NASA CONTRACTOR
REPORT

NASA CR-120496

REDUCTION AND ERROR ANALYSIS OF THE AVE II PILOT EXPERIMENT DATA

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October 1974

Prepared for

NASA-GEORGE C. MARSHALL SPACE FLIGHT CENTER
Marshall Space Flight Center, Alabama 35812

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
NASA CR-120496		

4. TITLE AND SUBTITLE
Reduction and Error Analysis of the AVE II Pilot Experiment Data

5. REPORT DATE
October 1974

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
Henry E. Fuelberg

8. PERFORMING ORGANIZATION REPORT #

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Center for Applied Geosciences
Texas A&M University
College Station, Texas 77843

10. WORK UNIT NO.

11. CONTRACT OR GRANT NO.
NAS8-26751

12. SPONSORING AGENCY NAME AND ADDRESS
National Aeronautics and Space Administration
Washington, D. C. 20546

13. TYPE OF REPORT & PERIOD COVERED
Contractor Report

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES This report is based on work performed under Contract NAS8-26751 and is published to describe the data reduction techniques and present an error analysis of the rawinsonde data from the AVE II Pilot Experiment. This work was conducted under the direction of Mr. Robert Turner, Aerospace Environment Division, MSFC.

16. ABSTRACT

This report describes the reduction techniques used to process data from the pilot experiment of the second NASA Atmospheric Variability Experiment (AVE IIP), which was conducted during a 24-hour period beginning at 1200 GMT on May 11, 1974, and ending at 1200 GMT on May 12, 1974. Each step of the data handling process is described through the presentation of computer flowcharts, programs, equations, and narrative. An error analysis of the final output is presented, and results of the AVE IIP reduction process are compared with results from the National Weather Service. The AVE IIP sounding data contain more detail than National Weather Service data, but the two data sets may be used together without difficulty.

17. KEY WORDS
Atmosphere
Sounding
Reduction
Computer Program
Error Analysis

18. DISTRIBUTION STATEMENT
Unclassified - Unlimited

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified	140	NTIS

MSFC - Form 3292 (Rev December 1972)

For sale by National Technical Information Service, Springfield, Virginia 22151

FOREWORD

This report is one of several to be published from research conducted under NASA Contract NAS8-26751 entitled "Reduction and Error Analysis of the AVE II Pilot Experiment Data." This effort is sponsored by the NASA Office of Applications under the direction of Marshall Space Flight Center's Aerospace Environment Division. The results presented in this report represent only a portion of the total research effort. Other reports will be published as the research progresses. Previously published research results appear in NASA TMX-64877 entitled "Data for NASA's AVE II Pilot Experiment, Part 1: 25-mb Sounding Data and Synoptic Charts."

ACKNOWLEDGMENTS

Many people contributed directly or indirectly to the preparation of this report. No less than approximately 20 people made contributions in data handling. The author is grateful for the help of every person who worked behind the scenes to accomplish the task of processing the AVE IIP data. The author wishes to express his sincere appreciation to Dr. James R. Scoggins for his invaluable aid. His guidance and helpful suggestions have added greatly to the quality of the final product. Additional thanks are extended to Miss Marilyn Kocurek and Mrs. Nancy Fucik for typing the manuscript and preparing the figures and to Mr. Jim Arnold, Mr. Greg Wilson, and Mr. Jim Overall for their suggestions and stimulating discussions.

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REDUCTION AND ERROR ANALYSIS OF THE AVE II PILOT EXPERIMENT DATA

by

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I. INTRODUCTION

The pilot experiment for the second NASA Atmospheric Variability Experiment (AVE IIP) was conducted during a 24-hour period beginning at 1200 GMT on May 11, 1974, and ending at 1200 GMT on May 12, 1974. Fifty-four rawinsonde stations took part in the experiment supported by the National Aeronautics and Space Administration (NASA). Rawinsonde soundings were taken at 3-hour intervals during the period which yielded a total of 470 soundings. The names and locations of the stations taking part in the AVE II pilot experiment are given in Fig. 1 and Table 1.

This report describes the data reduction techniques used to process the original baseline, angle, and ordinate data, and presents an error analysis of the final output. Copies of all computer programs used in the reduction process are presented. Instructions for using the programs and sample output are given as well.

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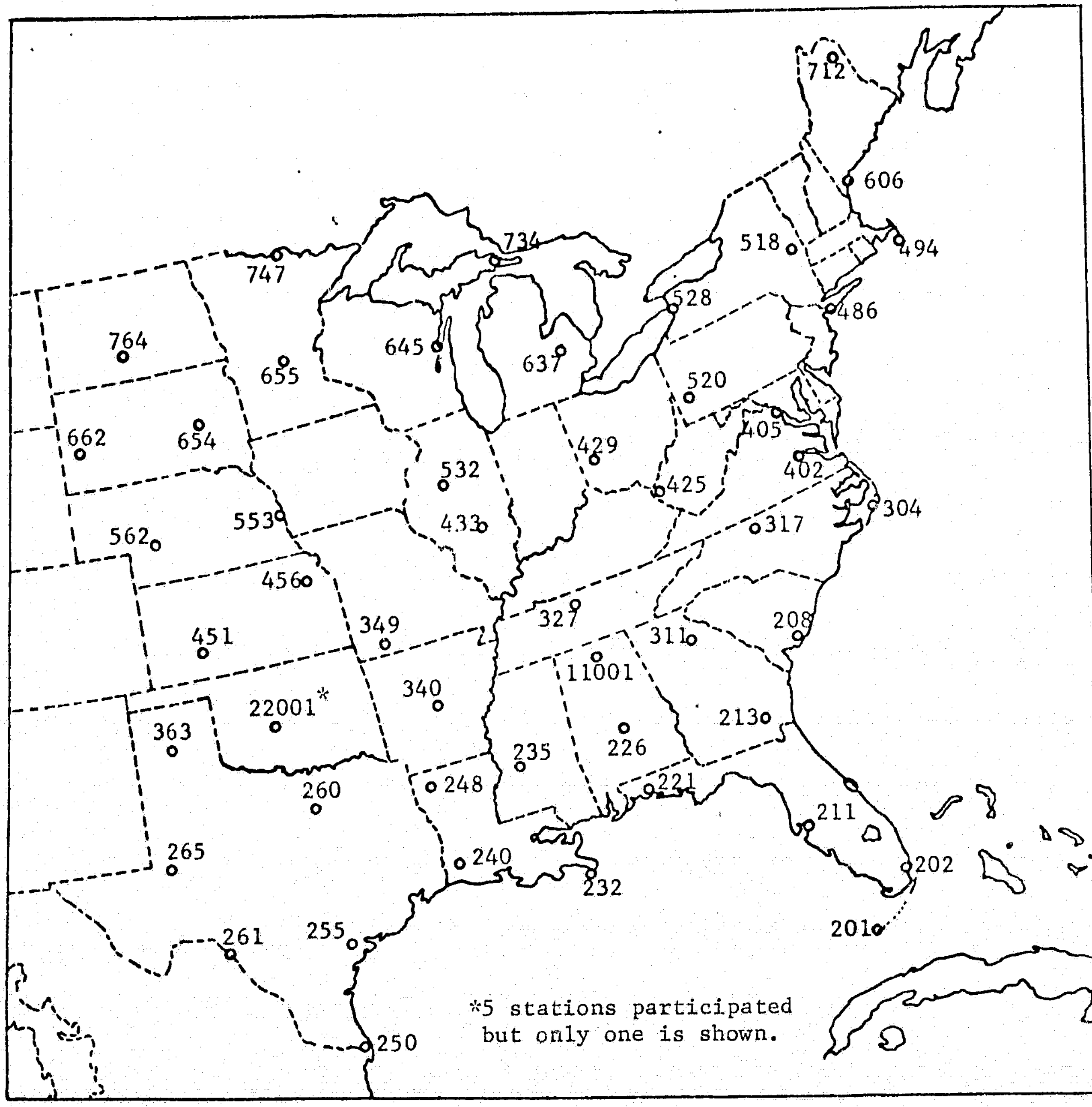


Fig. 1. Rawinsonde stations participating in AVE II pilot experiment.

Table 1

Rawinsonde Stations Participating in AVE II Pilot Experiment

Station Number	Location
11001 (MSF)	Marshall Space Flight Center, Alabama
22001 (OUN)	Norman, Oklahoma
22002 (FSI)	Ft. Sill, Oklahoma
22003 (LNS)	Lindsay, Oklahoma
22004 (FTC)	Ft. Cobb, Oklahoma
22005 (CHK)	Chickasha, Oklahoma
201 (EYW)	Key West, Florida
202 (MIA)	Miami, Florida
208 (CHS)	Charleston, South Carolina
211 (TPA)	Tampa, Florida
213 (AYS)	Waycross, Georgia
221 (VPS)	Eglin AFB, Florida
226 (MGM)	Montgomery, Alabama
232 (BVE)	Boothville, Louisiana
235 (JAN)	Jackson, Mississippi
240 (LCH)	Lake Charles, Louisiana
248 (SHV)	Shreveport, Louisiana
250 (BRO)	Brownsville, Texas
255 (VCT)	Victoria, Texas
260 (SEP)	Stephenville, Texas
261 (DRT)	Del Rio, Texas
265 (MAF)	Midland, Texas
304 (HAT)	Hatteras, North Carolina
311 (AHN)	Athens, Georgia
317 (GSO)	Greensboro, North Carolina
327 (BNA)	Nashville, Tennessee
340 (LIT)	Little Rock, Arkansas
349 (UMN)	Monette, Missouri
363 (AMA)	Amarillo, Texas
402 (WAL)	Wallops Island, Virginia
405 (IAD)	Dulles Airport, Virginia
425 (HTS)	Huntington, West Virginia
429 (DAY)	Dayton, Ohio
433 (SLO)	Salem, Illinois
451 (DOC)	Dodge City, Kansas
456 (TOP)	Topeka, Kansas
486 (JFK)	Kennedy Airport, New York
494 (CHH)	Chatam, Massachusetts
518 (ALB)	Albany, New York
520 (PIT)	Pittsburg, Pennsylvania
528 (BUF)	Buffalo, New York
532 (PIA)	Peoria, Illinois
553 (OMA)	Omaha, Nebraska
562 (LBF)	North Platte, Nebraska

Table 1 (Continued)

Rawinsonde Stations Participating in AVE II Pilot Experiment

Station Number	Location
606 (PWM)	Portland, Maine
637 (FNT)	Flint, Michigan
645 (GRB)	Green Bay, Wisconsin
654 (HUR)	Huron, South Dakota
655 (STC)	St. Cloud, Minnesota
662 (RAP)	Rapid City, South Dakota
712 (CAR)	Caribou, Maine
734 (SSM)	Sault Ste Marie, Michigan
747 (INL)	International Falls, Minnesota
764 (BIS)	Bismarck, North Dakota

II. DATA REDUCTION PROCEDURES

The steps used to reduce the angle and ordinate data to a finished, usable product are shown in Fig. 2. Each of these steps is described in the following sections of this report. General features of the programming language and the computer facilities used at Texas A&M University are described in Appendix A.

A. Data Extraction

The original records for all rawinsonde flights were forwarded to the Marshall Space Flight Center where angle, ordinate, and baseline data were extracted from the records and punched into cards by personnel from Texas A&M University under the supervision of NASA personnel.

A baseline card was punched for each sounding which contained surface data and temperature and moisture calibration variables. Table 2 gives the name and column location of all data on the baseline cards. Figure 3 shows a sample baseline card. The station height was generally missing which was indicated by a field of nines in the appropriate columns.

A series of data cards containing ordinate information was punched for each sounding. A typical sounding run ascended to about 20 mb and contained about 160 ordinate cards. A list of the data contained on an ordinate card is given in Table 3, and a sample card is shown in Fig. 3. Contact number and pressure were always indicated on the cards, but missing values of temperature ordinate, humidity ordinate, or time were indicated by filling the particular columns with nines. Information for the cards was obtained from the original strip chart of the sounding and the pressure calibration chart for the individual

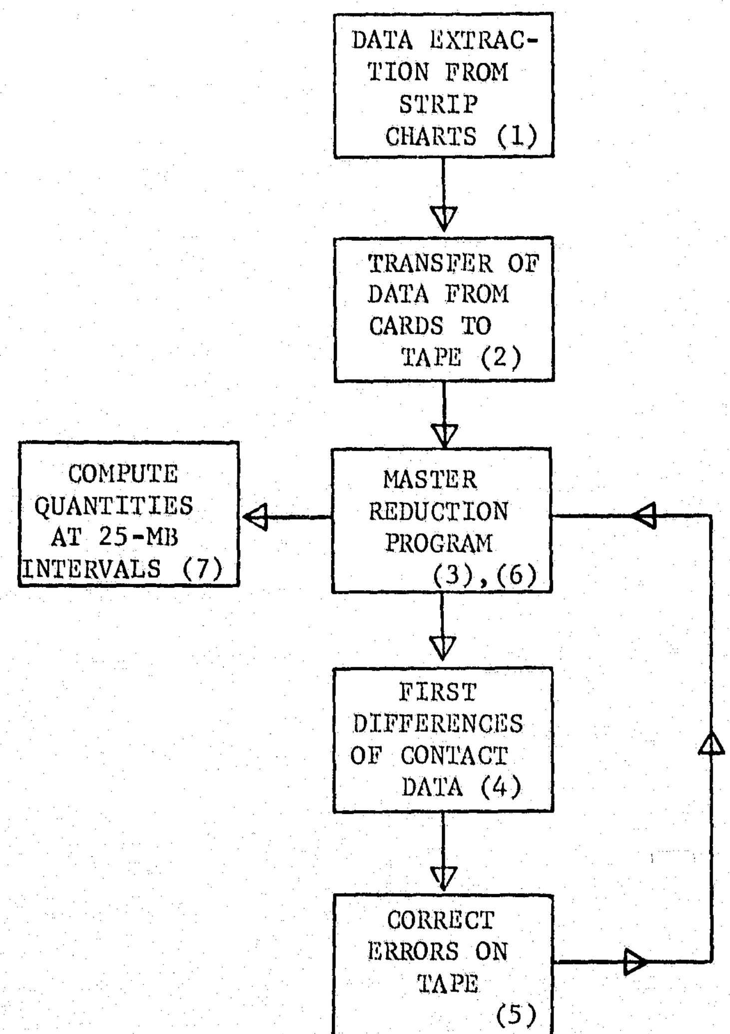


Fig. 2. Steps of the data reduction process.

Table 2

Baseline Data Cards

Columns	Variable
1	GMD type.
3-6	Station elevation in meters.
8-11	Pressure contact number at the surface.
13-18	Surface pressure in millibars.
20-23	Surface temperature in degrees Celsius.
25-28	Surface relative humidity in percent.
30-33	Baseline temperature corresponding to an ordinate of 37.6 units. The temperature is always negative, but the minus sign is omitted.
35-38	Baseline relative humidity at -40C and ordinate 46.
40-43	Surface wind speed in meters per second.
45-47	Surface wind direction in degrees.
50-51	Month of rawinsonde release.
53-54	Day of rawinsonde release.
56-57	Year of rawinsonde release.
59-62	Time of rawinsonde release in GMT.
64-68	Station identification number.
72	Angle identifier. A '1' indicates that angle data for the sounding run are given every minute while a blank indicates that angle data are available every 30 sec. This value was punched after the cards were received at Texas A&M University.

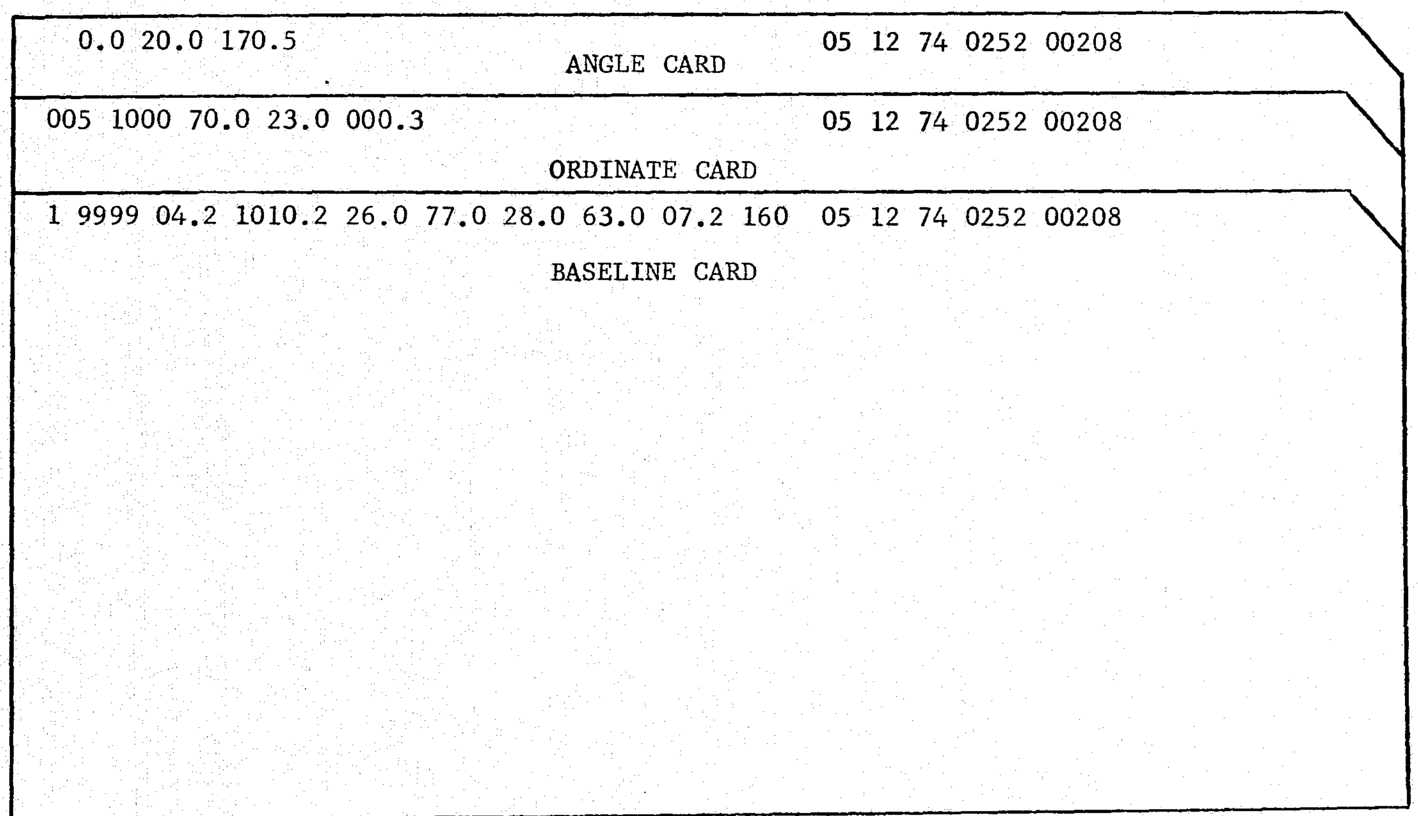


Fig. 3. Sample baseline, ordinate, and angle cards.

Table 3

Ordinate Data Cards

Columns	Variable
1-3	Pressure contact number corresponding to the given pressure.
5-8	Pressure at the given contact.
10-13	Temperature ordinate.
15-18	Humidity ordinate.
20-24	Time from rawinsonde release.
50-51	Month of rawinsonde release.
53-54	Day of rawinsonde release.
56-57	Year of rawinsonde release.
59-62	Time of rawinsonde release in GMT.
64-68	Station identification number.
72	A '1' indicates the last card of the ordinate deck.
73	A '1' indicates that either the temperature ordinate or the time from release have been manually interpolated. This value was punched after the cards were received at Texas A&M University.

sonde. If one wished to manually interpolate temperature ordinate or time, this could be done, and by punching a '1' in column 73, the fact would be indicated by an asterisk in the final output. Manual interpolation was rarely done, however. Interpolation schemes using the reduction program are described in detail in subsequent sections of the report. The date, time, and station number given in columns 50-68 are sometimes erroneous due to mistakes in keypunching and should not be relied upon by users, but this data is always correct on the baseline card.

Angle data for each sounding were punched on a separate deck of cards. In most cases, angles were available every 30 sec by reading them directly from the recorder charts, but in some instances, either at 0000 GMT or 1200 GMT, the rawinsonde operators recorded angles at only 1-min intervals. As shown in Table 2, this fact is indicated on the baseline card. Table 4 describes the contents of the angle cards while Fig. 3 shows a sample card. After investigation it was decided not to perform manual smoothing or to manually check elevation angles, but instead to do this by use of the reduction program. Missing data were indicated by nines in the particular columns. As was the case for the ordinate data, the sounding descriptions given in columns 50-68 are sometimes erroneous and should not be used.

As angle and ordinate decks were completed the data were checked for errors by NASA personnel by computing first differences on the raw data. Errors were corrected as they were found; this was the first phase of error checking.

Table 4

Angle Data Cards

Columns	Variable
1-5	Time from rawinsonde release.
7-10	Elevation angle.
12-16	Azimuth angle.
50-51	Month of rawinsonde release.
53-54	Day of rawinsonde release.
56-57	Year of rawinsonde release.
59-62	Time of rawinsonde release in GMT.
64-68	Station identification number.
72	A '1' indicates the last card of the angle deck.
73	A '1' indicates that some type of manual smoothing was performed on the data at Texas A&M University.
74	A '1' indicates that the elevation angle was less than some given quantity.

B. Transfer of the Data to Tape

After the initial data check, the cards were forwarded to Texas A&M University for further processing. A complete sounding deck consisting of a baseline card, ordinate cards, and angle cards was created for each rawinsonde run. Care was taken to insure that stations and times were correctly matched. The sounding decks were then arranged according to increasing station identification number, and within the same station by increasing time, in preparation for transfer to magnetic tape.

A program was written to transfer the card decks to magnetic tape and to create a "leader card" which would precede the baseline information of each sounding. The "leader card" contains the date, time, and station number of the sounding that was found in columns 50-68 of the baseline card and also contains the total number of cards (records) for the sounding. This quantity enables one to quickly skip over a complete sounding when using the tape. The format of the leader card is given in Table 5; baseline, ordinate, and angle data on magnetic tape have the same format as when the data were on cards (Tables 2-4). A copy of the computer program and instructions for its use are found in Appendix B.

A simple program was written to print the contents of the raw data tape. A copy of the program along with instructions for its use are found in Appendix C. The program simply reads each record and prints the contents as they appeared on the original cards. The data list produced by the program proved valuable in later error checking procedures.

Tab! 5

Format of the "Leader Cards"

Columns	Variable
1-2	Month of rawinsonde release.
4-5	Day of rawinsonde release.
7-8	Year of rawinsonde release.
10-13	Time of rawinsonde release in GMT.
15-19	Station identification number.
21-24	Total number of cards (records) comprising the sounding.

C. Master Reduction Program

This program was the most important in the data reduction process since it computed meteorological parameters for each pressure contact from baseline, ordinate, and angle data that had been previously stored on tape. A copy of the program is found in Appendix D along with instructions for its use. The accuracy of the output is described in Section III. The program can be conveniently divided into several functional components as follows to facilitate its description; a flowchart of the program is given in Fig. 4.

1. Program Initialization. The first section of the program initializes the necessary arrays, defines functions to compute temperature (RESIST) and virtual temperature (XVIRT), and defines constants to be used in humidity determination (DATAC). All variables that will be printed and transferred to magnetic tape as final output are initially defined to be zero. The station roster containing the station identification number, elevation, latitude, longitude, and name is read from data cards followed by the number of soundings to process or skip. All of the remaining data is read from magnetic tape.

2. Baseline Calibration. The first record to be read from tape is the "leader card" described in Table 5. If one desires to compute consecutive soundings beginning with the first sounding, the information on the "leader card" is not used; however, if one wishes to calculate certain soundings and skip others, the information is used to read raw sounding data, skip the computation phase, and then begin with the next "leader card" until the desired station and time are

located. The baseline data for the sounding to be computed are read using the format described in Table 2. Baseline temperature constants are set up at this stage for later use in computing temperature at each pressure contact. The equations used in this section of the program and the temperature computation section are identical to those currently used by the National Weather Service (NWS) and are described by Billions (1965). The baseline equations are reproduced here:

$$RTB = EXP\left[16.0082991 - 0.9966256 \cdot LOG_e(2 \cdot 37.6)\right] - 48000.0, \quad (1)$$

$$RK1 = TO + 273.15, \quad (2)$$

$$RM1 = 5.3018981 \left(\frac{1.0}{303.0} - \frac{1.0}{RK1}\right), \quad (3)$$

$$RM2 = \frac{-2.47991E\text{-}3 + \left[(2.47991E\text{-}3)^2 - 4.0 \cdot 5.89986E\text{-}5 \cdot RM1\right]^{\frac{1}{2}}}{2.0 \cdot 5.89986E\text{-}5}, \text{ and} \quad (4)$$

$$RM3 = \frac{14000.0}{RTB} \cdot EXP(RM2). \quad (5)$$

TO is the negative temperature corresponding to an ordinate of 37.6 units; the value RM3 is used later.

Constants to be used later in humidity computation are evaluated next. The scheme used in this program is based on a procedure described in IRIG Document 108-72 published by the White Sands Missile Range (1972). The 20 constants for humidity computation (HC1-HC20) are based on the following equations:

$$\begin{array}{ccccccc} HC1 & = & C1 & + & C2 & \cdot & RHO \\ \vdots & & \vdots & & \vdots & & \vdots \\ HC20 & = & C39 & + & C40 & \cdot & RHO \end{array} \quad (6)$$

C1 through C20 are constants determined by the type of humidity element used in the sonde, while RHO is the baseline humidity at a temperature of -40C and ordinate 46. The differences between the humidity computation procedures of the NWS and this program will be described in Section III-C.

3. Reading the Ordinate Data. The ordinate data described in Table 3 are read from magnetic tape. Although pressure contact number and the corresponding pressure are always available, time from release, humidity ordinates, and temperature ordinates may be missing. Since time at each pressure contact is necessary in the reduction scheme, a linear interpolation procedure is used to assign time where it is missing. If interpolation is performed, a locator array (IORIN) is used to mark this fact on the final output with an asterisk. Missing temperature values are interpolated in a later section, but humidity is not interpolated.

4. Reading the Angle Data. Most raw angle data were obtained for 30-sec intervals, but at 0000 GMT and 1200 GMT, the data at some stations were available at only 1-min intervals (I1MIN = 1). In many cases the 30-sec angle data did not begin at the time of release but began at some time after release; therefore, the first angle record is checked to determine if it begins at time = 0. If it does not begin at time = 0, a linear interpolation scheme is used to fill in the missing time, but the missing angles themselves are not interpolated. The fact that interpolation was performed would appear in the final output as missing wind data. Once the angles are determined to begin

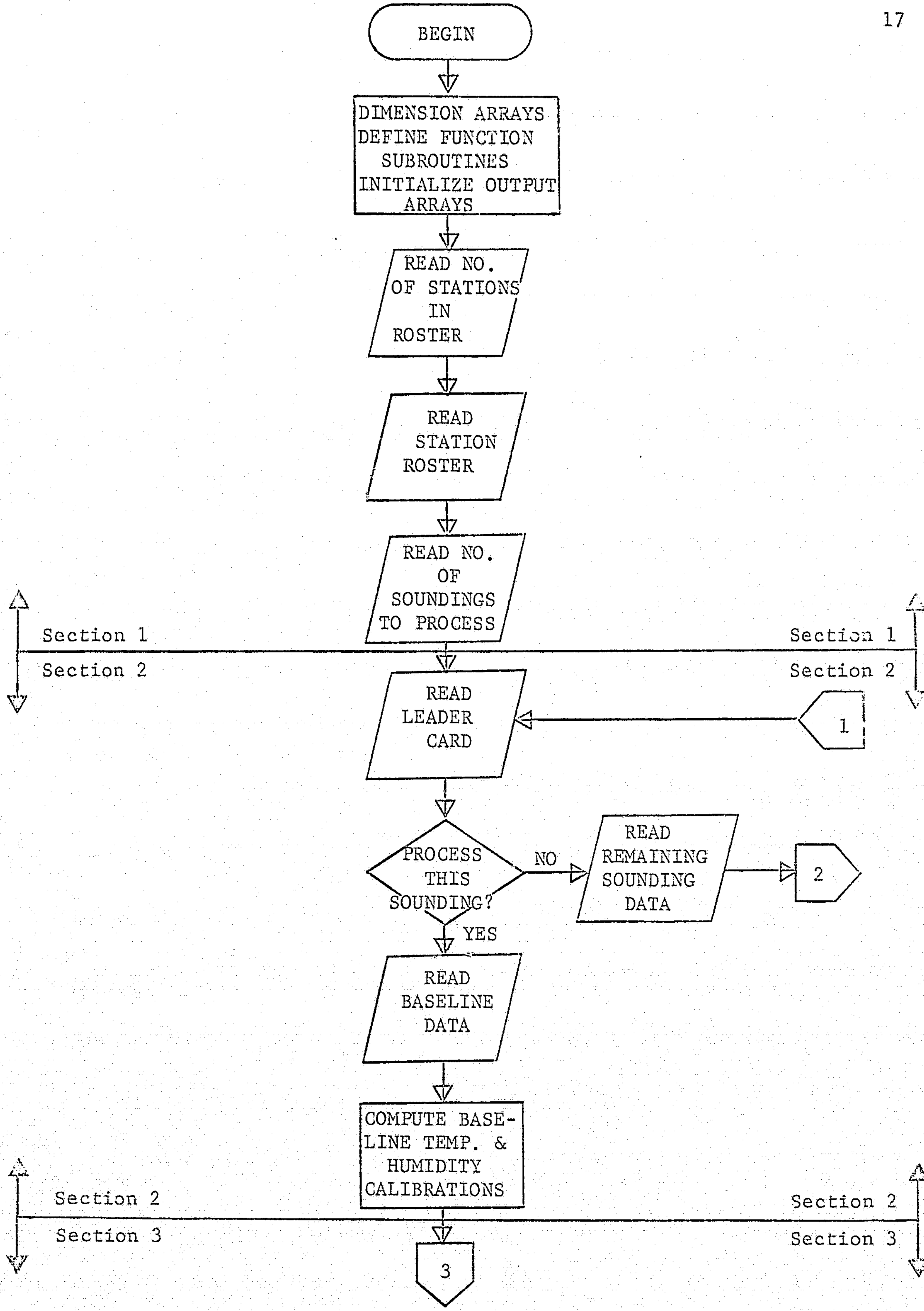


Fig. 4. Flowchart of the Master Reduction Program.

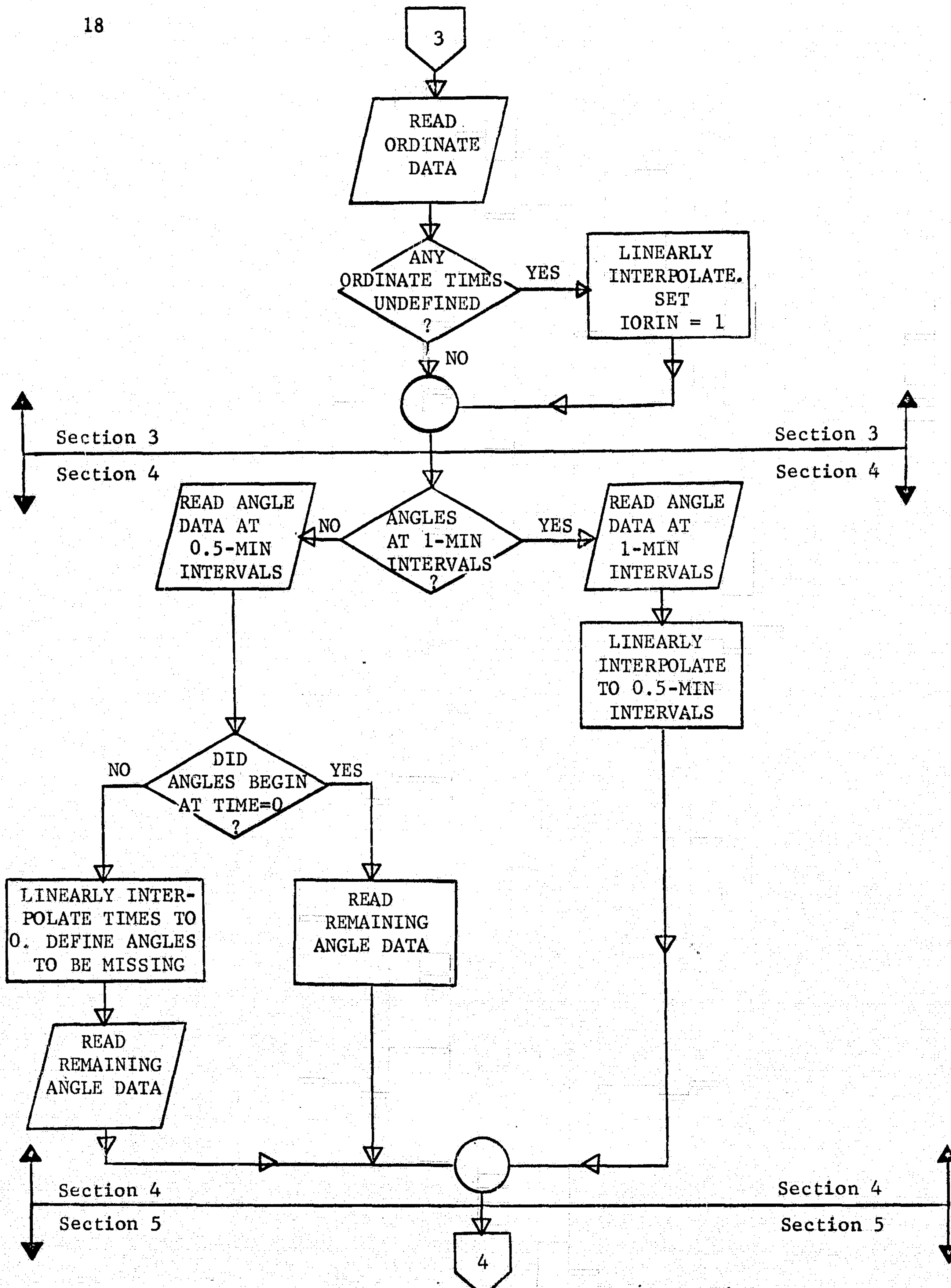
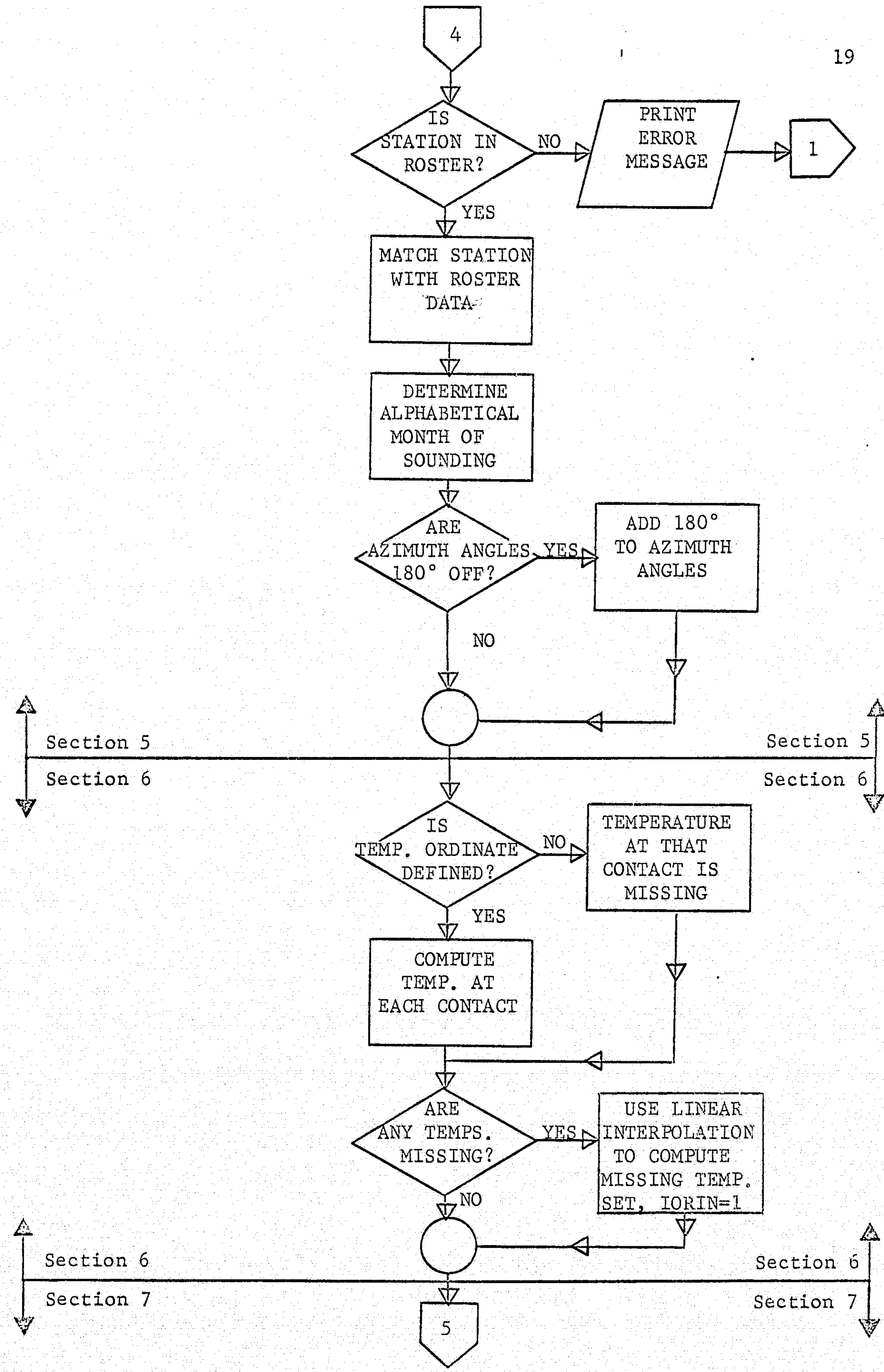


Fig. 4. (Continued)



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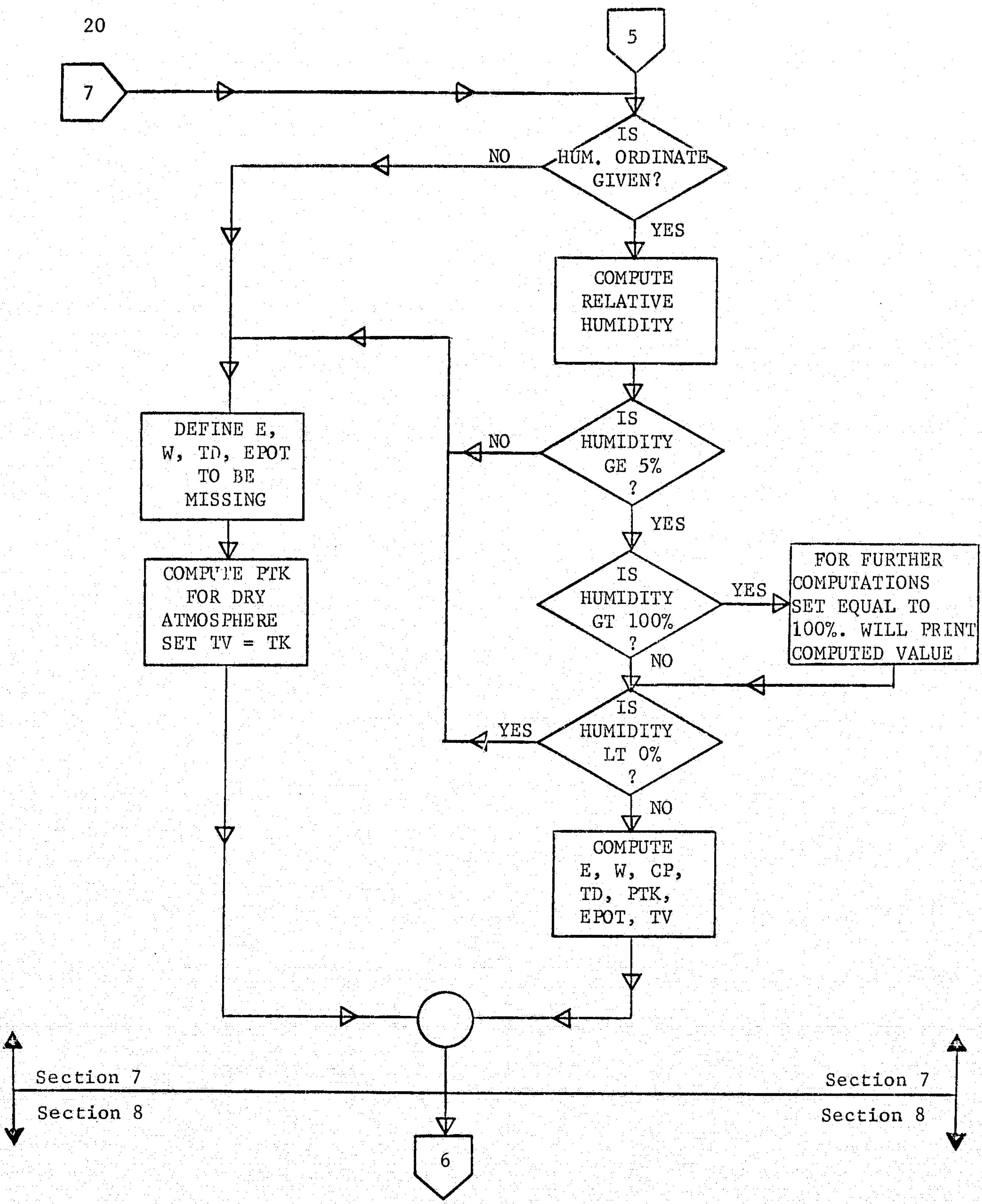

