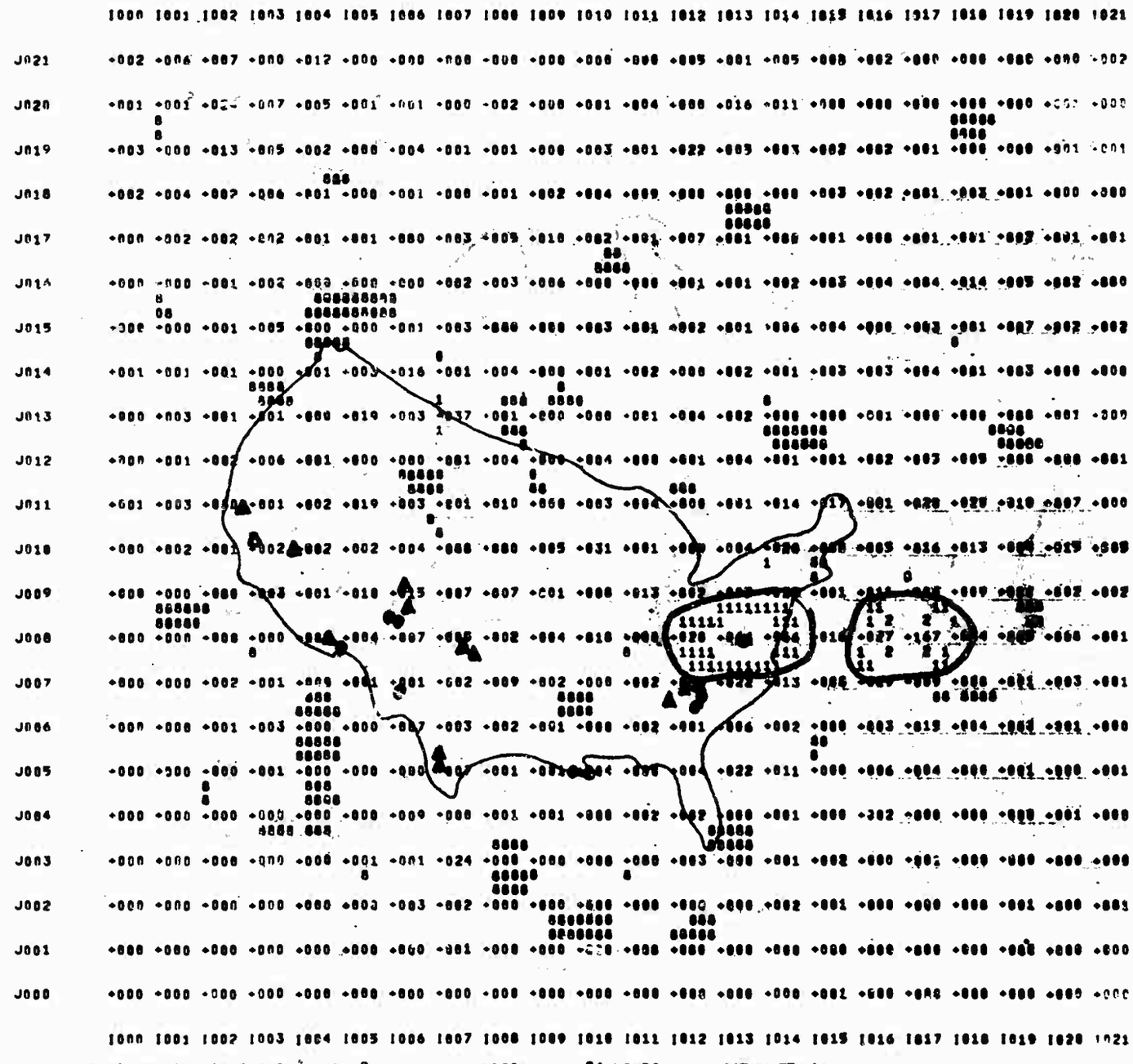

I000 I001 I002 I003 I004 I005 I006 I007 I008 I009 I010 I011 I012 I013 I014 I015 I016 I017 I018 I019 I020 I021
J021
J020
J019
J018
J017
J016
J015
J014
J013
J012
J011
J010
J009
J008
J007
J006
J005
J004
J003
J002
J001
J000
I000 I001 I002 I003 I004 I005 I006 I007 I008 I009 I010 I011 I012 I013 I014 I015 I016 I017 I018 I019 I020 I021
VERT GRAD OF VT _ LAYER 2 PROG. 24 HOURS 00Z 23 FEB 65



KINETIC ENERGY _LAYER 2 PROG. 24 HOURS 00Z 23 FEB 65



KINT ENERGY DIFF LAYER 2 PROG. 24 HOURS 00Z 23 FEB 65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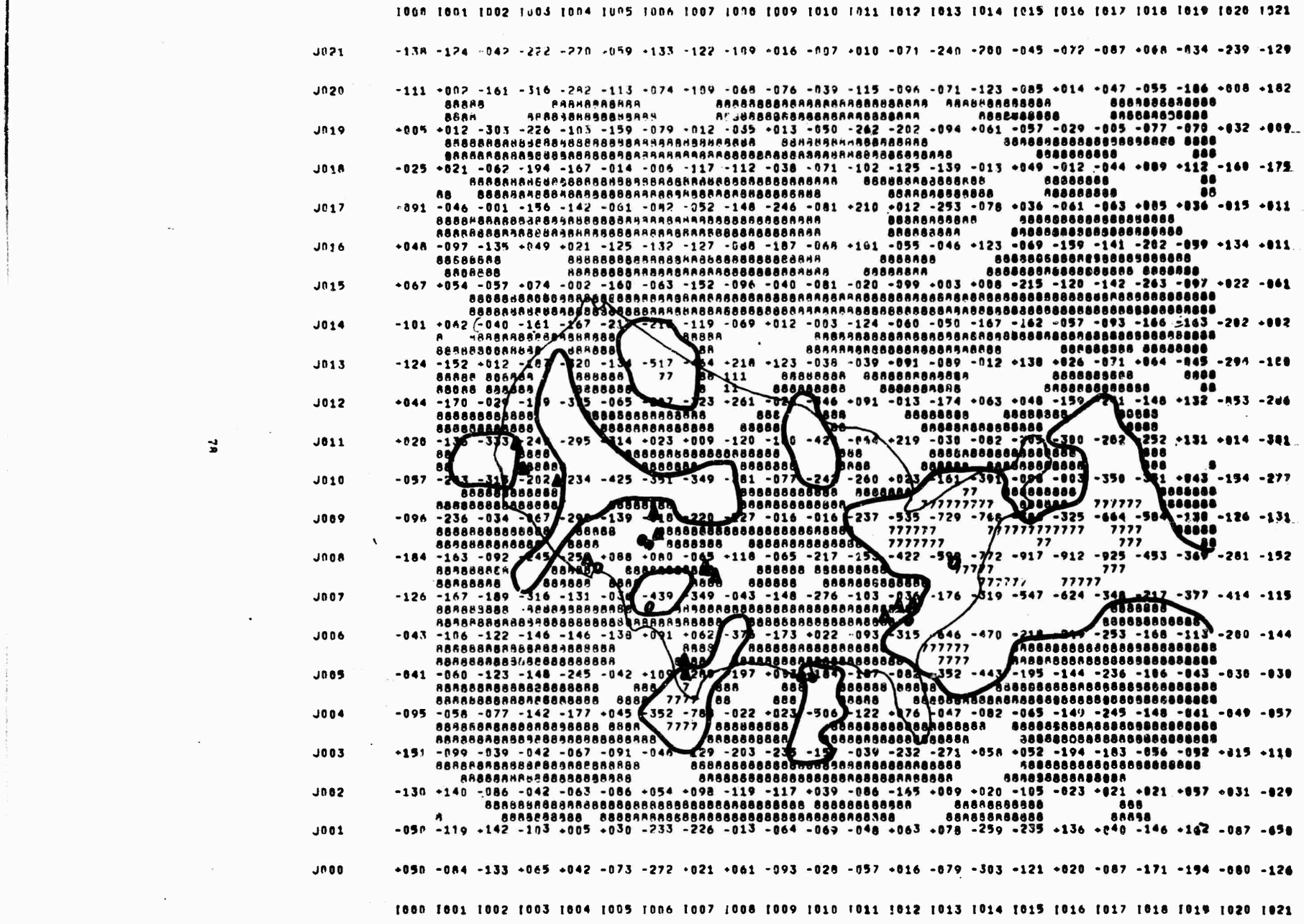
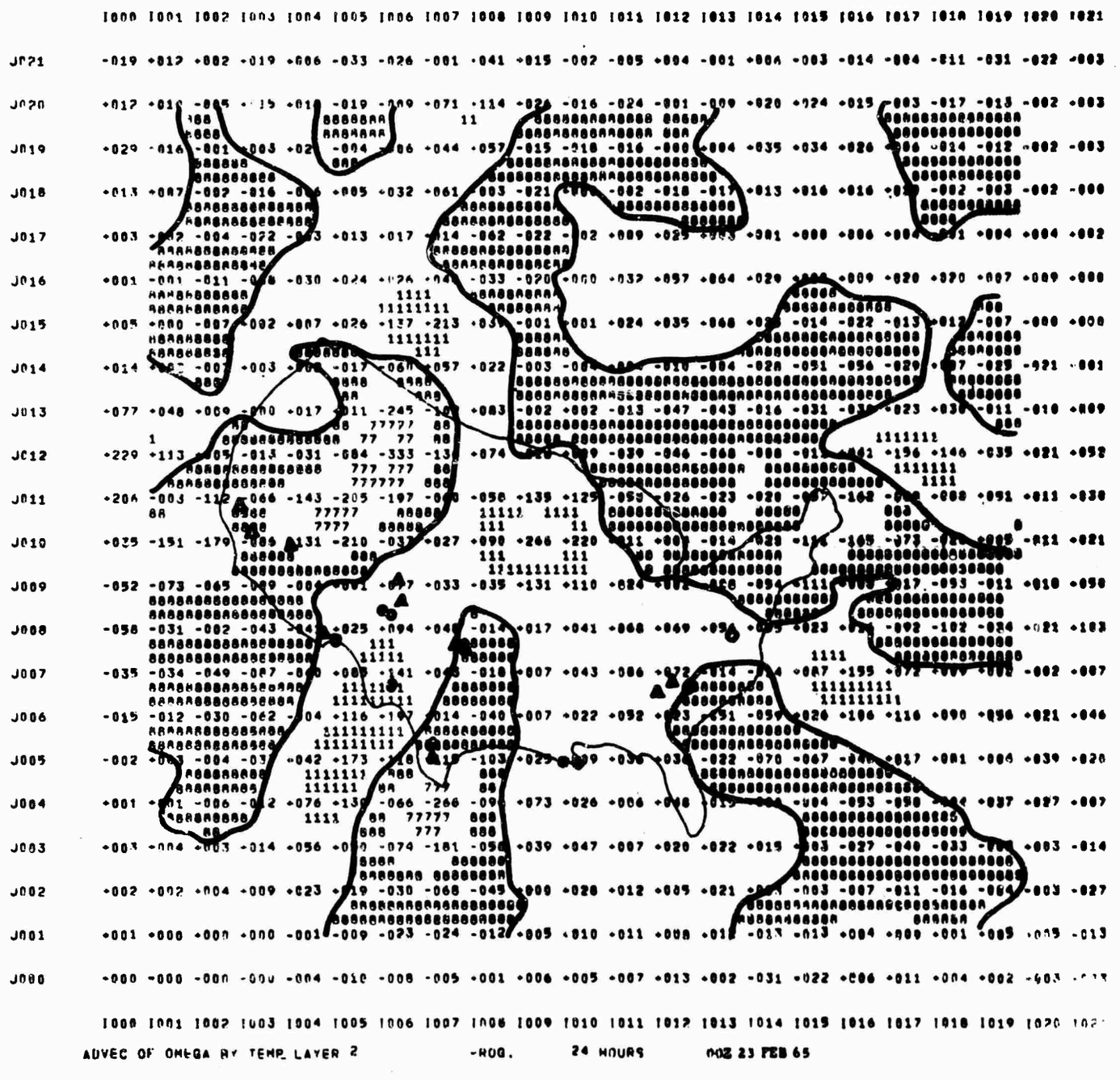
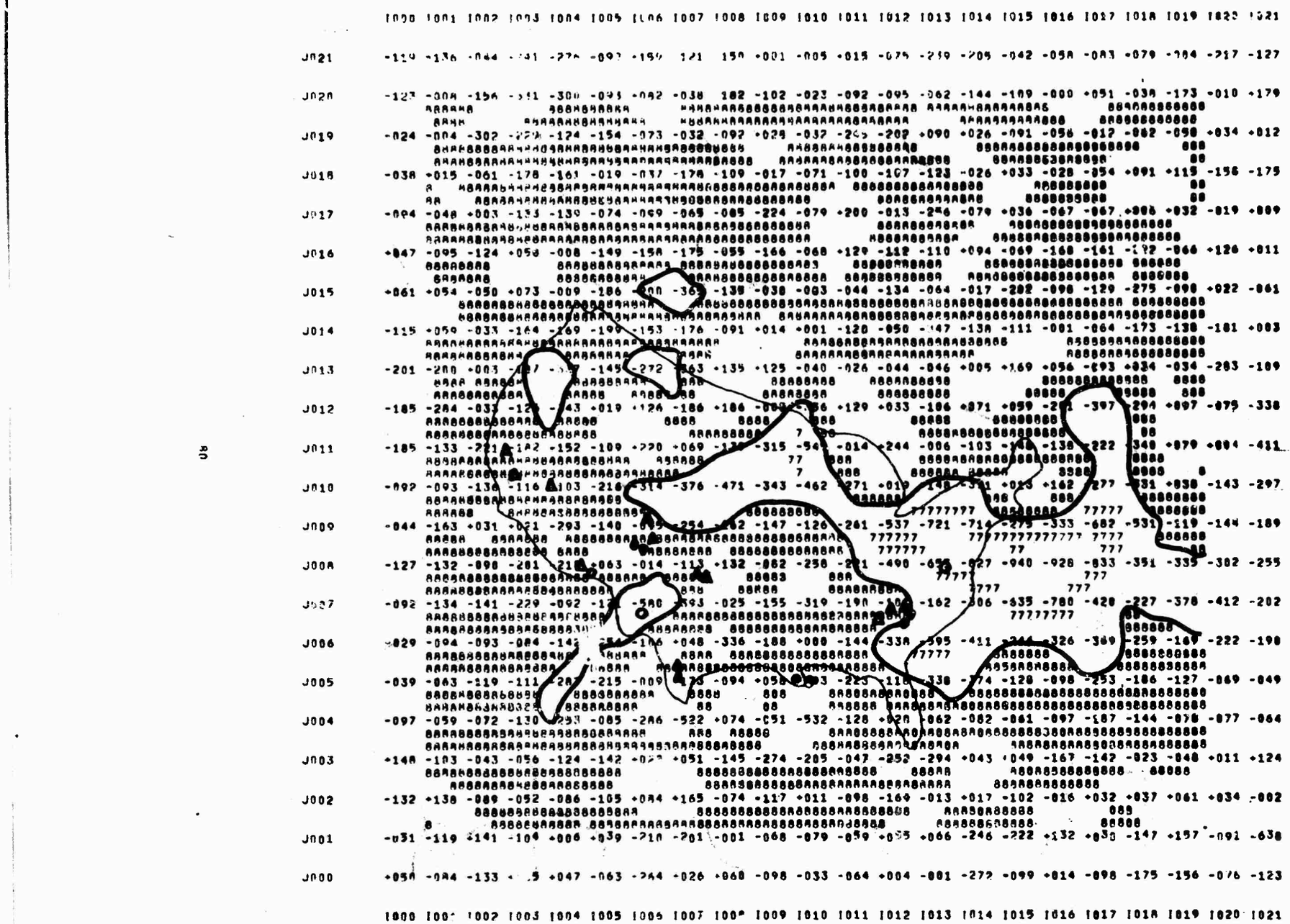
J021
J020
J019
J018
J017
J016
J015
J014
J013
J012
J011
J010
J009
J008
J007
J006
J005
J004
J003
J002
J001
J000
I000 I001 I002 I003 I004 I005 I006 I007 I008 I009 I010 I011 I012 I013 I014 I015 I016 I017 I018 I019 I020 I021
CHNG IN KINETIC ENERGY LAYER 2
PROG.
24 HOURS
ON 23 FEB 65


I000 I001 I002 I003 I004 I005 I006 I007 I008 I009 I010 I011 I012 I013 I014 I015 I016 I017 I018 I019 I020 I021
J021 -138 -124 -042 -222 -270 -059 +133 -122 -109 +016 -007 +010 -071 -240 -200 -045 -072 -087 +068 -034 -239 -129
J020 -111 +002 -161 -316 -282 -113 -074 -109 -068 -076 -039 -115 -096 -071 -123 -085 +014 +047 -055 -186 +008 +182
J019 +005 +012 -303 -226 -103 -159 -079 -012 -035 +013 -050 -262 -202 +094 +061 -057 -029 -005 -077 -070 +032 +009
J018 -025 +021 -062 -194 -167 -014 -006 -117 -112 -038 -071 -102 -125 -139 -013 +049 -012 -044 +089 +112 -160 -172
J017 -091 -046 -001 -156 -142 -061 -042 -052 -148 -246 -081 +210 +012 -253 -078 +036 -061 -063 +085 +036 -015 +011
J016 +048 -097 -135 +049 +021 -125 -132 -127 -068 -187 -068 +101 -055 -046 +123 -069 -159 -141 -202 -059 +134 +011
J015 +067 +054 -057 +074 -002 -160 -063 -152 -096 -040 -081 -020 -099 +003 +008 -215 -120 -142 -263 -097 +022 -061
J014 -101 +042 -040 -161 -167 -215 -214 -119 -069 +012 -003 -124 -060 -050 -167 -162 -057 -093 -166 -163 -202 +002
J013 -124 -152 +012 -187 -220 -154 -517 -264 +218 +123 -038 -039 -091 -089 -012 +138 +026 -071 +064 -045 -294 -188
J012 +044 -170 -020 -189 -315 -065 -207 -223 +261 -020 -046 +091 -013 -174 +063 +048 -159 -241 -148 +132 -053 -206
J011 +020 -138 -333 -224 -295 -214 +023 +009 -120 -140 -42 -044 +219 -038 -082 -205 -380 -282 -252 +131 +014 -381
J010 -057 -231 -312 -202 -234 -425 -351 -349 -181 -077 -247 -260 +023 -161 -391 -098 -003 -350 -351 +043 -194 -277
J009 -096 -236 -034 -167 -202 -139 -118 -220 -227 -016 -016 -237 -535 -729 -768 -[illegible] -325 -664 -504 -138 -126 -131
J008 -184 -163 -092 -245 -254 +088 +080 -065 +118 -065 -217 -153 -422 -598 -772 -917 -912 -925 -453 -369 -281 -152
J007 -126 -167 -189 -316 -131 -038 -439 -349 -043 -148 -276 -103 -036 -176 -319 -547 -624 -348 -217 -377 -414 -115
J006 -043 -106 -122 -146 -146 -138 +091 +062 -378 -173 +022 -093 -315 -646 -470 -218 -[illegible] -253 -168 -113 -200 -144
J005 -041 -060 -123 -148 -245 -042 +109 -200 -197 +093 -184 -107 -082 -352 -443 -195 -144 -236 -106 -043 -038 -038
J004 -095 -058 -077 -142 -177 +045 -352 -788 -022 +023 -506 -122 +076 -047 -082 -065 -149 -245 -148 -041 -049 -057
J003 +151 -099 -039 -042 -067 -091 -048 -229 -203 -235 -157 -039 -232 -271 +058 +052 -194 -183 -056 -092 +015 +110
J002 -130 +140 -086 -042 -063 -086 +054 +098 -119 -117 +039 -086 -145 +009 +020 -105 -023 +021 +021 +057 +031 -029
J001 -050 -119 +142 -103 +005 +030 -233 -226 -013 -064 -069 -048 +063 +078 -259 -235 +136 +040 -146 +102 -087 -058
J000 +050 -084 -133 +065 +042 -073 -272 +021 +061 -093 -028 -057 +016 -079 -303 -121 +020 -087 -171 -194 -080 -126
I000 I001 I002 I003 I004 I005 I006 I007 I008 I009 I010 I011 I012 I013 I014 I015 I016 I017 I018 I019 I020 I021
PROG MAT FIELD - LAYER 2 PROG. 24 HOURS 00Z 23 FEB 65


I000 I001 I002 I003 I004 I005 I006 I007 I008 I009 I010 I011 I012 I013 I014 I015 I016 I017 I018 I019 I020 I021
J021 -019 +012 +002 -019 +006 -033 -026 -001 +041 +015 -002 -005 +004 -001 +004 -003 -014 -004 -011 -031 -022 +003
J020 +017 +010 -005 -015 +010 -019 -009 +071 +114 +024 -016 -024 -001 -009 +020 +024 +015 -003 -017 -013 -002 +003
J019 +029 -016 -001 +003 +02 -004 +06 +044 +057 -015 -018 -016 -000 +004 +035 +034 +026 +006 -014 -012 +002 -003
J018 +013 +007 -002 -016 -0 +005 +032 +061 -003 -021 -002 -018 -017 +013 +016 +016 -002 -003 -002 -000
J017 +003 -002 -004 -022 -03 +013 +017 -014 -062 -022 -02 +009 +025 +001 +000 +006 +004 +001 +004 +004 +002
J016 +001 -001 -011 -0 -030 +024 +026 +04 -033 -020 +000 +032 +057 +064 +029 +009 +020 +020 +007 +009 +000
J015 +005 +000 -007 -002 +007 +026 -137 -213 -03 -001 +001 +024 +035 +068 +0 -014 -022 -013 -007 -000 +000
J014 +014 -007 +003 +0 -017 -06 +057 +022 -003 -0 -010 -004 -028 -051 -056 -029 -007 -025 -021 +001
J013 +077 +048 +009 -000 +017 +011 -245 -1 +083 -002 +002 -013 -047 -043 -016 -031 -0 -023 +03 -011 -010 +009
J012 +229 +113 +005 -013 -031 -084 -333 -13 +074 -0 -039 -046 -068 -08 -01 -041 +196 +146 +035 +021 +052
J011 +204 -003 -112 -066 -143 -205 -197 -0 -058 +135 +129 -05 -026 -023 -028 -0 -162 -0 +008 +091 +011 +030
J010 +035 -151 -179 -0 +131 -210 -03 +027 +090 +266 +220 +1 +00 -014 -028 -1 -165 -173 -0 +0 -011 +021
J009 -052 -073 -065 -009 -00 +001 +07 +033 -035 +131 +110 +02 +0 -09 -111 +0 -017 -093 -011 +010 +050
J008 -058 -031 -002 -043 -1 +025 +094 +04 -014 +017 +041 +068 +069 +0 +0 +023 +0 -092 -102 -024 +021 +103
J007 -035 -034 -049 -087 -0 +0 +141 +0 -018 +007 +043 +086 +072 +14 +0 +087 +155 +072 +0 +0 -002 +007
J006 -015 -012 -030 -062 -0 +116 +19 +014 -040 +007 +022 +092 +0 -091 -09 +026 +106 +116 +090 +056 +021 +046
J005 -002 +0 -004 -03 +042 +173 +1 -103 +02 +0 +036 +0 -022 -070 -067 -0 +017 +081 +004 +039 +020
J004 +001 +0 -006 -0 +076 +13 -066 -266 -09 +073 +026 +006 +0 -0 -004 -053 -0 +037 +027 +007
J003 +003 -004 +003 -014 +056 +0 -074 -181 -05 +039 +047 +007 +020 +022 +019 +0 -027 -040 -033 -0 +003 -014
J002 +002 +002 +004 +009 +023 +0 -030 -068 -045 +0 +028 +012 +005 +021 +0 -003 -007 -011 -016 -0 -003 -027
J001 +001 +000 +000 +000 -001 -009 -023 -024 -012 +005 +010 +011 +008 +0 -0 -013 +004 +009 +001 +005 -005 -013
J000 -000 -000 -000 -000 -004 -010 -008 -005 +001 +006 +005 +007 +013 +002 -031 +022 +006 +011 +004 +002 -003
I000 I001 I002 I003 I004 I005 I006 I007 I008 I009 I010 I011 I012 I013 I014 I015 I016 I017 I018 I019 I020
ADVEC OF OMEGA BY TEMP LAYER 2 -MOD. 24 HOURS 00Z 23 FEB 65


I000 I001 I002 I003 I004 I005 I006 I007 I008 I009 I010 I011 I012 I013 I014 I015 I016 I017 I018 I019 I020 I021
J021 -119 -136 -044 -141 -226 -093 -169 121 150 +001 -005 +015 -075 -219 -205 -042 -058 -083 +079 -104 -217 -127
J020 -123 -008 -156 -111 -300 -091 -042 -038 182 -102 -023 -092 -095 -062 -144 -109 -000 +051 -038 -173 -010 +179
J019 -024 -004 -302 -229 -124 -154 -073 -032 -092 +026 -037 -245 -207 +090 +026 -091 -056 -012 -062 -098 +034 +012
J018 -038 +015 -061 -178 -161 -019 -037 -178 -109 -017 -071 -100 -107 -123 -026 +033 -028 -054 +091 +119 -156 -179
J017 -094 -048 +003 -133 -139 -074 -069 -065 -085 -224 -079 +200 -013 -256 -079 +036 -067 -067 +008 +032 -019 +009
J016 +047 -095 -124 +058 -008 -149 -158 -175 -055 -166 -068 +129 -112 -110 +094 -069 -168 -161 -192 -066 +126 +011
J015 +061 +054 -050 +073 -009 -186 -200 -363 -138 -038 -003 -044 -134 -064 -017 -202 -098 -129 -275 -098 +022 -061
J014 -115 +059 -033 -164 -169 -199 -153 -176 -091 +014 +001 -128 -050 -147 -138 -111 -001 -064 -173 -138 -181 +003
J013 -201 -200 +003 -197 -157 -145 -272 -263 +135 +125 -040 -026 -044 -046 +005 +169 +056 -093 +034 -034 -283 -189
J012 -185 -284 -033 -121 -243 +019 +124 -186 +186 -009 -136 +129 +033 -106 +071 +059 -201 -397 -294 +097 -079 -338
J011 -185 -133 -221 -182 -152 -109 +220 +069 -139 -315 -543 -014 +244 -006 -103 -148 -138 -222 -340 +079 +004 -411
J010 -092 -093 -136 -116 -103 -216 -314 -376 -471 -343 -462 -271 +019 -148 -341 +013 +162 -277 -331 +038 -143 -297
J009 -044 -163 +031 +021 -293 -140 -099 -254 -162 -147 -126 -261 -537 -721 -714 -275 -333 -682 -531 -119 -144 -189
J008 -127 -132 -098 -201 -218 +063 -014 -113 +132 -082 -256 -221 -490 -636 -027 -040 -028 -033 -351 -335 -302 -255
J007 -092 -134 -141 -229 -092 -121 -580 -393 -025 -155 -319 -190 -100 -162 -306 -635 -780 -428 -227 -378 -412 -202
J006 -029 -094 -093 -084 -143 -254 -106 +048 -336 -188 +000 -144 -338 -595 -411 -244 -326 -369 -259 -169 -222 -198
J005 -039 -063 -119 -111 -284 -215 -009 -170 -094 +056 -093 -223 -116 -338 -174 -128 -098 -253 -186 -127 -069 -049
J004 -097 -059 -072 -130 -253 -085 -246 -522 +074 -051 -532 -128 +028 -062 -082 -061 -097 -187 -144 -078 -077 -064
J003 +148 -103 -043 -056 -124 -142 -022 +051 -145 -274 -205 -047 -252 -294 +043 +049 -167 -142 -023 -048 +011 +124
J002 -132 +138 -089 -052 -086 -105 +084 +165 -074 +117 +011 -098 -169 -013 +017 -102 -016 +032 +037 +061 +034 -002
J001 -031 -119 +141 -104 +006 +039 -210 -201 -001 -068 -079 -059 +055 +066 -246 -222 +132 +038 -147 +197 -091 -638
J000 +058 -084 -133 -[illegible]5 +047 -063 -244 -026 +068 -098 -033 -064 +004 -001 -272 -099 +014 -098 -175 -156 -076 -123
I000 I001 I002 I003 I004 I005 I006 I007 I008 I009 I010 I011 I012 I013 I014 I015 I016 I017 I018 I019 I020 I021
PROG KAT FIELD LAYER 2 PROG. 24 HOURS 00Z 23 FEB 65

