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AD 668922

Research and Development Technical Report
ECOM- 0296-3

BALLISTIC WINDS STUDY

QUARTERLY REPORT

REPORT NO. 3

BY

FREDERICK P. OSTBY, JR.

MAY 1968

ECOM

UNITED STATES ARMY ELECTRONICS COMMAND · FORT MONMOUTH, N.J.

CONTRACT NO. DAAB07-67-C0296

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May 1968

BALLISTIC WINDS STUDY

Quarterly Report

Report No. 3

1 September 1967 to 30 November 1967

Contract No. DAAB07-67-C0296

Project No. 1T0-25001-A-126-01-19

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U.S. ARMY ELECTRONICS COMMAND, FORT MONMOUTH, N.J.

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ABSTRACT

Some preliminary analyses were derived from the CRAM objective analysis program. The program has been generalized so that various grid intervals may be conveniently tested. There also has been a modification which will permit use of a cathode-ray tube to generate maps of the program output.

Two sets of analyses were made. One used a 10-km grid interval while the other used a finer 5-km grid interval. The finer grid mesh analysis fits the data more closely than the 10-km grid.

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1.0 INTRODUCTION

This report describes technical progress during the third quarter, September 1, 1967 through November 30, 1967 of the contract year, under Contract DAAB07-67-C0296, "Ballistic Winds Techniques Study."

The primary emphasis during this quarter was directed toward experimentation with the CRAM (Conditional Relaxation Analysis Method) objective analysis program. The program has been generalized so that the grid interval may be specified as an input parameter, thus permitting testing of more than one grid mesh. During this past quarter, tests were initiated using several grid intervals and some examples are included herein. These tests are continuing into the fourth quarter.

Additional versatility and refinements have been incorporated into the analysis program package. Nearly all of this development effort has been accomplished within other contracts and therefore has not required expenditure of resources from this project. Some of these features which are applicable to our project are discussed in this report.

2.0 ADDITIONAL PROGRAM FEATURES

Several new features available in the CRAM computer program package hav~ heen incorporated for use in the Ballistic Winds Study. There are other features which could be used at some future time.

One new feature being used is a revised initial guess procedure. Our previous initial-guess field generation was accomplished by the use of a surface-fitting technique in which the independent variables were derived using a screening multiple regression procedure. This scheme had the weakness that although the surface fit would yield fairly representative values over the interior regions of the analysis area, the values near the edges of the grid or away from data areas were unrealistic at times. An alternative method was formulated which is computationally quicker, yields more representative values, and also incorporates information from other levels (zones) through a build-up procedure.

In this scheme, we make use of a very coarse grid (40 km between grid points). Each station location is assigned to the grid point nearest it (see Fig. 2-1). The difference (C) is computed between each station's observation value (ϕ_k) and the corresponding analyzed value from the level below ($\hat{\phi}_{k-1}$) at that station's horizontal coordinates, i.e., $C = (\phi_k - \hat{\phi}_{k-1})$. The differences represent corrections which are applied to grid points on the coarse grid. Overall corrections ($\tilde{C}$) are then computed for each grid point of the coarse grid from the following:

$$\tilde{C}_{i,j} = \frac{\left(\sum_{n=1}^{N} C_n\right)_{i,j}}{N_{i,j}} \qquad \text{for } i = 1,5,9, \ldots, \text{etc.} \quad j = 1,5,9, \ldots, \text{etc.} \qquad (2\text{-}1)$$

Thus it can be seen that (1) the overall corrections are computed for only grid points of the coarse grid and (2) if more than one station is associated with a grid point, the overall correction is the average of the "n" individual corrections.

Those coarse grid points which have no stations assigned are corrected by a simple scanning procedure. The grid-point values are then smoothed. Conversion is then made back to the standard size grid with the values at the initial grid points being generated by interpolation. This field of corrections is then added to the analysis of the level below to generate the initial guess field.

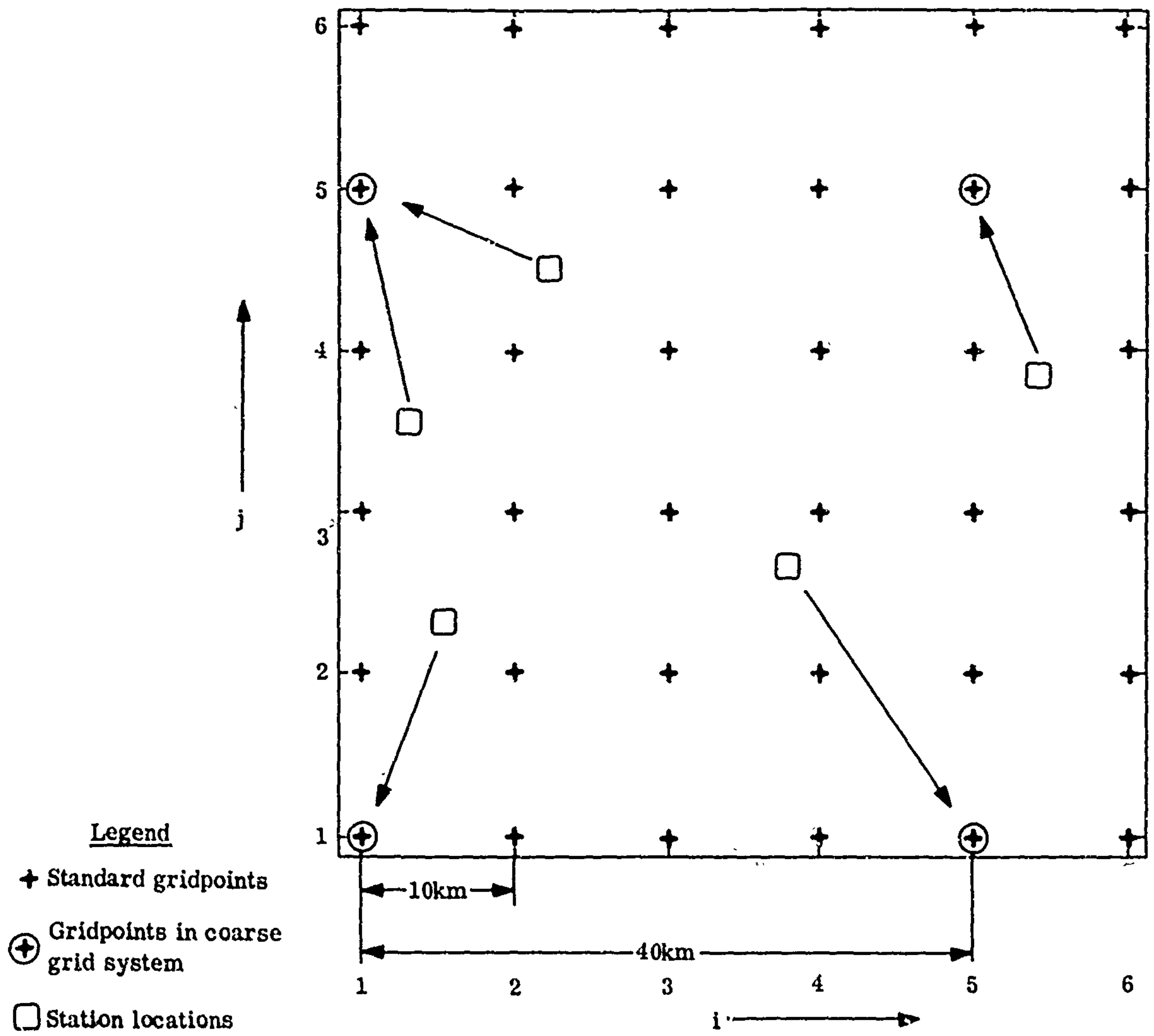

Fig. 2-1. Schematic representation showing how stations are assigned to gridpoints in the initial-guess procedure for a case in which the basic grid interval is 10km.

A second new feature of the program is that the distance between grid points is now an input parameter which means that analyses using various grid intervals can be tested and compared. Initial testing of the basic 10-km grid interval being used and a proposed finer grid of 5 km was conducted. Some examples of this are shown in the next section.

One additional feature being employed involves an alternative form of computer output. Contoured maps can now be generated using a cathode-ray tube. The program outputs a tape which contains x,y-coordinates for points on lines representing each isopleth. This tape is fed into a cathode-ray tube (Stromberg Carlson 4020) and activates an electron beam which traces out the x,y-coordinate of the isopleths, the observational data, and any analyzed maxima or minima. A camera photographs the image on the cathode-ray tube and thereby provides output in the form of prints and/or microfilm. To illustrate this feature, analyses of 5-km and 10-km zone winds are included in this form in the next section. Standard contoured analyses in computer printout form are optionally available through use of an input parameter in the program.

Another feature, but not being used at this time, is an option in the program which permits alternative analysis techniques to be used. One of these is the so-called successive approximative technique (SAT). Additional features permit calculation of special fields such as stream function, divergence, and vorticity.

3.0 PRELIMINARY ANALYSIS TESTS

A limited test was conducted of the analysis program using the 5-km grid spacing (i.e., half the grid interval which had been used for previous tests). For zones 1, 4, 7, and 10, 0800 MST 6 February 1965, u, v-zone wind components were analyzed using both the 5- and 10-km grid intervals. The cathode-ray tube was used to generate the output which is shown in Figs. 3-1 through 3-16.