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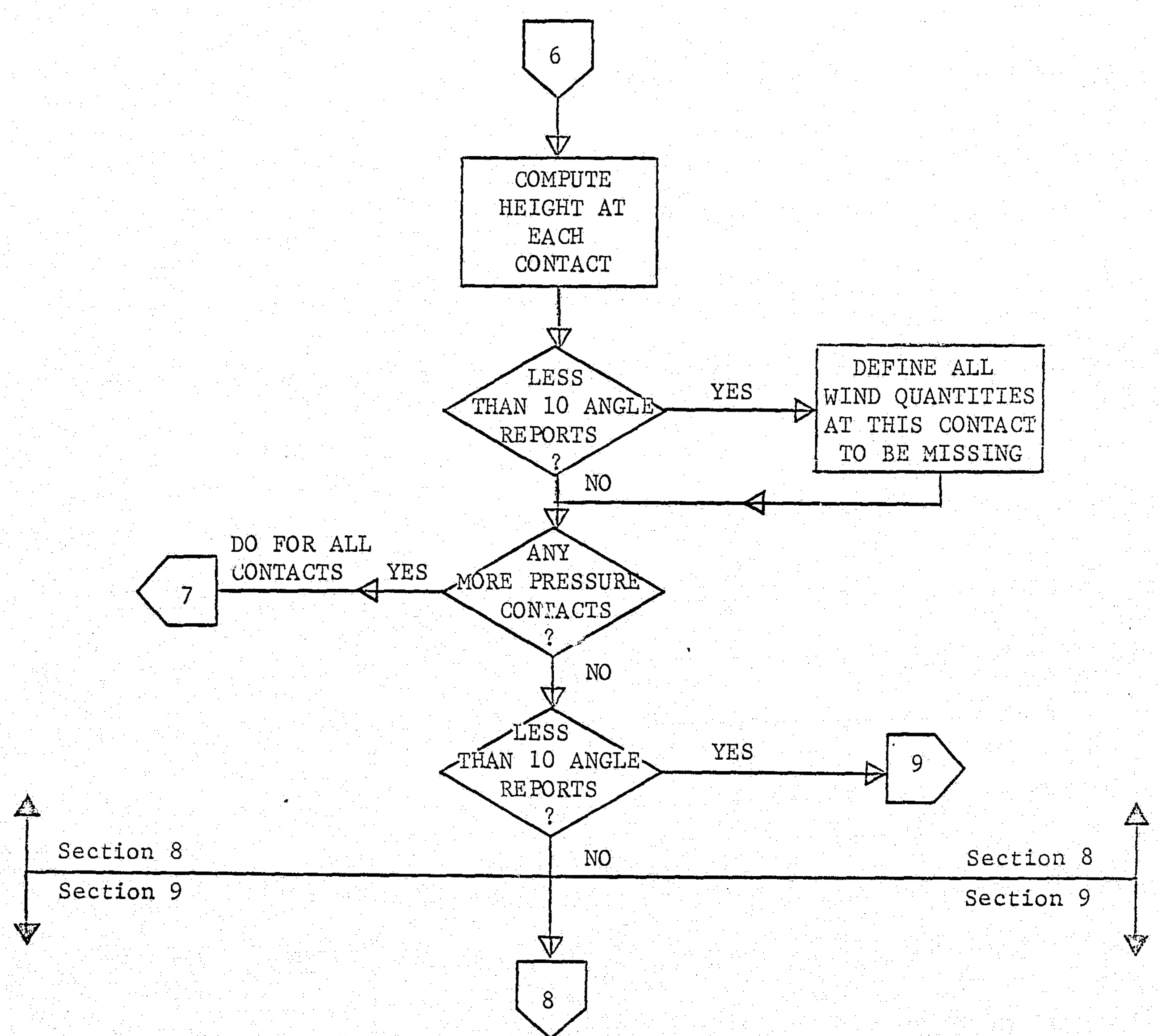

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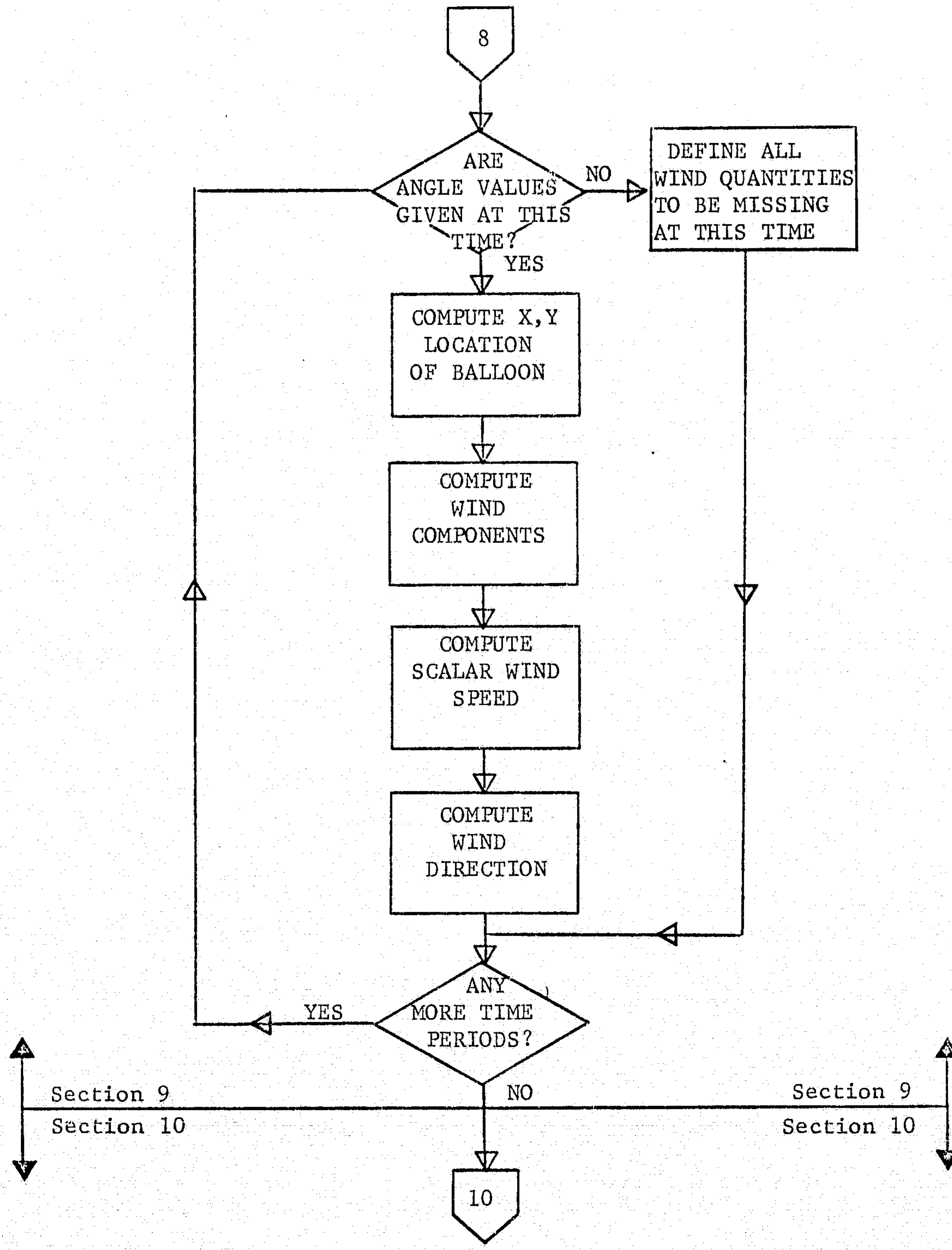

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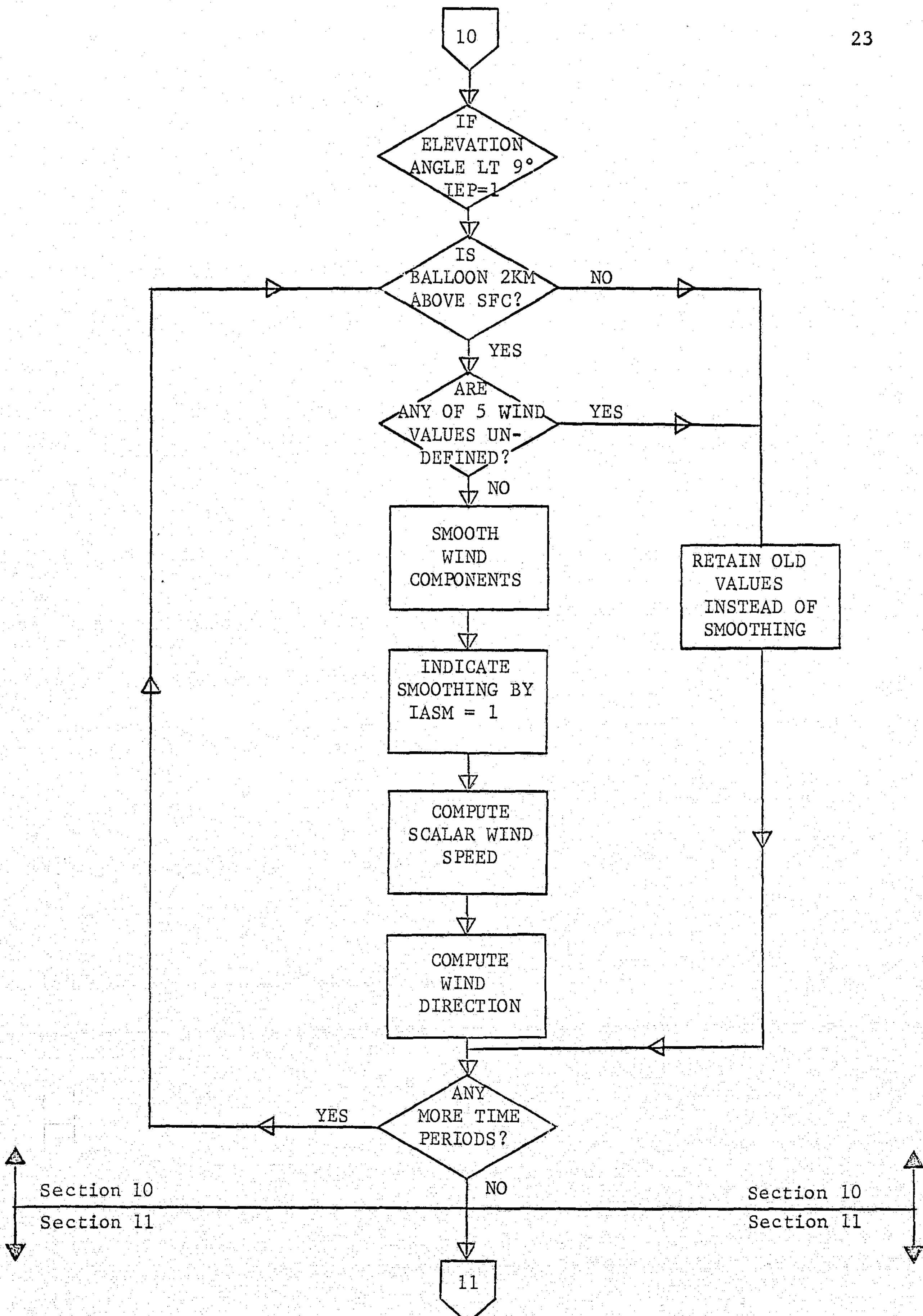

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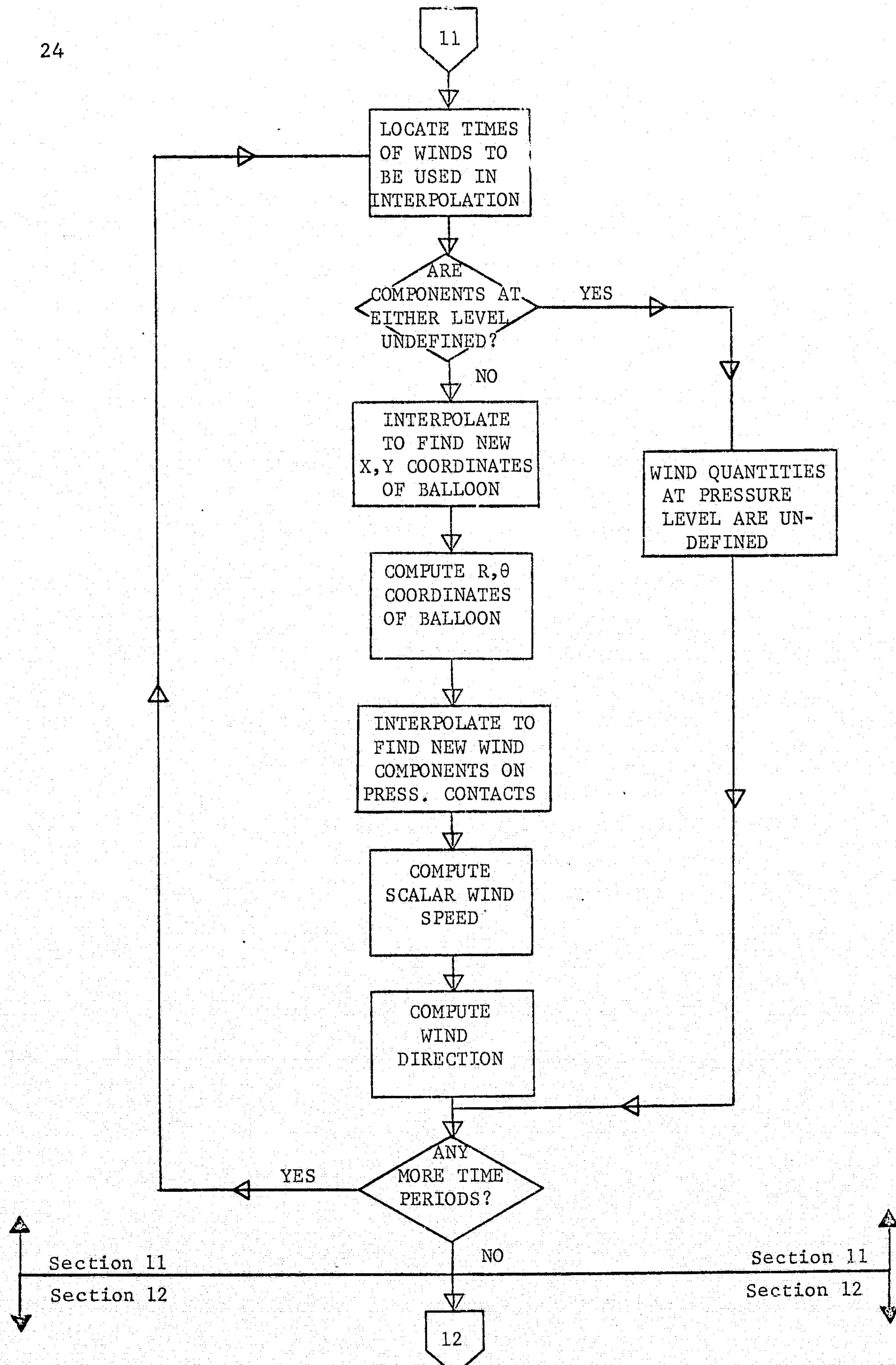

Fig. 4. (Continued)

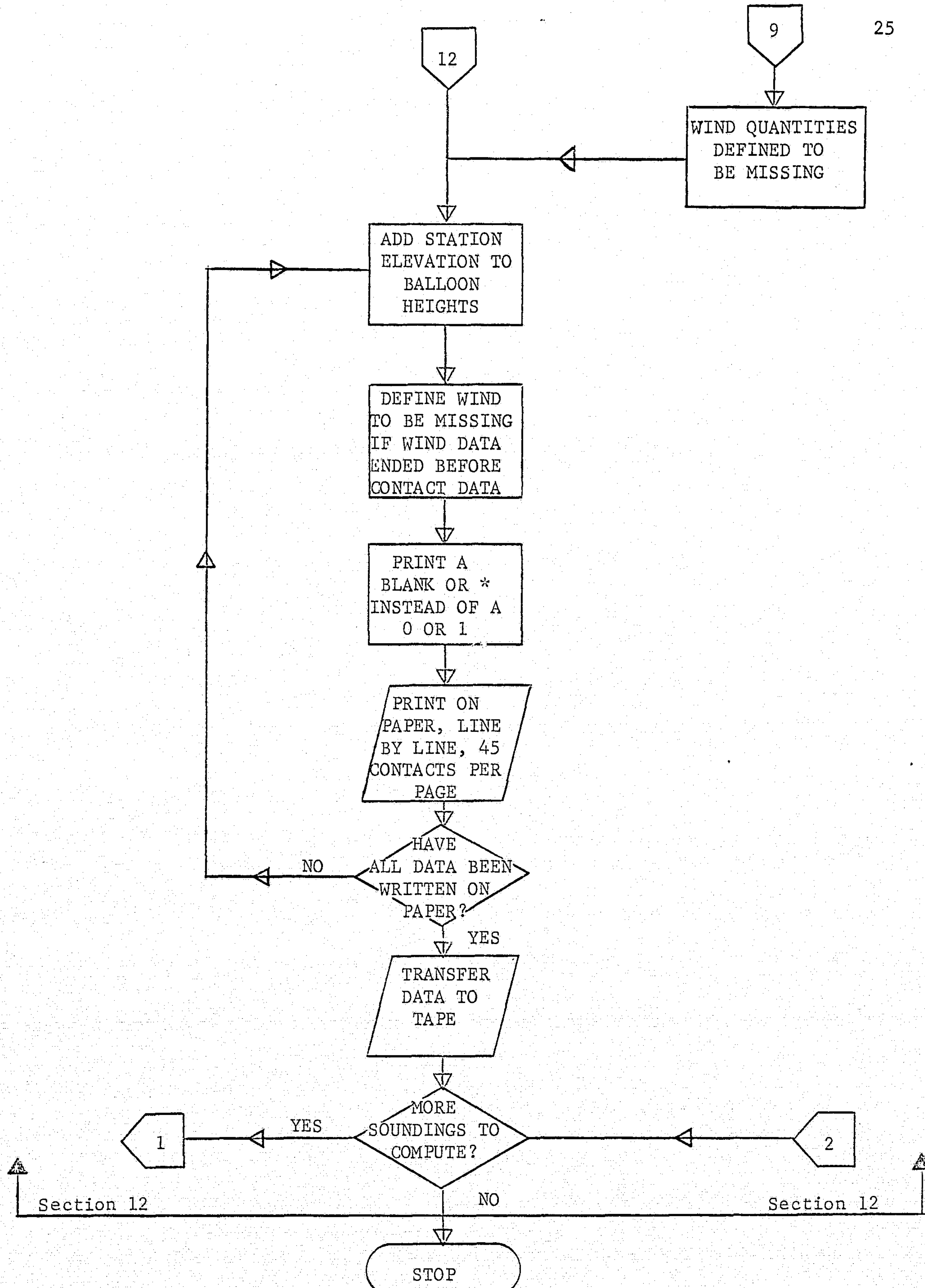

Fig. 4. (Continued)

at time of release, or after the missing times are interpolated back to the time of release, the angles are read without use of the procedure just described. This is possible because missing angle times are not encountered at any place in the data except at the beginning. The angles themselves may be missing, however.

No angle data on the tapes that was at 1-min intervals failed to begin at the time of release; therefore, no interpolation was necessary for these data. The angle data are read at 1-min increments and then linearly interpolated to give values every 30 sec. This interpolation process is indicated by a statement at the top of the output data for that sounding.

5. <u>Assignment of Station Parameters</u>. This section matches the station identification number of the sounding being computed with that of a station number in the roster so that station elevation and name are retrieved for further use. The subroutine MOPRT is called at this time to convert the numerical month of the sounding to the alphabetical name of the month. Also, azimuth angles for the four stations operated by the National Severe Storms Laboratory (22002-22005) are modified 180° to account for the different orientation of their rawinsonde tracking device.

6. <u>Temperature Computation</u>. Temperature at each pressure contact is determined by use of the following equations (Billions, 1965):

$$RE = EXP\left[16.0082991-0.9966256\cdot LOG_e(2\cdot TORD)\right] - 48000.0, \tag{7}$$

$$R4 = LOG_e\left(\frac{RM3\cdot RE}{14000.0}\right), \tag{8}$$

$$RK = \frac{1.0}{1.0/303.0+4.6774E\text{-}4\cdot R4+1.11278E\text{-}5\cdot (R4)^2}, \text{ and} \tag{9}$$

$$TC = RK - 273.15 \ . \tag{10}$$

TORD is the temperature ordinate at the pressure contact while RM3 is a result of the baseline computation (Eq. 5). TC is temperature in degrees Celsius. If the temperature ordinate is missing at a particular contact, the temperature is first defined to be missing and then linear interpolation is used in a subsequent section to fill the gap. The array IORIN is used to mark the location of this interpolation in the final output.

7. <u>Computation of Other Thermodynamic Quantities</u>. This section computes thermodynamic variables at each pressure contact; relative humidity is the first quantity to be computed. If the humidity ordinate is missing, all other moisture-related quantities at the contact are defined to be missing, and potential temperature (PTK) is computed according to the equation:

$$PTK = TK\left(\frac{1000.0}{P}\right)^{0.286} \tag{11}$$

where P is pressure and TK is temperature in degrees Kelvin at the contact. Virtual temperature is set equal to the ambient temperature when relative humidity cannot be computed. This equation and many of the other thermodynamic equations to follow may be found in texts such as Hess (1959) and IRIG Document 108-72 (1972). If the humidity ordinate is given, relative humidity (HP) is computed using the procedure described in IRIG Document 108-72 and given by:

$$HP = (HC1+HC2\cdot TP)X^9 + (HC3+HC4\cdot TP)X^8 + \ldots + (HC17+HC18\cdot TP)X$$
$$+ (HC19+HC20\cdot TP). \tag{12}$$

The values of HC were obtained from the baseline calibration (Eq. 6); TP is temperature at the contact in degrees Celsius while X is defined by the equation

$$X = \frac{HORD-46}{41} \quad . \tag{13}$$

HORD is the humidity ordinate at the pressure contact. If relative humidity is less than 5%, it and the other moisture variables are defined to be missing and Eq. (11) is used to compute potential temperature. In this situation, virtual temperature is again set equal to ambient air temperature. In some cases the procedure described above for computing relative humidity gives values greater than 100%. This could be due to improper baseline temperature or humidity calibration or due to faulty sonde sensors. Minor errors in the baseline data can lead to the computed supersaturations. The reduction program truncates relative humidity to a maximum value of 100% for use in further computations, but prints the computed value even though it may be greater than 100%. Users may then decide what action to take regarding use of the data.

The following equations are used to compute the remaining thermodynamic quantities based on relative humidity between 5% and 100%.

Vapor pressure in millibars (E):

$$E = HP \cdot 0.0611(10)^{(7.5 \cdot TP)/(237.3+TP)} \quad . \tag{14}$$

Mixing ratio in gm/Kg (W):

$$W = \frac{623.0 \cdot E}{P-E} \quad . \tag{15}$$

The specific heat of moist air in cal gm^{-1} deg^{-1} (CP):

$$CP = 0.24(1.0 + 0.84 \cdot \frac{W}{1000.0}) \quad . \tag{16}$$

The temperature of the dew point in degrees Celsius (TD):

$$TD = \frac{237.3 \cdot LOG_e(E) - 186.527}{8.286 - LOG_e(E)} \quad . \tag{17}$$

The potential temperature of moist air in degrees Kelvin (PTK):

$$PTK = TK\left(\frac{1000.0}{P-E}\right)^{RD/CP} \quad . \tag{18}$$

RD is the gas constant for dry air, namely 6.87E-2 cal gm^{-1} deg^{-1}.

Equivalent potential temperature in degrees Kelvin (EPOT):

$$EPOT = PTK \cdot EXP \left(\frac{EL \cdot W/1000.0}{CP \cdot TSA}\right) \tag{19}$$

where EL is the latent heat of vaporization at the lifting condensation level of air at the pressure contact, and TSA is the approximate temperature of air in degrees Kelvin at the lifting condensation level. of air at the pressure contact, and TSA is the approximate temperature of air in degrees Kelvin at the lifting condensation level. Virtual temperature in degrees Kelvin (TV):

$$TV = \frac{TK}{1.0-(0.379 \cdot \frac{E}{P})} \quad . \tag{20}$$

8. Computation of Height at 30-sec Intervals. Height of the sonde above ground level (YS) is computed using the hypsometric equation:

$$YS = SYS + \frac{RD}{g} \cdot \frac{TV_K + TV_{K-1}}{2} \cdot LOG_e\left(\frac{P_{K-1}}{P_K}\right) \tag{21}$$

where SYS is the height of the sonde at the preceding contact, g is acceleration of gravity, and K and K-1 are the current and preceding pressure contacts, respectively.

If there are less than ten angle observations for the sounding being computed, winds are not computed. Quantities dependent on the angles are then defined to be missing, and the program skips to the printing section of the program.

If there are more than ten angle observations, height of the sonde is determined at 30-sec increments corresponding to the times of angle observations. This is achieved by a linear interpolation of height based on time from release which is common to both the height and angle data.

9. Computation of Wind at 30-sec Intervals. Wind quantities are computed every 30 sec until the angle data are depleted. If angle data are not available at some time within the run, all quantities that are angle-dependent at that time are defined to be missing. The distance of the sonde from the station over a curved earth (SC) is computed using a procedure by Danielsen and Duquet (1966). The equation is:

$$SC = RAD \left(\cos^{-1} \left[\frac{\cos(THETA)}{1 + \frac{HINT}{RAD}} \right] - THETA \right). \qquad (22)$$

where RAD is the earth's radius, THETA is the elevation angle between the station and the sonde, and HINT is the height of the sonde above ground level. The X- and Y-location coordinates of the sonde, XS and

ZS, respectively, are then easily determined from SC and the azimuth angle of the sonde (AZ) using the equations:

$$XS = SC \left[SIN(AZ) \right] \quad , \text{ and} \tag{23}$$

$$ZS = SC \left[COS(AZ) \right] \quad . \tag{24}$$

Wind direction and speed at the surface are read from the baseline card; the east-west component (WWE) and the north-south component (WSN) at the first level above the ground (30 sec after release) are obtained by computing a forward difference of the sonde locations over a 30-sec interval (DT = 30). After this time, centered differences over a 1-min interval (DT = 60) are used to obtain the components; in both cases the following equations are used:

$$WWE(K-1) = \frac{XS(K)-XS(K-2)}{DT} \quad , \text{ and} \tag{25}$$

$$WSN(K-1) = \frac{ZS(K)-ZS(K-2)}{DT} \quad . \tag{26}$$

The scalar wind speed is given by:

$$WS(K-1) = \left\{ \left[WWE(K-1) \right]^2 + \left[WSN(K-1) \right]^2 \right\}^{\frac{1}{2}} \quad . \tag{27}$$

Wind direction is obtained by first computing the value of A from the equation:

$$A = \left\{ TAN^{-1} \left[\left| \frac{WWE(K-1)}{WSN(K-1)} \right| \right] \right\} \cdot 57.29578 \quad . \tag{28}$$

Since division by zero is undefined, steps must be taken to insure that this action is never attempted in Eq. (28). Therefore, the absolute value of WSN is never allowed to be smaller than 1.0E-5. After computing A, the following quadrant corrections are applied to determine wind direction:

$$\text{If } \frac{WWE}{WSN} \leq 0 \text{ and } WWE \leq 0; \quad DIR = 360° - A. \tag{29}$$

$$\text{If } \frac{WWE}{WSN} \leq 0 \text{ and } WWE > 0; \quad DIR = 180° - A. \tag{30}$$

$$\text{If } \frac{WWE}{WSN} > 0 \text{ and } WWE \leq 0; \quad DIR = A + 180°. \tag{31}$$

$$\text{If } \frac{WWE}{WSN} > 0 \text{ and } WWE > 0; \quad DIR = A. \tag{32}$$

Finally, so wind direction (WD) is that direction from which the wind is blowing, the following corrections are applied:

$$D = DIR + 180°; \tag{33}$$

$$\text{If } D > 360°, \ WD = D - 360°; \text{ but} \tag{34}$$

$$\text{If } D \leq 360°, \ WD = D. \tag{35}$$

10. Smoothing the Winds. A five point smoothing is performed on the wind components previously obtained at 30-sec intervals. The smoothing process does not begin until the time from release that corresponds to the sonde being 2.0 km above the surface. Once begun, the smoothing process continues through the remaining time periods except that if any one of the five values to be used in the smooth is missing, no smoothing is performed at that time, and the original components are retained. When smoothing is performed, the following equations are used:

$$S1 = \sum_{K=1}^{5} \left[WWE(K) \cdot CD(K) \right], \text{ and} \tag{36}$$

$$S2 = \sum_{K=1}^{5} \left[WSN(K) \cdot CD(K) \right]. \tag{37}$$

S1 is the smoothed east-west wind component, and S2 is the smoothed north-south wind component. The values of CD are the following binomial smoothing coefficients:

CD(1) = 0.06,
CD(2) = 0.25,
CD(3) = 0.38,
CD(4) = 0.25, and
CD(5) = 0.06.

The new components are used to determine a new wind direction and speed as was done in Eqs. (27-35). A locator array (IASM) is used to indicate which values have been smoothed, and the array IEP is used to indicate which wind values have been based on elevation angles less than 9°.

11. Interpolation of the Smoothed Winds to Pressure Contacts. Thus far the ordinate and wind data have been treated independently; the former were computed for pressure contacts which are approximately 0.5 min apart near the surface and up to 1.5 min apart near the tops of typical soundings (20 mb). The latter were computed at 0.5-min intervals and then smoothed. Since time from release is common to both sets of data, it is possible to interpolate the smoothed winds and assign values to times corresponding to the pressure contacts. The X and Y coordinates of the sonde are first linearly interpolated and used

to determine the range and azimuth angle of the sonde location. This is done in a manner similar to that of computing wind direction and speed except that coordinates and not wind components are used in this section. Wind components at the pressure contacts are determined by interpolation of the smoothed components which are then used to compute wind direction and speed at the contact according to Eqs. (27-35). If either of the two values used for linear interpolation is missing, the interpolated quantity is defined to be missing, and if either value has been smoothed or based on an elevation angle less than 9°, the interpolated quantity is defined to be smoothed and/or based on a low elevation angle, respectively.

12. Printing the Results. This section of the program writes the results on paper and magnetic tape. Before doing so several last minute items are handled. Station elevation is added to the sonde heights above ground level which were used in wind computation. In the event that wind quantities became missing and could not be interpolated before the last ordinate value, the winds at these levels are defined as missing. Arrays showing the location of temperature interpolation, wind smoothing, and low elevation angles are defined to print an asterisk or blank instead of a 1 or a 0.

Data for 45 pressure contacts are printed per page in addition to the headings. A description of the column headings is given in Table 6 and a sample of the output is shown in Fig. 5. Station identification number, along with the date and time of release of the sonde are given at the top of the page. If angle data were available every minute

Table 6

Column Headings for Output from the Master Reduction Program

TIME (MIN)	Time after balloon release.
CNTCT	Contact number.
HEIGHT (GPM)	Height of corresponding pressure surface in geopotential meters.
PRES (MB)	Pressure in millibars.
TEMP (DG C)	Ambient temperature in degrees Celsius. NOTE: An asterisk indicates that time from release and/or temperature were linearly interpolated.
DEW PT (DG C)	Dew point temperature in degrees Celsius.
DIR (DG)	Wind direction measured clockwise from true north and is the direction from which the wind is blowing.
SPEED (M/SEC)	Scalar wind speed in meters per second. NOTE: An asterisk indicates that wind quantities are based on an elevation angle that is less than 9°.
U COMP (M/SEC)	The E-W wind component, positive toward the east and negative toward the west.
V COMP (M/SEC)	The N-S wind component, positive toward the north and negative toward the south.
POT T (DG K)	Potential temperature in degrees Kelvin.
E POT T (DG K)	Equivalent potential temperature in degrees Kelvin.
MX RTO (GM/KG)	Mising ratio in grams per kilogram.
RH (PCT)	Relative humidity in percent.
RANGE (KM)	Distance balloon is from release point along a radius vector.
AZ (DG)	Direction toward balloon measured clockwise from true north.

STATION NO. 532
PEORIA, ILL

11 MAY 1974
2315 GMT

156 26. 0

TIME MIN	CNTCT	HEIGHT GPM	PRES MB	TEMP DG C	DEW PT DG C	DIR DG	SPEED M/SEC	U COMP M/SEC	V COMP M/SEC	POT T DG K	E POT T DG K	MX RTO GM/KG	RH PCT	RANGE KM	AZ DG
0.0	6.5	200.0	981.5	19.4	10.1	290.0	5.1	4.8	-1.7	295.2	316.4	8.0	55.0	0.0	0.
0.1	7.0	239.5	977.0	18.8	9.2	308.0	11.8	9.3	-7.3	294.9	314.9	7.5	53.7	0.3	114.
0.4	8.0	336.7	966.0	18.6	9.3	308.0	11.8	9.3	-7.3	295.6	316.1	7.7	54.8	0.3	114.
0.8	9.0	434.9	955.0	17.5	8.6	306.6	11.2	9.0	-6.7	295.5	315.2	7.4	55.7	0.5	120.
1.0	10.0	524.7	945.0	16.5	7.6	305.5	10.7	8.7	-6.2	295.3	314.0	7.0	55.8	0.6	122.
1.3	11.0	642.5	932.0	15.5	6.7	313.7	10.9	7.9	-7.6	295.3	313.2	6.6	55.9	0.8	122.
1.7	12.0	733.9	922.0	14.5	5.7	316.8	10.9	7.5	-7.9	295.2	312.1	6.3	55.8	1.0	126.
2.1	13.0	826.0	912.0	13.7	6.9	297.5	10.0	8.8	-4.6	295.3	313.8	6.9	63.6	1.3	130.
2.3	14.0	918.8	902.0	12.3	5.2	267.1	11.3	11.3	0.6	294.8	311.4	6.2	61.7	1.4	128.
2.7	15.0	1012.2	892.0	11.7	4.4	246.9	15.6	14.3	6.1	295.1	311.0	5.9	60.5	1.6	117.
3.0	16.0	1125.4	880.0	10.8	3.4	246.3	16.5	15.1	6.6	295.2	310.4	5.6	60.2	1.8	105.
3.4	17.0	1220.6	870.0	9.9	2.5	265.7	12.0	12.0	0.9	295.2	309.6	5.3	60.2	2.1	104.
3.7	18.0	1316.6	860.0	8.9	1.6	273.2	11.3	11.3	-0.6	295.1	308.9	5.0	60.1	2.3	103.
4.1	19.0	1413.4	850.0	7.8	1.5	274.8	11.5	11.4	-1.0	295.0	308.7	5.0	64.1	2.6	102.
4.4	20.0	1510.9	840.0	7.1	0.9	277.6	11.5	11.4	-1.5	295.2	308.5	4.9	64.3	2.8	101.
4.8	21.0	1629.1	828.0	5.7	-0.4	278.9	11.7	11.6	-1.8	294.9	307.2	4.5	64.5	3.1	101.
5.2	22.0	1718.5	819.0	5.0	-0.3	279.7	11.7	11.6	-2.0	295.1	307.7	4.6	68.2	3.3	101.
5.4	23.0	1818.7	809.0	4.2	-1.2	280.3	11.5	11.4	-2.1	295.2	307.2	4.3	68.0	3.5	101.
5.8	24.0	1919.9	799.0	3.7	-8.1	281.8	12.1	11.9	-2.5	295.5	302.9	2.6	41.9	3.8	101.
6.2	25.0	2012.0	790.0	4.5	-22.6	280.9	13.4	13.2	-2.5	297.1	299.5	0.8	11.8	4.1	101.
6.5	26.0	2136.5	778.0	4.5	-22.6	278.8	14.7	14.6	-2.3	298.4	300.9	0.8	11.8	4.3	101.
6.8	27.0	2241.7	768.0	4.2	-22.8	276.1	14.0	13.9	-1.5	299.2	301.6	0.8	11.8	4.6	101.
7.2	28.0	2337.4	759.0	3.7	-23.2	272.1	13.3	13.3	-0.5	299.6	302.0	0.8	11.9	4.9	100.
7.5	29.0	2434.1	750.0	3.3	-23.4	269.0	13.1	13.1	0.2	300.3	302.7	0.8	11.9	5.1	100.
7.8	30.0	2542.7	740.0	2.3	-24.1	266.3	13.2	13.1	0.8	300.3	302.6	0.7	12.0	5.4	99.
8.1	31.0	2630.4	732.0	2.0	-24.3	263.9	13.4	13.3	1.4	300.9	303.2	0.7	12.0	5.6	99.
8.5	32.0	2741.0	722.0	0.7	-25.2	261.7	14.0	13.8	2.0	300.6	302.8	0.7	12.2	5.9	98.
8.8	33.0	2841.6	713.0	0.2	-25.6	260.4	14.7	14.5	2.4	301.2	303.3	0.7	12.2	6.1	97.
9.1	34.0	2931.7	705.0	-1.1	-26.5	258.9	15.4	15.1	3.0	300.7	302.7	0.6	12.4	6.4	96.
9.4	35.0	3034.1	696.0	-1.6	-26.8	256.9	16.0	15.6	3.6	301.3	303.2	0.6	12.4	6.7	96.
9.7	36.0	3160.6	685.0	-2.7	-27.6	254.5	16.6	16.0	4.4	301.4	303.3	0.6	12.5	7.0	95.
10.1	37.0	3265.3	676.0	-3.0	-27.8	251.4	17.3	16.4	5.5	302.2	304.1	0.6	12.6	7.3	94.
10.4	38.0	3371.2	667.0	-4.2	-28.7	249.4	17.9	16.8	6.3	302.0	303.7	0.5	12.7	7.6	93.
10.7	39.0	3466.1	659.0	-5.0	-29.3	247.3	18.9	17.4	7.3	302.2	303.8	0.5	12.8	7.9	92.
11.1	40.0	3574.1	650.0	-5.6	-29.7	244.3	20.5	18.5	8.9	302.7	304.3	0.5	12.8	8.3	91.
11.5	41.0	3695.5	640.0	-6.0	-30.0	240.8	22.4	19.6	11.0	303.5	305.1	0.5	12.9	8.8	89.
11.8	42.0	3793.9	632.0	-6.5	-27.8	237.9	23.3	19.8	12.4	304.1	306.1	0.6	16.4	9.2	88.
12.0	43.0	3905.8	623.0	-7.4	-27.1	236.2	24.0	19.9	13.3	304.3	306.5	0.7	18.9	9.5	87.
12.3	44.0	4006.5	615.0	-7.2	-24.1	235.1	24.2	19.9	13.9	305.7	308.5	0.9	24.5	9.8	85.
12.9	45.0	4108.4	607.0	-7.7	-22.1	235.7	25.3	20.9	14.3	306.3	309.7	1.1	30.2	10.5	83.
13.2	46.0	4211.5	599.0	-8.6	-21.7	236.9	26.5	22.2	14.5	306.4	310.0	1.1	33.5	10.9	82.
13.6	47.0	4315.6	591.0	-9.6	-22.1	238.1	28.5	24.2	15.1	306.4	309.9	1.1	34.9	11.6	81.
13.9	48.0	4420.9	583.0	-9.4	-23.4	238.1	30.1	25.6	15.9	307.8	310.9	1.0	30.9	12.1	79.
14.3	49.0	4527.7	575.0	-9.4	-25.1	236.8	32.1	26.8	17.6	309.0	311.8	0.9	26.6	12.8	78.
14.7	50.0	4635.9	567.0	-9.7	-25.0	234.3	33.9	27.5	19.7	309.9	312.7	0.9	27.4	13.5	77.

Fig. 5. Sample output from the master reduction program.