9. APPENDIX D

THE CLEAR AIR TURBULENCE FORECAST COMPUTER PROGRAM

```
                                                                    KAT FORECAST
                                                                    BEGIN SLEEPING PROGRAM
                                                                    COMPUTES 500 TO 300 MB LAYER
                    00600                   ORG     6300B
00600   20 0 01461                          STA     TIME            PUT DATE TIME IN A REGISTER
        50 0 00000
00601   75 4 00674          START           RTJ     READD2          READS PACKED LOWER LEVEL D FIELD INTO
                                                                    FS4
        50 0 00000
00602   75 4 00702          +               RTJ     UNPCKD2         UNPACKS LOWER LEVEL D FIELD INTO FS1
        50 0 00000
00603   75 4 00722          +               RTJ     READT2          READS LOWER LEVEL TEMPERATURE FIELD
                                                                    INTO FS4
        50 0 00000
00604   75 4 00730          +               RTJ     UNPCKT2         UNPACKS LOWER LEVEL TEMPERATURE FIELD
                                                                    INTO FS3
        50 0 00000
00605   75 4 00661          +               RTJ     READD1          READS PACKED UPPER LEVEL D FIELD INTO
                                                                    FS4
        50 0 00000
00606   75 4 00667          +               RTJ     UNPCKD1         UNPACKS UPPER LEVEL D FIELD INTO FS0
        50 0 00000
00607   75 4 00707          +               RTJ     READT1          READS UPPER LEVEL TEMPERATURE FIELD IN
                                                                    TO FS4
        50 0 00000
00610   75 4 00715          +               RTJ     UNPCKT1         UNPACKS UPPER LEVEL TEMPERATURE FIELD
                                                                    INTO FS2
        50 0 00000
00611   75 4 00735          +               RTJ     REWIND          REWINDS TU 3 CH 5/6
        50 0 00000
00612   75 4 00741          +               RTJ     REWIND1         REWINDS TU 2 CH 5/6
        50 0 00000
00613   75 4 01274          +               RTJ     PRINT           PRINTS LOWER HEIGHT FIELD
        50 0 00000
00614   75 4 00745          +               RTJ     SINF            GENERATES SINE FIELD STORS IN FS4
        50 0 00000
00615   75 4 00750          +               RTJ     VORTIS1         COMPUTES VORTICITY FIELD FROM UPPER
                                                                    LEVEL D FIELD STORS IN FS5
        50 0 00000
00616   75 4 00755          +               RTJ     VORTIS2         COMPUTES VORTICITY FIELD FROM LOWER
                                                                    LEVEL D FIELD STORS IN FS6
        50 0 00000
00617   75 4 00762          +               RTJ     LAPLAC1         COMPUTES LAPLACIAN OF UPPER LEVEL VORT
                                                                    ICITY FIELD STORS IN FS0
        50 0 00000
00620   75 4 00770          +               RTJ     LAPLAC2         COMPUTES LAPLACIAN OF LOWER LEVEL VORT
                                                                    ICITY FIELD STORS IN FS1
        50 0 00000
```

```
00621   75 4 00776    +    RTJ   HORIZ    COMPUTES AVERAGE LAPLACIAN BETWEEN
        50 0 00000                        UPPER AND LOWER LEVELS STORS IN FS5
00622   75 4 01320    +    RTJ   PRINT1   PRINTS LAPLACIAN OF VORTICITY
        50 0 00000
00623   75 4 01003    +    RTJ   RMAT     STORS SCALED MAP FACTOR IN FS6
        50 0 00000
00624   75 4 01011    +    RTJ   UTHM1    COMPUTES U COMPONENT OF THERMAL WIND
        50 0 00000                        AT LOWER LEVEL STORS IN FS0
00625   75 4 01027    +    RTJ   UTHM2    COMPUTES U COMPONENT OF THERMAL WIND
        50 0 00000                        AT LOWER LEVEL STORS IN FS1
00626   75 4 01045    +    RTJ   DUTHM    COMPUTES U COMPONENT DIFFERANCE
                                          BETWEEN UPPER AND LOWER LEVELS STORS
        50 0 00000                        IN FS0
00627   75 4 01052    +    RTJ   VTHM1    COMPUTES V COMPONENT OF THERMAL WIND
        50 0 00000                        AT LOWER LEVEL STORS IN FS1
00630   75 4 01070    +    RTJ   VTHM2    COMPUTES V COMPONENT OF THERMAL WIND
        50 0 00000                        AT UPPER LEVEL STORS IN FS2
00631   75 4 01106    +    RTJ   DVTHM    COMPUTES V COMPONENT DIFFERANCE
                                          BETWEEN UPPER AND LOWER LEVELS STORS
        50 0 00000                        IN FS1
00632   75 4 01113    +    RTJ   DTHM     COMPUTES VERTICAL GRADIENT OF
        50 0 00000                        THERMAL WIND STORS IN FS0
00633   75 4 01343    +    RTJ   PRINT2   PRINTS VERTICAL GRADIENT OF VT
        50 0 00000
00634   75 4 01123    +    RTJ   KAT1     HORIZ MINUS DTHM STORS IN FS5
        50 0 00000
00635   75 4 00674    +    RTJ   READD2   SEE ABOVE
        50 0 00000
00636   75 4 00702    +    RTJ   UNPCKD2  SEE ABOVE
        50 0 00000
00637   75 4 00661    +    RTJ   READD1   SEE ABOVE
        50 0 00000
00640   75 4 00667    +    RTJ   UNPCKD1  SEE ABOVE
        50 0 00000
00641   75 4 00735    +    RTJ   REWIND   REWINDS TU 3 CH 5/6
        50 0 00000
00642   75 4 00741    +    RTJ   REWIND1  REWINDS TU 2 CH 5/6
        50 0 00000
00643   75 4 00745    +    RTJ   SINF     SEE ABOVE
        50 0 00000
```

```
00644   75 4 01303          *       RTJ     MHAT        SEE ABOVE
        50 0 00000

00645   75 4 01130          *       RTJ     UGEOS1      COMPUTES U COMPONENT OF GEOSTROPHIC
                                                        WIND AT UPPER LEVEL STONS IN FS2
        50 0 00000

00646   75 4 01146          *       RTJ     UGEOS2      COMPUTES U COMPONENT OF GEOSTROPHIC
                                                        WIND AT LOWER LEVEL STONS IN FS3
        50 0 00000

00647   75 4 01164          *       RTJ     UGEOS       COMPUTES AVERAGE U COMPONENT STONS
                                                        IN FS2
        50 0 00000

00650   75 4 01173          *       RTJ     VGEOS1      COMPUTES V COMPONENT OF GEOSTROPHIC
                                                        WIND AT UPPER LEVEL STONS IN FS3
        50 0 00000

00651   75 4 01211          *       RTJ     VGEOS2      COMPUTES V COMPONENT OF GEOSTROPHIC
                                                        WIND AT LOWER LEVEL STONS IN FS0
        50 0 00000

00652   75 4 01227          *       RTJ     VGEOS       COMPUTES AVERAGE V COMPONENT STONS
                                                        IN FS0
        50 0 00000

00653   75 4 01236          *       RTJ     KINETIC     COMPUTES V SQUARE STONS IN FS0
                                                        COMPUTES V SQ DIFF STONS IN FS4
        50 0 00000

00654   75 4 01366          *       RTJ     PRINT3      PRINTS KINETIC ENERGY FIELD
        50 0 00000

00655   75 4 01246          *       RTJ     KAT2        STONS PREVIOUS TERMS IN FS4
        50 0 00000

00656   75 4 01411          *       RTJ     PRINT4      PRINTS PROG KAT FIELD
        50 0 00000

00657   75 4 01253          *       RTJ     LAYER2      COMPUTES 300 TO 200 MB LAYER
        50 0 00000

00660   76 0 00000          *       SLS                 END OF STEERING PROGRAM USES OFF LINE
                                                        PRINTING
        50 0 00000

00661   75 0 00300          READD1  SLJ     **
        50 0 00000

00662   12 0 01461          *       LDA     TIME
        14 0 01434                  LDQ     NAME1

00663   75 4 01707          *       RTJ     MAG
        00 0 00000                  00      0,0

00664   50 0 01477          HIGHD   ENI     MAA
        50 0 01300                  ENI     1300B

00665   50 0 43641                  ENI     FS4
        50 0 01424                  ENI     READERR

00666   75 0 00661                  SLJ     READ01
        50 0 00000

00667   75 0 00200          UNPCKD1 SLJ     **
        50 0 00000                  ENI     0,0
```

```
00670   73 0 00077      *       SLJ     ***
        00 0 43641              FS4
00671   00 0 00441              00      FS0
        00 0 02431                      2C538
00672   73 0 00301      *       RTJ     MAB
        00 0 00007              FNI     7
00673   73 0 00667              SLJ     UNPCKD1
        00 0 00000
00674   73 0 00060      READD2  SLJ     **
        00 0 00000
00675   12 0 01401      *       LDA     TIME
        12 0 01402              LDO     NAME2
00676   73 0 00707      *       RTJ     MAG
        00 0 00000              0,0
00677   00 0 01477              MAA
        00 0 01300              13008
00700   00 0 00441              FNI     FS4
        00 0 01402              FNI     READER4
00701   73 0 00074              SLJ     READD2
        00 0 00000
00702   73 0 00300      UNPCKD2 SLJ     **
        00 0 00000              FNI     0,A
00703   73 0 00705      *       SLJ     FS4
        00 0 43641              FS4
00704   00 0 00441              00      FS1
        00 0 02431                      2453B
00705   73 0 00701      *       RTJ     MAB
        00 0 00007              FNI     7
00706   73 0 00737              SLJ     UNPCKD2
        00 0 00000
00707   73 0 00000      READT1  SLJ     **
        00 0 00000
00710   12 0 01441      *       LDA     TIME
        12 0 01442              LDO     NAME3
00711   73 0 00707      *       RTJ     MAG
        00 0 00000              0,0
00712   00 0 01477      MIGHT   FNI     MAA
        00 0 01300              13008
00713   00 0 00441              FNI     FS4
        00 0 01402              FNI     READER4
00714   73 0 00707              SLJ     READT1
        00 0 00000
00715   73 0 00000      UNPCKT1 SLJ     **
        00 0 00000              FNI     0,A
00716   73 0 00720      *       SLJ     ***
        00 0 43641              FS4
00717   00 0 00441              00      FS2
        00 0 02431                      2453B
```

```
00720   75 4 04361      *       RTJ     WAB
        50 0 00007              ENI     7
00721   75 0 00715              SLJ     UNPCKT1
        50 0 00000
00722   75 0 00000      READT2  SLJ     **
        50 0 00000
00723   13 0 01441      *       LDA     TIME
        16 0 01444              LDQ     NAME4
00724   75 4 03707      *       RTJ     MAC
        00 0 00300              00      0,0
00725   50 0 01472              ENI     MAA
        50 0 01300              ENI     1300B
00726   50 0 43641              ENI     FS4
        50 0 01465              ENI     READERR
00727   75 0 00722              SLJ     READT2
        50 0 00000
00730   75 0 00000      UNPCKT2 SLJ     **
        50 6 00000              ENI     0,6
00731   75 0 00733      *       SLJ     *+2
        00 0 43641              00      FS4
00732   00 0 34001              00      FS3
        50 0 02453              00      2453B
00733   75 4 04361      *       RTJ     WAB
        50 0 00007              ENI     7
00734   75 0 00730              SLJ     UNPCKT2
        50 0 00000
00735   75 0 00000      REMIND  SLJ     **
        50 0 00000
00736   75 4 01477      *       RTJ     MAA
        00 0 11306              00      113068
00737   75 0 00735      *       SLJ     REMIND
        50 0 00000
00740   75 0 01471      *       SLJ     WINDERR
        50 0 00000
00741   75 0 00200      REMIND1 SLJ     **
        50 0 00000
00742   75 4 01477      *       RTJ     MAA
        50 0 11206              00      112068
00743   75 0 00741      *       SLJ     REMIND1
        50 0 00000
00744   75 0 01471      *       SLJ     WINDERR
        50 0 00000
00745   75 0 00200      SINF    SLJ     **
        50 0 00000
00746   75 4 04161      *       RTJ     SAI
        50 0 43641              ENI     FS4
00747   75 0 00745      *       SLJ     SINF
        50 0 00000
```

```
00750   75 0 00000      VORTIS1  SLJ     **
        40 0 00000
00751   75 4 04235      *        RTJ     SAR
        40 0 43441               ENI     PS4
00752   20 0 04441               ENI     PS0
        40 0 53501               ENI     PS5
00753   50 0 01407               ENI     VORTBR1
        50 0 04075               ENI     SAH
00754   75 0 00750               SLJ     VORTIS1
        50 0 00000
00755   75 0 00000      VORTIS2  SLJ     **
        50 0 00000
00756   75 4 04235      *        RTJ     SAR
        50 0 43441               ENI     PS4
00757   20 0 13101               ENI     PS1
        50 0 43141               ENI     PS6
00760   50 0 01470               ENI     VORTBR2
        50 0 04075               ENI     SAH
00761   75 0 00755               SLJ     VORTIS2
        50 0 00000
00762   75 0 00000      LAPLAC1  SLJ     **
        50 0 00300
00763   75 4 04047      *        RTJ     SAD
        00 0 04441               00      PS0
00764   00 0 31201               00      PS5
        00 0 01443               00      LAPERR1
00765   75 4 04073      *        RTJ     SAH
        50 0 04073               ENI     SAD+24B
00766   20 0 04061               ENI     SAD+12B
        50 0 04061               ENI     SAD+12B
00767   75 0 00762               SLJ     LAPLAC1
        50 0 00000
00770   75 2 00000      LAPLAC2  SLJ     **
        50 0 03300
00771   75 4 04047      *        RTJ     SAD
        00 0 14501               00      PS1
00772   00 3 63141               00      PS6
        00 0 01444               00      LAPERR2
00773   75 4 04073      *        RTJ     SAH
        50 3 04073               ENI     SAD+24B
00774   50 3 04061               ENI     SAD+12B
        50 0 04061               ENI     SAD+12B
00775   75 0 00770               SLJ     LAPLAC2
        50 0 00000
00776   75 0 00000      HORIZ    SLJ     **
        50 4 00000               ENI     0,4
00777   12 4 04241      LOOP1    LDA     PS0,3
        14 4 14501               ADD     PS1,4
```

```
01000   11 0 00001          ANS   1
        20 4 04404          STA   FS0,4

01001   54 4 07600    *     ISK   76000,4
        75 0 00777          SLJ   LOOP1

01002   75 0 00776          SLJ   HORIZ
        50 0 00000

01003   75 0 00303    MHAT  SLJ   **
        50 0 00000

01004   75 4 04214    *     RTJ   SAH
        00 0 01462          DD    HATERR

01005   50 3 43641          ENI   FS4
        50 0 63341          ENI   FS2

01006   75 4 04075    *     RTJ   SAH
        00 0 04223          DD    SAJ+78

01007   50 0 04223          ENI   SAJ+78
        50 0 04223          ENI   SAJ+78

01010   75 0 01003          SLJ   MHAT
        50 0 00000

01011   75 0 00303    UTHM1 SLJ   **
        50 0 00000

01012   75 4 04075    DIF1  RTJ   SAH
        00 0 01015          DD    OUTSIDE

01013   50 0 01317    *     ENI   INSIDE
        50 0 01317          ENI   INSIDE

01014   75 0 01011    *     SLJ   UTHM1
        50 0 00000

01015   10 0 00000    OUTSIDE ENA 0
        20 2 04441          STA   FS0,2

01016   75 0 01212          SLJ   DIF1
        50 0 00000

01017   12 3 43641    INSIDE LDA  FS4,2
        01 0 00001          ARS   1

01020   14 0 01434          ADD   CONST1
        20 0 01455          STA   LOCAT1

01021   26 0 01435          MUF   LOCAT1
        20 0 01455          STA   LOCAT1

01022   12 3 24141          LDA   FS2,3
        15 1 24141          SUB   FS2,1

01023   20 0 01456          STA   LOCAT2
        12 0 01453          LDA   CONST2

01024   26 2 63241          MUF   FS0,2
        26 0 01456          MUF   LOCAT2

01025   27 0 01455          DVF   LOCAT1
        27 2 24141          DVF   FS2,2

01026   20 2 04441          STA   FS0,2
        75 0 01012          SLJ   DIF1

01027   75 0 00000    UTHM2 SLJ   **
        50 0 00000
```

```
01030  75 4 04073  DIF2    RTJ   SAM
       00 0 01053          00    OUTSID2
01031  50 0 01032  *       ENI   INSID2
       50 0 01035          ENI   INSID2
01032  75 0 01037  *       SLJ   UTHM2
       50 0 00000
01033  10 2 00000  OUTSID2 ENA   0
       20 2 14101          STA   FS1,2
01034  75 0 01030          SLJ   DIF2
       00 0 00000
01035  12 2 42041  INSID2  LDA   FS4,2
       31 0 00001          ARS   1
01036  14 0 01434          ADD   CONST1
       20 0 01435          STA   LOCAT1
01037  16 0 01435          MUF   LOCAT1
       20 0 01435          STA   LOCAT1
01040  12 1 34301          LDA   FS3,3
       14 1 34001          SUB   FS3,1
01041  20 2 01436          STA   LOCAT2
       12 0 01437          LDA   CONST2
01042  24 2 42141          MUF   FS4,2
       20 2 01436          MUF   LOCAT2
01043  27 0 01435          DVF   LOCAT1
       27 2 34501          DVF   FS5,2
01044  20 2 14301          STA   FS1,2
       75 0 01040          SLJ   DIF2
01045  75 0 00000  OUTHM   SLJ   **
       50 4 00000          ENI   0,4
01046  12 4 04441  LOOP4   LDA   FS0,4
       14 4 14301          SUB   FS1,4
01047  20 4 04441          STA   FS0,4
       50 0 00000
01050  54 4 07600  *       ISK   7600B,4
       75 0 01046          SLJ   LOOP4
01051  75 0 01045          SLJ   OUTHM
       20 0 00000
01052  75 0 00000  VTHM1   SLJ   **
       50 0 00000
01053  75 4 04073  DIF3    RTJ   SAM
       00 3 01056          00    OUTSID3
01054  50 0 01060  *       ENI   INSID3
       50 0 01060          ENI   INSID3
01055  75 0 01052  *       SLJ   VTHM1
       50 0 00000
01056  10 0 00200  OUTSID3 ENA   0
       20 2 14101          STA   FS1,2
01057  75 0 01053          SLJ   DIF3
       50 0 00000
```

```
01060   12 2 43641      INSID3  LDA     FS4,2
        01 1 00001              ARS     1
01061   14 0 01434              ADD     CONST1
        20 0 01455              STA     LOCAT1
01062   26 0 01455              MUF     LOCAT1
        20 0 01455              STA     LOCAT1
01063   12 2 24142              LDA     FS2+1,2
        15 2 24140              SUB     FS2-1,2
01064   20 0 01456              STA     LOCAT2
        12 0 01435              LDA     CONST2
01065   26 2 63341              MUF     FS6,2
        26 0 01456              MUF     LOCAT2
01066   27 0 01455              DVF     LOCAT1
        27 2 24141              DVF     FS2,2
01067   20 2 14301              STA     FS1,2
        75 0 01053              SLJ     DIF3
01070   75 0 00060      VTHM2   SLJ     **
        50 0 00000
01071   75 4 04075      DIF4    RTJ     SAH
        00 0 01074              DD      OUTSID4
01072   50 0 01076      *       ENI     INSID4
        50 0 01076              ENI     INSID4
01073   75 0 01070      *       SLJ     VTHM2
        50 0 00000
01074   10 0 00000      OUTSID4 ENA     0
        20 2 24141              STA     FS2,2
01075   75 0 01071              SLJ     DIF4
        50 0 00000
01076   12 2 43641      INSID4  LDA     FS4,2
        01 0 00001              ARS     1
01077   14 0 01434              ADD     CONST1
        20 0 01455              STA     LOCAT1
01100   26 0 01455              MUF     LOCAT1
        20 0 01455              STA     LOCAT1
01101   12 2 34002              LDA     FS3+1,2
        15 2 34000              SUB     FS3-1,2
01102   20 0 01456              STA     LOCAT2
        12 0 01435              LDA     CONST2
01103   26 2 63341              MUF     FS6,2
        26 0 01456              MUF     LOCAT2
01104   27 0 01455              DVF     LOCAT1
        27 2 34001              DVF     FS3,2
01105   20 2 24141              STA     FS2,2
        75 0 01071              SLJ     DIF4
01106   75 0 00000      DVTHM   SLJ     **
        50 4 00000              ENI     0,4
01107   12 4 24141      LOOP7   LDA     FS2,4
        15 4 14301              SUB     FS1,4
```

```
01110   20 4 14301          STA   FS1,4
        50 0 00000
01111   54 4 07600    *     ISK   7600B,4
        75 0 01147          SLJ   LOOP7
01112   75 0 01106          SLJ   OVTHM
        50 0 00000
01113   75 0 00000    OTHM  SLJ   **
        50 4 00000          ENI   0,4
01114   12 4 04441    LOOP8 LDA   FS0,4
        26 4 04441          MUF   FS0,4
01115   20 4 04441          STA   FS0,4
        12 4 14301          LDA   FS1,4
01116   26 4 14301          MUF   FS1,4
        14 4 04441          ADD   FS0,4
01117   75 4 04412    *     RTJ   VAD
        00 0 01466          00    SQERR
01120   20 4 04441    *     STA   FS0,4
        50 0 00000
01121   54 4 07600    *     ISK   7600B,4
        75 0 01114          SLJ   LOOP8
01122   75 0 01113          SLJ   OTHM
        50 0 00000
01123   75 0 00000    KAT1  SLJ   **
        50 4 00000          ENI   0,4
01124   12 4 53501    LOOP9 LDA   FS5,4
        15 4 04441          SUB   FS0,4
01125   20 4 53501          STA   FS5,4
        50 0 00000
01126   54 4 07600    *     ISK   7600B,4
        75 0 01124          SLJ   LOOP9
01127   75 0 01123          SLJ   KAT1
        50 0 00000
01130   75 0 00000    UGEOS1 SLJ  **
        50 0 00000
01131   75 4 04075    DIF5  RTJ   SAH
        00 0 01134          00    OUTSID5
01132   50 0 01136    *     ENI   INSID5
        50 0 01136          ENI   INSID5
01133   75 0 01130    *     SLJ   UGEOS1
        50 0 00000
01134   10 2 00000    OUTSID5 ENA 0
        20 2 24141          STA   FS2,2
01135   75 0 01131          SLJ   DIF5
        50 0 00000
01136   12 2 43641    INSID5 LDA  FS4,2
        31 5 00001          ARS   1
01137   14 0 01434          ADD   CONST1
        20 0 01455          STA   LOCAT1
```

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01140   26 0 01455          MUF   LOCAT1
        20 3 01455          STA   LOCAT1

01141   12 3 04441          LDA   FS0,3
        15 1 04441          SUB   FS0,1

01142   20 0 01456          STA   LOCAT2
        12 0 01435          LDA   CONST2

01143   26 2 63341          MUF   FS6,2
        26 0 01456          MUF   LOCAT2

01144   27 0 01455          DVF   LOCAT1
        20 2 24141          STA   FS2,2

01145   75 0 01131          SLJ   DIF5
        50 0 00000

01146   75 0 00000  UGEOS2   SLJ   **
        50 0 00000

01147   75 4 04075  DIF6     RTJ   SAM
        00 0 01152          00    OUTSID6

01150   50 0 01154  *        ENI   INSID6
        50 0 01154          ENI   INSID6

01151   75 0 01146  *        SLJ   UGEOS2
        50 0 00000

01152   10 0 00000  OUTSID6  ENA   0
        20 2 34001          STA   FS3,2

01153   75 0 01147          SLJ   DIF6
        50 0 00000

01154   12 2 63441  INSID6   LDA   FS4,2
        01 0 00001          ARS   1

01155   14 0 01434          ADD   CONST1
        20 0 01455          STA   LOCAT1

01156   26 0 01455          MUF   LOCAT1
        20 0 01455          STA   LOCAT1

01157   12 3 14301          LDA   FS1,3
        15 1 14301          SUB   FS1,1

01160   20 0 01456          STA   LOCAT2
        12 0 01435          LDA   CONST2

01161   26 2 63341          MUF   FS6,2
        26 0 01456          MUF   LOCAT2

01162   27 0 01455          DVF   LOCAT1
        20 2 34001          STA   FS3,2

01163   75 0 01147          SLJ   DIF6
        50 0 00000

01164   75 0 00000  UGEOS    SLJ   **
        50 4 00000          ENI   0,4

01165   12 4 24141  LOOP10   LDA   FS2,4
        05 0 00003          ALS   3

01166   20 0 01455          STA   LOCAT1
        12 4 34001          LDA   FS3,4

01167   05 0 00003          ALS   3
        14 0 01455          ADD   LOCAT1
```

```
01170   20 4 24141          STA   FS2,4
        50 5 00000

01171   54 4 07600          ISK   76000,4
        75 5 01165          SLJ   LOOP1

01172   75 5 01164          SLJ   UGEOS
        50 5 00000

01173   75 5 00300  VGEOS1  SLJ   **
        50 5 00000

01174   75 4 04075  DIF7    RTJ   SAH
        00 5 01177          00    OUTSID7

01175   50 5 01201  *       ENI   INSID7
        53 5 01201          ENI   INSID7

01176   75 5 01173  *       SLJ   VGEOS1
        50 5 00000

01177   10 5 00000  OUTSID7 ENA   0
        20 2 34001          STA   FS3,2

01200   75 5 01174          SLJ   DIF7
        50 5 00000

01201   12 2 43641  INSID7  LDA   FS4,2
        01 5 00001          ARS   1

01202   14 5 01434          ADD   CONST1
        20 5 01455          STA   LOCAT1

01203   26 5 01455          MUF   LOCAT1
        20 5 01455          STA   LOCAT1

01204   12 2 04442          LDA   FS0+1,2
        15 2 04440          SUB   FS0-1,2

01205   20 5 01456          STA   LOCAT2
        12 5 01435          LDA   CONST2

01206   26 2 43341          MUF   FS6,2
        26 5 01456          MUF   LOCAT2

01207   27 5 01455          DVF   LOCAT1
        20 2 34001          STA   FS3,2

01210   75 5 01174          SLJ   DIF7
        50 5 00000

01211   75 5 00300  VGEOS2  SLJ   **
        50 5 00000

01212   75 4 04075  DIF8    RTJ   SAH
        00 5 01215          00    OUTSID8

01213   50 5 01217  *       ENI   INSID8
        53 5 01217          ENI   INSID8

01214   75 5 01211  *       SLJ   VGEOS2
        50 5 00000

01215   10 5 00000  OUTSID8 ENA   0
        20 2 04441          STA   FS0,2

01216   75 5 01212          SLJ   DIF8
        50 5 00000

01217   12 2 43641  INSID8  LDA   FS4,2
        01 5 00001          ARS   1
```

```
01220   14 4 01434          ADD   CONST1
        25 4 01455          STA   LOCAT1

01221   26 4 01455          MUF   LOCAT1
        20 0 01455          STA   LOCAT1

01222   12 2 14302          LDA   FS1+1,2
        15 2 14300          SUB   FS1-1,2

01223   20 0 01456          STA   LOCAT2
        12 0 01435          LDA   CONST2

01224   26 2 63141          MUF   FS0,2
        26 0 01456          MUF   LOCAT2

01225   27 0 01455          DVF   LOCAT1
        25 2 04441          STA   FS0,2

01226   75 0 01212          SLJ   DIFB
        50 0 00000

01227   75 0 00000  VGEOS    SLJ   **
        50 4 00003          ENT   0,4

01230   12 4 34001  LOOP11   LDA   FS3,4
        35 4 00003          ALS   3

01231   20 0 01455          STA   LOCAT1
        12 4 04441          LDA   FS0,4

01232   05 0 00003          ALS   3
        14 0 01455          ADD   LOCAT1

01233   20 4 04441          STA   FS0,4
        50 0 00000

01234   54 4 07600  *        ISK   7600B,4
        75 0 01230          SLJ   LOOP11

01235   75 0 01227          SLJ   VGEOS
        50 0 00000

01236   75 0 00000  KINETIC  SLJ   **
        50 4 00003          ENT   0,4

01237   12 4 24141  LOOP12   LDA   FS2,4
        26 4 24141          MUF   FS2,4

01240   20 0 01455          STA   LOCAT1
        12 4 04441          LDA   FS0,4

01241   26 4 04441          MUF   FS0,4
        20 0 01456          STA   LOCAT2

01242   14 0 01455          ADD   LOCAT1
        01 0 00001          ARS   1

01243   20 4 04441          STA   FS0,4
        50 0 00000

01244   54 4 07600  *        ISK   7600B,4
        75 0 01237          SLJ   LOOP12

01245   75 0 01236          SLJ   KINETIC
        50 0 00000

01246   75 0 00000  KAT2     SLJ   **
        50 4 00000          ENT   0,4

01247   12 4 53201  LOOP13   LDA   FS5,4
        15 4 04441          SUB   FS0,4
```

```
01250   20 4 04441          STA   FSD,4
        50 0 00000
01251   34 4 07600    *     ISK   76000,4
        75 0 01247          SLJ   LOOP1
01252   75 0 01246          SLJ   KAT2
        50 0 00000
01253   75 0 00000    LAYER2 SLJ   0,0
        12 0 01446          LDA   COUNT
01254   05 0 00001          ALS   1
        20 0 01446          STA   COUNT
01255   73 3 01253          AJPM  LAYER2
        12 0 01437          LDA   NAME1A
01256   20 0 01436          STA   NAME1
        12 0 01441          LDA   NAME2A
01257   20 0 01440          STA   NAME2
        12 0 01443          LDA   NAME3A
01260   20 0 01442          STA   NAME3
        12 0 01445          LDA   NAME4A
01261   20 0 01444          STA   NAME4
        12 0 01447          LDA   LEVEL2
01262   20 0 01316          STA   TITLE+3
        20 0 01341          STA   TITLE1+3
01263   20 0 01364          STA   TITLE2+3
        20 0 01407          STA   TITLE6+3
01264   20 0 01432          STA   TITLE7+3
        12 0 01450          LDA   A2
01265   20 0 01306          STA   A1
        12 0 01451          LDA   B2
01266   20 0 01307          STA   B1
        12 0 01452          LDA   C2
01267   20 0 01311          STA   C1
        12 0 01453          LDA   D2
01270   20 0 01310          STA   D1
        12 0 01454          LDA   E2
01271   01 0 01305          SAL   E1
        12 0 01457          LDA   TAPUNIT
01272   01 0 00664          SAL   HIGHO
        01 0 00712          SAL   HIGH1
01273   75 0 00601          SLJ   START
        50 0 00000
01274   75 0 00000    PRINT SLJ   0,0
        10 0 77777          ENA   777776
01275   20 0 00017          STA   17B
        50 0 00000
01276   75 0 01302    *     SLJ   *+4
        00 0 00000          0
01277   00 0 14101          00    FS1
        36 0 63141          FS6
```

```
01300   00 0 00047                      00      39
        00 0 00035                      00      29

01301   00 0 00022                      00      18
        00 0 00010                      00      8

01302   75 4 04371          *           RTJ     WAE
        00 0 00000                      00      0

01303   75 4 02202          *           RTJ     MAC
        00 0 63341                      00      FS6,0

01304   75 0 01274          *           SLJ     PRINT
        77 7 63341                      77      FS6,7

01305   00 0 01460          E1          00      TAU
        00 0 00004                      00      4

01306   13 1 11710          A1          OCT     1311171047640243
        47 6 40243

01307   02 4 76132          B1          OCT     0247613261070664
        61 3 70664

01310   00 1 42600          D1          OCT     0014260000000000
        00 0 00000

01311   01 3 56000          C1          OCT     0135600000000000
        00 0 00000

01312   00 0 00026                      00      22
        00 0 00026                      00      22

01313   20 4 34624          TITLE       BCD     4, LOWER LEVEL Z FIELD    LAYER 1
        65 5 12043

01314   65 3 56543          TITLE       BCD     4, LOWER LEVEL Z FIELD    LAYER 1
        20 3 12066

01315   71 6 54364          TITLE       BCD     4, LOWER LEVEL Z FIELD    LAYER 1
        20 2 02020

01316   43 6 13065          TITLE       BCD     4, LOWER LEVEL Z FIELD    LAYER 1
        51 2 00120

01317   75 0 01274                      SLJ     PRINT
        50 0 00000

01320   75 0 00000          PRINT1      SLJ     **
        50 0 00000

01321   75 0 01325          *           SLJ     *+4
        00 0 00000                      00      0

01322   00 0 53501                      00      FS5
        00 0 63341                      00      FS6

01323   00 0 00047                      00      39
        00 0 00035                      00      29

01324   00 0 00022                      00      18
        00 0 00010                      00      8

01325   75 4 04371          *           RTJ     WAE
        00 0 00000                      00      0

01326   75 4 02202          *           RTJ     MAC
        00 0 63341                      00      FS6,0

01327   75 0 01320                      SLJ     PRINT1
        77 7 63341                      77      FS6,7
```

```
01330   00 1 01460              TAU     DEC     1
        00 0 00001

01331   00 0 00000              TAU1    OCT     0
        00 0 00000

01332   20 4 03700              TAU2    DEC     50-1847
        00 0 00000

01333   00 0 00000              TAU3    OCT     0
        00 0 00000

01334   04 4 31463              TAU4    DEC     150-2847
        14 6 31463

01335   00 1 00026              TAU5    DEC     23
        00 0 00023                      DEC     19

01336   20 4 36147      TITLE1  BCD     4, LAPLACIAN OF VORTICITY LAYER 1
        43 6 16371

01337   61 4 52046      TITLE1  BCD     4, LAPLACIAN OF VORTICITY LAYER 5
        66 2 02546

01340   51 4 37163      TITLE1  BCD     4, LAPLACIAN OF VORTICITY LAYER 1
        71 2 33120

01341   43 6 13765      TITLE1  BCD     4, LAPLACIAN OF VORT   ITY LAYER 1'
        51 2 00120

01342   75 1 01320              SLJ     PRINT1
        50 0 00000

01343   75 0 00300      PRINT2  SLJ     **
        50 0 00300

01344   75 0 01352      *       SLJ     *+4
        00 0 00000              0

01345   00 0 04441              DO      FS0
        00 1 63361              FS6

01346   00 0 00047              DO      39
        00 0 00035              DO      29

01347   00 0 00022              DO      18
        00 0 00010              DO      8

01350   75 4 04371      SKIP    RTJ     MAE
        00 0 00000              0

01351   73 4 02202      *       RTJ     MAC
        00 1 63341              FS6,0

01352   75 0 01343              SLJ     PRINT2
        77 7 63361              FS6,7

01353   00 1 01460              TAU     DEC     1
        00 0 00001

01354   00 0 00000              TAU1    OCT     0
        00 0 00000

01355   20 4 00000              TAU2    DEC     50-1847
        00 1 00003

01356   00 0 00000              TAU3    OCT     0
        00 0 00000

01357   00 4 31463              TAU4    DEC     250-3047
        14 6 31463
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01360   00 0 00026                      00    22
        00 0 00026                      00    22
01361   20 2 56551          TITLE2      BCD   4, VERT GRAD OF VT        LAYER 1
        23 2 06751
01362   61 6 42046          TITLE2      BCD   4, VERT GRAD OF VT        LAYER 1
        66 2 02523
01363   20 2 02020          TITLE2      BCD   4, VERT GRAD OF VT        LAYER 1
        20 2 02020
01364   43 6 13065          TITLE2      BCD   4, VERT GRAD OF VT        LAYER 1
        51 2 00120
01365   75 0 01343                      SLJ   PRINT2
        50 0 00000
01366   75 0 00000          PRINT3      SLJ   **
        50 0 00000
01367   75 0 01373          *           SLJ   *+4
        00 0 00000                      00    0
01370   00 0 04441                      00    FS0
        00 0 63341                      00    FS6
01371   00 0 00047                      00    39
        00 0 00035                      00    29
01372   00 0 00022                      00    18
        00 0 00010                      00    8
01373   75 4 04371          *           RTJ   WAE
        00 0 00000                      00    0
01374   75 4 02202          *           RTJ   MAC
        00 0 63341                      00    FS6,0
01375   75 0 01366                      SLJ   PRINT3
        77 7 63341                      77    FS6,7
01376   00 0 01460                      00    TAU
        00 0 00001                      00    1
01377   00 0 00000                      OCT   0
        00 0 00000
01400   20 0 00000                      DEC   50-1547
        00 0 00000
01401   00 0 00000                      OCT   0
        00 0 00000
01402   01 4 63146                      DEC   50-2847
        31 4 63146
01403   00 0 00026                      00    22
        00 0 00026                      00    22
01404   20 4 27145          TITLE4      BCD   4, KINETIC ENERGY         LAYER 1
        65 2 37163
01405   20 6 54565          TITLE4      BCD   4, KINETIC ENERGY         LAYER 1
        51 6 73020
01406   20 2 02020          TITLE4      BCD   4, KINETIC ENERGY         LAYER 1
        20 2 02020
01407   43 6 13065          TITLE4      BCD   4, KINETIC ENERGY         LAYER 1
        51 2 00120
```

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01410   75 0 01366                      SLJ     PRINT3
        50 0 00000

01411   75 0 00300          PRINT4      SLJ     **
        50 0 00300

01412   75 0 01416          *           SLJ     *+4
        00 0 00000                      00      0

01413   00 0 04441                      00      FS0
        00 0 63341                      00      FS6

01414   00 0 00047                      00      39
        00 0 00035                      00      29

01415   00 0 00022                      00      18
        00 0 00010                      00      8

01416   75 4 04371          *           RTJ     WAE
        00 0 00000                      00      0

01417   75 4 02202          *           RTJ     WAE
        00 0 63341                      00      FS6,0

01420   75 0 01411                      SLJ     PRINT4
        77 7 63341                      77      FS6,7

01421   00 0 01460                      00      TAU
        00 0 00001                      00      1

01422   00 0 00000                      OCT     0
        00 0 00000

01423   20 0 00000                      DEC     50-1847
        00 0 00005

01424   00 0 00000                      OCT     0
        00 0 00000

01425   03 1 46314                      DEC     10-1847
        63 1 46314

01426   00 0 00026                      20      22
        00 0 00026                      00      22

01427   20 4 75146          TITLE7      BCD     4, PROG KAT FIELD       LAYER 1
        67 2 04261

01430   23 2 06671          TITLE7      BCD     4, PROG KAT FIELD       LAYER 1
        65 4 36420

01431   20 2 02020          TITLE7      BCD     4, PROG KAT FIELD       LAYER 1
        20 2 02020

01432   43 6 13065          TITLE7      BCD     4, PROG KAT FIELD       LAYER 1
        51 2 00120

01433   75 0 01411                      SLJ     PRINT4
        50 0 00000

01434   20 0 00000          CONST1      DEC     50-1847
        00 0 00000

01435   05 5 11512          CONST2      DEC     176370-6047
        62 5 77555

01436   64 2 02303          NAME1       OCT     6420200317122020
        12 1 22020

01437   64 2 02302          NAMF1A      OCT     6420200217122020
        12 1 22020
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01440   64 2 02005      NAME2     OCT   64202005312122020
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01441   64 2 02003      NAME2A    OCT   64202003312122020
        12 1 22020

01442   23 2 02003      NAME3     OCT   23202003312122020
        12 1 22020

01443   23 2 02002      NAME3A    OCT   23202002312122020
        12 1 22020

01444   23 2 02005      NAME4     OCT   23202005312122020
        12 1 22020

01445   23 2 02003      NAME4A    OCT   23202003312122020
        12 1 22020

01446   17 7 77777      COUNT     OCT   17777777777777777
        77 7 77777

01447   43 6 13065      LEVEL2    OCT   43613065512002220
        51 2 00220

01450   07 2 47764      A2        OCT   07247764514014743
        15 1 14743

01451   01 0 30675      B2        OCT   01030675720265T3
        72 3 26573

01452   02 7 34000      C2        OCT   02734000000000000
        00 0 00000

01453   77 0 12577      D2        OCT   77012577777777777
        77 7 77777

01454   00 0 00300      E2        OCT   2
        00 0 00002

01455           01456   LOCAT1    BSS   1
01456           01457   LOCAT2    BSS   1
01457   00 0 00000      TAPUNIT   OCT   50001200
        50 0 01200

01460   00 0 00000      TAU       DEC   24
        00 0 00030

01461   12 1 21208      TIME      OCT   12121205120106O5
        17 1 10605

01462   76 0 01005      MATERR    SLS   MHAT
        50 0 00000

01463   76 0 00762      LAPERR1   SLS   LAPLAC1
        50 0 00000

01464   76 0 00770      LAPERR2   SLS   LAPLAC2
        50 0 00000

01465   76 0 00601      READERR   SLS   READ01
        50 0 00000

01466   76 0 01113      SOERR     SLS   D/HH
        50 0 00000

01467   76 0 00750      VORTERR1  SLS   VORTIS1
        50 0 00100
```
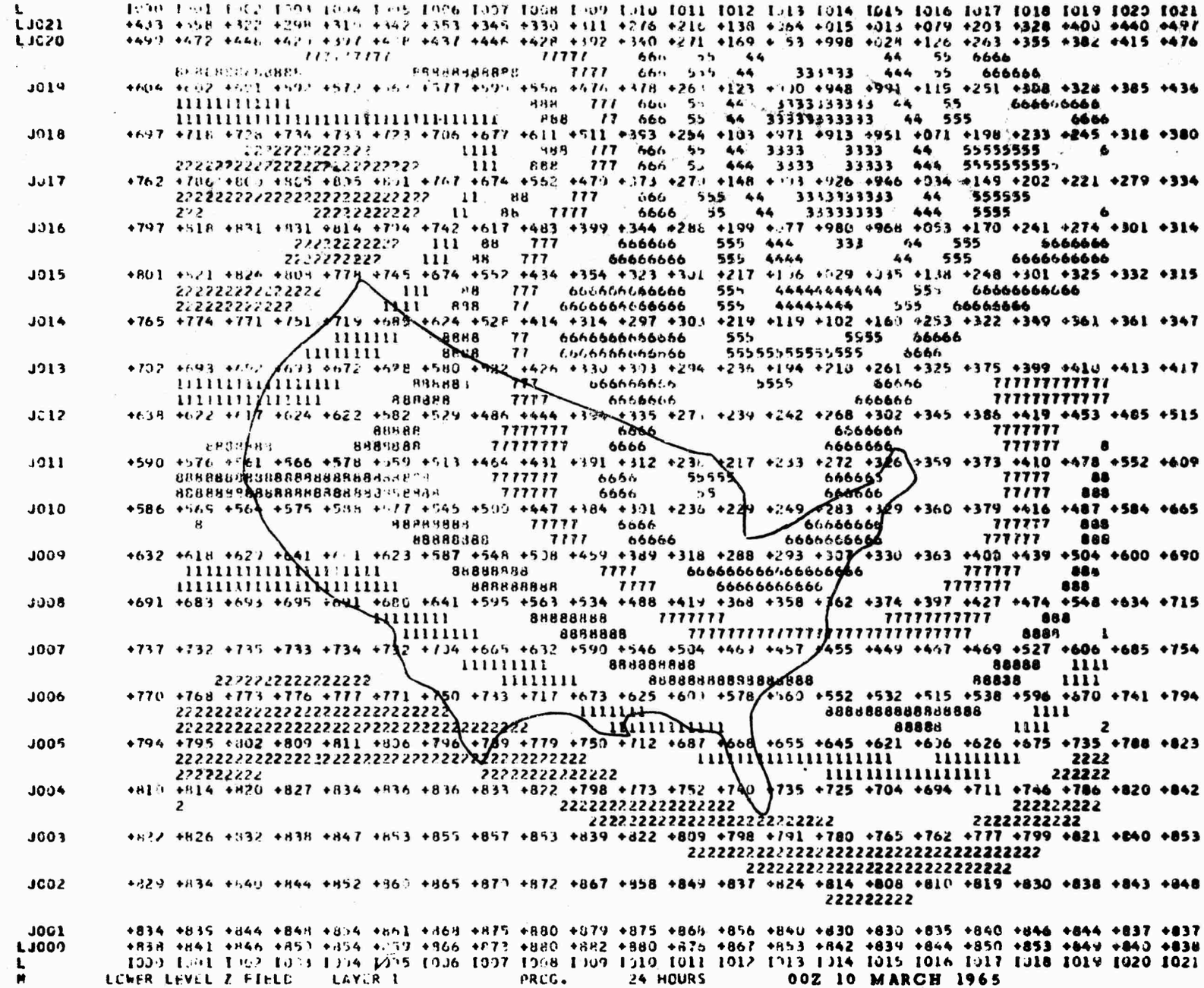
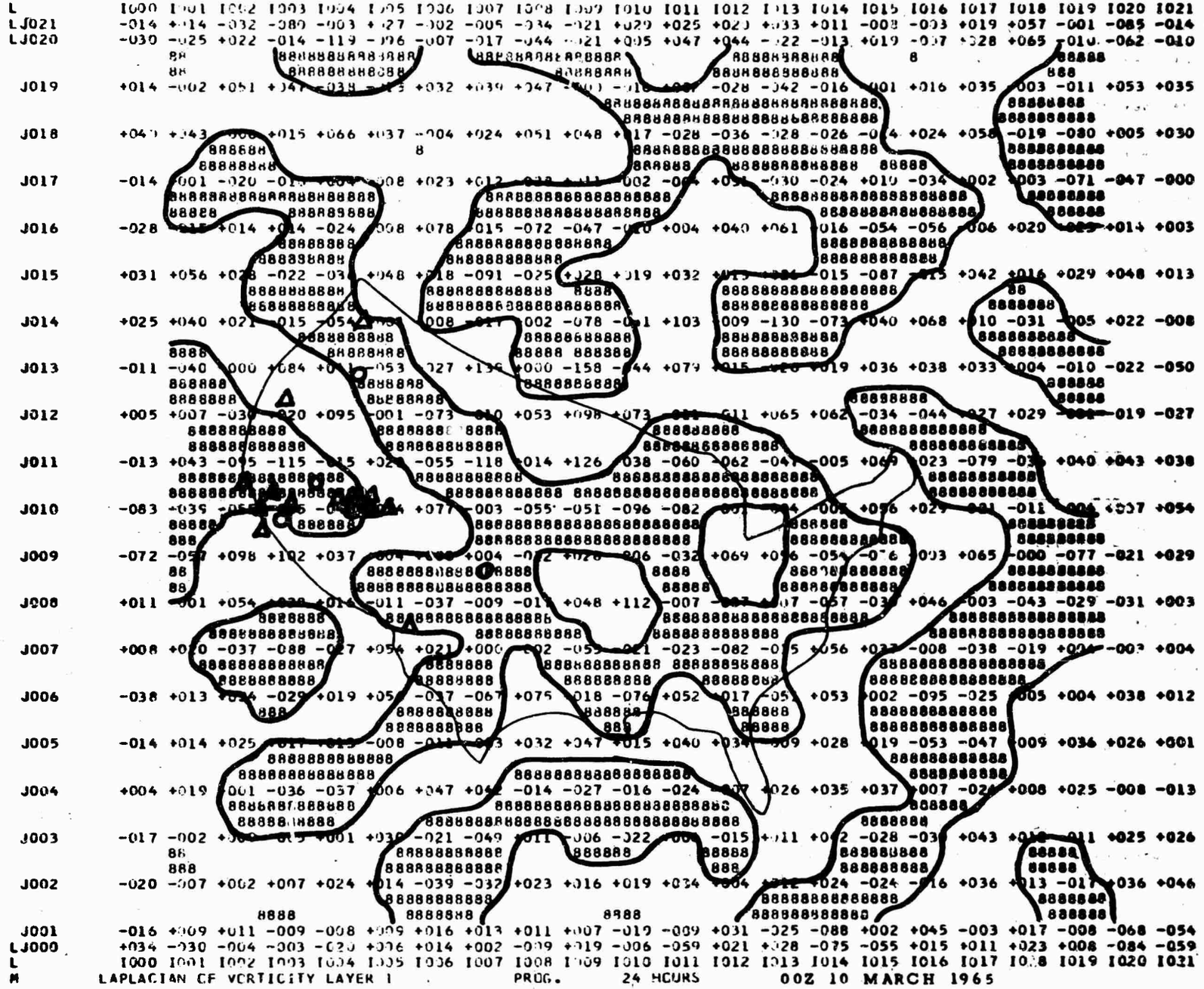

