

BRL



CONTRACT 169

FINAL REPORT

UPPER ATMOSPHERE WINDS FROM
GUN LAUNCHED VERTICAL PROBES

(Includes
Barbados, 21-22 June 1967
Yuma, 12 June 1967)

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SPACE INSTRUMENTS RESEARCH, INC.

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GUN LAUNCHED VERTICAL PROBES

Includes
(Barbados, 21-22 June 1967)
(Yuma, 12 June 1967)

Prepared for

Commanding Officer
USA Aberdeen Research & Development Center
ATTN: AMXRD-XSE
Aberdeen Proving Ground, Maryland 21005

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Prepared by:

Approved by:

John Fagot

John Fagot
Research Assistant

Howard D. Edwards

Howard D. Edwards
Technical Director

William Epler

William Epler
Research Assistant

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SPACE INSTRUMENTS RESEARCH, INC.
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Three TMA Trails on 21-22 June 1967 and 12 June 1967	

NOTE: The wind vector as given in this report is considered to point in the direction toward which the wind is blowing, (that is, a west wind is toward the west). Most meteorologists are accustomed to a 180° difference, (that is, a west wind is from the west).

INTRODUCTION

For several years upper atmospheric winds over the lower West Indies have been studied by firing high altitude ballistic probes from a specially modified sixteen-inch naval gun. The installation of a similar 16" gun at Yuma Proving Ground, Arizona, early in 1966 has made possible a similar study of winds in this region. These firings are being carried out by the U. S. Army Ballistic Research Laboratories, Aberdeen Proving Ground, Maryland, under the direction of Dr. Charles H. Murphy, and by the Space Research Institute of McGill University, Canada, under the direction of Dr. G.V. Bull.*

Atmospheric winds are studied by releasing chemical trails from the gun-fired probes during the upper portion of their trajectories. To date, the primary chemical which has been released is trimethyl aluminum (TMA). TMA produces a chemiluminescent glow in regions of the atmosphere above 85 kilometers, thus allowing the trails to be photographed while being distorted by upper atmosphere winds. The photographs are then reduced to provide wind information by Space Instruments Research, Inc. (SIR), using computer techniques.

The purpose of this report is to summarize results of these studies for the period from June 21 through June 22, 1967, and June 12, 1967. A "Table of Trail Information" is given on page 20 and lists the trail number, shot number, date, time and altitude interval. Previous results for winds over Barbados, West Indies,

*Present address is Space Research Institute, P. O. Box 144, North Troy, Vermont

are covered in Technical Reports No. 1, 2, 3, 5, 8, and 9. Technical Reports No. 4, 6, and 7 cover previous results for winds over Yuma, Arizona. Included in this report are ground plots for all previous shots that had both an up and down trail. The ground plots are divided into two sections: (1) the trails formed at Barbados, and (2) the trails formed at Yuma. Trail information for all of the shots covered in the ground plots can be found in earlier BRL reports. Only shots with both an up and down trail are included.

DATA ACQUISITION

The chemical trails are formed almost vertically over the Island of Barbados (longitude 59.4°W , latitude 13.0°N) and extend from an altitude of approximately 85 kilometers through apogee. The Yuma trails are formed almost directly over the gunsite (longitude 114.3°W latitude 32.9°N) and extend from an altitude of approximately 85km through apogee. In some firings, TMA is also released on the down leg of the trajectory. To the unaided eye, the chemical release first appears as a straight white trail resembling a jet contrail. Within a minute or so, the trail is distorted into strange shapes by the upper atmospheric winds and fades from view within approximately fifteen minutes after initial release.

Space Instruments Research has established eight photographic triangulation stations on the Islands of Barbados, St. Vincent, Grenada, and Tobago, with two sites per island. These sites are located to the west and south of Barbados at distances of 190 to 290 kilometers (see Figure 1). While only one site on each of two islands is required for data reduction purposes, the eight sites have been found desirable because of cloud conditions in the area.

Three photographic triangulation stations have been established at Yuma and Gila Bend, Arizona, and Blythe, California. These sites are located at distances of up to 150 kilometers from the gunsite (see figure 2).

Equipment at each site, built by SIR, consists of a camera

unit containing two seven-inch focal length cameras mounted on a concrete pedestal, and an electronic control unit. Cameras are automatically pulsed to take exposures of 3, 6 and 12 seconds duration every 30 seconds.

Since commercial power is either unreliable or unavailable at many site locations, SIR has developed a battery operated 115-volt power supply for the control equipment. The power supply is tuning-fork controlled and provides 60 cycle power with an accuracy of 0.005% for the camera programmer so that pictures can be taken simultaneously at each site. A data block containing 24 tiny lights, mounted in each camera unit, records time, firing number, and site information in the corner of each frame of film.

A short wave radio net connecting all sites and the launch control center has been installed by SIR to enable the launch control officer to be informed of weather conditions at the sites and to synchronize picture taking operations with the firing of the gun. Most sites are operated by local personnel who have been trained by SIR.

During a typical night's operation, the gun is fired at one to two hour intervals, from sunset to sunrise. Photographs are taken by all sites during the time that the trail is visible. The film is then returned to Atlanta for processing and data reduction.

DATA REDUCTION

Several computer programs have been developed which make it possible to calculate upper atmosphere winds from measurements made directly on the photographs of the luminous trails.

Since the method used is basically three-dimensional triangulation using spherical trigonometry, it is necessary to know precisely the direction each camera was pointed during a given firing. The direction is determined by first taking accurate measurements of the locations of several star images on the film, and then computing the azimuth and elevation of the optical axis of the camera by means of a computer program. This computer program makes use of the celestial coordinates of some 6,000 stars which have been stored on magnetic tape.

Wind speeds and directions are then determined from the location of the trail in space at a succession of known times. The location is found, using either a point location program or a trail location program, or both, and depends on the physical shape of the chemical release cloud.

Point location method. If the chemical release exhibits discrete points (resulting either from turbulence or from the nature of the release mechanism) and these points can be identified on films from two or more islands, the point location program can be used to calculate the position of each point in longitude, latitude, and altitude above sea level.

These calculations are made from data taken at successive times. A wind program is then used to calculate both vertical and horizontal winds from the motion of these points as a function of time.

Trail location method. Most of the chemical releases produce a smooth trail having few, if any, identifiable points. In such cases, film coordinates of a large number of incremental points along the film image of the trail are fed into the computer from data from two or more sites. The trail location program attempts to triangulate each point from one site with many points from another site, finally choosing points from both sites whose optical paths from camera into space form the closest spatial intersection. After doing many hundreds of such calculations, the computer is able to construct coordinates for a mathematical curve in the shape of the trail in space. Then, as with the point location program, winds can be determined from the motion of the curve with time. Here, however, it must be assumed that vertical winds are essentially zero. This assumption is borne out by previous studies which have shown vertical winds in this altitude region to be of the order of a few meters per second compared to horizontal winds ranging up to 150 meters per second.

Corrections for variables such as atmospheric refraction, rotation of camera about optical axis, and camera focal length, are incorporated into the programs to maintain high accuracy. Focal length and camera rotation are, in fact, calculated from measurements of the positions of star images on the films.

INTERPRETATION OF DATA

Following the "Table of Trail Information", horizontal wind velocities are presented in tabular form and in plots of wind speed, direction, and components.

Winds were calculated at altitude intervals of one kilometer. Points on the various plots show the actual computed result, as listed in the table preceding the plot. A curve has been fitted to each set of points to aid in detecting wind patterns and to indicate reliability of the plotted results. Each curve has been drawn with a knowledge of intermediate results leading to the wind calculations and of the consistency of the winds as calculated between each of the five or more time intervals used. In cases where point-to-point curve fitting was not thought to reflect actual variations in wind speed, direction, or components, a more appropriate smooth curve has been drawn. Otherwise, the curves are fitted directly to the data points. Results of certain portions of the trails are at times less accurate than others due to the spatial orientation of those trail segments relative to the available photographic stations. Less accurate data can also result from photographs obscured by haze and clouds and from trails of short duration.

Wind speed plot. This plot shows the speed of the wind in meters per second as a function of height in kilometers above sea level.

Wind direction plot. The wind vector is considered to point in

the direction toward which the wind is moving. The direction plot shows the direction of this vector in degrees clockwise from north as seen from above. Thus, a wind direction toward the east would be 90 degrees.

Wind components plot. While plots of wind direction and speed do completely describe the wind vector, it has been found helpful in studying wind patterns to present the north-south (N-S) and east-west (E-W) velocity components of the vector. In the north-south plot, north is positive; south is negative. In the east-west plot, east is positive; west negative. Components are plotted in meters per second versus height in kilometers.

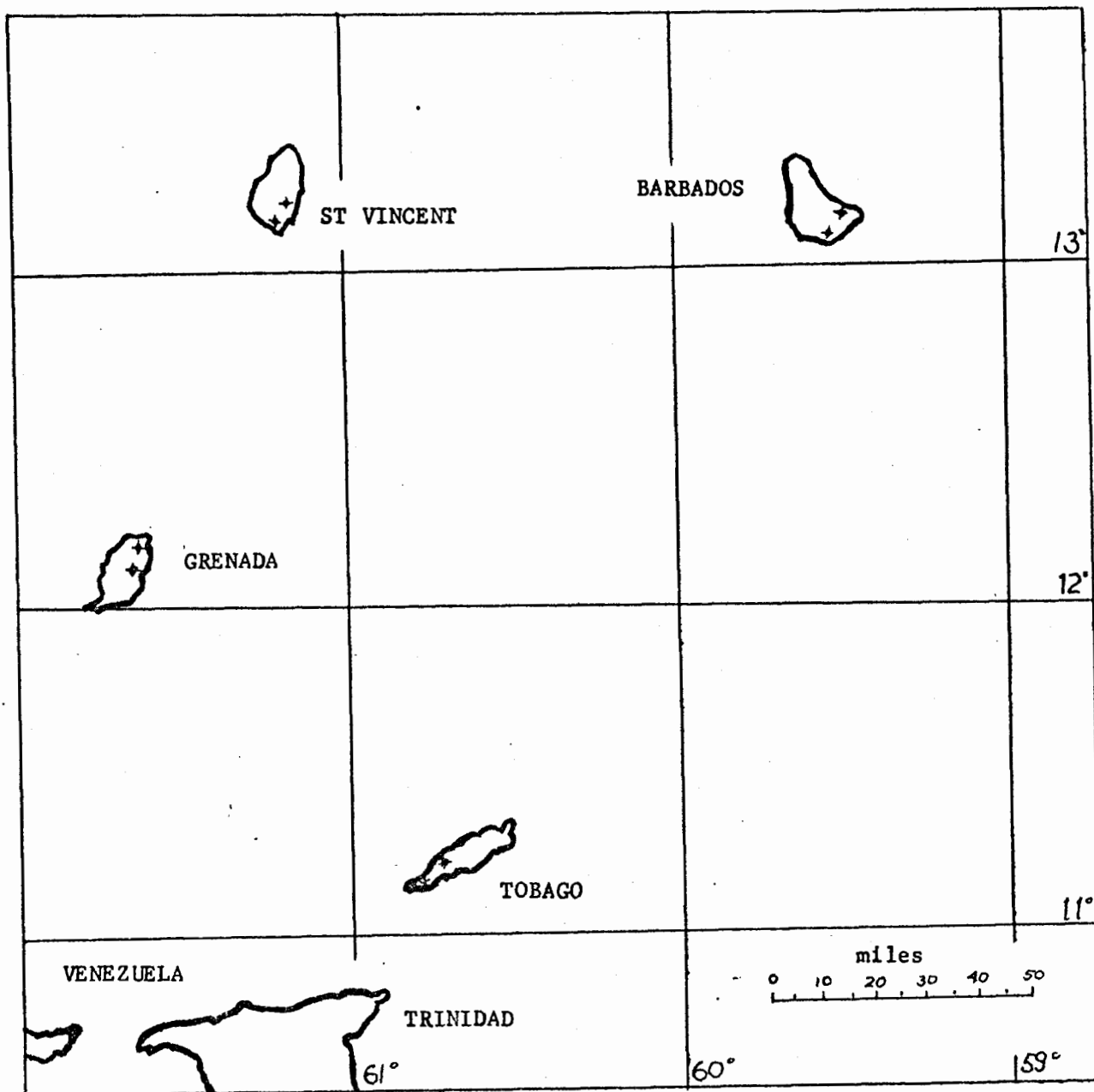
The wind direction and components described above are referenced to true north. In addition, components have been calculated relative to magnetic north for comparison with other ionospheric phenomena. These components are not plotted but are listed in the tabulations preceding each set of plots.

Throughout this report, where shorter notation was desirable, "Up" or "U" and "Down" or "D" have replaced uptrail and downtrail, respectively.

Ground Plot. This is a plot of the path of the probe with respect to latitude and longitude. Though the altitude of the probe is not plotted, the altitude in km. is marked along the curve so that the path of the vehicle can more easily be followed.

FIG. 1

Location of S.I.R. photographic stations

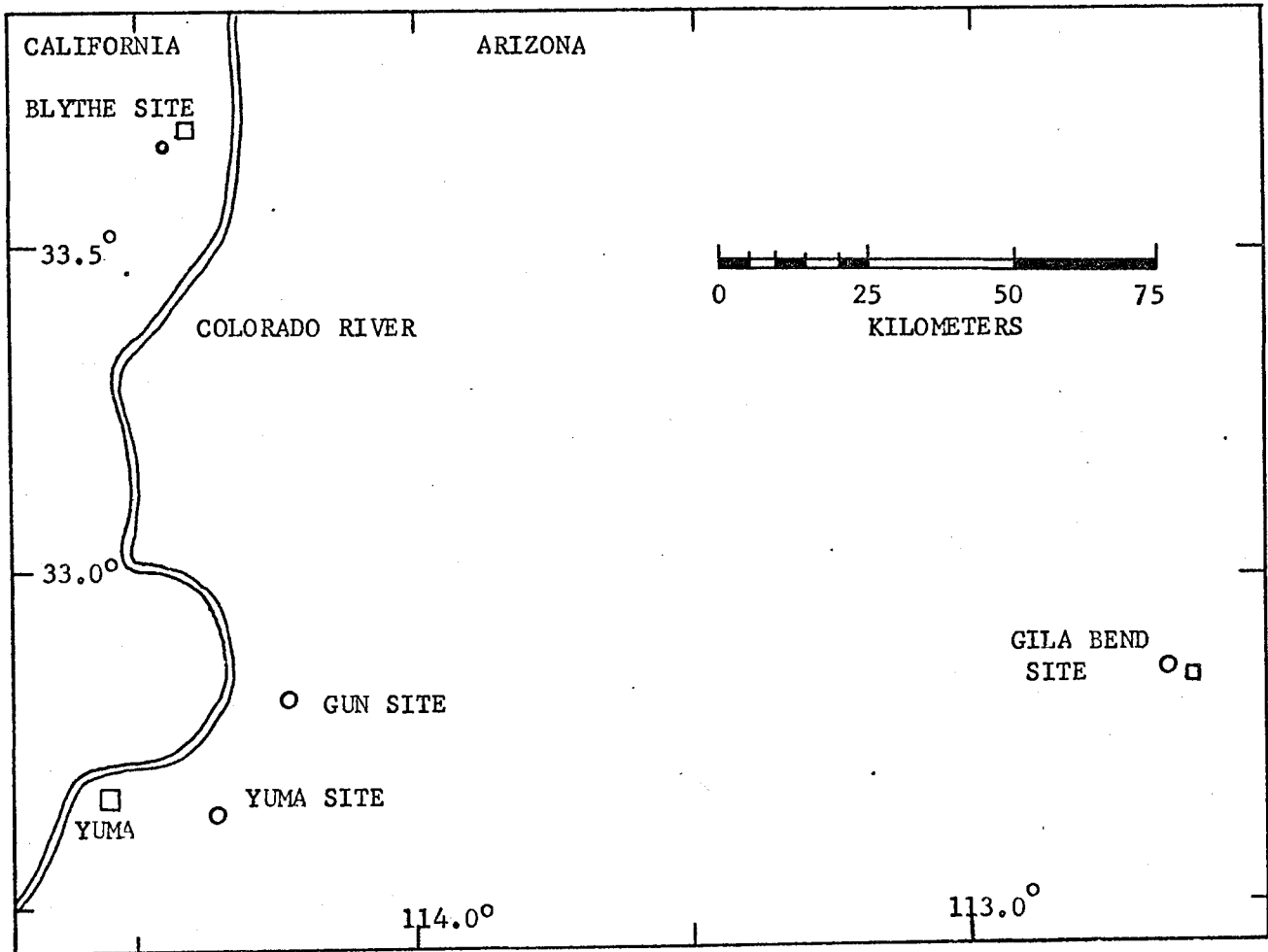


Two stations are located on each of the four islands, as shown. While only one station on each of any two islands is sufficient for determination of winds by triangulation, several stations were found necessary because of prevalent cloud conditions in the area. Accuracy of the data reduction is also increased by use of films from more than two islands.