The contours are formed in this procedure by the connection of line segments which is the reason for the lack of curvature of the contours. This problem can be easily overcome by using a finer output grid. There are two intensities of lines. The darker lines represent each 5 knots. There is no automatic labelling of isopleths, but the appropriate labels can be inferred from the plotted data. The lighter of the two sets of numbers represents the observational data where the decimal point represents the observation location. The darker numbers are maxima and minima of the analysis. These are defined as values higher (or lower) than the eight surrounding grid points. The grid region is similar to that used previously. That is, the grid locations range from 50 to 66 in the "x" direction and from 345 to 361 in the "y" direction. The same region is used for the 5-km grid except that the grid units are 50.0, 50.5, 51.0, etc., giving a 33 by 33 grid network as opposed to the 17 by 17 grid using the 10-km spacing.

This type of output allows for more convenient visual inspection than does the machine contoured printout page, especially when it is noted that the fine-grid output would require four pages of printout pasted together to portray the analysis. One can also see both the analysis and the observational data on the same map.

Some of the shortcomings of this type of output are the lack of curvature of isopleths, the absence of labels for contours, and the occasional observation of numbers when data and extrema are located near one another.

Examinations of Figs. 3-1 through 3-16 shows that the finer mesh allows for the inclusion of much more detail than does the 10-km grid. As one would expect, the analyses on the finer grid (33 by 33) fit the observational data more closely than do the analyses on the 17 by 17 grid. There is a tendency for more closed centers to be analyzed on the finer grid. For example, the zone 4 u-component analyses (Figs. 3-3 and 3-4 show a single maximum in the lower left with a value of 25.3 for the 10-km grid (Fig. 3-3), whereas there are two centers of maximum "u" of 24.4 and 24.3 knots in the 5-km grid analysis shown in Fig. 3-4. One method of making a comparative evaluation of the two analyses is to compare them on the basis of ballistic corrections derived from them and applied to the concurrent artillery firings which took place during the data collection. This will be done during the next contract interval.

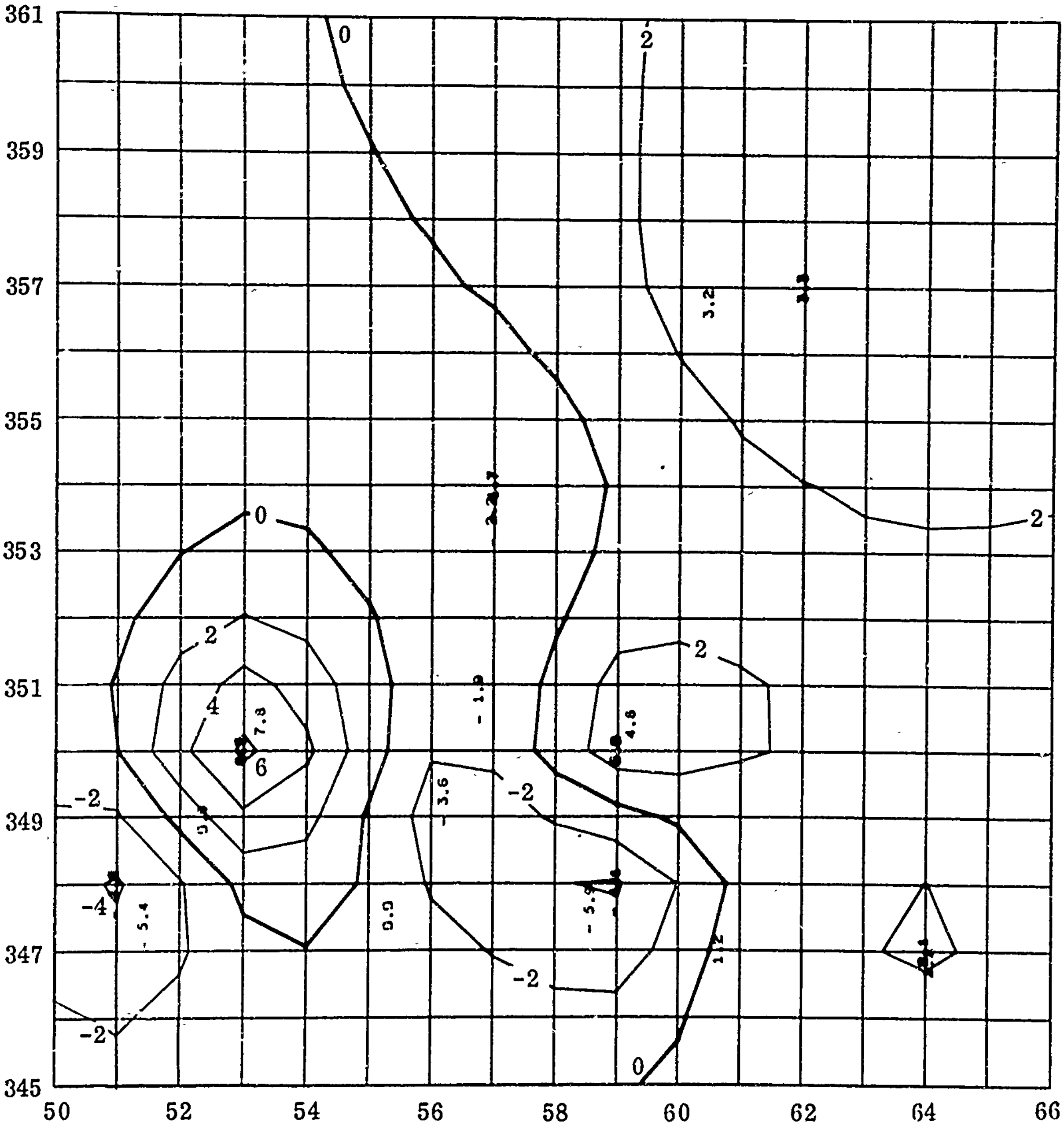

Fig. 3-1. Zone 1, u-component analysis (knots). 10-km grid. 0800 MST 6 Feb 1965.

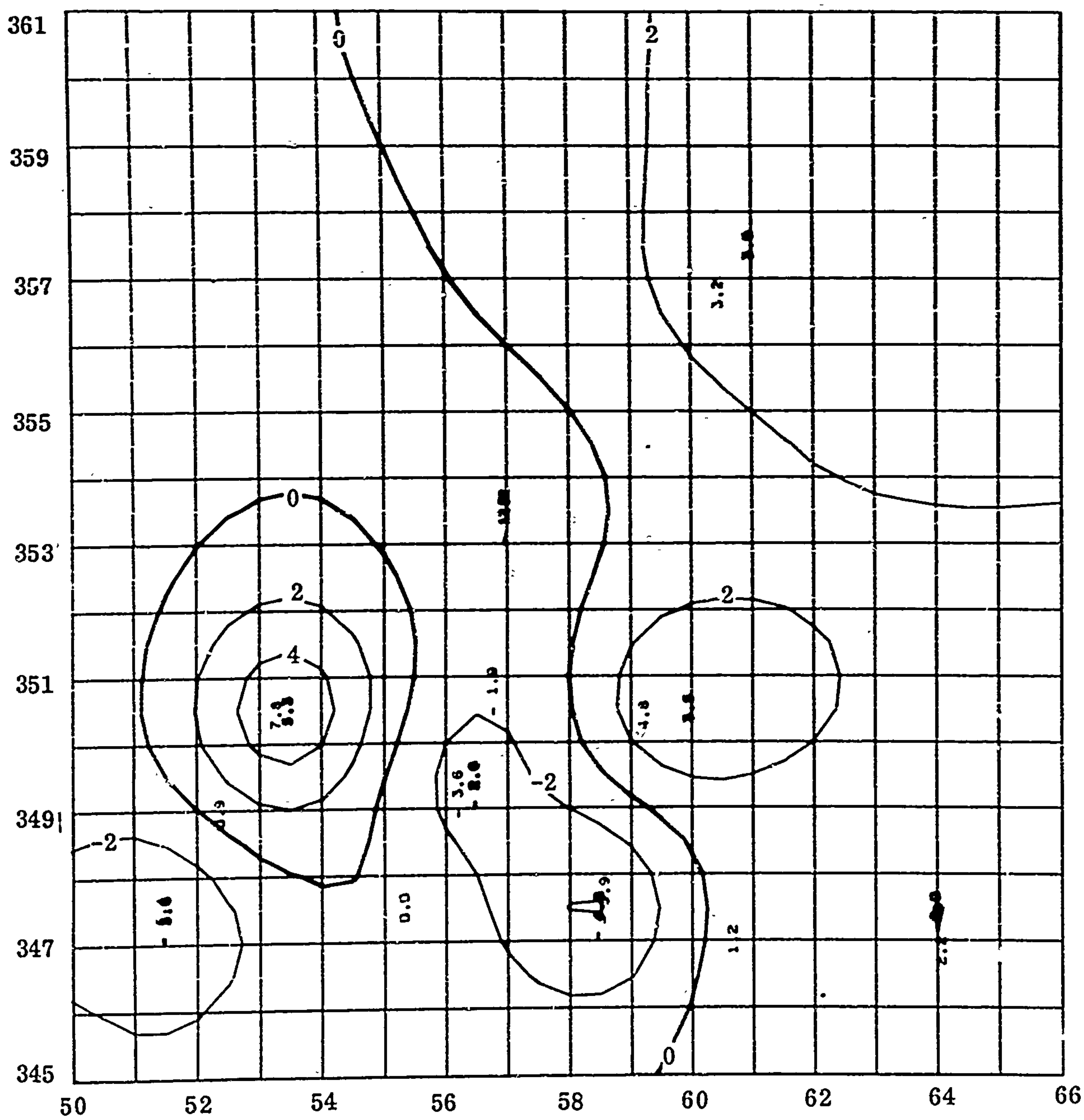

Fig. 3-2. Zone 1, u-component analysis (knots). 5-km grid. 0800 MST 6 Feb 1965.