01470	76 0 00755 52 0 00000	WORTEN2	SLS	WORTES2
01471	76 0 00735 50 0 00000	WINDERR	SLS	REWIND
01472	02202	MAA	LIB	MAA
02202	03707	MAC	LIB	MAC
03707	04047	MAG	LIB	MAG
04047	04075	SAD	LIB	SAD
04075	04161	SAH	LIB	SAH
04161	04214	SAI	LIB	SAI
04214	04235	SAJ	LIB	SAJ
04235	04312	SAR	LIB	SAR
04312	04341	VAB	LIB	VAB
04341	04371	WAB	LIB	WAB
04371	04441	WAE	LIB	WAE
04441	14301	FS0	BSS	4000
14301	24141	FS1	BSS	4000
24141	34001	FS2	BSS	4000
34001	43641	FS3	BSS	4000
43641	53501	FS4	BSS	4000
53501	63341	FS5	BSS	4000
63341	73201	FS6	BSS	4000
73201	00000		END	

10. APPENDIX E

PRINTED FIELDS FROM THE CLEAR AIR TURBULENCE FORECAST COMPUTER PROGRAM FOR 00Z 10 MARCH 65 THROUGH 12Z 13 MARCH 65


LOWER LEVEL Z FIELD LAYER 1 PROG. 24 HOURS 00Z 10 MARCH 1965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LJ021 -014 +014 -032 -080 -003 +027 -002 -005 -034 -021 +029 +025 +020 +033 +011 -008 -003 +019 +057 -001 -085 -014
LJ020 -030 -025 +022 -014 -119 -096 -007 -017 -044 -021 +005 +047 +044 -022 -013 +019 -037 +028 +065 -010 -062 -010
J019 +014 -002 +051 +047 -038 +032 +039 +047 -028 -042 -016 +001 +016 +035 -003 -011 +053 +035
J018 +040 +043 +015 +066 +037 -004 +024 +051 +048 +017 -028 -036 -028 -026 -014 +024 +058 -019 -080 +005 +030
J017 -014 +001 -020 -015 +008 +023 +012 -002 -004 +051 -030 -024 +010 -034 +002 +003 -071 -047 -000
J016 -028 +014 +014 -024 +078 +015 -072 -047 +004 +040 +061 -016 -054 -056 +006 +020 +014 +003
J015 +031 +056 +028 -022 -036 +048 +018 -091 -025 +028 +019 +032 -015 -087 +042 +016 +029 +048 +013
J014 +025 +040 +021 -015 -054 -002 -078 +103 -009 -130 -073 +040 +068 +010 -031 -005 +022 -008
J013 -011 -040 +000 +084 +053 +027 +000 -158 +079 +019 +036 +038 +033 +004 -010 -022 -050
J012 +005 +007 -030 -020 +095 -001 -073 +053 +098 +073 +065 +062 -034 -044 -027 +029 -019 -027
J011 -013 +043 -095 -115 +020 -055 -118 +014 +126 +038 -060 -062 -047 -005 +069 +023 -079 +040 +043 +038
J010 -083 +077 -003 -055 -051 -096 -082 +056 +029 -011 +037 +054
J009 -072 -057 +098 +102 +037 +004 +026 -032 +069 +056 -054 -076 +093 +065 -000 -077 -021 +029
J008 +011 -001 +054 +011 -037 -009 +048 +112 -007 +007 -057 +046 -003 -043 -029 -031 +003
J007 +008 +010 -037 -088 -027 +054 +021 +000 -055 -021 -023 -082 -015 +056 +033 -008 -038 -019 +004 -003 +004
J006 -038 +013 +034 -029 +019 +052 -037 -067 +075 +018 -076 +052 +017 -055 +053 +002 -095 -025 +005 +004 +038 +012
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J003 -017 -002 +000 -019 +001 +030 -021 -049 +011 -006 -022 +000 -015 +011 +042 -028 -030 +043 +010 -011 +025 +026
J002 -020 -007 +002 +007 +024 +014 -039 -032 +023 +016 +019 +034 +004 +012 +024 -024 -016 +036 +013 -017 +036 +046
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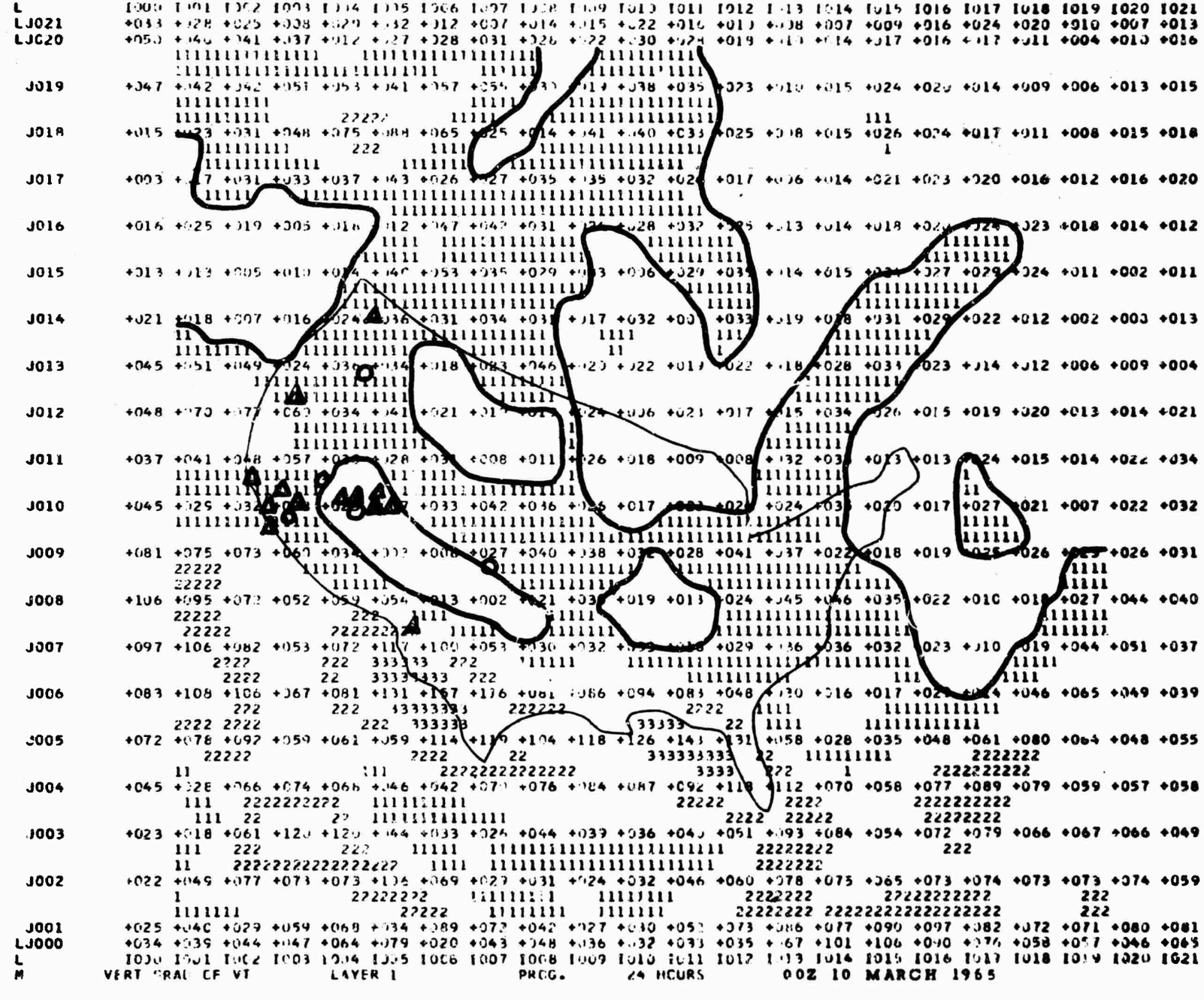
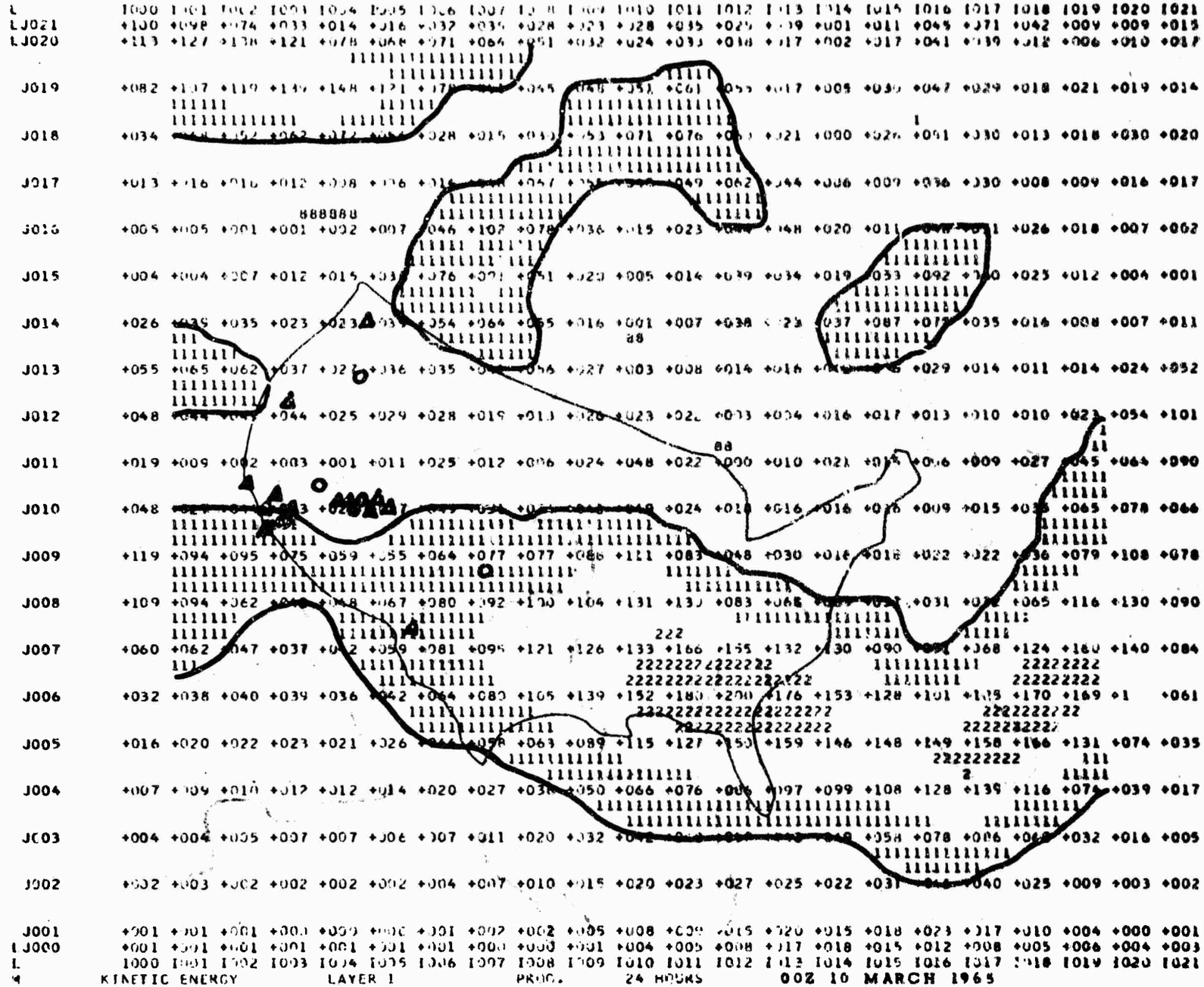
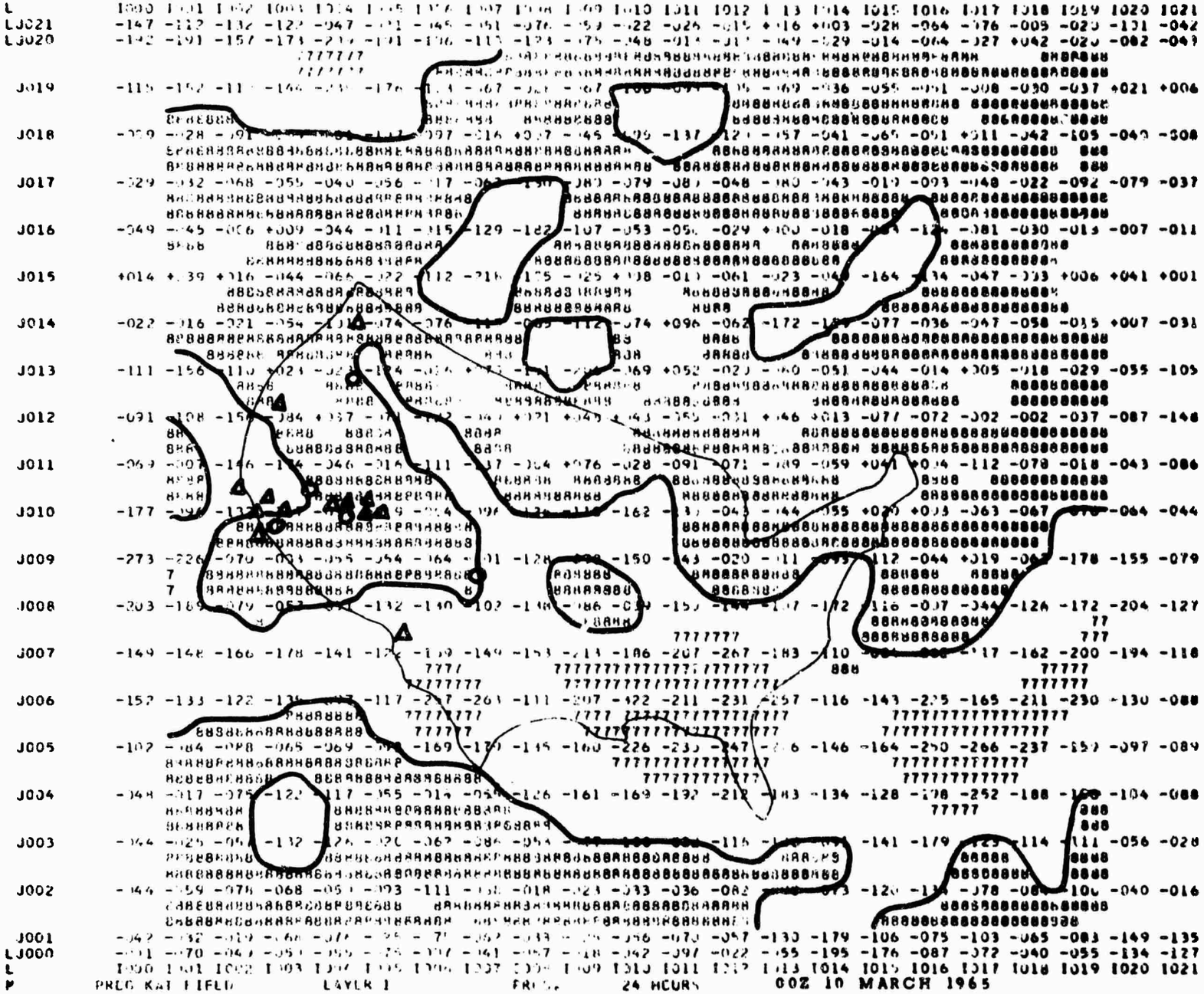
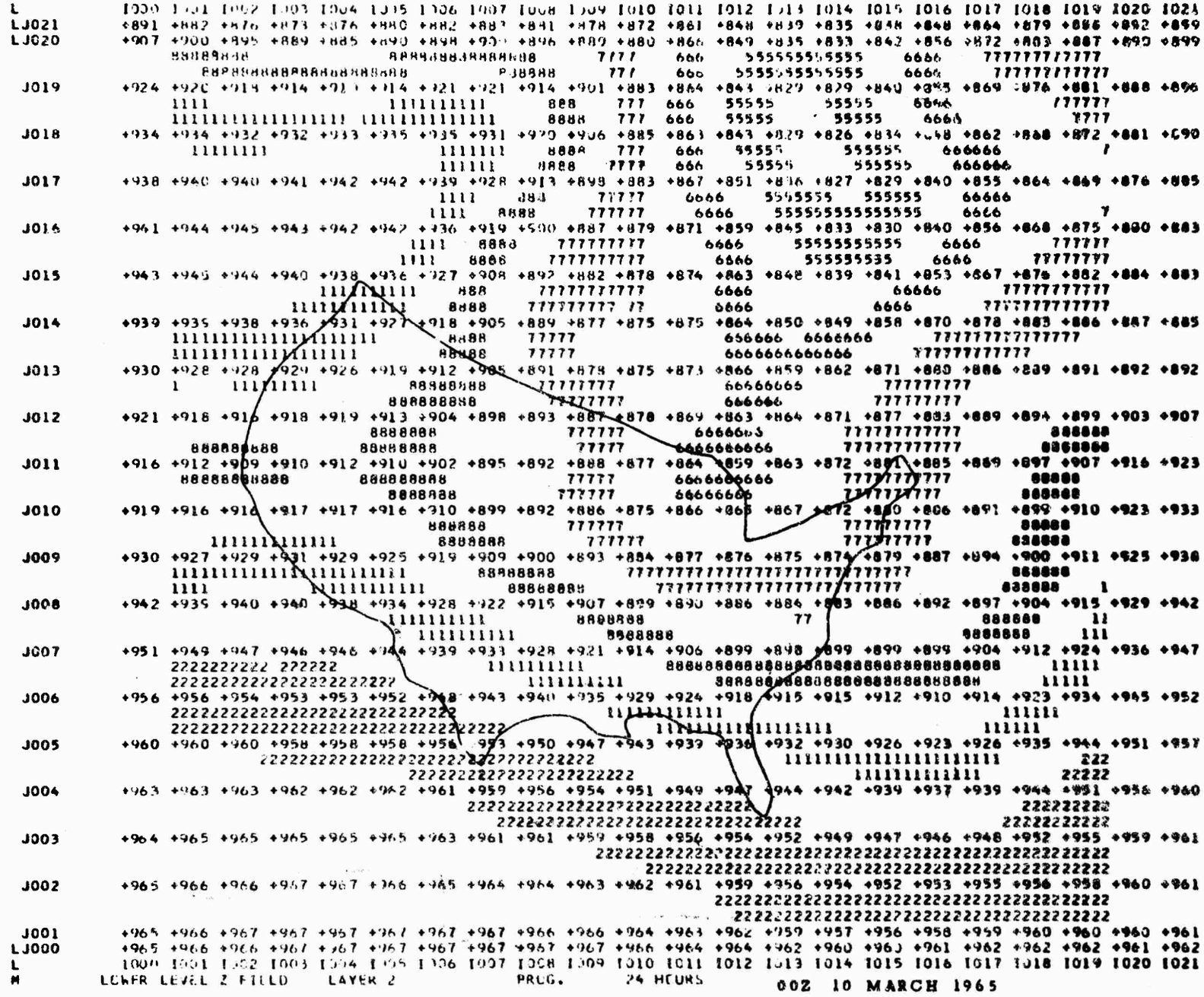
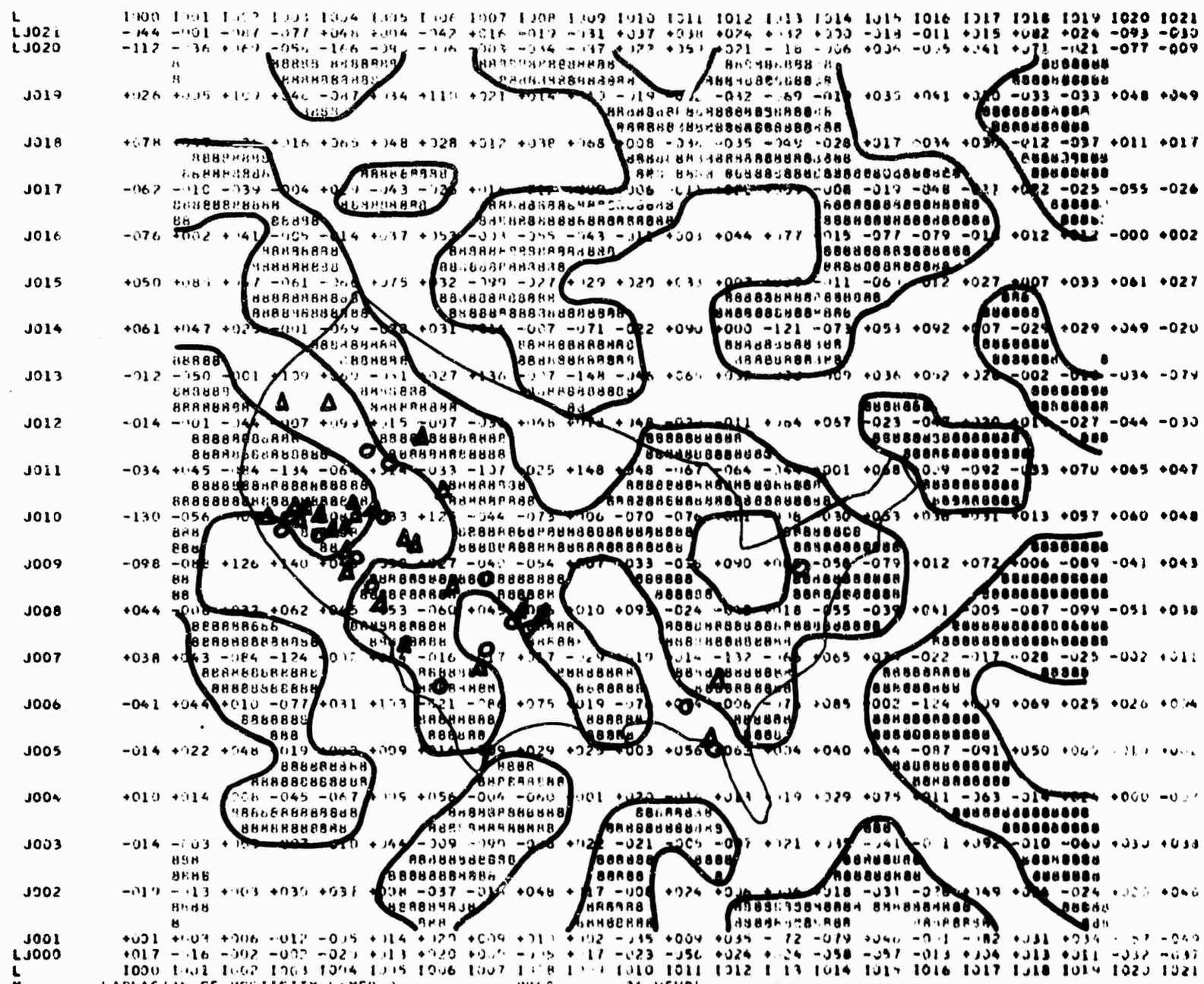
LJ000 +034 -030 -004 -003 -020 +026 +014 +002 -009 +019 -006 -059 +021 +028 -075 -055 +015 +011 +023 +008 -084 -059
L I000 I001 I002 I003 I004 I005 I006 I007 I008 I009 I010 I011 I012 I013 I014 I015 I016 I017 I018 I019 I020 I021
M LAPLACIAN OF VORTICITY LAYER 1 PROG. 24 HOURS 00Z 10 MARCH 1965