FIGURE 2

LOCATION OF SIR PHOTOGRAPHIC STATIONS

H.A.R.P. - YUMA



REFERENCES - ERRATA SHEET

A. HARP--Scientific Publications

22. Delete "(accepted for June issue)"
Add "pp. 640-644, June 1968."

B. BRL HARP Reports

Add:

26. Boyer, E.D., Five-Inch Gun Meteorological Sounding Site,
Highwater, Quebec, BRL Memo Report, (in press), July 1968

C. HARP--SRI Reports

1. Add "(AD834218)"
15. Add "(AD666746)"
16. Add "(AD666744)"

D. HARP--Other Publications

Omit footnote which follows #30.

34. Add "(AD667917)"

Add:

40. Broglio, E.P., Development of the HARP Battery, Final Report,
Eagle-Picher Industries, Inc., December 1967. (AD665409).
41. Williamson, L. E., Gun Launched Probes--Parachute Expulsion
Tests Under Simulated Environment, ECOM-5179, February 1968.
(AD667908).

E. HARP--Related Publications

Add:

9. Eppes, Richard, Review of Experimental Programs for Blast
Intercept and Traversal, and Feasibility of Using a Large
Bore Gun Facility for Launching Vehicles for Blast Intercept,
U. S. Army Missile Command RS-TR-66-12, RA66-8, October 1966,
(AD804118).
10. A Feasibility Study of the Scramjet In-Tube Concept (U),
General Applies Science Laboratories, TR669, AFAPL-TR-67-131,
November 1967. (AD388535).

REFERENCES

A. HARP--Scientific Publications

1. Bull, G. V. and Murphy, C. H., "Gun Launched Missiles for Upper Atmosphere Research," AIAA Preprint 64-18, January 1964.
2. Bull, G. V., "Development of Gun Launched Vertical Probes for Upper Atmosphere Studies," Can. Aero. & Space Journ., Vol. 10, pp. 236-247, October 1964.
3. Raymond, H. A., "Orbit Injection Control for HARP," Can. Aero. & Space Journ., Vol. 11, pp. 154-159, May 1965.
4. Eyre, F. W., "The Development of Large Bore Gun Launched Rockets," Can. Aero. & Space Journ., Vol. 12, pp. 143-149, April 1966.
5. Murphy, C. H., Bull, G. V., and Edwards, H. D., "Ionospheric Winds Measured by Gun Launched Projectiles," Journ. Geo. Res. 71, pp. 4535-4545, October 1966.
6. Wright, J. W., Murphy C. H., and Bull, G. V., "Sporadic E and the Wind Structure of the E Region," Journ. Geo. Res., Vol. 72, pp. 1443-1460, March 1, 1967.
7. Murphy, C. H. and Bull, G. V., "A Review of Project HARP," Planetology and Space Mission Planning, Annals of the New York Academy of Sciences, Vol. 140, Art. 4, pp. 337-357, December 1966.
8. Bull, G. V. and Murphy, C. H., "Gun Boosted Rockets for High Performance Sounding Missions," AIAA Sounding Rocket Vehicle Technology Specialist Conference Proceedings, pp. 581-593, February 1967.
9. Murphy, C. H. and Bull, G. V., "Aerospace Application of Gun Launched Projectiles and Rockets," Space Program Impact on Range Development, pp. 241-270, American Astronautical Society, 1967. (See also SRI-TL-1, AD 662058).
10. Millman, P. M., "Big Gun on Barbados," Sky and Telescope, Vol. 32, pp. 64-67, August 1966.
11. Wright, J. W., Murphy, C. H., and Bull, G. V., "Profiles of Winds in the Lower Thermosphere by the Gun-Launched Probe Technique and Their Relation to Ionospheric Sporadic E," Space Research VII, North-Holland Publishing Company, Amsterdam, pp. 113-122, 1966.

12. Wright, J. W., and Fedor, L. S., "Comparison of Ionospheric Drift Velocities by Spaced Receiver Technique with Neutral Winds from Luminous Rocket Trails," Space Research VII, North-Holland Publishing Company, Amsterdam, pp. 67-72, 1966.
13. Williamson, L. Edwin, and Boyer, E. D., "The Gun-Launched Meteorological Sounding System," AMS/AIAA Paper 66-382, March 1966.
14. Murphy, C. H., Bull, G. V., and Wright, J. W., "Motions of an Electron Cloud Released from a Gun-Launched Projectile," Journ. Geo. Res. 72, pp. 3511-3514, July 1, 1967.
15. Bull, G. V., Murphy, C. H., and Lyster, D., "Multipoint Ignition in HARP Guns," Proceedings, 2nd ICRPG/AIAA Solid Propulsion Conference, CPIA Publication No. 141, Vol. 1, pp. 511-533, April 1967. (AD 380975)
16. Murphy, C. H., and Bull, G. V., "Night-Time Variation of Ionospheric Winds over Barbados, W. I.," Journ. Geo. Res. 72, pp. 4831-4837, October 1, 1967.
17. Murphy, C. H., and Bull, G. V., "Ionospheric Winds over Yuma, Arizona, Measured by Gun Launched Projectiles," AIAA Preprint 68-33, January 1968, and Journ. Geo. Res. 73, pp. 3005-3015, May 1, 1968.
18. Marks, S. T., "High-g Component Test," ORDNANCE, Vol. LII, pp. 386-388, January 1968,
19. Cox, R. N., "The Case for Gun-Launched Space Probes," New Scientist, 36, pp. 337-340, November 9, 1967.
20. Bull, G. V., "Project HARP," ORDNANCE Vol. LII, pp. 482-486, March-April 1968.
21. Murphy, C. H., and Bull, G. V., "General Properties of Ionospheric Winds," Proceedings of the 3rd National Conference on Aerospace Meteorology, American Meteorological Society, pp. 488-494, May 1968.
22. Murphy, C. H., and Bull, G. V., "Gun-Launched Probes over Barbados," Bulletin of the American Meteorological Society, Vol. 49, (accepted for June issue).
23. Gossard, Earl E., and Paulson, M. R., "A Case Study of a Periodic Structure in the Atmosphere Near the 90 KM Level," Journal of Atmospheric and Terrestrial Physics, 30, pp. 885-896, May 1968.
24. Wright, J. W., "The Interpretation of Ionospheric Radio Drift Measurements - I. Some Results of Experimental Comparisons with Neutral Wind Profiles," Journal of Atmospheric and Terrestrial Physics, 30, pp. 919-930, May 1968.

B. BRL HARP Reports

1. MacAllister, L. C. and Bradley, J. W., "Comments on the Use of Guns to Launch High Altitude Probes," BRL Memo Report 1252, March 1960. (AD 237038)
2. Marks, S. T., MacAllister, L. C., Gehring, J. W., Vitagliano, H. D., and Bentley, B. T., "Feasibility Test of an Upper Atmosphere Gun Probe System," BRL Memo Report 1368, October 1961. (AD 267354)
3. Marks, S. T., and Boyer, E. D., "A Second Test of an Upper Atmosphere Gun Probe System," BRL Memo Report 1464, April 1963. (AD 405889)
4. Boyer, E. D., "Five-Inch HARP Tests at Wallops Island, September 1963," BRL Memo Report 1532, January 1964. (AD 430232)
5. Mermagen, W. H., "High 'G' Telemetry for Ballistic Range Instrumentation," BRL Memo Report 1566, April 1964. (AD 444246)
6. Mermagen, W. H., "Telemetry Experiments Conducted on the HARP Project in British West Indies and Wallops Island, Virginia, During the Period Jan-Mar 1964," BRL Memo Report 1578, July 1964. (AD 449867)
7. Mermagen, W. H., "HARP 250 Mc Telemetry Experiments, Jun-Oct 1964," BRL Memo Report 1614, November 1964. (AD 459576)
8. Cruickshank, W. J., "High 'G' UHF Telemetry for Gun-Launched Sounding Probes," BRL Memo Report 1632, January 1965. (AD 463928)
9. Cruickshank, W. J., "A Feasibility Test of a 1750 Mc/s Telemetry and Tracking System for Five-Inch HARP Projectiles," BRL Memo Report 1651, May 1965. (AD 469653)
10. Mermagen, W. H., "HARP 250 Mc/s Telemetry Experiments, Wallops Island, March 1965," BRL Memo Report 1694, September 1965. (AD 631268)
11. Evans, J. W., "Evaluation of a Tunnel-Diode Oscillator for Use in Gun Probe Telemetry," BRL Memo Report 1711, November 1965. (AD 631514)
12. Brown, J. A., and Marks, S. T., "Feasibility Test of a Potential Meteorological Shell for the Standard 175 MM Gun," BRL Tech Note 1584, February 1966. (AD 631245)
13. Marks, S. T., Pilcher, J. O., and Brandon, F., "The Development of a High Acceleration Testing Technique for the Electronic Instrumentation of HARP Projectile Systems," BRL Memo Report 1738, March 1966. (AD 635782)
14. Braun, Walter F., "An Inbore Velocity Measuring Probe System for Large Caliber Guns," BRL Tech Note 1610, April 1966. (AD 637280)

15. Murphy, C. H., Bull, Gerald V., and Edwards, H. D., "Upper Atmosphere Winds Measured by Gun-Launched Projectiles," BRL Memo Report 1747, May 1966. (AD 637850)
16. Evans, J. W., "Development of Gun Probe Payloads and a 1750 Mc/s Telemetry," BRL Memo Report 1749, May 1966. (AD 637747)
17. Mermagen, W. H., Cruickshank, W. J., and Vratovic, F., "VHF and UHF High-G Telemetry Instrumentation for HARP Vehicles," BRL Memo Report 1768, May 1966. (AD 640596)
18. Frankle, J. M., "An Interior Ballistic Study of a 24-inch Gun for Project HARP," BRL Tech Note 1606, May 1966. (AD 486743)
19. Boyer, Eugene D., "Five-Inch HARP Tests at Barbados, West Indies, January-February 1966," BRL Memo Report 1771, July 1966. (AD 640438)
20. Boyer, E. D., and MacAllister, L. C., "Seven-Inch HARP Gun Launched Vertical Probe System: Initial Development," BRL Memo Report 1770, July 1966. (AD 640825)
21. Murphy, C. H., and Bull, G. V., "Review of the High Altitude Research Program (HARP)," BRL Report 1327, July 1966. (AD 645284)
22. Murphy, C. H., and Bull, G. V., "HARP 5-inch and 16-inch Guns at Yuma Proving Ground, Arizona," BRL Memo Report 1825, February 1967. (AD 654123)
23. Bull, G. V., Murphy, C. H., and Lyster, D., "Multipoint Ignition in HARP Guns," BRL Memo Report 1832, March 1967. (AD 654370)
24. Cruickshank, W. J., "1750 MHz Telemetry/Sensor Results from HARP Firings at Barbados and Wallops Island, 1965," BRL Memo Report 1824, February 1967. (AD 815761)
25. Boyer, E. D., Williamson, L. E., "Five-Inch HARP System - Initial Test Series - Fort Greeley, Alaska," BRL Tech Note 1657, May 1967. (AD 655267)

C. HARP--SRI Reports

(Partial List)

1. Staff, Department of Mechanical Engineering, Project HARP - Description and Status, Report 62-5, 1962.
2. Staff, Department of Mechanical Engineering, Project HARP - McGill University, Report on the First Twelve Firings and Status as of July 30, 1963, Report 63-5, November 1963.
3. Eyre, F. W., The Martlet 2A Ballistic Vehicle-Summarized Performance Data, TN 64-4, May 1964.

4. Groundwater, F. M., Report on Martlet 3B Series of Firings, SRI-H-R-7, September 1964.
5. Eyre, F. W., Ballistic Development Testing of M8-M Propellant in the 16" Barbados Gun, SRI-H-R-1, November 1964.
6. McKee, R. M., A Parametric Study of Multi-Stage Gun Launched Rockets, SRI-H-R-2, March 1965.
7. Staff, SRI, Report on the December 1964 Test Firing Series, SRI-H-R-3, April 1965.
8. McKee, R. M., Continuation of Gun-Launched Rocket Parametric Study, SRI-H-R-5, May 1965.
9. Luckert, H. J., Report of the March 1965 Test Firing Series Project HARP, SRI-H-R-9, July 1965. (AD 662058)
10. Luckert, H. J., Report of the May/June 1965 Test Firing Series Project HARP, SRI-H-R-10, September 1966. (AD 649116)
11. Bull, G. V., Lyster, D., and Parkinson, G. V., Orbital and High Altitude Probing Potential of Gun-Launched Rockets, SRI-H-R-13, October 1966. (AD 807731)
12. Parkinson, G. V., Simple Internal Ballistics Theory for Single and Double Chamber Guns, SRI-H-TN-4, August 1966.
13. Bull, G. V., Aikenhead, B., Palacio, L., and Lyster, D., A Gun Launch Target Placement System, SRI-2-TN-4, August 1966. (AD 475146)
14. Braithwaite, K., and Luckert, H. J., Report of the August/September 1966 Test Firing Series Project HARP, SRI-R-17, December 1967. (AD 825694)
15. Murphy, C. H., and Bull, G. V., Aerospace Application of Gun Launched Projectiles and Rockets, SRI-TL-1, March 1967. (AD 662058) (Reissued as SRI-R-24, February 1968)
16. Luckert, H. J., Report of the November 1965 Test Firing Series Project HARP, SRI-R-20, January 1968.