STATION NO. 532
PEORIA, ILL

11 MAY 1974
2315 GMT

156 26. 0

TIME MIN	CNTCT	HEIGHT GPM	PRES MB	TEMP DG C	DEW PT DG C	DIR DG	SPEED M/SEC	U COMP M/SEC	V COMP M/SEC	POT T DG K	E POT T DG K	MX RTO GM/KG	RH PCT	RANGE KM	AZ DG
15.1	51.0	4773.1	557.0	-10.3	-25.1	231.4	35.5	27.8	22.2	310.8	313.7	0.9	28.5	14.3	76.
15.4	52.0	4870.5	550.0	-10.7	-22.9	229.4	36.5	27.7	23.8	311.4	314.9	1.1	35.8	14.9	75.
15.8	53.0	4982.9	542.0	-11.7	-27.0	227.5	36.9	27.2	24.9	311.5	314.0	0.8	26.7	15.7	73.
16.2	54.0	5096.9	534.0	-11.4	-34.0	226.4	36.3	26.3	25.0	313.1	314.5	0.4	13.4	16.5	72.
16.4	55.0	5197.9	527.0	-12.2	-34.5	226.1	35.6	25.6	24.7	313.5	314.8	0.4	13.5	17.0	71.
16.9	56.0	5329.4	518.0	-13.1	-35.2	226.1	33.6	24.3	23.3	313.8	315.1	0.4	13.6	17.8	70.
17.3	57.0	5447.8	510.0	-14.0	-35.8	227.3	33.2	24.4	22.5	314.2	315.4	0.3	13.7	18.5	69.
17.7	58.0	5552.7	503.0	-14.0	-35.8	228.8	33.4	25.1	22.0	315.4	316.7	0.4	13.7	19.2	68.
18.0	59.0	5659.0	496.0	-14.5	-36.2	230.0	33.9	25.9	21.8	316.0	317.2	0.3	13.7	19.8	67.
18.4	60.0	5782.1	488.0	-15.1	-36.7	231.2	33.4	26.1	20.9	316.8	318.0	0.3	13.8	20.7	67.
18.8	61.0	5891.1	481.0	-16.2	-37.5	232.5	32.7	25.9	19.9	316.8	317.8	0.3	13.9	21.4	66.
19.1	62.0	6001.2	474.0	-17.3	-38.3	233.4	32.4	26.0	19.3	316.7	317.8	0.3	14.0	22.0	66.
19.5	63.0	6112.6	467.0	-18.0	-38.8	234.5	33.1	26.9	19.2	317.2	318.2	0.3	14.1	22.7	65.
19.9	64.0	6225.2	460.0	-18.9	-39.5	235.3	35.1	28.9	20.0	317.4	318.3	0.3	14.2	23.5	65.
20.3	65.0	6322.8	454.0	-20.0	-40.3	236.1	37.0	30.7	20.7	317.2	318.1	0.2	14.3	24.4	65.
20.7	66.0	6471.0	445.0	-21.1	-41.1	236.7	38.3	32.0	21.0	317.7	318.5	0.2	14.4	25.3	64.
21.1	67.0	6587.8	438.0	-22.3	-42.1	237.4	38.6	32.5	20.8	317.6	318.4	0.2	14.5	26.3	64.
21.4	68.0	6706.0	431.0	-23.2	-42.8	238.2	38.2	32.5	20.2	317.9	318.6	0.2	14.6	26.9	64.
21.7	69.0	6808.4	425.0	-24.1	-43.5	238.8	37.9	32.5	19.6	318.0	318.7	0.2	14.7	27.6	64.
22.1	70.0	6929.3	418.0	-25.3	-44.4	239.5	37.7	32.5	19.2	318.0	318.6	0.2	14.8	28.5	64.
22.5	71.0	7069.4	410.0	-26.0	-44.9	239.3	37.8	32.5	19.3	318.9	319.5	0.2	14.9	29.4	64.
22.9	72.0	7193.9	403.0	-26.8	-45.5	238.2	38.0	32.3	20.0	319.4	320.0	0.2	15.0	30.3	63.
23.3	73.0	7302.0	397.0	-27.6	-46.1	237.0	38.8	32.6	21.1	319.8	320.3	0.1	15.0	31.2	63.
23.7	74.0	7429.8	390.0	-28.1	-46.5	236.0	40.3	33.4	22.6	320.7	321.3	0.1	15.1	32.1	63.
24.1	75.0	7540.9	384.0	-29.0	-47.2	235.1	42.4	34.8	24.2	320.9	321.5	0.1	15.2	33.1	63.
24.5	76.0	7672.4	377.0	-29.3	-47.4	234.3	44.5	36.1	25.9	322.3	322.8	0.1	15.2	34.1	63.
24.9	77.0	7786.8	371.0	-30.1	-48.0	232.6	43.9	34.9	26.6	322.7	323.2	0.1	15.3	35.3	62.
25.3	78.0	7902.7	365.0	-31.1	-48.9	230.0	41.4	31.7	26.6	322.8	323.3	0.1	15.4	36.4	62.
25.7	79.0	8020.1	359.0	-31.5	-49.2	227.3	39.2	28.8	26.6	323.8	324.3	0.1	15.4	37.3	62.
26.2	80.0	8139.3	353.0	-31.9	-49.5	225.2	39.6	28.1	27.9	324.9	325.3	0.1	15.5	38.2	61.
26.7	81.0	8280.8	346.0	-32.2	-49.7	225.0	43.3	30.6	30.6	326.4	326.8	0.1	15.5	39.4	61.
27.1	82.0	8404.3	340.0	-32.0	-49.6	224.8	45.9	32.3	32.6	328.2	328.6	0.1	15.5	40.5	60.
27.5	83.0	8529.7	334.0	-33.2	-50.5	223.8	46.3	32.1	33.5	328.2	328.6	0.1	15.6	41.7	60.
27.8	84.0	8656.8	328.0	-34.4	-51.4	222.8	45.3	30.8	33.2	328.3	328.7	0.1	15.7	42.5	60.
28.2	85.0	8785.7	322.0	-35.2	-52.1	222.2	44.7	30.0	33.1	328.9	329.3	0.1	15.8	43.4	59.
28.8	86.0	8916.5	316.0	-36.4	-53.0	222.6	46.3	31.4	34.1	329.0	329.4	0.1	15.9	44.9	58.
29.3	87.0	9049.3	310.0	-36.9	-53.4	222.6	49.0	33.1	36.1	330.1	330.4	0.1	16.0	46.3	58.
29.5	88.0	9161.6	305.0	-37.6	-53.9	222.4	50.1	33.7	37.0	330.7	331.0	0.1	16.1	46.9	58.
30.1	89.0	9298.4	299.0	-38.5	-54.7	219.1	49.6	31.3	38.4	331.3	331.5	0.1	16.1	48.7	57.
30.5	90.0	9414.1	294.0	-39.2	-55.2	216.0	47.2	27.8	38.2	331.9	332.2	0.1	16.2	50.0	57.
30.8	91.0	9555.1	288.0	-40.4	99.9	214.6	46.7	26.5	38.4	332.2	999.9	99.9	999.9	50.6	56.
31.4	92.0	9674.2	283.0	-41.3	99.9	214.5	50.5	28.6	41.6	332.7	999.9	99.9	999.9	51.9	56.
31.8	93.0	9795.2	278.0	-41.7	99.9	215.5	55.2	32.1	45.0	333.8	999.9	99.9	999.9	53.1	55.
32.3	94.0	9913.0	273.0	-42.6	99.9	215.9	58.5	34.3	47.4	334.2	999.9	99.9	999.9	55.0	55.
32.6	95.0	10042.6	268.0	-43.6	99.9	215.7	58.4	34.1	47.5	334.5	999.9	99.9	999.9	56.1	54.

Fig. 5. (Continued)

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TIME MIN	CNTCT	HEIGHT GPM	PRES MB	TEMP DG C	DEW PT DG C	DIR DG	SPEED M/SEC	U COMP M/SEC	V COMP M/SEC	POT T DG K	E POT T DG K	MX RTO GM/KG	RH PCT	RANGE KM	AZ DG
33.2	96.0	10169.0	263.0	-44.3	99.9	214.4	54.6	30.8	45.0	335.3	999.9	99.9	999.9	58.0	54.
33.5	97.0	10323.3	257.0	-45.4	99.9	213.7	52.7	29.2	43.8	335.9	999.9	99.9	999.9	59.4	53.
34.0	98.0	10454.0	252.0	-46.6	99.9	213.4	53.2	29.3	44.4	336.1	999.9	99.9	999.9	59.5	53.
34.3	99.0	10586.6	247.0	-47.9	99.9	212.8	52.8	28.6	44.4	336.1	999.9	99.9	999.9	61.2	52.
34.8	100.0	10694.2	243.0	-48.5	99.9	210.3	48.6	24.6	42.0	336.8	999.9	99.9	999.9	62.8	52.
35.3	101.0	10858.3	237.0	-49.8	99.9	208.1	44.3	20.9	39.1	337.2	999.9	99.9	999.9	64.1	51.
35.8	102.0	10997.5	232.0	-50.8	99.9	211.2	47.4*	24.6	40.5	337.6	999.9	99.9	999.9	64.8	51.
36.3	103.0	11110.7	228.0	-51.1	99.9	216.5	55.2*	32.8	44.4	338.9	999.9	99.9	999.9	66.4	51.
36.5	104.0	11254.8	223.0	-51.4	99.9	218.3	58.5*	36.2	45.9	340.6	999.9	99.9	999.9	67.4	50.
36.9	105.0	11401.5	218.0	-53.1	99.9	219.5	56.0*	35.6	43.2	340.2	999.9	99.9	999.9	68.8	50.
37.3	106.0	11520.5	214.0	-54.4	99.9	219.9	50.3*	32.2	38.6	340.0	999.9	99.9	999.9	70.1	50.
37.8	107.0	11641.2	210.0	-55.2	99.9	220.3	45.0*	29.1	34.3	340.6	999.9	99.9	999.9	71.2	50.
38.2	108.0	11764.0	206.0	-55.0	99.9	221.1	44.3*	29.1	33.4	342.7	999.9	99.9	999.9	72.2	50.
38.7	109.0	11857.6	203.0	-55.5	99.9	222.2	44.1*	29.6	32.7	343.4	999.9	99.9	999.9	73.7	50.
39.2	110.0	12016.4	198.0	-56.0	99.9	223.5	39.9*	27.4	28.9	345.1	999.9	99.9	999.9	75.1	49.
39.8	111.0	12212.0	192.0	-56.3	99.9	225.2	31.5*	22.3	22.2	347.6	999.9	99.9	999.9	76.4	49.
40.1	112.0	12380.0	187.0	-55.2	99.9	225.0	28.4*	20.1	20.1	352.1	999.9	99.9	999.9	77.0	49.
40.5	113.0	12483.5	184.0	-54.4	99.9	222.8	27.3*	18.6	20.0	355.0	999.9	99.9	999.9	77.1	49.
40.8	114.0	12624.2	180.0	-54.7	99.9	220.6	29.0*	18.9	22.0	356.7	999.9	99.9	999.9	77.8	49.
41.3	115.0	12768.1	176.0	-54.5	99.9	219.0	31.3*	19.7	24.3	359.3	999.9	99.9	999.9	78.8	49.
41.9	116.0	12952.0	171.0	-56.0	99.9	220.7	32.9*	21.5	24.9	359.9	999.9	99.9	999.9	79.9	49.
42.3	117.0	13102.1	167.0	-57.1	99.9	223.7	34.7*	24.0	25.1	360.4	999.9	99.9	999.9	80.6	49.
43.0	118.0	13216.7	164.0	-57.6	99.9	229.2	40.5*	30.7	26.5	361.4	999.9	99.9	999.9	82.4	49.
43.7	119.0	13373.1	160.0	-56.3	99.9	234.9	39.5*	32.3	22.7	366.2	999.9	99.9	999.9	84.1	49.
44.3	120.0	13534.6	156.0	-54.4	99.9	241.8	27.1*	23.9	12.8	372.2	999.9	99.9	999.9	85.5	49.
44.9	121.0	13658.9	153.0	-54.7	99.9	250.3	14.6*	13.7	4.9	373.7	999.9	99.9	999.9	86.1	49.
45.3	122.0	13827.9	149.0	-56.0	99.9	250.9	11.3*	10.7	3.7	374.3	999.9	99.9	999.9	86.3	49.
45.8	123.0	13956.9	146.0	-57.1	99.9	245.8	12.1*	11.1	5.0	374.5	999.9	99.9	999.9	86.3	49.
46.2	124.0	14087.9	143.0	-58.5	99.9	241.6	16.1*	14.2	7.6	374.4	999.9	99.9	999.9	86.7	49.
46.7	125.0	14265.9	139.0	-59.5	99.9	238.1	24.0*	20.4	12.7	375.6	999.9	99.9	999.9	87.3	50.
47.4	126.0	14448.3	135.0	-60.2	99.9	237.6	36.4*	30.7	19.5	377.6	999.9	99.9	999.9	88.7	50.
47.9	127.0	14588.1	132.0	-61.1	99.9	242.9	35.8*	31.9	16.3	378.4	999.9	99.9	999.9	89.7	50.
48.4	128.0	14779.3	128.0	-61.1	99.9	256.1	25.6*	24.8	6.2	381.8	999.9	99.9	999.9	91.5	50.
49.0	129.0	14926.4	125.0	-61.5	99.9	273.8	18.8*	18.8	-1.2	383.7	999.9	99.9	999.9	90.7	50.
49.4	130.0	15026.4	123.0	-61.5	99.9	263.6	22.9*	22.8	2.6	385.5	999.9	99.9	999.9	91.4	50.
50.1	131.0	15283.8	118.0	-61.5	99.9	256.4	23.2*	22.6	5.4	390.1	999.9	99.9	999.9	92.8	51.
50.6	132.0	15443.9	115.0	-60.2	99.9	274.4	11.3*	11.3	-0.9	395.3	999.9	99.9	999.9	93.6	51.
51.1	133.0	15608.6	112.0	-60.8	99.9	356.0	7.2*	0.5	-7.2	397.3	999.9	99.9	999.9	93.4	51.
51.6	134.0	15777.2	109.0	-61.5	99.9	351.6	5.4*	0.8	-5.3	399.0	999.9	99.9	999.9	92.6	51.
52.2	135.0	15949.8	106.0	-62.6	99.9	254.9	11.8*	11.4	3.1	400.1	999.9	99.9	999.9	92.8	51.
52.8	136.0	16127.4	103.0	-61.3	99.9	260.6	16.7	16.4	2.7	405.9	999.9	99.9	999.9	93.8	51.
53.5	137.0	16373.4	99.0	-61.1	99.9	289.7	14.6	13.7	-4.9	410.9	999.9	99.9	999.9	94.2	52.
54.3	138.0	16564.5	96.0	-61.1	99.9	271.1	15.0	15.0	-0.3	414.5	999.9	99.9	999.9	94.5	52.
54.9	139.0	16829.4	92.0	-60.2	99.9	255.8	14.0	13.6	3.4	421.3	999.9	99.9	999.9	95.0	52.
55.7	140.0	17037.3	89.0	-57.8	99.9	260.5	5.2	5.1	0.9	430.1	999.9	99.9	999.9	95.7	52.

Fig. 5. (Continued)

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TIME MIN	CNTCT	HEIGHT GPM	PRES MB	TEMP DG C	DEW PT DG C	DIR DG	SPEED M/SEC	U COMP M/SEC	V COMP M/SEC	POT T DG K	E POT T DG K	MX RTO GM/KG	RH PCT	RANGE KM	AZ DG
56.4	141.0	17253.9	86.0	-57.1	99.9	283.2	2.5	2.4	-0.6	435.7	999.9	99.9	999.9	95.5	52.
57.2	142.0	17478.1	83.0	-58.2	99.9	247.8	8.7	8.1	3.3	438.1	999.9	99.9	999.9	95.7	52.
58.0	143.0	17789.5	79.0	-57.6	99.9	259.8	9.5	9.4	1.7	445.4	999.9	99.9	999.9	96.3	52.
58.8	144.0	18034.6	76.0	-56.3	99.9	259.9	7.5	7.4	1.3	453.1	999.9	99.9	999.9	96.7	53.
59.7	145.0	18290.4	73.0	-56.3	99.9	235.5	6.1	5.0	3.5	458.4	999.9	99.9	999.9	96.8	53.
60.5	146.0	18556.8	70.0	-56.5	99.9	226.9	7.5	5.5	5.1	463.6	999.9	99.9	999.9	97.6	53.
61.4	147.0	18835.2	67.0	-56.0	99.9	247.9	11.7	10.9	4.4	470.5	999.9	99.9	999.9	97.4	53.
62.3	148.0	19126.4	64.0	-56.2	99.9	247.1	16.7	15.4	6.5	476.3	999.9	99.9	999.9	98.6	53.
63.3	149.0	19431.5	61.0	-56.3	99.9	33.6	11.4	-6.3	-9.5	482.5	999.9	99.9	999.9	99.1	53.
64.3	150.0	19751.3	58.0	-57.0	99.9	36.4	6.4	-3.8	-5.2	488.1	999.9	99.9	999.9	97.7	53.
65.2	151.0	20087.3	55.0	-57.3	99.9	238.8	13.5	11.6	7.0	494.8	999.9	99.9	999.9	98.1	53.
66.3	152.0	20441.9	52.0	-57.3	99.9	240.5	9.0	7.8	4.4	502.8	999.9	99.9	999.9	99.3	53.
67.4	153.0	20819.6	49.0	-55.0	99.9	144.1	1.5	-0.9	1.2	516.8	999.9	99.9	999.9	99.8	53.
68.6	154.0	21224.3	46.0	-53.9	99.9	268.8	3.7	3.7	0.1	528.9	999.9	99.9	999.9	99.2	53.
69.8	155.0	21658.0	43.0	-53.3	99.9	32.3	4.6	-2.4	-3.9	540.8	999.9	99.9	999.9	99.3	53.
71.1	156.0	21964.2	41.0	-54.1	99.9	92.3	2.9	-2.9	0.1	546.2	999.9	99.9	999.9	99.1	53.
72.5	157.0	22454.6	38.0	-51.6	99.9	55.1	4.8	-4.0	-2.8	564.5	999.9	99.9	999.9	99.0	53.
74.0	158.0	22987.6	35.0	-52.2	99.9	51.1	5.0	-3.9	-3.1	576.4	999.9	99.9	999.9	98.2	53.
75.7	159.0	23568.2	32.0	-51.7	99.9	32.6	7.6	-4.1	-6.4	592.6	999.9	99.9	999.9	97.8	53.
77.3	160.0	24205.7	29.0	-52.4	99.9	58.2	19.4	-16.5	-10.2	607.8	999.9	99.9	999.9	97.5	53.
79.2	161.0	24913.7	26.0	-51.3	99.9	999.9	99.9	99.9	99.9	630.1	999.9	99.9	999.9	999.9	999.

Fig. 5. (Continued)

(I1MIN = 1) instead of every one-half minute (I1MIN = 0), a statement to this effect is printed next. The three numbers in the upper right-hand corner are from left to right the number of pressure contacts printed, the pressure at the highest contact, and the value of I1MIN. Missing data are indicated by printing nines in the appropriate columns. The data transferred to magnetic tape are described in Table 7.

D. First Differences of Contact Data

A program was written to compute first differences of the output from the master reduction program in order to locate errors which had not been detected when first differences were computed on the raw data. A copy of the program is given in Appendix E. The program reads the sounding identification data and the contact data from magnetic tape and then computes first differences of each quantity except pressure contact number. If one of the values is missing, the first difference value is also defined to be missing; values marked with an asterisk in the contact data are also marked by an asterisk in the first difference program. Results from the first difference program are printed in the same format as the results from the master reduction program; a sample is shown in Fig. 6. Values printed at each contact are first differences except for pressure contact itself where the forward contact number is printed. The output from the program was scanned visually to locate possible errors. Actual errors were corrected by use of the following program.

Table 7

Data Transferred to Magnetic Tape

Quantity	Dimension
Station identification number	None
Station name	7
Day of rawinsonde release	None
Month of rawinsonde release (IX, IY, IZ)	None
Year of rawinsonde release	None
Time of rawinsonde release	None
Number of pressure contacts in sounding	None
Minimum sounding pressure	None
Angle time identifier (I1MIN)	None
Time after balloon release	230
Contact number	230
Height of pressure surface	230
Pressure	230
Temperature	230
Interpolation indicator	230
Dew point temperature	230
Wind direction	230
Scalar wind speed	230
Elevation angle indicator	230
E-W wind component	230
N-S wind component	230
Potential temperature	230
Equivalent potential temperature	230
Mixing ratio	230
Relative humidity	230
Range of balloon	230
Direction of balloon	230

FIRST DIFFERENCES

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TIME MIN	CNTCT	HEIGHT GPM	PRES MB	TEMP DG C	DEW PT DG C	DIP DG	SPEED M/SEC	U COMP M/SEC	V COMP M/SEC	POT T DG K	E POT T DG K	MX RTO GM/KG	RH PCT	RANGE KM	AZ DG
0.1	7.0	39.5	-4.5	-0.6	-0.9	18.0	6.7	4.5	-5.5	-0.3	-1.5	-0.5	-1.3	0.3	114.
0.3	8.0	97.2	-11.0	-0.2	0.1	0.0	0.0	0.0	0.0	0.8	1.2	0.1	1.1	0.0	0.
0.4	9.0	98.1	-11.0	-1.1	-0.7	-1.4	-0.6	-0.3	0.6	-0.1	-0.9	-0.3	0.9	0.2	6.
0.2	10.0	89.8	-10.0	-1.0	-1.0	-1.0	-0.4	-0.2	0.4	-0.2	-1.2	-0.4	0.1	0.1	2.
0.3	11.0	117.8	-13.0	-1.0	-0.9	8.1	0.2	-0.8	-1.3	0.1	-0.8	-0.3	0.1	0.2	0.
0.4	12.0	91.4	-10.0	-1.0	-1.0	3.1	-0.1	-0.5	-0.4	-0.2	-1.1	-0.4	-0.1	0.3	4.
0.4	13.0	92.1	-10.0	-0.8	1.2	-19.3	-0.9	1.4	3.3	0.2	1.7	0.6	7.8	0.3	4.
0.2	14.0	92.8	-10.0	-1.4	-1.7	-30.4	1.4	2.5	5.2	-0.6	-2.4	-0.7	-2.0	0.1	-2.
0.4	15.0	93.5	-10.0	-0.6	-0.8	-20.2	4.2	3.0	5.5	0.3	-0.4	-0.3	-1.1	0.2	-11.
0.3	16.0	113.2	-12.0	-0.9	-1.0	-0.6	1.0	0.8	0.5	0.1	-0.7	-0.3	-0.3	0.2	-12.
0.4	17.0	95.2	-10.0	-0.9	-0.9	19.4	-4.5	-3.1	-5.7	-0.0	-0.8	-0.3	0.0	0.3	-1.
0.3	18.0	96.0	-10.0	-0.9	-0.9	7.5	-0.7	-0.7	-1.5	-0.0	-0.7	-0.3	-0.1	0.2	-1.
0.4	19.0	96.7	-10.0	-1.1	-0.1	1.6	0.2	0.1	-0.3	-0.2	-0.1	0.0	4.0	0.3	-1.
0.3	20.0	97.6	-10.0	-0.7	-0.6	2.8	-0.0	-0.1	-0.6	0.2	-0.2	-0.2	0.2	0.2	-0.
0.4	21.0	118.2	-12.0	-1.4	-1.3	1.3	0.3	0.2	-0.3	-0.3	-1.3	-0.4	0.1	0.3	-0.
0.4	22.0	89.4	-9.0	-0.7	0.1	0.8	-0.0	-0.0	-0.2	0.2	0.4	0.1	3.8	0.3	-0.
0.2	23.0	100.2	-10.0	-0.9	-0.9	0.5	-0.2	-0.2	-0.1	0.1	-0.5	-0.2	-0.3	0.2	-0.
0.4	24.0	101.2	-10.0	-0.5	-6.9	1.5	0.6	0.5	-0.4	0.3	-4.3	-1.7	-26.1	0.3	0.
0.4	25.0	92.1	-9.0	0.5	-14.5	-0.9	1.3	1.3	-0.1	1.7	-3.4	-1.8	-30.1	0.3	0.
0.3	26.0	124.5	-12.0	0.0	0.0	-2.1	1.3	1.4	0.3	1.3	1.4	0.0	0.0	0.3	0.
0.3	27.0	105.2	-10.0	-0.3	-0.2	-2.8	-0.8	-0.7	0.8	0.7	0.7	-0.0	0.0	0.3	-0.
0.4	28.0	95.7	-9.0	-0.5	-0.4	-4.0	-0.6	-0.6	1.0	0.5	0.4	-0.0	0.1	0.3	-0.
0.3	29.0	96.7	-9.0	-0.3	-0.2	-3.0	-0.2	-0.2	0.7	0.7	0.6	-0.0	0.0	0.2	-0.
0.3	30.0	108.6	-10.0	-1.0	-0.7	-2.7	0.0	0.0	0.6	0.1	-0.1	-0.0	0.1	0.2	-1.
0.3	31.0	87.7	-8.0	-0.3	-0.2	-2.4	0.2	0.1	0.6	0.6	0.6	-0.0	0.0	0.2	-1.
0.4	32.0	110.6	-10.0	-1.3	-0.9	-2.2	0.6	0.5	0.6	-0.3	-0.4	-0.0	0.1	0.3	-1.
0.3	33.0	100.6	-9.0	-0.5	-0.3	-1.3	0.7	0.7	0.4	0.5	0.5	-0.0	0.0	0.3	-1.
0.3	34.0	90.2	-8.0	-1.3	-0.9	-1.5	0.7	0.6	0.5	-0.5	-0.6	-0.0	0.1	0.3	-1.
0.3	35.0	102.3	-9.0	-0.5	-0.3	-2.0	0.7	0.5	0.7	0.6	0.5	-0.0	0.0	0.3	-1.
0.3	36.0	126.5	-11.0	-1.1	-0.8	-2.3	0.6	0.4	0.8	0.1	0.0	-0.0	0.1	0.3	-1.
0.4	37.0	104.8	-9.0	-0.3	-0.2	-3.1	0.7	0.4	1.1	0.8	0.8	-0.0	0.0	0.4	-1.
0.3	38.0	105.9	-9.0	-1.2	-0.9	-2.1	0.6	0.4	0.8	-0.2	-0.3	-0.0	0.1	0.3	-1.
0.3	39.0	94.9	-8.0	-0.8	-0.5	-2.1	1.0	0.6	1.0	0.2	0.1	-0.0	0.1	0.3	-1.
0.4	40.0	107.9	-9.0	-0.6	-0.4	-2.9	1.6	1.1	1.6	0.5	0.5	-0.0	0.1	0.4	-1.
0.4	41.0	121.5	-10.0	-0.5	-0.3	-3.5	2.0	1.1	2.1	0.8	0.8	-0.0	0.0	0.4	-1.
0.3	42.0	98.4	-8.0	-0.4	2.2	-2.8	0.9	0.2	1.4	0.6	1.0	0.1	3.5	0.4	-1.
0.2	43.0	111.9	-9.0	-0.9	0.8	-1.8	0.6	0.1	1.0	0.2	0.4	0.1	2.4	0.3	-1.
0.3	44.0	100.7	-8.0	0.1	3.0	-1.1	0.2	-0.1	0.5	1.3	2.0	0.2	5.6	0.4	-2.
0.6	45.0	102.0	-8.0	-0.4	1.9	0.6	1.1	1.0	0.4	0.7	1.2	0.2	5.7	0.7	-3.
0.3	46.0	103.1	-8.0	-0.9	0.4	1.2	1.2	1.3	0.2	0.1	0.3	0.1	3.3	0.4	-1.
0.4	47.0	104.1	-8.0	-1.0	-0.4	1.2	2.0	2.0	0.6	-0.0	-0.1	-0.0	1.5	0.6	-1.
0.3	48.0	105.3	-8.0	0.1	-1.3	0.1	1.6	1.4	0.8	1.4	1.1	-0.1	-4.0	0.5	-1.
0.4	49.0	106.8	-8.0	0.0	-1.7	-1.4	1.9	1.2	1.7	1.2	0.8	-0.1	-4.3	0.7	-1.
0.4	50.0	108.2	-8.0	-0.3	0.1	-2.4	1.8	0.7	2.2	0.9	1.0	0.0	0.8	0.7	-1.
0.4	51.0	137.2	-10.0	-0.6	-0.1	-2.9	1.7	0.3	2.4	0.9	0.9	0.0	1.1	0.8	-1.

Fig. 6. Sample output from the first difference program.

FIRST DIFFERENCES

STATION NO. 532
PEORIA, ILL

11 MAY 1974
2315 GMT

156 26. 0

TIME MIN	CNTCT	HEIGHT GPM	PRES MB	TEMP DG C	DEW PT DG C	DIR DG	SPEED M/SEC	U COMP M/SEC	V COMP M/SEC	POT T DG K	E POT T DG K	MX RTO GM/KG	RH PCT	RANGE KM	AZ DG
0.3	52.0	97.3	-7.0	-0.4	2.1	-2.0	1.0	-0.1	1.6	0.6	1.3	0.2	7.3	0.6	-1.
0.4	53.0	112.5	-8.0	-1.0	-4.1	-1.8	0.4	-0.5	1.1	0.1	-0.9	-0.3	-9.1	0.8	-2.
0.4	54.0	114.0	-8.0	0.3	-6.9	-1.1	-0.6	-1.0	0.1	1.6	0.5	-0.4	-13.3	0.8	-1.
0.2	55.0	101.0	-7.0	-0.7	-0.5	-0.4	-0.7	-0.6	-0.3	0.3	0.3	-0.0	0.1	0.5	-1.
0.5	56.0	131.5	-9.0	-1.0	-0.7	0.1	-1.9	-1.4	-1.4	0.4	0.3	-0.0	0.1	0.9	-1.
0.4	57.0	118.4	-8.0	-0.8	-0.6	1.1	-0.5	0.1	-0.8	0.4	0.3	-0.0	0.1	0.7	-1.
0.4	58.0	104.9	-7.0	0.0	0.0	1.5	0.3	0.8	-0.5	1.2	1.3	0.0	0.0	0.7	-1.
0.3	59.0	106.3	-7.0	-0.6	-0.4	1.2	0.5	0.8	-0.2	0.6	0.6	-0.0	0.1	0.6	-1.
0.4	60.0	123.1	-8.0	-0.6	-0.4	1.3	-0.4	0.1	-0.9	0.8	0.8	-0.0	0.1	0.9	-1.
0.4	61.0	109.0	-7.0	-1.1	-0.8	1.2	-0.7	-0.1	-1.0	-0.1	-0.1	-0.0	0.1	0.7	-1.
0.3	62.0	110.1	-7.0	-1.1	-0.8	0.9	-0.3	0.1	-0.6	-0.0	-0.1	-0.0	0.1	0.5	-0.
0.4	63.0	111.4	-7.0	-0.7	-0.5	1.1	0.6	0.9	-0.1	0.5	0.5	-0.0	0.1	0.7	-0.
0.4	64.0	112.7	-7.0	-0.9	-0.7	0.9	2.1	2.0	0.8	0.2	0.1	-0.0	0.1	0.8	-0.
0.4	65.0	97.6	-6.0	-1.1	-0.8	0.7	1.9	1.8	0.7	-0.2	-0.2	-0.0	0.1	0.9	-0.
0.4	66.0	148.2	-9.0	-1.1	-0.8	0.7	1.2	1.2	0.3	0.5	0.4	-0.0	0.1	0.9	-0.
0.4	67.0	116.8	-7.0	-1.2	-0.9	0.7	0.3	0.5	-0.2	-0.1	-0.1	-0.0	0.1	1.0	-0.
0.3	68.0	118.2	-7.0	-0.9	-0.7	0.7	-0.3	-0.0	-0.6	0.3	0.2	-0.0	0.1	0.7	-0.
0.3	69.0	102.5	-6.0	-0.9	-0.7	0.7	-0.3	0.0	-0.5	0.1	0.0	-0.0	0.1	0.7	-0.
0.4	70.0	120.9	-7.0	-1.2	-0.9	0.6	-0.2	0.0	-0.5	-0.0	-0.1	-0.0	0.1	0.9	-0.
0.4	71.0	140.1	-8.0	-0.7	-0.5	-0.1	0.1	0.0	0.1	0.9	0.9	-0.0	0.1	0.9	-0.
0.4	72.0	124.5	-7.0	-0.8	-0.6	-1.1	0.3	-0.1	0.8	0.5	0.5	-0.0	0.1	0.9	-0.
0.4	73.0	108.1	-6.0	-0.8	-0.6	-1.2	0.8	0.2	1.1	0.3	0.3	-0.0	0.1	0.9	-0.
0.4	74.0	127.8	-7.0	-0.5	-0.4	-1.0	1.5	0.9	1.4	0.9	0.9	-0.0	0.1	0.9	-0.
0.4	75.0	111.1	-6.0	-0.9	-0.7	-0.8	2.1	1.4	1.7	0.2	0.2	-0.0	0.1	0.9	-0.
0.4	76.0	131.5	-7.0	-0.3	-0.2	-0.8	2.1	1.3	1.7	1.3	1.3	-0.0	0.0	1.0	-0.
0.4	77.0	114.4	-6.0	-0.8	-0.6	-1.7	-0.6	-1.3	0.7	0.4	0.4	-0.0	0.1	1.2	-0.
0.4	78.0	115.8	-6.0	-1.1	-0.8	-2.6	-2.5	-3.1	-0.0	0.1	0.1	-0.0	0.1	1.1	-0.
0.4	79.0	117.4	-6.0	-0.4	-0.3	-2.8	-2.2	-2.9	0.0	1.0	1.0	-0.0	0.0	0.9	-0.
0.5	80.0	119.2	-6.0	-0.4	-0.3	-2.1	0.4	-0.7	1.3	1.0	1.0	-0.0	0.0	0.9	-1.
0.5	81.0	141.5	-7.0	-0.3	-0.2	-0.2	3.7	2.5	2.7	1.5	1.5	-0.0	0.0	1.1	-1.
0.4	82.0	123.5	-6.0	0.1	0.1	-0.2	2.6	1.7	2.0	1.8	1.8	0.0	-0.0	1.1	-0.
0.4	83.0	125.4	-6.0	-1.2	-0.9	-1.0	0.4	-0.3	0.9	0.1	0.0	-0.0	0.1	1.2	-0.
0.3	84.0	127.1	-6.0	-1.2	-0.9	-0.9	-1.0	-1.2	-0.2	0.1	0.0	-0.0	0.1	0.8	-0.
0.4	85.0	128.9	-6.0	-0.8	-0.6	-0.7	-0.6	-0.8	-0.1	0.6	0.6	-0.0	0.1	0.9	-0.
0.6	86.0	130.8	-6.0	-1.2	-0.9	0.4	1.6	1.4	1.0	0.1	0.1	-0.0	0.1	1.5	-1.
0.5	87.0	132.8	-6.0	-0.5	-0.4	-0.0	2.6	1.8	2.0	1.1	1.1	-0.0	0.1	1.4	-0.
0.2	88.0	112.3	-5.0	-0.7	-0.5	-0.2	1.1	0.6	0.9	0.6	0.6	-0.0	0.1	0.6	-0.
0.6	89.0	136.8	-6.0	-0.9	-0.7	-3.2	-0.5	-2.5	1.5	0.6	0.5	-0.0	0.1	1.8	-1.
0.4	90.0	115.7	-5.0	-0.7	-0.5	-3.1	-2.4	-3.5	-0.3	0.6	0.6	-0.0	0.1	1.3	-0.
0.3	91.0	140.9	-6.0	-1.2	99.9	-1.4	-0.5	-1.3	0.2	0.3	999.9	99.9	999.9	0.6	-0.
0.6	92.0	119.2	-5.0	-0.8	99.9	-0.1	3.8	2.1	3.2	0.5	999.9	99.9	999.9	1.3	-1.
0.4	93.0	121.0	-5.0	-0.4	99.9	1.0	4.8	3.5	3.4	1.1	999.9	99.9	999.9	1.3	-0.
0.5	94.0	122.8	-5.0	-1.0	99.9	0.4	3.3	2.3	2.4	0.3	999.9	99.9	999.9	1.9	-1.
0.3	95.0	124.5	-5.0	-1.0	99.9	-0.3	-0.1	-0.3	0.1	0.4	999.9	99.9	999.9	1.0	-0.
0.6	96.0	126.4	-5.0	-0.7	99.9	-1.3	-3.8	-3.3	-2.4	0.8	999.9	99.9	999.9	1.9	-1.

Fig. 6. (Continued)

FIRST DIFFERENCES

STATION NO. 532
PEORIA, ILL

11 MAY 1974
2315 GMT

156 26. 0

TIME MIN	CNTCT	HEIGHT GPM	PRES MB	TEMP DG C	DEW PT DG C	DIR DG	SPEED M/SEC	U COMP M/SEC	V COMP M/SEC	POT T DG K	E POT T DG K	MX RTO GM/KG	RH PCT	RANGE KM	AZ DG
0.3	97.0	154.3	-6.0	-1.1	99.9	-0.7	-1.9	-1.6	-1.2	0.6	999.9	99.9	999.9	1.4	-0.
0.5	98.0	130.7	-5.0	-1.1	99.9	-0.3	0.5	0.1	0.6	0.2	999.9	99.9	999.9	0.1	-1.
0.3	99.0	132.6	-5.0	-1.3	99.9	-0.7	-0.5	-0.8	-0.0	-0.0	999.9	99.9	999.9	1.7	-0.
0.5	100.0	107.6	-4.0	-0.6	99.9	-2.5	-4.1	-4.0	-2.4	0.7	999.9	99.9	999.9	1.6	-0.
0.5	101.0	164.1	-6.0	-1.3	99.9	-2.2	-4.3	-3.7	-2.9	0.4	999.9	99.9	999.9	1.3	-1.
0.5	102.0	139.2	-5.0	-1.0	99.9	3.1	3.1*	3.7	1.4	0.5	999.9	99.9	999.9	0.7	-0.
0.5	103.0	113.2	-4.0	-0.3	99.9	5.2	7.8*	8.2	3.9	1.2	999.9	99.9	999.9	1.6	-0.
0.2	104.0	144.1	-5.0	-0.3	99.9	1.8	3.3*	3.4	1.5	1.7	999.9	99.9	999.9	1.1	-0.
0.4	105.0	146.7	-5.0	-1.7	99.9	1.2	-2.4*	-0.6	-2.7	-0.4	999.9	99.9	999.9	1.4	-0.
0.4	106.0	119.0	-4.0	-1.3	99.9	0.4	-5.8*	-3.4	-4.6	-0.1	999.9	99.9	999.9	1.3	-0.
0.5	107.0	120.7	-4.0	-0.8	99.9	0.5	-5.3*	-3.1	-4.3	0.6	999.9	99.9	999.9	1.1	-0.
0.4	108.0	122.8	-4.0	0.2	99.9	0.7	-0.7*	-0.0	-0.9	2.1	999.9	99.9	999.9	0.9	-0.
0.5	109.0	93.6	-3.0	-0.5	99.9	1.1	-0.2*	0.5	-0.7	0.7	999.9	99.9	999.9	1.5	-0.
0.5	110.0	158.8	-5.0	-0.5	99.9	1.4	-4.2*	-2.1	-3.8	1.7	999.9	99.9	999.9	1.4	-0.
0.6	111.0	195.6	-6.0	-0.3	99.9	1.7	-8.4*	-5.1	-6.7	2.5	999.9	99.9	999.9	1.4	-0.
0.3	112.0	168.0	-5.0	1.1	99.9	-0.1	-3.0*	-2.2	-2.1	4.5	999.9	99.9	999.9	0.5	0.
0.4	113.0	103.4	-3.0	0.8	99.9	-2.3	-1.1*	-1.6	-0.0	2.9	999.9	99.9	999.9	0.1	0.
0.3	114.0	140.7	-4.0	-0.3	99.9	-2.1	1.7*	0.3	1.9	1.7	999.9	99.9	999.9	0.7	-0.
0.5	115.0	143.8	-4.0	0.2	99.9	-1.7	2.3*	0.8	2.3	2.6	999.9	99.9	999.9	1.0	-0.
0.6	116.0	183.9	-5.0	-1.4	99.9	1.8	1.7*	1.8	0.6	0.6	999.9	99.9	999.9	1.1	-0.
0.4	117.0	150.2	-4.0	-1.2	99.9	3.0	1.8*	2.5	0.2	0.5	999.9	99.9	999.9	0.7	-0.
0.7	118.0	114.6	-3.0	-0.5	99.9	5.5	5.8*	6.7	1.4	1.0	999.9	99.9	999.9	1.7	-0.
0.7	119.0	156.3	-4.0	1.3	99.9	5.7	-1.0*	1.7	-3.8	4.8	999.9	99.9	999.9	1.7	0.
0.6	120.0	161.5	-4.0	1.5	99.9	6.9	-12.4*	-8.5	-9.9	6.0	999.9	99.9	999.9	1.5	0.
0.6	121.0	124.3	-3.0	-0.3	99.9	8.5	-12.5*	-10.1	-7.9	1.5	999.9	99.9	999.9	0.5	0.
0.4	122.0	169.0	-4.0	-1.3	99.9	0.7	-3.3*	-3.1	-1.2	0.6	999.9	99.9	999.9	0.2	0.
0.5	123.0	129.0	-3.0	-1.2	99.9	-5.1	0.8*	0.4	1.3	0.2	999.9	99.9	999.9	-0.0	0.
0.4	124.0	131.0	-3.0	-1.3	99.9	-4.2	4.0*	3.1	2.7	-0.1	999.9	99.9	999.9	0.4	0.
0.5	125.0	178.0	-4.0	-1.0	99.9	-3.5	7.9*	6.2	5.1	1.2	999.9	99.9	999.9	0.6	0.
0.7	126.0	182.4	-4.0	-0.7	99.9	-0.5	12.4*	10.3	6.8	1.9	999.9	99.9	999.9	1.3	0.
0.5	127.0	139.9	-3.0	-0.9	99.9	5.4	-0.6*	1.2	-3.2	0.9	999.9	99.9	999.9	1.1	0.
0.5	128.0	191.1	-4.0	0.0	99.9	13.1	-10.2*	-7.1	-10.1	3.3	999.9	99.9	999.9	1.8	0.
0.6	129.0	147.2	-3.0	-0.4	99.9	17.7	-6.7*	-6.0	-7.4	1.9	999.9	99.9	999.9	-0.8	0.
0.4	130.0	100.0	-2.0	0.0	99.9	-10.2	4.1*	4.0	3.8	1.8	999.9	99.9	999.9	0.7	0.
0.7	131.0	257.3	-5.0	0.0	99.9	-7.1	0.3*	-0.2	2.9	4.6	999.9	99.9	999.9	1.4	0.
0.5	132.0	160.1	-3.0	1.2	99.9	18.0	-11.9*	-11.3	-6.3	5.2	999.9	99.9	999.9	0.8	0.
0.5	133.0	164.7	-3.0	-0.5	99.9	81.6	-4.1*	-10.8	-6.4	2.0	999.9	99.9	999.9	-0.2	0.
0.5	134.0	168.6	-3.0	-0.7	99.9	-4.4	-1.9*	0.3	1.9	1.7	999.9	99.9	999.9	-0.8	0.
0.6	135.0	172.6	-3.0	-1.1	99.9	-96.8	6.4*	10.6	8.4	1.1	999.9	99.9	999.9	0.2	0.
0.6	136.0	177.6	-3.0	1.3	99.9	5.7	4.9*	5.0	-0.3	5.7	999.9	99.9	999.9	1.0	0.
0.7	137.0	245.9	-4.0	0.2	99.9	29.1	-2.1	-2.7	-7.6	5.0	999.9	99.9	999.9	0.4	0.
0.8	138.0	191.1	-3.0	0.0	99.9	-18.5	0.5	1.3	4.6	3.6	999.9	99.9	999.9	0.3	0.
0.6	139.0	264.9	-4.0	0.9	99.9	-15.4	-1.0	-1.4	3.7	6.8	999.9	99.9	999.9	0.5	0.
0.8	140.0	207.9	-3.0	2.4	99.9	4.7	-8.8	-8.5	-2.6	8.8	999.9	99.9	999.9	0.7	0.
0.7	141.0	216.6	-3.0	0.7	99.9	22.7	-2.7	-2.7	-1.4	5.6	999.9	99.9	999.9	-0.2	0.