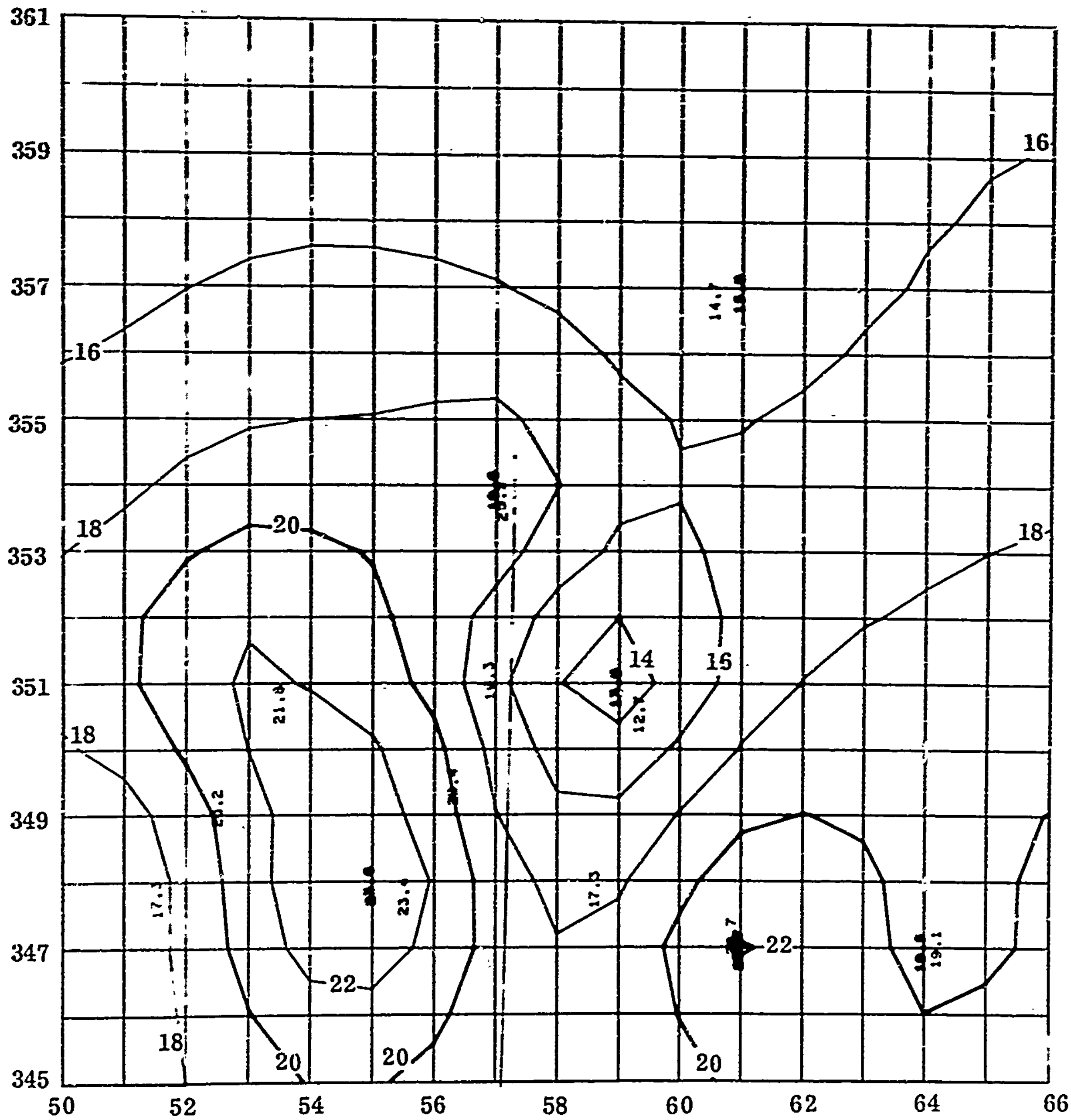

Fig. 3-3. Zone 4, u-component analysis (knots). 10-km grid. 0800 MST 6 Feb 1965.

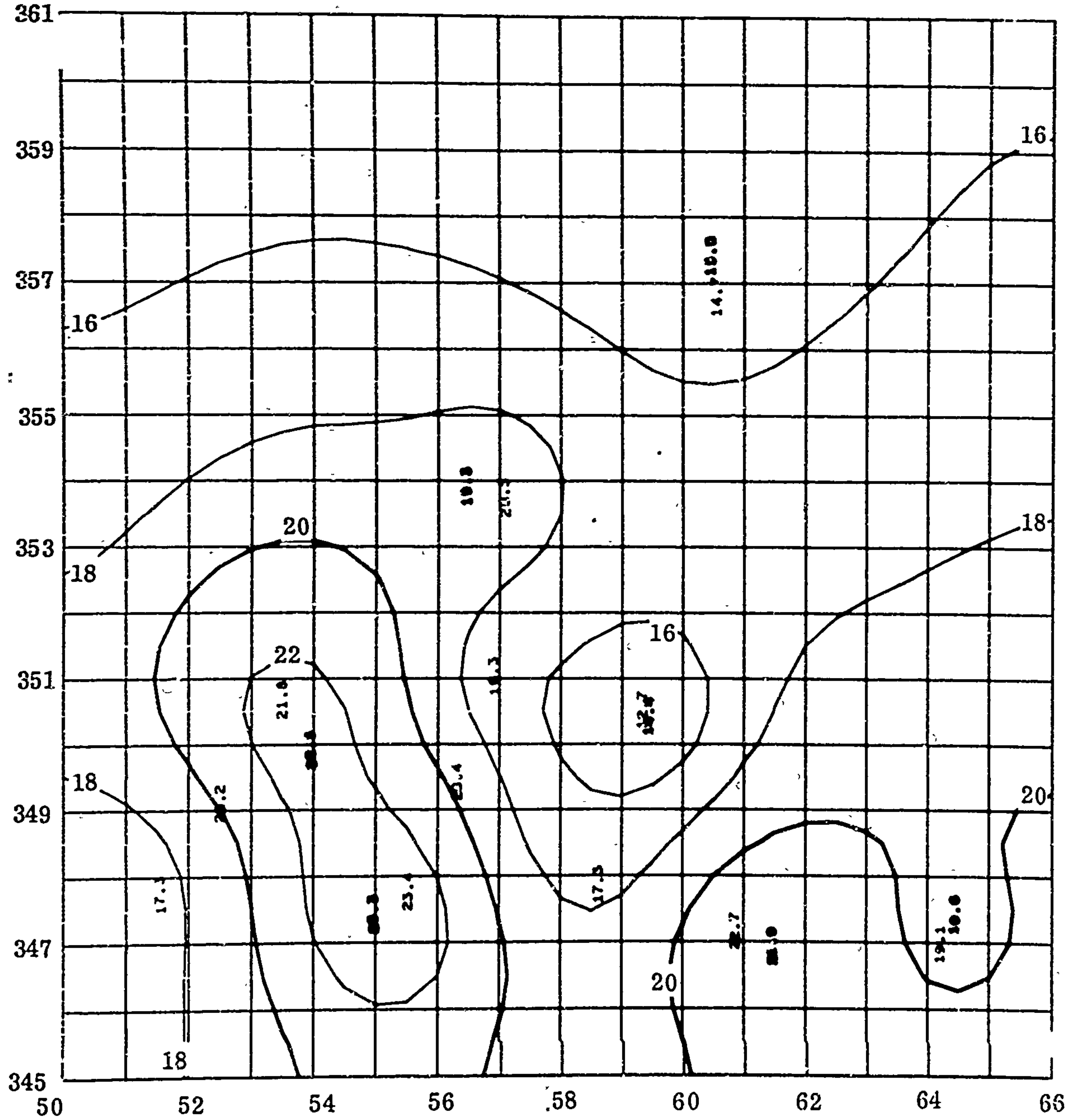

Fig. 3-4. Zone 4, u-component analysis (knots). 5-km grid. 0800 MST 6 Feb 1965.