D. HARP--Other Publications

1. Wasserman, S., Lattal, G., Smolnik, J., Parametric Studies on Use of Boosted Artillery Projectiles for High Altitude Research Probes, Project HARP, Picatinny Arsenal Technical Report No. 3147, January 1964. (AD 601409)

2. Wasserman, S., Bull, G. V., Murphy, C. H., Rocket Assist Projectiles for High Altitude Research Probes (Project HARP), Bulletin of the 20th Interagency Solid Propulsion Meeting, July 1964, Vol. IV, Chemical Propulsion Information Agency Publication No. 49B, pp. 371-382, October 1964. (AD 355356)
3. Northcote, D. L. S., HARP 1/4 Scale Models General Description of Instrumentation, Inspection Services, Canadian DND TN 5/64, December 1964.
4. White, C. E., Sound Pressure Level Measurements of the HARP 16.5" Smoothbore Gun at Barbados during the Durings in December 1964, Inspection Services, Canadian Department of National Defence, TN 1/65, January 1965.
5. Investigation of the Effect of Ram Force on Breech Pressure and Muzzle Velocity in the 16.5" Smoothbore Gun, Inspection Services, Canadian DND, TN 4/65, February 1965.
6. Brown, J. A., and Marks, S. T., "High Altitude Gun Probe Systems for Meteorological Measurements," The Meteorological Rocket Network, IRIG Document 111-64, pp. 211-221, February 1965. (AD 464583)
7. Lorimor, George, Analysis of Carriages Suitable for 7-inch HARP Gun, Rock Island Arsenal Report 3-65, January 1965.
8. Wilkin, N. D., TM Research Program - High-g Tests of Components, HDL TM-65-33, July 1965. (AD 622405)
9. Spalinger, R. E., Sound and Pressure Level Measurements of the HARP-Barbados 16.5-inch Gun with a 51 ft. Muzzle Extension, Eglin Air Force Base, APGC-TR-65-50, July 1965. (AD 467721)
10. McCluney, Eugene L., Theoretical Trajectory Performance of 5" Gun Probe System, ECOM 5015, ERDA, WSMR, October 1965. (AD 473271)
11. Fuller, R. N., Upper Atmosphere Winds from Gun Launched Probes (Barbados July 1964-August 1965) BRL Contract 169, Report 1. (AD 662198)
12. Fuller, R. N., Upper Atmosphere Winds from Gun Launched Vertical Probes (Barbados, 20-23 September 1965) BRL Contract 169, Report 2. (AD 662203)
13. Block, A. V., Kodis, A. L., Smith, L. C., High Altitude Gun Probes (Development of Langmuir Probes) Final Report, G.C.A.T.R. 65-15-G, September 1965. (AD 633920)
14. Williamson, L. E., Gun-Launched Vertical Probes at White Sands Missile Range, Atmospheric Sciences Office ECOM-5030, February 1966. (AD 482330)
15. Rossmiller, R., and Salsbury, M., 16-inch HARP Work at Rock Island Arsenal - Summary Report, Rock Island Arsenal Technical Report 66-1493, April 1966. (AD 482573)

16. Fuller, R. N., Upper Atmosphere Winds from Gun Launched Vertical Probes (Barbados 16-23 November 1965) BRL Contract 169, Report 3. (AD 662204)
17. Perrine, R. H., HARP 7-15 June 1966, Firing Report 6147, Yuma Proving Ground, Arizona, October 1966.
18. Murphy, C. H., and Bull, G. V., "Review of the High Altitude Research Program," The Fluid Dynamic Aspects of Ballistics, AGARD CP 10, September 1966, pp. 403-437. (AD 805753)
19. Mermagen, W. H., Cruickshank, W. J., Vratovic, F., "VHF and UHF High-g Telemetry for HARP Vehicles," The Fluid Dynamic Aspects of Ballistics, AGARD CP 10, September 1966, pp. 439-464. (AD 805753)
20. Lorimor, George, 7-inch HARP Final Report, Rock Island Arsenal Technical Report 66-3411, November 1966. (AD 808327L)
21. Fuller, R. N., Upper Atmosphere Winds from Gun Launched Vertical Probes (Yuma, 13-15 June 1966) BRL Contract 169, Report 4. (AD 662717)
22. Lorimor, George, 7-inch HARP (Navy Model) Final Report, Rock Island Arsenal Technical Report 67-296, January 1967. (AD 808813L)
23. Fuller, R. N. Upper Atmosphere Winds from Gun Launched Vertical Probes (Barbados, 17-25 February 1966), BRL Contract 169, Report 5. (AD 662718)
24. Kennedy, Bruce, Muzzle Velocity Measurement, Atmospheric Sciences Laboratory, ECOM 5083, October 1966. (AD 642859)
25. Edwards, J. W., Kirk, B. P., Temchin, J. R., Carsey, J. N., Survey of Developments in Gun-Launched High Altitude Probes, U. S. Naval Propellant Plant, NPP/RP 66-7, September 1966.
26. McCluney, E. L., Projectile Dispersion as Caused by Barrel Displacement in the 5-inch Gun Probe System, ECOM 5060, July 1966. (AD 639960)
27. Pulfer, J. K., Telemetry Systems for Gun-Launched Upper Atmosphere Probes, National Research Council of Canada, ERB-742, June 1966. (AD 655874)
28. Anthony, M., and Epler, W., Upper Atmosphere Winds from Gun Launched Vertical Probes (Yuma, 16-19 November 1966) BRL Contract 169, Report 6. (AD 662719)
29. Galati, L., and Marhefka, A., Concept Study of a Gun-Launched Anti-missile System GLAM (U), Picatinny Arsenal SMUPA-TK-900, July 1964.
30. Gun Launched Vehicles Cost Effectiveness Study, Lockheed Missiles and Space Company, LMSC-688043, 29 September 1967. (Contract DA-HC19-67-C-0055) (AD 826497-1)*

*USGO except with prior approval of Environmental Sciences Division, Army Research Office, Arlington, Virginia 22204.

31. Anthony, M., and Epler, W., Upper Atmosphere Winds from Gun Launched Vertical Probes (Yuma, 26-27 October 1966) BRL Contract 169, Report 7, August 1967. (AD 662727)
32. Mead, J. B., Parkison, E. H., and Witten, L., Measurement of Geo-Electric Fields and Upper Atmosphere Parameters by Release of Barium Vapors, Research Institute for Advance Studies, Martin Marietta Company, November 1967. (AD 662066)
33. Kantor, Arthur J., Winds in the Tropics, 90 to 135 km, Air Force Cambridge Research Laboratories INAP No. 80, June 1967.
34. Nordquist, Walter S., A Study of Acoustic Monitoring of the Gun Probe System, Atmospheric Sciences Laboratory ECOM-5166, November 1967.
35. Powell, L. W., Poseidon-Sofar Bomb Impact Survival Tests-Status Report, USN Special Projects Office, SpP TM 012066, 7 February 1966.
36. Weigle, Francis G., Acoustic Signature of Martlet 2C Vehicle Impact on the Ocean Surface, USN Underwater Sound Laboratory, New London, Connecticut, USL TM 2211-112-67, 31 August 1967.
37. Meteorological Rocket Network Firings: Data Reports, August 1965 issue to present, Superintendent of Documents, Washington, D. C., 20402, \$36.00 per year. (HARP wind and temperature data up to 80 km in all issues; wind data above 85 km in January 1967, June 1967, January 1968 issues.)
38. Fagot, John, and Epler, Wm., Upper Atmosphere Winds from Gun Launched Vertical Probes (Barbados, 19-20 September 1966), BRL Contract 169, Report 8, April 1968.
39. Fagot, John, and Epler, Wm., Upper Atmosphere Winds from Gun Launched Vertical Probes (Barbados, 15-16 February 1967) BRL Contract 169, Report 9, April 1968.

E. HARP--Related Publications

1. Valenti, A. M., Molder, S., and Salter, G. R., Gun Launching Supersonic Combustion Ramjets, Astronautics and Aerospace Engineering, Vol. 1, pp. 24-29, December 1963.
2. An Evaluation of Payload Delivery Systems for Nike-X (U), Brown Engineering, Huntsville, Alabama, TN AS-214, 15 September 1966. (Contract No. DA-01-021-AMC-90031 CY)
3. Gossard, Earl E., The Apparent Movement of the Spectral Components in Fading Records of Ionospherically Reflected Radio Waves, Journ. Geo. Res., Vol. 72, pp. 1563-1570, 1 March 1967.

4. Hurst, N. J., and Burleson, W. G., Analysis, Design, and Cogent Flights of the First Large Diameter Gun Launched Test Bodies - Lahive, U. S. Army Missile Command Report RS-TR-67-4, April 1967. (AD 818372)
5. Billings, R. G., and Atmore, R. F., A Study to Guide Research and Development Toward an Operational Meteorological Sounding Rocket System, Final Report on NASA Contract NASW-1522, Thiokol Chemical Corporation, April 1967, NASA CR-91057. (N68-11977)
6. Fedor, L. S., A Statistical Approach to the Determination of Three Dimensional Ionospheric Drifts, Journ. Geo. Res. 72, pp. 5401-5415, 1 November 1967.
7. Blackwell, Edward L., Generation and Use of an Artificial Ionosphere, AIAA Paper 67-789, October 1967.
8. Williamson, L. E., and Kennedy, B., Meteorological Shell for Standard Artillery Pieces - A Feasibility Study, Atmospheric Sciences Laboratory, ECOM-5161, October 1967.

TABLE OF TRAIL INFORMATION

TRAIL NO.	TRAIL NAME	DATE	TIME	ALTITUDES (KM)
B-67	CAIRO	21 JUNE 1967	22:47:00AST	89-107
B-68	DURBAN	22 JUNE 1967	19:51:00AST	95-110
Y-26	38	12 JUNE 1967	20:14:04MST	117-136

TABULATIONS AND PLOTS

THREE TMA TRAILS 21-22 JUNE, AND 12 JUNE 1967

NOTE: The wind vector as given in this report is considered to point in the direction toward which the wind is blowing (that is, a west wind is toward the west). Most meteorologists are accustomed to a 180° difference, (that is, a west wind is from the west).

TRAIL NO. B67 CAIRO
 BARBADOS 21 JUNE 1967 22-47-00 AST
 UP TRAIL

ALTITUDE (KM)	WIND HEADING (DEG)	WIND VELOCITY (M/S)	WIND COMPONENTS (M/S)			
			GEOGRAPHIC		MAGNETIC	
			N-S	E-W	N-S	E-W
89.0	241.5	53.7	-25.6	-47.2	-15.3	-51.5
90.0	256.4	41.6	-9.8	-40.4	-1.3	-41.6
91.0	264.2	30.0	-3.0	-29.9	3.2	-29.9
92.0	285.1	17.2	4.5	-16.7	7.8	-15.4
93.0	339.5	25.8	24.2	-9.0	25.5	-3.8
94.0	13.3	39.1	38.1	9.0	35.4	16.7
95.0	12.5	58.1	56.7	12.5	52.9	23.9
96.0	337.0	67.5	62.2	-26.3	66.3	-12.9
97.0	334.3	72.3	65.1	-31.4	70.2	-17.3
98.0	331.0	78.4	68.5	-38.0	74.9	-23.1
99.0	330.9	80.2	70.1	-39.0	76.6	-23.7
100.0	339.9	39.6	37.2	-13.6	39.2	-5.6
101.0	352.6	26.4	26.2	-3.4	26.3	2.1
102.0	145.5	60.2	-49.6	34.1	-55.6	23.1
103.0	146.1	86.3	-71.6	48.1	-80.0	32.3
104.0	153.5	108.1	-96.7	48.3	-104.6	27.3
105.0	170.0	102.1	-100.6	17.8	-102.1	-3.3
106.0	178.5	91.0	-91.0	2.4	-89.5	-16.4
107.0	184.7	85.6	-85.3	-7.0	-82.0	-24.4

BARBADOS
DOWN TRAIL

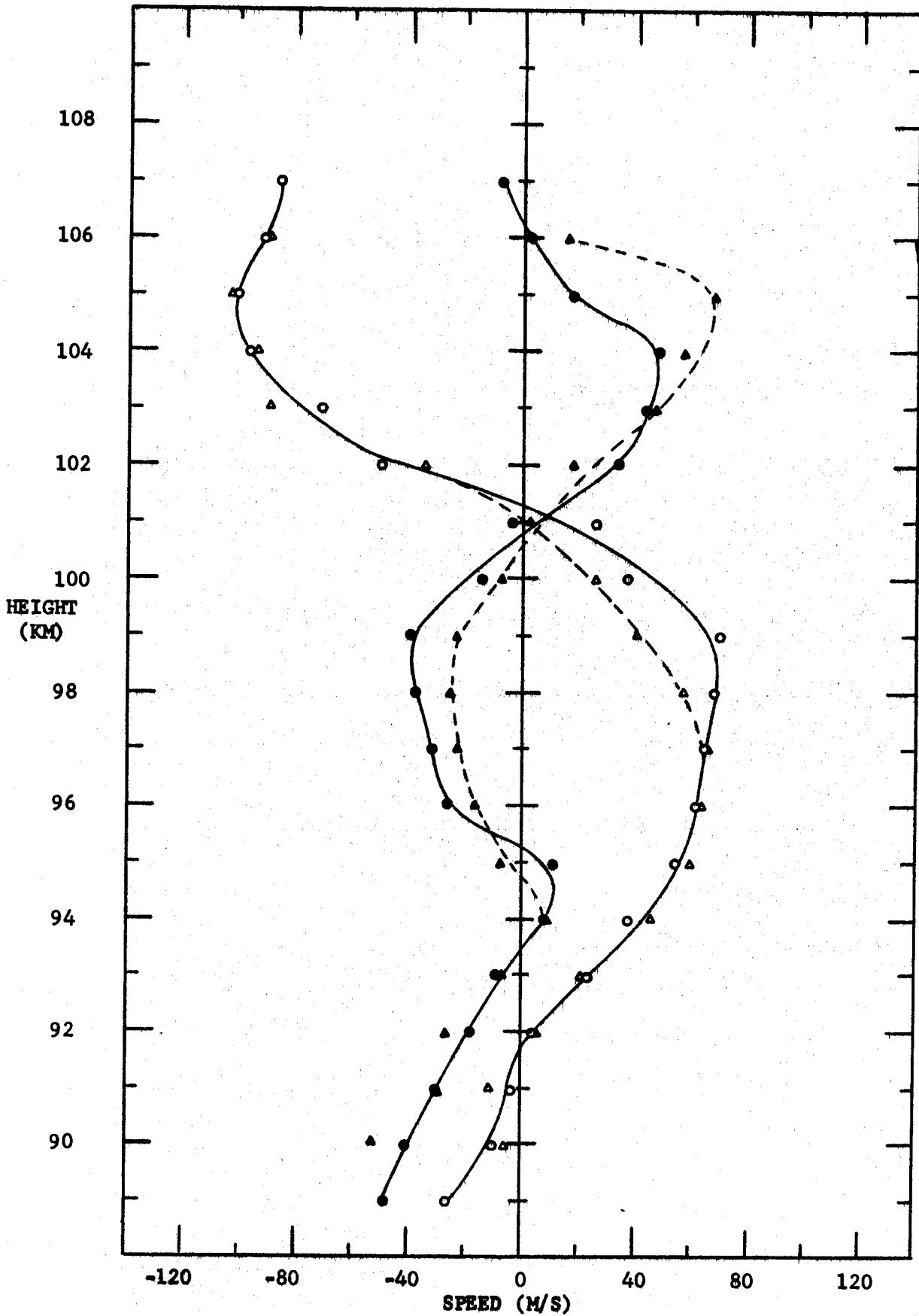
TRAIL NO. B67 CAIRO
21 JUNE 1967 22-47-00 AST

ALTITUDE (KM)	WIND HEADING (DEG)	WIND VELOCITY (M/S)	WIND COMPONENTS (M/S)			
			GEOGRAPHIC		MAGNETIC	
			N-S	E-W	N-S	E-W
90.0	263.5	52.6	-5.9	-52.2	5.0	-52.3
91.0	250.5	31.5	-10.5	-29.7	-4.2	-31.2
92.0	279.4	26.0	4.3	-25.7	9.5	-24.3
93.0	343.0	21.9	20.9	-6.4	21.8	-2.0
94.0	10.8	48.1	47.3	9.0	44.4	18.6
95.0	353.7	59.9	59.5	-6.6	59.6	5.8
96.0	345.6	64.3	62.3	-16.0	64.3	-2.8
97.0	341.1	69.0	65.3	-22.3	68.5	-8.4
98.0	336.1	62.5	57.2	-25.3	61.2	-13.0
99.0	329.7	46.3	40.0	-23.3	43.9	-14.6
100.0	343.1	27.2	26.0	-7.9	27.1	-2.4
101.0	36.9	4.0	3.2	2.4	2.6	3.0
102.0	152.7	38.3	-34.1	17.6	-37.0	10.2
103.0	152.3	100.6	-89.1	46.8	-96.8	27.4
104.0	148.9	108.9	-93.2	56.3	-102.8	35.9
105.0	146.8	122.7	-102.7	67.1	-114.3	44.5
106.0	170.1	90.9	-89.5	15.6	-90.8	-3.2