Fig. 6. (Continued)

FIRST DIFFERENCES

STATION NO. 532
PEORIA, ILL

11 MAY 1974
2315 GMT

156 26. 0

TIME MIN	CNTCT	HEIGHT GPM	PRES MB	TEMP DG C	DEW PT DG C	DIR DG	SPEED M/SEC	U COMP M/SEC	V COMP M/SEC	POT T DG K	E POT T DG K	MX RTO GM/KG	RH PCT	RANGE KM	AZ DG
0.8	142.0	224.1	-3.0	-1.0	99.9	-35.4	6.2	5.6	3.9	2.4	999.9	99.9	999.9	0.2	0.
0.8	143.0	311.4	-4.0	0.5	99.9	12.0	0.8	1.3	-1.6	7.3	999.9	99.9	999.9	0.6	0.
0.8	144.0	245.1	-3.0	1.3	99.9	0.0	-2.0	-2.0	-0.4	7.7	999.9	99.9	999.9	0.4	0.
0.9	145.0	255.8	-3.0	0.0	99.9	-24.4	-1.4	-2.4	2.1	5.2	999.9	99.9	999.9	0.1	0.
0.8	146.0	266.4	-3.0	-0.2	99.9	-8.5	1.4	0.4	1.6	5.2	999.9	99.9	999.9	0.8	0.
0.9	147.0	278.3	-3.0	0.5	99.9	21.0	4.2	5.4	-0.7	6.9	999.9	99.9	999.9	-0.2	-0.
0.9	148.0	291.3	-3.0	-0.2	99.9	-0.8	5.0	4.5	2.1	5.8	999.9	99.9	999.9	1.2	0.
1.0	149.0	305.0	-3.0	-0.2	99.9	-213.5	-5.3	-21.7	-16.0	6.2	999.9	99.9	999.9	0.5	0.
1.0	150.0	319.8	-3.0	-0.7	99.9	2.8	-5.0	2.5	4.3	5.5	999.9	99.9	999.9	-1.4	0.
0.9	151.0	336.0	-3.0	-0.3	99.9	202.4	7.1	15.4	12.2	6.7	999.9	99.9	999.9	0.3	0.
1.1	152.0	354.6	-3.0	0.0	99.9	1.7	-4.6	-3.8	-2.6	8.0	999.9	99.9	999.9	1.2	0.
1.1	153.0	377.7	-3.0	2.3	99.9	-96.4	-7.5	-8.6	-3.2	14.0	999.9	99.9	999.9	0.6	0.
1.2	154.0	404.7	-3.0	1.1	99.9	124.7	2.2	4.5	-1.1	12.1	999.9	99.9	999.9	-0.6	-0.
1.2	155.0	433.7	-3.0	0.6	99.9	-236.5	0.9	-6.1	-3.9	11.8	999.9	99.9	999.9	0.1	0.
1.3	156.0	306.2	-2.0	-0.8	99.9	59.9	-1.7	-0.4	4.0	5.5	999.9	99.9	999.9	-0.1	-0.
1.4	157.0	490.4	-3.0	2.5	99.9	-37.1	2.0	-1.1	-2.9	18.3	999.9	99.9	999.9	-0.1	-0.
1.5	158.0	533.0	-3.0	-0.6	99.9	-4.0	0.1	0.1	-0.3	11.8	999.9	99.9	999.9	-0.8	0.
1.7	159.0	580.6	-3.0	0.5	99.9	-18.5	2.6	-0.2	-3.3	16.2	999.9	99.9	999.9	-0.4	0.
1.6	160.0	637.5	-3.0	-0.6	99.9	25.6	11.8	-12.4	-3.8	15.2	999.9	99.9	999.9	-0.2	0.

Fig. 6. (Continued)

E. Correct Errors on Tape

Many errors in the baseline, angle, and ordinate data were found after output from the first difference program was examined. Since most soundings contained at least one error, a program was written to substitute correct data records for incorrect ones. A copy of the program is presented in Appendix F. The original data were read from tape; the corrections were read from cards; and the corrected data were then transferred to a second tape. Three types of cards were needed to make the corrections. The first card specified the number of records to be corrected within the given sounding. If no corrections were needed, the data were simply transferred from the first tape to the second tape without modification. If corrections were needed, a second card was read for each correction that specified the location of the record to be corrected. This location was determined by manually counting down to the error on the raw data listing. For example, an error may be located on the fifth record of the sounding. Finally, a corrected data card with the original format followed each error location card. If corrections were needed in a sounding, the program read each record from the original tape and transferred it to the new tape until the location corresponding to the correction was reached; then the corrected card was substituted for the old record, and this was transferred to tape. The process continued until all corrections to the sounding had been made and all records of the original tape had been transferred to the new tape.

F. Master Reduction Program Using Corrected Data

Since many corrections were made to the original data, it was decided to recompute each sounding using the master reduction program described in Section II-C. No changes were made in the program or the type of output produced.

G. Interpolation of Pressure Contact Data to 25-mb Increments

Meteorological charts are frequently plotted for constant pressure surfaces; therefore, a program was written to interpolate the output from the master reduction program onto surfaces that are 25 mb apart. A copy of the program is found in Appendix G, and a flowchart is given in Fig. 7. The program assigns all of the surface values to level one (I = 1) of the new arrays (B and IB) and then linearly interpolates quantities to 25-mb pressure surfaces from 1000 mb (I = 2) up to 25 mb (I = 41). Since pressure contacts used in interpolation are only about 12 mb apart near the surface and 3 mb apart near the top of the sounding, it is possible to use linear interpolation instead of logarithmic interpolation. If the particular 25-mb level does not lie between the surface pressure value and the minimum pressure at the top of the sounding, the data for that 25-mb pressure surface are defined to be missing. Since wind direction may oscillate around 360°, care must be taken to guard against fictitious directions. If data needed in the interpolation of a quantity are missing, the interpolated quantity is also defined to be missing, and if quantities marked by an asterisk are used in the interpolation process, they are also marked by an asterisk in the output of this program. A sample of the

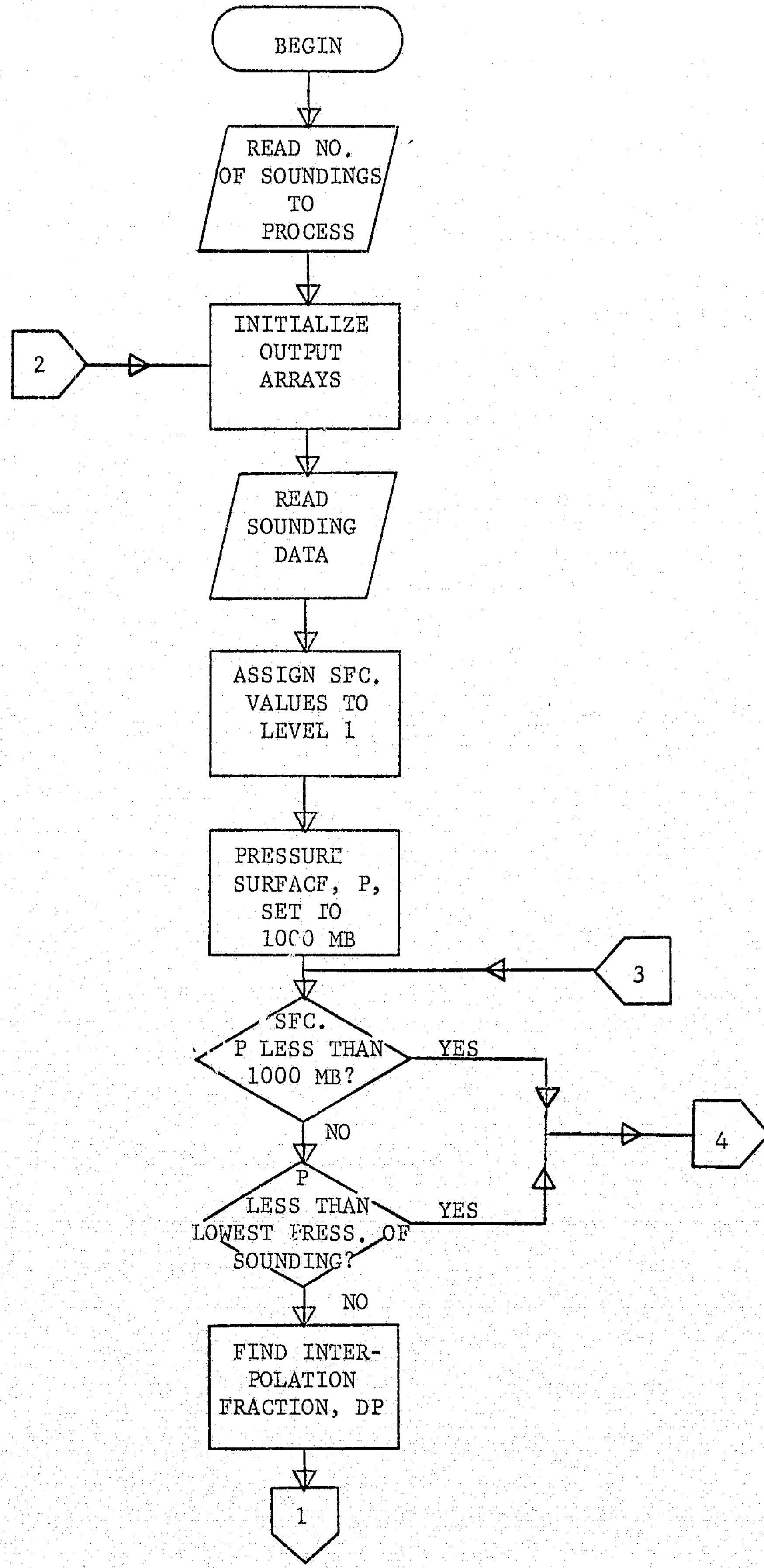

Fig. 7. Flowchart of the program to convert pressure contact data to 25-mb increments.

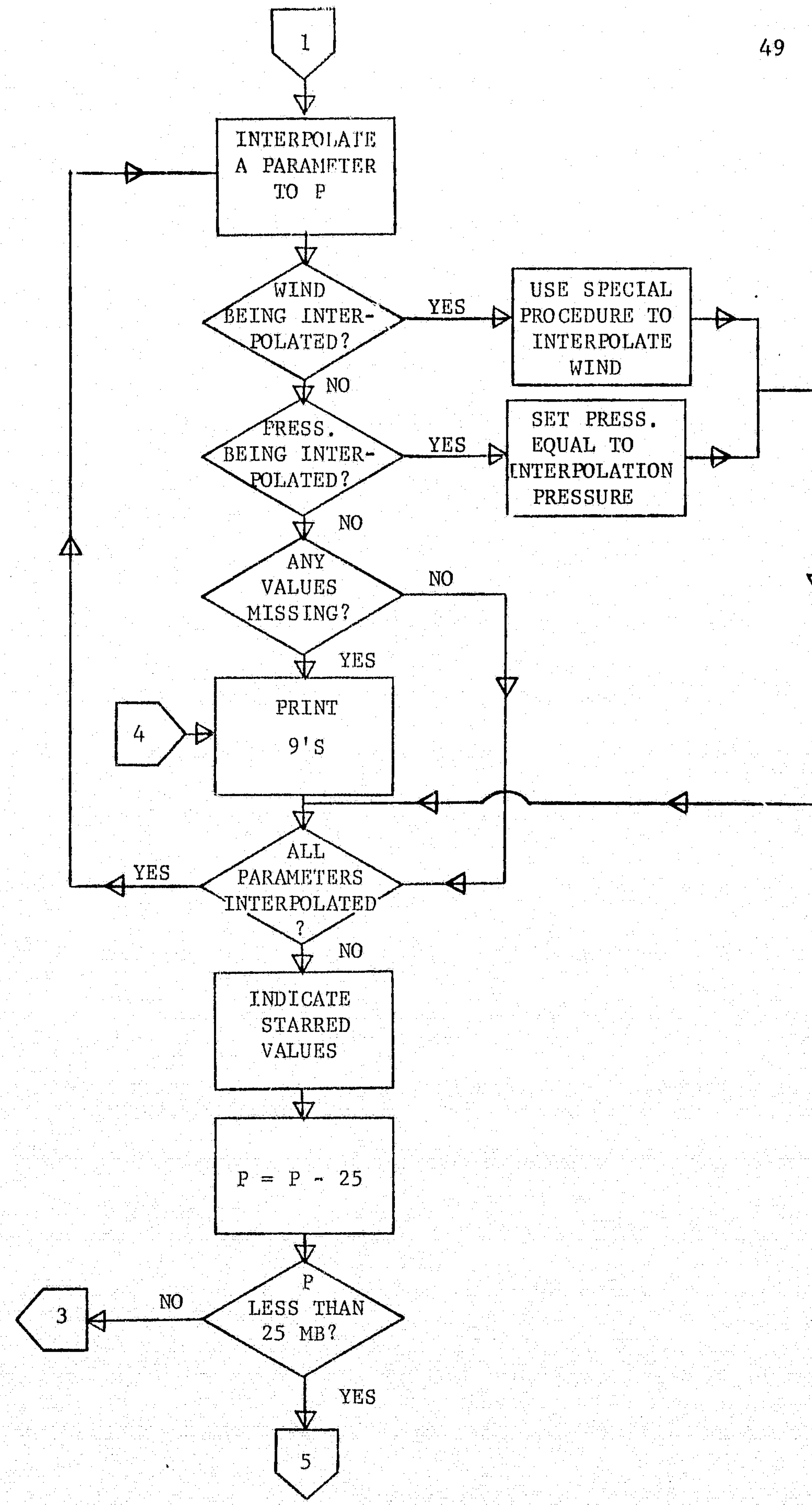

Fig. 7. (Continued)

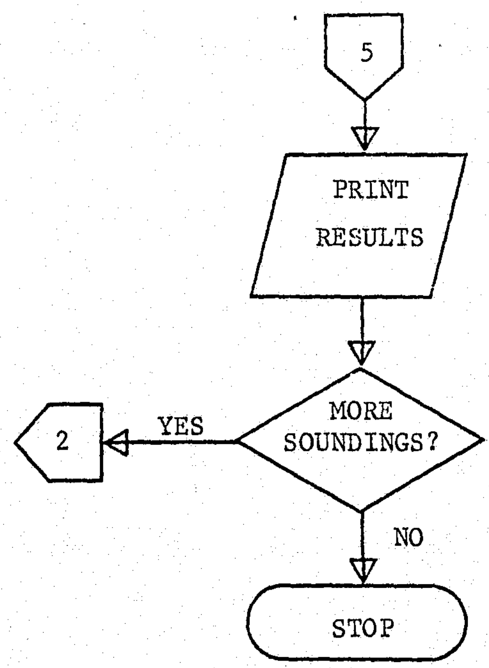

Fig. 7. (Continued)

output is presented in Fig. 8 where the column headings are the same as those described in Table 6. The results of the interpolation program are transferred to magnetic tape in the same order as described in Table 7, except items which had a dimension of 230 now have a dimension of 50.

H. Errors Remaining in the Output

In spite of efforts to correct all errors in the final output, some remaining errors have been detected. Since the errors are few in number, and since another pass through the data would be a lengthy and costly process, these errors were not changed. They are listed in Appendix H along with the necessary steps to correct each of them where possible. Missing soundings are listed in Appendix I.

STATION NO. 532
PEORIA, ILL

11 MAY 1974
2315 GMT

156 26. 0

TIME MIN	CNTCT	HEIGHT GPM	PRES MB	TEMP DG C	DEW PT DG C	DIR DG	SPEED M/SEC	U COMP M/SEC	V COMP M/SEC	POT T DG K	E POT T DG K	MX RTO GM/KG	RH PCT	RANGE KM	AZ DG
0.0	6.5	200.0	981.5	19.4	10.1	290.0	5.1	4.8	-1.7	295.2	316.4	8.0	55.0	0.0	0.
99.9	99.9	99.9	1000.0	99.9	99.9	99.9	99.9	99.9	99.9	99.9	999.9	99.9	999.9	999.9	999.
0.2	7.2	257.2	975.0	18.7	9.2	308.0	11.8	9.3	-7.3	295.0	315.2	7.5	53.9	0.3	114.
0.9	9.5	479.8	950.0	17.0	8.1	306.1	11.0	8.9	-6.4	295.4	314.6	7.2	55.7	0.5	121.
1.6	11.7	706.5	925.0	14.8	6.0	315.8	10.9	7.6	-7.8	295.2	312.4	6.4	55.8	1.0	125.
2.4	14.2	937.5	900.0	12.2	5.0	263.0	12.2	11.9	1.7	294.8	311.3	6.1	61.4	1.5	126.
3.2	16.5	1173.0	875.0	10.3	3.0	256.0	14.3	13.6	3.8	295.2	310.0	5.4	60.2	2.0	104.
4.1	19.0	1413.4	850.0	7.8	1.5	274.8	11.5	11.4	-1.0	295.0	308.7	5.0	64.1	2.6	102.
4.9	21.3	1658.9	825.0	5.5	-0.4	279.2	11.7	11.6	-1.9	294.9	307.4	4.5	65.7	3.2	101.
5.8	23.9	1909.8	800.0	3.7	-7.4	281.6	12.1	11.8	-2.4	295.4	303.3	2.8	44.5	3.7	101.
6.6	26.3	2168.1	775.0	4.4	-22.6	278.0	14.5	14.4	-2.0	298.6	301.1	0.8	11.8	4.4	101.
7.5	29.0	2434.1	750.0	3.3	-23.4	269.0	13.1	13.1	0.2	300.3	302.7	0.8	11.9	5.1	100.
8.4	31.7	2707.8	725.0	1.1	-25.0	262.4	13.8	13.7	1.8	300.7	302.9	0.7	12.1	5.8	98.
9.3	34.6	2988.6	700.0	-1.4	-26.7	257.8	15.7	15.4	3.3	301.0	303.0	0.6	12.4	6.6	96.
10.1	37.1	3277.1	675.0	-3.1	-27.9	251.2	17.4	16.4	5.6	302.2	304.0	0.6	12.6	7.4	94.
11.1	40.0	3574.1	650.0	-5.6	-29.7	244.3	20.5	18.5	8.9	302.7	304.3	0.5	12.8	8.3	91.
12.0	42.8	3880.9	625.0	-7.2	-27.2	236.6	23.8	19.9	13.1	304.3	306.4	0.7	18.3	9.4	87.
13.2	45.9	4198.6	600.0	-8.4	-21.8	236.7	26.4	22.0	14.5	306.4	309.9	1.1	33.0	10.9	82.
14.3	49.0	4527.7	575.0	-9.4	-25.1	236.8	32.1	26.8	17.6	309.0	311.8	0.9	26.6	12.8	78.
15.4	52.0	4870.5	550.0	-10.7	-22.9	229.4	36.5	27.7	23.8	311.4	314.9	1.1	35.8	14.9	75.
16.5	55.2	5227.2	525.0	-12.4	-34.6	226.1	35.1	25.3	24.4	313.5	314.8	0.4	13.5	17.2	71.
17.8	58.4	5598.3	500.0	-14.2	-36.0	229.3	33.6	25.5	21.9	315.7	316.9	0.3	13.7	19.5	68.
19.1	61.9	5985.4	475.0	-17.1	-38.2	233.3	32.5	26.0	19.4	316.7	317.8	0.3	14.0	21.9	66.
20:5	65.4	6388.7	450.0	-20.5	-40.7	236.3	37.6	31.3	20.8	317.5	318.3	0.2	14.3	24.8	65.
21.7	69.0	6808.4	425.0	-24.1	-43.5	238.8	37.9	32.5	19.6	318.0	318.7	0.2	14.7	27.6	64.
23.1	72.5	7247.9	400.0	-27.2	-45.8	237.6	38.4	32.5	20.6	319.6	320.2	0.2	15.0	30.8	63.
24.6	76.3	7710.5	375.0	-29.5	-47.6	233.8	44.3	35.7	26.2	322.4	322.9	0.1	15.2	34.5	63.
26.4	80.4	8199.9	350.0	-32.0	-49.6	225.1	41.2	29.2	29.1	325.5	325.9	0.1	15.5	38.7	61.
28:0	84.5	8721.3	325.0	-34.8	-51.7	222.5	45.0	30.4	33.2	328.6	329.0	0.1	15.8	43.0	59.
30.0	88.8	9275.6	300.0	-38.4	-54.6	219.7	49.6	31.7	38.2	331.2	331.5	0.1	16.1	48.4	57.
32.1	93.6	9868.9	275.0	-42.2	99.9	215.8	57.2	33.4	46.4	334.0	999.9	99.9	999.9	54.3	55.
34.1	98.4	10507.1	250.0	-47.1	99.9	213.2	53.0	29.0	44.4	336.1	999.9	99.9	999.9	60.2	53.
36.4	103.6	11197.1	225.0	-51.3	99.9	217.5	57.1*	34.8	45.3	339.9	999.9	99.9	999.9	67.0	51.
39.0	109.6	11952.9	200.0	-55.8	99.9	223.0	41.5*	28.3	30.4	344.4	999.9	99.9	999.9	74.5	50.
41.4	115.2	12804.8	175.0	-54.8	99.9	219.3	31.6*	20.0	24.4	359.4	999.9	99.9	999.9	79.0	49.
45.2	121.8	13785.7	150.0	-55.7	99.9	250.8	12.1*	11.4	4.0	374.2	999.9	99.9	999.9	86.3	49.
49.0	129.0	14926.4	125.0	-61.5	99.9	273.8	18.8*	18.8	-1.2	383.7	999.9	99.9	999.9	90.7	50.
53.3	136.8	16311.9	100.0	-61.2	99.9	282.4	15.1	14.4	-3.0	409.6	999.9	99.9	999.9	94.1	52.
59.1	144.3	18119.9	75.0	-56.3	99.9	251.7	7.0	6.6	2.0	454.9	999.9	99.9	999.9	96.7	53.
67.0	152.7	20693.7	50.0	-55.8	99.9	176.2	4.0	2.0	2.3	512.1	999.9	99.9	999.9	99.7	53.
99.9	99.9	99.9	25.0	99.9	99.9	99.9	99.9	99.9	99.9	99.9	999.9	99.9	999.9	999.9	999.

Fig. 8. Sample output from the program to convert pressure contact data to 25-mb increments.

III. ERROR ANALYSIS OF THE DATA

Accuracy of meteorological data is an important consideration in its use. This is especially true when small-scale temporal and spatial features are being studied since these features may have amplitudes which approach the limit of accuracy of the data. The accuracy of data is dependent on several factors -- the type of equipment being used at a station, the reduction procedures used to process the data, human factors in calibrating and tracking the sonde, and handling the data. Current estimates of errors in the input data will be given in this section along with a discussion of how these errors affect the final product of the master reduction program and the program to interpolate data to constant-pressure surfaces.

A. Stated Accuracy of the Thermodynamic Data

1. Temperature. Case (1962) adopts a root-mean-square (rms) error of 0.7C based on laboratory determination, while Weidner and Chambers (1967) believe that a value of 1.4C is more realistic operationally. Hodge and Harmantas (1965) found rms differences between military and NWS sondes to be about 0.5C under field conditions. It is believed that rms errors in the AVE IIP temperature data are approximately 1C.

2. Pressure. Radiosondes are calibrated after manufacture so that each pressure contact on the baroswitch corresponds to a certain atmospheric pressure. By comparing baroswitch pressures with those obtained hydrostatically using radiosonde temperatures and balloon heights measured by a high precision radar, Weidner and Chambers (1967)

found that baroswitch errors are generally small. The rms errors were determined to be approximately 1.3 mb from the surface to 400 mb, 1.1 mb from 400 to 100 mb, and 0.7 mb between 100 and 10 mb. These errors are considered representative of the AVE IIP data.

3. Humidity. A carbon strip element is used now as the humidity sensor in radiosondes. Case (1962) reports an rms error of 10% in the sensor. The current specifications for the carbon element are ±3% at 25C, ±5% at temperature less than 25C plus an allowance for hysteresis of ±4% above a value 33% relative humidity, and ±5% at humidities between 10% and 33% (Brousaides, 1973). Brousaides concludes that use of carbon humidity data at values below 20% is unwarranted except for the trend information that is provided. AVE IIP humidity data are thought to be generally within 10% of the true values.

4. Pressure Altitude. Altitude of the sonde is determined by use of the hypsometric equation in which pressure, temperature, and humidity are variables. Errors in temperature, however, are the greatest source of error in height determination. The worst possible situation arises when temperature errors are systematically of the same sign through great depths of the atmosphere. Table 8 shows the height error at various pressures due to a systematic temperature error of 1C. These errors are larger than would be expected in the AVE IIP data inasmuch as the errors in temperature generally are of both signs. Scoggins and Smith (1973), based on a study of AVE I data, concluded that realistic rms errors in pressure altitude are on the order of 10

Table 8

Errors in Altitude Due to a Systematic Temperature Error of 1C

Pressure mb	Altitude gpm
50	87.7
100	67.5
200	47.1
300	35.3
400	26.8
500	20.7
600	15.3
700	10.7
800	6.7
900	3.1
1000	0

gpm at 500 mb, 20 gpm at 300 mb, and 50 gpm at 50 mb. An analysis of the AVE IIP data suggests comparable errors.

B. Accuracy of the Wind Data

The AVE IIP wind data were computed in several stages beginning with finite differencing over 1-min intervals each 30 sec. These "raw" winds were smoothed, and the smoothed values were then interpolated to pressure contacts. The accuracy of the "raw" wind data will be described in detail, but the effects of smoothing and interpolation on accuracy must be described in more general terms.

1. Accuracy of the "Raw" Winds. Scoggins (1963) developed a statistical technique for evaluating errors in wind data that will be used in this section. If F is a function of X, Y, and Z, and if these are in error by ΔX, ΔY, and ΔZ, then F is in error by an amount ΔF which is given by the Taylor's series as:

$$\Delta F = \frac{\partial F}{\partial X} \Delta X + \frac{\partial F}{\partial Y} \Delta Y + \frac{\partial F}{\partial Z} \Delta Z \ . \tag{38}$$

The equation is valid if ΔX, ΔY, and ΔZ are small compared with $\partial F/\partial X$, $\partial F/\partial Y$, and $\partial F/\partial Z$; it was assumed that all terms involving squares, higher powers, and cross products of ΔX, ΔY, and ΔZ are negligible, and that higher derivatives are small in value. After squaring both sides of Eq. (38) and replacing each term by its average value, the following equation is obtained when one assumes that errors in X, Y, and Z are independent:

$$\sigma_F^{\ 2} = \left(\frac{\partial F}{\partial X} \sigma_X\right)^2 + \left(\frac{\partial F}{\partial Y} \sigma_Y\right)^2 + \left(\frac{\partial F}{\partial Z} \sigma_Z\right)^2 \ . \tag{39}$$

The symbol σ denotes rms error.

Radar or radio direction-finding equipment is used to measure azimuth and elevation angles of the balloon while the hypsometric equation is used to determine its height. For the purpose of this discussion, a flat earth will be assumed although this was not done in the actual reduction process described earlier. The X, Y, and Z coordinates of the balloon are given by:

$$X = Z \ \mathrm{COT}(E) \ \mathrm{SIN}(A) \tag{40}$$

$$Y = Z \ \mathrm{COT}(E) \ \mathrm{COS}(A) \tag{41}$$

$$Z = \frac{R}{g} \overline{T}^{*} \ \mathrm{LOG}_e\left(\frac{p_1}{p_2}\right) \tag{42}$$

where E is elevation angle, A is azimuth angle, R is the gas constant, g is acceleration due to gravity, $\overline{T}^*$ is mean virtual temperature, and p_1 and p_2 are pressures at two levels. Errors in X, Y, and Z can then be evaluated by use of Eq. (39). The assumptions made are that errors in E, A, $\overline{T}^*$, and p are independent of each other, and that errors in each parameter are normally distributed. Results from the AVE I angle data, recorded at 6-sec intervals, indicate that there is some systematic component to the elevation angles at values below 10°*, but generally the above assumptions are thought to be valid for the AVE IIP data which was recorded at 30-sec intervals. Errors in Z are mostly due to errors in temperature and not errors in pressure or moisture. Application of Eq. (39) to Eqs. (40-42) yields:

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*Personal communication with Mr. W. W. Vaughan, Chief, Aerospace Environment Division, NASA Marshall Space Flight Center, Huntsville, Alabama, 35812.

$$\sigma_X^2 = \left[\sigma_Z \cdot \mathrm{COT(E)} \cdot \mathrm{SIN(A)}\right]^2 + \left[\sigma_E \cdot Z \cdot \mathrm{CSC}^2\mathrm{(E)} \cdot \mathrm{SIN(A)}\right]^2 + \left[\sigma_A \cdot Z \cdot \mathrm{COT(E)} \cdot \mathrm{COS(A)}\right]^2 , \quad (43)$$

$$\sigma_Y^2 = \left[\sigma_Z \cdot \mathrm{COT(E)} \cdot \mathrm{COS(A)}\right]^2 + \left[\sigma_E \cdot Z \cdot \mathrm{CSC}^2\mathrm{(E)} \cdot \mathrm{COS(A)}\right]^2 + \left[\sigma_A \cdot Z \cdot \mathrm{COT(E)} \cdot \mathrm{SIN(A)}\right]^2 , \text{ and} \quad (44)$$

$$\sigma_Z^2 = (\sigma_T \frac{R}{g} \mathrm{LOG}_e \frac{p_1}{p_2})^2 \quad . \quad (45)$$

It is generally assumed that $\sigma_A = \sigma_E = 0.05°$ for the GMD-1 used in the AVE II pilot experiment (Danielsen and Duquet, 1966); however, Weiss and Georgian (1969) indicate that these values are not equal, are larger than those generally assumed, and greatly dependent on elevation angle. A value of 1C is assumed for σ_T. If one assumes that A = 90°, the value of σ_X will be a maximum, while if A = 0°, the value of σ_Y is a maximum. The rms error of wind speed components σ_{wx} and σ_{wy} is given by

$$\sigma_{wx} = \frac{\left[\sigma^2_{x2} + \sigma^2_{x1}\right]^{\frac{1}{2}}}{\Delta t} , \text{ and} \quad (46)$$

$$\sigma_{wy} = \frac{\left[\sigma^2_{y2} + \sigma^2_{y1}\right]^{\frac{1}{2}}}{\Delta t} \quad (47)$$

where subscripts 2 and 1 refer to consecutive measurements. These equations can be simplified by assuming $\sigma^2_{x2} = \sigma^2_{x1}$ and $\sigma^2_{y2} = \sigma^2_{y1}$, which is reasonable over short time periods. The "raw" winds computed by the AVE IIP reduction program are based on angle measurements that are 60 sec apart (Δt = 60). Finally, the rms error of the scalar wind ($\sigma_{|V|}$) is given by:

$$\sigma_{|V|} = \left[\sigma^2_{wx} + \sigma^2_{wy}\right]^{\frac{1}{2}} \quad . \tag{48}$$

$\sigma_{|V|}$ is a maximum at either 0° or 90°.

Figure 9 shows the results of the computations at various elevation angles and pressures; heights used for corresponding pressure values are those of a standard atmosphere. RMS errors increase with increasing height and with decreasing elevation angle. Maximum rms errors for AVE IIP data at 700 mb range from about 2.5 m/sec at an elevation angle of 10° to about 0.5 m/sec at an elevation angle of 40°. At 500 mb the errors are 4.5 m/sec and 0.8 m/sec at the same elevation angles; while at 300 mb the errors are 7.8 m/sec and 1.0 m/sec, respectively. Users of the data should remember that these values are maxima since the azimuth angle was assumed to be either 0° or 90°.

These errors of the "raw" wind are in agreement with those cited for the AVE I data by Scoggins and Smith (1973). Data published by the Air Force Missile Test Center (1963) are also in good agreement with those of the AVE II pilot experiment. RMS vector errors were given as a function of altitude and constant mean wind speed through a layer. By assuming an ascent rate of 1,000 ft/min, the elevation angle of the sonde at each altitude could be determined. RMS vector errors for an elevation angle of 12.5° are plotted on Fig. 9. The results agree well with the AVE II results. Results by Reiter (1963), given in Fig. 9 for an elevation angle of 10°, are also consistent with those of the AVE II pilot experiment. The errors cited by Reiter are based on a time interval of 2 min and an error in angle measurement of 0.075°.

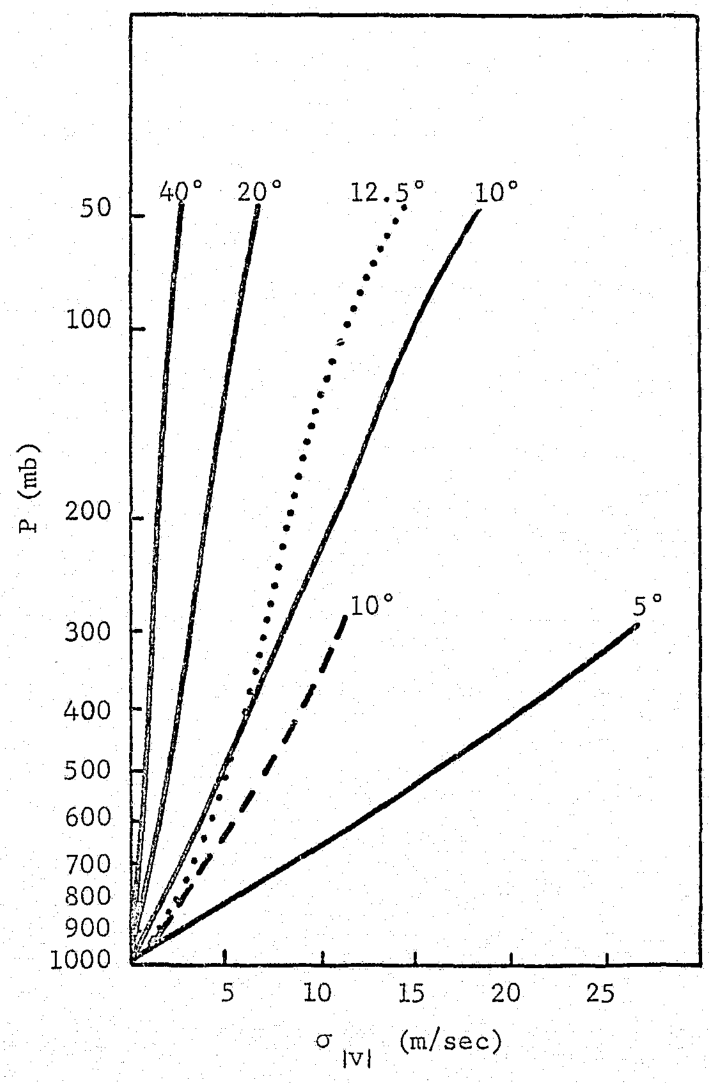

Fig. 9. RMS errors of scalar wind speed as a function of pressure and elevation angle. Results for AVE IIP are given as solid line. Results by the Air Force Missile Test Center (1963) are given as a dotted line. Results by Reiter (1963) are given as a dashed line.

When θ is small, $\sin\theta \approx \tan\theta$; therefore, rms errors in wind direction (σ dir) may be approximated by:

$$\sigma_{dir} \approx \mathrm{SIN}^{-1}\left(\frac{\sigma_{wy}}{|V|}\right) \quad . \tag{49}$$

where $|V|$ is the scalar wind speed. Since the error is dependent on the azimuth angle of the sonde, maximum errors can be given by making $A = 0°$. Results for the AVE IIP data are plotted as a function of pressure and elevation angle in Fig. 10. At 700 mb the scalar wind speed is assumed to be 15 m/sec, while at 500 mb, 300 mb, and 100 mb, it is assumed to be 20 m/sec, 25 m/sec, and 20 m/sec, respectively. Errors for other geometric conditions and wind speeds would be different. The errors increase with decreasing pressure and decreasing elevation angle. Errors in AVE IIP wind direction at 700 mb range from about 9.5° at an elevation angle of 10° to about 1.3° at an elevation angle of 40°. At 500 mb the errors are 13.4° and 1.8 at the same elevation angle, while at 300 mb the errors are 18.0 and 2.5, respectively. If the azimuth angle at 300 mb were 90° instead of 0°, the rms error would be 2.4° at an elevation angle of 10°. The results are in agreement with those cited for the AVE I data by Scoggins and Smith (1973), and those obtained by personal communication with Mr. W. W. Vaughan of NASA - Huntsville, Alabama. If one assumes that the rms vector errors given by the Air Force Missile Test Center (1963) are maximum errors, the maximum rms direction error will be given by:

$$\sigma_{dir} = \mathrm{TAN}^{-1}\left(\frac{\sigma_{vect}}{|V|}\right) \quad . \tag{50}$$

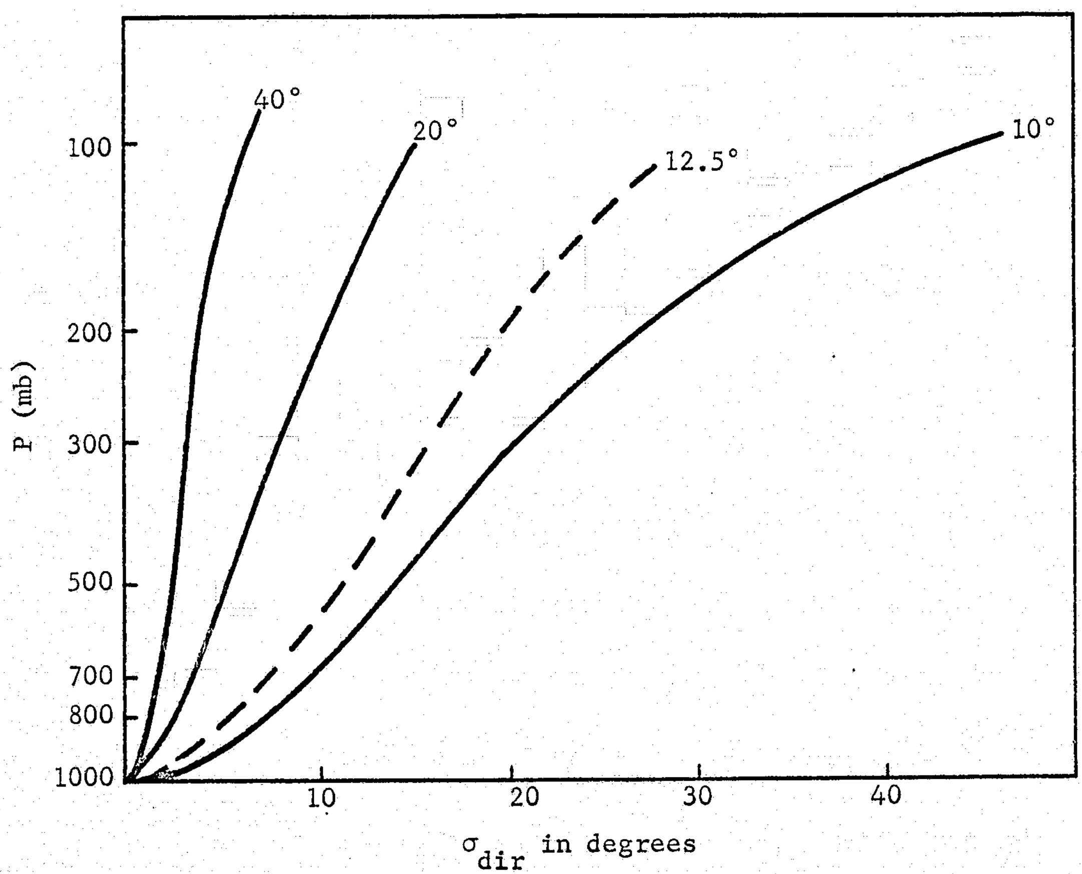

Fig. 10. RMS errors of wind direction as a function of pressure and elevation angle. The values are maximum for the stated elevation angles and pressures. Results at 12.5° are based on data supplied by the Air Force Missile Test Center (1963).

RMS errors for an elevation angle of $12.5°$ are given in Fig. 10 for the same scalar wind speeds that were used previously. Good agreement can be seen between these values and those cited for the AVE IIP data.

The results presented above are not strictly valid when angle data are available at only 1-min intervals. These angle data are interpolated to 0.5-min intervals which constitutes a smoothing process on the input values. The degree of smoothing is dependent on the angle profile, but generally, the accuracy statements made earlier are still applicable.

In conclusion, it may be stated that the rms errors cited above for the "raw" winds are in general agreement with those obtained from other sources and are highly dependent on balloon location and ambient wind speed.

2. Accuracy of the Smoothed Winds. Figure 11 shows "raw" wind speed plotted as a function of time from release for Eglin Air Force Base, Florida at 1200 GMT on 11 May, 1974. In this example elevation angles ranged from 16° shortly after release to 30° near the top of the sounding. The figure indicates many small-scale variations in wind speed that become more apparent with increasing altitude. While some of these variations are indeed mesoscale meteorological phenomena, many are simply due to inaccuracies in the angle data which were truncated to the nearest 0.1° at 30-sec intervals. It was felt desirable to smooth these winds so that very small-scale features would be suppressed.

"Raw" wind speeds for Rapid City, South Dakota at 0300 GMT on 12 May, 1974 are shown in Fig. 12 where the elevation angle ranges from

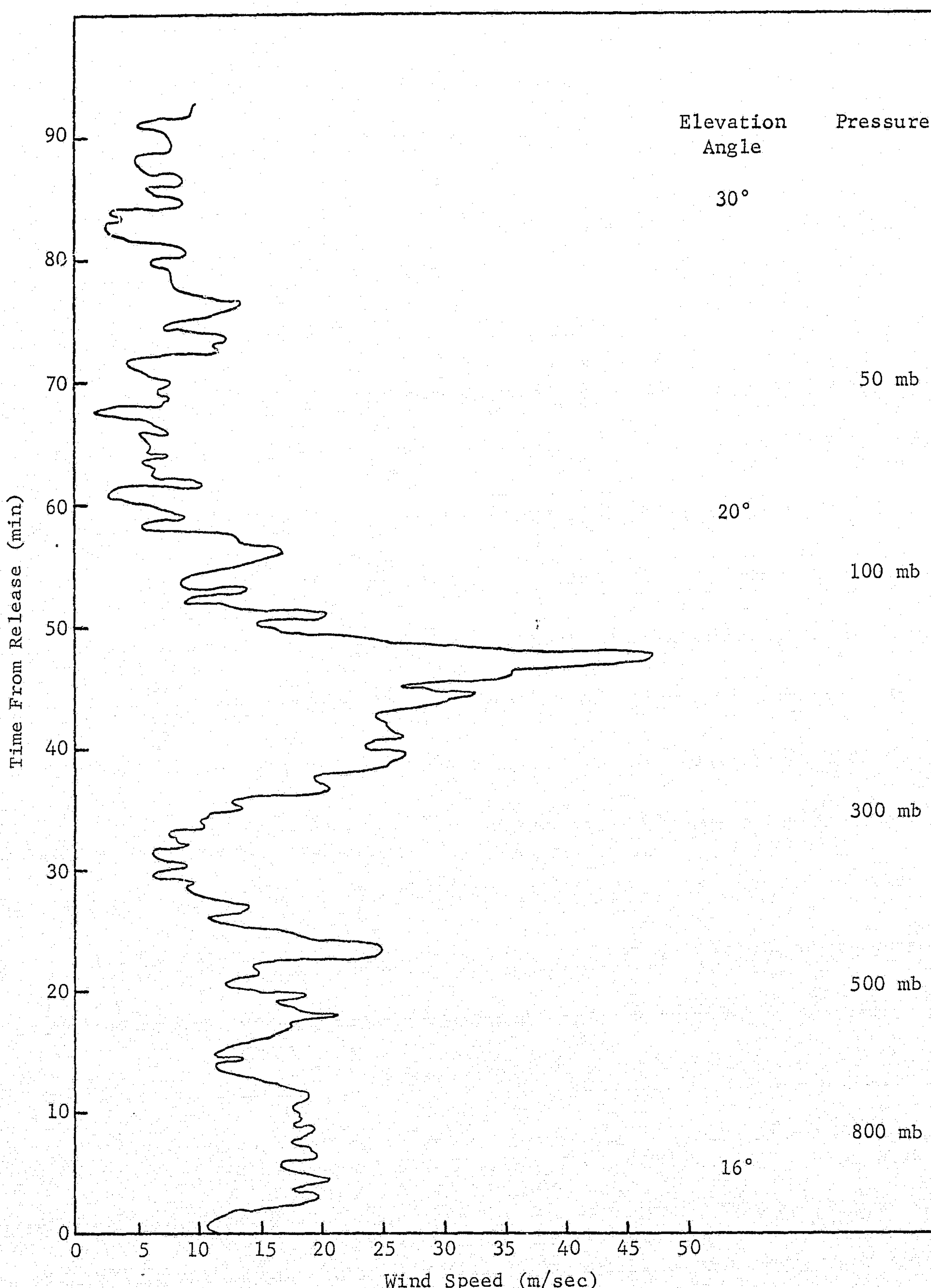

Fig. 11. "Raw" wind speeds at Eglin Air Force Base, Florida at 1200 GMT on 11 May, 1974.