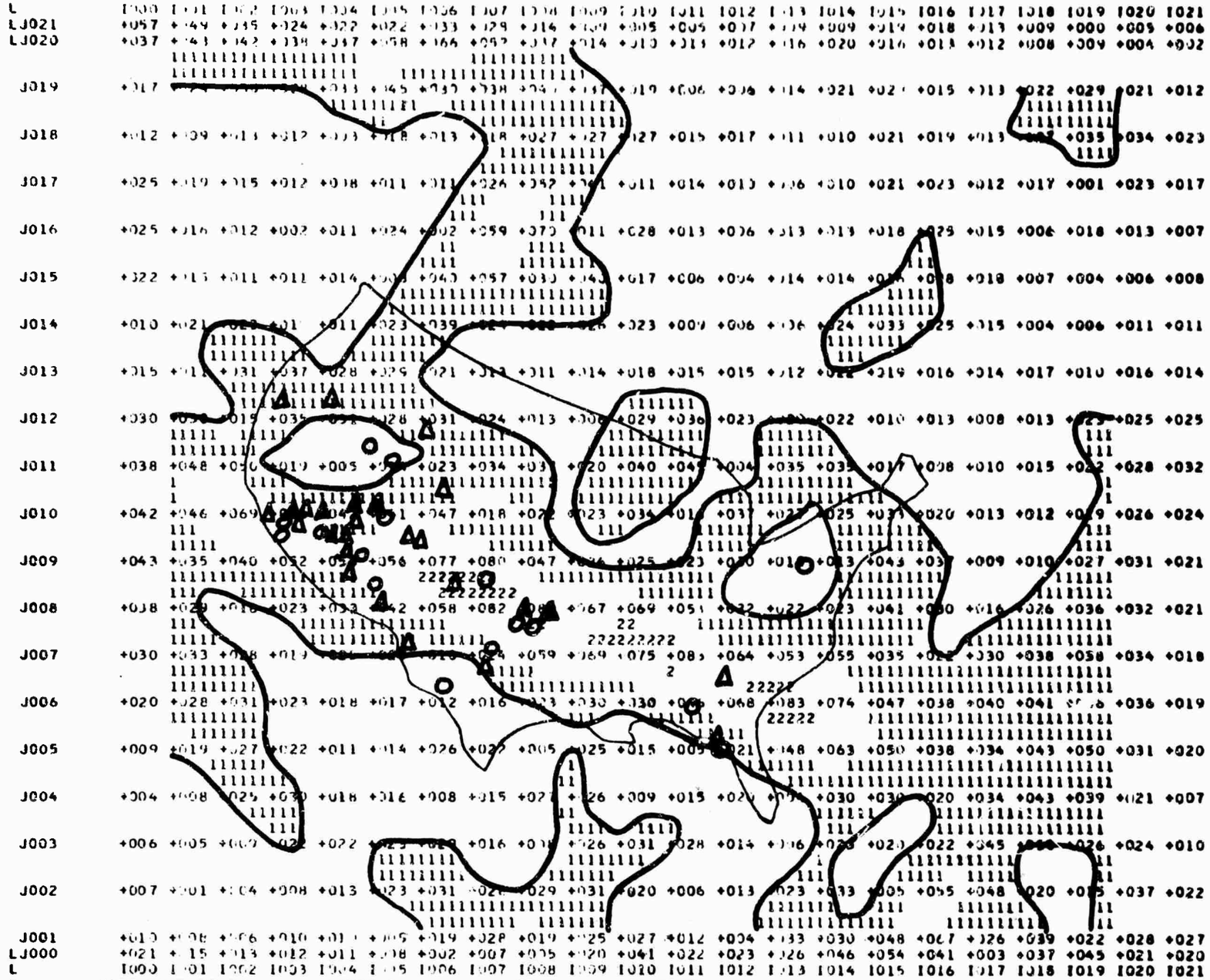

VERT CRAL CF VT
LAYER 1
PROG.
24 HOURS
00Z 10 MARCH 1965


KINETIC ENERGY LAYER 1 PROG. 24 HOURS 00Z 10 MARCH 1965


PRES KAT FIELD
LAYER 1
24 HOURS
00Z 10 MARCH 1965


LOWER LEVEL Z FIELD LAYER 2
PROG. 24 HOURS
00Z 10 MARCH 1965


LAPLACIAN OF VORTICITY LAYER 2
PROG. 24 HOURS
00Z 10 MARCH 1965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J021
J020
J019
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J015
J014
J013
J012
J011
J010
J009
J008
J007
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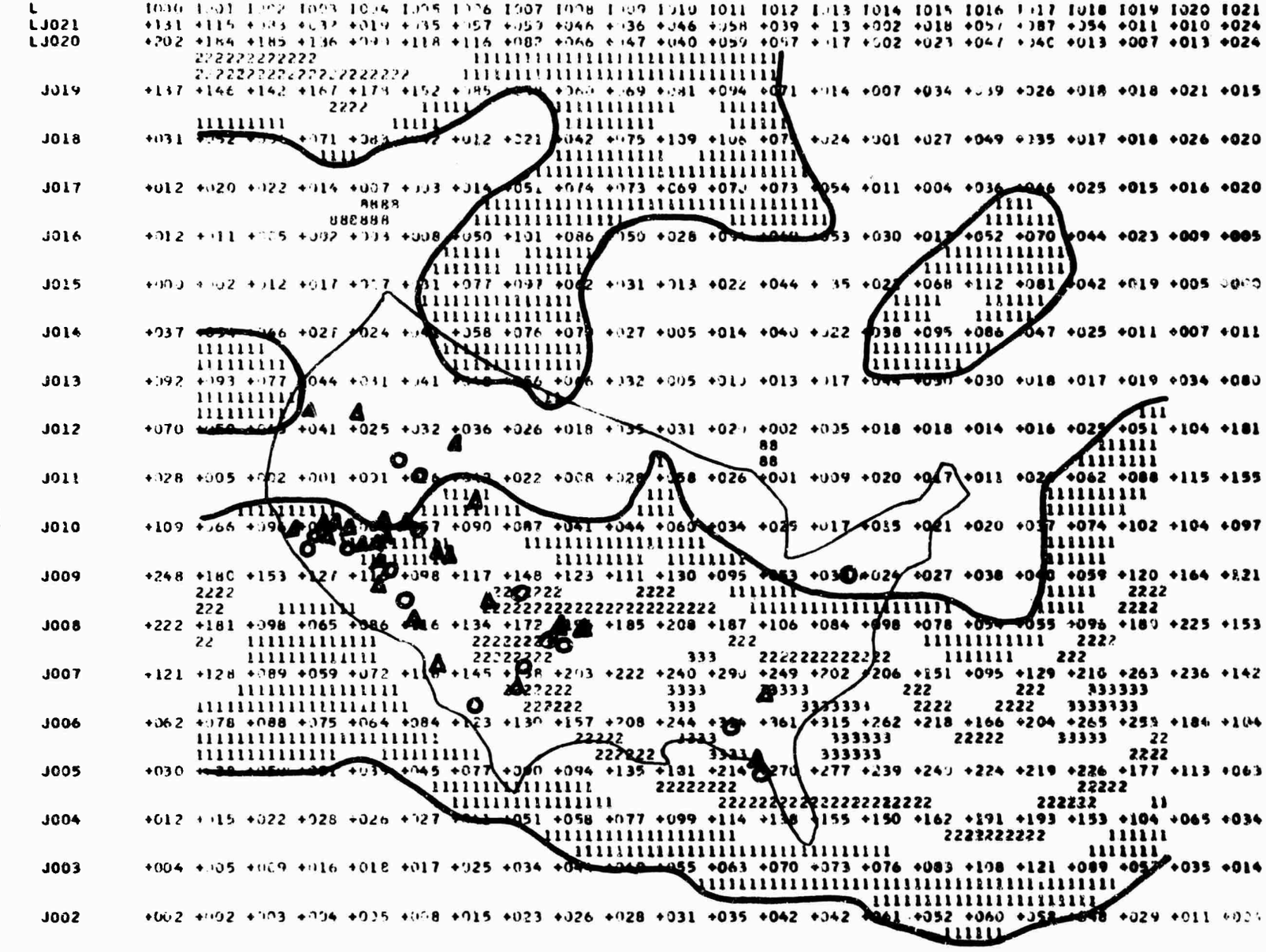
J003
J002
J001
J000
VERT GRAD OF VT
LAYER 2
PROG.
24 HOURS
00Z 10 MARCH 1965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J021 +131 +115 +083 +062 +019 +035 +057 +059 +046 +036 +046 +058 +039 +013 +002 +018 +057 +087 +054 +011 +010 +024
J020 +202 +184 +185 +136 +091 +118 +116 +082 +066 +047 +040 +059 +057 +017 +002 +023 +047 +040 +013 +007 +013 +024
J019 +187 +146 +142 +167 +179 +152 +085 +060 +069 +081 +094 +071 +014 +007 +034 +039 +026 +018 +018 +021 +015
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J016 +012 +011 +005 +002 +004 +008 +050 +101 +086 +050 +028 +053 +030 +013 +052 +070 +044 +023 +009 +005
J015 +000 +002 +012 +017 +027 +031 +077 +097 +062 +031 +013 +022 +044 +035 +028 +068 +112 +081 +042 +019 +005 +000
J014 +037 +054 +066 +027 +024 +058 +076 +079 +027 +005 +014 +040 +022 +038 +095 +086 +047 +025 +011 +007 +011
J013 +092 +093 +077 +044 +041 +041 +066 +066 +032 +005 +010 +013 +017 +044 +090 +030 +018 +017 +019 +034 +080
J012 +070 +050 +041 +025 +032 +036 +026 +018 +035 +031 +021 +002 +035 +018 +018 +014 +016 +025 +051 +104 +181
J011 +028 +005 +002 +001 +001 +022 +008 +028 +058 +026 +001 +009 +020 +017 +011 +026 +062 +088 +115 +155
J010 +109 +066 +090 +087 +090 +087 +041 +044 +060 +034 +025 +017 +035 +021 +020 +037 +074 +102 +104 +097
J009 +248 +180 +153 +127 +098 +117 +148 +123 +111 +130 +095 +053 +030 +024 +027 +038 +040 +059 +120 +164 +221
J008 +222 +181 +098 +065 +086 +134 +172 +185 +208 +187 +106 +084 +098 +078 +054 +055 +096 +180 +225 +153
J007 +121 +128 +089 +059 +072 +145 +203 +222 +240 +290 +249 +202 +206 +151 +095 +129 +216 +263 +236 +142
J006 +062 +078 +088 +075 +064 +084 +123 +130 +157 +208 +244 +361 +315 +262 +218 +166 +204 +265 +259 +184 +104
J005 +030 +038 +054 +061 +039 +045 +077 +090 +094 +135 +181 +214 +270 +277 +239 +240 +224 +219 +226 +177 +113 +063
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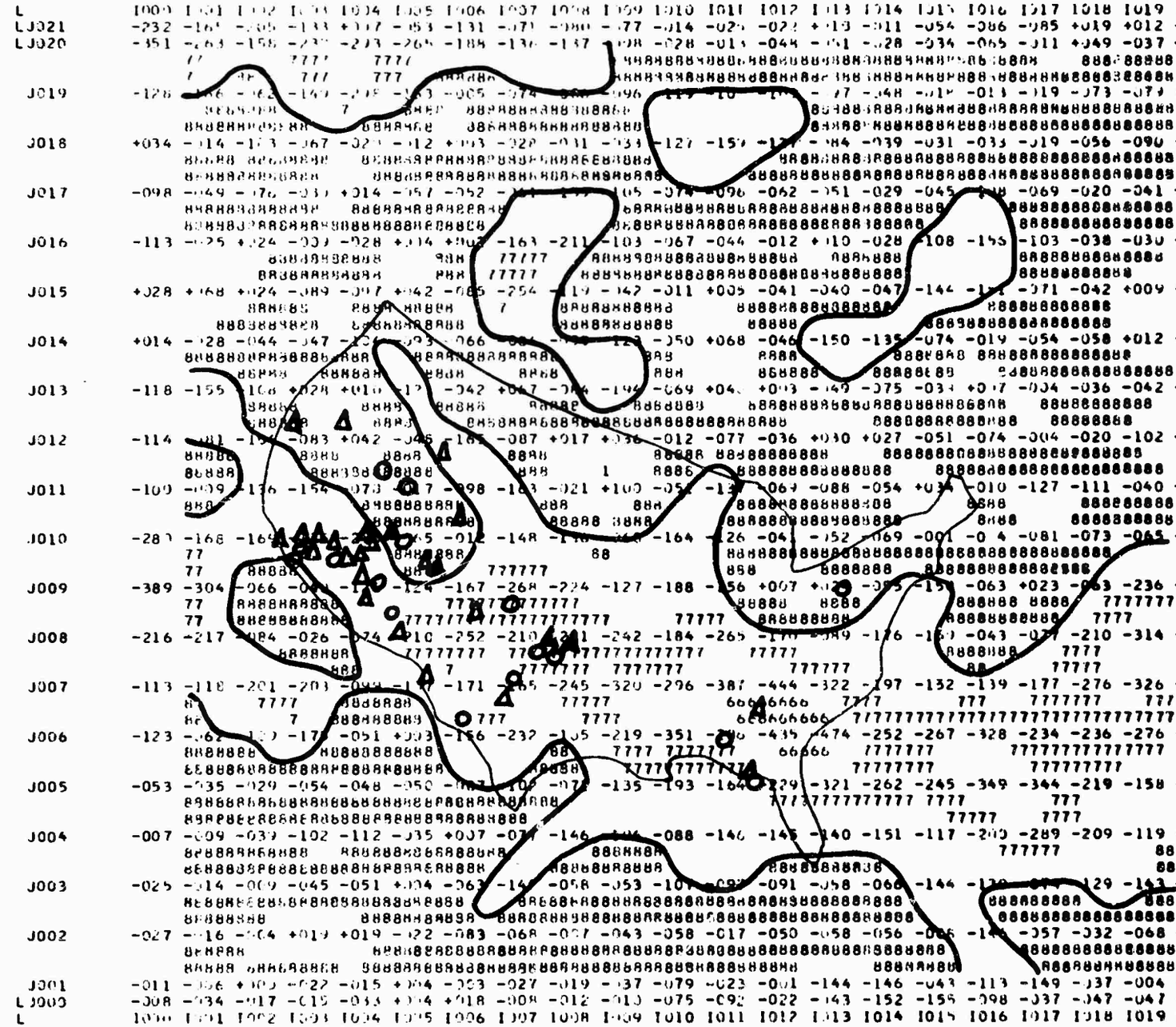
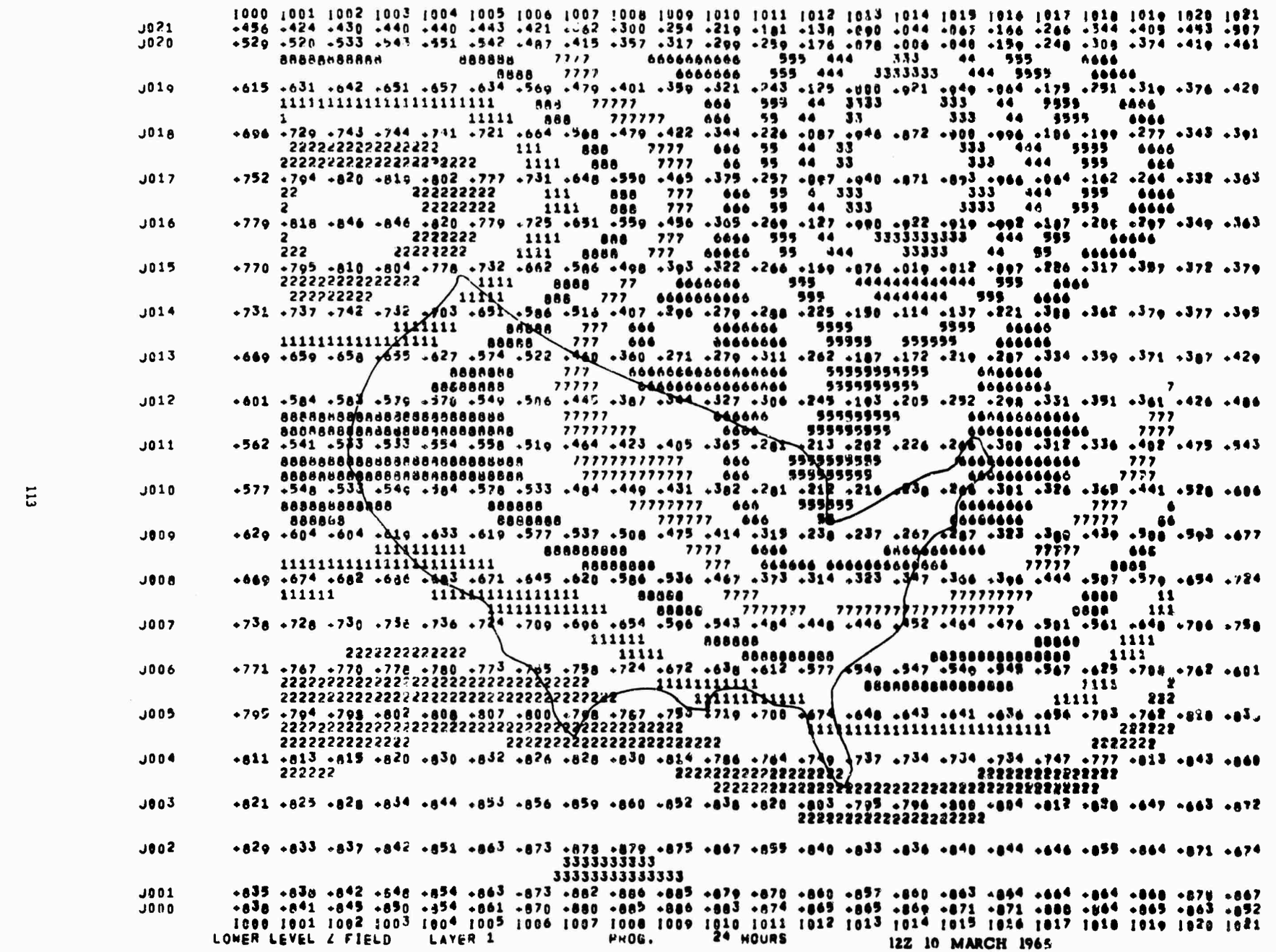
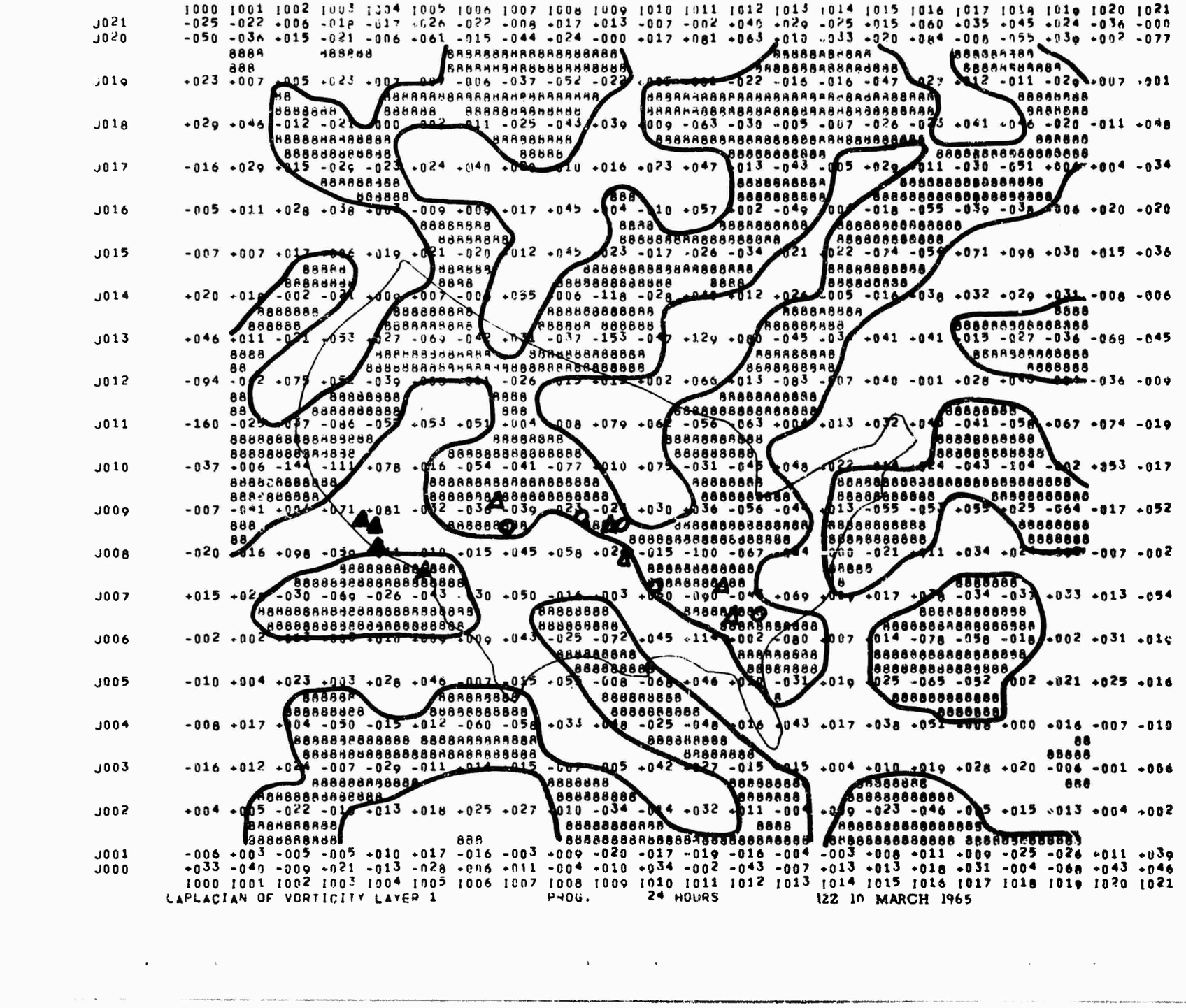
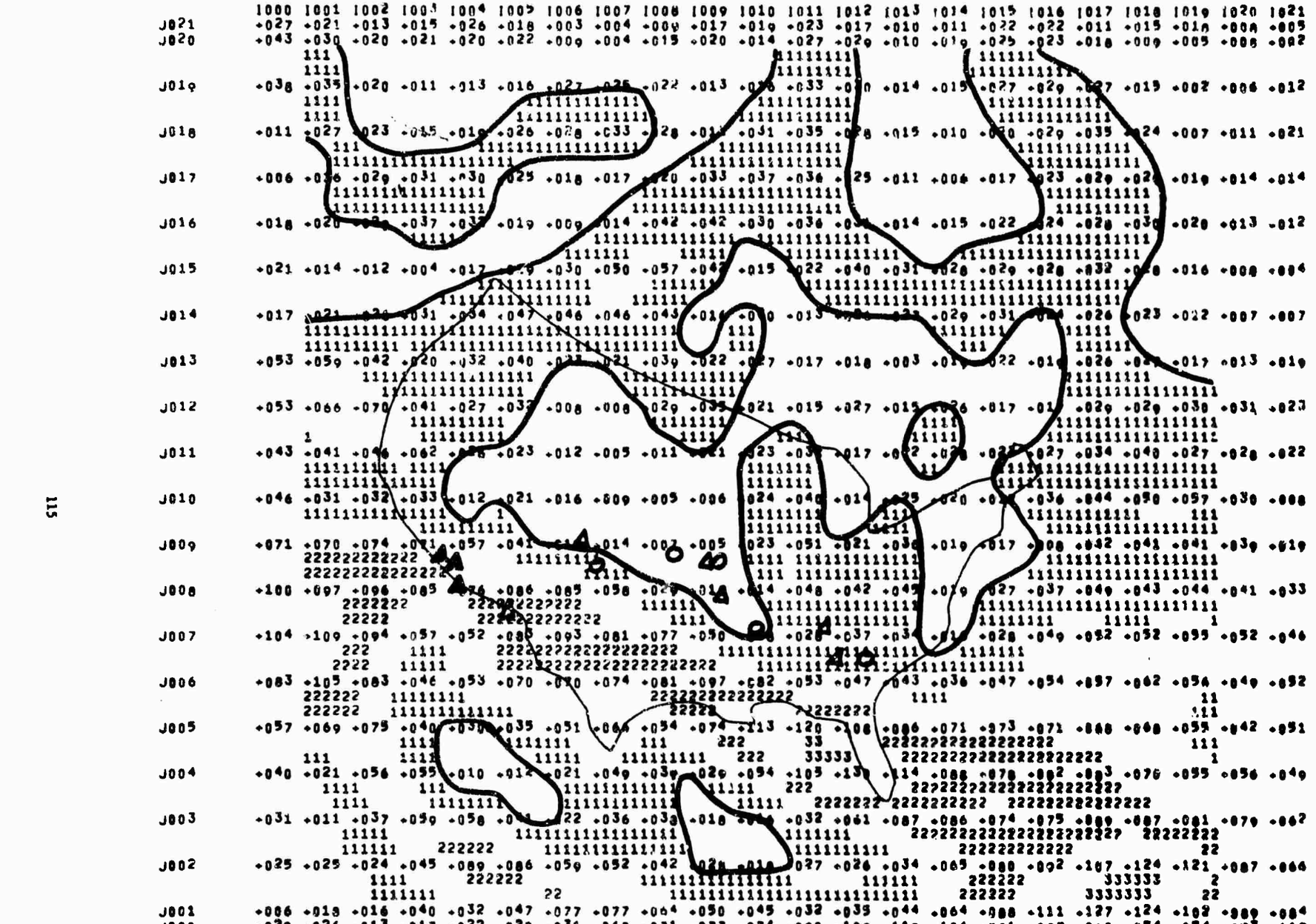
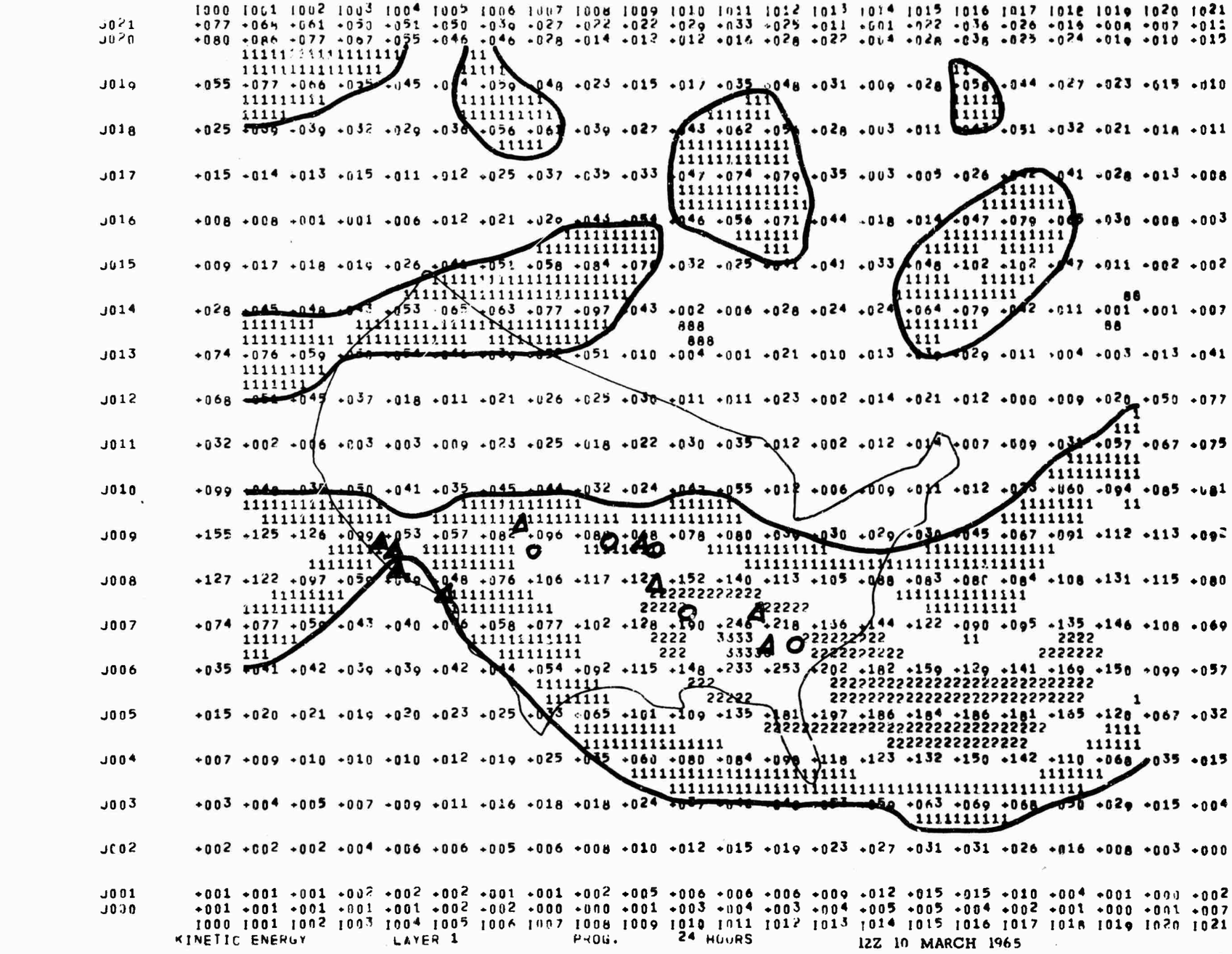
J001 +002 +001 +001 +001 +000 +001 +004 +008 +010 +014 +017 +020 +022 +037 +040 +036 +041 +045 +040 +030 +016 +005 +001
LJ000 +004 +003 +002 +001 +001 +001 +000 +001 +003 +006 +012 +014 +022 +041 +048 +044 +044 +038 +023 +014 +010 +009
I000 I001 I002 I003 I004 I005 I006 I007 I008 I009 I010 I011 I012 I013 I014 I015 I016 I017 I018 I019 I020 I021
KINETIC ENERGY LAYER 2 PROG. 24 HOURS 00Z 10 MARCH 1965

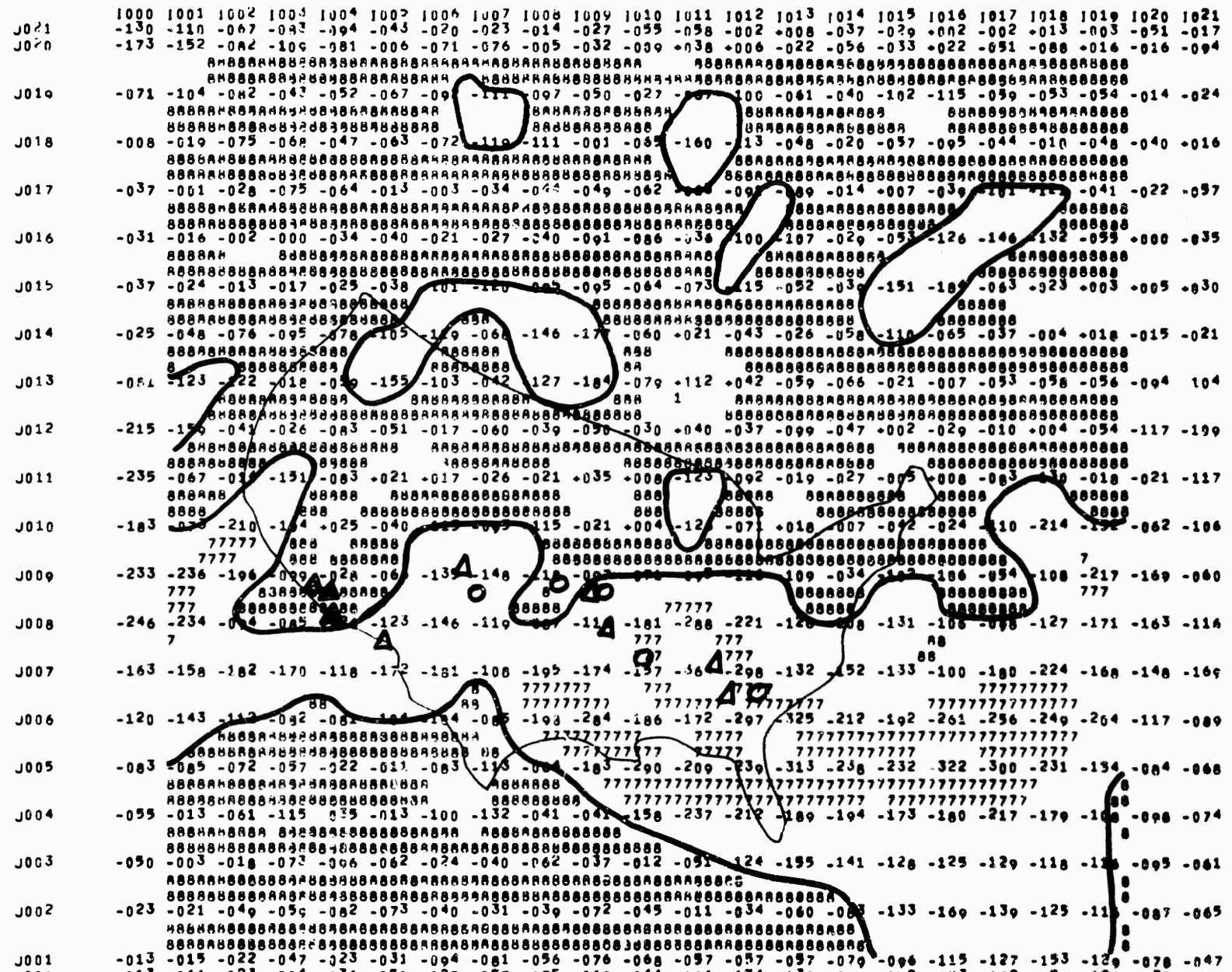

PROG KAI FIELD LAYER 2 PROG. 24 HOURS 00Z 10 MARCH 1965


LOWER LEVEL Z FIELD
LAYER 1
PROG.
24 HOURS
12Z 10 MARCH 1965


LAPLACIAN OF VORTICITY LAYER 1
PROG. 24 HOURS
122 10 MARCH 1965


VERY GRAD OF VT
LAYER 1
PROG.
24 HOURS
12Z 10 MARCH 1965


KINETIC ENERGY LAYER 1 PROG. 24 HOURS 12Z 10 MARCH 1965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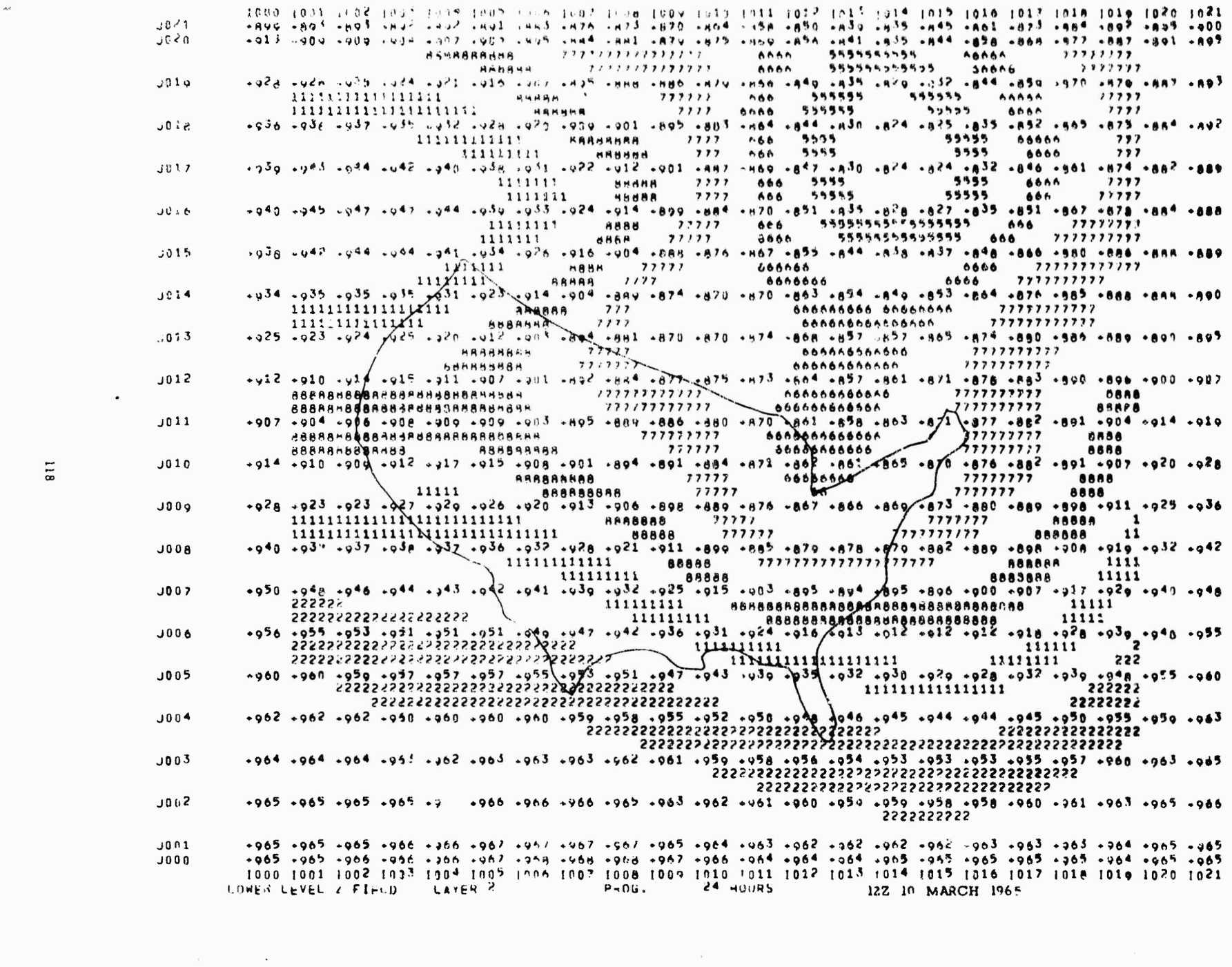
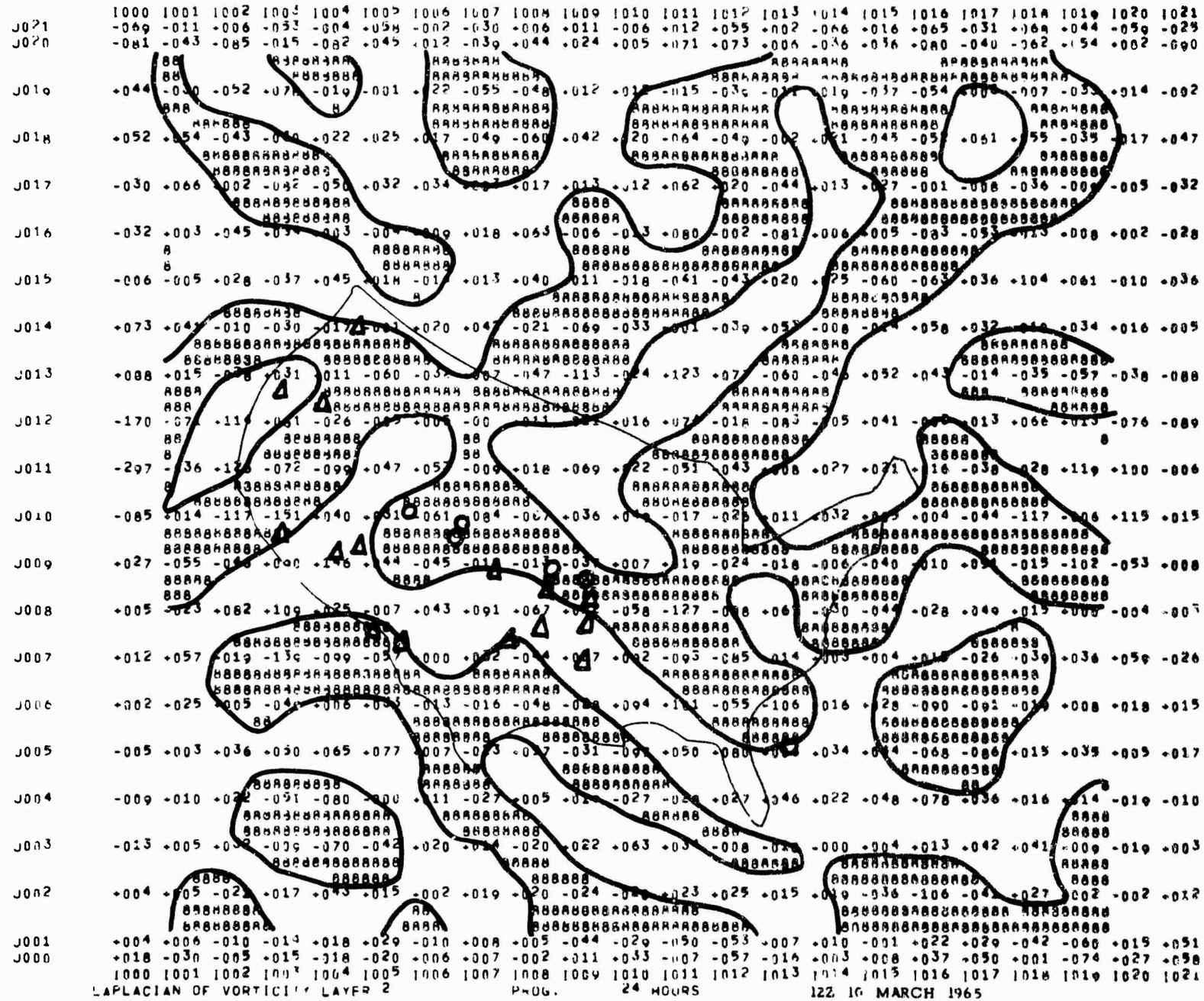
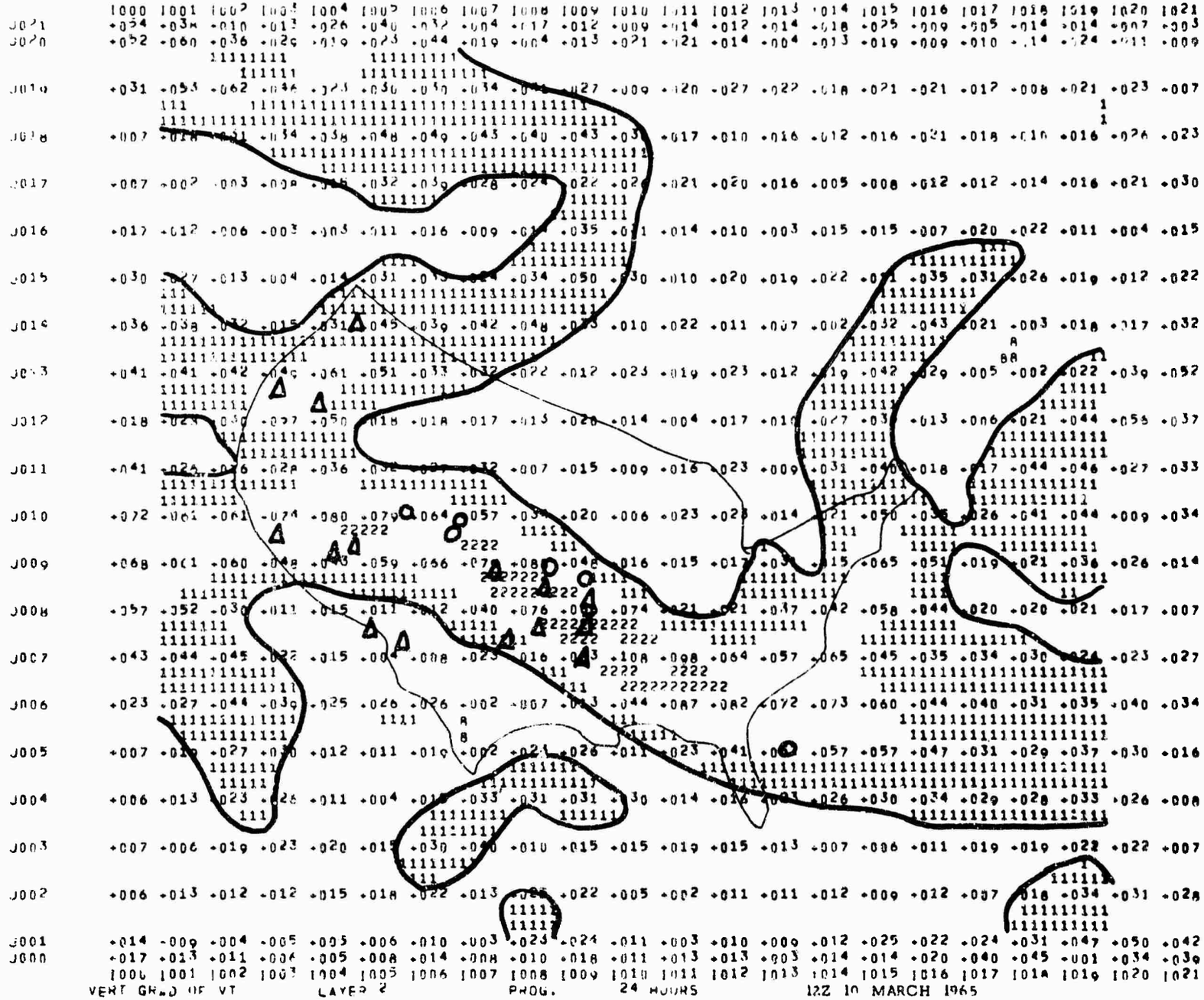
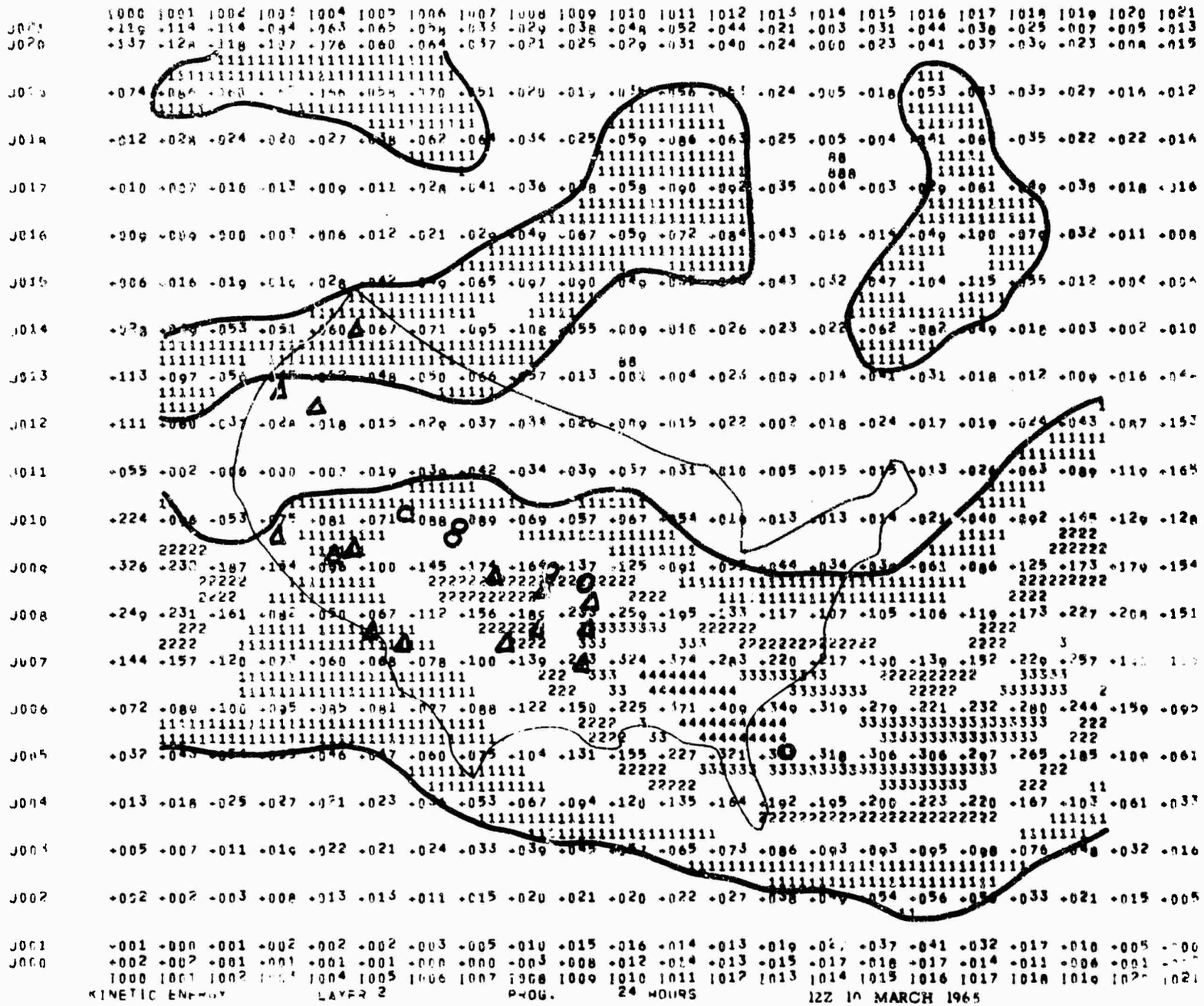
PROG KAT FIELD
LAYER 1
PROG.
24 HOURS
12Z 10 MARCH 1965