WIND COMPONENTS

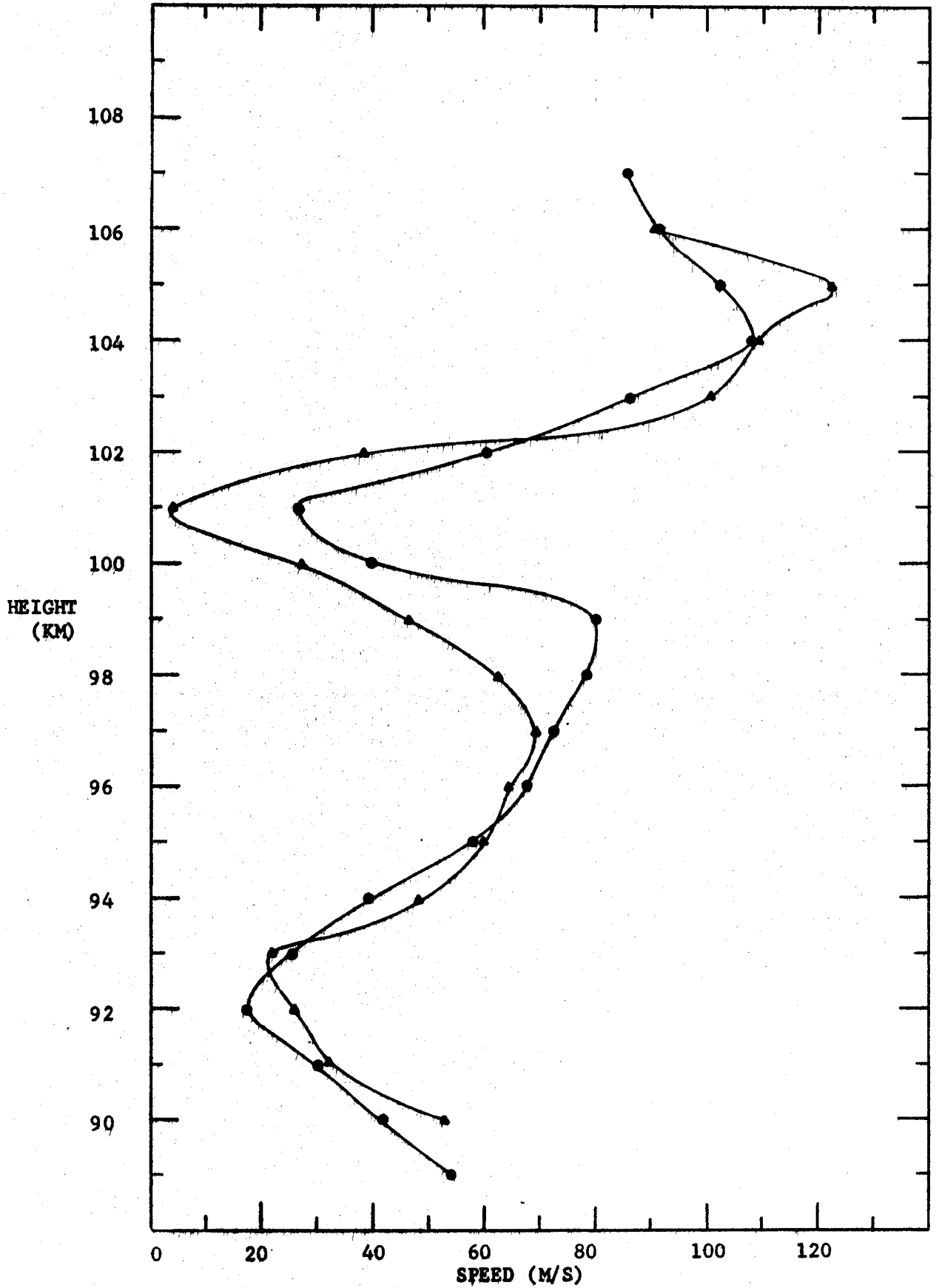
UP DOWN
N-S ○ N-S △
E-W ● E-W ▲

TRAIL NO. B67 CAIRO
21 JUNE 1967 22:47:00 AST
H.A.R.P. BARBADOS



WIND SPEED
UPTRAIL ●
DOWNTRAIL ▲

TRAIL NO. B67 CAIRO
21 JUNE 1967 22:47:00 AST
H.A.R.P., BARBADOS

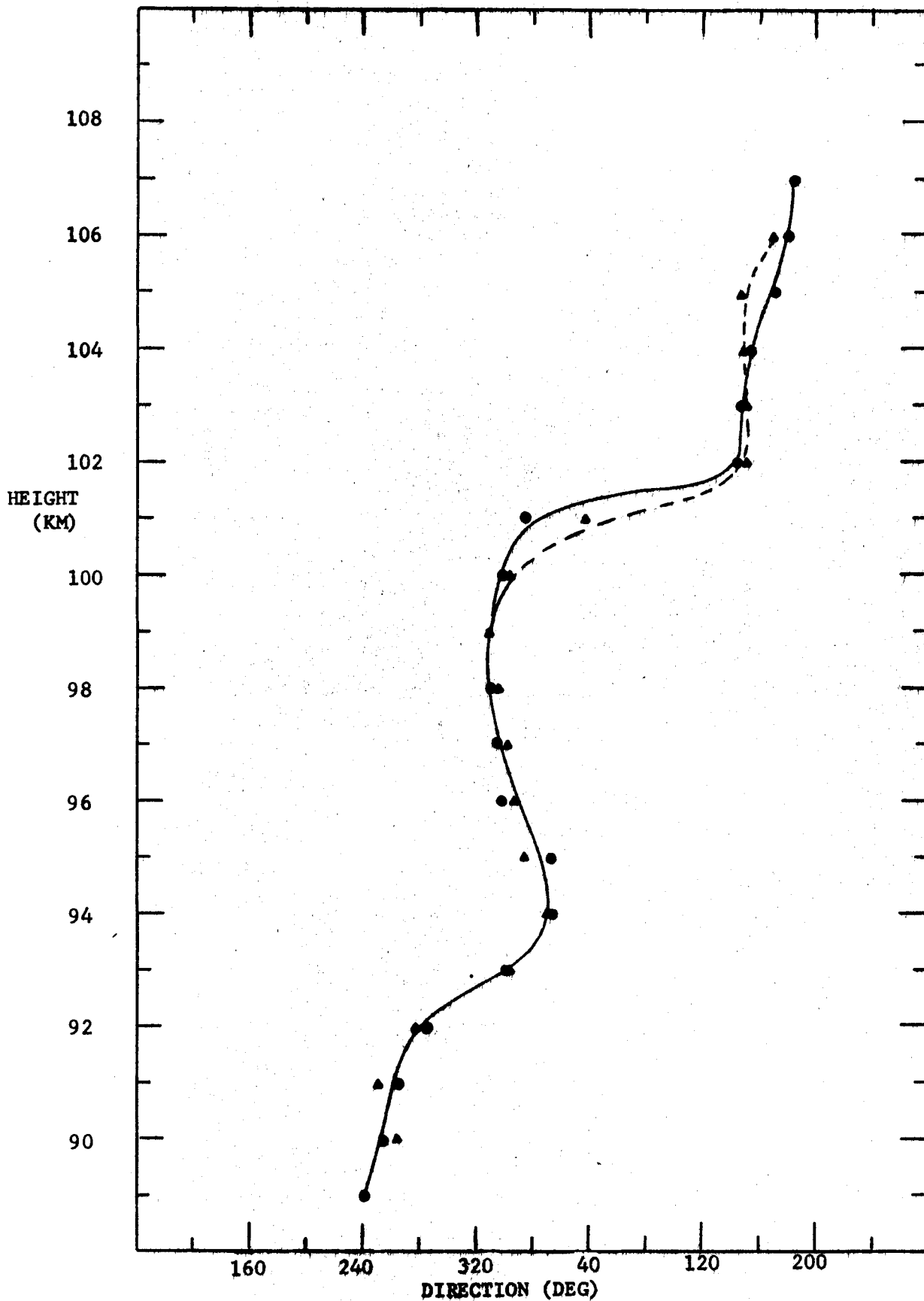


WIND DIRECTION

TRAIL NO. B67 CAIRO
21 JUNE 1967 22:47:00 AST
H.A.R.P. BARBADOS

UPTRAIL ●

DOWNTAIL ▲



BARBADOS TRAIL NO. B68 DURBAN
 UP TRAIL 22 JUNE 1967 19-51-00 AST

ALTITUDE (KM)	WIND HEADING (DEG)	WIND VELOCITY (M/S)	WIND COMPONENTS (M/S)			
			GEOGRAPHIC		MAGNETIC	
			N-S	E-W	N-S	E-W
95.0	189.3	72.0	-71.1	-11.6	-67.2	-26.0
96.0	220.1	60.0	-45.9	-38.6	-37.0	-47.2
97.0	283.8	62.1	14.8	-60.3	26.9	-56.0
98.0	307.7	94.4	57.7	-74.7	71.9	-61.2
99.0	318.6	105.6	79.2	-69.9	91.9	-52.1
100.0	330.7	126.7	110.5	-62.0	120.9	-37.9
101.0	332.5	124.0	117.0	-58.3	124.0	-46.6
102.0	347.5	78.7	76.8	-17.1	78.7	-0.9
103.0	7.8	55.3	54.8	7.5	52.1	18.6
104.0	12.0	48.5	47.4	10.1	44.3	19.7
105.0	17.5	35.4	33.8	10.7	30.9	17.4
106.0	13.1	30.7	29.9	6.9	27.8	12.9
107.0	311.5	40.0	26.5	-30.0	32.1	-23.9
108.0	292.6	49.6	19.1	-45.8	28.1	-40.9
109.0	270.8	49.1	0.7	-49.1	10.8	-47.9
110.0	272.1	50.1	1.8	-50.1	12.1	-48.7

BARBADOS
 DOWN TRAIL

TRAIL NO. B68 DURBAN
 22 JUNE 1967 19-51-00 AST

ALTITUDE (KM)	WIND HEADING (DEG)	WIND VELOCITY (M/S)	WIND COMPONENTS (M/S)			
			GEOGRAPHIC		MAGNETIC	
			N-S	E-W	N-S	E-W
96.0	235.2	63.4	-36.2	-52.0	-24.7	-58.3
97.0	259.7	63.5	-11.3	-62.5	1.8	-63.5
98.0	295.3	78.7	33.6	-71.2	47.6	-62.7
99.0	313.8	99.7	69.0	-72.0	82.4	-56.2
100.0	327.0	124.4	104.4	-67.7	116.1	-44.7
101.0	332.7	113.8	101.1	-52.2	109.7	-30.2
102.0	339.2	95.2	89.0	-33.7	94.0	-14.6
103.0	5.5	57.1	56.8	5.5	54.4	17.1
104.0	16.0	45.6	43.8	12.6	40.3	21.4
105.0	24.0	37.9	34.6	15.4	30.7	22.2
106.0	312.4	41.7	28.1	-30.8	33.8	-24.3
107.0	309.0	46.5	29.3	-36.1	36.1	-29.3
108.0	284.3	57.8	14.3	-56.0	25.5	-51.8
109.0	274.4	53.7	4.2	-53.6	15.2	-51.6
110.0	265.1	52.6	-4.5	-52.4	6.4	-52.2