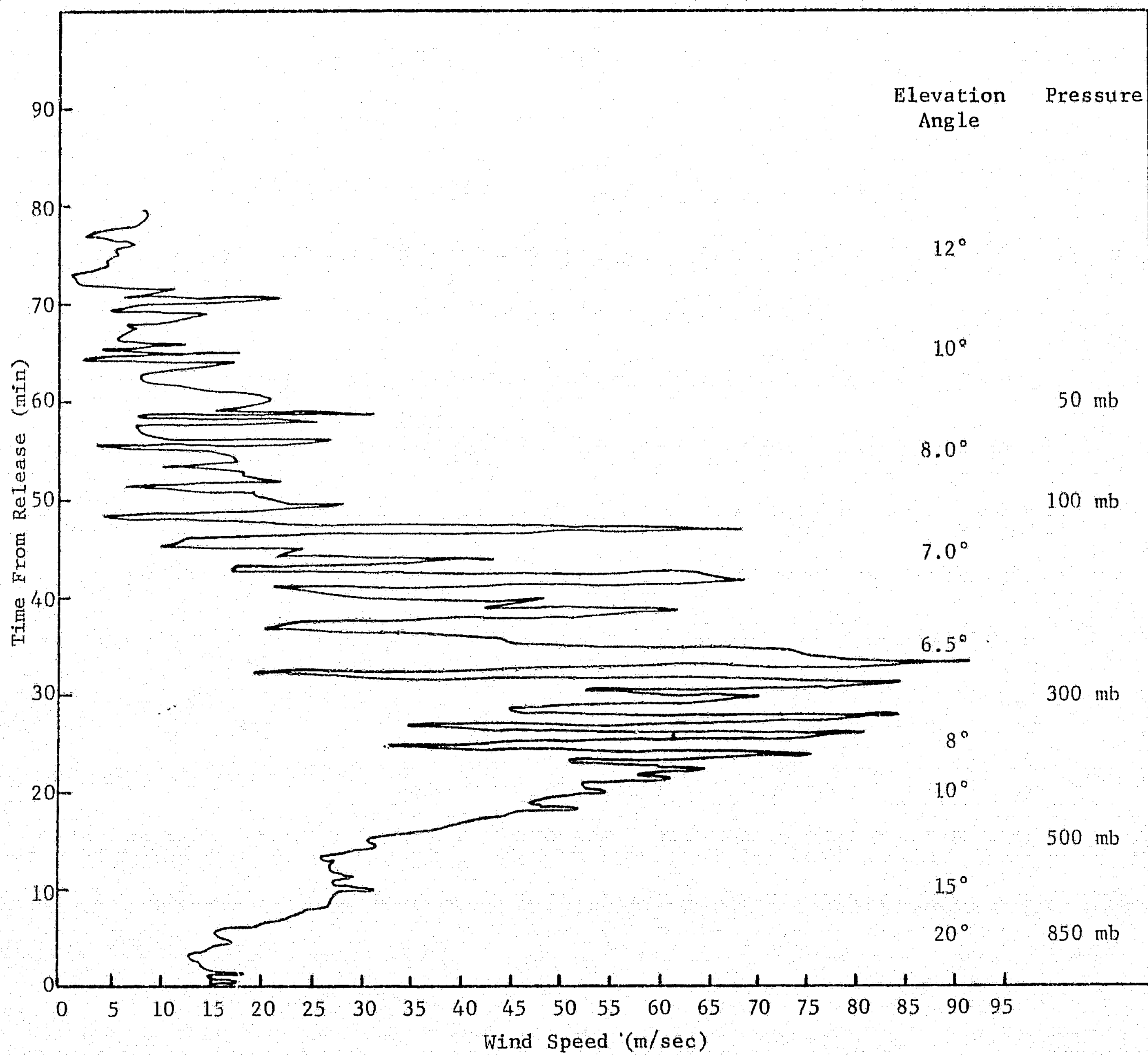

Fig. 12. "Raw" wind speeds at Rapid City, South Dakota at 0300 GMT on 12 May, 1974.

about 20° near the surface to 6.5° at about 40 min after release to 12° near the top of the sounding. The wind speeds are observed to become very erratic at elevation angles below about 10° with most of these fluctuations undoubtedly being non-meteorological in nature. Similar results were obtained in the AVE I data when elevation angles were less than 10°.* Danielsen and Duquet (1966) found that errors in the elevation angles increase to 10 and 15 times the generally accepted rms error of 0.05° when the elevation angle is less than 10°. They concluded that the increase in error was due to the inability of the tracking unit to discriminate between direct and ground-reflected or refracted signals. Some method of smoothing is clearly needed to suppress the large oscillations in wind speed associated with low elevation angles.

Several smoothing techniques were investigated in order to find a procedure which would perform the types of smoothing needed, be practical from a programming and cost viewpoint, and lend itself to error analysis procedures. Smoothing the angle databy least square polynomial fitting was considered, but results obtained when this procedure was used on AVE I data were not satisfactory according to personal communication with NASA personnel. The application of smoothing functions to the elevation angles and finite differencing over larger time intervals were considered but not used.

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*Personal communication with Mr. W. W. Vaughan, Chief, Aerospace Environment Division, NASA Marshall Space Flight Center, Huntsville, Alabama, 35812.

It was finally decided to apply 5-point binomial coefficients to the "raw" wind components that were obtained at 30-sec intervals, and then to recompute scalar wind speed and direction using the smoothed components. The response function for the 5-point weighted average is shown in Fig. 13. Changes in speed with a frequency higher than 1 cycle/min are completely eliminated by the smoothing process while events of lower frequency are smoothed to a lesser extent. For example, 81% of the amplitude of changes in speed with a frequency of 1 cycle/5 min would be retained by the procedure, and 25% of the amplitude of changes in speed with a frequency of 1 cycle/2 min would be retained. Assuming an ascent rate of 1000 ft/min, this means that 81% of the measured shear in a 2500-ft layer of the atmosphere would be retained by the smoothing technique, and 25% of the measured shear in a 1000-ft layer would be retained. Angle data were available at 0.5-min (approximately 500-ft) intervals. Based on an analysis of the wind data, it was decided not to begin the smoothing process until the balloon was 2.0 km above the ground. Figure 14 shows the results of the smoothing process which for purpose of illustration was not begun until 23 min after release. A comparison of Fig. 11 with Fig. 14 reveals the effect of smoothing. The accuracy of the smoothed winds is greater than that of the original winds although an exact comparison of the accuracies cannot be made.

3. Accuracy of Pressure Contact Winds. Smoothed wind components at 0.5-min intervals were interpolated on the basis of time from release to correspond to data given for the pressure contacts. New scalar wind

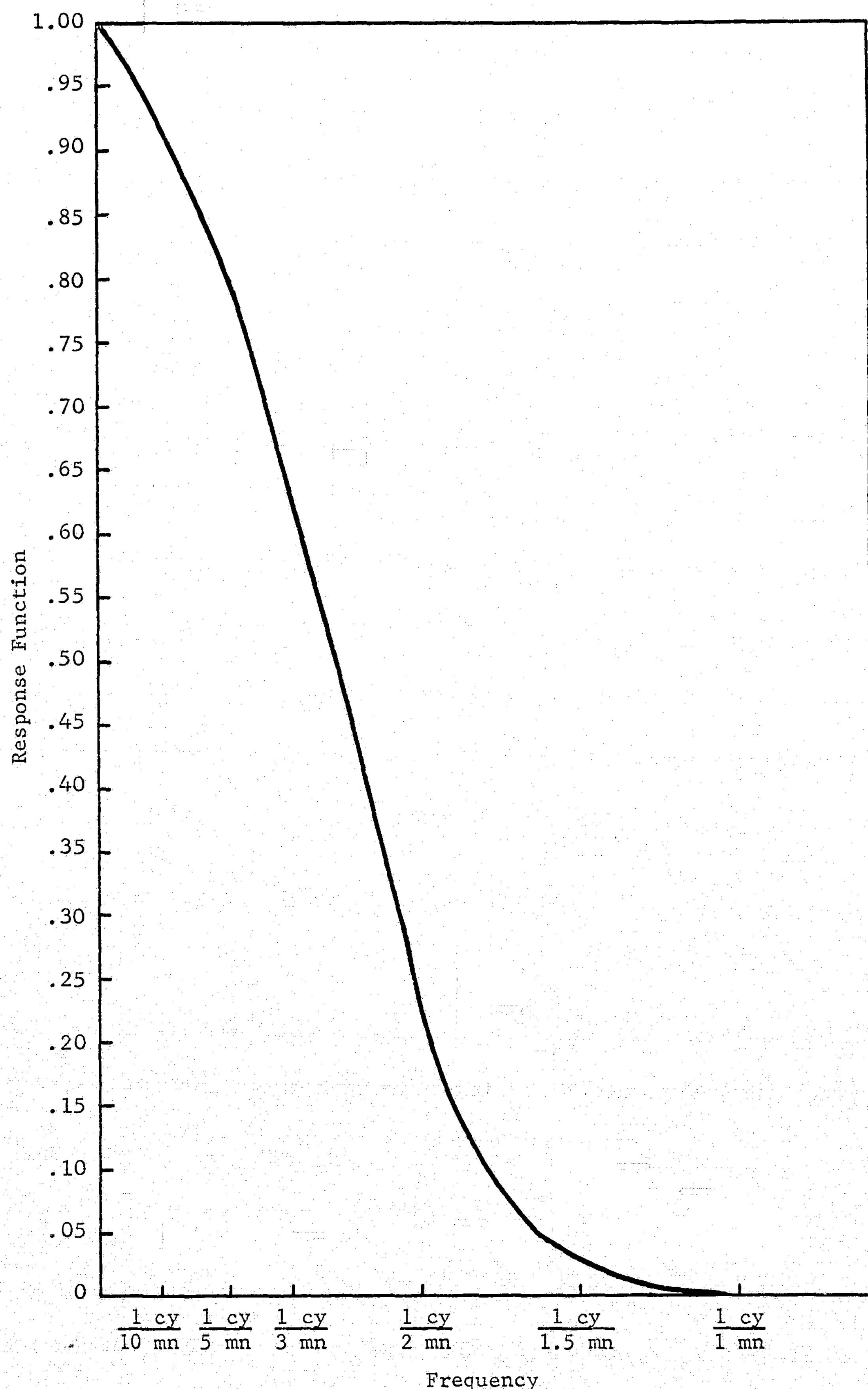

Fig. 13. Response function for a 5-point weighted average using binomial coefficients.

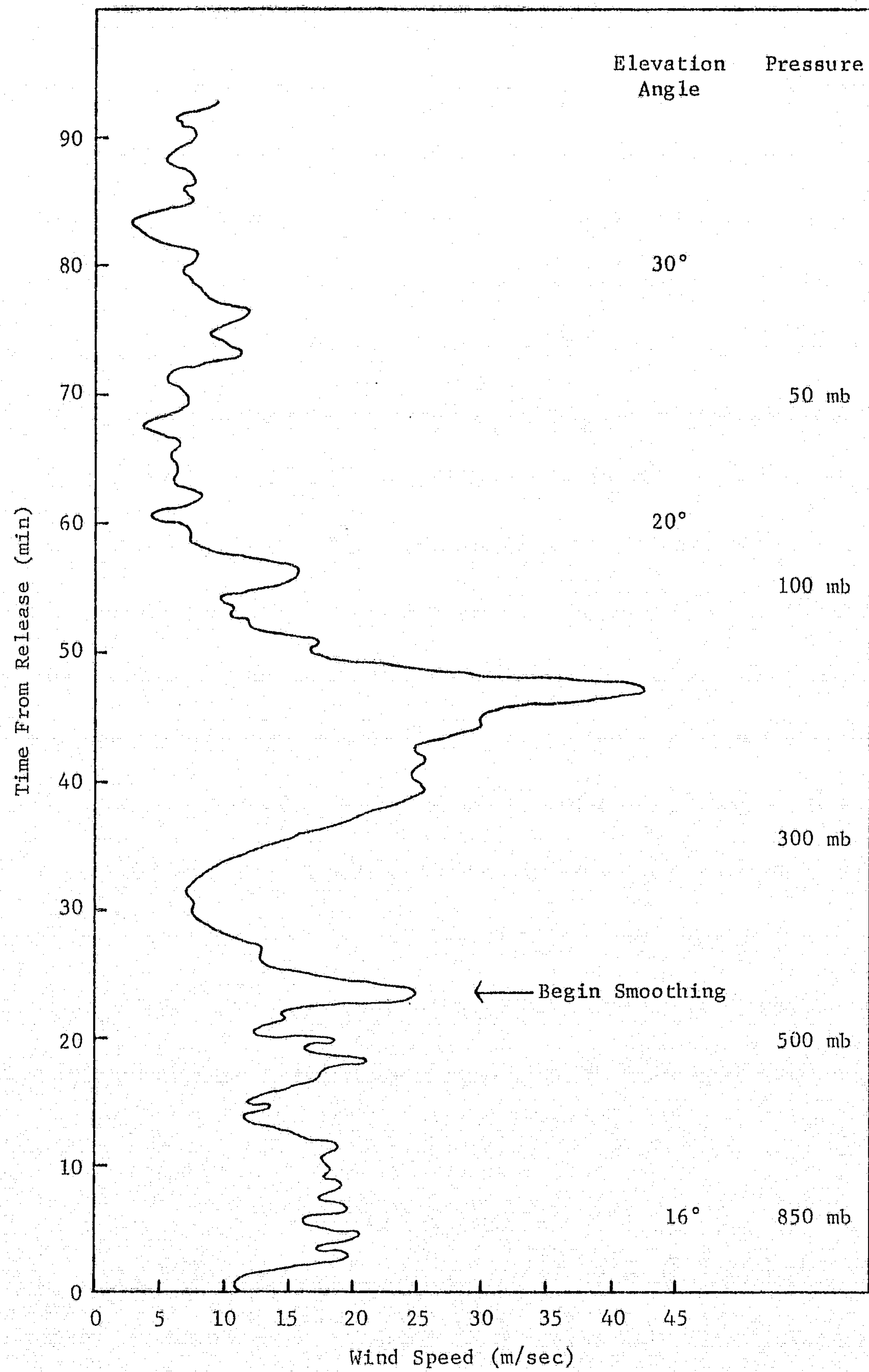

Fig. 14. Wind speeds after the application of a 5-point binomial smoothing function at Eglin Air Force Base, Florida at 1200 GMT on 11 May, 1974. Smoothing did not begin until 23 min after release for this example.

speeds and directions were then computed. Near the surface, pressure contacts occur at approximately 0.5-min intervals so that no great amount of smoothing is involved in matching the winds with the contact data. At higher altitudes, the difference in time between successive pressure contacts increases so that at 200 mb the difference is about 0.6 min, at 50 mb about 1.0 min, and at 25 mb about 1.5 min. At these higher levels, more and more smoothing is involved in the interpolation process. Figure 15 shows the results of the interpolation process on the smoothed winds in Fig. 14. The added smoothing due to the larger time interval between pressure contacts is evident near the top of the sounding. This is not undesirable because the elevation angle generally decreases with altitude causing poorer quality wind data.

Figure 16 shows the results of smoothing and interpolation to pressure contacts of the wind speeds shown in Fig. 12 where the elevation angle becomes as low as 6.5°. A great improvement is evident although there are still fluctuations with periods of several minutes and amplitudes of several tens of m/sec. Figure 17 shows a time series of wind profiles for Topeka, Kansas, in which the minimum elevation angle for each profile decreased from 10.1° at the first time period to 6.8° at the last time period. Major features of the wind field can be tracked with time in spite of the decreasing elevation angle. Figure 18 reveals the same tracking capability in cases of higher elevation angles. Instead of resorting to even more powerful and complicated smoothing techniques, it was decided to mark wind values on the output with an asterisk if they were based on an elevation angle

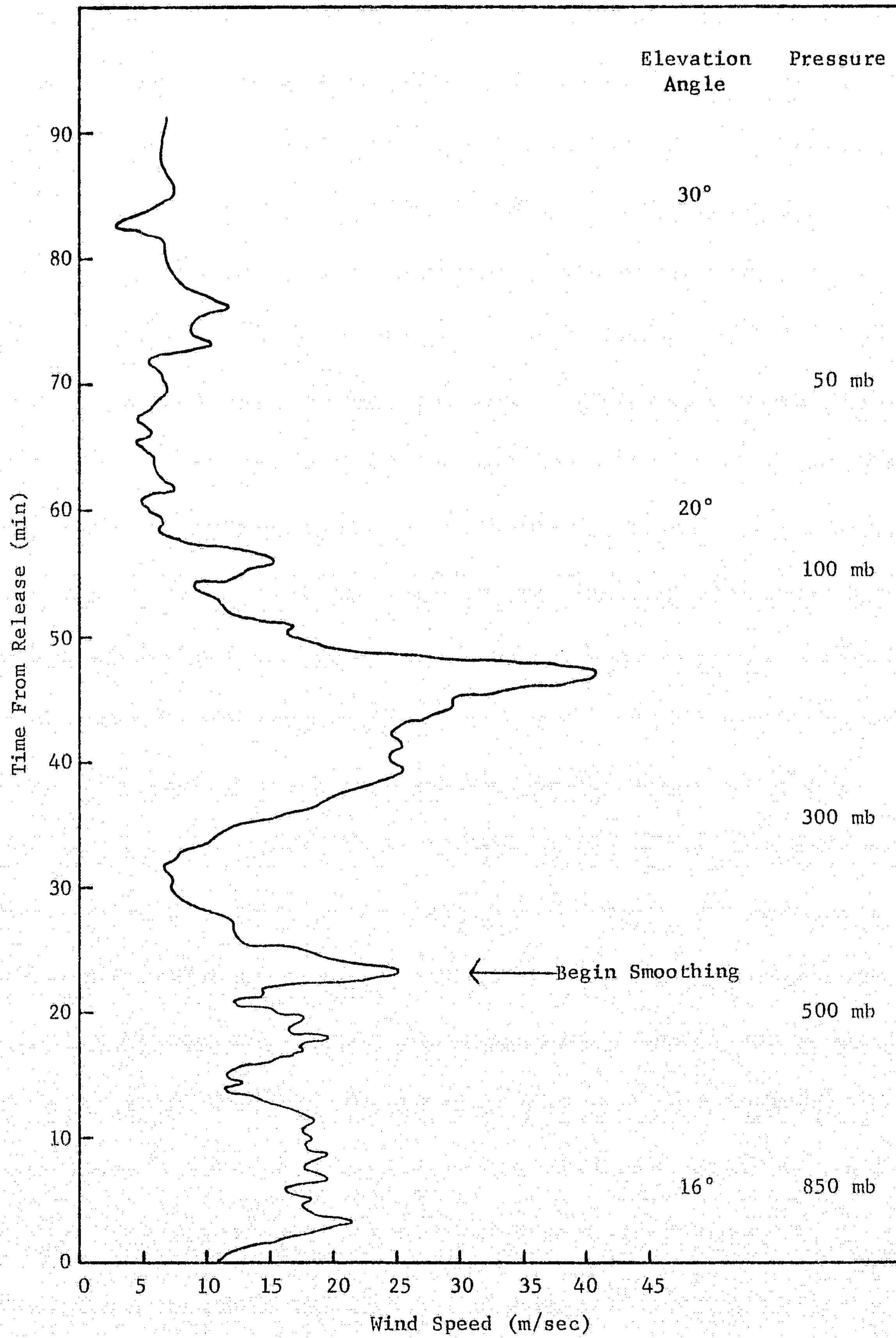

Fig. 15. Wind speeds on the pressure contacts at Eglin Air Force Base, Florida at 1200 GMT on 11 May, 1974.

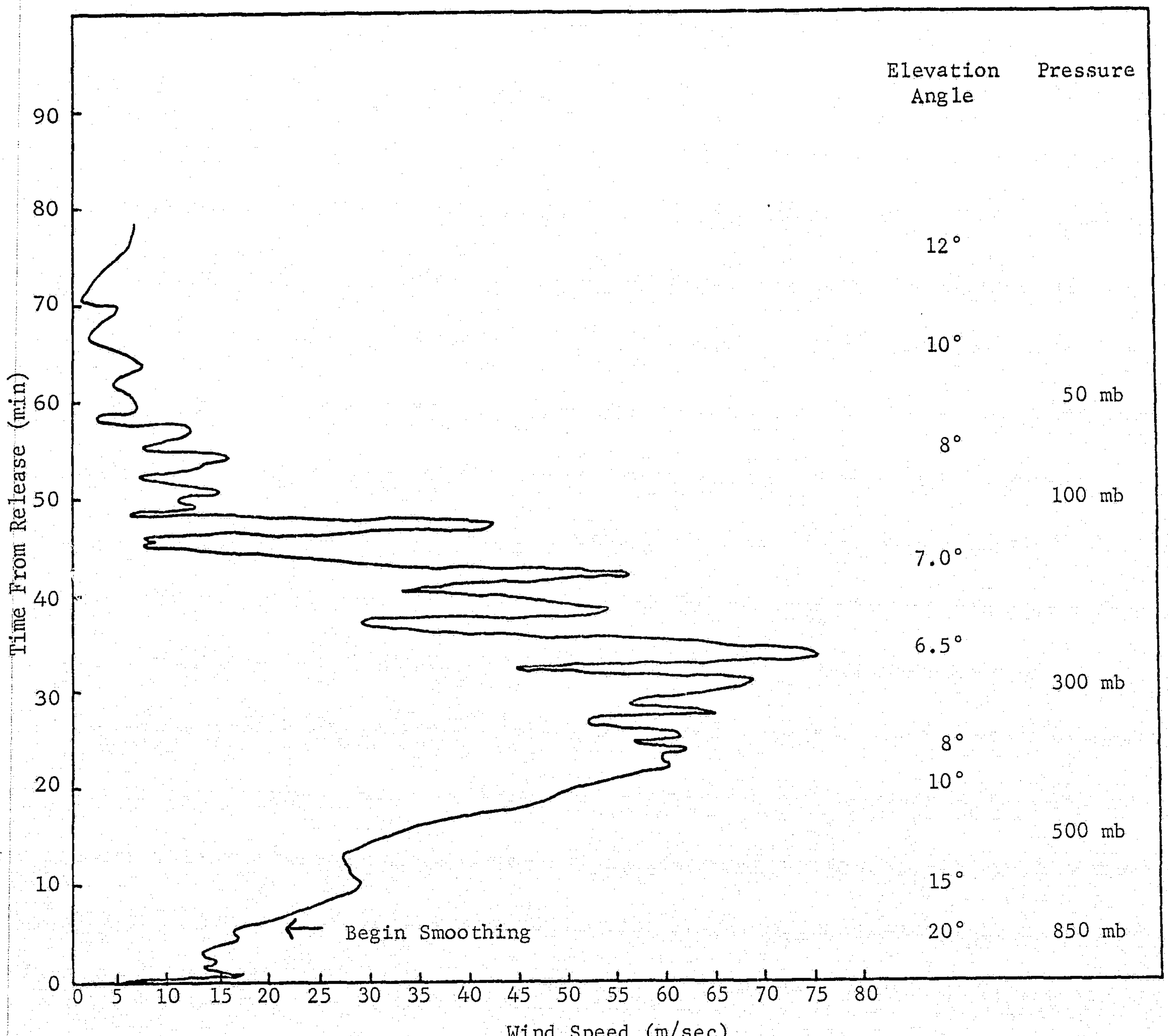

Fig. 16. Wind speeds on the pressure contacts at Rapid City, South Dakota at 0300 GMT on 12 May, 1974.

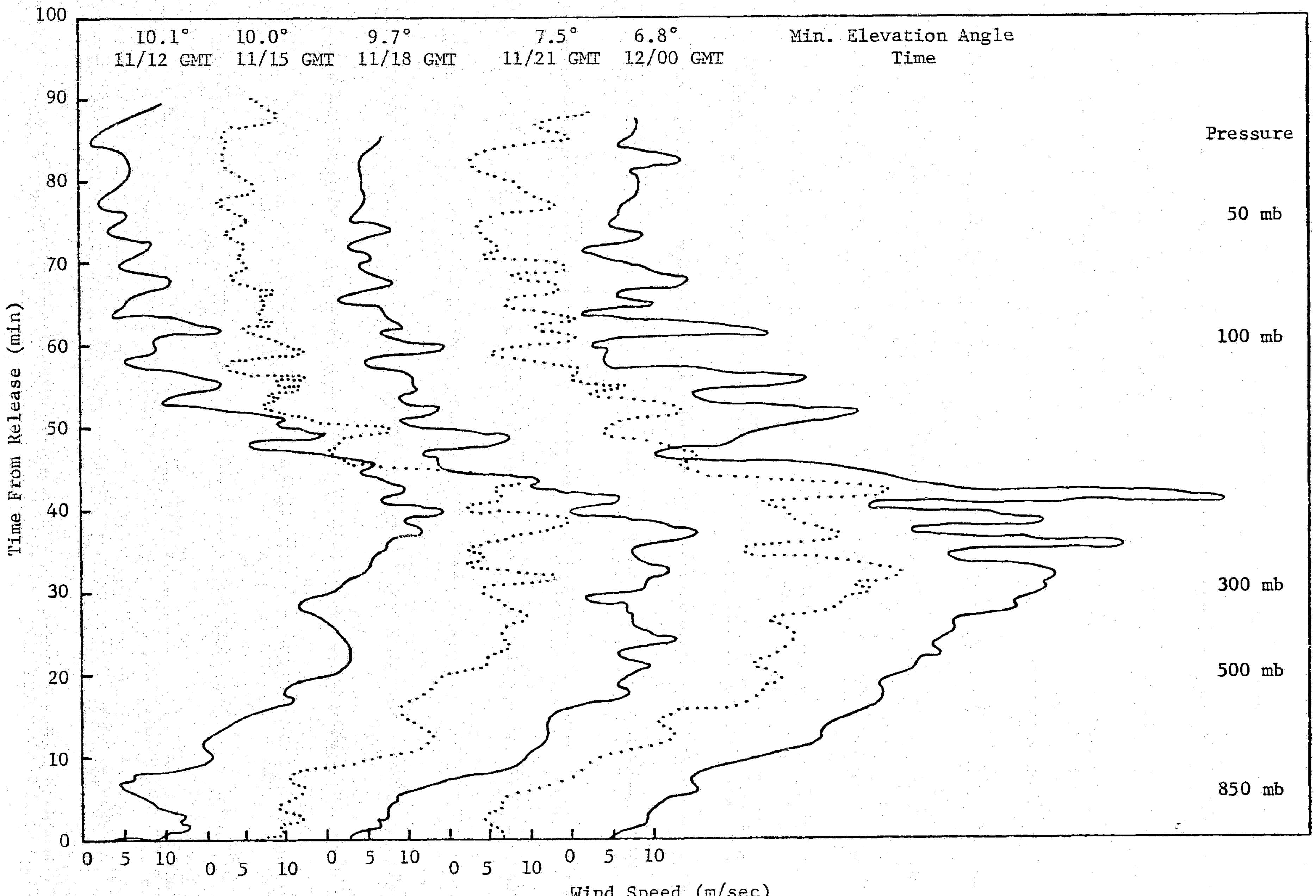

Fig. 17. Time series of wind speed at Topeka, Kansas from 1200 GMT on 11 May, 1974 to 0000 GMT on 12 May, 1974.

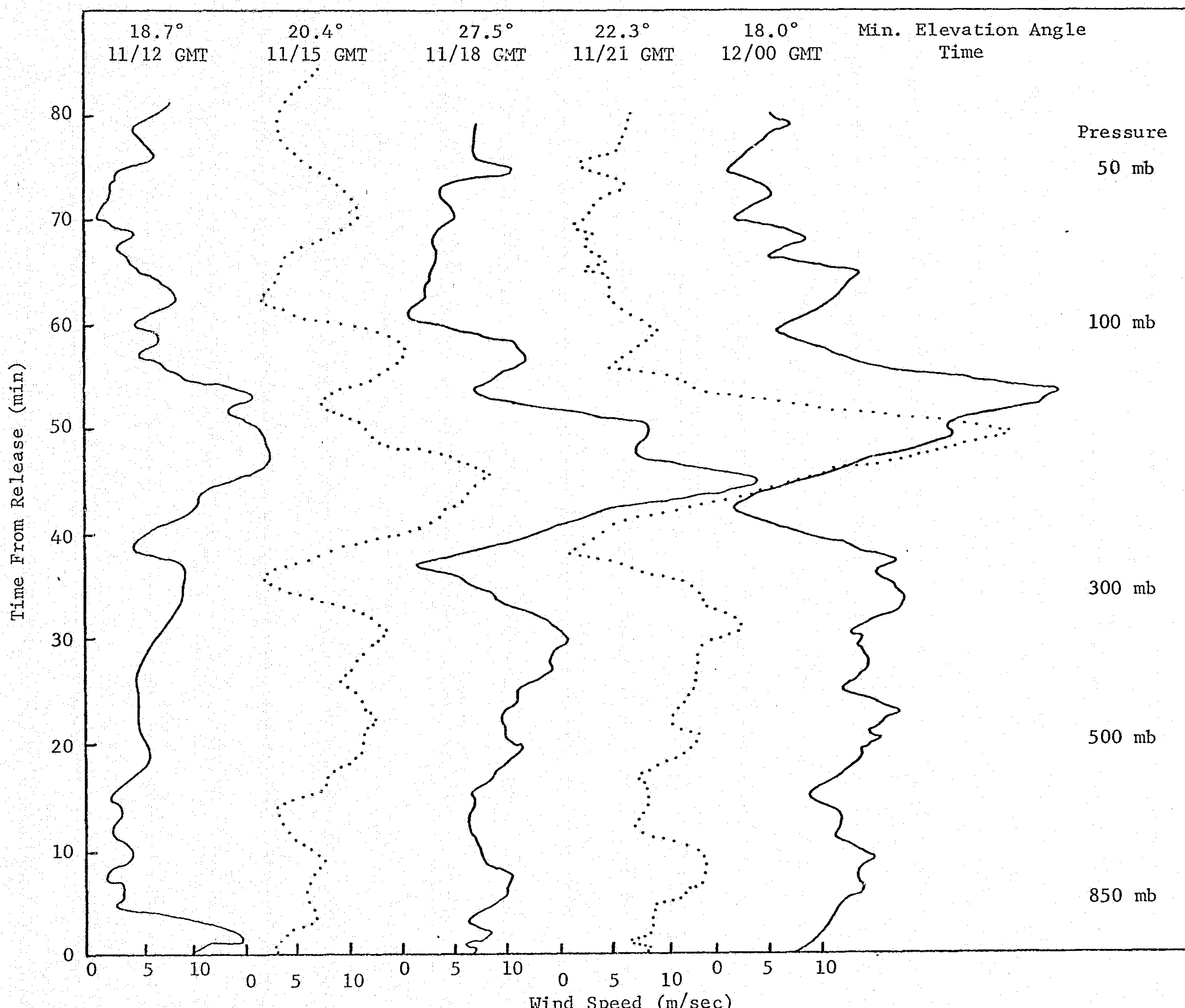

Fig. 18. Time series of wind speed at Charleston, South Carolina from 1200 GMT on 11 May, 1974 to 0000 GMT on 12 May, 1974.

that was less than 9°. This action seems justified based on Figs. 17 and 18 and the accuracy of data presented earlier for winds based on low elevation angles. Users can then determine their own use of the particular piece of information. It should be noted that there are relatively few soundings which contain elevation angles as low as those described in Figs. 12, 16, and 17.

The accuracy of the AVE IIP (average) wind data on pressure contacts is greater than that stated for the "raw" winds because of the added smoothing and interpolation of this stage. In addition, errors cited for the "raw" winds were maxima for the stated elevation angles and pressure surfaces.

4. Accuracy of the Winds at 25-mb Intervals. Linear interpolation was used to obtain winds at 25-mb intervals. The winds being interpolated had previously been smoothed and interpolated to pressure contacts as described earlier. The accuracy of the winds is similar to the values cited p ,iously.

C. Comparison of AVE IIP Results with that Obtained by the National Weather Service

It is desirable that the results of the AVE IIP reduction process be compatible with those obtained by the National Weather Service so that, if required, data from both sources may be used interchangeably. This section will not seek to demonstrate the superiority of either reduction procedure although the pressure contact results that are derived from AVE IIP data contain far more information than that received from the NWS. Figures 19-21 contain sounding data processed

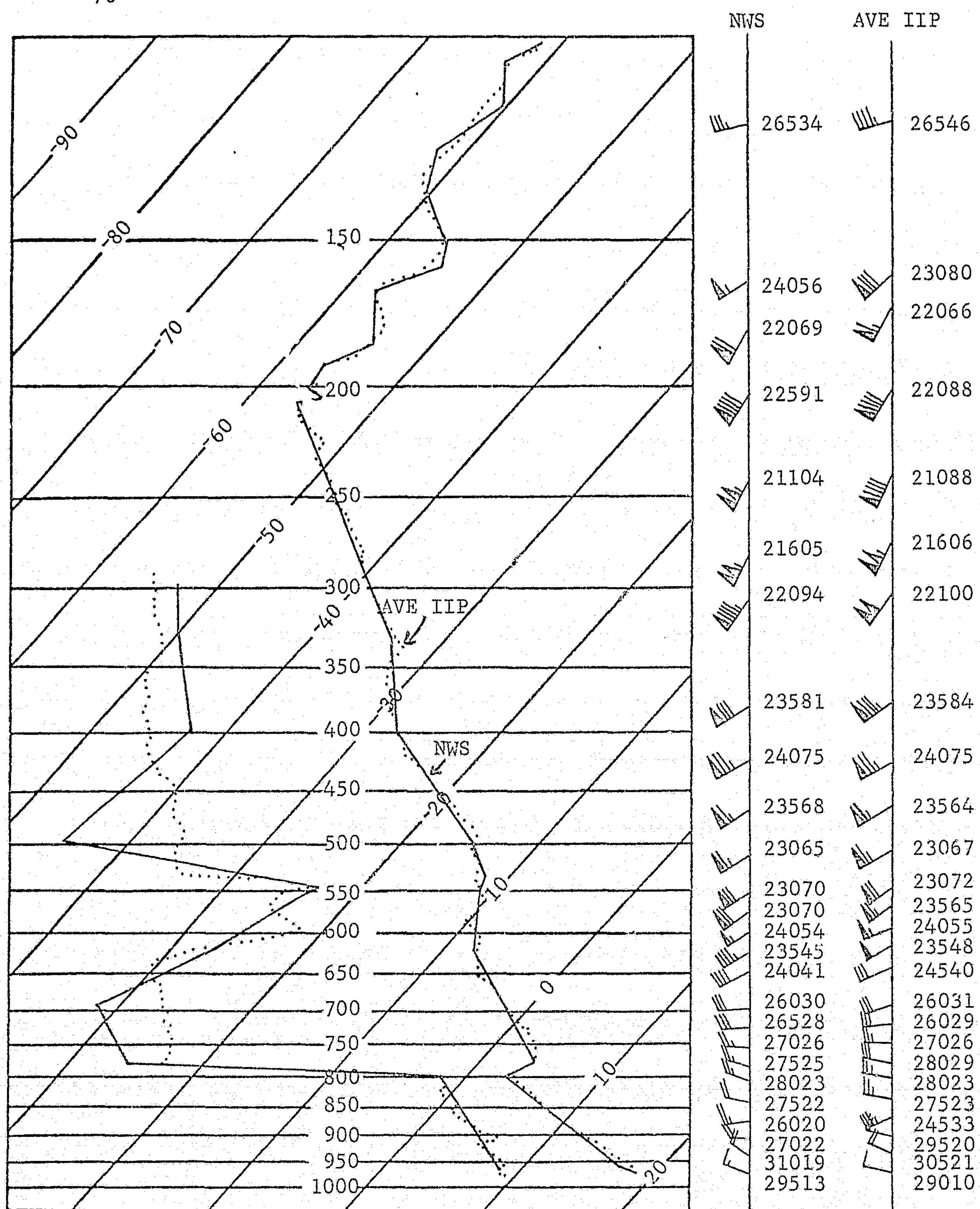

Fig. 19. AVE IIP and National Weather Service soundings for Peoria, Illinois at 0000 GMT on 12 May, 1974. The minimum antenna elevation angle was 8.4°.

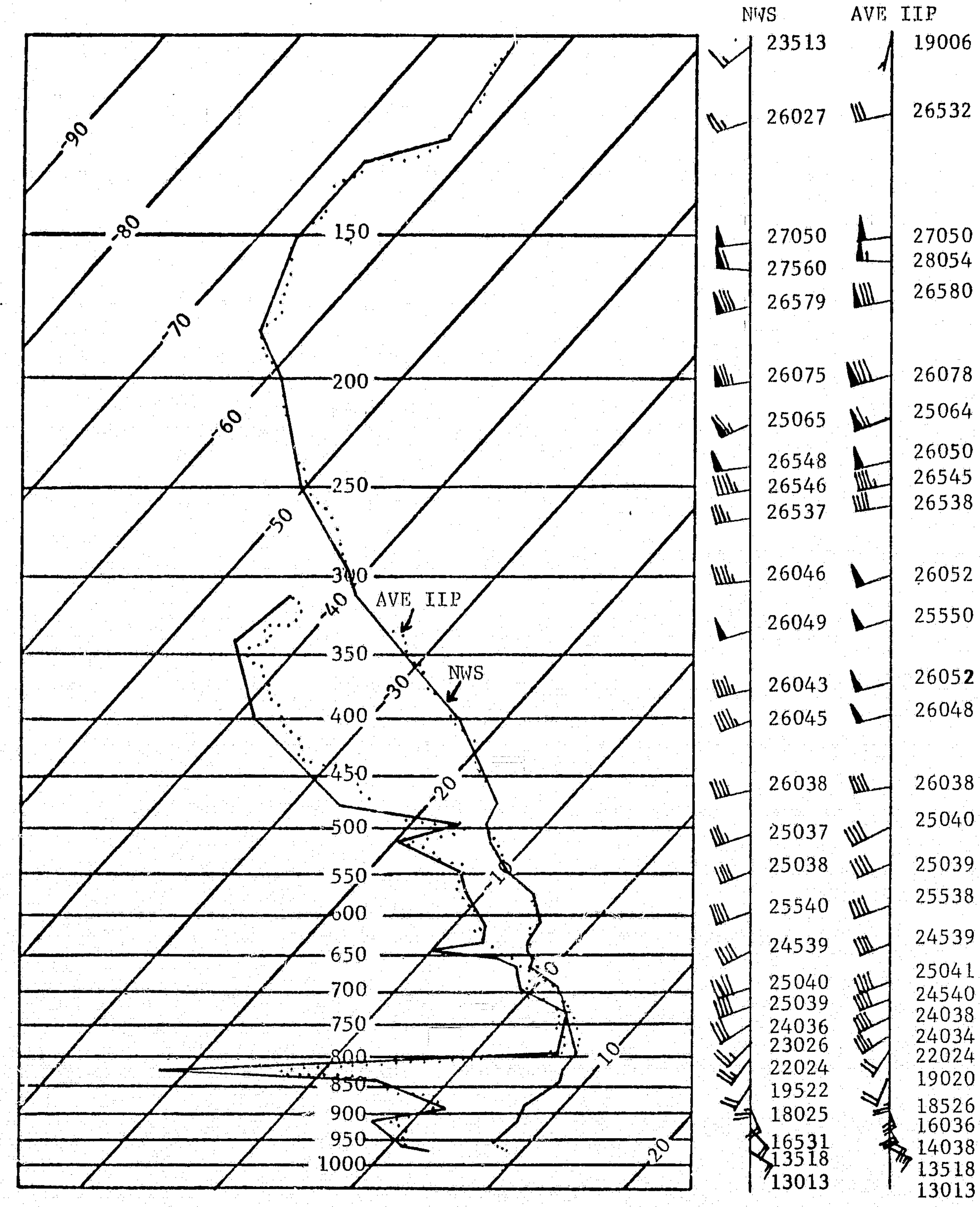

Fig. 20. AVE IIP and National Weather Service soundings for Flint, Michigan at 1200 GMT on 11 May, 1974. The minimum antenna elevation angle was 12.0°.