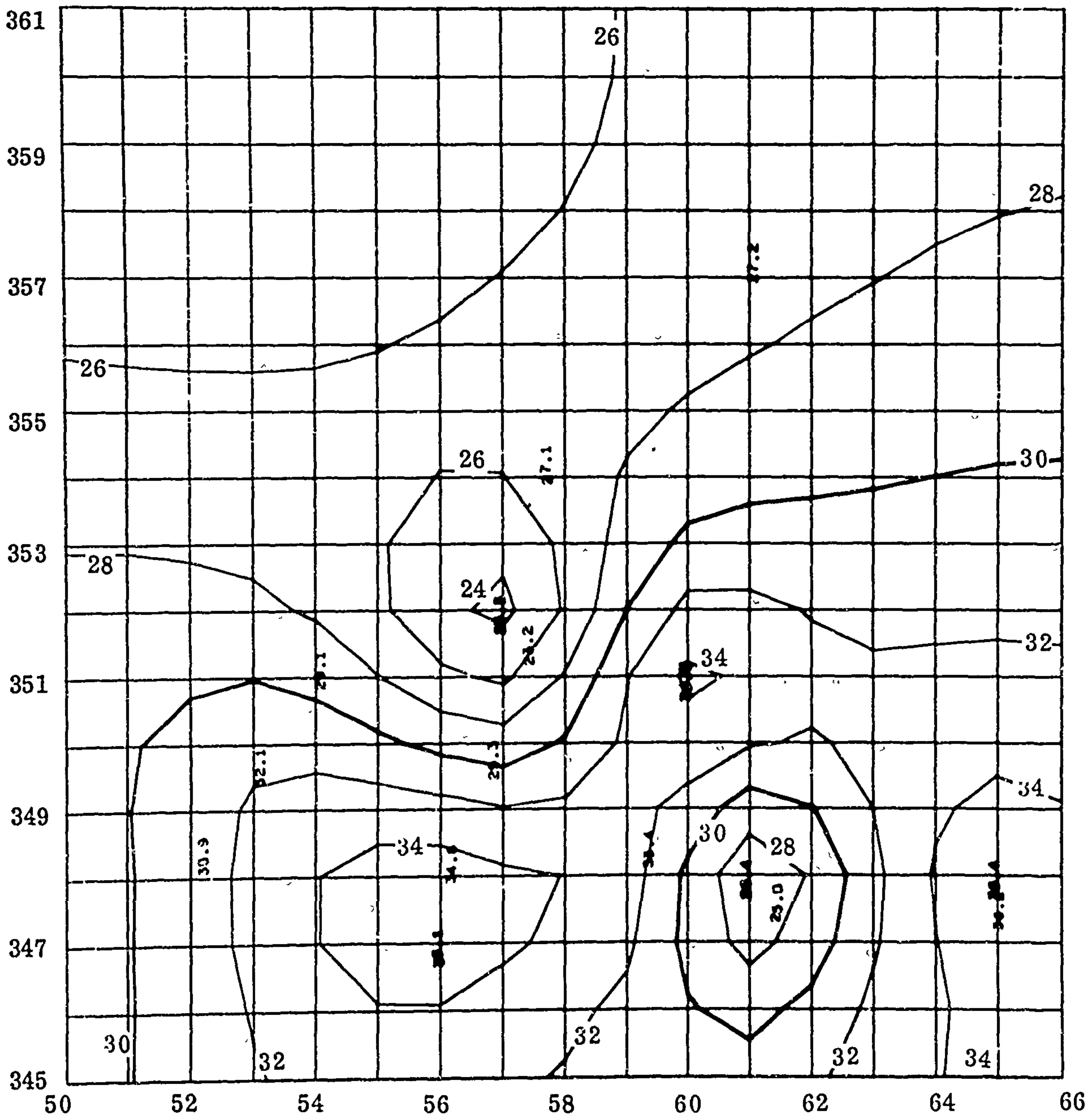

Fig. 3-5. Zone 7, u-component analysis (knots). 10-km grid. 0800 MST 6 Feb 1965.

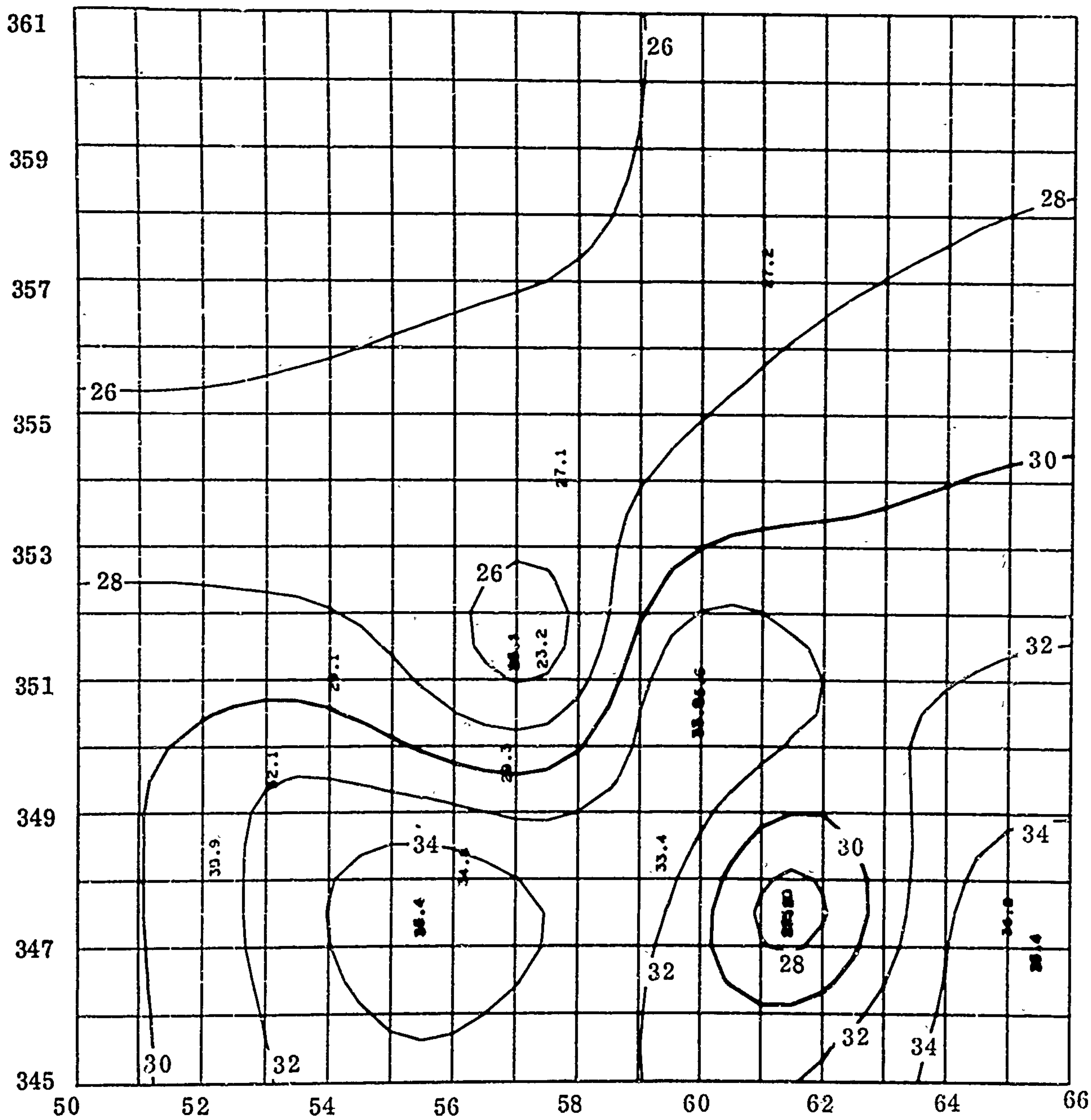

Fig. 3-6. Zone 7, u-component analysis (knots). 5-km grid. 0800 MST 6 Feb 1965.