WIND COMPONENTS
NORTH-SOUTH

UP
○

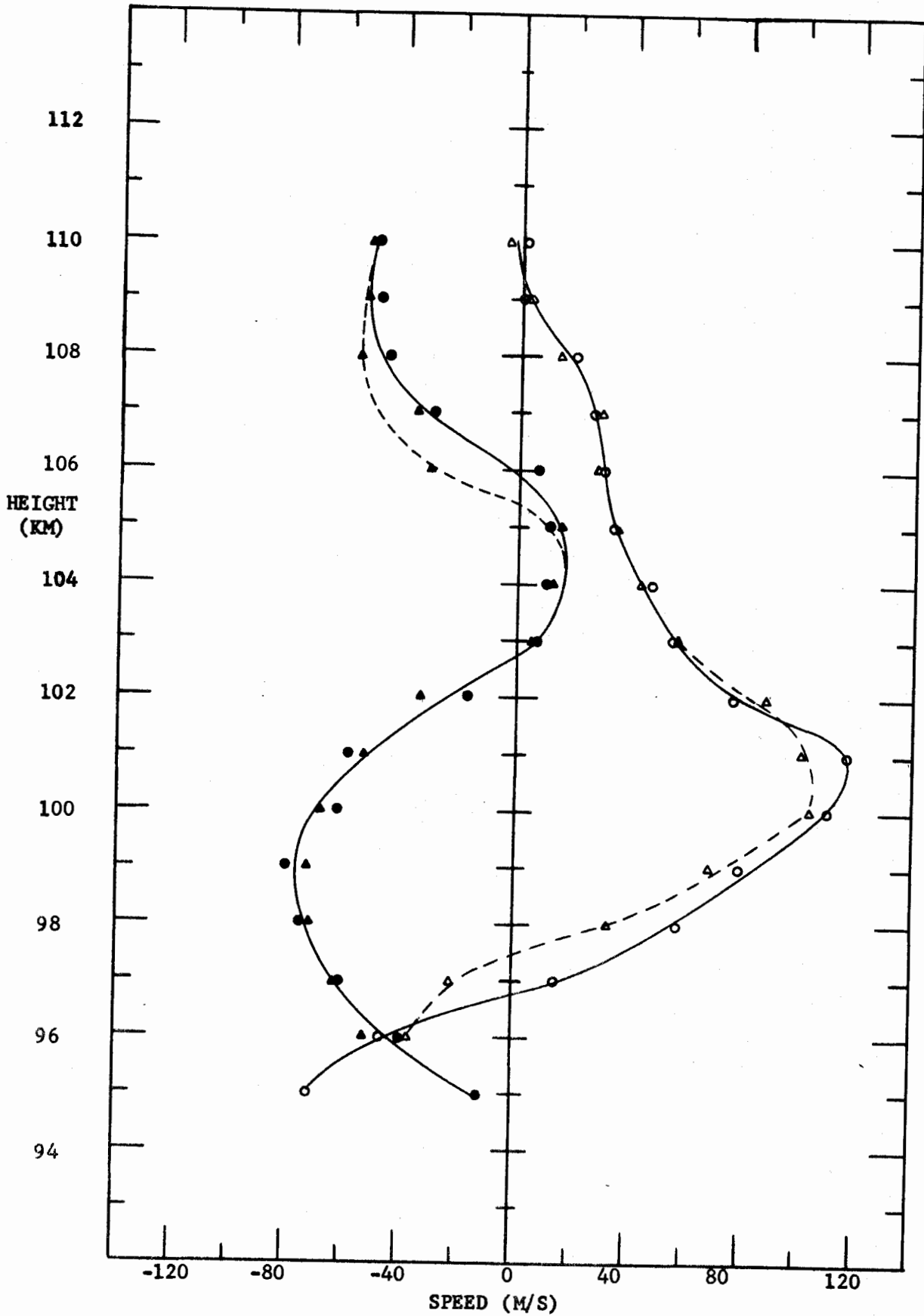
DOWN
△

EAST-WEST

●

▲

TRAIL NO. B-68 DURBAN
22 JUNE 1967 19:51:00 AST
H.A.R.P. BARBADOS



WIND SPEED

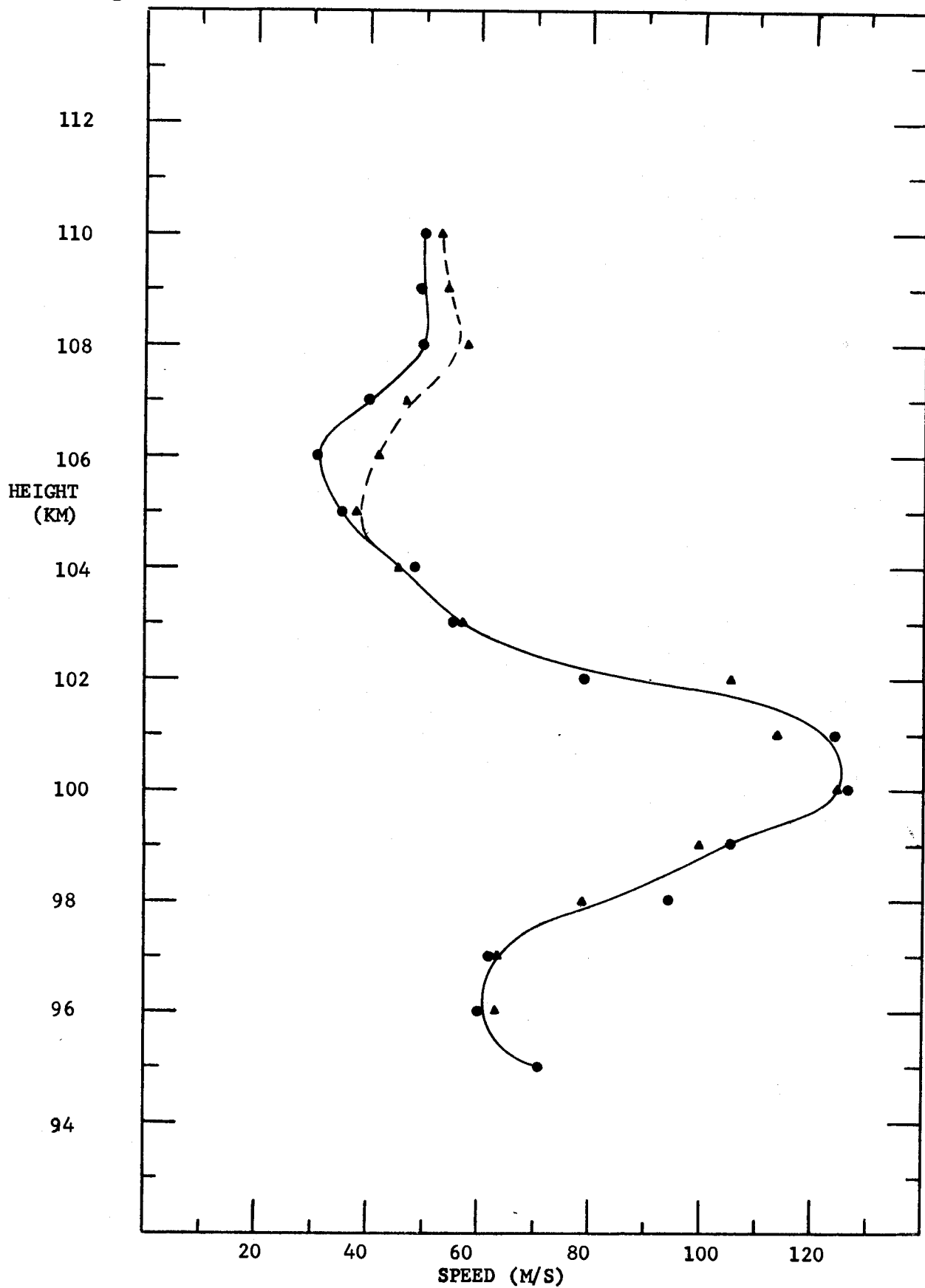
UP ●

DOWN ▲

TRAIL NO. B-68 DURBAN

22 JUNE 1967 19:51:00 AST

H.A.R.P. BARBADOS

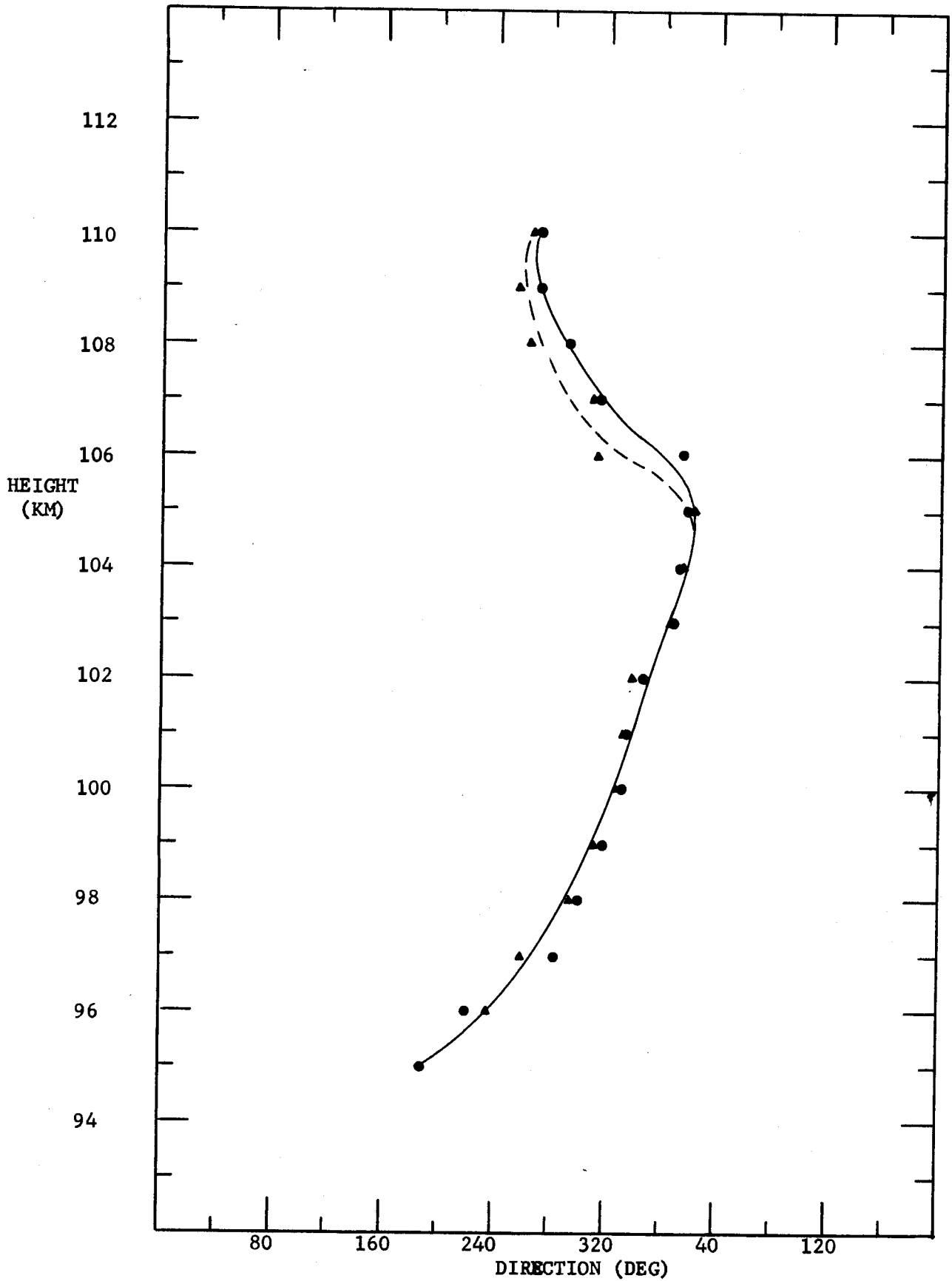


WIND DIRECTION

TRAIL NO. B-68 DURBAN
22 JUNE 1967 19:51:00 AST
H.A.R.P. BARBADOS

UP ●

DOWN ▲



YUMA TRAIL NO. Y-26
 UP TRAIL 12 JUNE 1967 20-14-04 MST

ALTITUDE (KM)	WIND HEADING (DEG)	WIND VELOCITY (M/S)	WIND COMPONENTS (M/S)			
			GEOGRAPHIC		MAGNETIC	
			N-S	E-W	N-S	E-W
117.0	59.3	112.8	57.6	97.0	79.8	79.7
118.0	63.0	96.3	43.7	85.8	63.6	72.3
119.3	68.1	83.7	31.2	77.6	49.5	67.4
120.0	78.9	76.1	14.7	74.7	32.8	68.7
122.0	78.8	70.2	13.6	68.9	30.3	63.4
124.0	77.1	57.2	12.8	55.8	26.2	50.9
126.0	77.9	66.9	14.0	65.4	29.8	59.9
128.0	76.7	48.9	11.2	47.6	22.6	43.3
130.0	97.5	15.6	2.0	15.5	5.8	14.5
132.0	175.1	12.4	12.3	1.0	12.2	-2.1
134.0	197.2	25.9	24.7	7.7	25.8	1.3
136.0	201.8	47.5	44.1	17.7	47.1	6.2