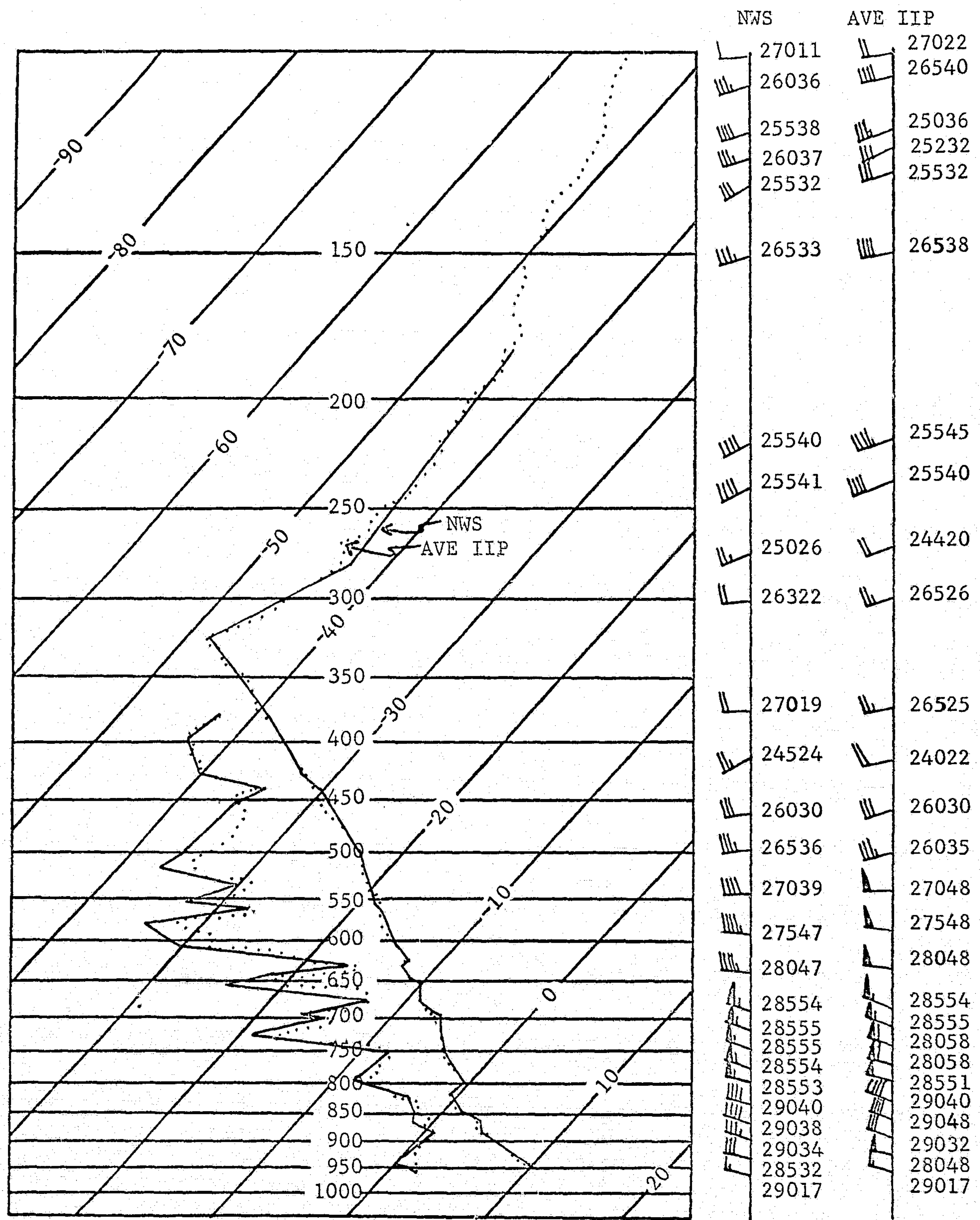

Fig. 21. AVE IIP and National Weather Service soundings for St. Cloud, Minnesota at 0000 GMT on 12 May, 1974. The minimum antenna elevation angle was 10.3°.

by the AVE II procedure and data that is transmitted nationally over teletypewriter circuits by the NWS. Figures 22-35 show constant-pressure charts obtained from either AVE IIP data or NWS data for the 850-, 700-, 500-, 400-, 300-, 200-, and 100-mb levels for 1200 GMT on 12 May, 1974. The two sets of figures will be the basis of comparison between the two methods of data reduction.

1. Temperature Comparisons. The temperature computation scheme used in AVE IIP is the same as that currently used by the NWS and previously described in Section II-C of this report. A comparison of Figs. 19-35 reveals a very close agreement between the two sources of data. The similarity is especially evident in the three soundings.

2. Humidity Comparisons. The procedure used by the NWS for computing humidity is somewhat different from that used in AVE IIP (Section II-C). The NWS system uses a baseline ordinate corresponding to a relative humidity of 50% after the baseline data has been locked in on their evaluator. Their reduction equations make use of constants in all computations with the constants being derived from the baseline check. Separate equations, depending on whether high or low ordinate values are encountered, are used in the evaluation process. Different procedures are used by the NWS to evaluate the dew point temperature as well. The NWS procedure sets humidity at 20% if the computed value is less than 20% while the AVE IIP procedure outputs the computed value down to a value of 5% where it is then defined to be missing. Dew point depression is set at 30C at relative humidities lower than 20% in the NWS procedure while the AVE IIP scheme computes values until the relative humidity is below 5%.

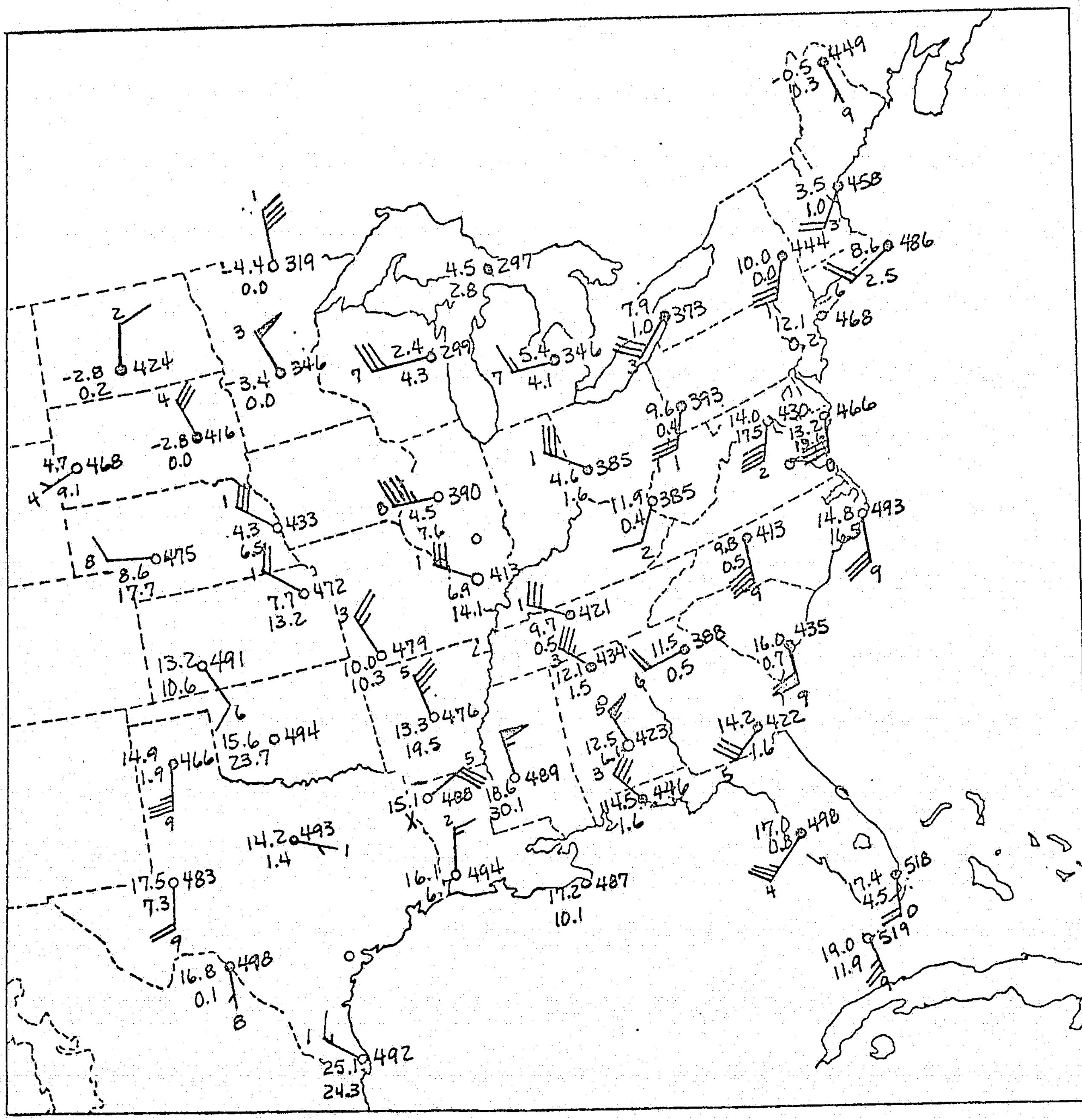

Fig. 22. 850-mb chart for 1200 GMT on 12 May, 1974 using AVE IIP data.

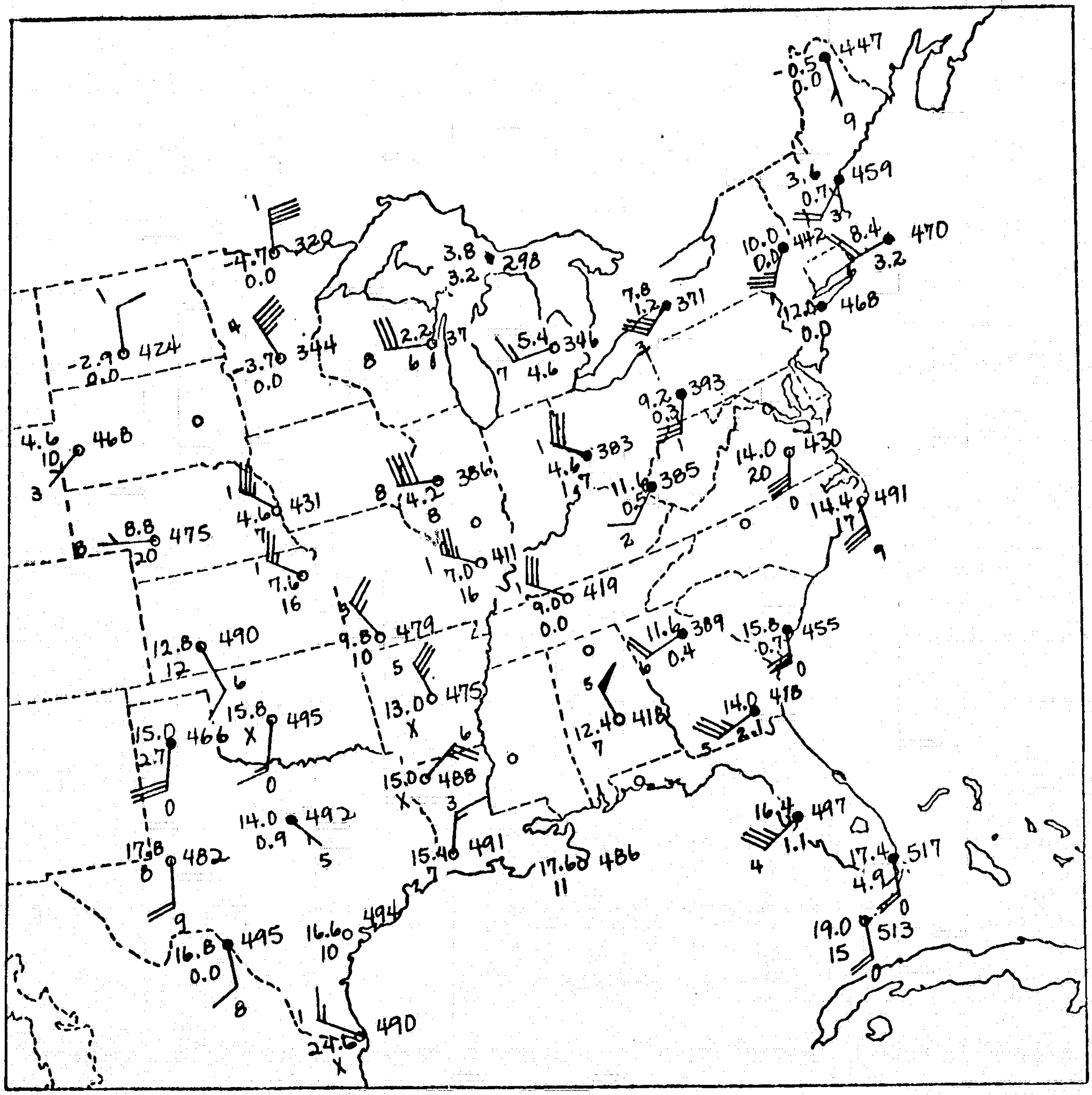

Fig. 23. 850-mb chart for 1200 GMT on 12 May, 1974 using National Weather Service data.

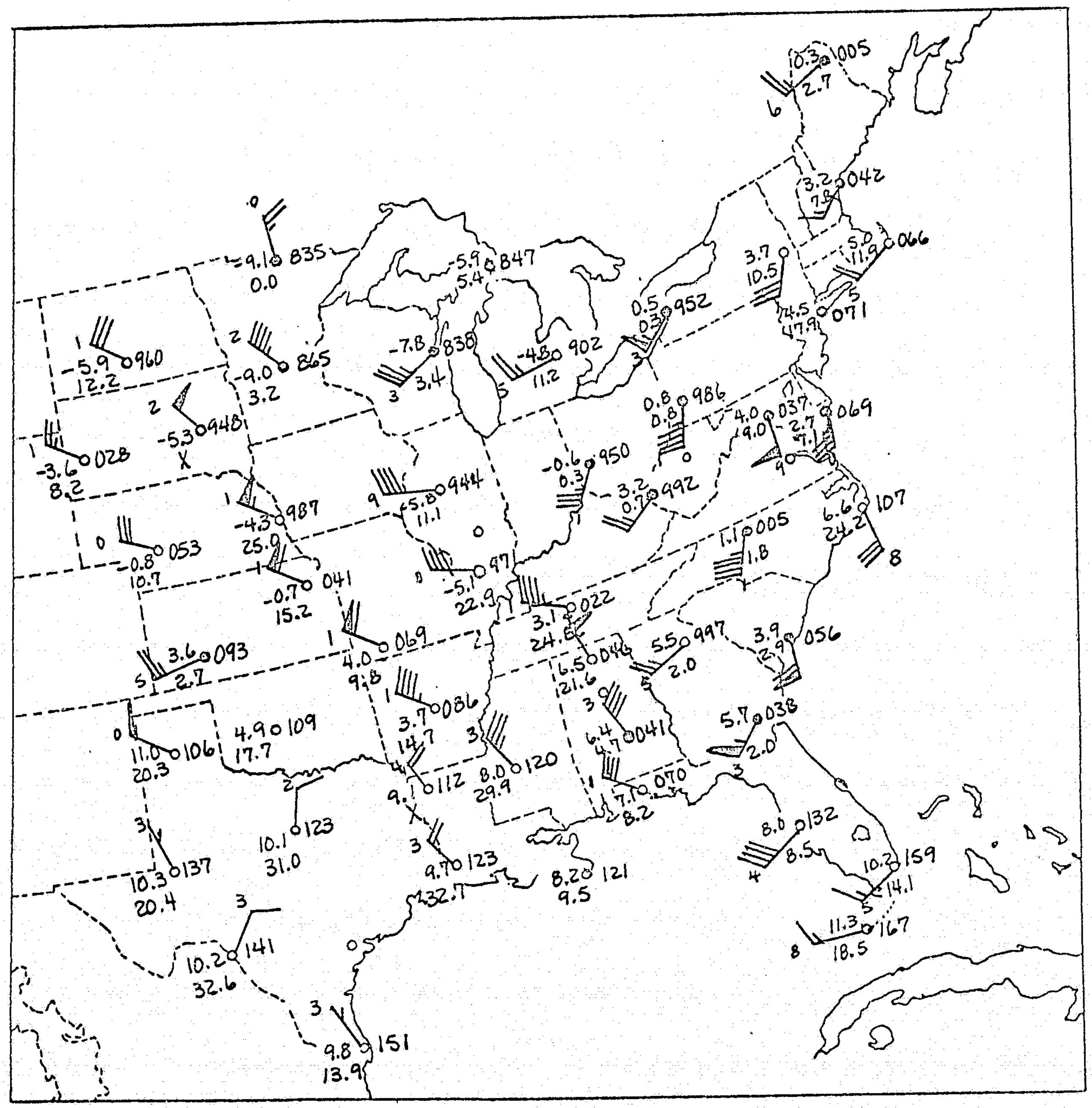

Fig. 24. 700-mb chart for 1200 GMT on 12 May, 1974 using AVE IIP data.

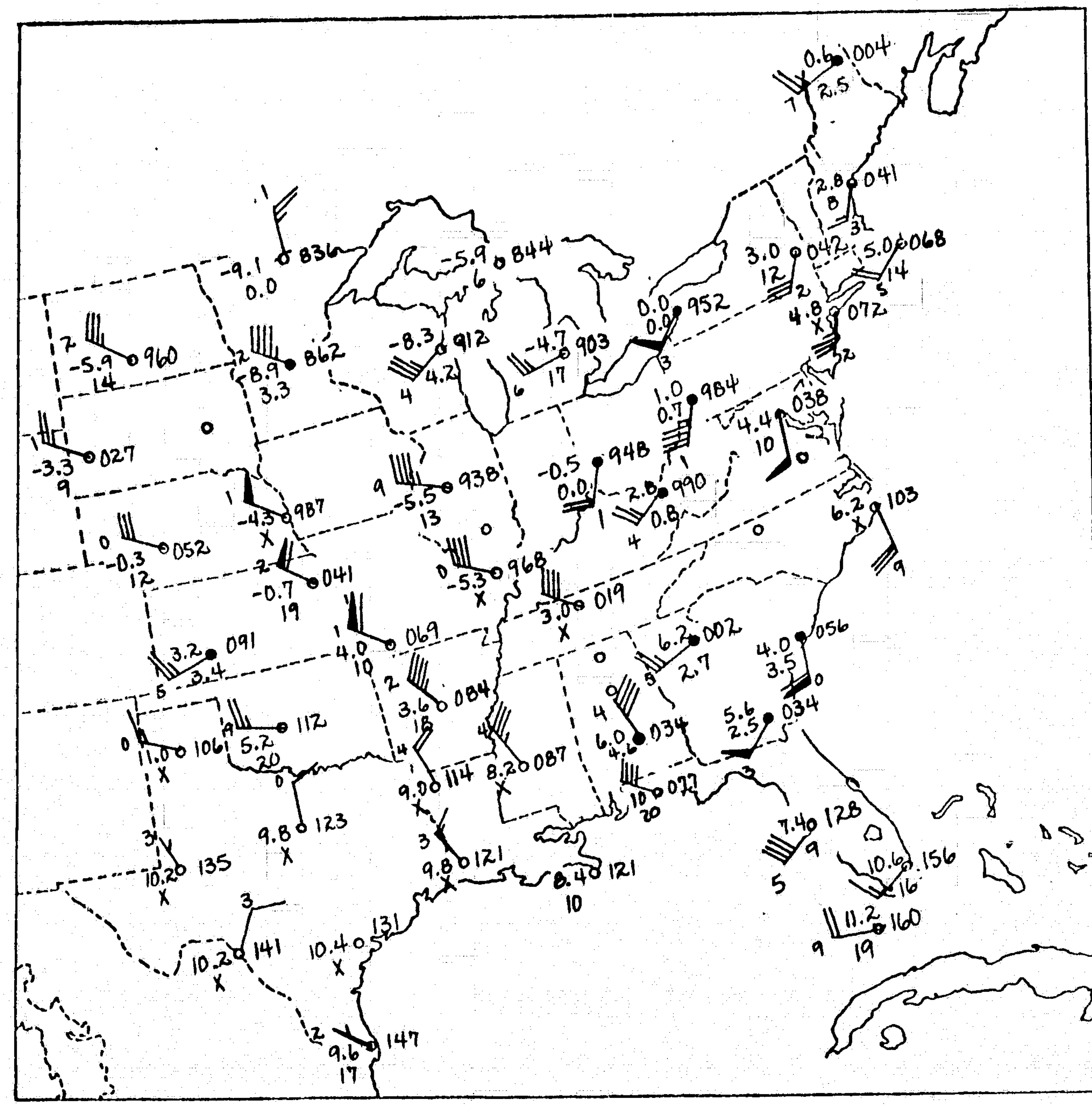

Fig. 25. 700-mb chart for 1200 GMT on 12 May, 1974 using National Weather Service data.

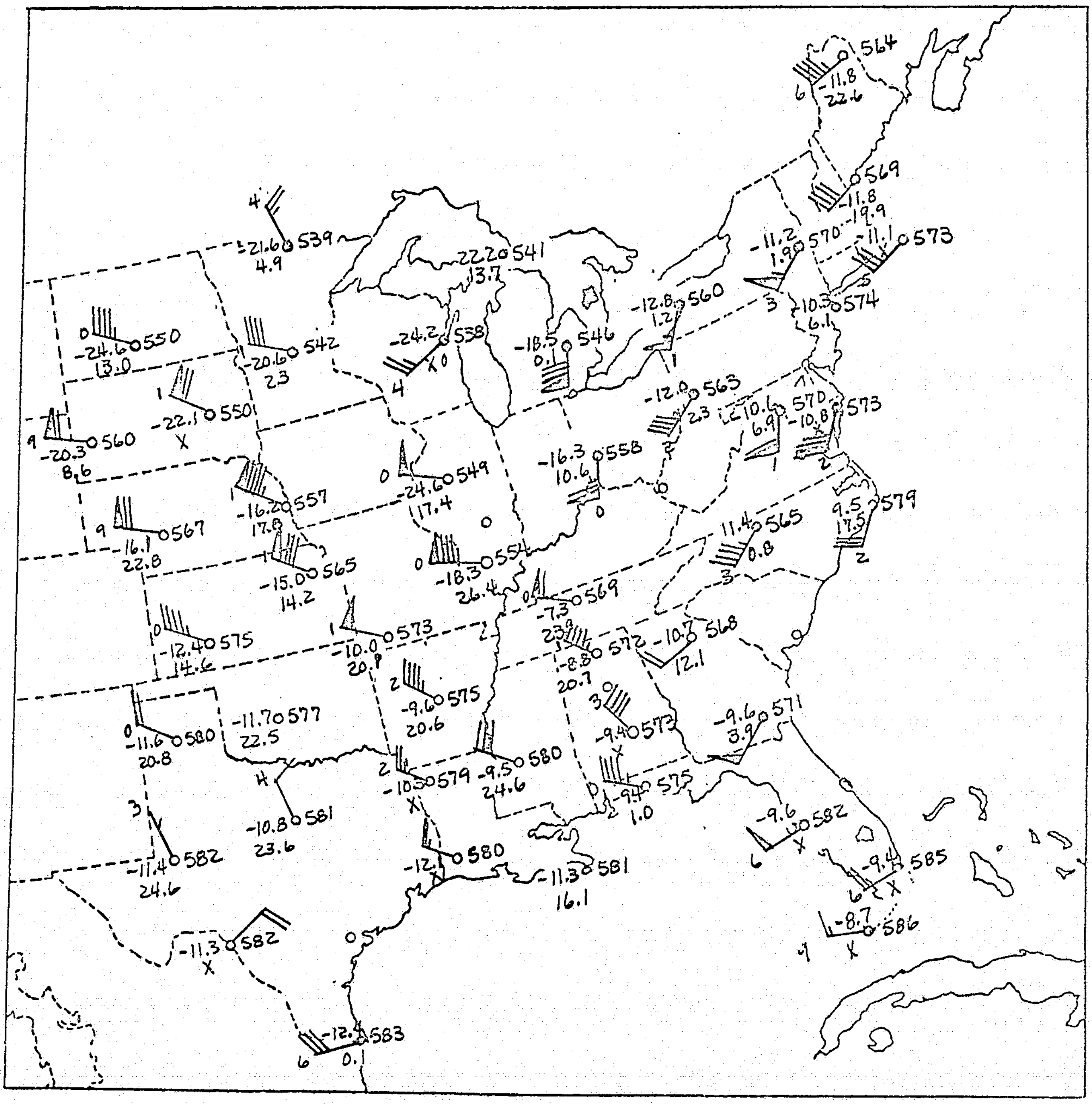

Fig. 26. 500-mb chart for 1200 GMT on 12 May, 1974 using AVE IIP data.

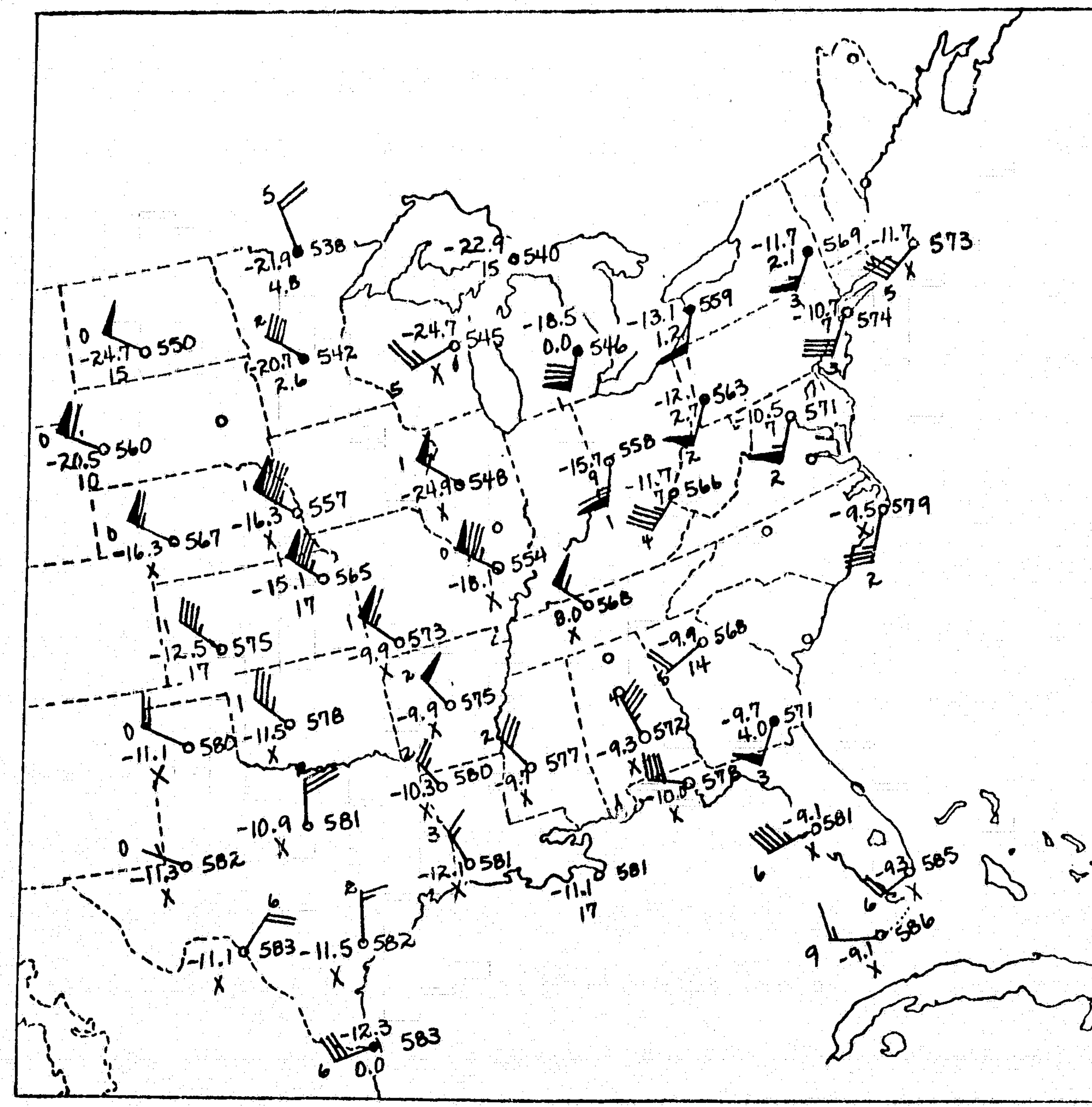

Fig. 27. 500-mb chart for 1200 GMT on 12 May, 1974 using National Weather Service data.

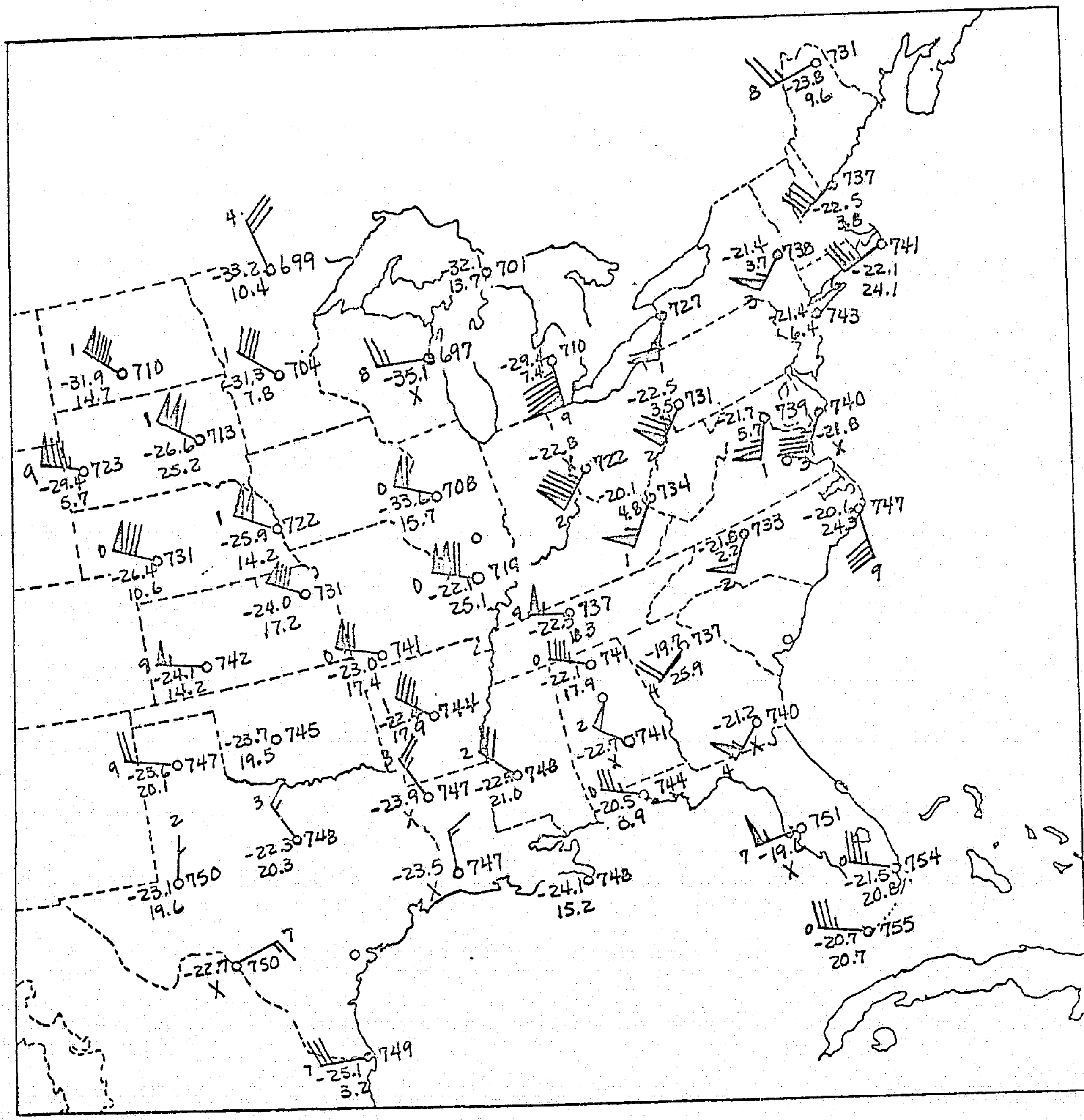

Fig. 28. 400-mb chart for 1200 GMT on 12 May, 1974 using AVE IIP data.

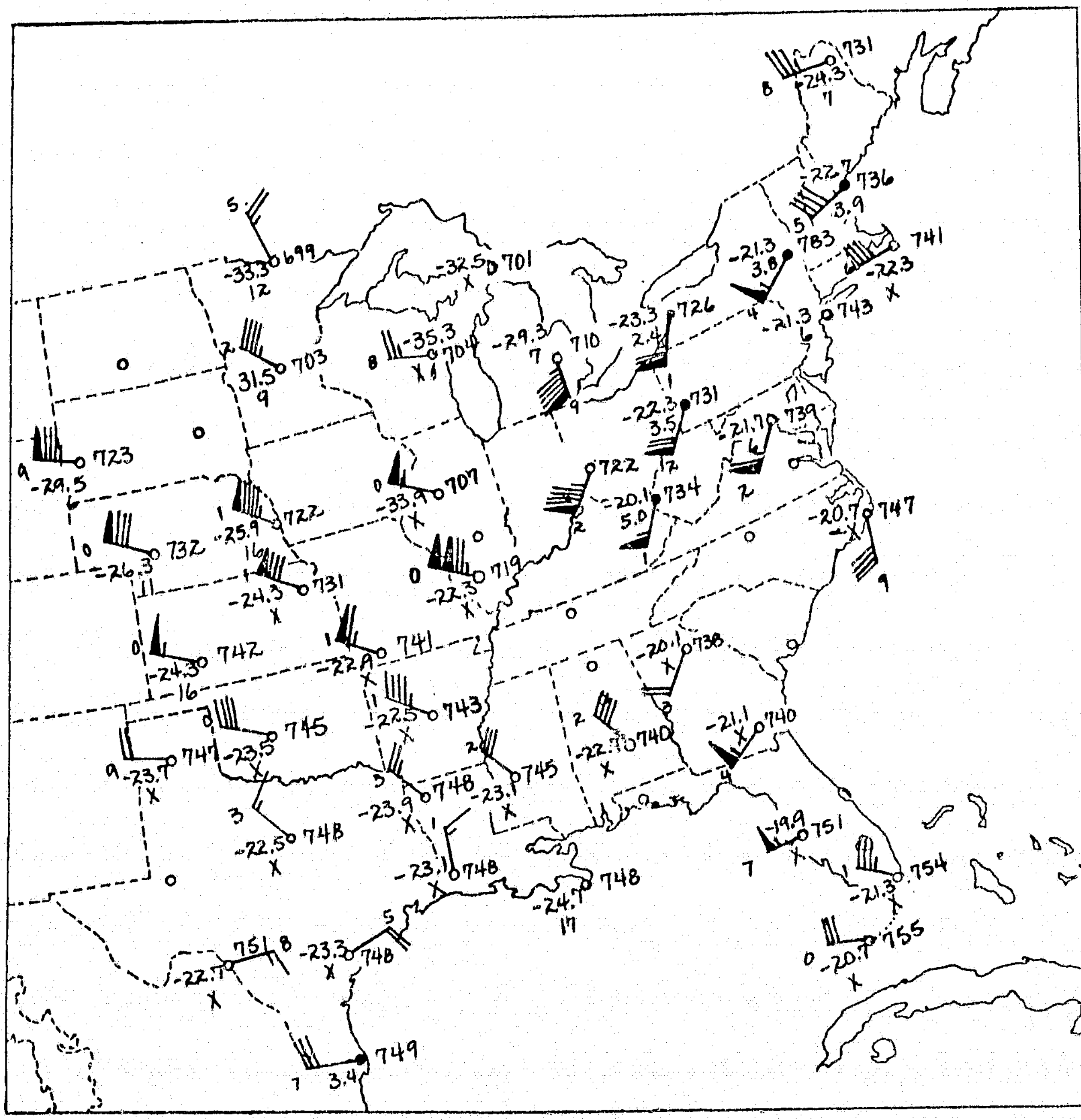

Fig. 29. 400-mb chart for 1200 GMT on 12 May, 1974 using National Weather Service data.

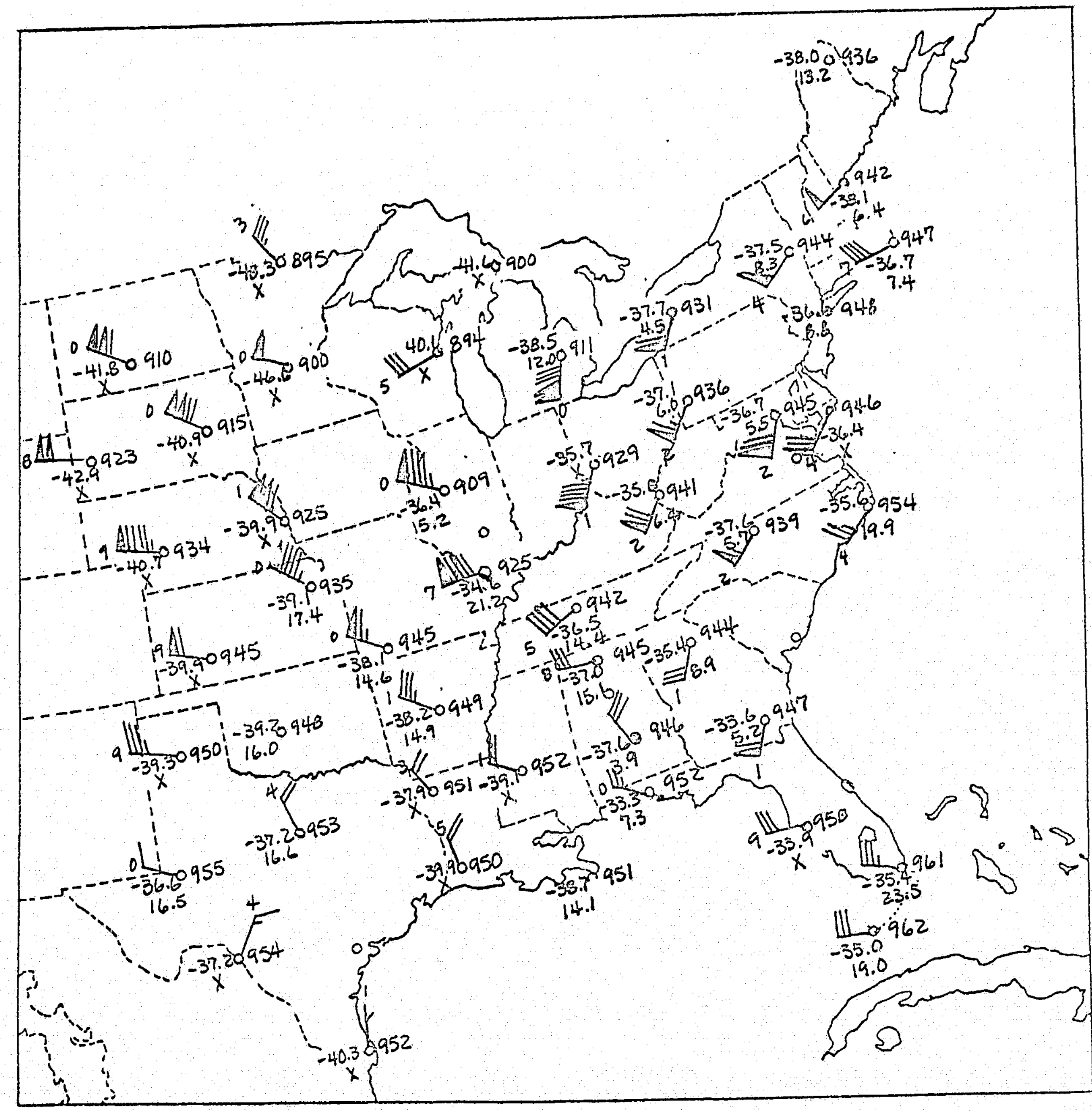

Fig. 30. 300-mb chart for 1200 GMT on 12 May, 1974 using AVE IIP data.

C-2

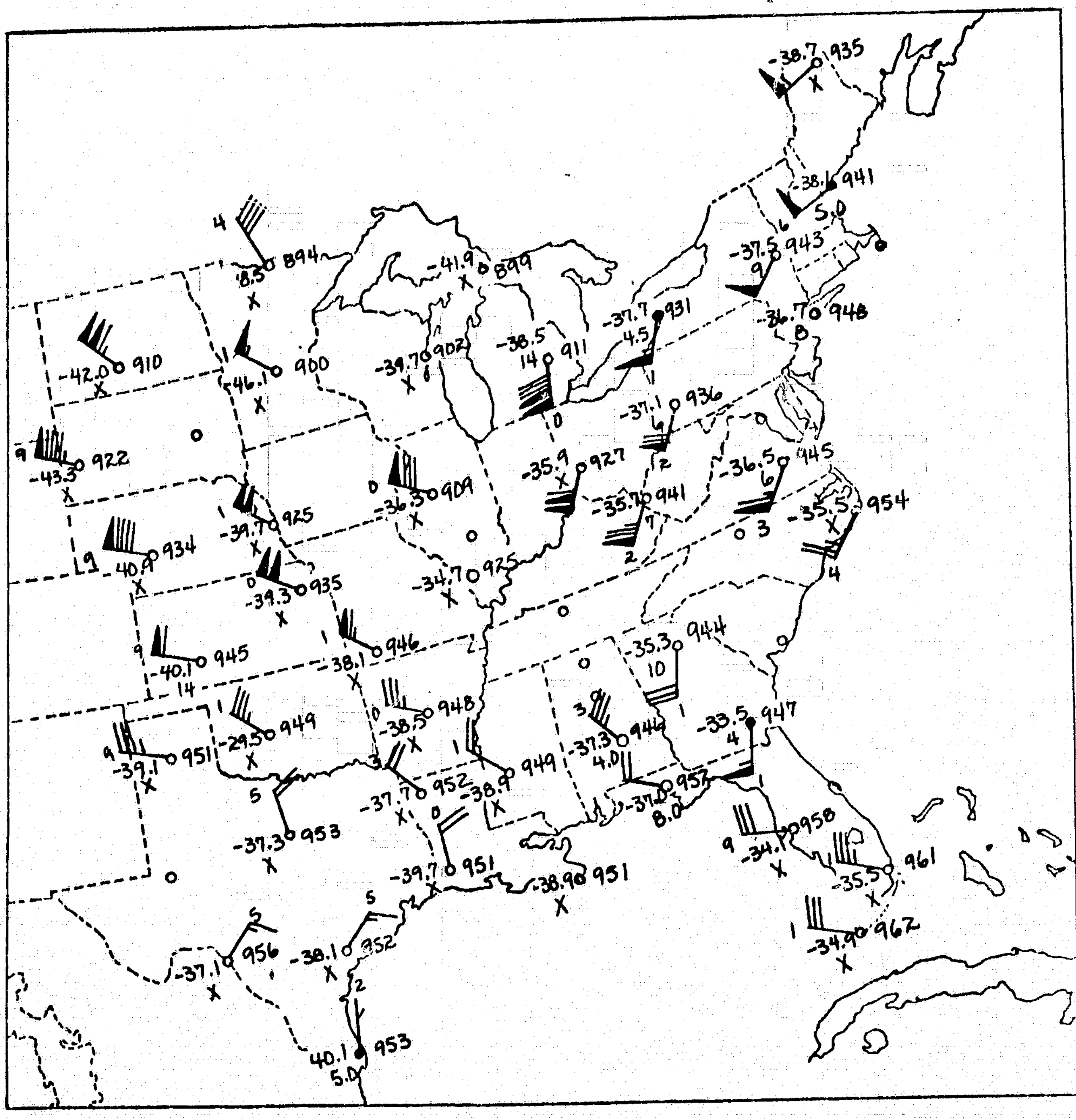

Fig. 31. 300-mb chart for 1200 GMT on 12 May, 1974
using National Weather Service data.