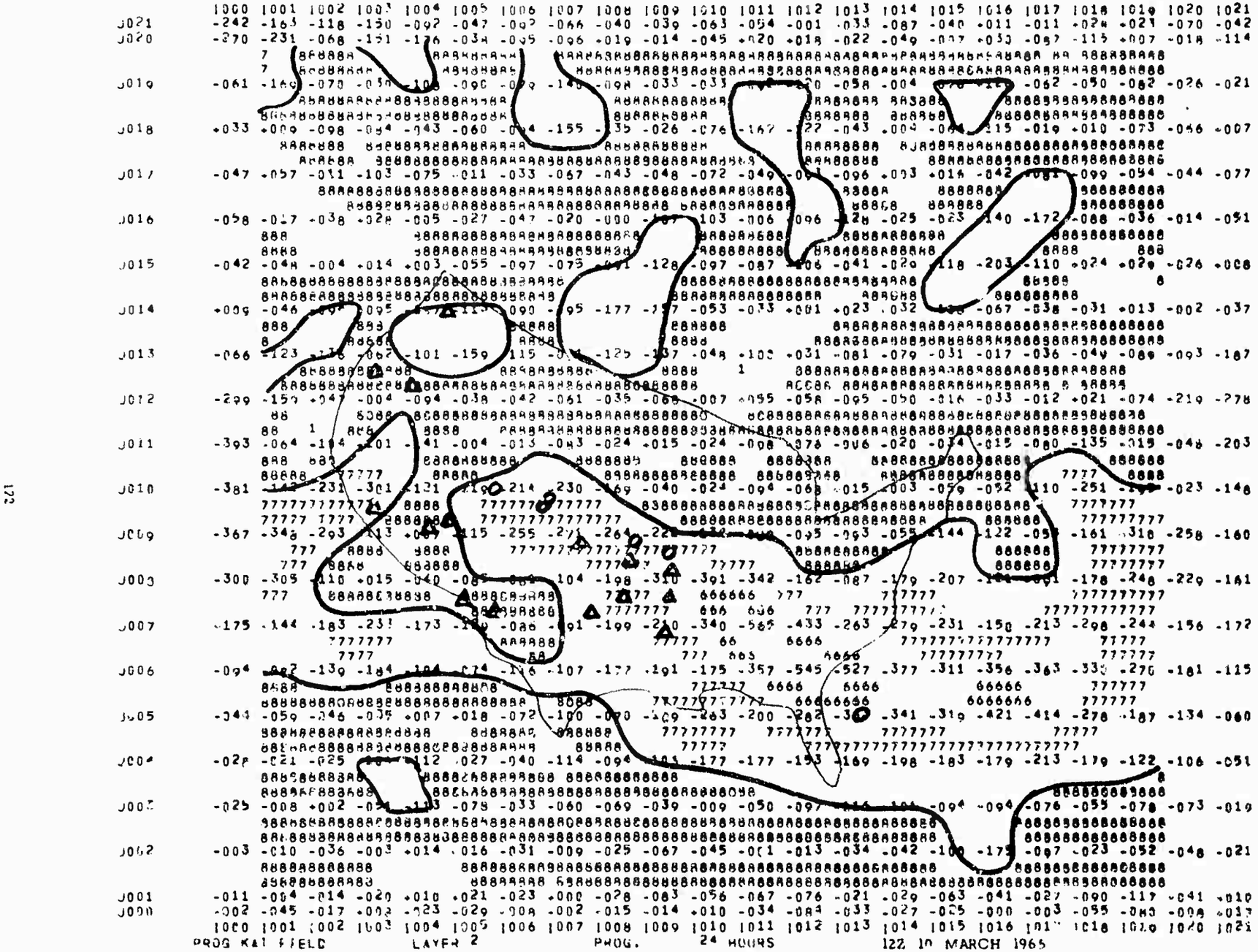


LOWER LEVEL Z FIELD LAYER 2 PROG. 24 HOURS 122 10 MARCH 1965


LAPLACIAN OF VORTICITY LAYER 2
PROG. 24 HOURS
122 16 MARCH 1965

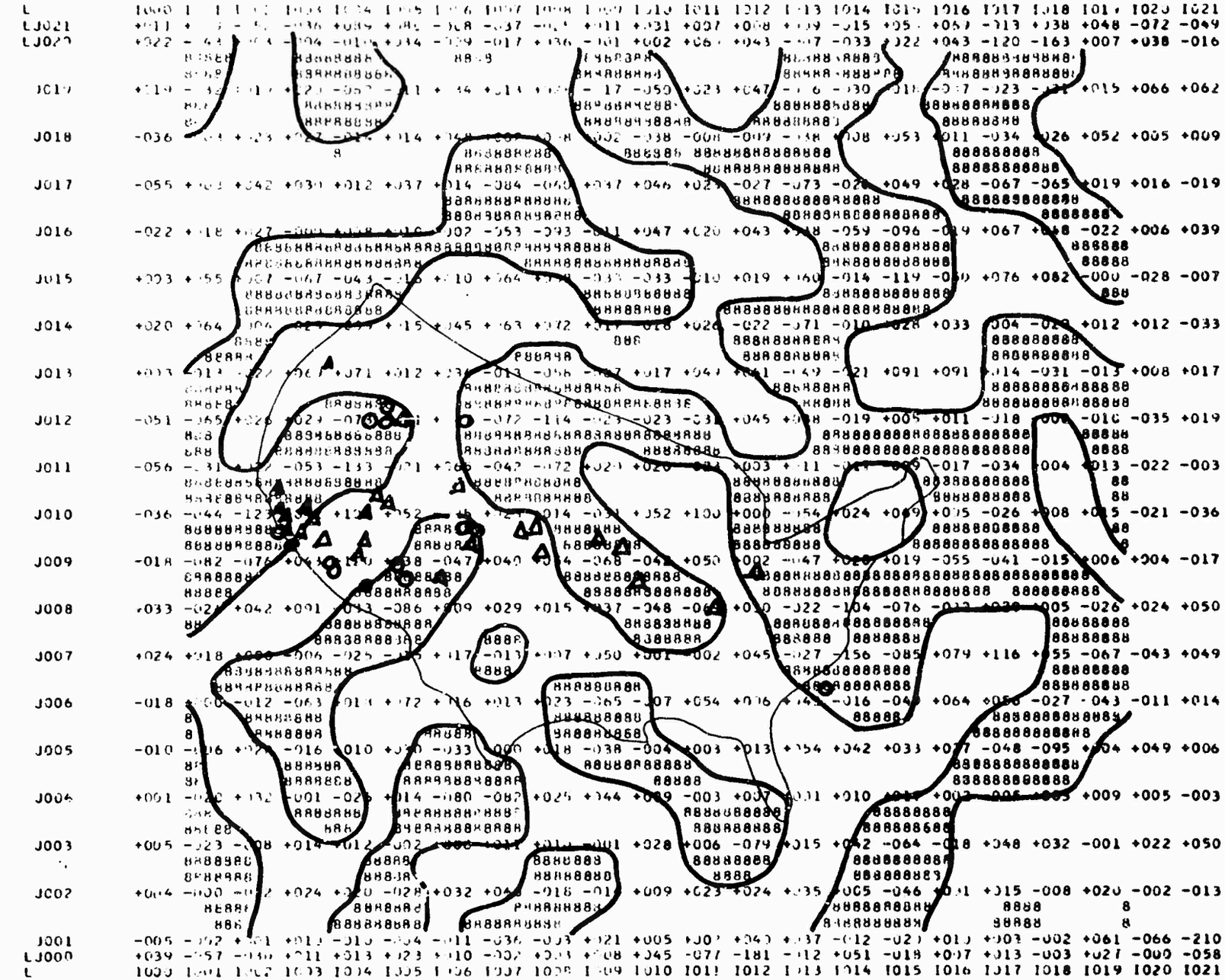

VERT GRAD OF VT
LAYER 2
PROG.
24 HOURS
12Z 10 MARCH 1965

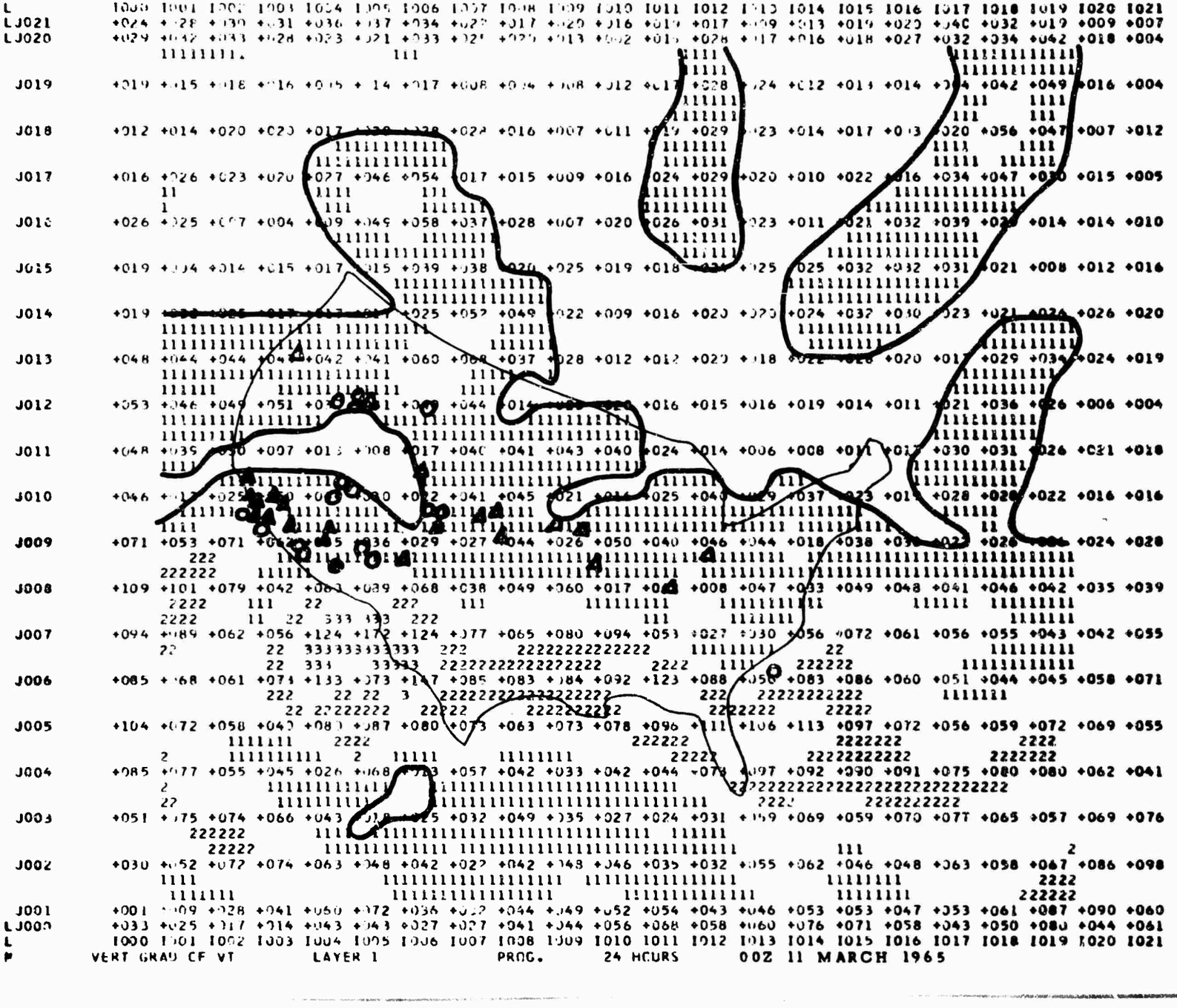

KINETIC ENERGY
LAYER 2
PROG.
24 HOURS
12Z 10 MARCH 1965



PROG KAI FIELD LAYER 2 PROG. 24 HOURS 12Z 10 MARCH 1965

LOWER LEVEL Z FIELD LAYER 1 PROG. 24 HOURS 002 11 MARCH 1965


LAPLACIAN OF VORTICITY LAYER 1
PROG. 24 HOURS
00Z 11 MARCH 1965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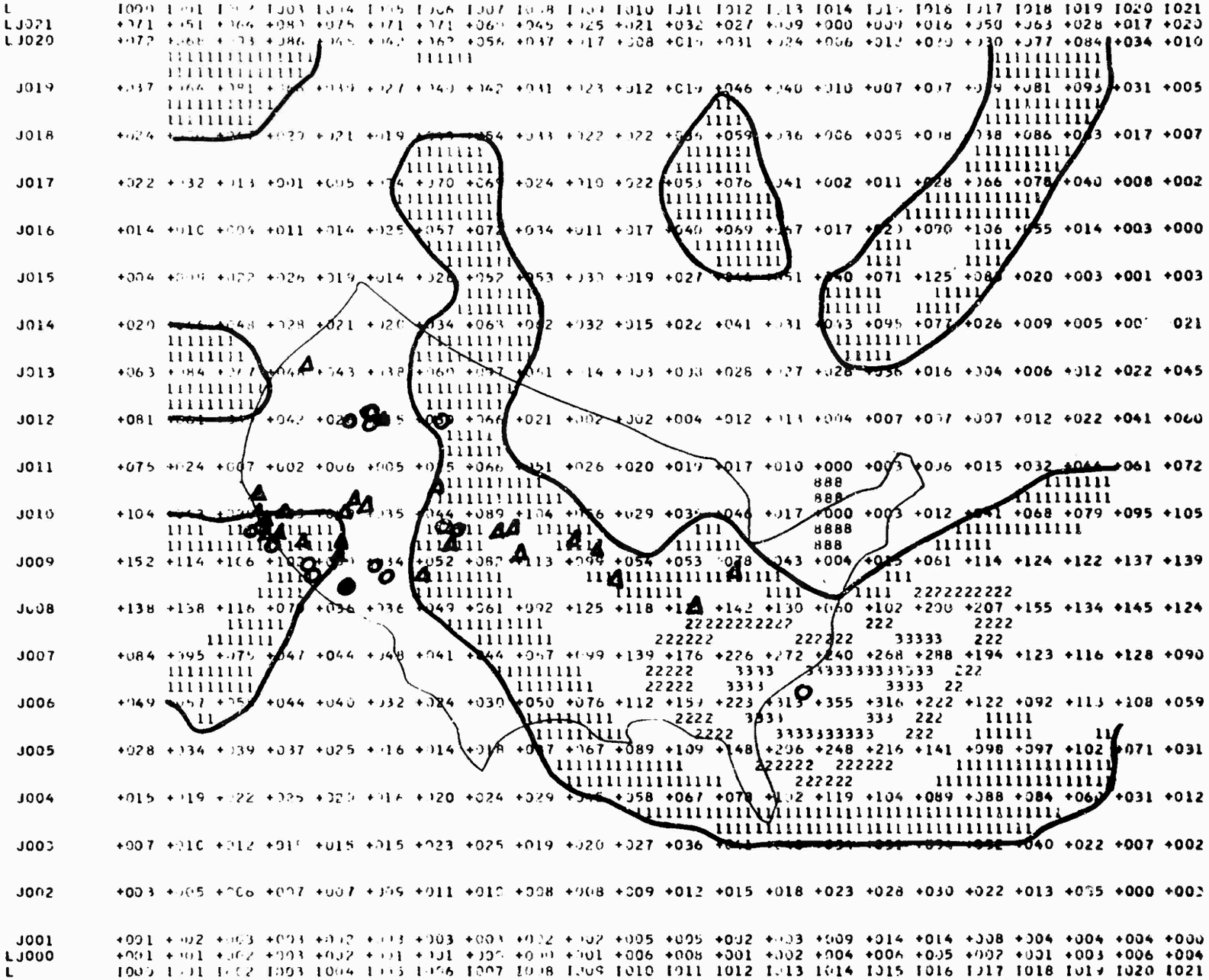
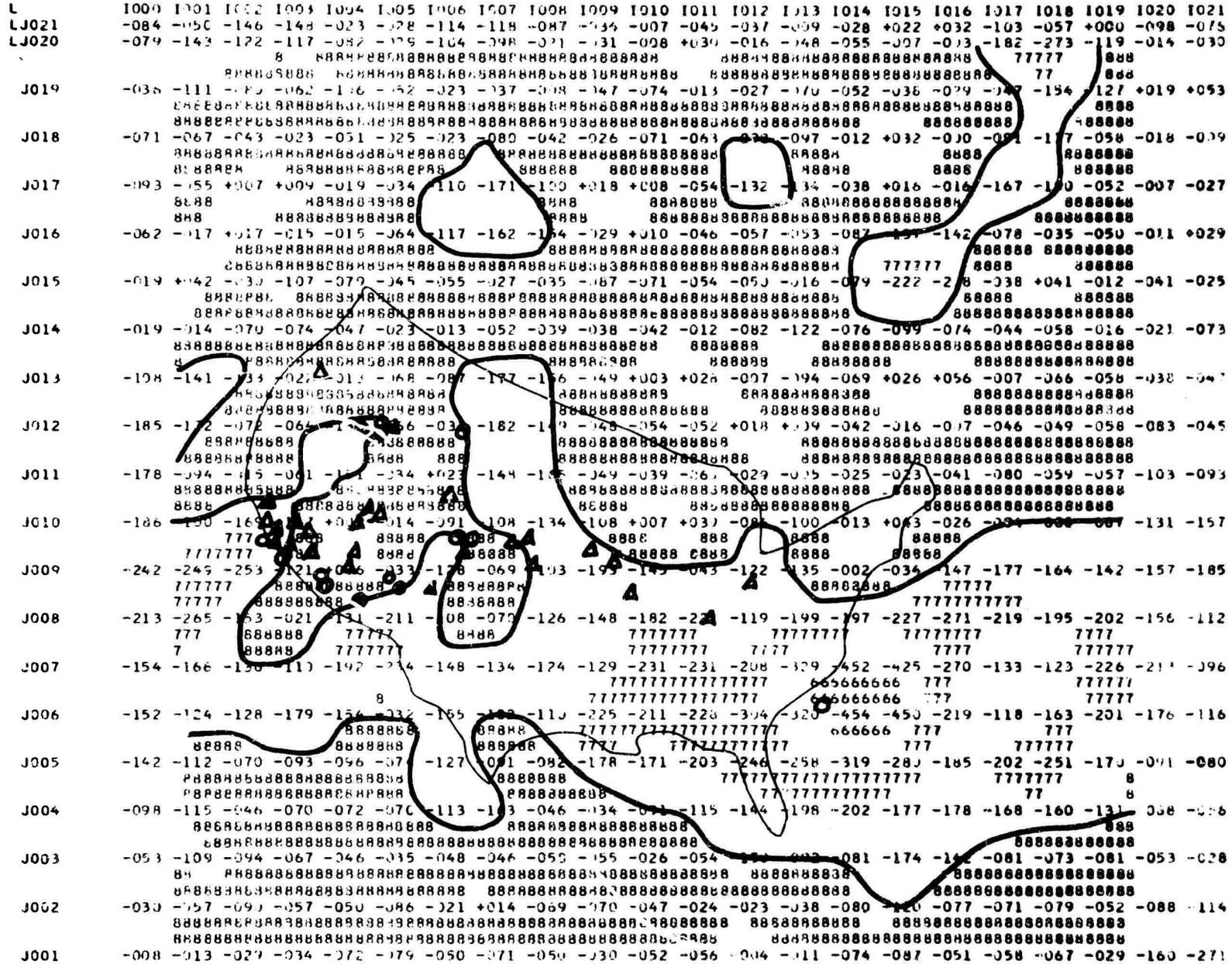
L I000 I001 I002 I003 I004 I005 I006 I007 I008 I009 I010 I011 I012 I013 I014 I015 I016 I017 I018 I019 I020 I021
P VERT GRAD OF VT LAYER 1 PROG. 24 HOURS 00Z 11 MARCH 1965


KINETIC ENERGY
LAYER 1
PROG. 24 HOURS
00Z 11 MARCH 1965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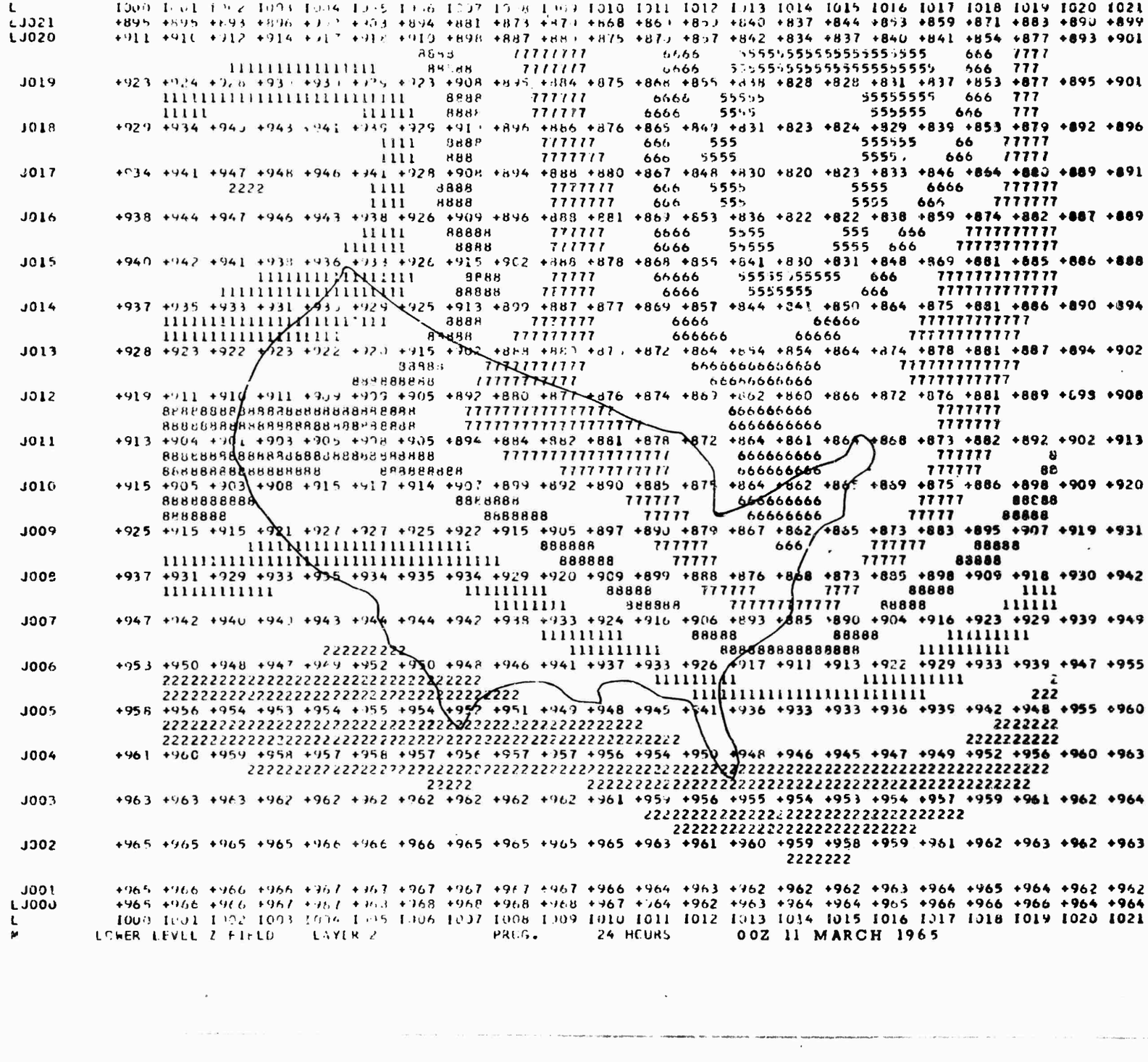
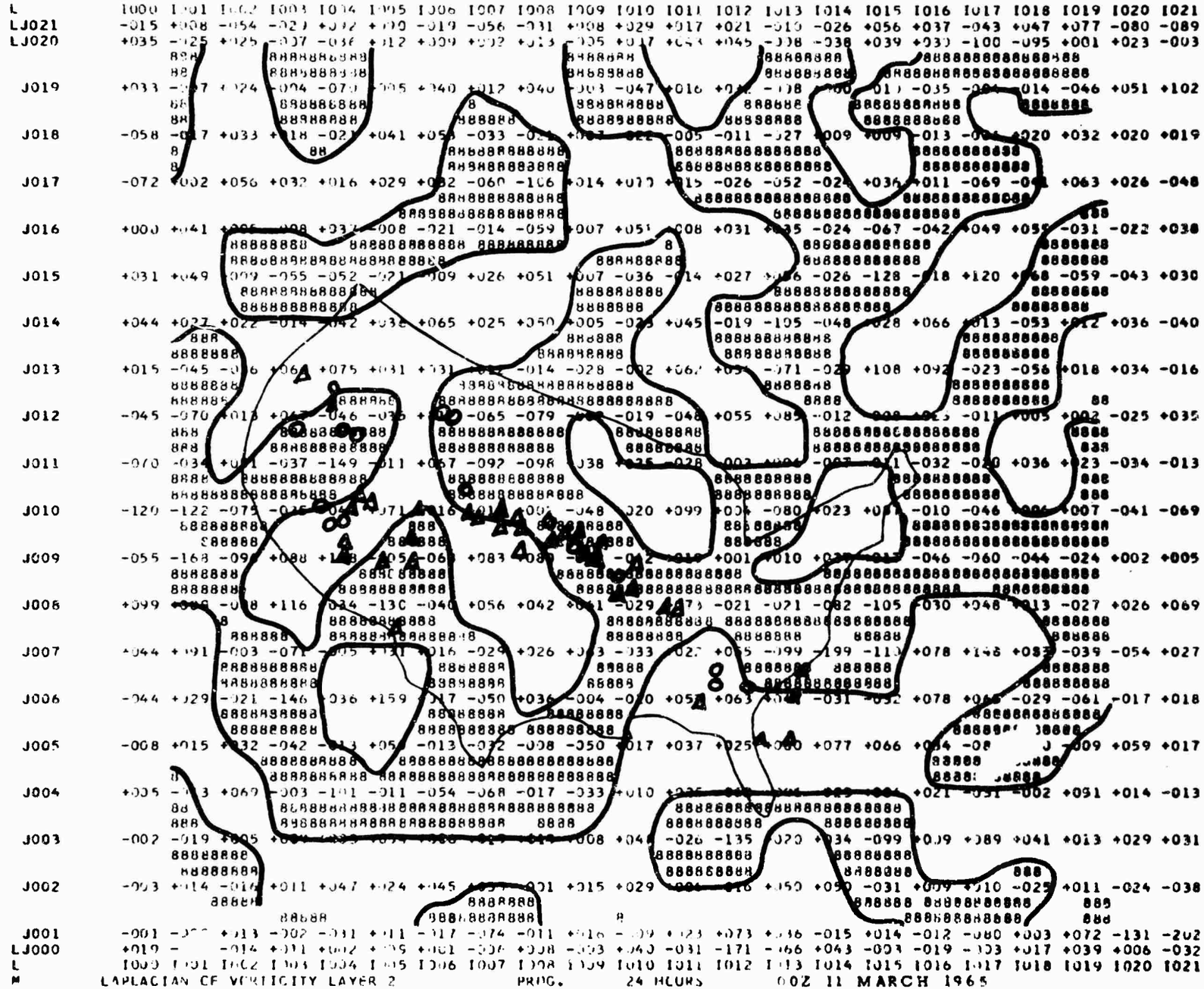
M PROG KAT FIELD LAYER 1 PROG. 24 HOURS 01Z 11 MARCH 1965


LOWER LEVEL Z FIELD LAYER 2
PROG. 24 HOURS
00Z 11 MARCH 1965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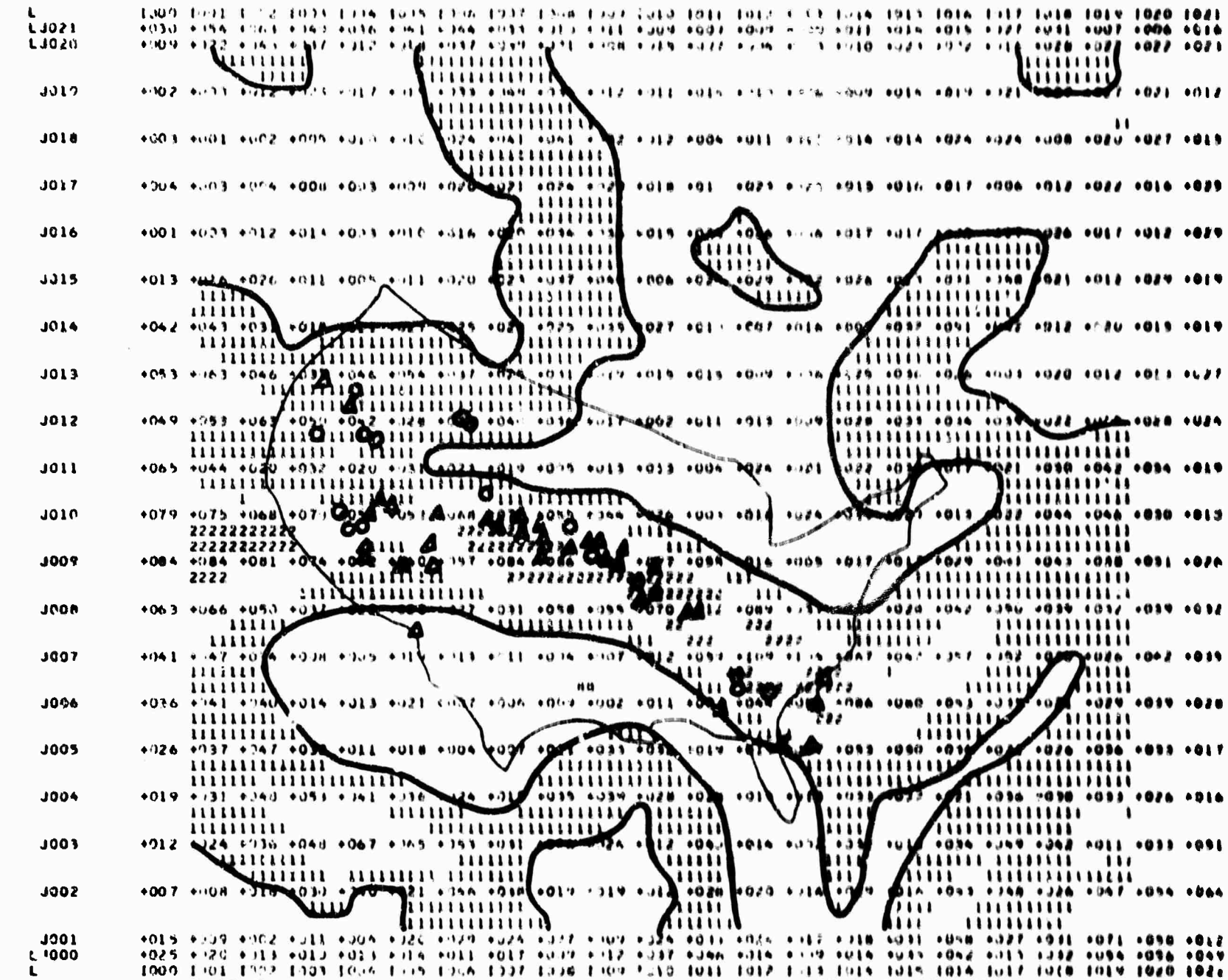
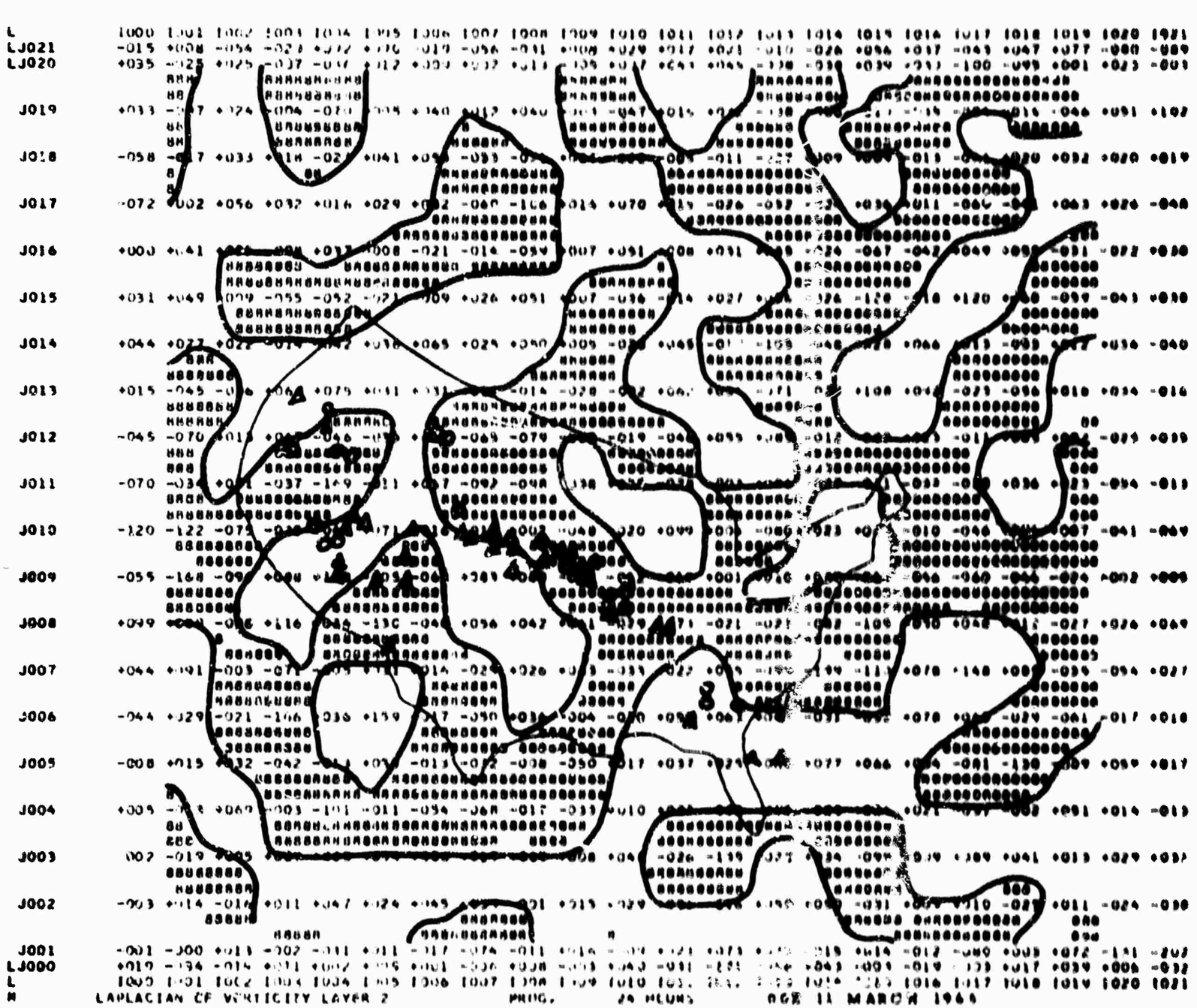
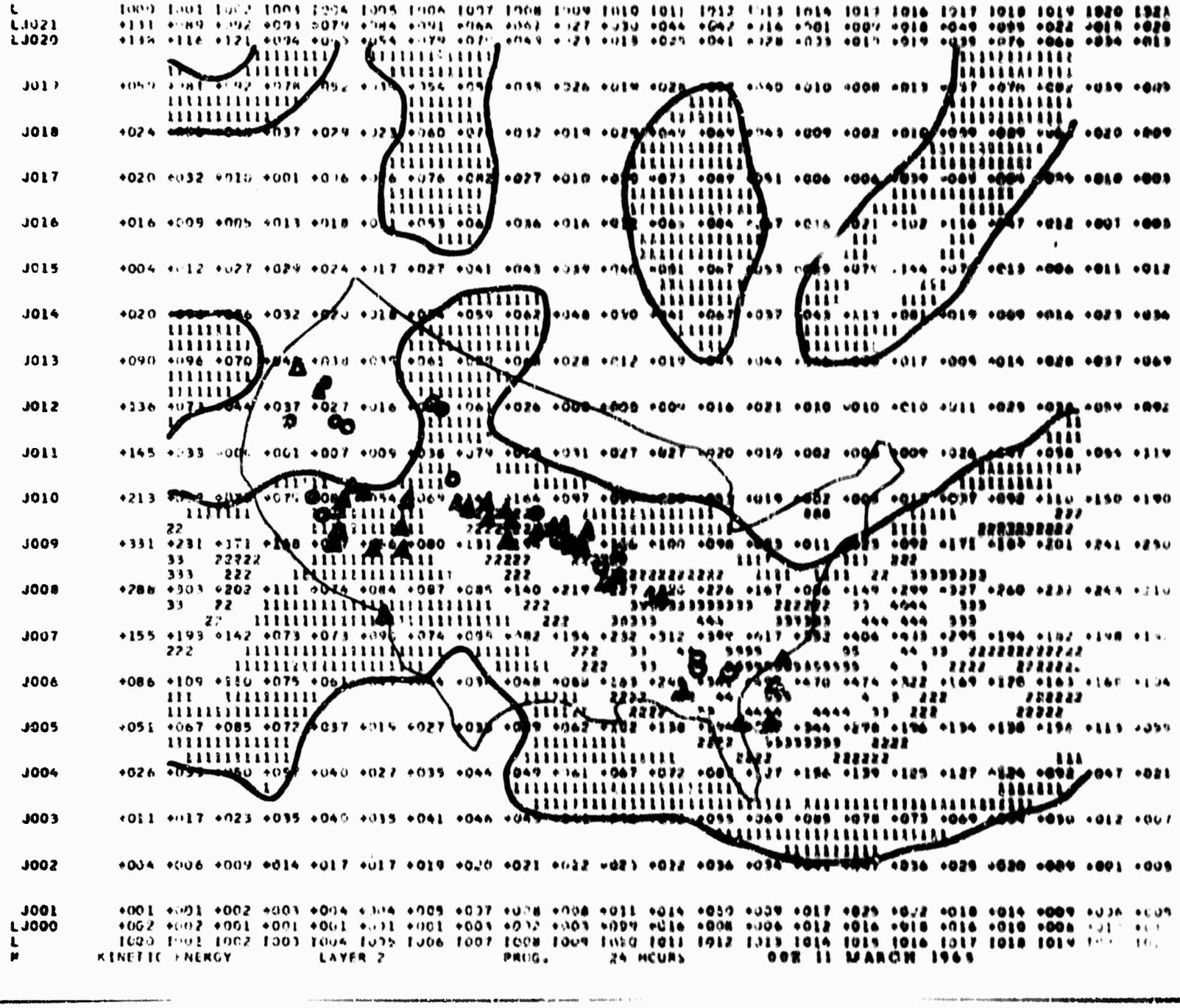
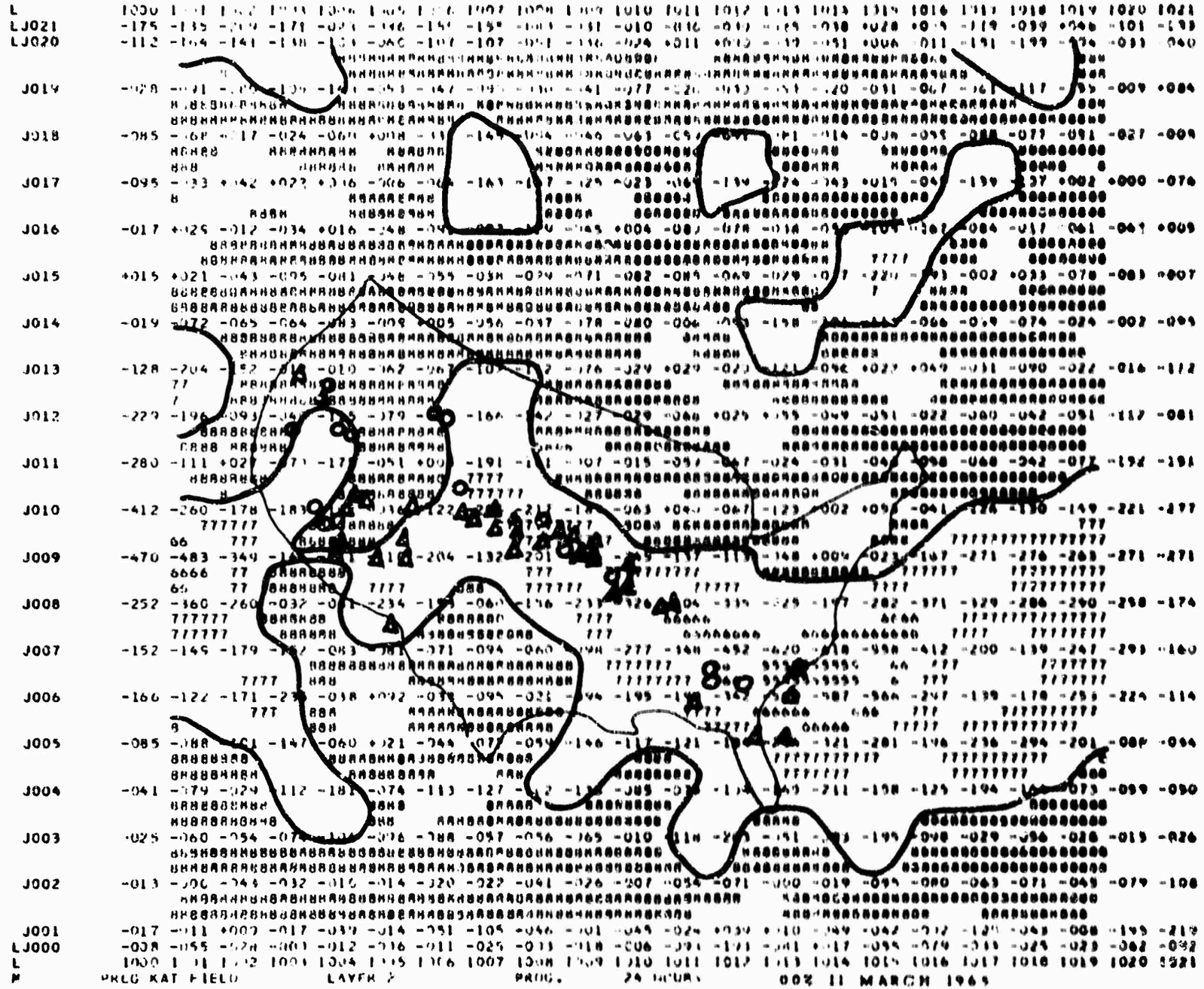
M LAPLACIAN OF VORTICITY LAYER 2 PROG. 24 HOURS 00Z 11 MARCH 1965