WIND COMPONENTS

UP

NORTH-SOUTH ○

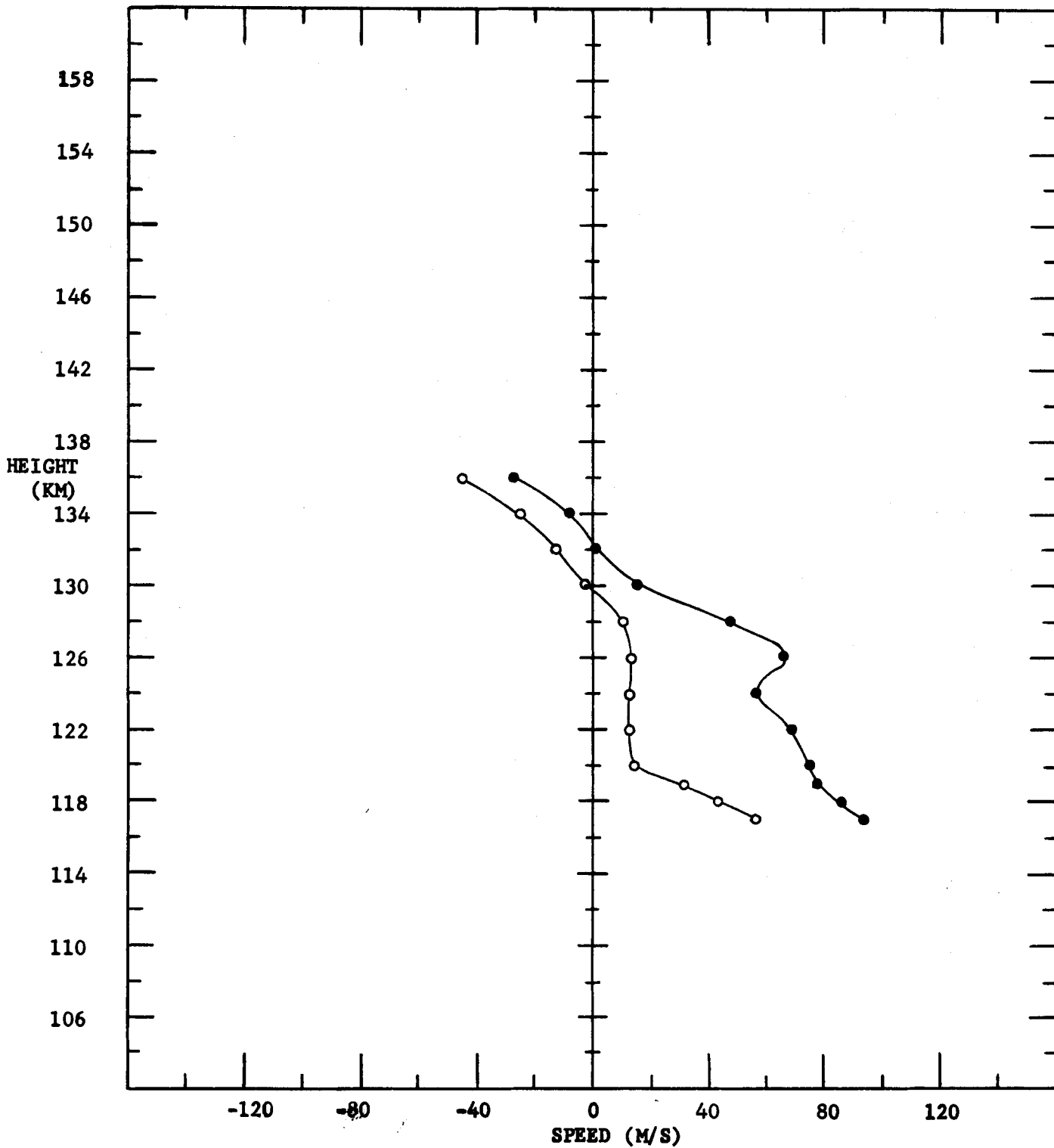
EAST-WEST ●

TRAIL NO. Y-26

12 JUNE 1967

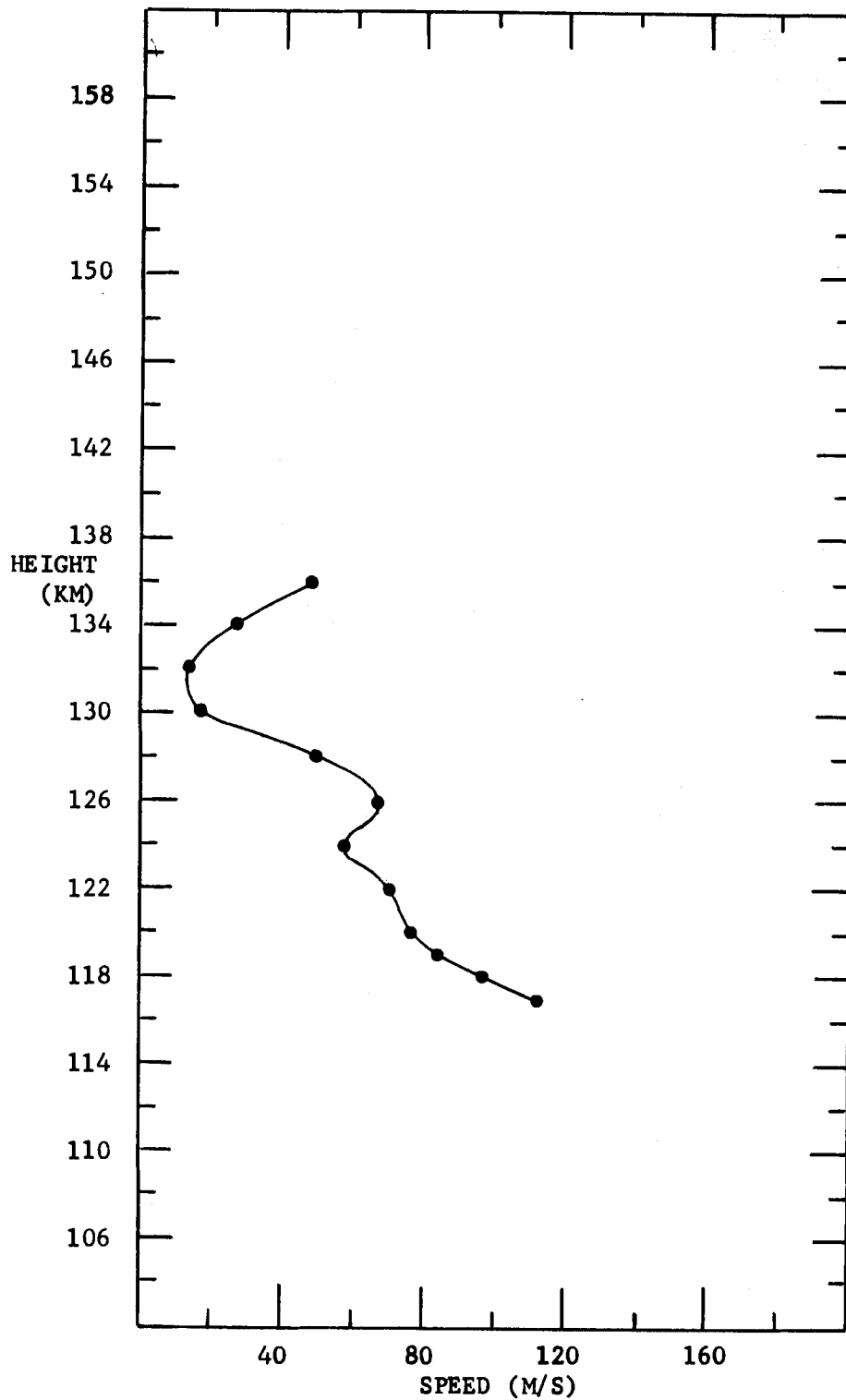
20:14:04 MST

H.A.R.P. YUMA



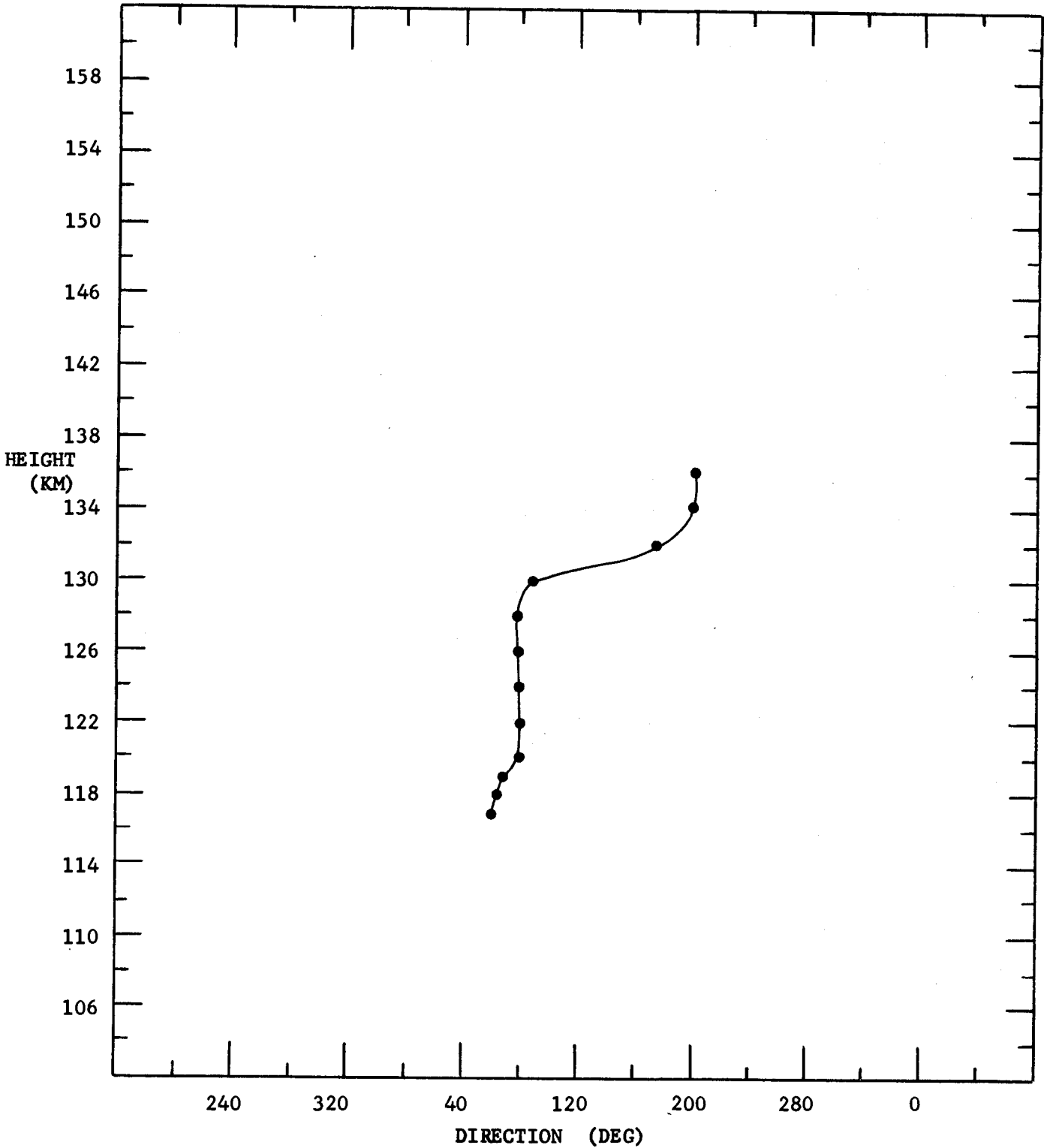
WIND SPEED
UP ●

TRAIL NO. Y-26
12 JUNE 1967
20:14:04 MST
H.A.R.P. YUMA



WIND DIRECTION
UP ●

TRAIL NO. Y-26
12 JUNE 1967
20:14:04 MST
H.A.R.P. YUMA



GROUND PLOTS

Barbados:

<u>*Report</u>	<u>Trail No.</u>	<u>Name</u>	<u>Time</u>
1	B-12	Elagabulus	288
2	B-19	Belair	278
3	B-31	Christ Church	338
	B-32	Dover	up 308 down 318
	B-33	Foul Bay	258
5	B-43	Inagua	283
	B-49	St. Thomas	263
8	B-51	Beta	U282, D292
	B-52	Gamma	352
	B-53	Delta	322
	B-55	Zeta	292
	B-57	Theta	262
9	B-59	Belfast	262
	B-61	Dublin	252
	B-63	Hollywood	U172, D252
	B-65	Limerick	252
10	B-67	Cairo	212
	B-68	Durban	342

Yuma:

4	Y-4	McConnell	U252, D272
6	Y-13	Shot 20	252
	Y-15	Shot 23	262
	Y-22	Shot 31	222

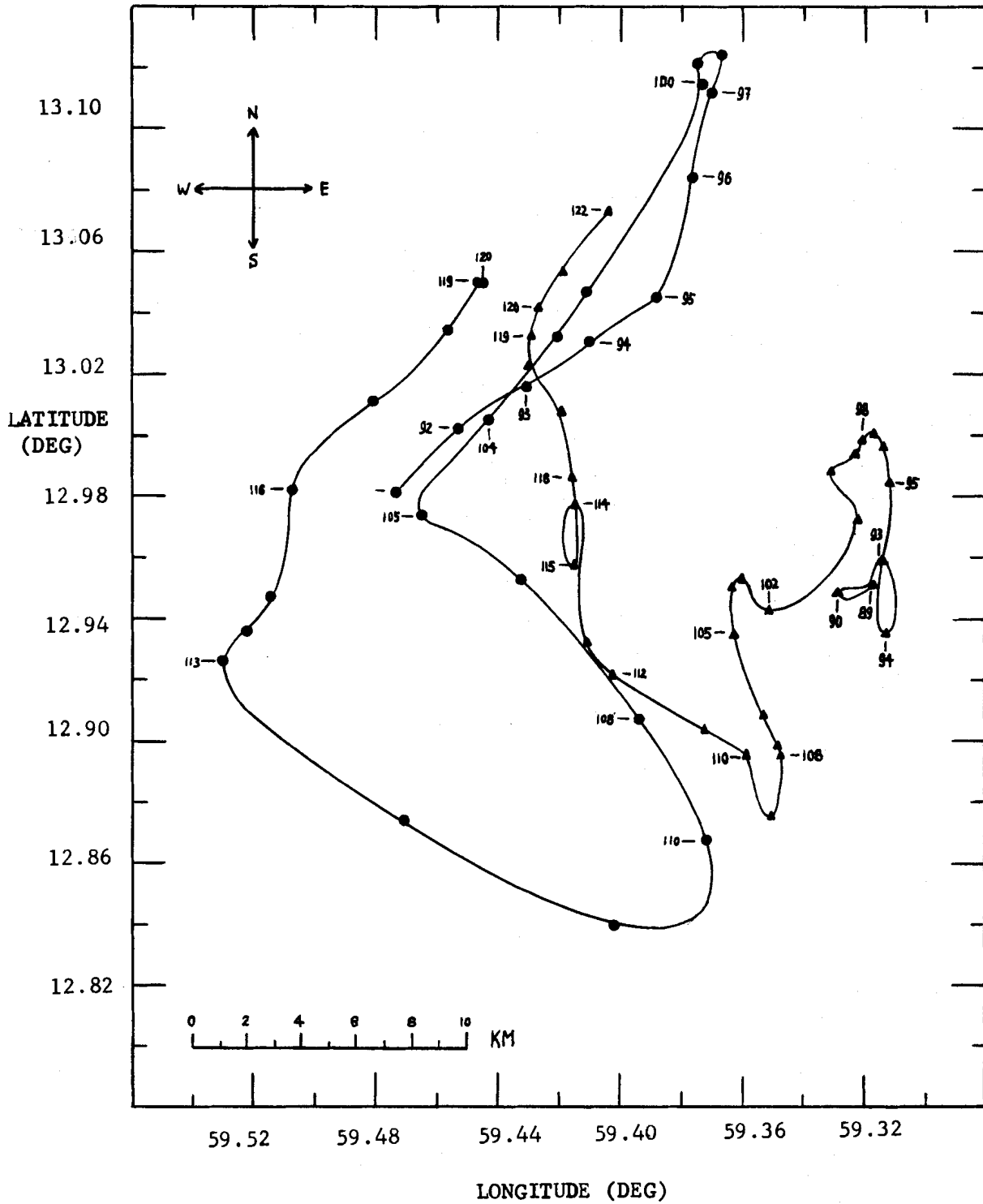
*This refers to the BRL contract report which contains the wind plots and tables.

GROUND PLOT
T + 288 SECONDS

H.A.R.P. BARBADOS
TRAIL NO. B-12
ELAGABULUS 4 JUNE 1965
01:34:56 A.S.T.

UPTRAIL ●

DOWNTAIL ▲

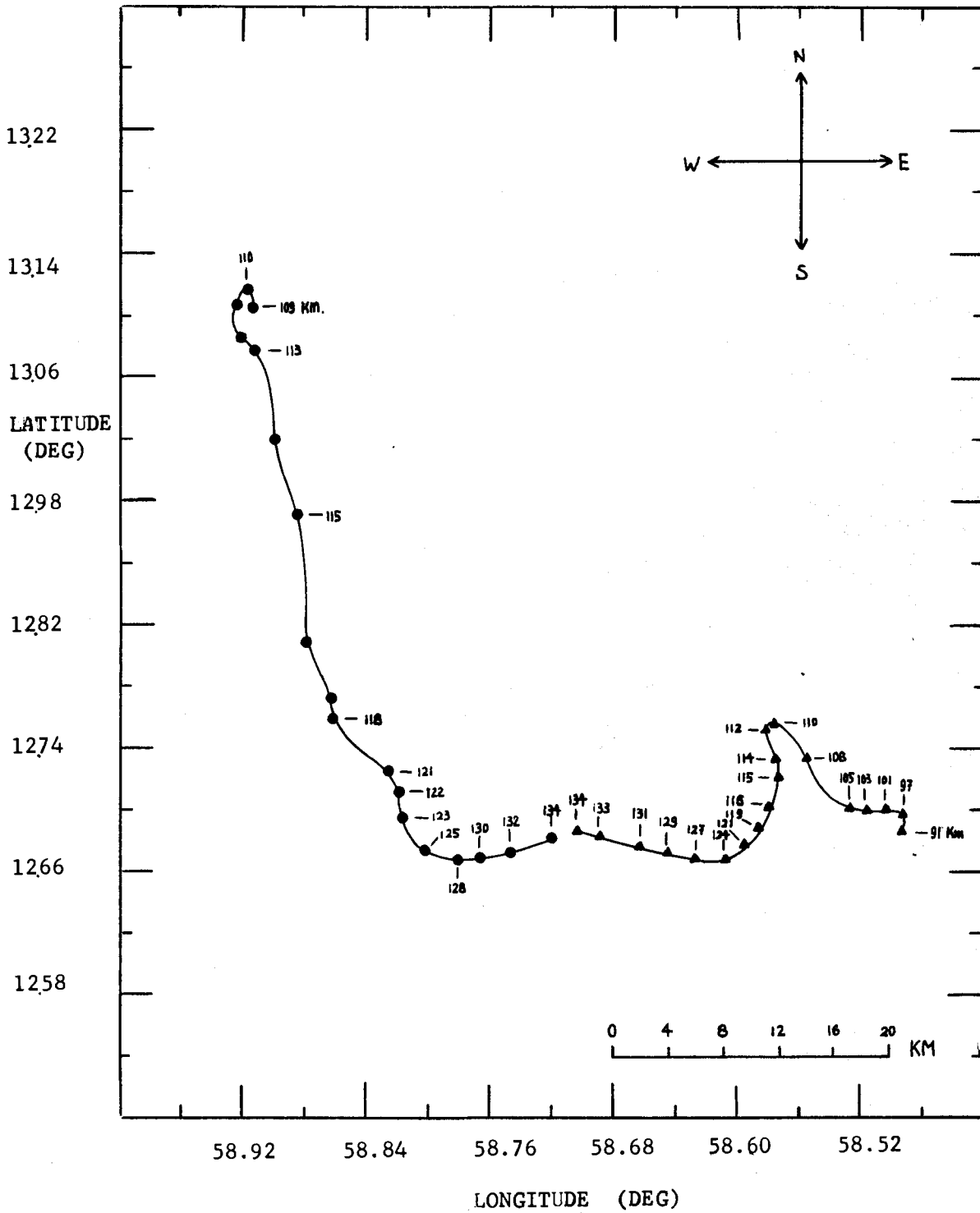


GROUND PLOT
T + 278

H.A.R.P. BARBADOS
TRAIL NO. B-19 BELAIR
20 SEPTEMBER 1965
19:30:00 A.S.T.

UPTRAIL ●

DOWNTRAIL ▲

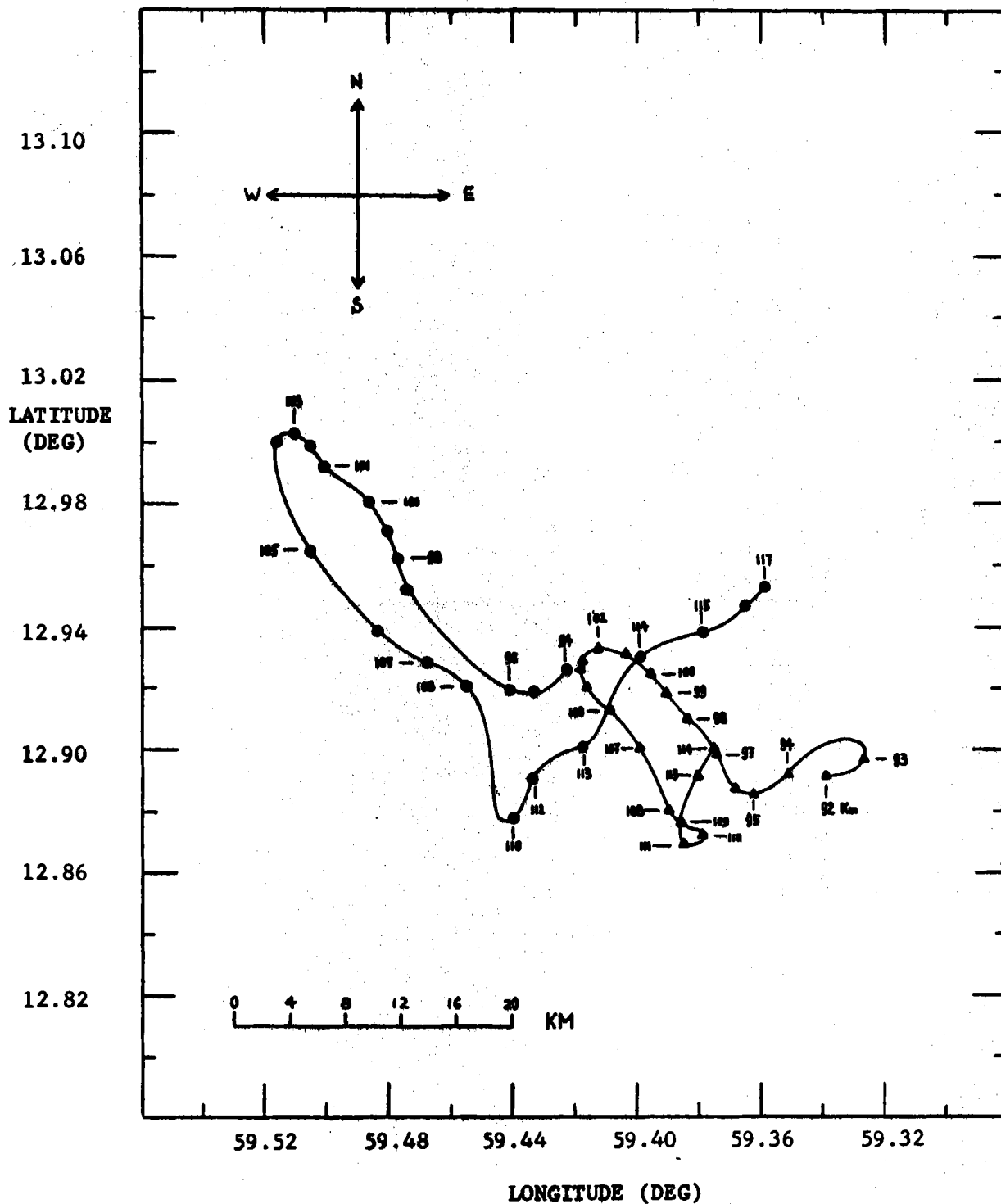


GROUND PLOT
T + 338 SECONDS

H.A.R.P. BARBADOS
TRAIL NO. B-31 CHRISTCHURCH
17 NOVEMBER 1965
18:15:00 A.S.T.