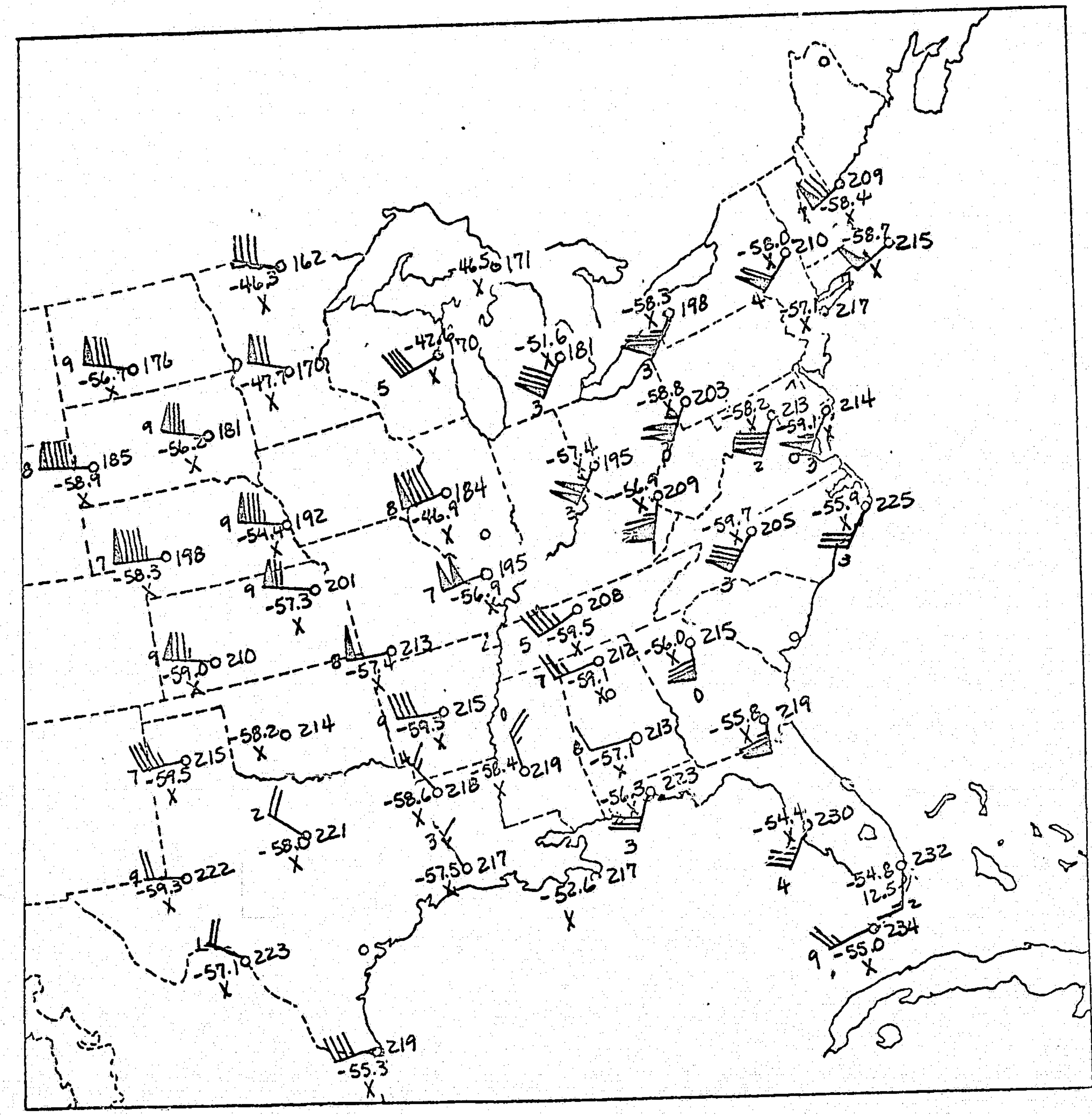

Fig. 32. 200-mb chart for 1200 GMT on 12 May, 1974 using AVE IIP data.

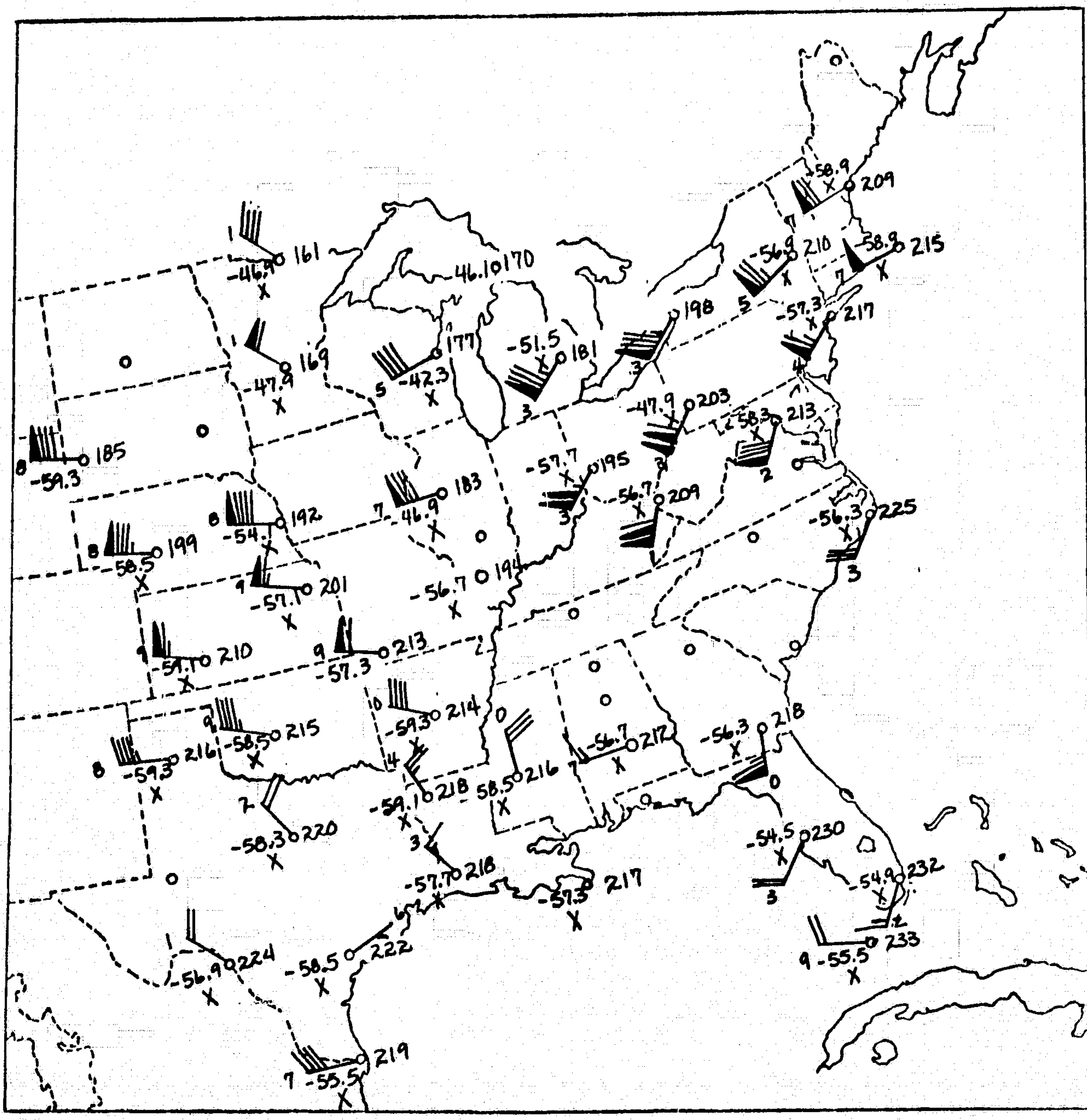

Fig. 33. 200-mb chart for 1200 GMT on 12 May, 1974 using National Weather Service data.

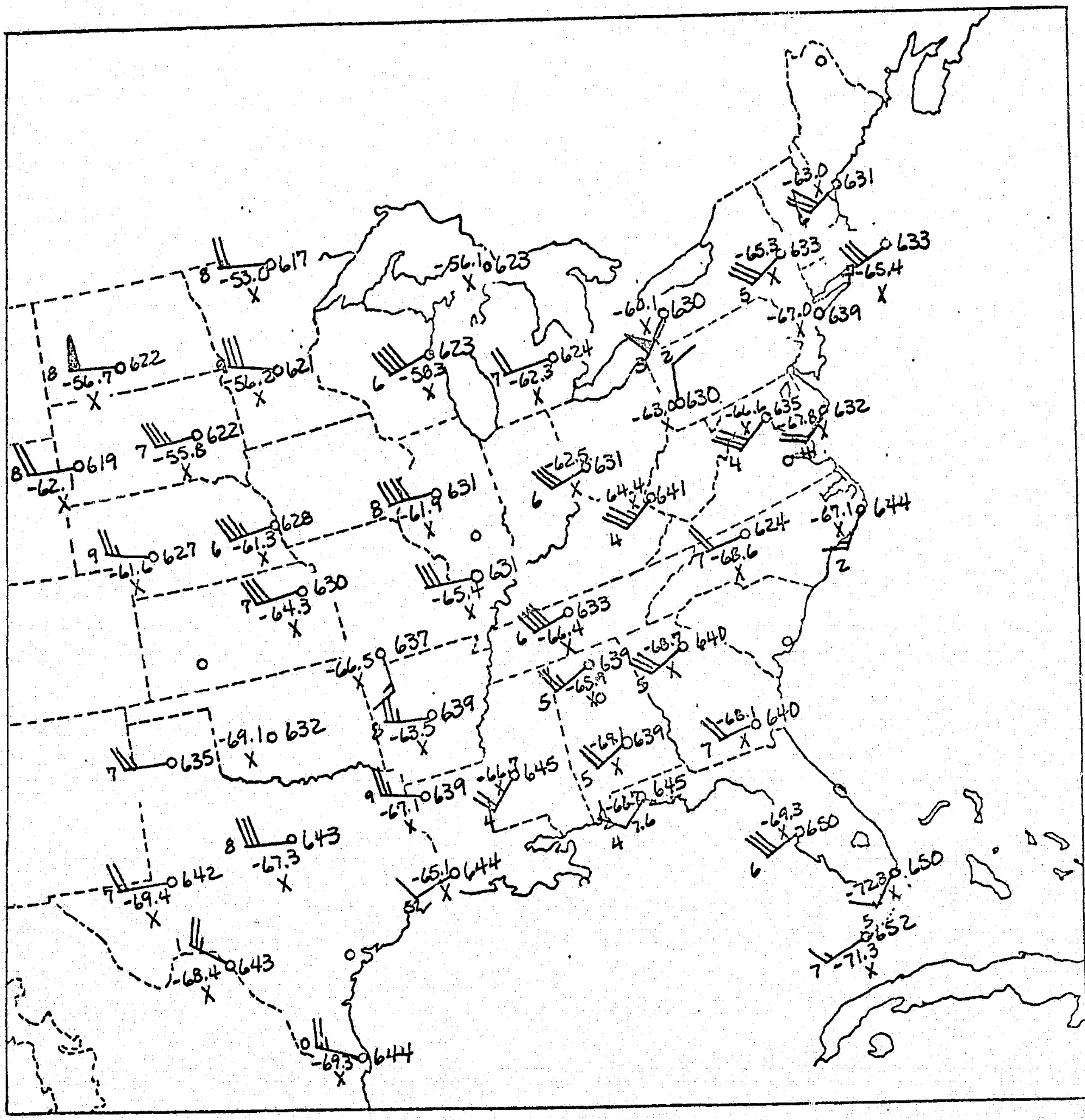

Fig. 34. 100-mb chart for 1200 GMT on 12 May, 1974 using AVE IIP data.

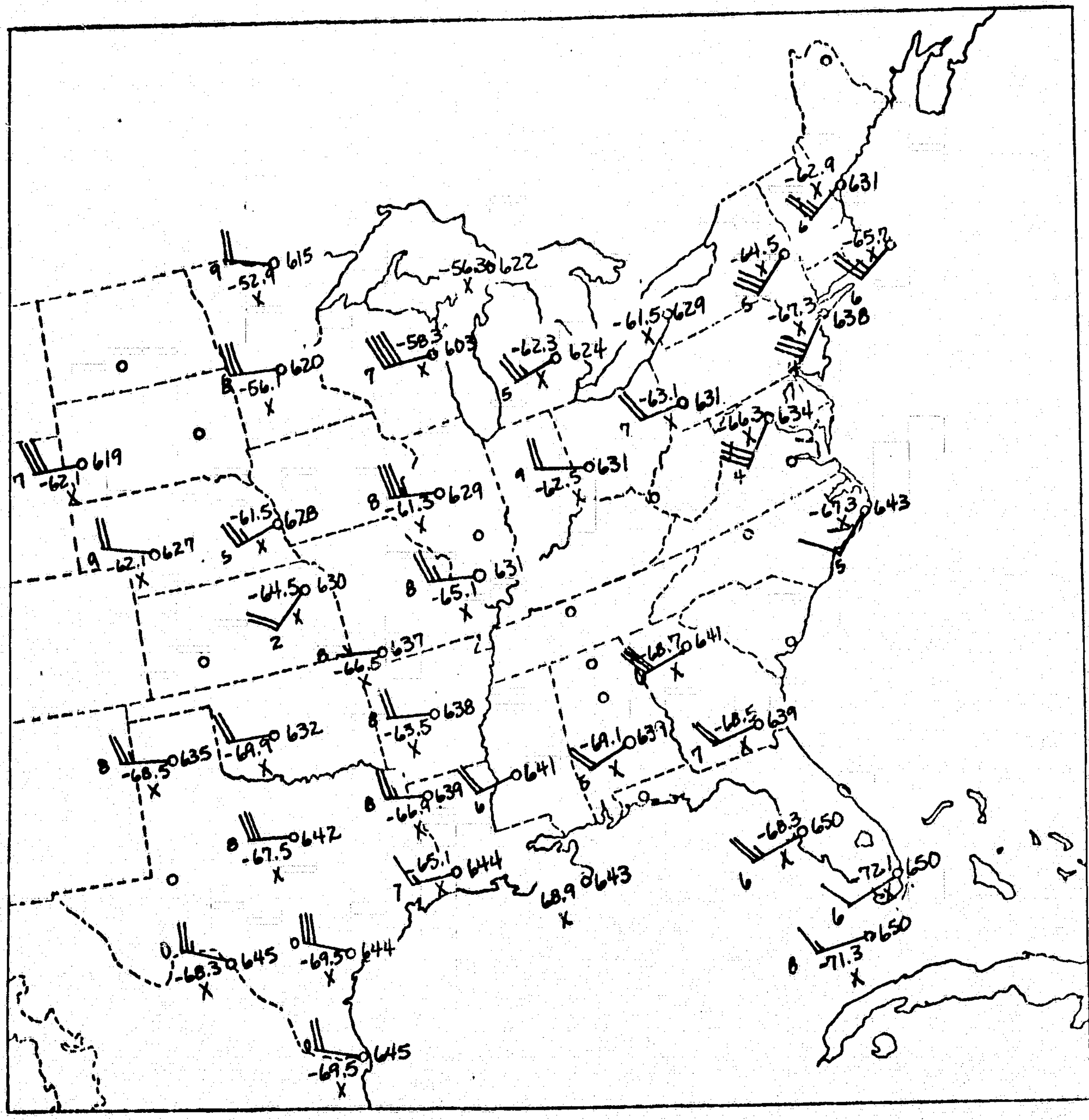

Fig. 35. 100-mb chart for 1200 GMT on 12 May, 1974 using National Weather Service data.

These differences in computational procedure appear as slight differences in dew point temperature in Figs. 19-21; the difference in data detail is quite noticeable. The constant pressure charts shown in Figs. 22-35 show slight differences in the results of the two procedures as well. No large systematic differences between results of the two procedures are indicated although NWS humidity values appear to be slightly lower than AVE IIP values in some cases, especially at low values of relative humidity. No significant problems should be encountered, however, in using NWS data around the borders of the AVE II pilot experiment area.

3. Height Comparisons. The same procedures for computing height are used in both the NWS and AVE IIP reduction schemes. Many more data points are used in the AVE IIP procedure so that these results should be superior to those obtained by the NWS. Figures 22-35 reveal only slight differences between heights, and there does not appear to be any systematic difference between results of the two procedures.

4. Wind Direction and Speed. The wind reduction procedure of the NWS differs from that used in AVE IIP which is described in Section II-C of this report. The NWS receives angle data at 1-min intervals instead of 30-sec intervals as obtained in the AVE II pilot experiment. The NWS scheme involves finite differencing over 2-min intervals below 14 km and over 4-min intervals above 14 km. If the elevation angle is less than 12°, it is smoothed by use of a 3-min average before the differencing process begins; the reduction process terminates at elevation angles below 6°. Figures 19-22 reveal no large differences between results of

the two procedures, even in areas of high wind speed such as in Fig. 19 for Peoria, Illinois.

In conclusion, the results of this section indicate that matching AVE IIP and NWS values of temperature, moisture, height, and wind at the borders of the AVE II data should pose no problems.

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APPENDIX A

General Features of the Reduction Programs

The reduction programs used at Texas A&M University were written using WATFIV, a FORTRAN IV compatible language developed at the University of Waterloo, Ontario, Canada. WATFIV is almost completely compatible with FORTRAN G and H, but the CHARACTER * declaration statement used in some of the programs cannot be used in FORTRAN G or H. Other restrictions between the various compilers may be found in texts on computer programming.

The data reduction process at Texas A&M University was performed using an IBM 360/65 computer with OS/MVT (Multiprogramming with a Variable Number of Tasks) and HASP (Houston Automatic Spooling Program). Use of these programs on other machines may require considerable program modification.

The comments made in the following appendices are meant to supplement the program descriptions that have previously been given and are mainly concerned with required input data and core allocation for the programs.

APPENDIX B

Use of the Card to Tape Program

Card decks described in Tables 2-4 are transferred to nine track tapes that are non-labeled. The DCB (Data Control Block) parameters are DCB = (RECFM = FB, LRECL = 80, BLKSIZE = 1600, DEN = 3). An object code of 5,608 bytes and an array area of 40,160 bytes are required. The data required for the program are one card specifying the number of soundings to be processed followed by the stated number of complete sounding decks. No printed output is produced by the execution of this program.

```
C     TRANSFER THE CARDS TO TAPE
C     SUMMER 1974--HENRY FUELBERG
C     CHARACTER * IS AN IMPORTANT FEATURE OF WATFIV
C
      CHARACTER*1 CI(80),ID(80),ONE/'1'/
      CHARACTER*80  CARD(500),CARDI
      EQUIVALENCE (CI,CARDI)
      REWIND1
C
C     READ THE NUMBER OF SOUNDINGS TO TRANSFER
C
      READ,NSOUND
      DO 20 M=1,NSOUND
      I=1
C
C     READ THE CARD
C
    4 READ(5,100) CARDI
  100 FORMAT(A80)
      IF(I.NE.1) GO TO 7
C
C     COMPUTE THE NEW 'LEADER CARD' USING BASELINE INFORMATION
C
      DO 6 L=50,69
      LL=L-49
    6 ID(LL)=CI(L)
    7 CARD(I)=CARDI
      IF(I.EQ.1) GO TO 2
C
C     A '1' IN COLUMN 72 INDICATES THE END OF THE ORDINATE DECK.
C     A '1' IN COLUMN 72 OF THE BASELINE CARD IS NOT CONSIDERED
C
      IF(CI(72).EQ.ONE) GO TO 3
C
C     COUNT THE NUMBER OF CARDS IN THE ORDINATE DECK
C
    2 I=I+1
      GO TO 4
C
C     ADD THE NUMBER OF CARDS IN THE ANGLE DECK
C
    3 I=I+1
C
C     READ THE CARD
C
      READ(5,100) CARDI
      CARD(I)=CARDI
C
C     A '1' IN COLUMN 72 INDICATES THE END OF THE ANGLE DECK
C
      IF(CI(72).EQ.ONE) GO TO 10
      GO TO 3
C
C     WRITE THE 'LEADER CARD' ON TAPE
C
   10 WRITE(1,5) (ID(LL),LL=1,20),I
    5 FORMAT(20A1,I4)
C
C     TRANSFER THE REMAINING CARDS TO TAPE
C
      WRITE(1,15) (CARD(J),J=1,I)


   15 FORMAT(A80)
   20 CONTINUE
      REWIND1
      STOP
      END
```

APPENDIX C

Use of the Tape to Print Program

No input data cards are required since the tape is read and printed until an END OF FILE mark is encountered. The same tape parameters that were used in creating the tape are used to read from it. The object code is 4,864 bytes while the array area is 80 bytes. The printed output resembles the original data decks.

```
C       THIS PROGRAM PRINTS THE RAW DATA TAPE
C       SUMMER 1974--HENRY FUELBERG
C
        DIMENSION NCARD(20)
        REWIND1
   10   READ(1,11,END=13) (NCARD(I),I=1,20)
   11   FORMAT(20A4)
        WRITE(6,12) (NCARD(I),I=1,20)
   12   FORMAT(1X,20A4)
        GO TO 10
   13   REWIND1
        STOP
        END
```