VERT GRAD OF VT
LAYER 2
PROG
24 HOURS
00Z 11 MARCH 1964



LAPLACIAN OF VORTICITY LAYER 2 PROG. 24 HOURS DGE 11 MARCH 1964


KINETIC ENERGY LAYER 2 PROG. 24 HOURS 00Z 11 MARCH 1965


PROG KAT FIELD
LAYER 2
PROG. 24 HOUR
00Z 11 MARCH 1965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J018 +633 +667 +713 +739 +758 +758 +716 +634 +531 +410 +336 +228 +118 +096 +944 +938 +957 +147 +196 +280 +388 +409
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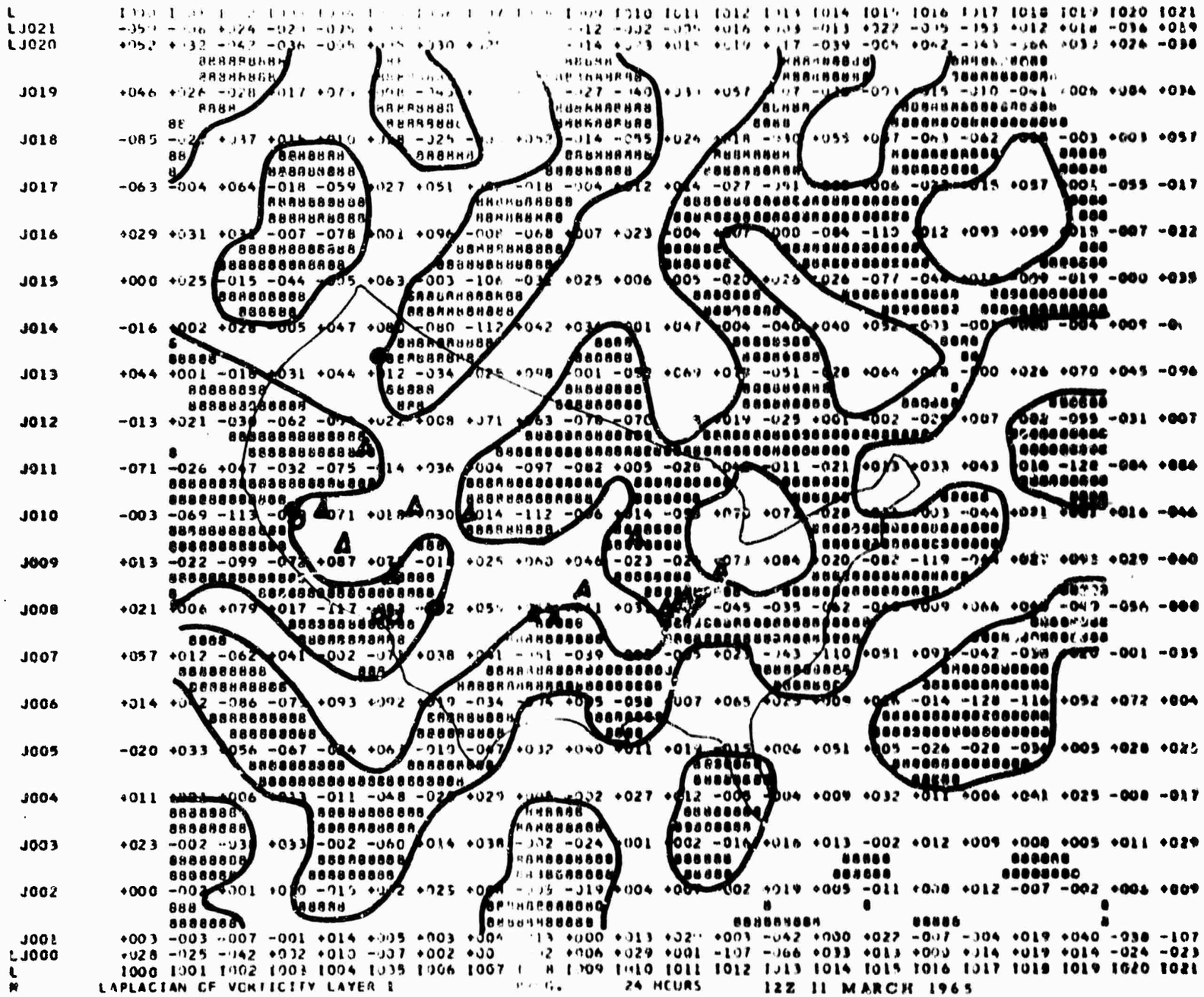
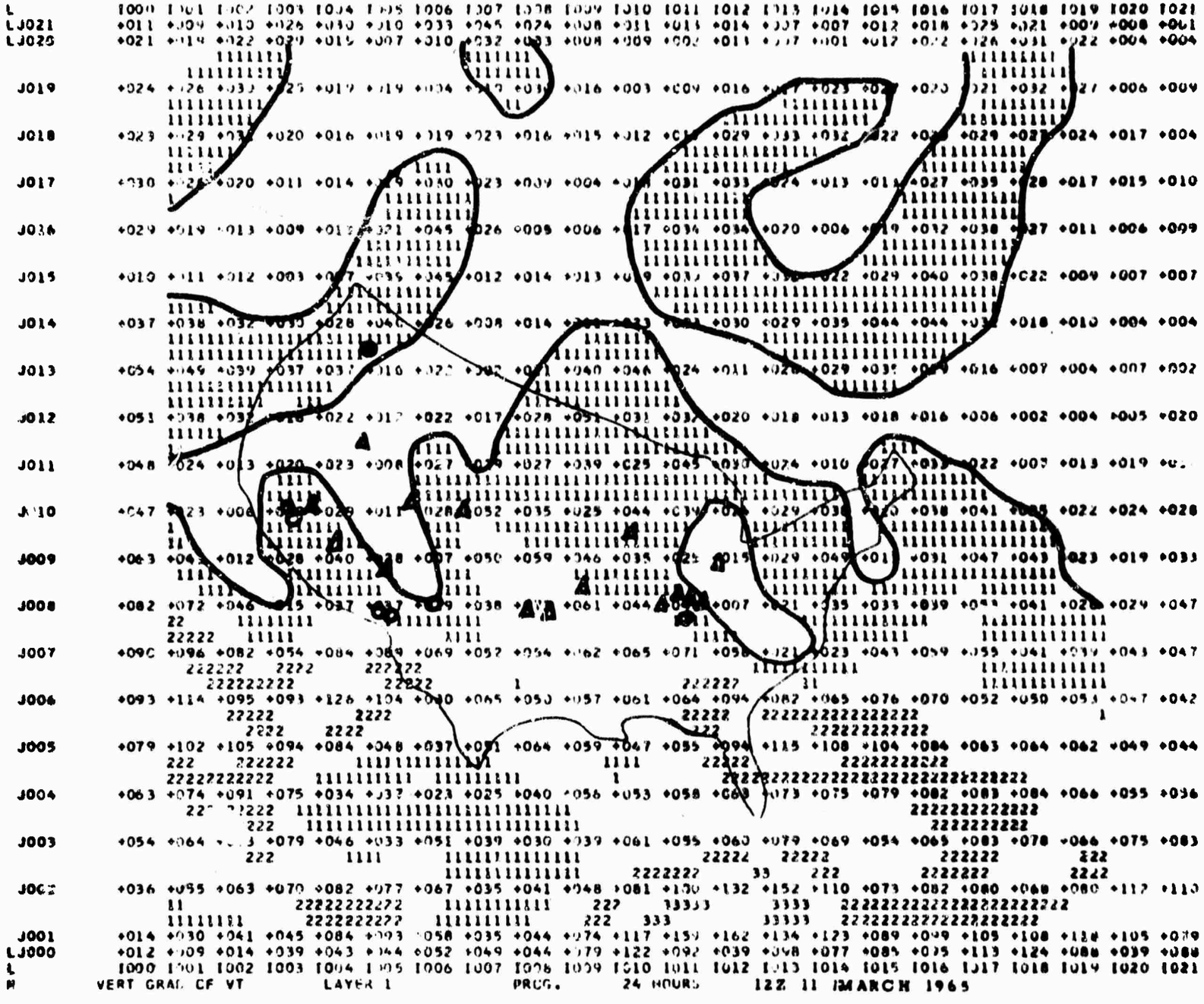
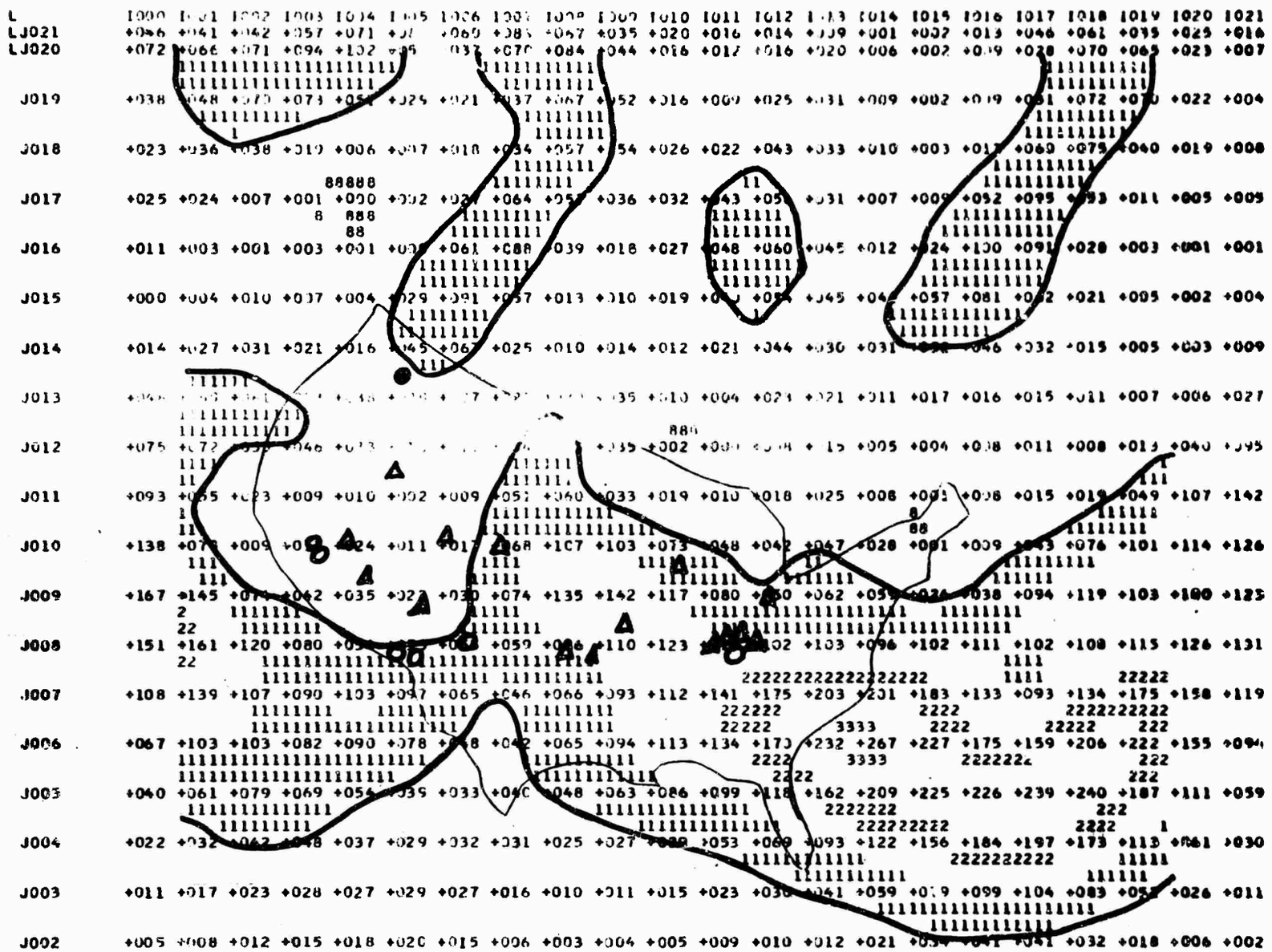
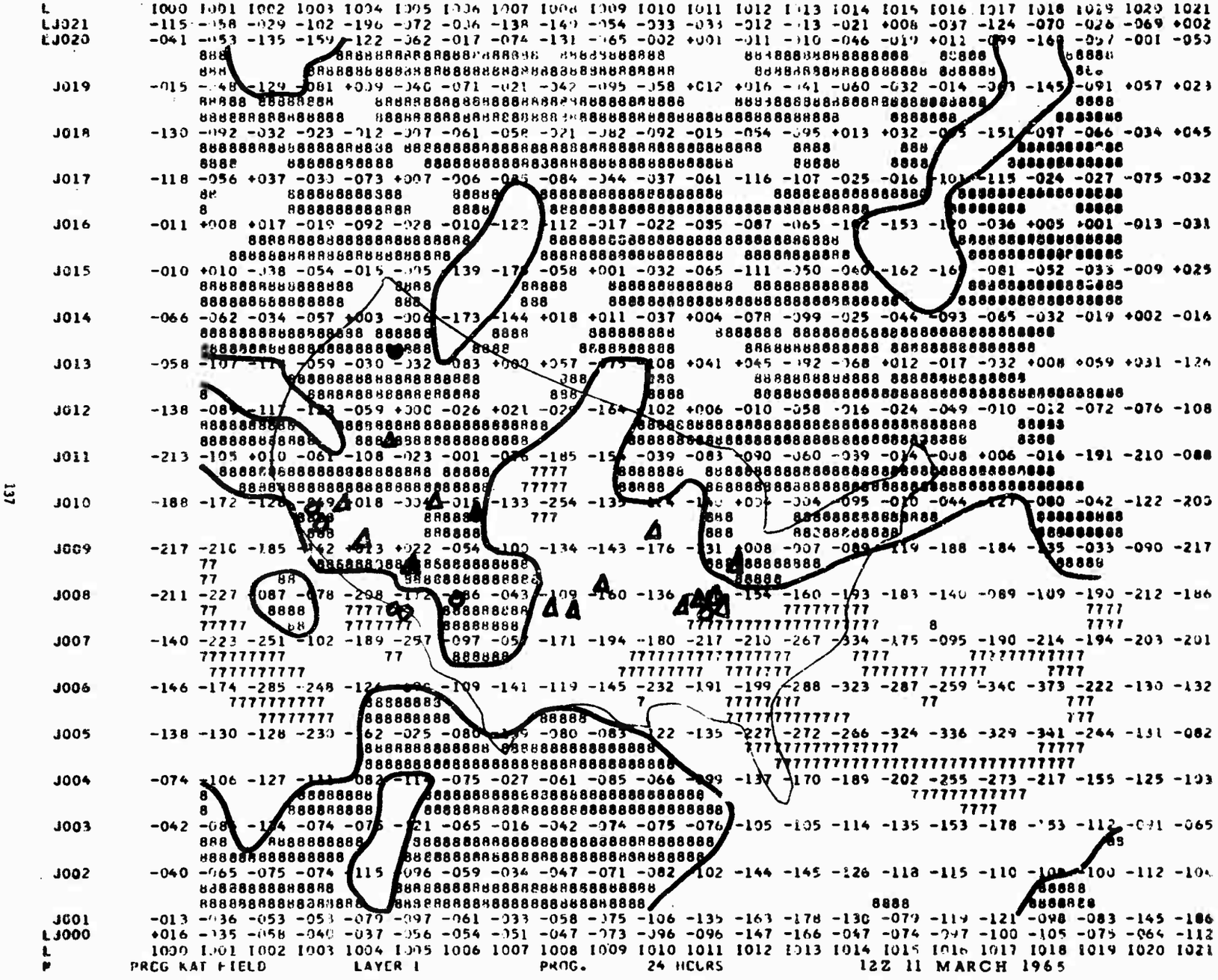
L 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021
F LOWER LEVEL Z FIELD LAYER 1 PROG. 24 HOURS 12Z 11 MARCH 1969


LAPLACIAN OF VORTICITY LAYER 1
24 HOURS
12Z 11 MARCH 1965


VERT GRAD OF VT
LAYER 1
PROG.
24 HOURS
12Z 11 MARCH 1965



KINETIC ENERGY LAYER 1 PROG. 24 HOURS 12Z 11 MARCH 1965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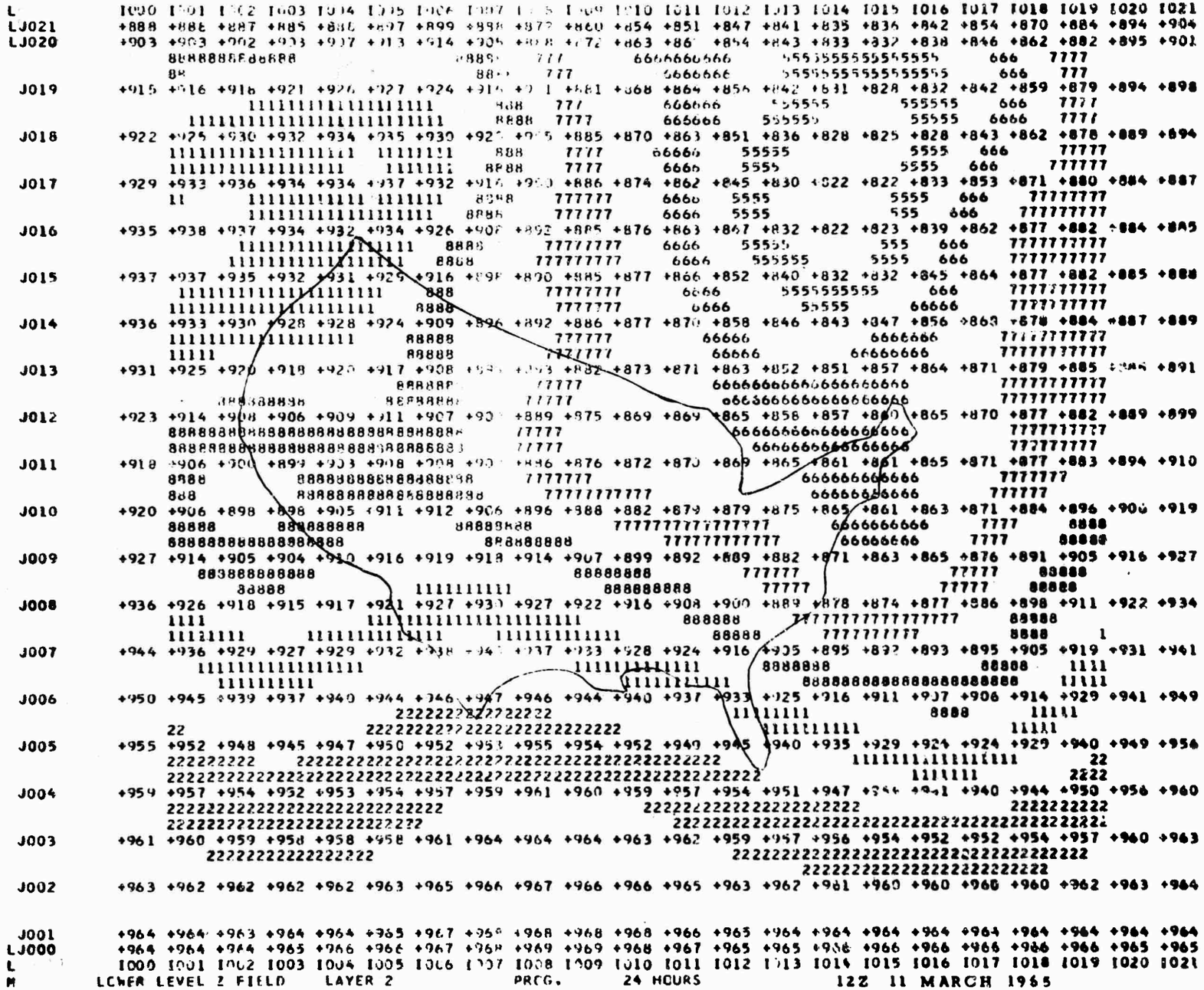
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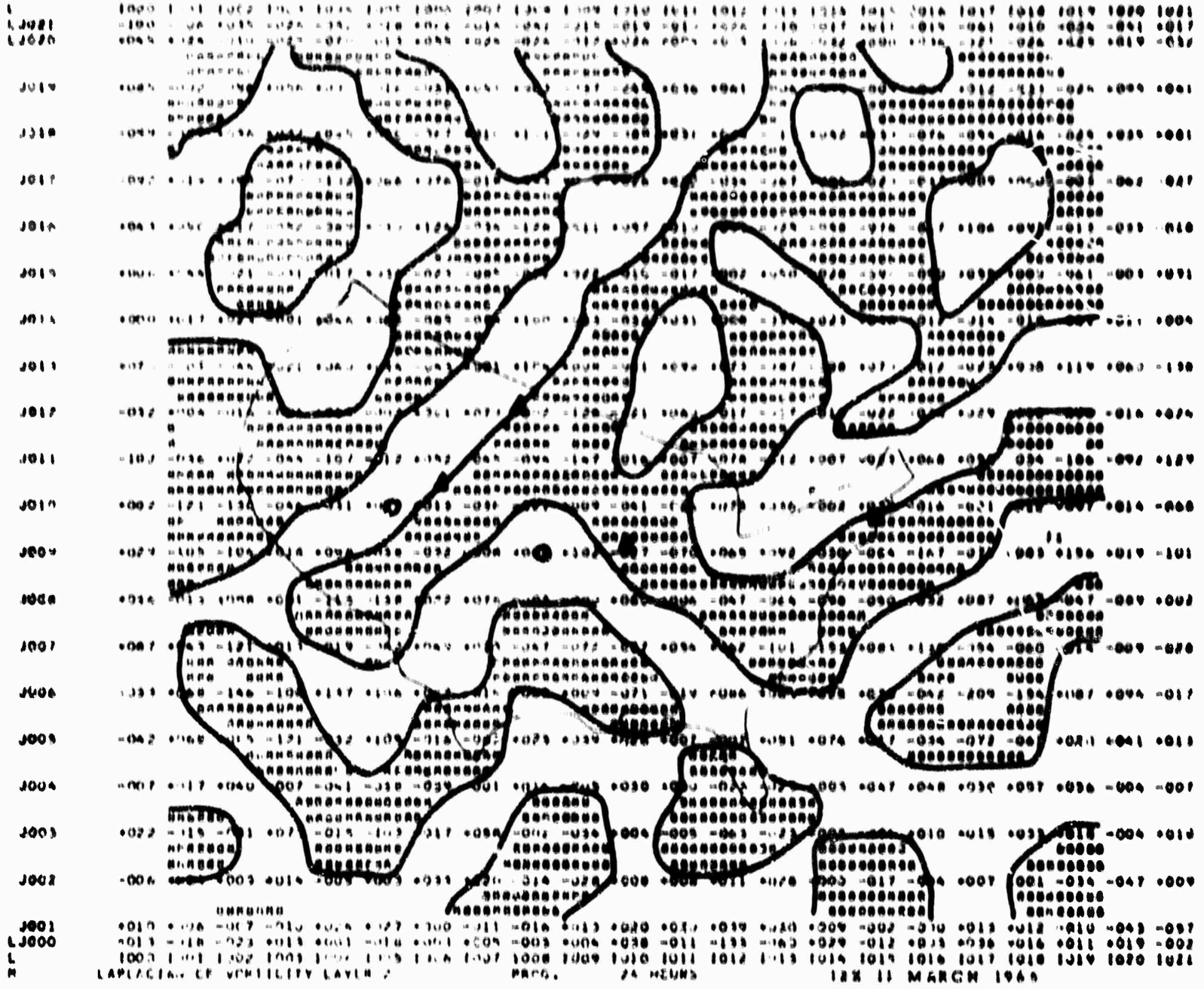
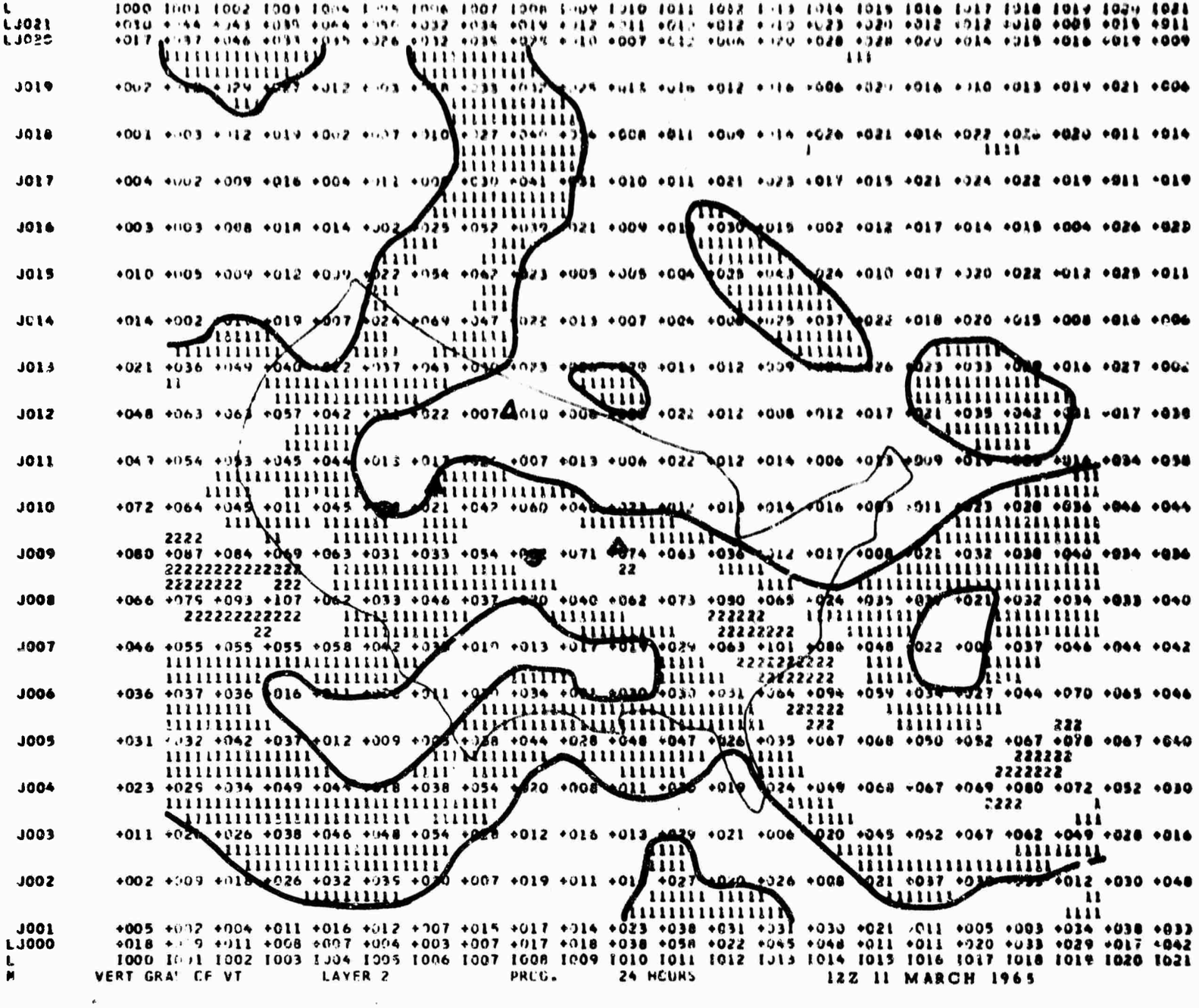


LAPLACIAN OF VORTICITY LAYER 2 PROG. 24 HOURS 12Z 11 MARCH 1969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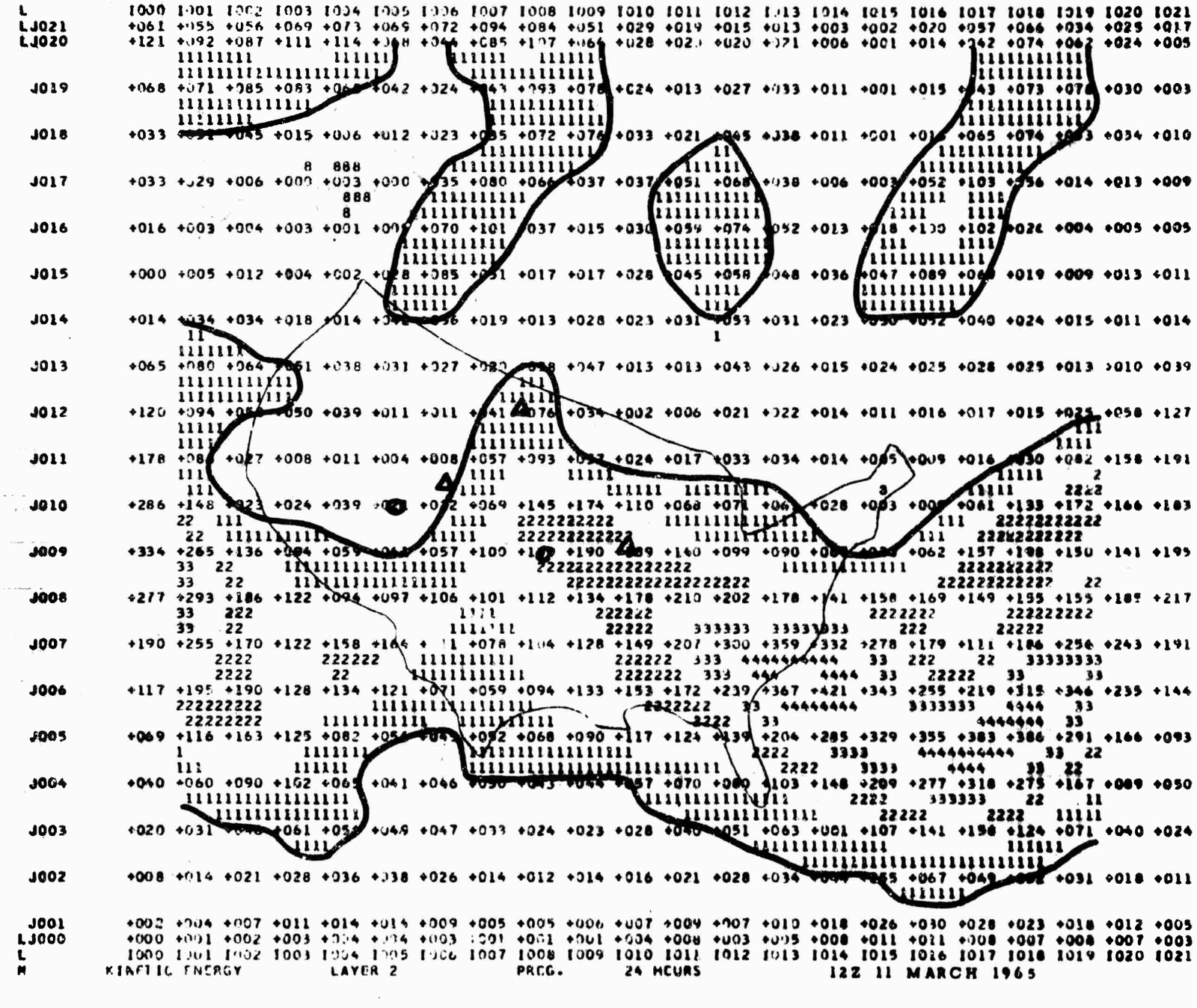
PROG.
24 HOURS
12Z 11 MARCH 1965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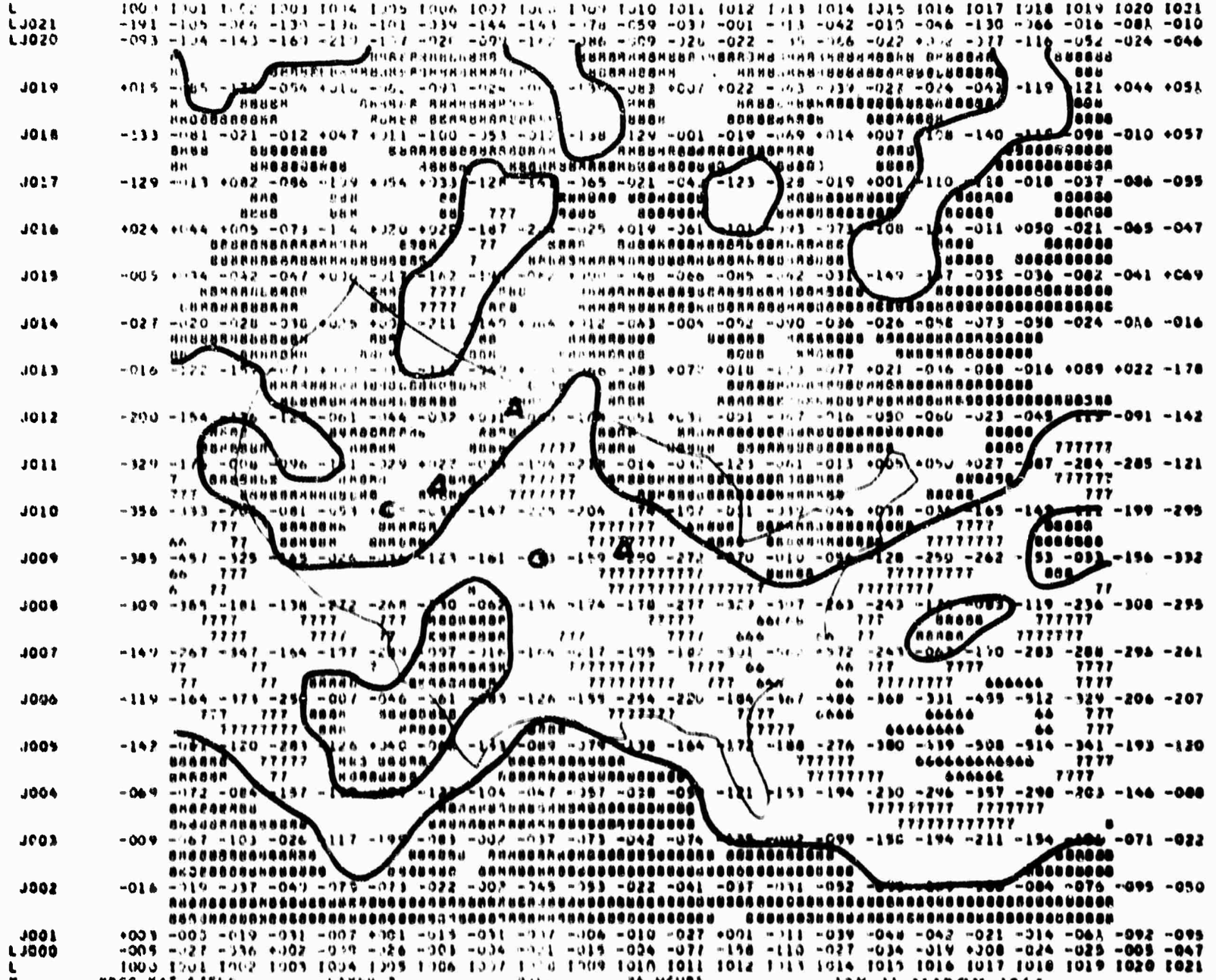
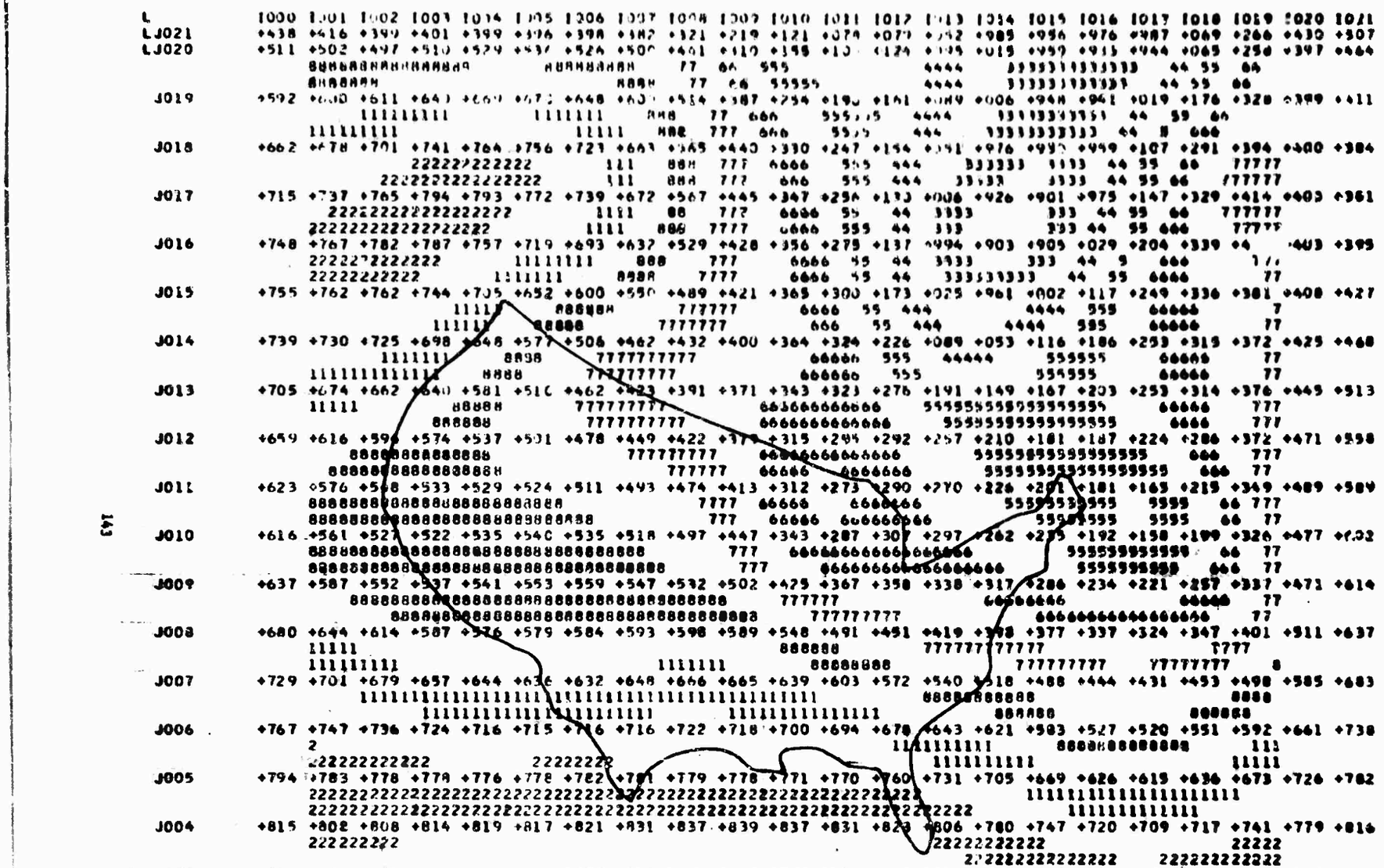