UPTRAIL ●

DOWNTAIL ▲

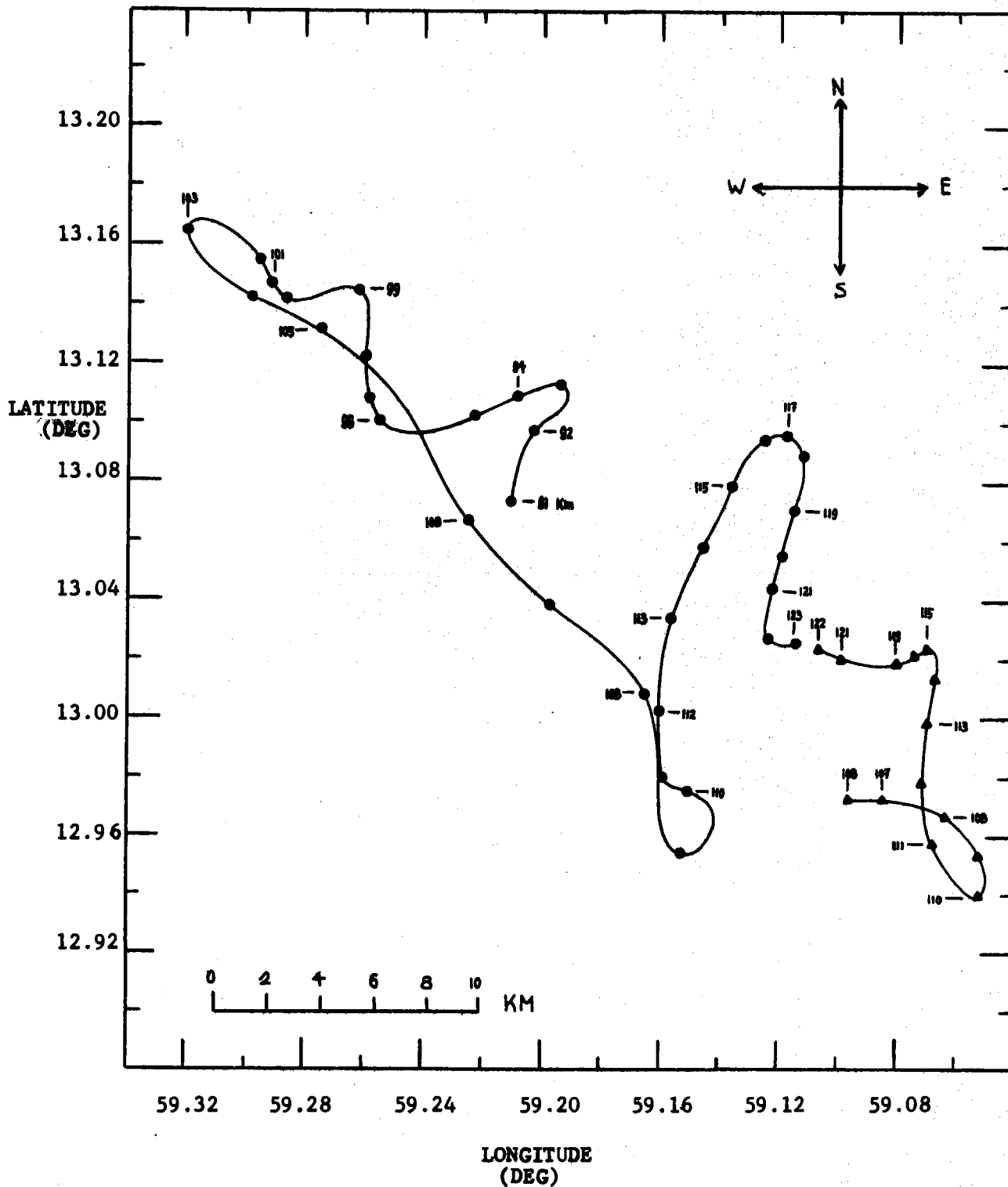


GROUND PLOT
UPTRAIL T +308 SECONDS
DOWNTRAIL T 318 SECONDS

H.A.R.P. BARBADOS
TRAIL NO. B-32 DOVER
17 NOVEMBER 1965
19:34:00, A.S.T.

UPTRAIL ●

DOWNTRAIL ▲

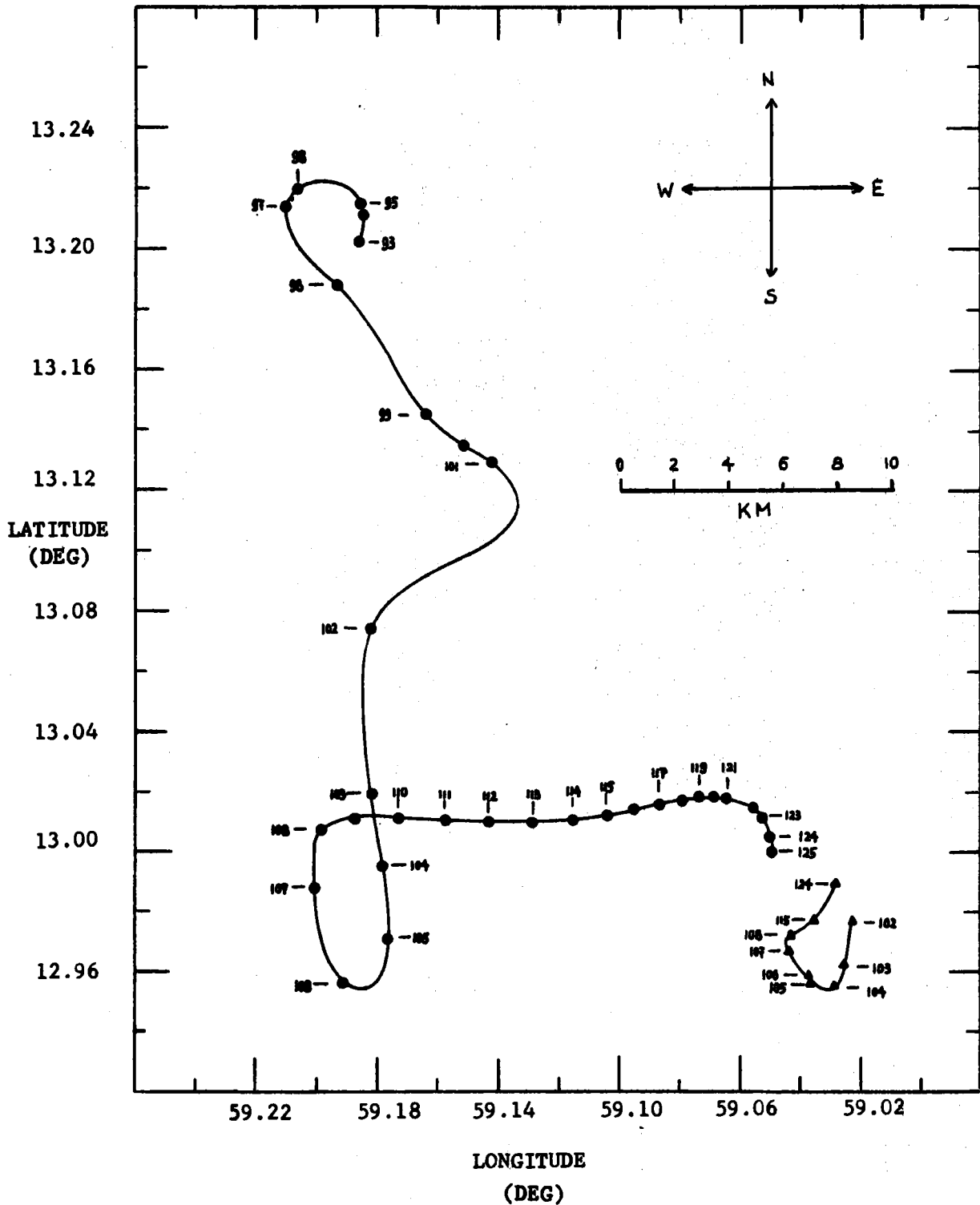


GROUND PLOT
T + 258 SECONDS

H.A.R.P. BARBADOS
TRAIL NO. B-33 FOUL BAY
17 NOVEMBER 1965
23:15:00 A.S.T.

UPTRAIL ●

DOWNTAIL ▲

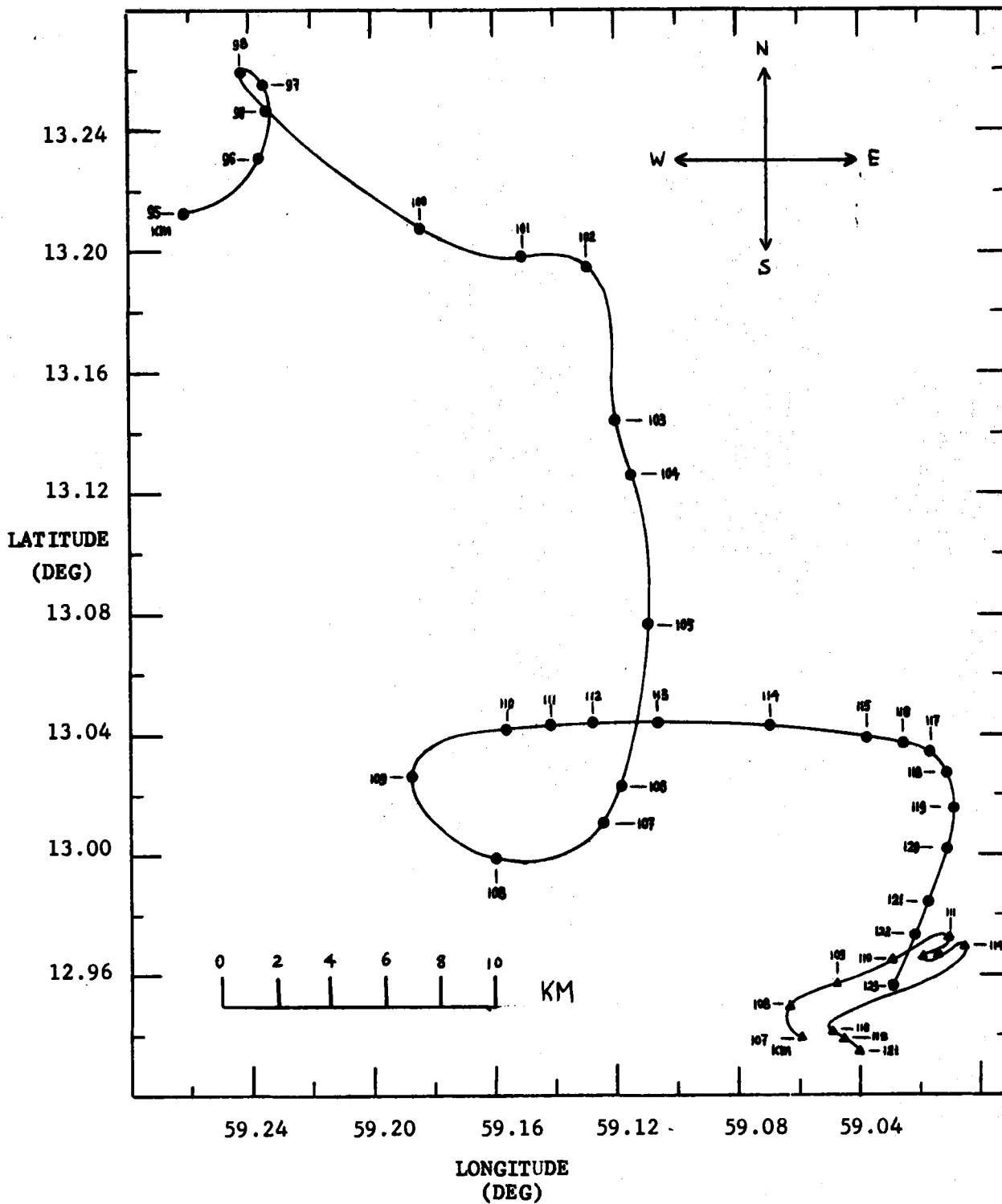


GROUND PLOT
UPTRAIL T + 283
DOWNTRAIL T + 293

H.A.R.P. BARBADOS
TRAIL NO. B-43 INAUGUE
17 FEBRUARY 1966
21:03:00 A.S.T.

UPTRAIL ●

DOWNTRAIL ▲



GROUND PLOT

T + 263

UPTRAIL ●

DOWNTRAIL ▲

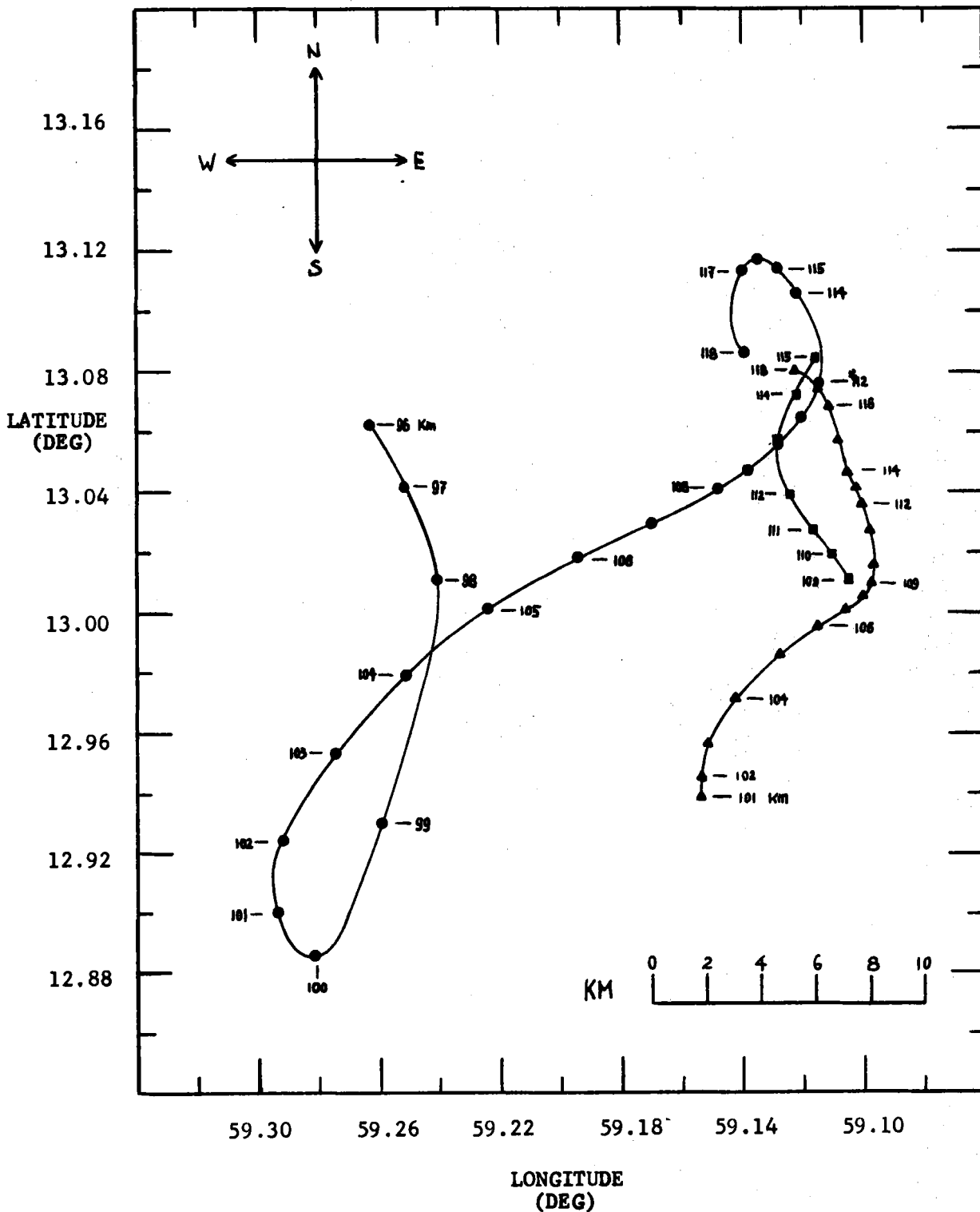
TRAIL "A" DOWNTRAIL ■

H.A.R.P. BARBADOS

TRAIL NO. B-49 ST. THOMAS

24 FEBRUARY 1966

05:23:30 A.S.T.