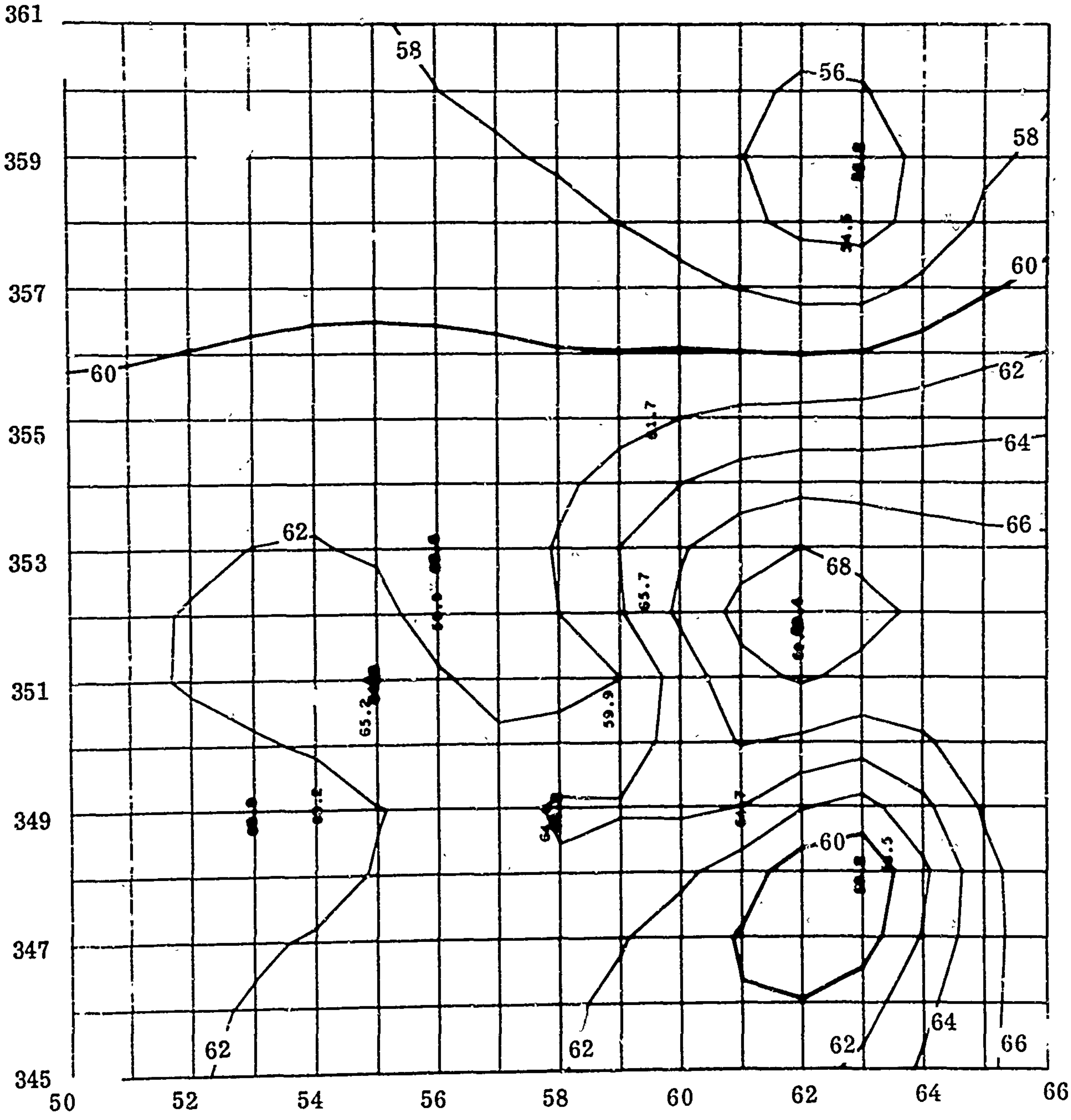

Fig. 3-7. Zone 10, u-component analysis (knots). 10-km grid. 0800 MST 6 Feb 1965.

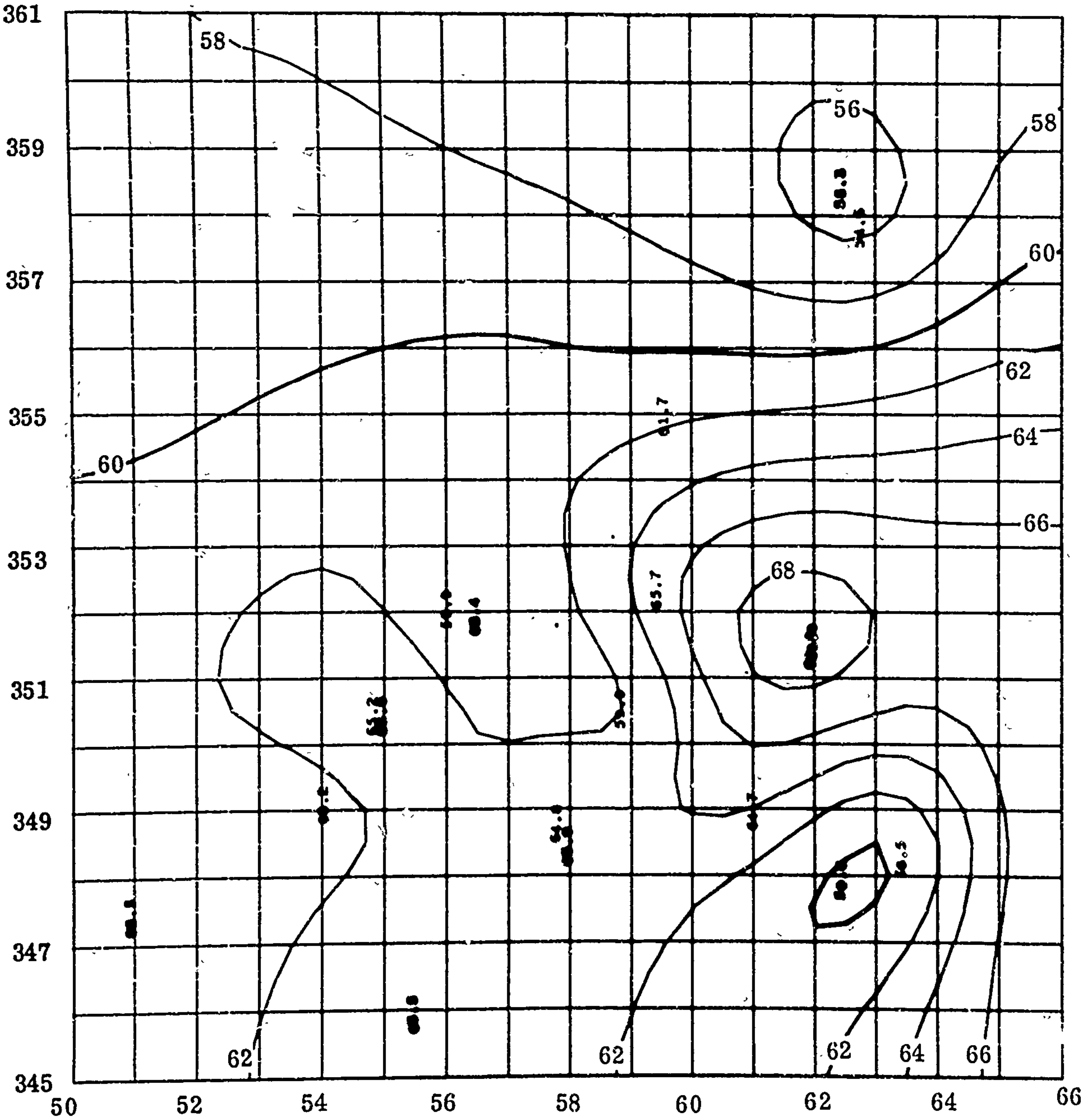

Fig. 3-8. Zone 10, u-component analysis (knots). 5-km grid. 0800 MST 6 Feb 1965.

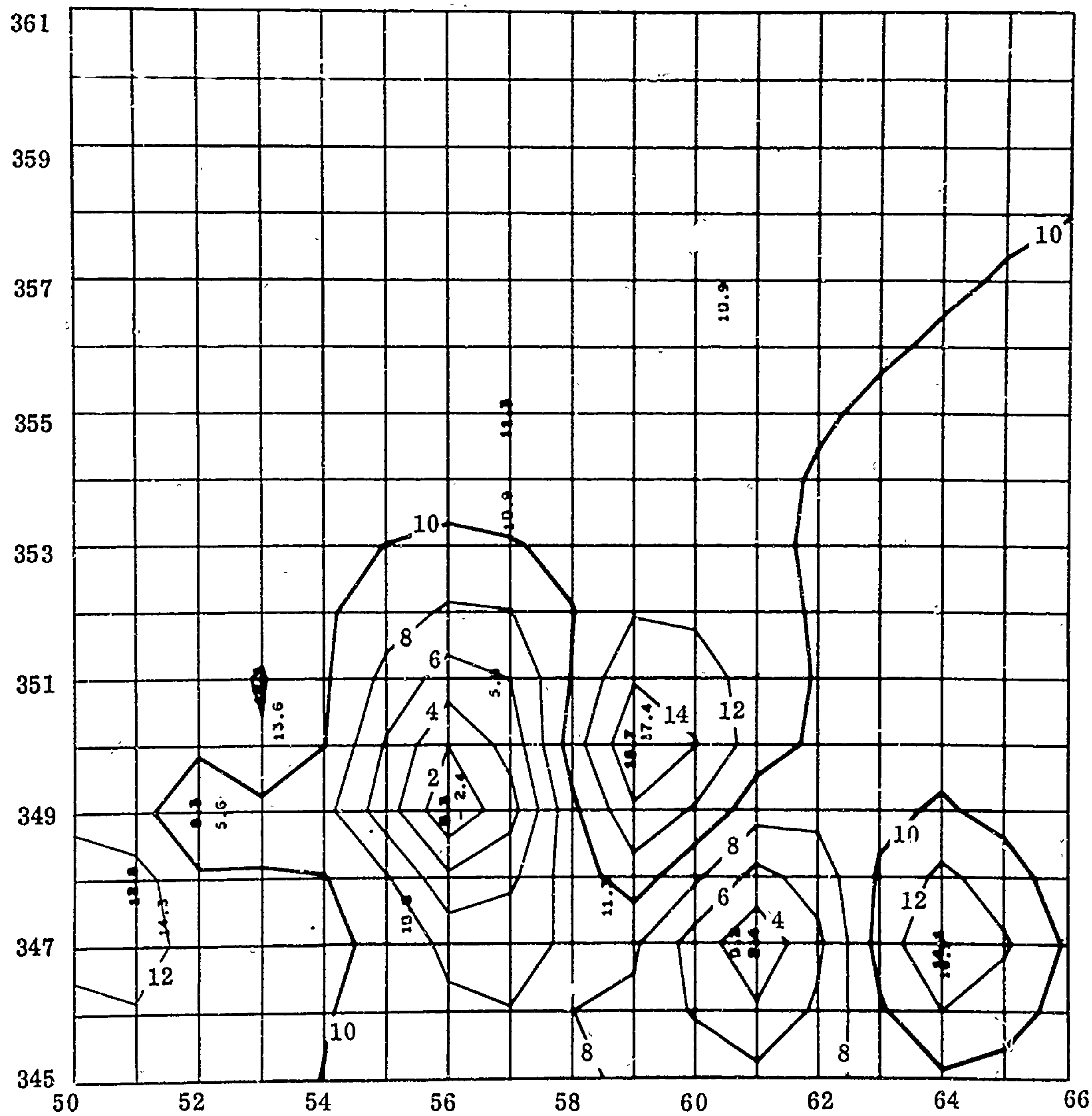

Fig. 3-9. Zone 1, v-component analysis (knots). 10-km grid. 0800 MST 6 Feb 1965.