APPENDIX D

Use of the Master Reduction Program

Angle, ordinate, and baseline data are read from magnetic tape with the DCB parameters described in Appendix B. The input format is described in Tables 2-5. The output data is placed on a non-labeled tape with DCB = (RECFM = VS, DEN = 3); no length of record or block size is specified. Data read from cards include the number of stations in the station roster, in this case 54, followed by a card describing each of the stations. The last card read specifies the number of consecutive soundings to be processed. The object code of the program is 29,840 bytes with an array area of 39,136 bytes. Printed output from the program is described in Section II-C and Fig. 5; the identical output is transferred to magnetic tape and is described in Table 7. The sounding identification data is followed by a series of 18 arrays in the order given in Table 6 that correspond to the contact data. Each array has a dimension of 230.

```
C      THIS PROGRAM REDUCES RAW RAWINSINDE DATA TO A FINISHED PRODUCT.
C      SUMMER 1974------HENRY FUELBERG
C      SONDES ARE WEATHER SERVICE TYPE WITH CARBON HUMIDITY ELEMENTS
C      DIMENSION NECESSARY ARRAYS
C
       DOUBLE PRECISION DEXP
       DIMENSION R(230),ATH(230),XXS(230),ZZS(230)
       DIMENSION WDD(230),WSS(230),CD(5)
       DIMENSION TMOR(230), P(230),TORD(230), HORD(230), TMNG(270),
      1THETA(270),AZ(270),XS(230),ZS(230),HM(230), TC(230),WD(230),
      2WS(230),C(40),HC(20),TV(230),TD(230),W(230),PTK(230),HINT(230),
      3STHT(60),STLA(60) ,STLG(60),EPOT(230),PHI(230),CTC(230)
       DIMENSION YS(230),WWE(230),WSN(230),WE(230),WN(230)
       INTEGER STID(60),ISTOP,ASTOP,IASM(270),IEP(270),IORIN(230)
       INTEGER BLANK,AST
       INTEGER IFP(230),NAME(7),NMS(70,7),NZ(6)
       DIMENSION U(230),V(230)
       RESIST(TORD) = DEXP(16.0082991-0.9966256*ALOG(2*TORD)) - 48000.
       XVIRT(XTMP,XE,XP)=XTMP/(1.0-(0.379*(XE/XP)))
C
C      DEFINE HUMIDITY  CONSTANTS TO BE USED
C
       DATA C/1220.7,-19.55,8.312,-.12738,1249.8,-19.307,11.732,-.17732,
      1      -1687.8,26.819,-6.1439,.09615,-2015.2,30.685,-12.115,.17848,
      2      347.2,-5.8167,-1.9779,.02492,774.05,-11.773,1.1014,-.01397,
      3      22.327,-.40763,.31303,-.00344,-112.87,1.6712,-.04262,
      4      -.00017,-57.854,.53914,-.15883,.00234,8.0627,.97356,
      5      .13845,.00032/
       DATA AST,BLANK/1H*,1H /
       RD=6.857E-2
C
C      DEFINITION OF IMPORTANT VARIABLES
C      ASTOP   THE LAST CARD IN THE ANGLE DECK IS INDICATED BY A '1' IN
C              COLUMN 72
C      ATH     IS AZIMUTH OF SONDE MEASURED CLOCKWISE FROM NORTH
C      AZ      IS ELEVATION ANGLE
C      CP      IS SPECIFIC HEAT OF MOIST AIR
C      CTC     IS PRESSURE CONTACT NUMBER
C      DT      IS THE INTERPOLATION WEIGHTING FACTOR
C      E       IS VAPOR PRESSURE
C      EL      IS LATENT HEAT OF EVAPORATION
C      EPOT    IS EQUIVALENT POTENTIAL TEMPERATURE
C      HINT    IS HEIGHT AT THE ANGLE TIMES, 30 SEC APART
C      HM      IS RELATIVE HUMIDITY
C      HORD    IS HUMIDITY ORDINATE
C      I1MIN   IF EQUAL TO 0 ANGLES ARE EVERY 30 SEC
C              IF EQUAL TO 1 ANGLES ARE EVERY 1 MIN
C      IASM    A  '1' IN COLUMN 73 INDICATES THAT MANUAL SMOOTHING WAS
C              DONE ON THE DATA CONTAINED ON THAT CARD
C      ID1     IS THE DAY OF THE SOUNDING
C      ID2     IS THE MONTH OF THE SOUNDING
C      ID3     IS THE YEAR OF THE SOUNDING
C      ID4     IS THE TIME OF THE SOUNDING
C      ID5     IS THE STATION NUMBER
C      IEP     A '1' IN COLUMN 74 INDICATES THAT THE ELEVATION ANGLE IS
C              LESS THAN 9 DG.  THESE ARE ALSO CHECKED BY THE PROGRAM
C      IFP     IS USED TO MARK WINDS THAT WERE COMPUTED WITH ELEVATION
C              ANGLES LESS THAN 9 DG
C      IORIN   A '1' INDICATES THAT VALUES ON THIS CARD HAVE BEEN
C              INTERPOLATED
C      ISTOP   A '1' IN COLUMN 72 TO INDICATE THE END OF THE ORDINATE
```

```
C              DATA
C       P      IS ATMOSPHERIC PRESSURE
C       PTK    IS POTENTIAL TEMPERATURE
C       R      IS RANGE OF SONDE FROM RELEASE
C       RESIST IS A FUNCTION USED TO COMPUTE TEMPERATURE
C       RHO    IS HUMIDITY AT ORDINATE 46 AND TEMP=-40C
C       RHSFC  IS SURFACE RELATIVE HUMIDITY
C       SC     IS THE SONDE'S DISTANCE OVER A CURVED EARTH
C       TC     IS TEMPERATURE
C       TD     IS DEW POINT TEMP
C       THETA  IS ELEVATION ANGLE
C       TMI    IS MEAN VIRTUAL TEMPERATURE
C       TMNG   IS TIME OF THE ANGLE OBSERVATION
C       TMOR   IS TIME OF THE CONTACT
C       TO     IS THE BASELINE TEMPERATURE AT 37.6 ORDINATES
C              TO HAS AN IMPLIED NEGATIVE VALUE
C       TORD   IS TEMPERATURE ORDINATE
C       TSC    IS THE APPROXIMATE TEMP AT THE LCL
C       TSFC   IS SURFACE TEMPERATURE
C       TV     IS VIRTUAL TEMPERATURE
C       U      IS THE EAST-WEST WIND COMPONENT AFTER INTERPOLATION
C       V      IS THE NORTH-SOUTH WIND COMPONENT AFTER INTERPOLATION
C       W      IS MIXING RATIO IN GM/KG
C       WD     IS WIND DIRECTION
C       WDD    IS WIND DIRECTION
C       WDI    IS SURFACE WIND DIRECTION
C       WE     IS THE EAST-WEST WIND COMPONENT AFTER SMOOTHING
C       WN     IS THE NORTH-SOUTH WIND COMPONENT AFTER SMOOTHING
C       WSI    IS SURFACE WIND SPEED
C       WS     IS SCALAR WIND SPEED
C       WSS    IS SCALAR WIND SPEED
C       WWE    IS THE EAST-WEST WIND COMPONENT BEFORE SMOOTHING
C       WSN    IS THE NORTH-SOUTH WIND COMPONENT BEFORE SMOOTHING
C       X      IS MIXING RATIO IN GM/GM
C       XS     IS THE X LOCATION COMPONENT
C       XVIRT  IS A FUNCTION USED TO COMPUTE THE VIRTUAL TEMPERATURE
C       XXS    IS THE X LOCATION OF THE SONDE ON A PRESSURE CONTACT
C       YS     IS BALLOON HEIGHT
C       ZS     IS THE Y LOCATION COMPONENT
C       ZZS    IS THE Y LOCATION OF THE SONDE ON A PRESSURE CONTACT
C
        REWIND1
        REWIND3
C
C       DEFINE ALL ARRAYS TO BE PRINTED LATER
C
        DO 345 I=1,230
        TMOR(I)=0.0
        CTC(I)=0.0
        YS(I)=0.0
        P(I)=0.0
        TC(I)=0.0
        IORIN(I)=0
        TD(I)=0.0
        WDD(I)=0.0
        WSS(I)=0.0
        IFP(I)=0
        U(I)=0.0
        V(I)=0.0
        PTK(I)=0.0
        EPOT(I)=0.0
```

```
      W(I)=0.0
      HM(I)=0.0
      R(I)=0.0
      ATH(I)=0.0
  345 CONTINUE
C
C     READ THESTATION ROSTER CONTAINING WMO NUMBER, STATION ELEVATION,
C     STATION LATITUDE, AND STATION NAME
C     NR IS THE NUMBER OF STATIONS IN THE ROSTER
C
      READ,NR
      DO 111 J=1,NR
      READ(5,501) STID(J),STHT(J),STLA(J),(NMS(J,K),K=1,7)
  501 FORMAT (I5,1X,F4.0,1X,F4.2,24X,7A4)
  111 CONTINUE
      READ,NSOUND
C
C
C     NSOUND IS THE NUMBER OF SOUNDINGS TO COMPUTE
C     BEGIN THE GRAND LOOP
C
C
      DO 999 IS=1,NSOUND
C
C
C     READ THE BASELINE DATA
C     THE FIRST BASELINE 'CARD' NEED NOT BE READ UNLESS ONE INTENDS TO
C     SEARCH THE TAPE.  THE TOTAL NUMBER OF CARDS IN THE SOUNDING DECK
C     IS CONTAINED ON THIS CARD
C
C
      READ(1,10)  (NZ(I),I=1,6)
   10 FORMAT(6A4)
C
C     READ THE SECOND 'CARD' WHICH CONTAINS BASELINE CALIBRATIONS AND
C     SURFACE MEASUREMENTS
C
      READ(1,274,ERR=9366) CTC(1),P(1),TSFC,RHSFC,TO,RHO,WSI,WDI,
     1ID2,ID1,ID3,ID4,ID5,I1MIN
  274 FORMAT(7X,F4.1,1X,F6.1,1X,F4.1,1X,F4.1,1X,F4.1,1X,F4.1,1X,F4.1,
     11X,F3.0,2X,I2,1X,I2,1X,I2,1X,I4,1X,I5,3X,I1)
      TMCR(1)=0.0
C
C     THE BASELINE TEMP (TO) CORRESPONDS TO AN ORDINATE (TCAL) OF 37.6
C
      TO=-1.0*TO
      TCAL=37.6
      IORIN(1)=0
C
C
C     SET UP THE BASELINE REFERENCE
C     WEATHER SERVICE TEMPERATURE ELEMENT
C
C
      RTB=RESIST(TCAL)
      RK1=TO+273.15
      RM1=5.3018981*(1.0/303.0-1.0/RK1)
      RM2=(-2.47991E-3+SQRT(2.47991E-3**2-4.*5.89986E-5*RM1))/
     1(2.*5.89986E-5)
      RM3=14000./RTB*EXP(RM2)
C
```

```
C       SET UP CONSTANTS TO BE USED IN HUMIDITY CALCULATIONS
C       CARBON HUMIDITY ELEMENT
C
        KX=0
        DO 103 J=1,40,2
        KX = KX + 1
  103   FC(KX) = C(J) + (C(J+1)*RHO)
C
C
C       READ THE ORDINATE DATA
C
C
        DO 233 IO=2,230
        READ(1,234,ERR=9366) CTC(IO),P(IO),TORD(IO),HORD(IO),TMOR(IO),
       1ISTOP,IORIN(IO)
        IF(ISTOP.NE.0) GO TO 235
  233   CONTINUE
  235   KLM=IO-1
  234   FORMAT(F3.0,1X,F4.0,1X,F4.1,1X,F4.1,1X,F5.1,47X,I1,I1)
C
C       KLM IS THE NUMBER OF CONTACTS
C       CHECK ORDINATES FOR MISSING TIME VALUES
C       USE LINEAR INTERPOLATION TO FILL IN GAPS
C       PRESSURE IS ALWAYS GIVEN EVEN IF TIME IS NOT GIVEN
C
        LTIN=0
        ITJ=0
        DO 1111 I=1,KLM
        IF(LTIN.EQ.0) ITJ=0
        IF(TMOR(I).NE.999.9) GO TO 1111
        IF(TMOR(I).EQ.999.9) T1=TMOR(I-1)
        IF (LTIN.NE.0) GO TO 1115
        DO 1112 J=I,KLM
        ITJ=ITJ+1
        IF(TMOR(J).NE.999.9) GO TO 1113
 1112   CONTINUE
 1113   T2=TMOR(J)
        DT=T2-T1
        ADT=DT/ITJ
 1115   TMOR(I)=TMOR(I-1)+ADT
        TORD(I)=99.9
        HORD(I)=99.9
C
C       INDICATE THAT INTERPOLATION WAS DONE
C
        IORIN(I)=1
        LTIN=ITJ-1
 1111   CONTINUE
        IF(ILMIN.NE.0) GO TO 3333
C
C
C       READ THE ANGLE DATA IF HALF MINUTE VALUES
C       IF TMNG (1).NE.0, INTERPOLATE THE TIMES BUT FILL IN THE MISSING
C       ANGLES WITH 9'S
C
C
        DO 237 IA=1,270
        READ(1,238,ERR=9366) TMNG(IA),THETA(IA),AZ(IA),ASTOP, IASM(IA),
       1IEP(IA)
        IF(TMNG(IA).EQ.999.9) GO TO 3777
        ING=(TMNG(1)/0.5)+0.1
```

```
      TMNG(ING+1)=TMNG(IA)
      THETA(ING+1)=THETA(IA)
      AZ(ING+1)=AZ(IA)
      IASM(ING+1)=IASM(IA)
      IEP(ING+1)=IEP(IA)
      TIME=0.0
      IF(ING.EQ.0) GO TO 3454
      DO 2378 IZ=1,ING
      TMNG(IZ)=TIME
      THETA(IZ)=99.9
      IEP(IZ)=0
      AZ(IZ)=999.9
      IASM(IZ)=0
      TIME=TIME+0.5
 2378  CONTINUE
      GO TO 3454
 3777 IF(ASTOP.NE.0) GO TO 239
 237  CONTINUE
 3454  ING=ING+2
C
C     READ THE ANGLES IN THE NORMAL FASHION NOW
C
      DO 2377 IA=ING,270
      READ(1,238,ERR=9366) TMNG(IA),THETA(IA),AZ(IA),ASTOP, IASM(IA),
     1 IEP(IA)
      IF(ASTOP.NE.0) GO TO 239
 2377 CONTINUE
 238  FORMAT(F5.1,1X,F4.1,1X,F5.1,55X,I1,I1,I1)
 239  KAT=IA-1
      IF(KAT.GT.230) KAT=228
      GO TO 4444
C
C     READ THE ANGLE DATA IF WHOLE MINUTE VALUES
C
 3333 DO 5555 IA=1,270,2
      READ(1,2388,ERR=9366) TMNG(IA),THETA(IA), AZ(IA),ASTOP,IASM(IA),
     1 IEP(IA)
      TMNG(IA+1)=TMNG(IA)+0.5
      THETA(IA+1)=99.9
      AZ(IA+1)=999.9
      IASM(IA+1)=0
      IEP(IA+1)=0
      IF(ASTOP.NE.0) GO TO 2399
 5555 CONTINUE
 2388 FORMAT(F5.1,1X,F4.1,1X,F5.1,55X,I1,I1,I1)
 2399 KAT=IA-1
      IF(KAT.GT.230) KAT=228
C
C     INTERPOLATE WHOLE MINUTE ANGLES TO HALF MINUTE VALUES
C
      DO 6666 K=2,KAT,2
      IF(THETA(K+1).EQ.99.9) GO TO 6667
      IF(THETA(K-1).EQ.99.9) GO TO 6667
      IF(AZ(K+1).EQ.999.9) GO TO 6667
      IF(AZ(K-1).EQ.999.9) GO TO 6667
      THETA(K)=THETA(K-1)+0.5*(THETA(K+1)-THETA(K-1))
      DAZ=AZ(K+1)-AZ(K-1)
      AZ(K)=AZ(K-1)+0.5*DAZ
      IF(ABS(DAZ).GT.180.) AZ(K)=AZ(K)+180.
      IF(AZ(K).GE.360.) AZ(K)=AZ(K)-360.
      GO TO 6666
```

```
 6667 THETA(K)=99.9
      AZ(K)=999.9
 6666 CONTINUE
C
C     CHECK THE ROSTER FOR THE PARTICULAR STATION TO ASSIGN
C     ELEVATION AND LATITUDE
C
 4444 DO 112 J=1,NR
      JS=J
      IF(ID5.EQ.STID(J)) GO TO 113
  112 CONTINUE
      WRITE(6,966)
  966 FORMAT(1H1,34HERROR--STATION ID IS NOT IN ROSTER)
      GO TO 999
  113 HT=STHT(JS)
      DO 26 I=1,7
      NAME(I)=NMS(JS,I)
   26 CONTINUE
      IF(ID5.EQ.259) ID5=260
C
C     AZIMUTH ANGLES AT NSSL STATIONS ARE 180 DEG OFF
C
      IF(ID5.LT.22002) GO TO 1213
      IF(ID5.GT.22005) GO TO 1213
      DO 1212 NSSL=1,KAT
      IF(AZ(NSSL).EQ.999.9) GO TO 1212
      AZ(NSSL)=AZ(NSSL)+180.0
      IF(AZ(NSSL).GE.360.0) AZ(NSSL)=AZ(NSSL)-360.0
 1212 CONTINUE
 1213 CONTINUE
C
C     CONVERT NUMERICAL MONTH TO ALPHABETICAL
C
      CALL MOPPT(ID2,IX,IY,IZ)
      TC(1)=TSFC
C
C
C     COMPUTE TEMPERATURE AT THE PRESSURE CONTACTS
C     WEATHER SERVICE TEMPERATURE EQUATIONS
C
C
      DO 444 K=2,KLM
      IF(TORD(K).EQ.99.9) GO TO 443
      RE = RESIST(TORD(K))
      R4=ALOG(RM3*RE/14000.0)
      RK=1./(1./303.+4.6774E-4*R4+1.11278E-5*R4**2)
      TP=RK-273.15
      TC(K)=TP
      GO TO 444
  443 TC(K)=99.9
  444 CONTINUE
C
C     CHECK FOR MISSING TEMPERATURES
C     USE LINEAR INTERPOLATICN TO FILL IN GAPS
C
      DO 4411 I=1,KLM
      IF(TC(I).NE.99.9) GO TO 4411
      DO 4412 J=I,KLM
      KOJ=J
      IF(TORD(J).NE.99.9) GO TO 4413
 4412 CONTINUE
```

```
 4413 DTKT=(TMOR(I)-TMOR(I-1))/(TMOR(KOJ)-TMOR(I-1))
      TC(I)=TC(I-1)+DTKT*(TC(KOJ)-TC(I-1))
      IORIN(I)=1
 4411 CONTINUE
C
C
C     COMPUTE OTHER THERMODYNAMIC VARIABLES AT THE CONTACTS
C
C
      DO 44 K=1,KLM
      TP=TC(K)
      TK=TC(K)+273.16
      IF(K.EQ.1) GO TO 787
C
C     IF HUMIDITY ORDINATE EQUALS 99.9, PRINT 9'S FOR MOISTURE VARIABLES
C
      IF(HORD(K).EQ.99.9) GO TO 523
      IF(HORD(K)) 523,523,52
C
C     X AS USED HERE IS NOT MIXING RATIO
C
  52  X = (HORD(K)-46.)/41.
      HP = 0.
      DO 521 KK=1,17,2
  521 HP = (HP+HC(KK) + HC(KK+1)*TP) * X
      HP = HP + HC(19) + HC(20) * TP
C
C     MOISTURE VARIABLES BASED ON A RELATIVE HUMIDITY LESS THAN 5 PCT
C     ARE PRINTED AS 9'S
C
  522 IF(HP-5.)    523,532,532
 523  HP=999.9
      TV(K) = TK
      TD(K) = 99.9
      E = 0.0
      PTK(K)=TK*((1000./(P(K)))**.286)
      EPOT(K)=999.9
      W(K)=99.9
      HM(K)=HP
      GO TO 537
 787  HP=RHSFC
C
C     THIS SECTION COMPUTES THERMODYNAMIC VARIABLES WHERE HUMIDITY IS
C     GREATER THAN 5 PCT
C
 532  HM(K)=HP
      IF(HP-100.) 534,534,533
C
C     PRINT HUMIDITY EVEN IF GREATER THAN 100
C     OTHER VALUES BASED ON A MAX VALUE OF 100
C
  533 HP = 100.
  534 E = HP * .0611 * 10.**((7.5*TP)/(237.3+TP))
C
C     X USED HERE IS MIXING RATIO
C
      X=(.623*E)/(P(K)-E)
      CP=.240*(1.0+0.84*X)
C
C     THIS WILL GIVE DEW POINT
C
```

```
      ELOG = ALOG10(E)
      TD(K) = ((237.3*ELOG)-186.527)/(8.286-ELOG)
      D=TC(K)-TD(K)
      TSC=TD(K)-(0.212+0.001571*TD(K)-0.000436*TC(K))*D
      TSA=TSC+273.16
      EL=597.3-.566*TSC
      PTK(K)=TK*((1000./(P(K)-E))**(RD/CP))
      EPOT(K)=PTK(K)*EXP((EL*X)/(CP*TSA))
      W(K)=X*1000.
      TV(K) = XVIRT(TK,E,P(K))
  537 CONTINUE
   53 IF(K-1)61,61,62
C
C
C     COMPUTE HEIGHT AT EACH CONTACT
C
C
   61 SYS=0.0
      GO TO 63
   62 TMI=(TV(K)+TV(K-1))/2.
      DYS=29.29085*TMI*ALOG(P(K-1)/P(K))
      SYS=SYS+DYS
C
C     DON'T COMPUTE WINDS IF LESS THAN 10 ANGLE REPORTS
C     INDICATE THIS BY DEFINING VALUES TO BE PRINTED WITH 9'S
C
   63 YS(K)=SYS
      IF(KAT.LT.10) WSS(K)=99.9
      IF(KAT.LT.10) WDD(K)=999.9
      IF(KAT.LT.10) IEP(K)=0
      IF(KAT.LT.10) IASM(K)=0
      IF(KAT.LT.10) U(K)=99.9
      IF(KAT.LT.10) V(K)=99.9
      IF(KAT.LT.10) R(K)=999.9
      IF(KAT.LT.10) ATH(K)=999.
   44 CONTINUE
      IF(KAT.LT.10) GO TO 921
C
C
C     INTERPOLATE HEIGHTS TO CORRESPOND TO ANGLE TIMES (30 SEC)
C     LINEAR INTERPOLATION BASED ON TIME IS USED
C
C
      IJT=1
      HINT(1)=0.0
      DO 701 I=2,KAT
      IF(TMNG(I).GT.TMOR(KLM))  GO TO 777
      IT=I
      DO 702  IJ=IJT,300
      IF(TMOR(IJ+1).GE.TMNG(I)) GO TO 703
  702 CONTINUE
  703 T1=TMOR(IJ+1)
      T2=TMOR(IJ)
      DT=(TMNG(I)-T1)/(T1-T2)
      HINT(I)= (YS(IJ+1)-YS(IJ))*DT+YS(IJ+1)
      IJT=IJ
  701 CONTINUE
  777 KT=IT-1
C
C
C     COMPUTE WINDS AT 30 SEC INTERVALS, 1 MIN OVERLAP
```

```
C
C
      DO 750 K=1,KT
C
C     CHANGE ANGLES TO RADIANS
C     IF AN ANGLE TO BE USED IS MISSING (9'S), WIND VARIABLES AND SONDE
C     LOCATION WILL BE PRINTED AS 9'S
C
      IF(THETA(K).EQ.99.9) GO TO 748
      IF(AZ(K).EQ.999.9) GO TO 748
      THETA(K)=THETA(K)/57.29578
      AZ(K)=AZ(K)/57.29578
      A=COS(THETA(K))/(1.+(HINT(K)/6371229.))
      SC=6371229.*(ARCOS(A)-THETA(K))
      GO TO 749
  748 XS(K)=99.9
      ZS(K)=99.9
      IF(K-3) 67,68,69
  749 XS(K)=SC*SIN(AZ(K))
      ZS(K)=SC*COS(AZ(K))
      IF(K-3)67,68,69
   68 DT=30.
C
C     WIND AT THE FIRST LEVEL (2) ABOVE GROUND IS A 30-SEC FORWARD
C     DIFFERENCE USING LEVELS 3 AND 2
C
      XS(1)=XS(2)
      ZS(1)=ZS(2)
      GO TO 71
   69 DT=60.0
   71 IF(XS(K).EQ.99.9) GO TO 751
      IF(XS(K-2).EQ.99.9) GO TO 751
      IF(ZS(K).EQ.99.9) GO TO 751
      IF(ZS(K-2).EQ.99.9) GO TO 751
C
C     COMPUTE THE WIND COMPONENTS
C
      WWE(K-1)=(XS(K)-XS(K-2))/DT
      WSN(K-1)=(ZS(K)-ZS(K-2))/DT
      IF(ABS(WSN(K-1)).GT.1.0E-5) GO TO 5151
      TT=WSN(K-1)
      WSN(K-1)=1.0E-5
      IF(TT.LT.0.0) WSN(K-1)=-1.0*WSN(K-1)
 5151 WS(K-1)=SQRT((WWE(K-1))**2 +(WSN(K-1))**2)
      B=WWE(K-1)/WSN(K-1)
      A=ATAN(ABS(B))*57.29578
      IF(B) 671,671,672
  671 IF(WWE(K-1)) 673,673,674
  673 A=360.-A
      GO TO 676
  674 A=180.-A
      GO TO 676
  672 IF(WWE(K-1)) 678,678,676
  678 A=A+180.
  676 CONTINUE
C
C     MODIFY WIND DIRECTION TO THE GENERAL MET CONVENTION
C
      A = A + 180.
      IF(A.GT.360.)  A = A - 360.
      WD(K-1) = A
```

```
   67 CONTINUE
      GO TO 750
  751 WWE(K-1)=99.9
      WSN(K-1)=99.9
      WS(K-1)=99.9
      WD(K-1)=999.9
  750 CONTINUE
C
C     WIND AT THE SURFACE IS DEFINED FROM THE BASELINE CARD
C
      WD(1)=WDI
      IF(WDI.EQ.999.) WD(1)=999.9
      WS(1)=WSI
      IF(WSI.EQ.99.9) WS(1)=99.9
C
C     SURFACE WIND COMPONENTS ARE DEFINED
C
      WWE(1)=WWE(2)
      WSN(1)=WSN(2)
      KT=KT-1
C
C
C     PERFORM A 5-POINT WEIGHTED AVERAGE ON 30 SEC WINDS--WIND
C     COMPONENTS ARE SMOOTHED
C     TRANSFER STORAGE OF WINDS
C
C
      DO 325 I=1,KT
      WDD(I)=WD(I)
      WSS(I)=WS(I)
  325 CONTINUE
C
C     BINOMIAL WEIGHT COEFFICIENTS ARE USED
C
      CD(1)=0.06
      CD(2)=0.25
      CD(3)=0.38
      CD(4)=0.25
      CD(5)=0.06
      DO 393 I=1,KT
      KTI=KT-I
      IF(KTI.LE.2) GO TO 306
C
C     SMOOTHING DOES NOT BEGIN UNTIL 2000 M ABOVE GROUND LEVEL
C
      IF(HINT(I).LT.2000.) GO TO 306
      K1=I-2
      K2=I+2
      K4=0
      S1=0.0
      S2=0.0
      DO 322 K=K1,K2
      K4=K4+1
C
C     IF  AWIND VALUE INVOLVED IN THE SMOOTH IS MISSING, DON'T
C     SMOOTH THAT POINT
C
      IF(WWE(K).EQ.99.9) GO TO 306
      IF(WSN(K).EQ.99.9) GO TO 306
C
C     LOCATE WINDS BASED ON AN ELEVATION ANGLE LESS THEN 9  DG
```

```
C
      IF(THETA(K).LT.0.157) IEP(I)=1
      S1=S1+WWE(K)*CD(K4)
      S2=S2+WSN(K)*CD(K4)
 322  CONTINUE
C
C     INDICATE THAT SMOOTHING WAS PERFORMED (IASM=1)
C
      IASM(I)=1
      WE(I)=S1
      WN(I)=S2
      IF(ABS(S2).GT.1.0E-5) GO TO 5152
      TT=S2
      S2=1.0E-5
      IF(TT.LT.0.0) S2=-1.0*S2
 5152 WS(I)=SQRT(S1**2+S2**2)
      B=S1/S2
      A=ATAN(ABS(B))*57.29578
      IF(B)471,471,472
 471  IF(S1) 473,473,474
 473  A=360.-A
      GO TO 476
 474  A=180.-A
      GO TO 476
 472  IF(S1) 478,478,476
 478  A=A+180.
 476  CONTINUE
C
C     MODIFY WIND DIRECTION TO THE GENERAL MET CONVENTION
C
      A=A+180.
      IF(A.GT.360.) A=A-360.
      WD(I)=A
      GO TO 393
 306  WD(I)=WDD(I)
      WS(I)=WSS(I)
      WE(I)=WWE(I)
      WN(I)=WSN(I)
 393  CONTINUE
C
C
C     LINEARLY INTERPOLATE WINDS ON BASIS OF TIME TO PLACE ON CONTACTS
C     SURFACE VALUES ARE COMPUTED FIRST
C
C
      WDD(1)=WD(1)
      WSS(1)=WS(1)
      IF(WDD(1).EQ.999.9) GO TO 888
      IF(WSS(1).EQ.99.9) GO TO 888
      T=180.+WD(1)
      IF(T.GE.360.) T=T-360.
      U(1)=WS(1)*SIN(T/57.29578)
      V(1)=WS(1)*COS(T/57.29578)
      GO TO 889
 888  U(1)=99.9
      V(1)=99.9
 889  R(1)=0.0
      ATH(1)=0.0
      ICT=1
      DO 613 I=2,300
      IF(TMOR(I).GT.TMNG(KT)) GO TO 921
```

```
      DO 614 J=ICT,300
      K=J
C
C     LOCATE LEVELS ON WHICH TO INTERPOLATE
C
      IF(TMNG(J+1).GE.TMOR(I)) GO TO 615
 614  CONTINUE
 615  ICT=K
C
C     DON'T TRY TO INTERPOLATE MISSING DATA (9'S)
C
      IF(WD(K).EQ.999.9) GO TO 3766
      IF(WD(K+1).EQ.999.9) GO TO 3766
C
C     KEEP UP WITH EL. ANGLES LESS THAN 10 DG AND POINTS THAT HAVE BEEN
C     SMOOTHED
C
      IF(IASM(K).EQ.1) IASM(I)=1
      IF(IASM(K+1).EQ.1) IASM(I)=1
      IF(IEP(K+1).EQ.1) IEP(I)=1
      IF(IEP(K).EQ.1) IEP(I)=1
      DT=(TMOR(I)-TMNG(K))/(TMNG(K+1)-TMNG(K))
C
C     COMPUTE LOCATION COMPONENTS ON PRESSURE CONTACTS
C
      XXS(I)=XS(K)+DT*(XS(K+1)-XS(K))
      ZZS(I)=ZS(K)+DT*(ZS(K+1)-ZS(K))
      IF(ABS(ZZS(I)).GT.1.0E-5) GO TO 5153
      TT=ZZS(I)
      ZZS(I)=1.0E-5
      IF(TT.LT.0.0) ZZS(I)=-1.0*ZZS(I)
C
C     COMPUTE RANGE (R) AND AZIMUTH (ATH) OF SONDE
C
 5153 IF(XXS(I).NE.ZZS(I)) GO TO 3033
      IF(XXS(I).EQ.99.9) R(I)=999.9
      IF(XXS(I).EQ.99.9) ATH(I)=999.
      GO TO 3034
 3033 R(I)=(SQRT((XXS(I))**2+(ZZS(I))**2))/1000.
      F=XXS(I)/ZZS(I)
      D=ATAN(ABS(F))*57.29578
      IF(F)6711,6711,6721
 6711 IF(XXS(I)) 6731,6731,6741
 6731 D=360.-D
      GO TO 6761
 6741 D=180.-D
      GO TO 6761
 6721 IF(XXS(I)) 6781,6781,6761
 6781 D=D+180.
 6761 D=D+180.
      IF(D.GT.360.) D=D-360.
      ATH(I)=D
 3034 CONTINUE
C
C     COMPUTE NEW WIND COMPONENTS, DIRECTION AND SPEED
C
      U(I)=WE(K)+DT*(WE(K+1)-WE(K))
      V(I)=WN(K)+DT*(WN(K+1)-WN(K))
      IF(ABS(V(I)).GT.1.0E-5) GO TO 5154
      TT=V(I)
      V(I)=1.0E-5
```

```
      IF(TT.LT.0.0) V(I)=-1.0*V(I)
C
C     USE WSS AND WDD FOR SPEED AND DIRECTION NOW
C
 5154 WSS(I)=SQRT((U(I))**2+(V(I))**2)
      B=U(I)/V(I)
      A=ATAN(ABS(B))*57.29578
      IF(B) 371,371,372
 371  IF(U(I)) 373,373,374
 373  A=360.-A
      GO TO 376
 374  A=180.-A
      GO TO 376
 372  IF(U(I)) 378,378,376
 378  A=A+180.
 376  A=A+180.
      IF(A.GT.360.) A=A-360.
      WDD(I)=A
C
C     MODIFY WIND DIRECTION TO THE GENERAL MET CONVENTION
C
      WDD(I)=WDD(I)+180.
      IF(WDD(I).GE.360.) WDD(I)=WDD(I)-360.
C
C     MAKE U POSITIVE POINTING EAST AND V POSITIVE POINTING NORTHWARD
C
      U(I)=-1.0*U(I)
      V(I)=-1.0*V(I)
      GO TO 613
 3766 WDD(I)=999.9
      WSS(I)=99.9
      U(I)=99.9
      V(I)=99.9
      IFP(I)=0
      R(I)=999.9
      ATH(I)=999.
 613  CONTINUE
C
C
C     PRINT THE RESULTS
C
C
 921  KH = 0
      IF(KAT.LT.10) KT=KAT
      DO 55 K=1,KLM
C
C     ADD STATION ELEVATION TO HEIGHT OF SONDE
C
      YS(K)=YS(K)+HT
C
C     PRINT 9'S IF WIND VALUES END BEFORE THERMO DATA
C
      IF(TMOR(K).GE.TMNG(KT-1)) U(K)=99.9
      IF(TMOR(K).GE.TMNG(KT-1)) V(K)=99.9
      IF(TMOR(K).GE.TMNG(KT-1)) R(K)=999.9
      IF(TMOR(K).GE.TMNG(KT-1)) ATH(K)=999.
      IF(TMOR(K).GE.TMNG(KT-1)) WDD(K)=999.9
      IF(TMOR(K).GE.TMNG(KT-1)) WSS(K)=99.9
      IF(TMOR(K).GE.TMNG(KT-1)) IFP(K)=0
      IF(TMOR(K).GE.TMNG(KT-1)) IASM(K)=0
C
```

```
C     PRINT A * TC SHOW SMOOTHING AND INTERPOLATION INSTEAD OF A 1
C
      IF(IORIN(K).EQ.0) IORIN(K)=BLANK
      IF(IORIN(K).EQ.1) IORIN(K)=AST
      IF(IFP(K).EQ.0) IFP(K)=BLANK
      IF(IFP(K).EQ.1) IFP(K)=AST
      IF(IASM(K).EQ.0) IASM(K)=BLANK
      IF(IASM(K).EQ.1) IASM(K)=AST
      IF(MOD(KH,45)) 94,93,94
   93 WRITE(6,90) ID5,(NAME(I),I=1,7),ID1,IX,IY,IZ,ID3,ID4,KLM,P(KLM),
     1IIMIN
   90 FORMAT(1H1,56X,'STATION NO. ',I5,/,51X,7A4,//,
     157X,I2,2X,3A3,'19',I2,/,61X,I4,1X,'GMT',50X,I3,1X,F5.0,2X,I1)
      IF(IIMIN.NE.0) WRITE(6,977)
  977 FORMAT(' ','ANGLES ON THE HALF MINUTE HAVE BEEN LINEARLY INTERPOLA
     1TED FROM WHOLE MINUTE VALUES')
      WRITE(6,962)
  962 FORMAT('0','TIME',4X,'CNTCT',4X,'HEIGHT',4X,'PRES',
     15X,'TEMP',3X,'DEW PT',4X,'DIR',4X,'SPEED',3X,
     2'U COMP',3X,'V COMP',3X,'POT T',3X,'E POT T',
     33X,'MX RTO',5X,'RH',4X,'RANGE',2X,'AZ')
      WRITE(6,963)
  963 FORMAT(' ',1X,'MIN',15X,'GPM',6X,'MB',6X,'DG C',
     14X,'DG C',6X,'DG',4X,'M/SEC',4X,'M/SEC',4X,
     2'M/SEC',4X,'DG K',4X,'DG K',6X,'GM/KG',4X,
     3'PCT',6X,'KM',3X,'DG',/)
   94 WRITE(6,60) TMOR(K),CTC(K),YS(K),P(K),TC(K),IORIN(K),
     1TD(K),WDD(K),WSS(K),IFP(K),U(K),V(K),PTK(K),EPOT(K),
     2W(K),HM(K),R(K),ATH(K)
   60 FORMAT(' ',F5.1,3X,F5.1,3X,F7.1,3X,F6.1,3X,F5.1,
     1A4,F5.1,3X,F5.1,3X,F5.1,A1,2X,F6.1,3X,F6.1,
     23X,F5.1,4X,F5.1,5X,F4.1,4X,F5.1,3X,F5.1,1X,F4.0)
      KH=KH+1
   55 CONTINUE
C
C     WRITE THE INFORMATION ON TAPE USING NO FORMAT
C
      WRITE(3)          ID5,NAME,ID1,IX,IY,IZ,ID3,ID4,
     1KLM,P(KLM),IIMIN,TMOR,CTC,YS,P,TC,
     2IORIN,TD,WDD,WSS,IFP,U,V,PTK,EPOT,
     3W,HM,R,ATH
  999 CONTINUE
      GO TO 9266
 9366 WRITE(6,9367)
 9367 FORMAT('1','ERROR IN READING TAPE')
 9266 CONTINUE
      REWIND1
      REWIND3
      STOP
      END
C
C
      SUBROUTINE MOPRT(IX,IA,IB,IC)
      DIMENSION IM1(12),IM2(12),IM3(12)
      DATA IM1/3HJAN,3HFEB,3HMAR,3HAPR,3HMAY,3HJUN,3HJUL,3HAUG,3HSEP,
     13HOCT,3HNOV,3HDEC/
      DATA IM2/3HUAR,3HRUA,3HCH ,3HIL ,3H   ,3HE  ,3HY  ,3HUST,
     13HTEM,3HOBE,3HEMB,3HEMB/
      DATA IM3/3HY  ,3HRY ,6*3H   ,3HBER,3HR  ,3HER ,3HER /
      II=IX
      IA=IM1(II)
```

```
      IB=IM2(II)
      IC=IM3(II)
      RETURN
      END
C
C     //$DATA
C
54
11001 C192 3466 08670              MARSHALL SPACE FLIGHT CENTER
22001 0362 0524 09746                        NORMAN, OKLA
22002 C362 3466 09881                       FT. SILL, OKLA
22003 C449 3479 09769                        LINDSAY, OKLA
22004 0423 3515 09847                       FT. COBB, OKLA
22005 C451 3510 09796                     CHICKASHA, OKLA
  201 0003 2458 08168                        KEY WEST, FLA
  202 C004 2583 08027                          MIAMI, FLA
  208 C013 3291 08002                      CHARLESTON, SC
  211 C008 2792 08252                          TAMPA, FLA
  213 0044 3125 08241                        WAYCROSS, GA
  221 C022 3050 08652                      EGLIN AFB, FLA
  226 C057 3225 08641                     MONTGOMERY, ALA
  232 0001 2933 08941                     BOOTHVILLE, LA
  235 01C0 3233 09008                       JACKSON, MISS
  240 C005 3008 09318                   LAKE CHARLES, LA
  248 C079 3250 09382                     SHREVEPORT, LA
  250 C0C7 2592 09743                  BROWNSVILLE, TEX
  255 C033 2883 09692                     VICTORIA, TEX
  259 0399 3233 09825                  STEPHENVILLE, TEX
  261 0314 2933 10092                      DEL RIO, TEX
  265 C873 3193 10219                     MIDLAND, TEX
  304 C004 0526 07537                       HATTERAS, NC
  311 0246 3394 08332                       ATHENS, GA
  317 C275 3608 07995                     GREENSBORO, NC
  327 C180 3625 08657                     NASHVILLE, TENN
  340 0079 3474 09224                   LITTLE ROCK, ARK
  349 C438 3690 09291                      MONETTE, MO
  363 1095 3524 10169                     AMARILLO, TEX
  402 0004 3784 07549                  WALLOPS ISLAND, VA
  405 0085 3898 07748                  DULLES AIRPORT, VA
  425 C246 3836 08254                    HUNTINGTON, WVA
  429 C298 3986 08410                      DAYTON, OHIO
  433 C175 3866 08898                        SALEM, ILL
  451 C791 3776 09998                    DODGE CITY, KAN
  456 C268 3907 09562                      TOPEKA, KAN
  486 0007 4066 07377              KENNEDY AIRPORT, N Y
  494 0016 4167 06998                      CHATAM, MASS
  518 C086 4275 07378                      ALBANY, N Y
  520 C359 4053 08024                    PITTSBURG, PA
  528 C218 4293 07874                      BUFFALO, N Y
  532 C200 4067 08968                      PEORIA, ILL
  553 C403 4136 09601                       OMAHA, NEB
  562 C847 4114 10068                 NORTH PLATTE, NEB
  606 0020 4366 07032                     PORTLAND, ME
  637 C236 4297 08375                      FLINT, MICH
  645 0210 4449 08815                   GREEN BAY, WIS
  654 C392 4439 09820                      HURON, S D
  655 0316 4558 09418                   ST CLOUD, MINN
  662 C966 4405 10307                   RAPID CITY, S D
  712 C191 4696 06801                     CARIBOU, ME
  734 C221 4686 07455               SAULT STE MARIE, MICH
  764 C503 4676 10075                    BISMARCK, N D

  747 C359 4857 09337             INTERNATIONAL FALLS, MINN
C     /*END
```

APPENDIX E

Use of the First Difference Program

The number of soundings beginning with the first on which first differences are computed is read from a card; results from the master reduction program are read from magnetic tape using DCB = (RECFM = VS, DEN = 3). The program has an object code of 8,240 bytes and an array area of 33,148 bytes. Results are printed using the same format that was used for the master reduction program (Fig. 6).

```
C THIS PROGRAM COMPUTES FIRST DIFFERENCES OF
C QUANTITIES COMPUTED AT PRESSURE CONTACTS
C SUMMER 1974--HENRY FUELBERG
C ARRAYS A AND IA ARE ORIGINAL SOUNDING DATA
C ARRAYS B AND IB ARE FIRST DIFFERENCE DATA
C
      DIMENSION A(230,16),B(230,16),IA(230,2),IB(230,2)
      INTEGER AST, BLANK, NAME(7)
      DATA AST, BLANK/1H*,1H /
      REWIND1
C
C N IS THE NUMBER OF SOUNDINGS TO COMPUTE
C
      READ, N
      DO 500 ISOUND=1,N
C
C     READ IN THE DATA
C
      READ(1,ERR=91,END=501) ID5,NAME,ID1,IX,IY,IZ,ID3,ID4,
     1KLM,PMIN,I1MIN,((A(I,J),I=1,230),J=1,5),(IA(I,1),I=1,230),
     2((A(I,J),I=1,230),J=6,8),(IA(I,2),I=1,230),
     3((A(I,J),I=1,230),J=9,16)
C
C COMPUTE FIRST DIFFERENCES
C
      KLM1=KLM-1
C
C COMPUTE BY ROWS
C
      DO 400 I=2,KLM1
C
C INITIALIZE IB ARRAYS WITH BLANKS
C
      IB(I,1)=BLANK
      IB(I,2)=BLANK
      K=I
C
C COMPUTE BY COLUMNS
C
      DO 300 L=1,16
C
C DON'T COMPUTE FIRST DIFFERENCES IF A VALUE WAS MISSING (9'S)
C
      IF(A(K,L).EQ.999.9)GO TO 313
      IF(A(K,L).EQ.99.9)GO TO 314
      IF(A(K-1,L).EQ.999.9)GO TO 313
      IF(A(K-1,L).EQ.99.9)GO TO 314
      B(K,L)=A(K,L)-A(K-1,L)
      GO TO 300
  313 B(K,L)=999.9
      GO TO 300
  314 B(K,L)=99.9
  300 CONTINUE
C
C KEEP UP WITH STARRED VALUES
C INDICATE INTERPOLATED VALUES BY A *
C INDICATE WINDS THAT WERE COMPUTED WITH ELEVATION ANGLES LESS THAN 10 DG.
C
      IF(IA(K,1).EQ.AST)IB(K,1)=AST
      IF(IA(K-1,1).EQ.AST)IB(K,1)=AST
      IF(IA(K,2).EQ.AST)IB(K,2)=AST
```

```
      IF(IA(K-1,2).EQ.AST)IB(K,2)=AST
  400 CONTINUE
C PRINT THE RESULTS AS BEFORE
      KH=0
      DO 55 K=2,KLM1
      IF(MOD(KH,45))94,93,94
   93 WRITE(6,90)ID5,(NAME(I),I=1,7),ID1,IX,IY,IZ,ID3,ID4,
     1KLM,PMIN,I1MIN
   90 FORMAT(1H1,'**FIRST DIFFERENCES**',36X,'STATION NO.  ',
     1I5,/,51X,7A4,//,57X,I2,2X,3A3,'19',I2,/,61X,I4,1X,
     2'GMT',50X,I3,1X,F5.C,2X,I1)
      IF(I1MIN.NE.0)WRITE(6,977)
  977 FORMAT(' ','HALF MINUTE ANGLES WERE LINEARLY INTERPOLATED')
      WRITE(6,962)
  962 FORMAT('0','TIME',4X,'CNTCT',4X,'HEIGHT',4X,'PRES',
     15X,'TEMP',3X,'DEW PT',4X,'DIR',4X,'SPEED',3X,
     2'U COMP',3X,'V COMP',3X,'POT T',3X,'E POT T',
     33X,'MX RTO',5X,'RH',4X,'RANGE',2X,'AZ')
      WRITE (6,963)
  963 FORMAT(' ',1X,'MIN',15X,'GPM',6X,'MB',6X,'DG C',
     14X,'DG C',6X,'DG',4X,'M/SEC',4X,'M/SEC',4X,
     2'M/SEC',4X,'DG K',4X,'DG K',6X,'GM/KG',4X,
     3'PCT',6X,'KM',3X,'DG',/)
C
C THE PRESSURE CONTACT A(K,2) IS NOT DIFFERENCED BUT  THE FORWARD
C VALUE IS PRINTED IN ORIGINAL FORM
C
   94 WRITE(6,60) B(K,1),A(K,2),(B(K,L),L=3,5),IB(K,1),
     1(B(K,L),L=6,8),IB(K,2),(B(K,L),L=9,16)
   60 FORMAT(' ',F5.1,3X,F5.1,3X,F7.1,3X,F6.1,3X,F5.1,
     1A4,F5.1,2X,F6.1,3X,F5.1,A1,2X,F6.1,3X,F6.1,
     23X,F5.1,4X,F5.1,5X,F4.1,4X,F5.1,3X,F5.1,1X,F4.0)
      KH=KH+1
   55 CONTINUE
  500 CONTINUE
      GO TO 501
   91 WRITE(6,911)
  911 FORMAT('1','ERROR IN READING THE TAPE')
      GO TO 501
  501 REWIND1
      STOP
      END
```

APPENDIX F

Use of the Correction Program

Two tapes are needed; the first contains the original angle, ordinate, and baseline data. The tape is non-labeled and has DCB = (RECFM = FB, LRECL = 80, BLKSIZE = 1600, DEN = 3). The second tape will contain the corrected data and has the same tape parameters as the first. The program has an object code of 7,040 bytes and an array area of 40,000 bytes. The first data card read specifies the total number of soundings for which data are to be transferred to the new tape. This card is followed by a sequence of cards for each sounding. One card specifies the number of corrections to be made on each sounding which is followed by a series of locator cards and correction cards that were described in Section II-E. If no corrections are made to a sounding, only the date and time of the sounding is printed on paper, but if corrections are made, the new sounding data is printed until two records after the final correction. The printed output facilitates a verification that the corrections have been made.

```
C     THIS PROGRAM REPLACES INCORRECT RECORDS ON THE RAW DATA TAPE
C     WITH THE CORRECT RECORDS
C     SUMMER 1974--HENRY FUELBERG
C
      CHARACTER*80 OCARD(500),NCARD
      REWIND1
      REWIND3
C
C      NSOUND IS THE NUMBER OF SOUNDINGS TO CHECK
C
      READ,NSOUND
      DO 100 ISOUND=1,NSOUND
C
C     NCOR IS THE NUMBER OF CORRECTIONS IN THE GIVEN SOUNDING .
C
      READ,NCOR
C
C     READ THE 'LEADER CARD'
C
      READ(1,102,ERR=906) IMO,IDA,IYR,ITM,ISTA,ICDS
  102 FORMAT(I2,1X,I2,1X,I2,1X,I4,1X,I5,2X,I3)
C
C     IF CORRECTIONS ARE TO BE MADE ON THE 'LEADER CARD',
C     HERE IS THE PLACE TO DO IT
C
      WRITE(3,102) IMO,IDA,IYR,ITM,ISTA,ICDS
C
C     WRITE THE 'LEADER CARD' ON TAPE AND PAPER
C     IF NO CORRECTIONS ARE TO BE MADE ON THIS SOUNDING,
C     THIS IS THE ONLY PRINTED INFORMATION THAT WILL APPEAR
C     FOR THIS SOUNDING
C
      WRITE(6,102) IMO,IDA,IYR,ITM,ISTA,ICDS
  951 CONTINUE
C
C     ICDS IS THE NUMBER OF RECORDS IN THE SOUNDING
C     READ ALL THE RECORDS IN THE SOUNDING
C
      DO 200 I=1,ICDS
C
C     OCARD IS THE RECORD CURRENTLY ON TAPE
C
      READ(1,202,ERR=906) OCARD(I)
```

```
  202 FORMAT(A80)
  200 CONTINUE
      IF(NCOR.NE.0) GO TO 300
C
C     WRITE THE RECORDS ON A NEW TAPE IF NO CORRECTIONS ARE NEEDED
C
      DO 250  I=1,ICDS
      WRITE(3,251) OCARD(I)
  251 FORMAT(A80)
  250  CONTINUE
      GO TO 100
  300 IST=1
C
C     MAKE SUBSTITUTIONS FOR INCORRECT RECORDS
C
      DO 400  J=1,NCOR
C
C     CARDNO IS THE NUMBER OF THE RECORD TO CORRECT
C
      READ,CARDNO
C
C     NCARD IS THE CORRECT RECORD TO BE PLACED ON TAPE
C
      READ(5,401) NCARD
  401 FORMAT(A80)
      DO 450 K=IST,ICDS
      KL=K
      IF(K.EQ.CARDNO) OCARD(K)=NCARD
C
C     WRITE ON TAPE AND PAPER ALL RECORDS UP TO THE LAST CORRECTION
C     OF THE SOUNDING
C
      WRITE(6,481) OCARD(K)
  481 FORMAT(1X,A80)
      WRITE(3,451) OCARD(K)
  451 FORMAT(A80)
      IF(K.EQ.CARDNO) GO TO 455
  450 CONTINUE
  455 CONTINUE
      IST=KL+1
  400 CONTINUE
      IF(IST.GT.ICDS) GO TO 100
C
C     WRITE THE REMAINING RECORDS ON TAPE
C
      WRITE(3,451) (OCARD(KZ),KZ=IST,ICDS)
C
C     WRITE TWO MORE RECORDS ON PAPER AFTER THE LAST INCORRECT RECORD
C
      WRITE(6,481)OCARD(IST)
      WRITE(6,481) OCARD(IST+1)
  100 CONTINUE
      GO TO 901
  906 WRITE(6,907)
  907 FORMAT('1','ERROR IN READING TAPE')
  901 REWIND1
      REWIND3
      STOP
      END
```

APPENDIX G

Use of the Pressure Interpolation Program

Data from the master reduction program is read from a non-labeled tape with DCB = (RECFM = VS, DEN = 3). A card is read that specifies the number of soundings that will be interpolated beginning with the first sounding on tape. The program has an object code of 9,768 bytes and an array area of 20,188 bytes. Results are printed on paper with the same format that was used in the master reduction program (Fig. 8), and they are transferred to a second non-labeled tape with DCB = (RECFM = VS, DEN = 3). The format of the tape is described in Table 7; quantities have a dimension of 50 instead of 230 which was used in the master reduction program.

```
C      CONVERT DATA TO 25-MB INCREMENTS
C      SUMMER 1974--HENRY FUELBERG

C      B IS THE 25-MB DATA
C      A IS ORIGIONAL DATA
C
       DIMENSION A(230,16), B(50,16), IA(230,2), IB(50,2)
       INTEGER AST, BLANK,NAME(7)
       DATA AST,BLANK/1H*,1H /
       REWIND1
       REWIND3
C
C      N IS THE NUMBER OF SOUNDINGS TO COMPUTE
C
       READ,N
       DO 500 LS=1,N
C
C      INITIALIZE THE NEW B ARRAY
C
       DO 503 I=1,50
       DO 504 J=1,16
       B(I,J)=0.0
 504   CONTINUE
       IB(I,1)=BLANK
       IB(I,2)=BLANK
 503   CONTINUE
C
C      READ IN THE DATA
C
       READ(1,ERR=91,END=501) ID5,NAME,ID1,IX,IY,IZ,ID3,ID4,
      1KLM,PMIN,I1MIN,((A(I,J),I=1,230),J=1,5),(IA(I,1),I=1,230),
      2((A(I,J),I=1,230),J=6,8),(IA(I,2),I=1,230),
      3((A(I,J),I=1,230),J=9,16)
C
C      LEVEL1 ON NEW SCHEME IS THE SURFACE
C
       DO 200 LA=1,16
       B(1,LA)=A(1,LA)
 200   CONTINUE
       IB(1,1)=IA(1,1)
       IB(1,2)=IA(1,2)
C
C      BEGIN LINEAR INTERPOLATION STARTING AT 1000 MB
C
       P=1000.
       DO 300 I=2,41
C
C      IF SURFACE PRESSURE IS LESS THAN THE PARTICULAR 25-MB LEVEL,
C      PRINT 9'S INSTEAD OF VALUES
C
       IF(P.GE.A(1,4)) GO TO 550
C
C      IF THE 25-MB PRESSURE IS LOWER THAN THE MINIMUM SOUNDING PRESSURE,
C      PRINT 9'S INSTEAD OF ACTUAL VALUES
C
       IF(P.LT.PMIN)  GO TO 550
       ICT=1
C
C FIND PRESSURE LEVELS ON WHICH TO INTERPOLATE
C
       DO 301 J=ICT,230
       K=J
       IF(A(J+1,4).LE.P) GO TO 302
 301   CONTINUE
```

```
 302  ICT=K
      B(I,4)=P
C
C     DP IS THE INTERPOLATION FRACTION
C
      DP=(P-A(K,4))/(A(K+1,4)-A(K,4))
      DO 305 L=1,16
C
C     DON'T INTERPOLATE PRESSURE (L.EQ.4)
C
      IF(L.EQ.4) GO TO 305
C
C     IF A VALUE USED IN THE INTERPOLATION IS MISSING PRINT 9'S
C
      IF(A(K+1,L).EQ.999.9) GO TO 313
      IF(A(K+1,L).EQ.99.9) GO TO 314
      IF(A(K,L).EQ.999.9) GO TO 313
      IF(A(K,L).EQ.99.9) GO TO 314
C
C     A SPECIAL SCHEME IS USED TO INTERPOLATE WIND DIRECTION
C     (L.EQ.7) SINCE IT MAY OSCILLATE AROUND 360 DEG
C
      IF(L.EQ.7) GO TO 320
      IF((L.EQ.16).AND.(A(K+1,16).EQ.999.)) GO TO 324
      IF((L.EQ.16).AND.(A(K,16).EQ.999.)) GO TO 324
      B(I,L)=A(K,L)+DP*(A(K+1,L)-A(K,L))
      GO TO 305
 313  B(I,L)=999.9
      GO TO 305
 314  B(I,L)=99.9
      GO TO 305
 324  B(I,16)=999.
      GO TO 305
 320  DAZ=A(K+1,L)-A(K,L)
      B(I,L)=A(K,L)+DP*DAZ
      IF(ABS(DAZ).GT.180.) B(I,L)=B(I,L)+180.
      IF(B(I,L).GE.360.) B(I,L)=B(I,L)-360.
 305  CONTINUE
C
C     KEEP UP WITH STARRED QUANTITIES
C
      IF(IA(K+1,1).EQ.AST) IB(I,1)=AST
      IF(IA(K,1).EQ.AST) IB(I,1)=AST
      IF(IA(K+1,2).EQ.AST) IB(I,2)=AST
      IF(IA(K,2).EQ.AST) IB(I,2)=AST
      GO TO 309
C
C     FILL IN MISSING DATA WITH 9'S
C
 550  DO 307 L=1,13
      B(I,L)=99.9
 307  CONTINUE
      B(I,4)=P
      B(I,12)=999.9
      B(I,14)=999.9
      B(I,15)=999.9
      B(I,16)=999.
C
C     SUBTRACT 25 MB FROM P AND INTERPOLATE AGAIN
C
 309  P=P-25.
```

```
 300   CONTINUE
C
C      PRINT THE RESULTS
C
       WRITE(6,90) ID5,(NAME(I),I=1,7),ID1,IX,IY,IZ,ID3,ID4,KLM,PMIN,
      1IIMIN
  90   FORMAT(1H1,56X,'STATION NO. ',I5,/,51X,7A4,//,
      157X,I2,2X,3A3,'19',I2,/,61X,I4,1X,'GMT',50X,I3,1X,F5.0,2X,I1)
       IF(IIMIN.NE.0) WRITE(6,977)
 977   FORMAT(' ','ANGLES ON THE HALF MINUTE HAVE BEEN LINEARLY INTERPOLA
      1TED FROM WHOLE MINUTE VALUES')
       WRITE(6,962)
 962   FORMAT('0','TIME',4X,'CNTCT',4X,'HEIGHT',4X,'PRES',
      15X,'TEMP',3X,'DEW PT',4X,'DIR',4X,'SPEED',3X,
      2'U COMP',3X,'V COMP',3X,'POT T',3X,'E POT T',
      33X,'MX RTO',5X,'RH',4X,'RANGE',2X,'AZ')
       WRITE(6,963)
 963   FORMAT(' ',1X,'MIN',15X,'GPM',6X,'MB',6X,'DG C',
      14X,'DG C',6X,'DG',4X,'M/SEC',4X,'M/SEC',4X,
      2'M/SEC',4X,'DG K',4X,'DG K',6X,'GM/KG',4X,
      3'PCT',6X,'KM',3X,'DG',/)
       DO 55 IZ=1,41
       WRITE(6,60) (B(IZ,I),I=1,5),IB(IZ,1),(B(IZ,I),I=6,8),
      1IB(IZ,2),(B(IZ,I),I=9,16)
  60   FORMAT(' ',F5.1,3X,F5.1,3X,F7.1,3X,F6.1,3X,F5.1,
      1A4,F5.1,3X,F5.1,3X,F5.1,A1,2X,F6.1,3X,F6.1,
      23X,F5.1,4X,F5.1,5X,F4.1,4X,F5.1,3X,F5.1,1X,F4.0)
  55   CONTINUE
       WRITE(3)                    ID5,NAME,ID1,IX,IY,IZ,ID3,ID4,
      1KLM,PMIN,IIMIN,((B(I,J),I=1,050),J=1,5),(IB(I,1),I=1,050),
      2((B(I,J),I=1,050),J=6,8),(IB(I,2),I=1,050),
      3((B(I,J),I=1,050),J=9,16)
 500   CONTINUE
       GO TO 501
  91   WRITE(6,911)
 911   FORMAT('1','ERROR IN READING THE TAPE')
 501   REWIND1
       REWIND3
       STOP
       END
```

APPENDIX H

Known Errors Remaining in the Reduced Data

Locations of errors in the basic parameters -- temperature, pressure, humidity, time -- are given by date and time. Errors in the basic parameters will be reflected in the quantities derived from them such as pressure-altitude, winds, potential temperature, etc. Suggested corrections are given where possible for some of the derived parameters; other corrections can be calculated from the corrected basic parameters and the appropriate equations.

Station	Date/GMT	
221 Eglin AFB, Florida	All time periods	Azimuth angles are 180° out of phase. Correct derived wind direction and balloon azimuth location by 180°. U and V wind components are 180° out of phase.
250 Brownsville, Texas	12/0600	The baseline (surface) wind direction should be 140°. Correct U and V wind components accordingly.
260 Stephenville, Texas	All time periods	SEP on the raw data tape is indicated as station 259 instead of station 260. The error does not exist in other tapes.
261 Del Rio, Texas	11/1500	The surface pressure should be 966.9 mb. Pressure-altitude may be corrected by subtracting 268 m from each value given.
261 Del Rio, Texas	11/2100	The surface wind direction should be 330°. Correct U and V wind components accordingly.
494 Chatam, Massachusetts	12/1200	The surface pressure should be 1013.7 mb. Pressure-altitude may be corrected by subtracting 34 m from each value given.

Station	Date/GMT	
520 Pittsburg, Pennsylvania	11/1800	The surface pressure should be 968.8 mb at contact 8.2. Correct pressure-altitude by subtracting 104 m from each value given. Contact 8 is non-existent.
520 Pittsburg, Pennsylvania	12/1200	The surface pressure should be 961.3 mb. Pressure-altitude may be corrected by subtracting 21 m from each value given.
528 Buffalo, New York	12/0900	Abrupt change in elevation angle at 46 min after release. Cause unknown.
637 Flint, Michigan	11/1500	The surface pressure should be 979.3 mb. Add 52 m to correct pressure-altitude.
734 Sault St. Marie, Michigan	All time periods	Sondes were released during light rain and/or fog in near freezing temperatures. Very high humidity values may be due to a faulty sensor, and cannot be corrected.
747 International Falls, Montana	All time periods	
11001 Marshall Space Flight Center, Ala.	All time periods	Incorrect station elevation was used; subtract 12 m from all heights.
22004 Ft. Cobb, Oklahoma	12/0100	The surface pressure should be 961.7 mb. Add 93 m to all heights to correct pressure altitude.
All stations	All time periods	Station number, date, and time should not be read from ordinate or angle records on the raw data tape since these values are often incorrect. These values should only be read from the baseline record.

APPENDIX I

Missing Soundings

Soundings were not computed at the following stations and times for the stated reasons. Soundings are available at other stations for each of the 9-time periods.

Station	Date/Time	Reason for Omission
208, Charleston	12/0252	Technical problems in the reduction process.
226, Montgomery	11/1500	Ordinate data not available due to a malfunction in equipment.
255, Victoria	12/1115	Technical problems in the reduction process.
265, Midland	11/1200	Ordinate data not available due to a malfunction in equipment.
22003, Lindsay	12/0300-12/1200	Soundings not taken.
22004, Ft. Cobb	12/0300-12/1200	Soundings not taken.
22005, Chickasha	12/0300-12/1200	Soundings not taken.

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