PROG KAT FIELD LAYER 2 24 HOURS 12Z 11 MARCH 1965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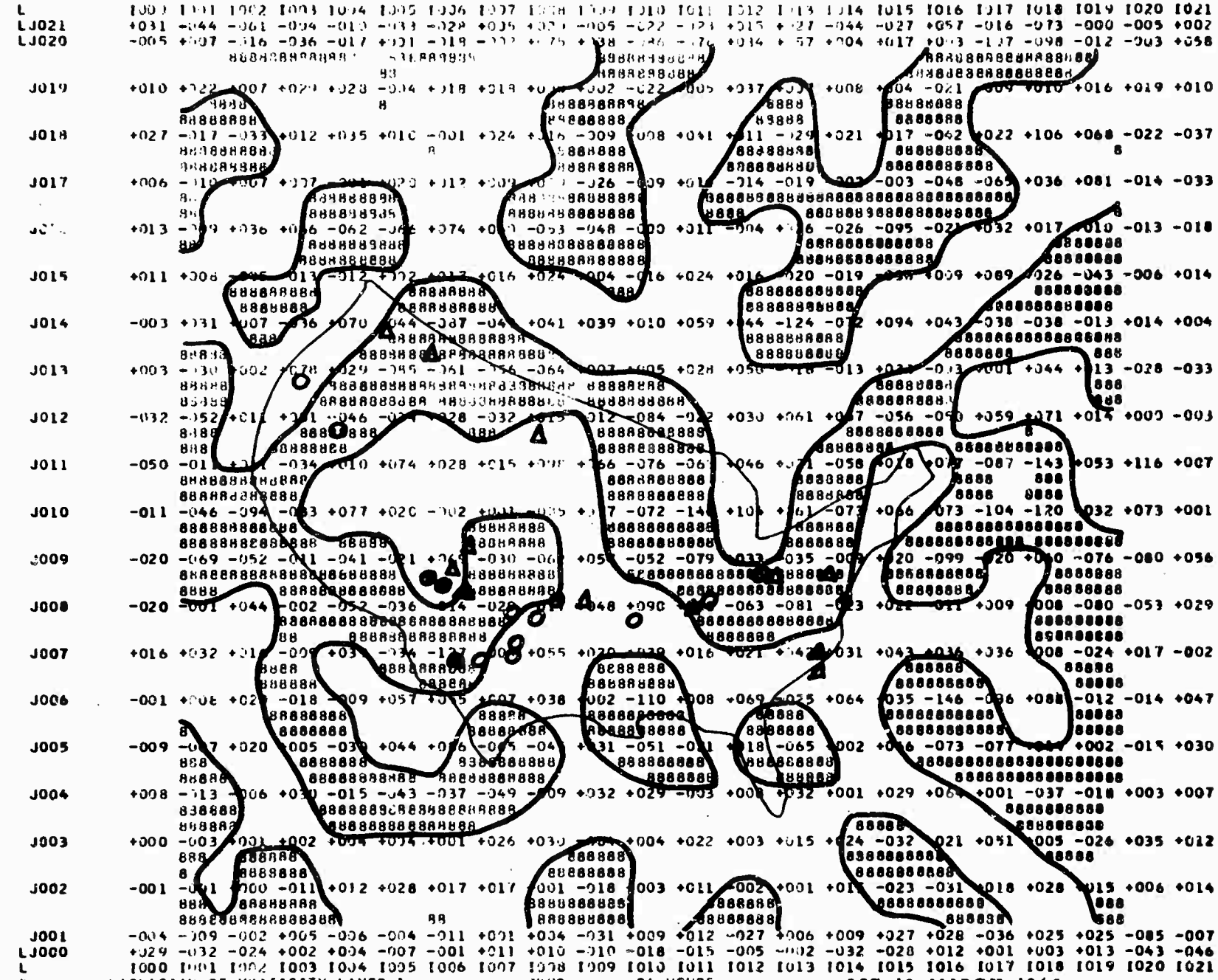
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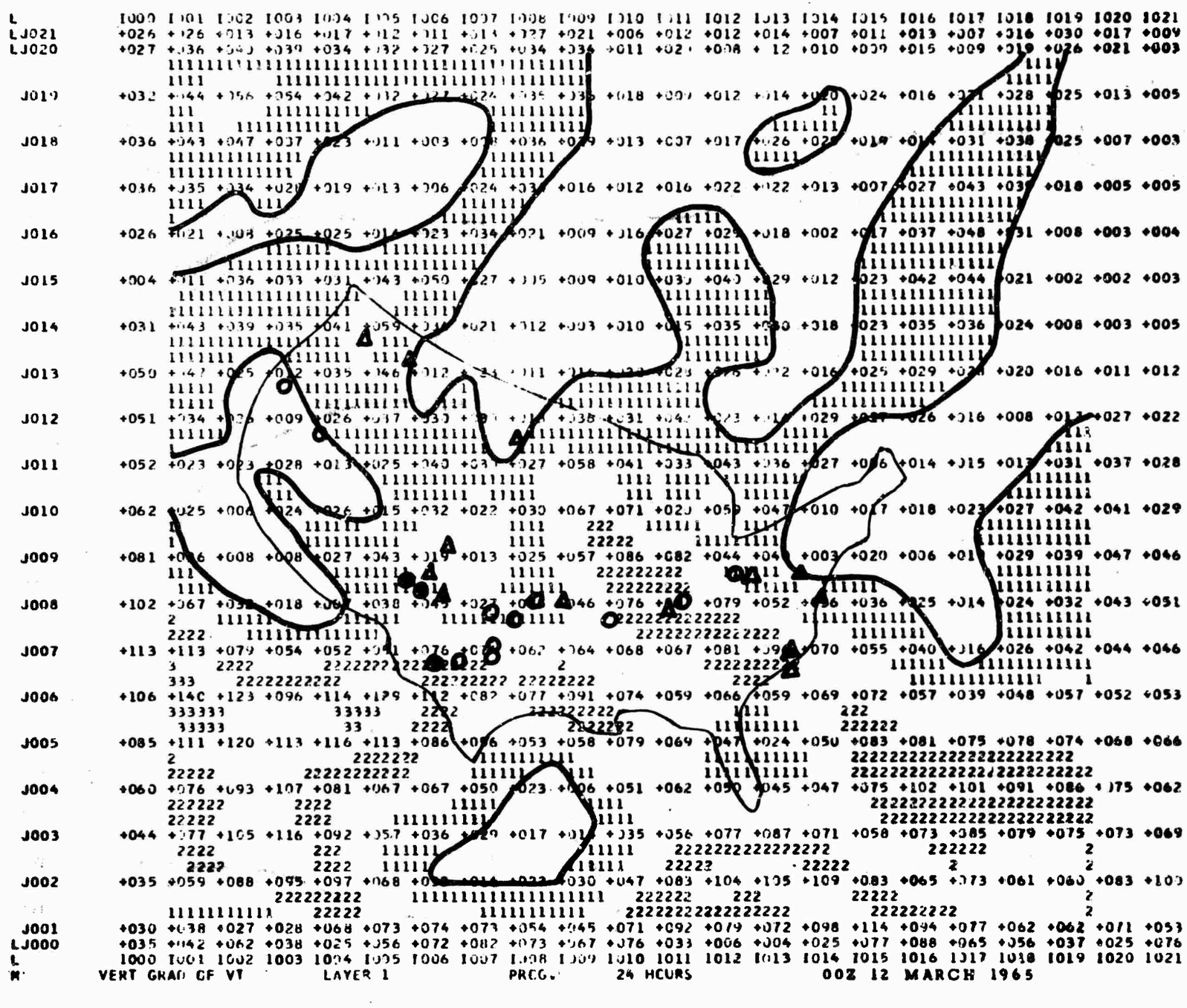
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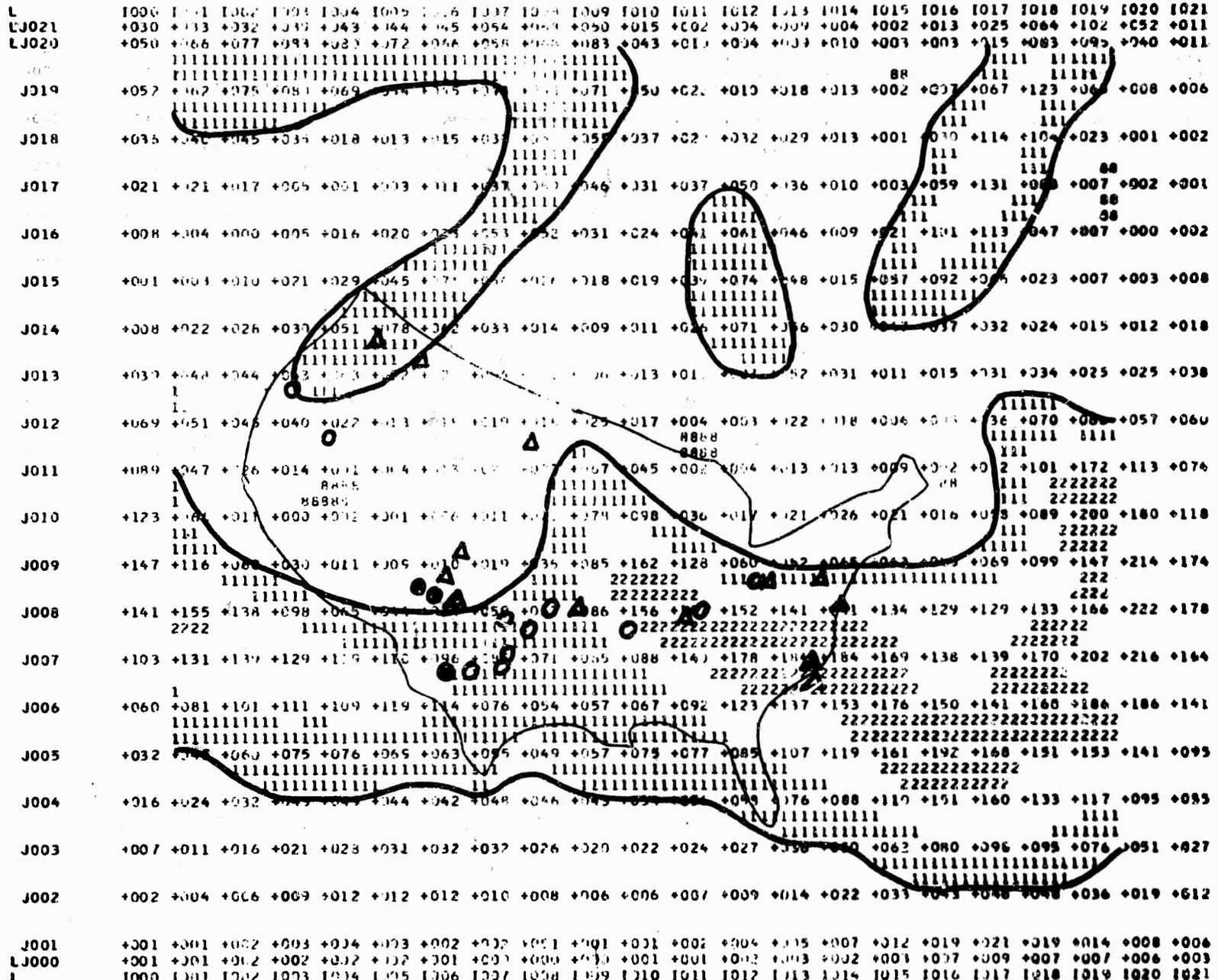
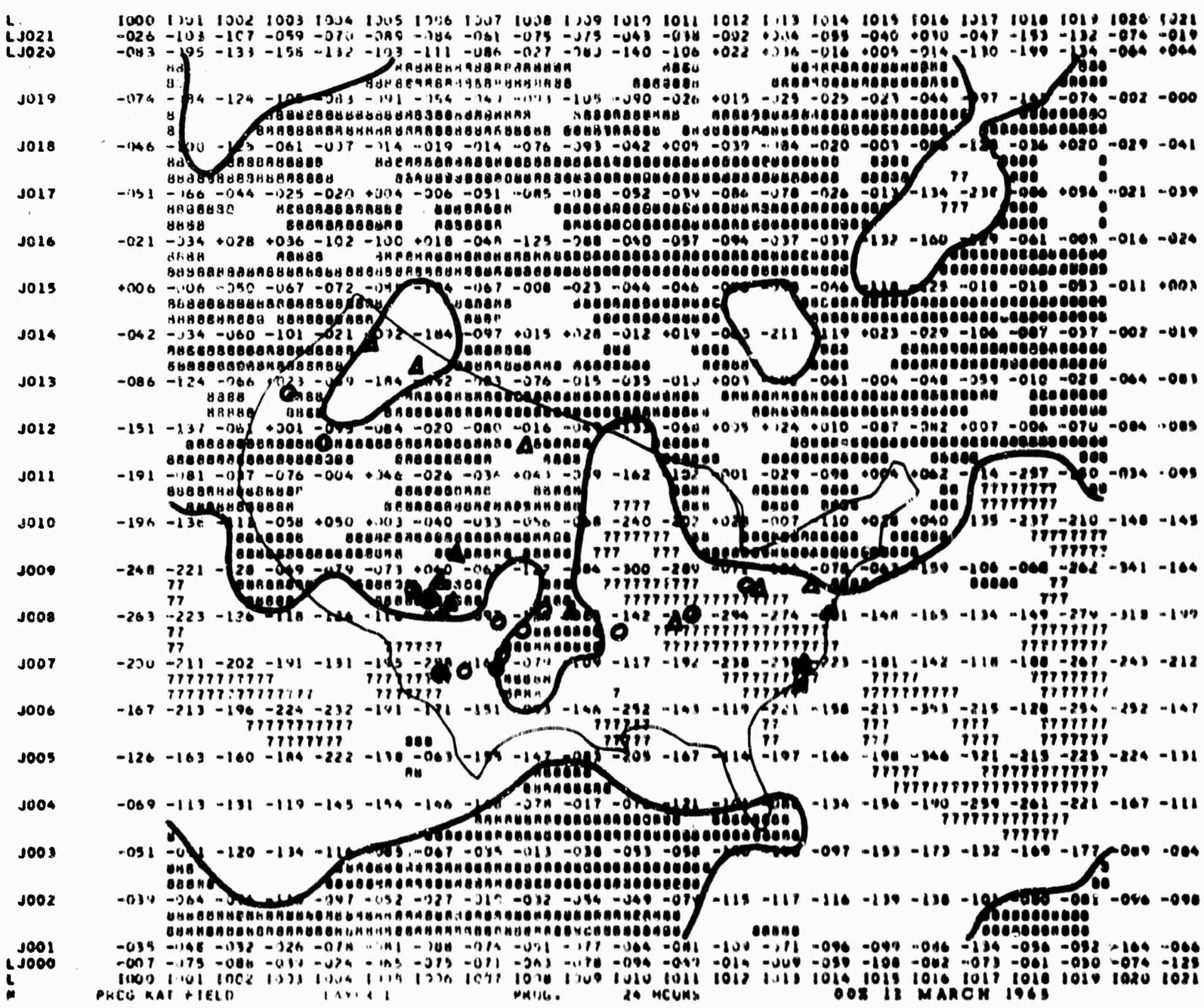
24 HOURS
00Z 12 MARCH 1965


KINETIC ENERGY LAYER 1 PROG. 24 HOURS 00Z 12 MARCH 1965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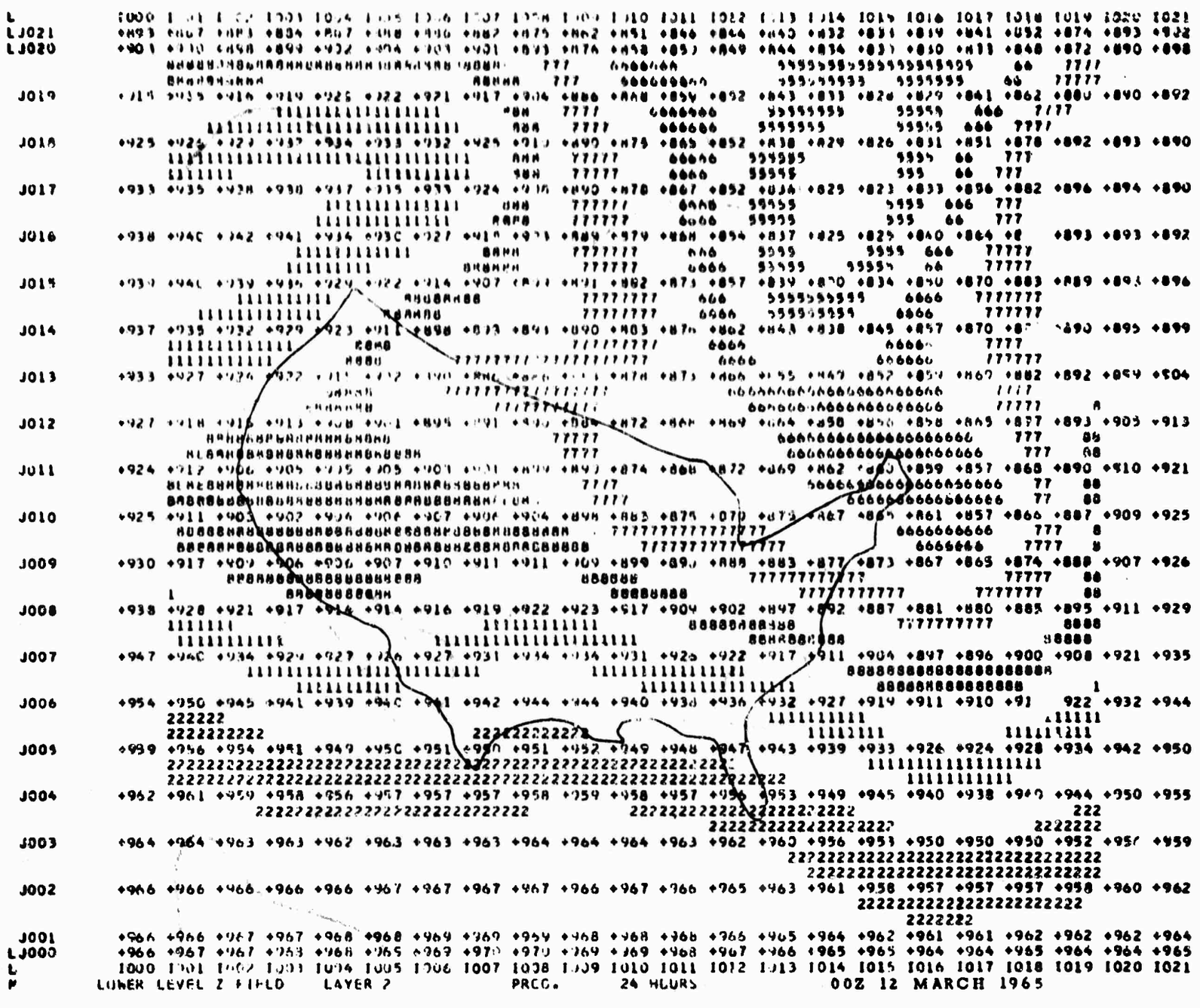

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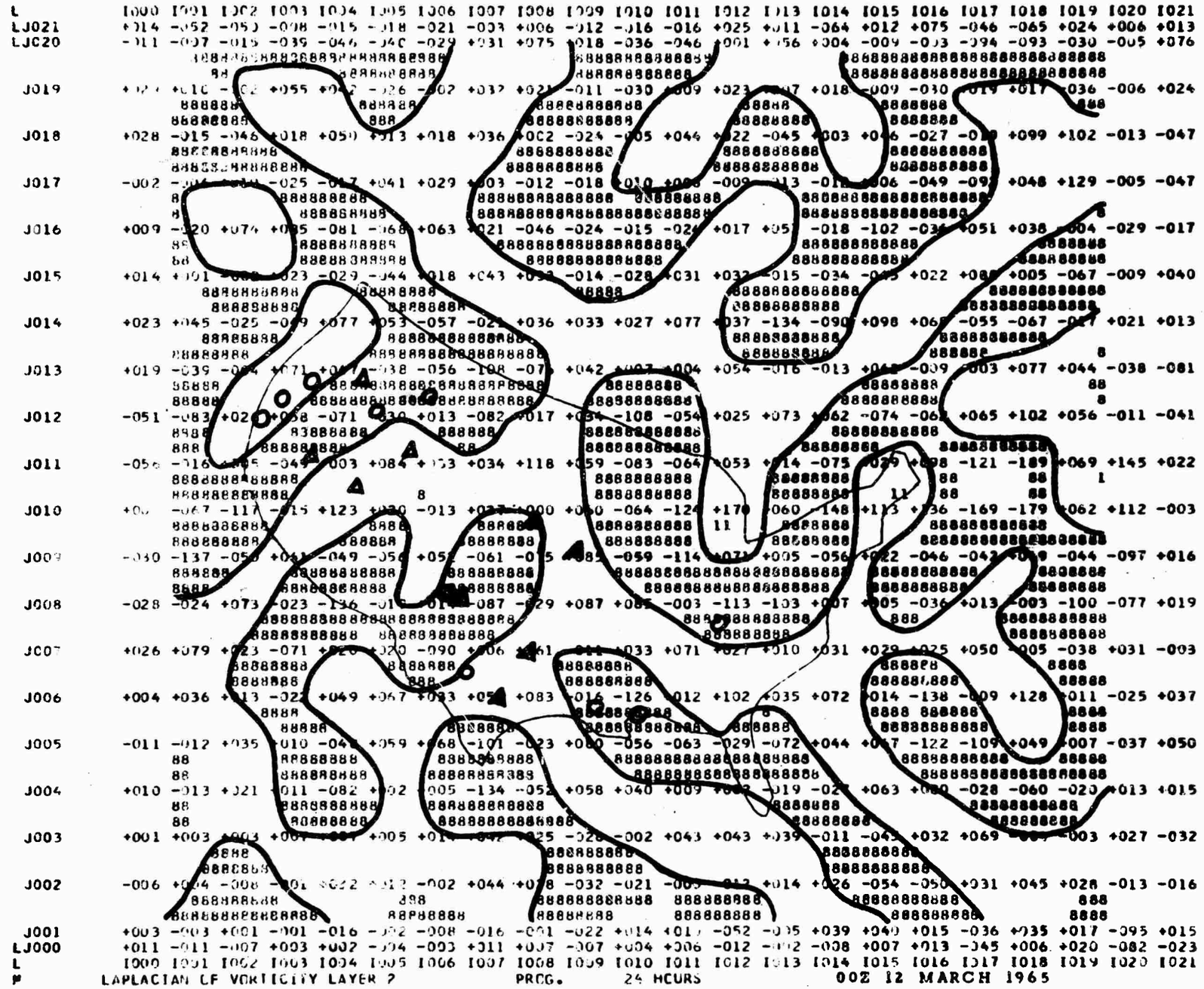
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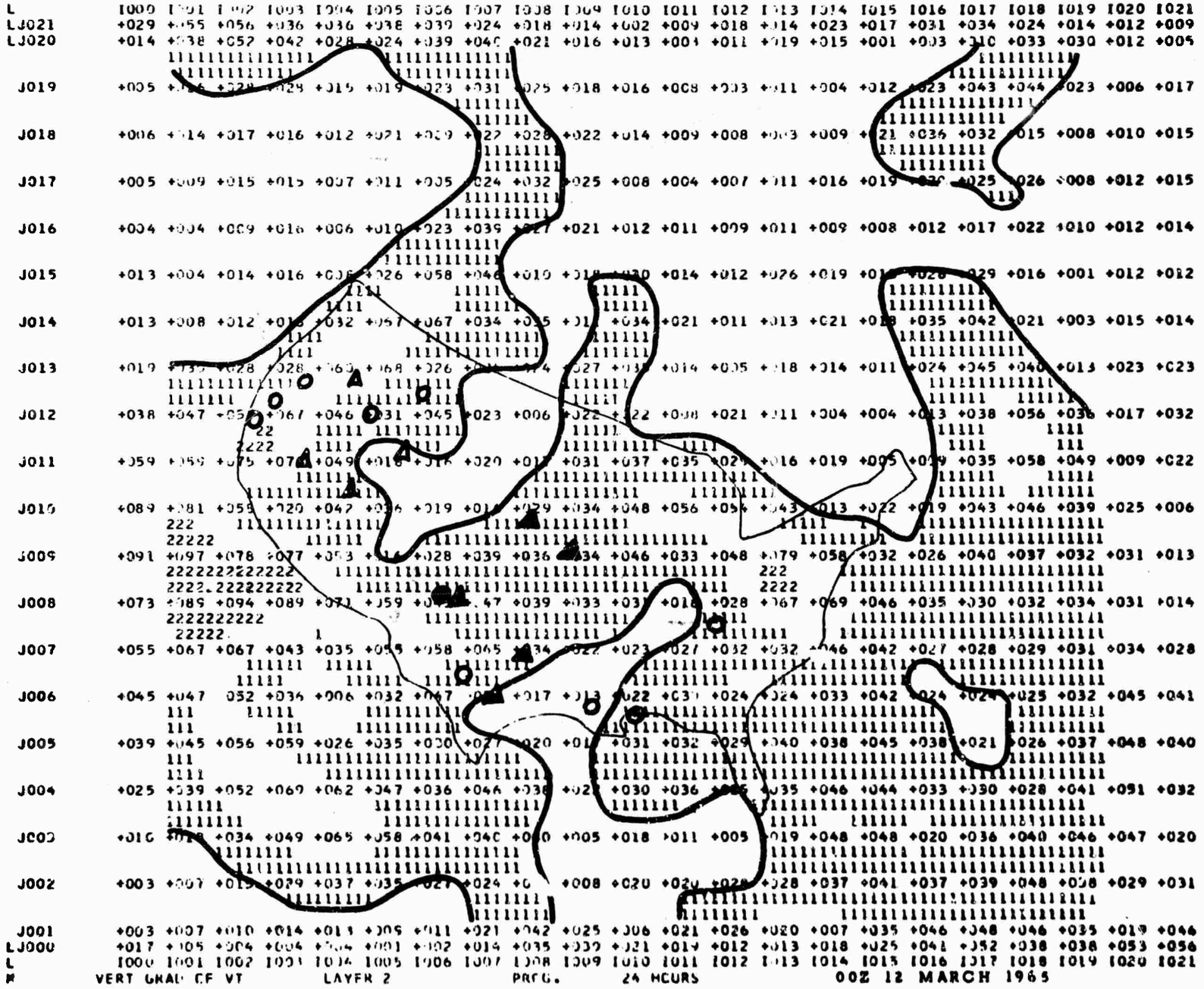
LAPLACIAN OF VORTICITY LAYER 2
PROG. 24 HOURS
00Z 12 MARCH 1965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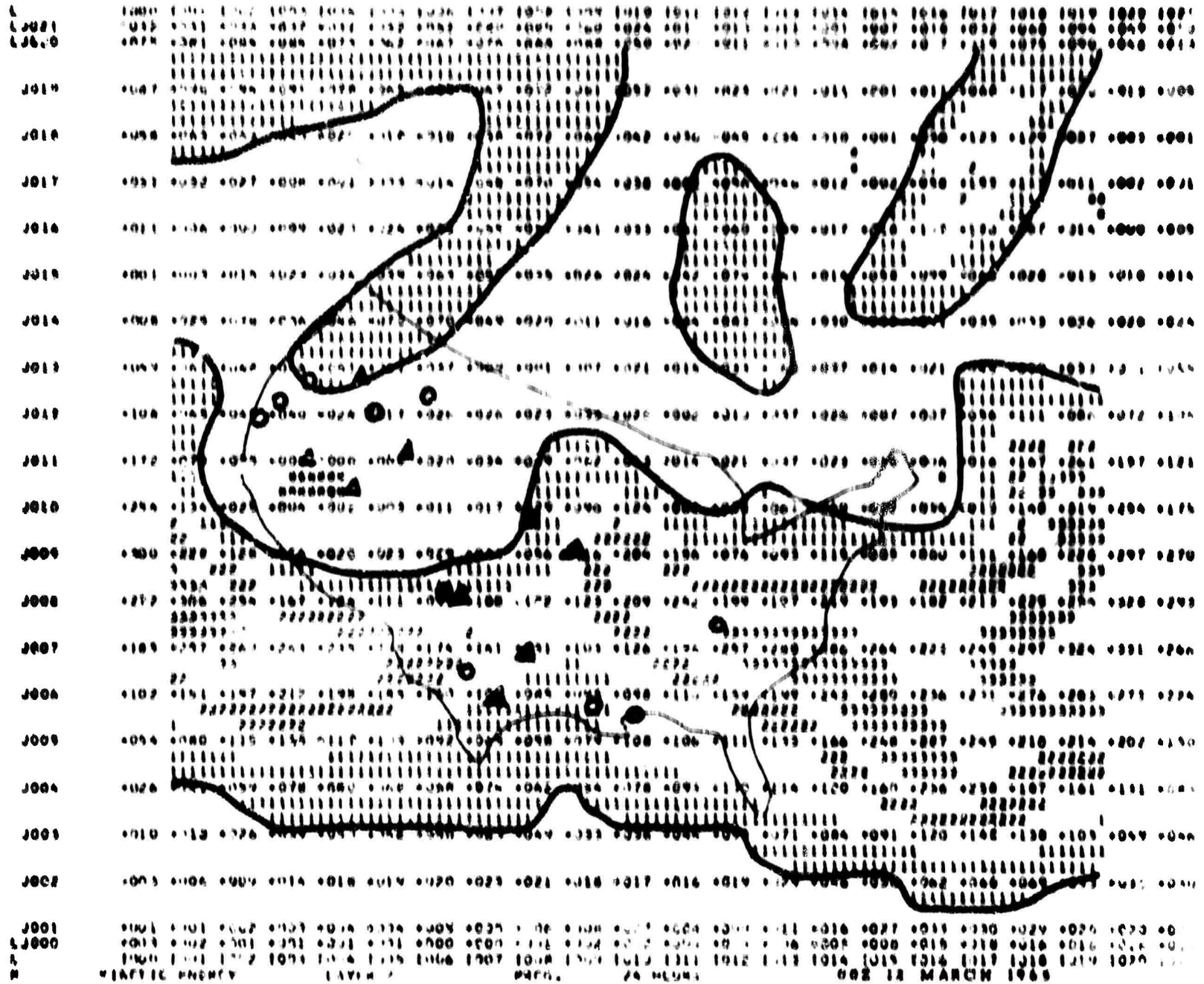
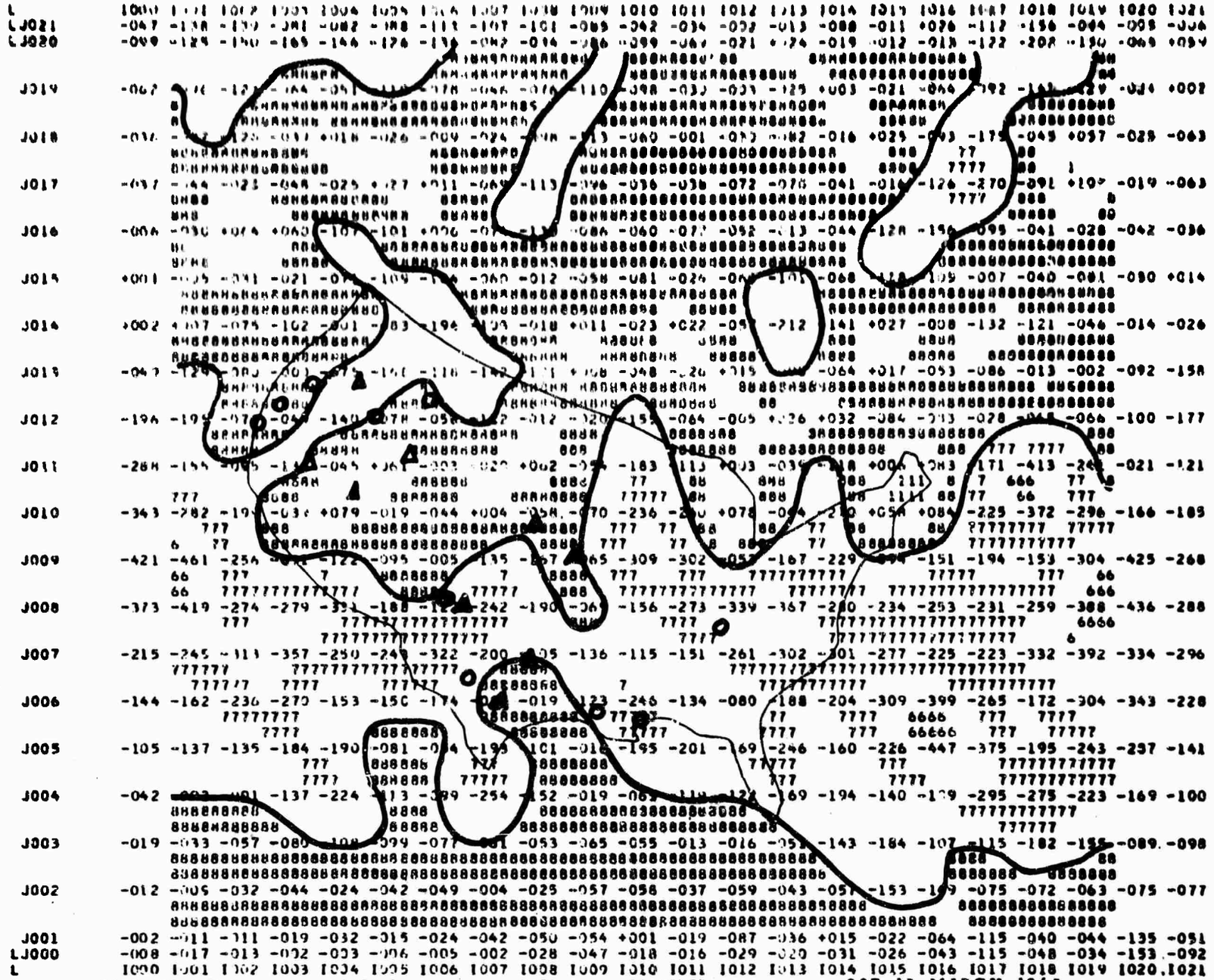
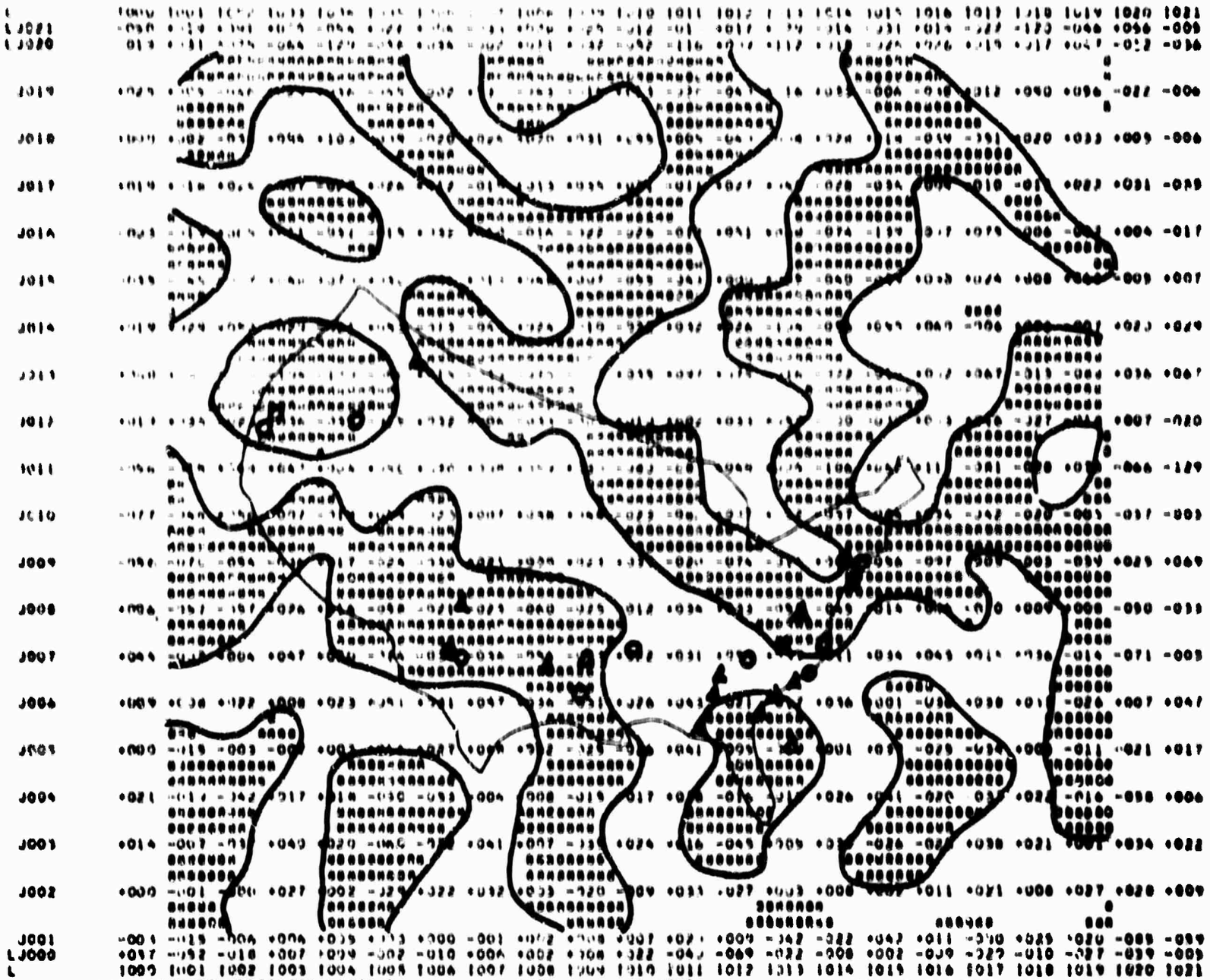
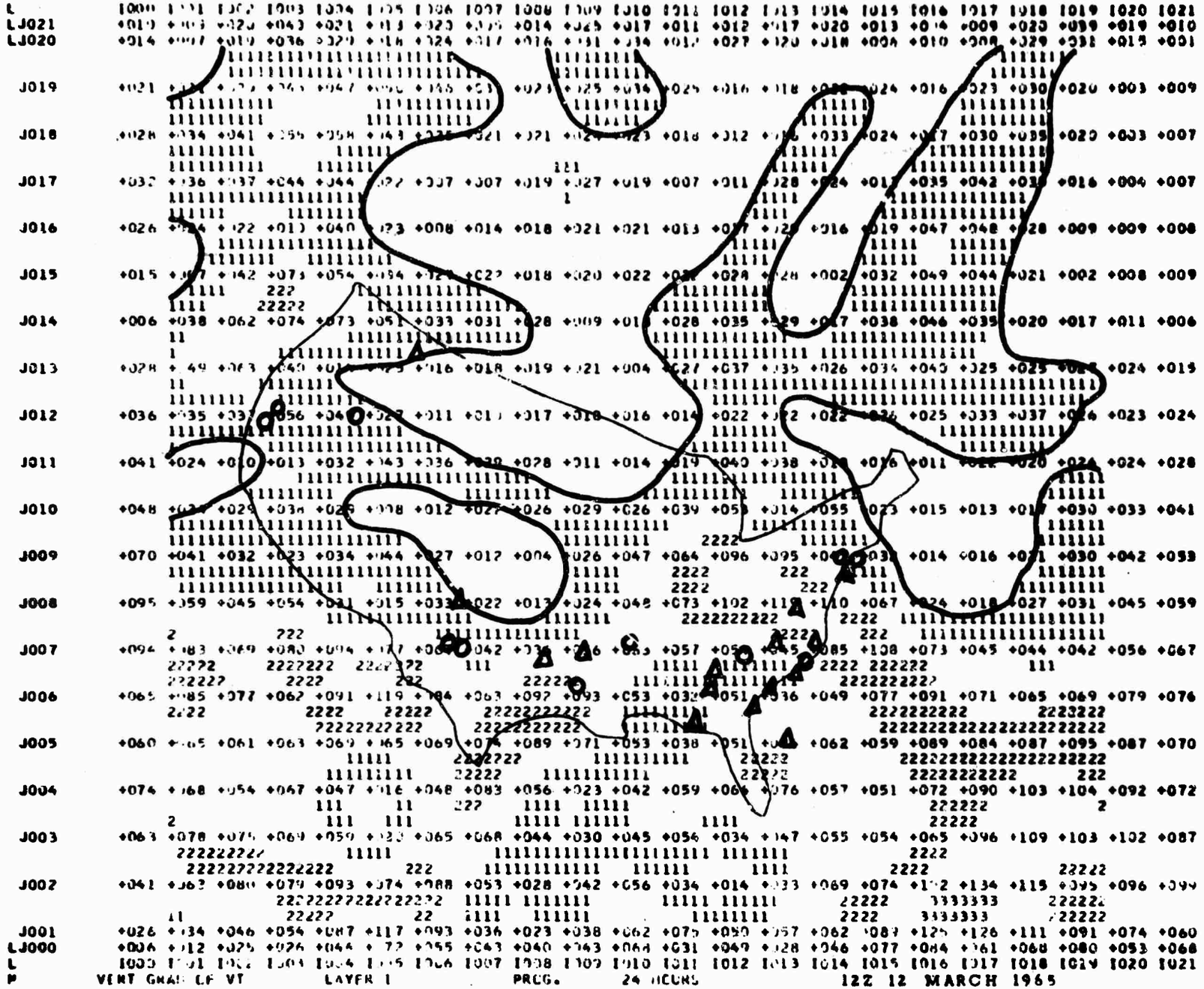
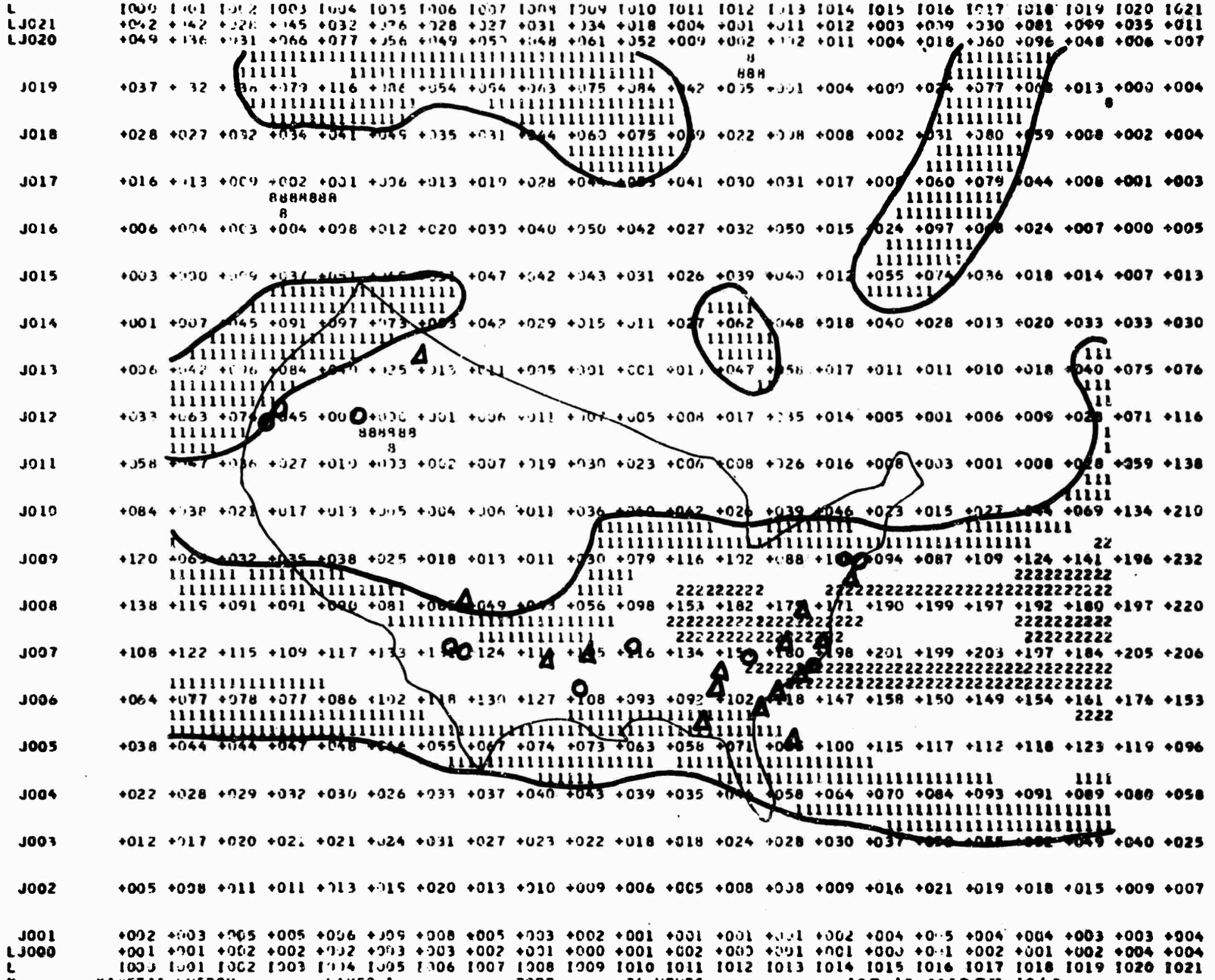