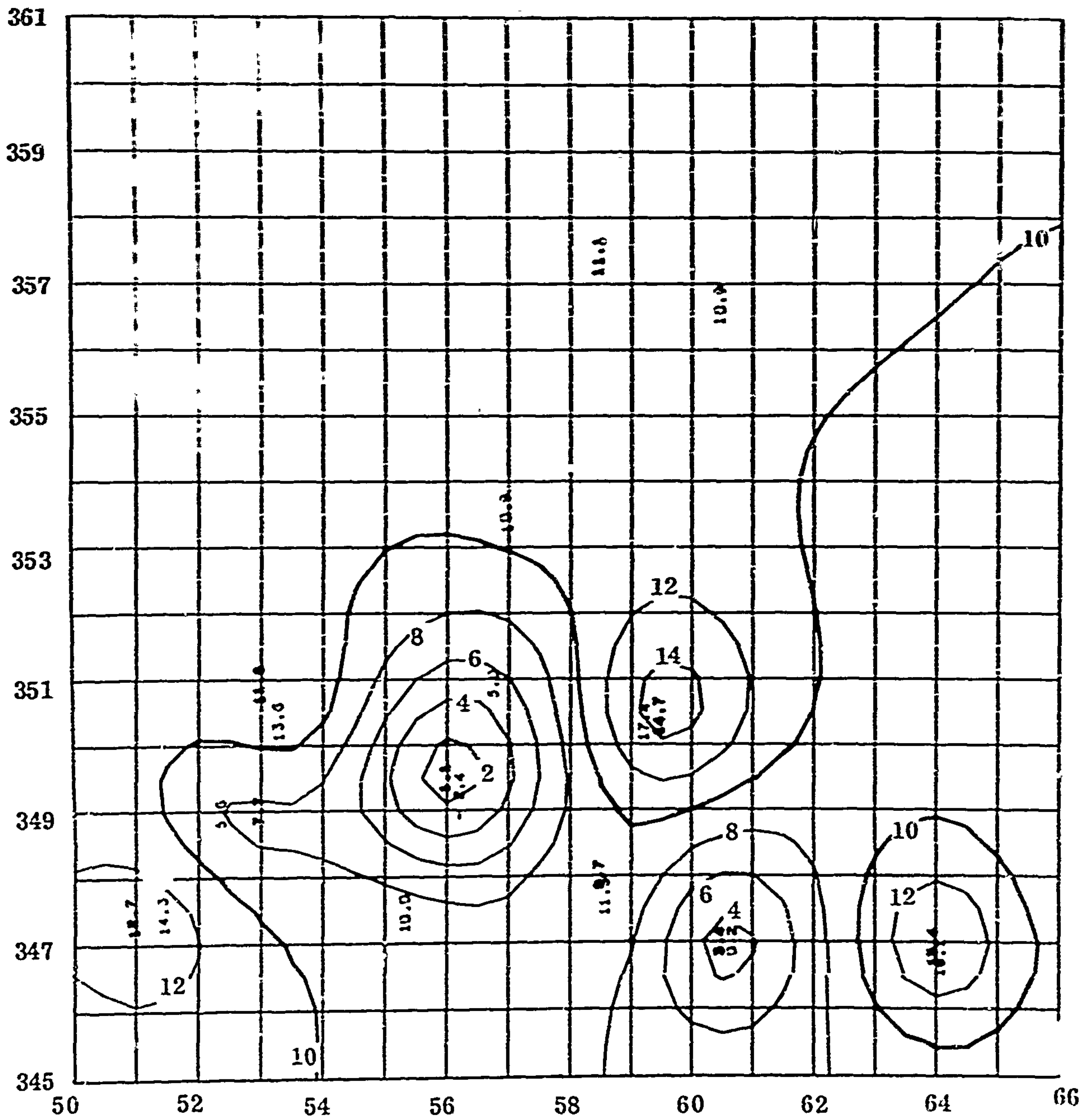

Fig. 3-10. Zone 1, v-component analysis (knots). 5-km grid. 0800 MST 6 Feb 1965.

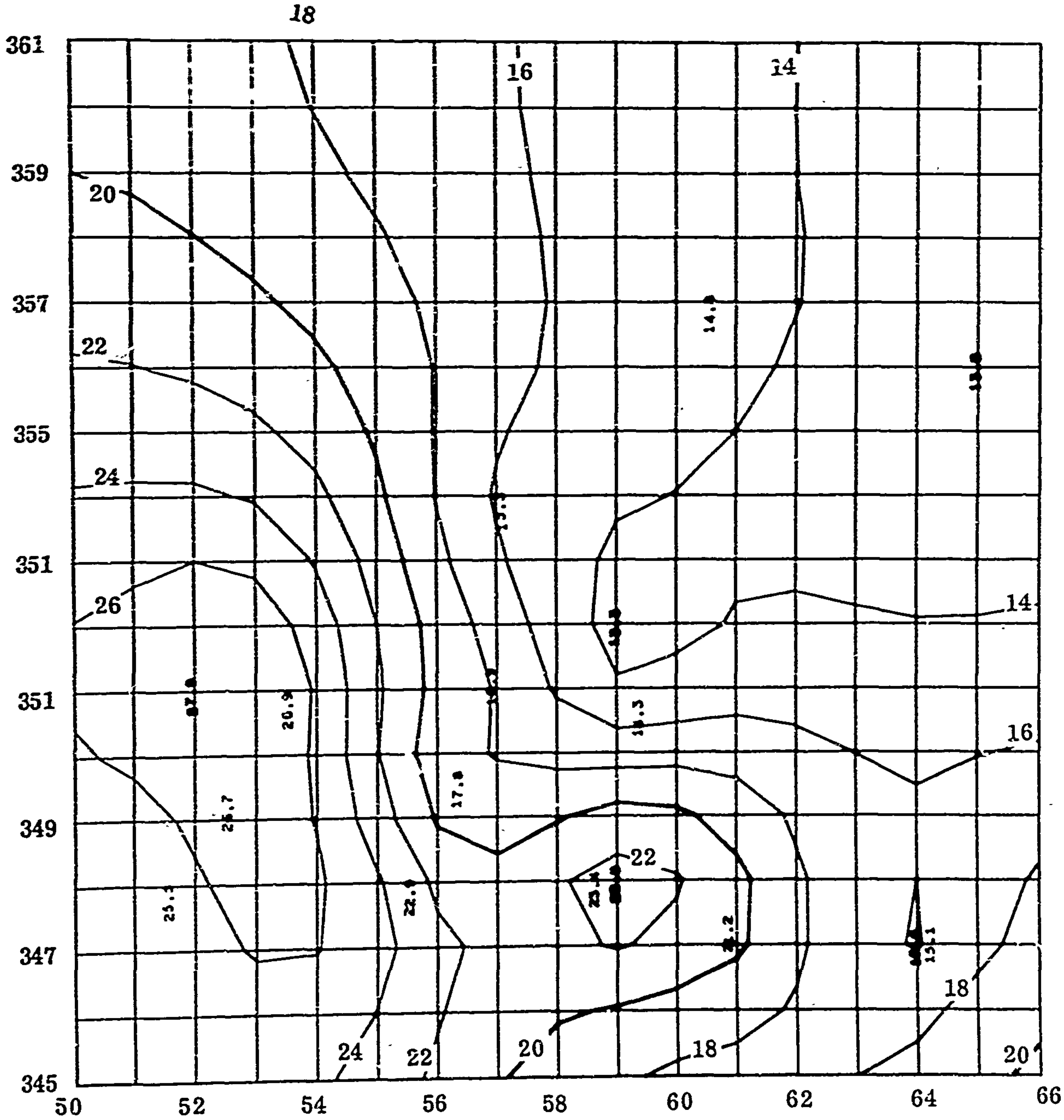

Fig. 3-11. Zone 4, v-component analysis (knots). 10-km grid. 0800 MST 6 Feb 1965.

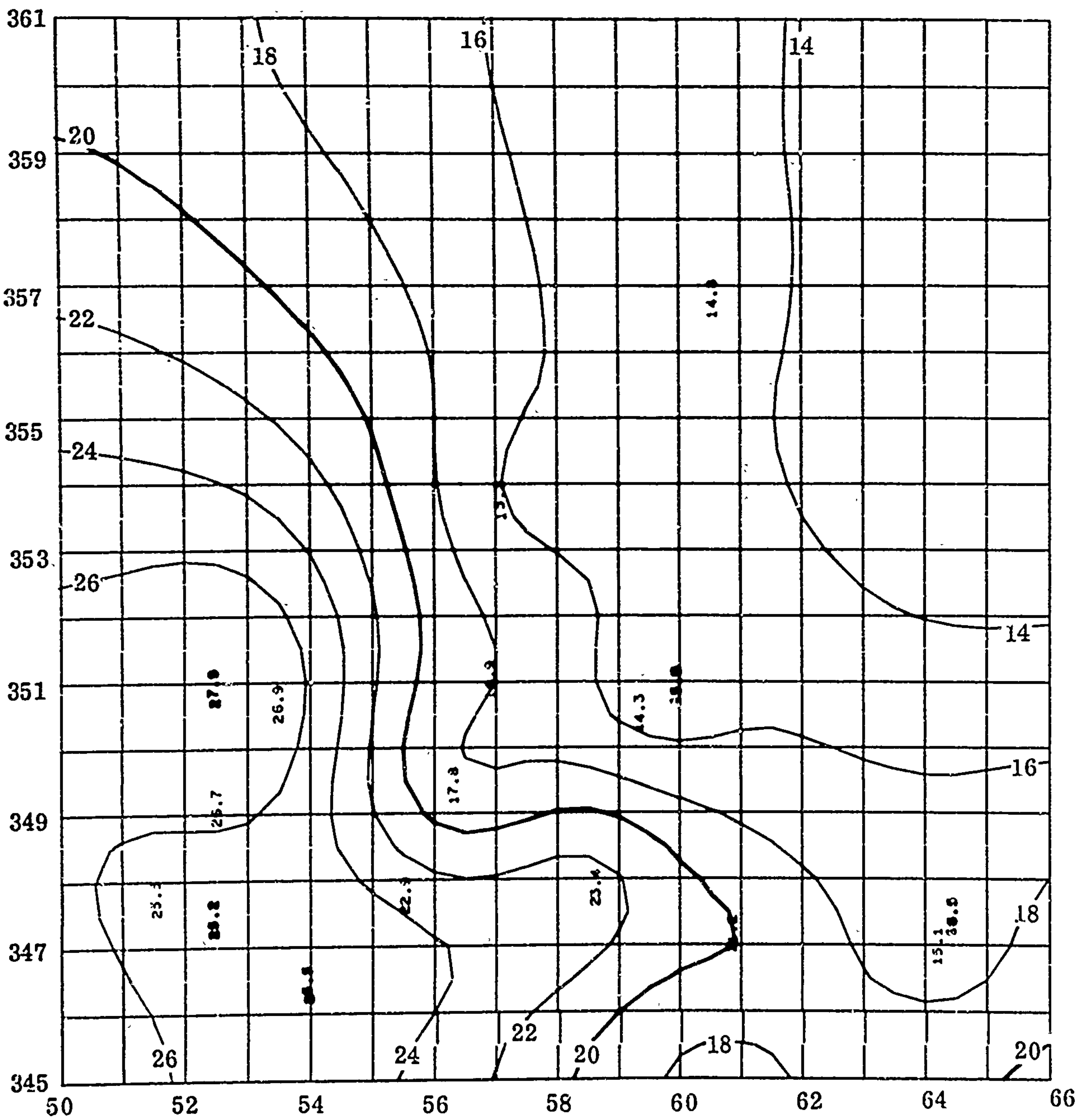

Fig. 3-12. Zone 4, v-component analysis (knots). 5-km grid. 0800 MST 6 Feb 1965.

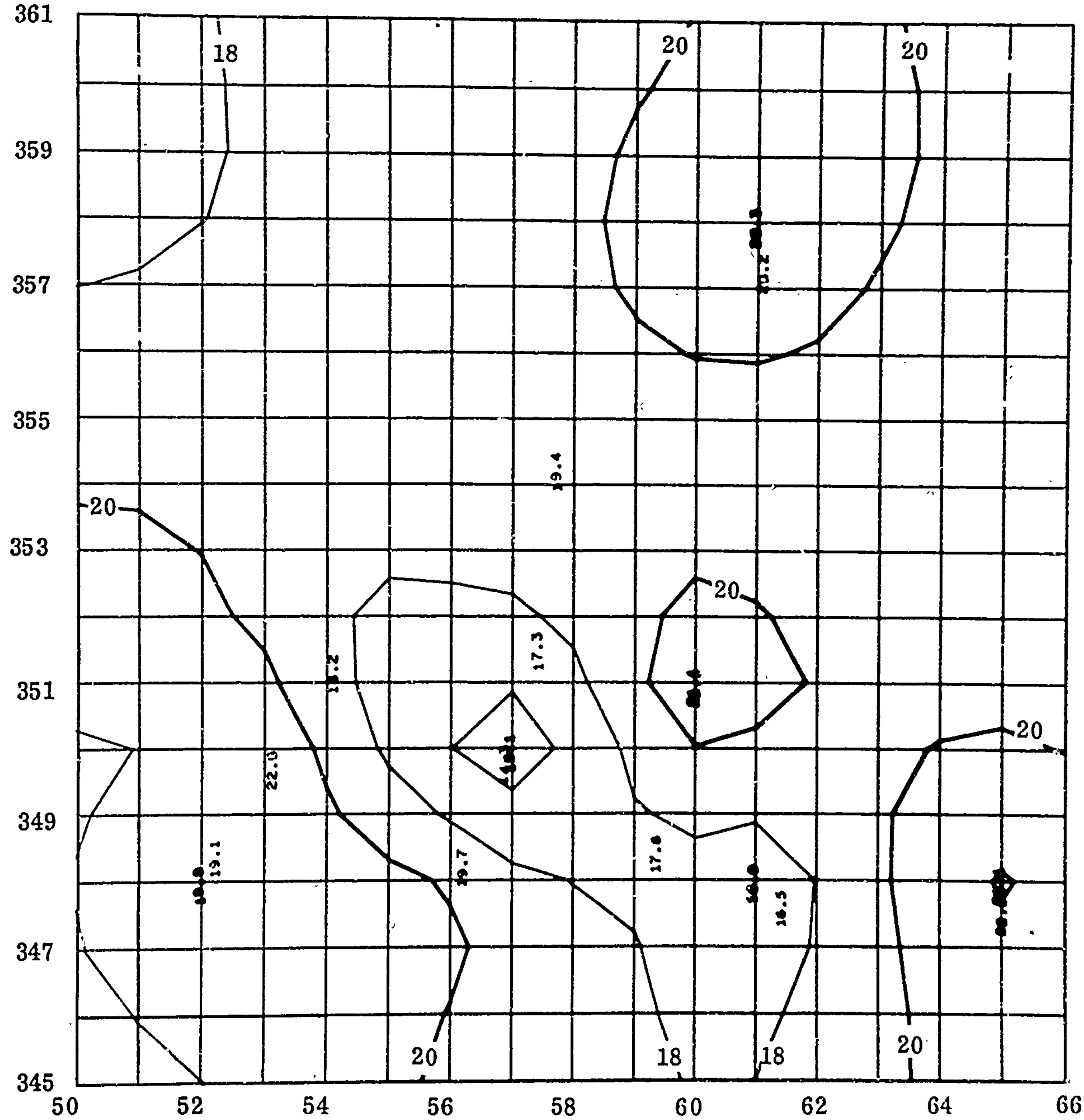

Fig. 3-13. Zone 7, v-component analysis (knots). 10-km grid. 0800 MST 6 Feb 1965.

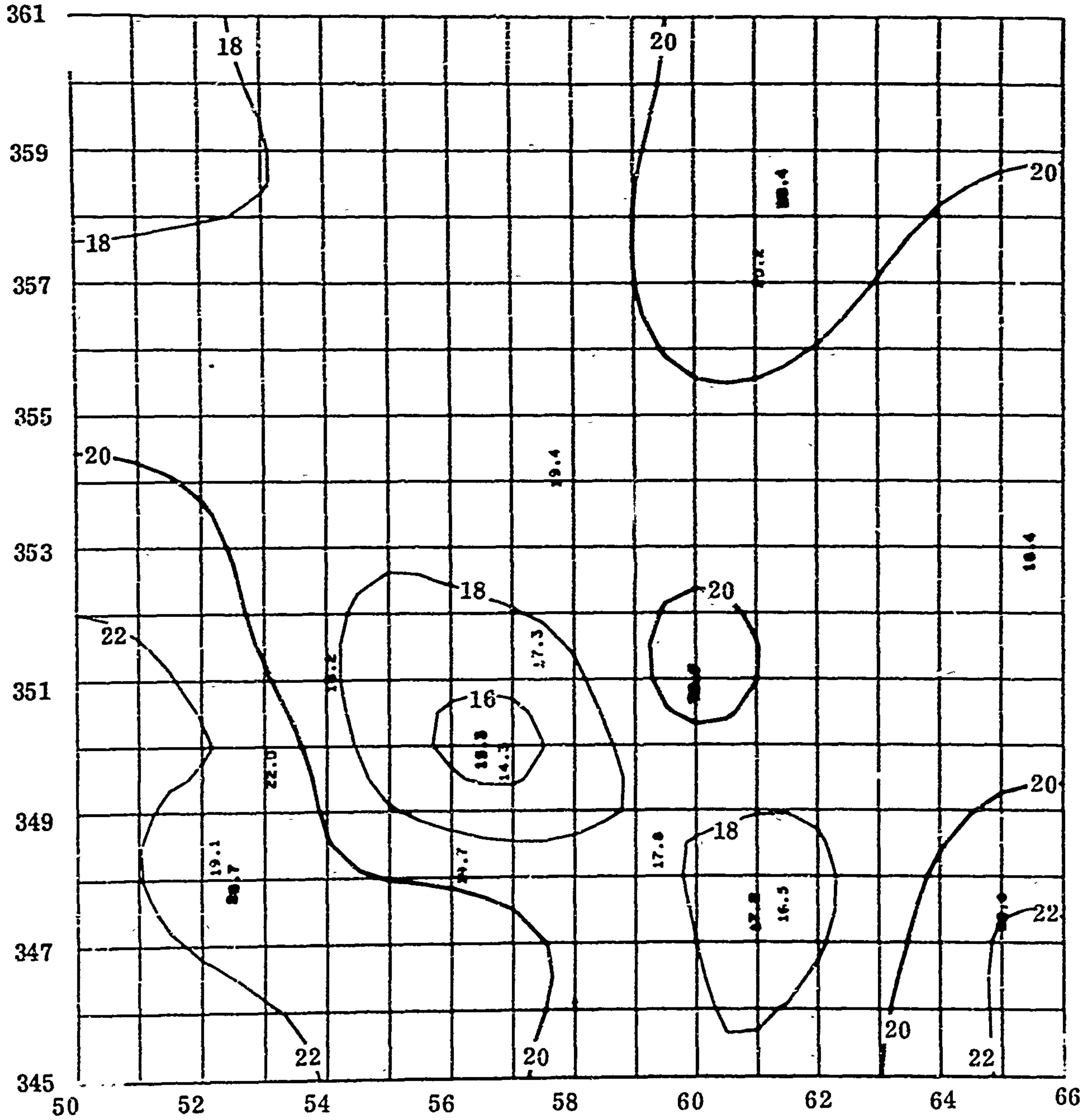

Fig. 3-14. Zone 7, v-component analysis (knots). 5-km grid. 0800 MST 6 Feb 1965.