PROG NAT FIELD LAYER 2 PROG. 24 HOURS 00Z 12 MARCH 1965


LAPLACIAN OF VORTICITY LAYER 1
PROG. 24 HOURS
12Z 12 MARCH 1968


VERT GRAD OF VT
LAYER 1
PROG.
24 HOURS
12Z 12 MARCH 1965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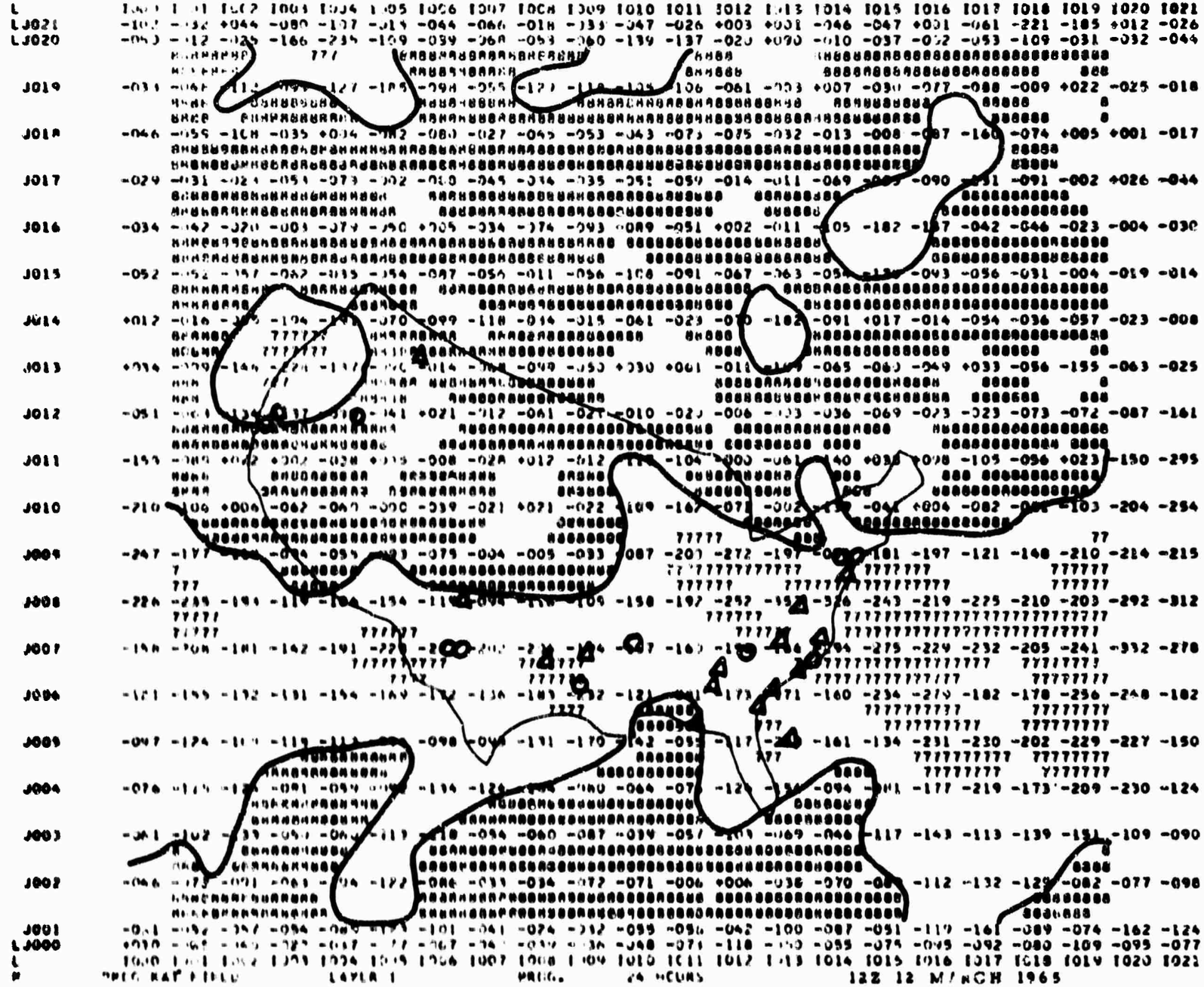
KINETIC ENERGY LAYER 1 PROG. 24 HOURS 12Z 12 MARCH 1965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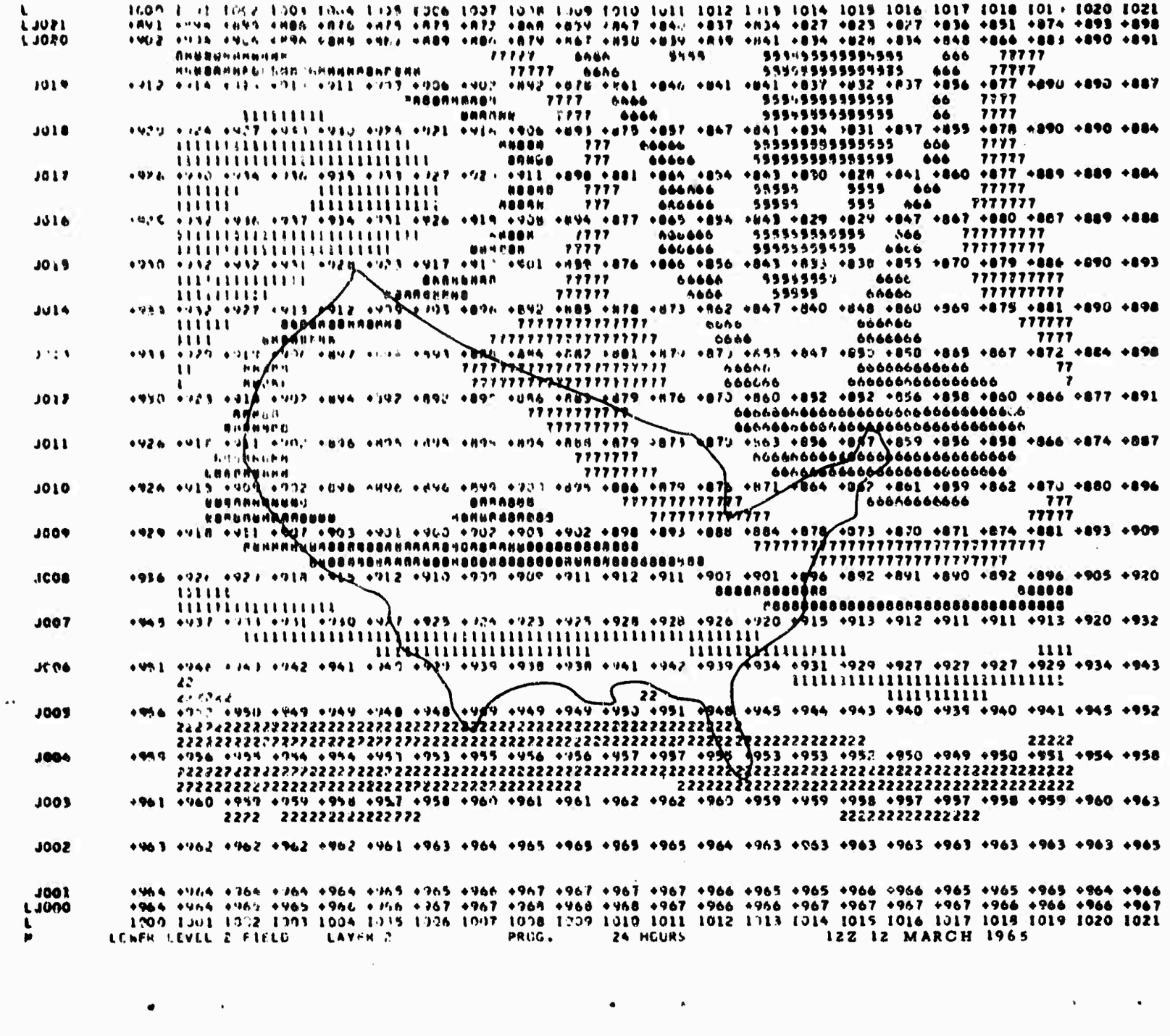
PROG RAM FIELD
LAYER 1
PROG.
24 HOURS
12Z 12 MARCH 1965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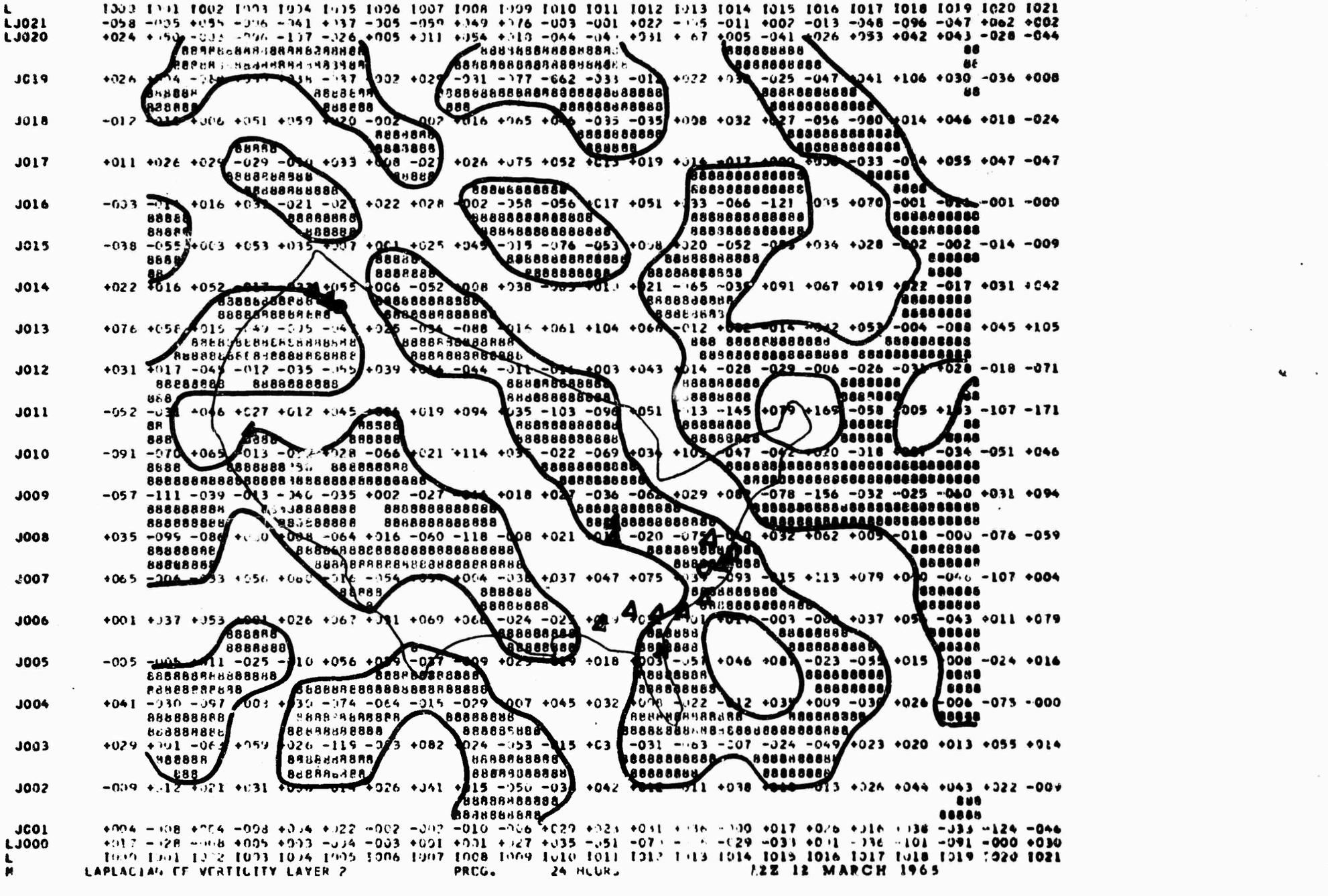
PROG. 24 HOURS
12Z 12 MARCH 1965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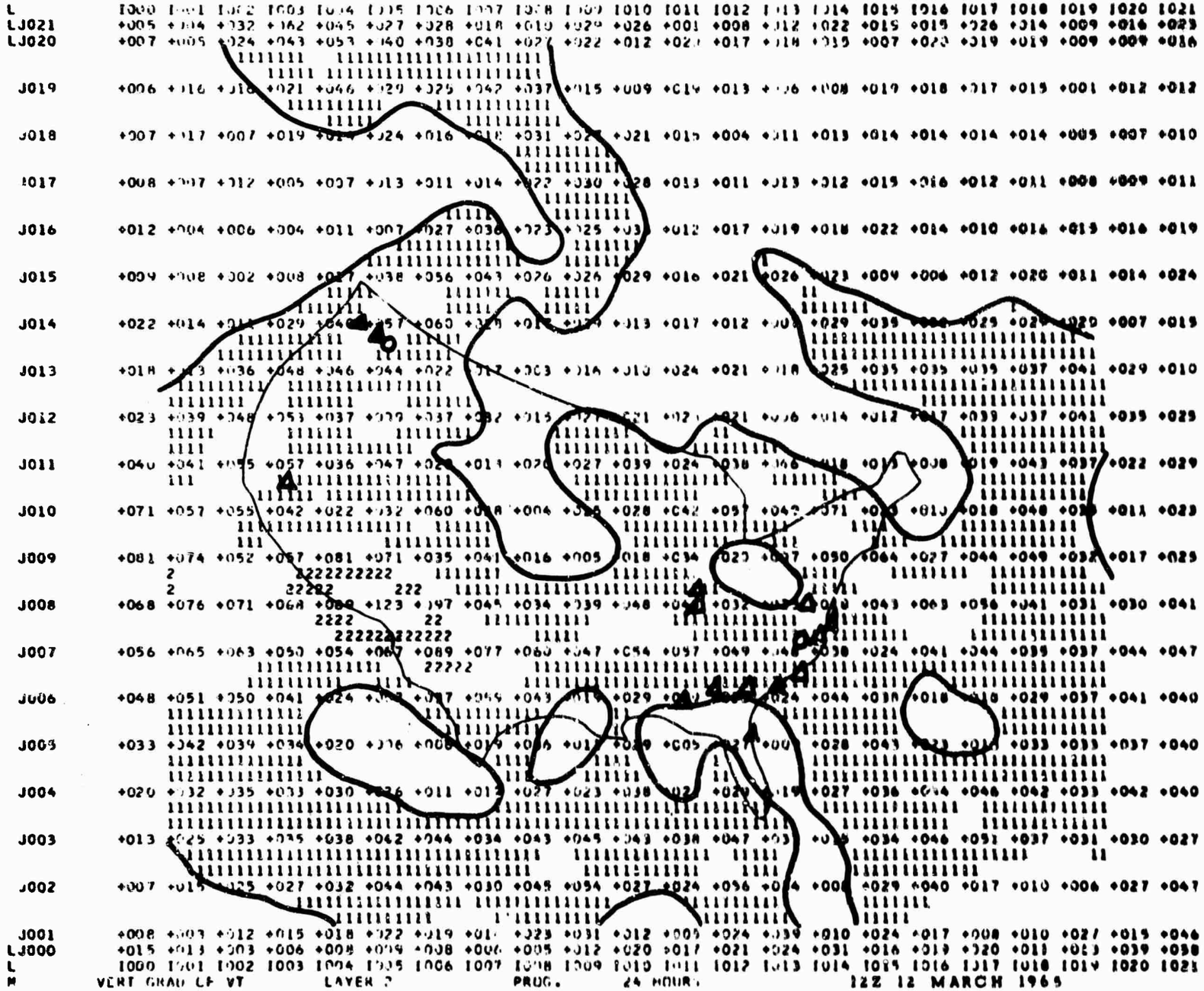
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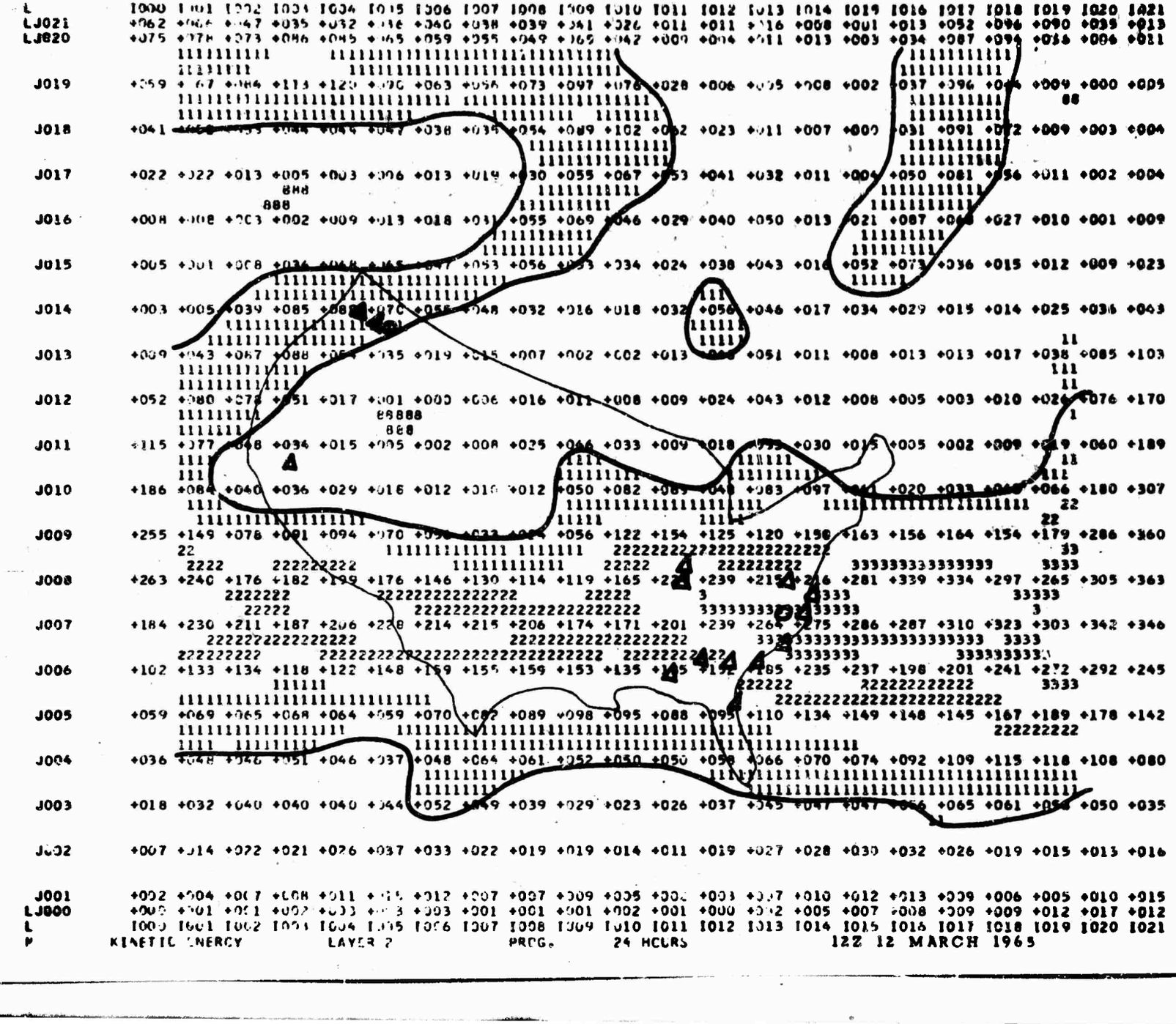
VERT GRAD OF VT LAYER 2 PROG. 24 HOURS 12Z 12 MARCH 1965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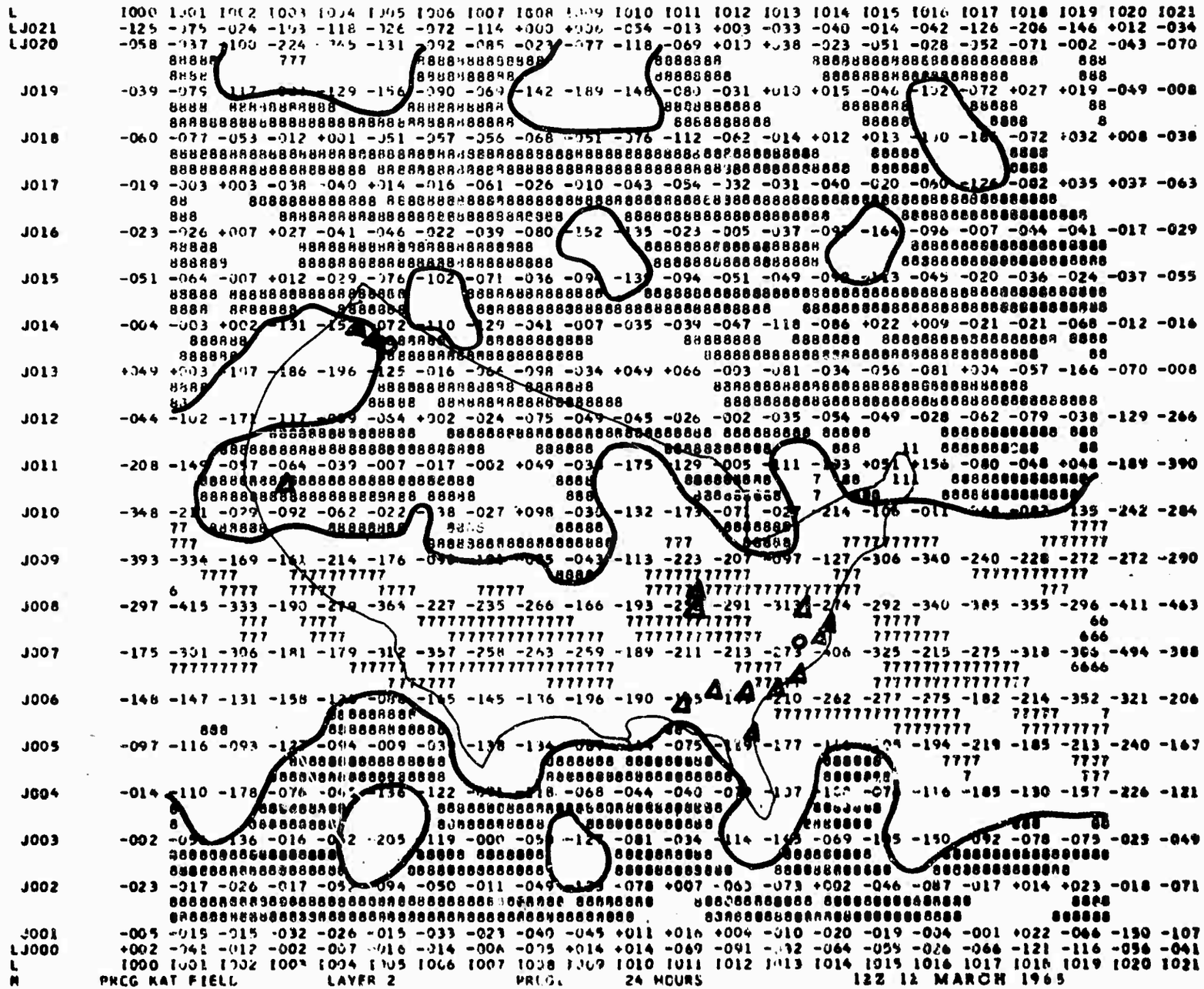
P KINETIC ENERGY LAYER 2 PROG. 24 HOURS 12Z 12 MARCH 1965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M PRCG KAT FIELD LAYER 2 PROG 24 HOURS 12Z 12 MARCH 1965

TABLE 1

AIRCRAFT TURBULENCE CRITERIA

CATEGORY	DEFINITION
LIGHT	A turbulent condition during which occupants may be required to use seat belts, but objects in the aircraft remain at rest.
MODERATE	A turbulent condition in which occupants require seat belts and occasionally are thrown against the belt. Unsecured objects in aircraft move about.
SEVERE	A turbulent condition in which the aircraft momentarily may be out of control. Occupants are thrown violently against the belt and back into the seat. Objects not secured in the aircraft are tossed about.
EXTREME	A rarely encountered turbulent condition in which the aircraft is violently tossed about, and is practically impossible to control. May cause structural damage to the aircraft.

FIELDS	DATE	TIME	LAYER	TOTAL # OF OCCR	% CORR	L - N		M		N - S		S	
						# OCCR	# CORR	# OCCR	# CORR	# OCCR	# CORR	# OCCR	# CORR
LAPLACIAN OF VORTICITY	10 MAR 65	00Z	1	19	79	11	7	6	5	2	1	0	0
VERTICAL GRADIENT OF THERMAL WIND	"	"	"	"	64	11	8	6	4	2	0	0	0
KINETIC ENERGY	"	"	"	"	26	11	3	6	2	4	0	0	0
KAT FIELD	"	"	"	"	32	11	5	6	3	4	2	3	3
LAPLACIAN OF VORTICITY	10 MAR 65	"	11	32	67	22	16	16	8	5	4	0	
VERTICAL GRADIENT OF THERMAL WIND	"	"	"	"	90	22	22	16	12	6	4	0	0
KINETIC ENERGY	"	"	"	"	86	22	19	16	13	6	6	0	0
KAT FIELD	"	"	"	"	76	22	17	16	12	6	3	0	0
LAPLACIAN OF VORTICITY	10 MAR 65	12Z	1	14	71	6	5	5	5	1	1	0	0
VERTICAL GRADIENT OF THERMAL WIND	"	"	"	"	57	6	4	5	3	3	1	0	0
KINETIC ENERGY	"	"	"	"	93	6	6	5	5	2	2	0	0
KAT FIELD	"	"	"	"	71	6	6	5	4	3	0	0	0
LAPLACIAN OF VORTICITY	10 MAR 65	"	11	21	71	15	9	6	6	0	0	0	0
VERTICAL GRADIENT OF THERMAL WIND	"	"	"	"	90	15	13	6	6	0	0	0	0
KINETIC ENERGY	"	"	"	"	90	15	13	6	6	0	0	0	0
KAT FIELD	"	"	"	"	90	15	13	6	6	0	0	0	0

TABLE 2

FIELDS	DATE	TIME	LAYER	TOTAL # OF OCCR	% CORR	L to M		M		M to S		S	
						# OCCR	# CORR	# OCCR	# CORR	# OCCR	# CORR	# OCCR	# CORR
LAPLACIAN OF VORTICITY	11 MAR 65	00Z	I	40	66	21	10	13	11	5	5	1	1
VERTICAL GRADIENT OF THERMAL WIND	"	"	"	"	100	21	21	13	13	5	5	1	1
KINETIC ENERGY	"	"	"	"	67	21	15	13	8	5	4	1	0
KAT FIELD	"	"	"	"	63	21	9	13	9	5	5	1	1
LAPLACIAN OF VORTICITY	11 MAR 65	00Z	II	51	71	31	21	16	11	4	4	0	0
VERTICAL GRADIENT OF THERMAL WIND	"	"	"	"	98	31	30	16	16	4	4	0	0
KINETIC ENERGY	"	"	"	"	88	31	29	16	12	4	4	0	0
KAT FIELD	"	"	"	"	82	31	25	16	13	4	4	0	0
LAPLACIAN OF VORTICITY	11 MAR 65	12Z	I	22	77	14	9	6	6	1	1	1	1
VERTICAL GRADIENT OF THERMAL WIND	"	"	"	"	86	14	11	6	6	1	1	1	1
KINETIC ENERGY	"	"	"	"	64	14	10	6	4	1	0	1	0
KAT FIELD	"	"	"	"	50	14	8	6	3	1	0	1	0
LAPLACIAN OF VORTICITY	11 MAR 65	12Z	II	5	60	3	3	2	0	0	0	0	0
VERTICAL GRADIENT OF THERMAL WIND	"	"	"	"	80	3	2	2	0	0	0	0	0
KINETIC ENERGY	"	"	"	"	60	3	2	2	1		0	0	0
KAT FIELD	"	"	"	"	40	3	1	2	1	0			0

TABLE 3

FIELDS	DATE	TIME	LAYER	TOTAL # OF OCCR	% CORR	L to M		M		M to S		S	
						# OCCR	# CORR	# OCCR	# CORR	# OCCR	# CORR	# OCCR	# CORR
LAPLACIAN OF VORTICITY	12 MAR 65	00Z	I	27	52	11	7	11	6	2	1	3	1
VERTICAL GRADIENT OF THERMAL WIND	"	"	"	"	92	11	10	11	10	2	2	3	3
KINETIC ENERGY	"	"	"	"	70	11	6	11	10	2	1	3	1
KAT FIELD	"	"	"	"	59	11	7	11	7	2	1	3	1
LAPLACIAN OF VORTICITY	12 MAR 65	00Z	II	19	53	4	2	9	5	5	2	1	1
VERTICAL GRADIENT OF THERMAL WIND	"	"	"	"	89	4	3	9	8	5	5	1	1
KINETIC ENERGY	"	"	"	"	63	4	1	9	5	5	5	1	1
KAT FIELD	"	"	"	"	48	4	2	9	5	5	2	1	1
LAPLACIAN OF VORTICITY	12 MAR 65	12Z	I	26	77	15	10	11	8	0	0	0	0
VERTICAL GRADIENT OF THERMAL WIND	"	"	"	"	100	15	15	11	11	0	0	0	0
KINETIC ENERGY	"	"	"	"	88	15	13	11	10	0	0	0	0
KAT FIELD	"	"	"	"	92	13	14	11	10	0	0	0	0
LAPLACIAN OF VORTICITY	12 MAR 65	12Z	II	16	81	12	9	2	2	2	2	0	0
VERTICAL GRADIENT OF THERMAL WIND	"	"	"	"	94	12	11	2	2	2	2	0	0
KINETIC ENERGY	"	"	"	"	94	12	11	2	2	2	2	0	0
KAT FIELD	"	"	"	"	87	12	11	2	1	2	2	0	0

TABLE 4

	All Categories	LIGHT TO MODERATE	MODERATE	MODERATE TO SEVERE	SEVERE
TOTAL NUMBER OF KAT OCCURRENCES	302	165	103	28	6
(10 MARCH 1965 TO 12 MARCH 1965)					
PERCENT CORRELATION (BY FIELD AND CATEGORY)					
LAPLACIAN OF VORTICITY		65	71	71	67
VERTICAL GRADIENT OF THERMAL WIND		90	89	93	100
KINETIC ENERGY		70	76	78	33
KAT FIELD		72	70	60	50
PERCENT CORRELATION (BY FIELD)					
LAPLACIAN OF VORTICITY	68				
VERTIC . GRADIENT OF THERMAL WIND	90				
KINETIC ENERGY	76				
KAT FIELD	70				

TABLE 5

UNCLASSIFIED

Security Classification

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

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4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Thesis

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ETTEL, Michael J.
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13. ABSTRACT

There is much disagreement as to (a) what causes clear air turbulence (turbulence which is not in or near convective clouds and is above 15,000 feet in altitude) and (b) which meteorological parameters can be used to detect and forecast its occurrence. The approach to this problem has been to relate not one parameter to clear air turbulence but various parameters. By summing these parameters areas can be defined where there is a high probability of encountering clear air turbulence. Each parameter has been based on a statistical study which found a relationship with clear air turbulence. The parameters used were horizontal and vertical shear, curvature, kinetic energy and their derivatives. The numerical forecasting program proposed here can be extended to the stratosphere when more reliable height and temperature fields are available. This program will have much more significance when intermediate forecast height fields, temperature fields and a grid of much smaller mesh length are available.

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Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Turbulence						
Clear Air Turbulence						