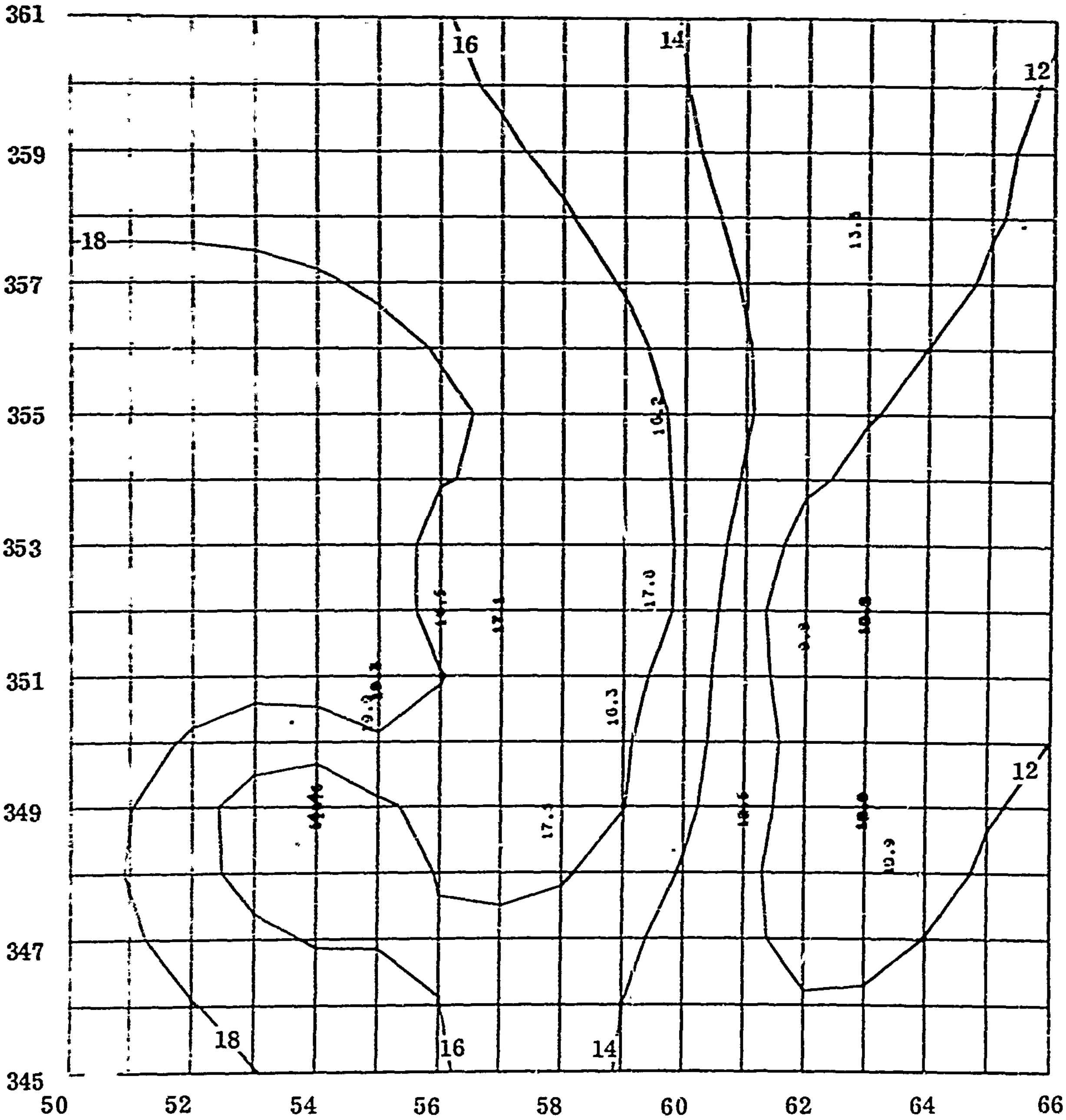

Fig. 3-15. Zone 10, v-component analysis (knots). 10-km grid. 0800 MST 6 Feb 1965.

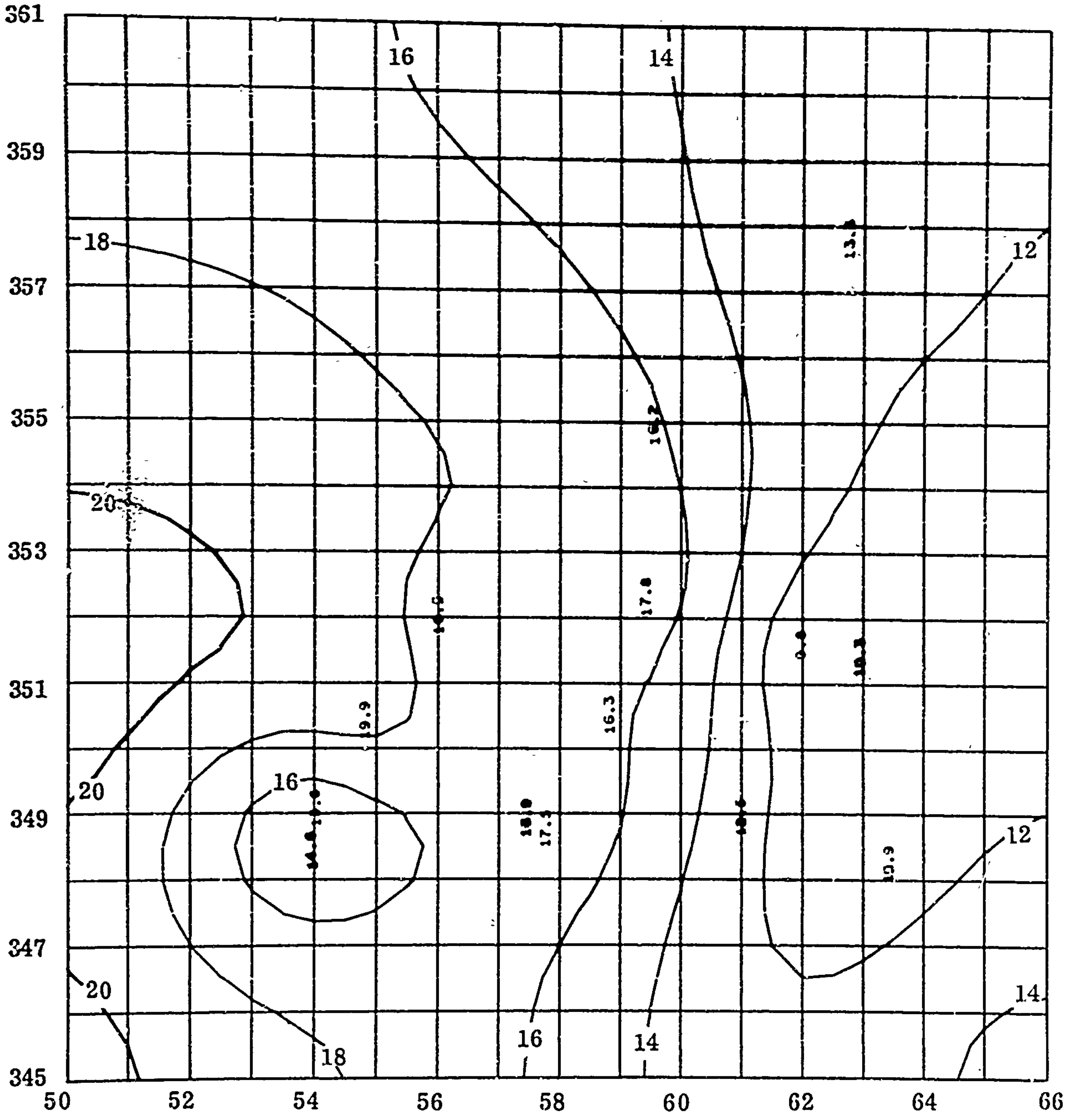

Fig. 3-16. Zone 10, v-component analysis (knots). 5-km grid. 0800 MST 6 Feb 1965.

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

Quarterly Report No. 3, 1 September 1967 to 30 November 1967

5. AUTHOR(S) *(Last name, first name, initial)*

Ostby, Frederick, P.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March 1968	32 + iv	None

8a. CONTRACT OR GRANT NO. DAAB07-67-C0296 b. PROJECT NO. c. 1T0-25001-A-126-01-19 d.	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)* ECOM-0296-3

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