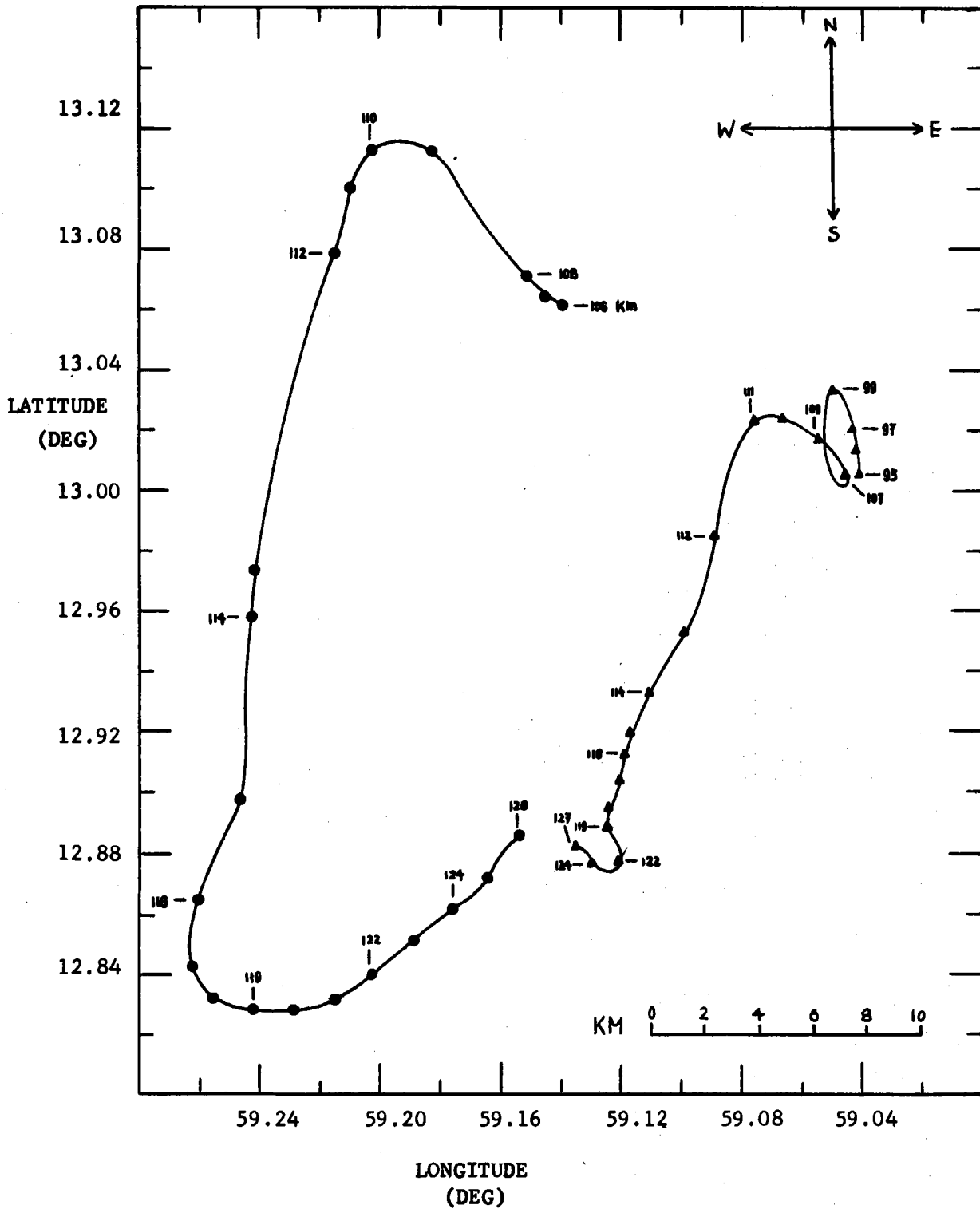


GROUND PLOT
 UPTRAIL T + 282 SECONDS
 DOWNTRAIL T + 292 SECONDS

H.A.R.P. BARBADOS
 TRAIL NO. B-51 BETA
 19 SEPTEMBER 1966
 20:55:09 A.S.T.

UPTRAIL ●

DOWNTRAIL ▲



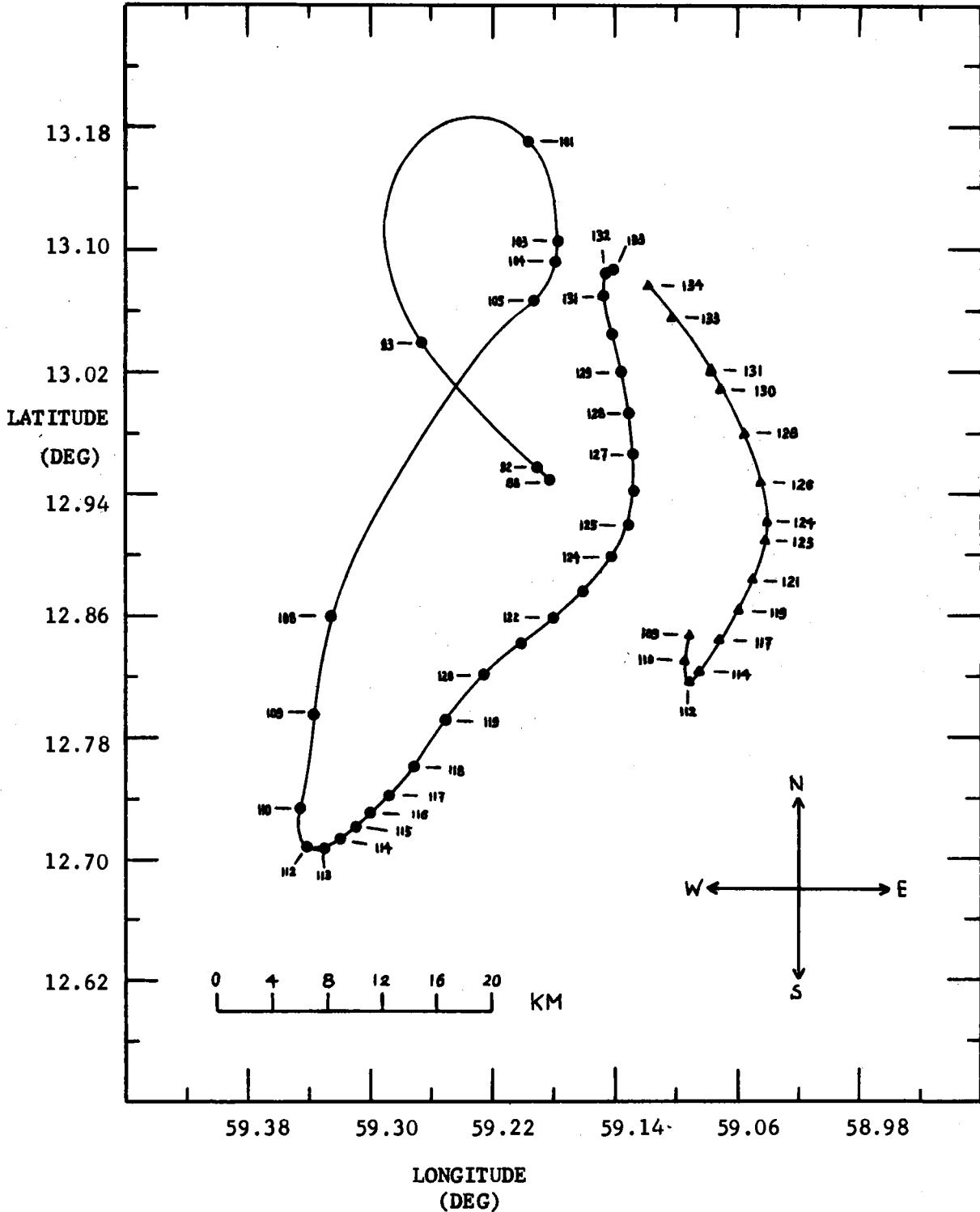
GROUND PLOT

T + 352

H.A.R.P. BARBADOS
TRAIL NO. B-52 GAMMA
19 SEPTEMBER 1966
22:24:06 A.S.T.

UPTRAIL ●

DOWNTRAIL ▲

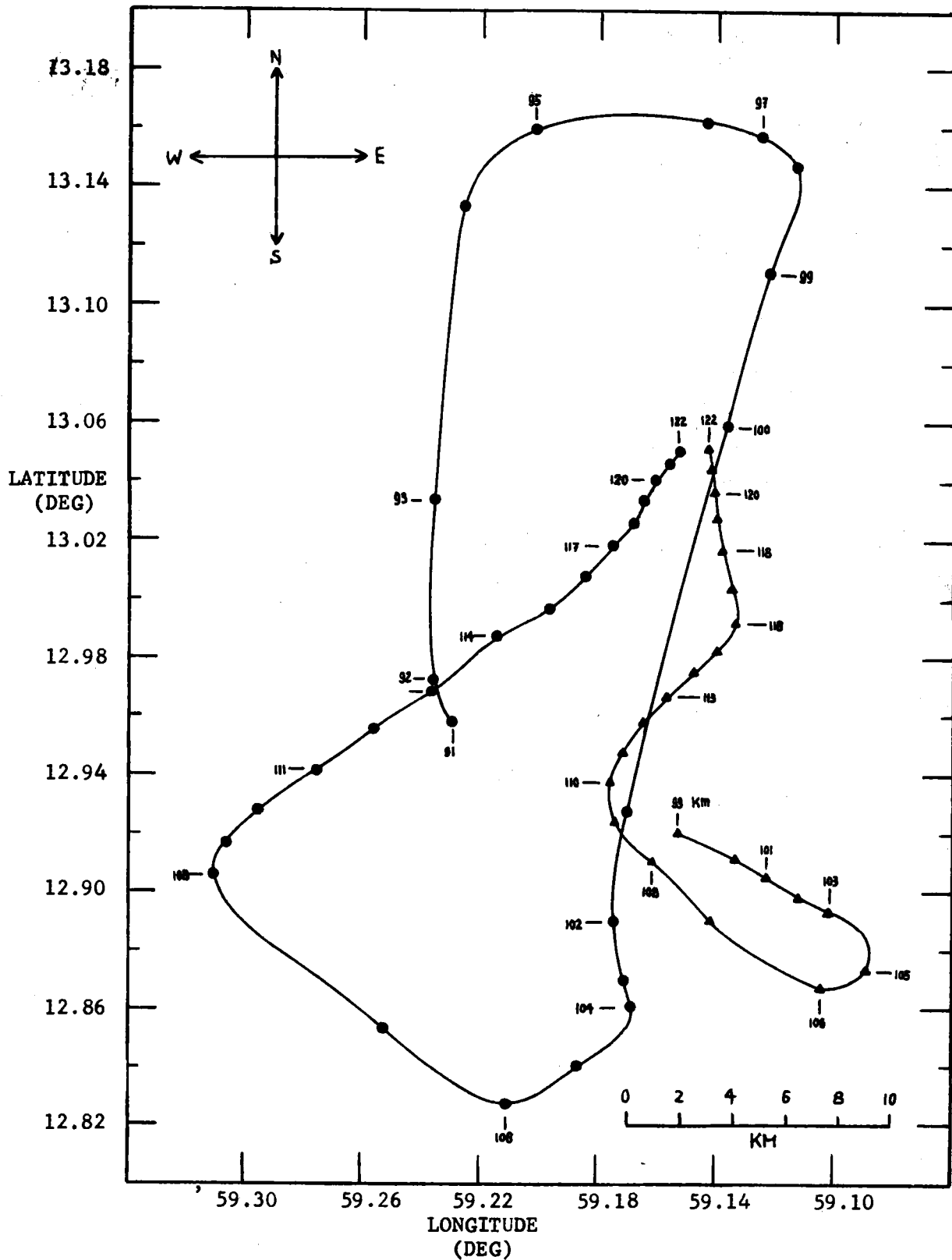


GROUND PLOT
T + 322

H.A.R.P. BARBADOS
TRAIL NO. B-53 DELTA
20 SEPTEMBER 1966
00:10:00 A.S.T.

UPTRAIL ●

DOWNTAIL ▲



GROUND PLOT

T + 292

UPTRAIL ●

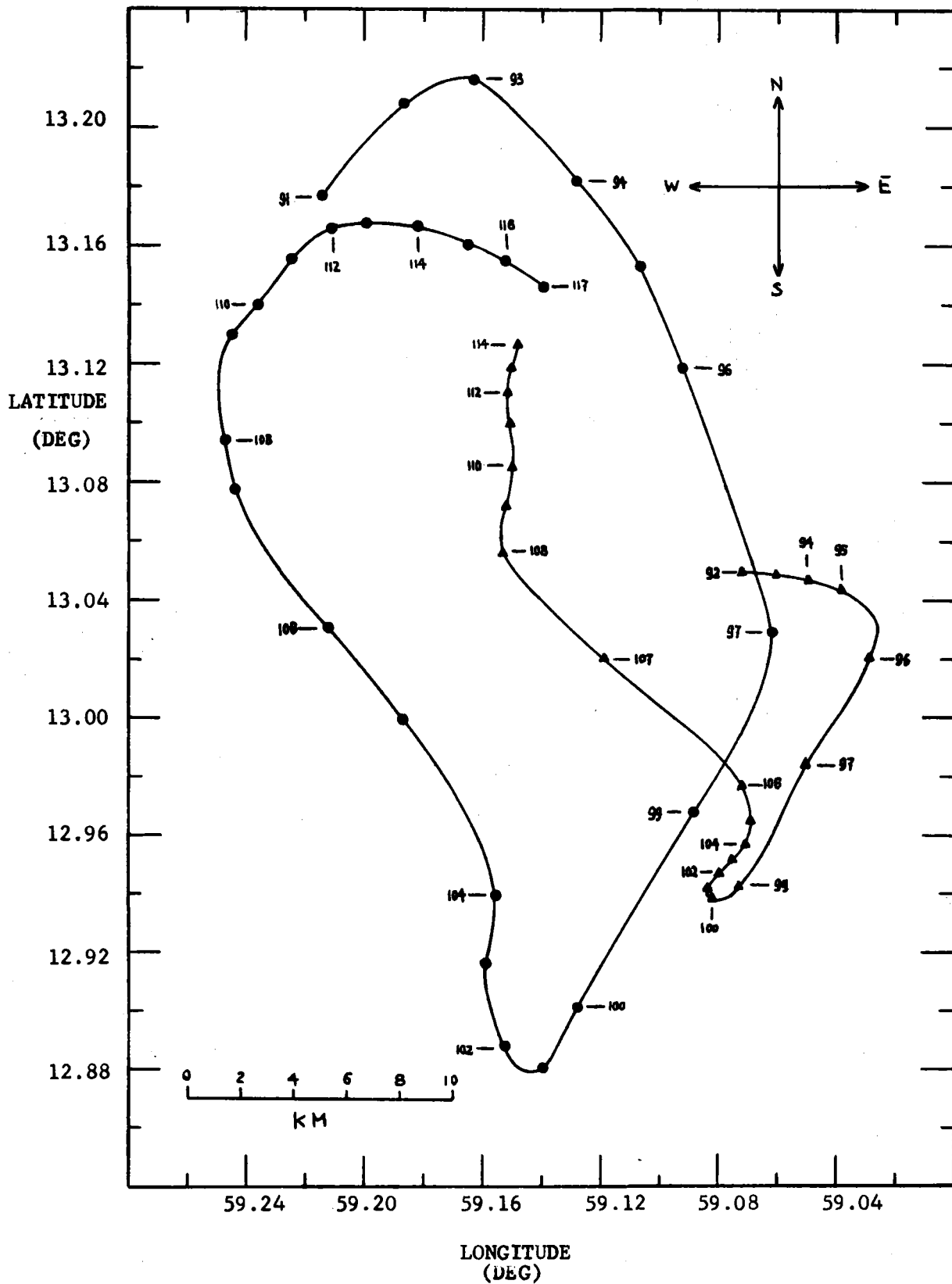
DOWNTRAIL ▲

H.A.R.P. BARBADOS

TRAIL NO. B-55 ZETA

20 SEPTEMBER 1966

02:24:00 A.S.T.

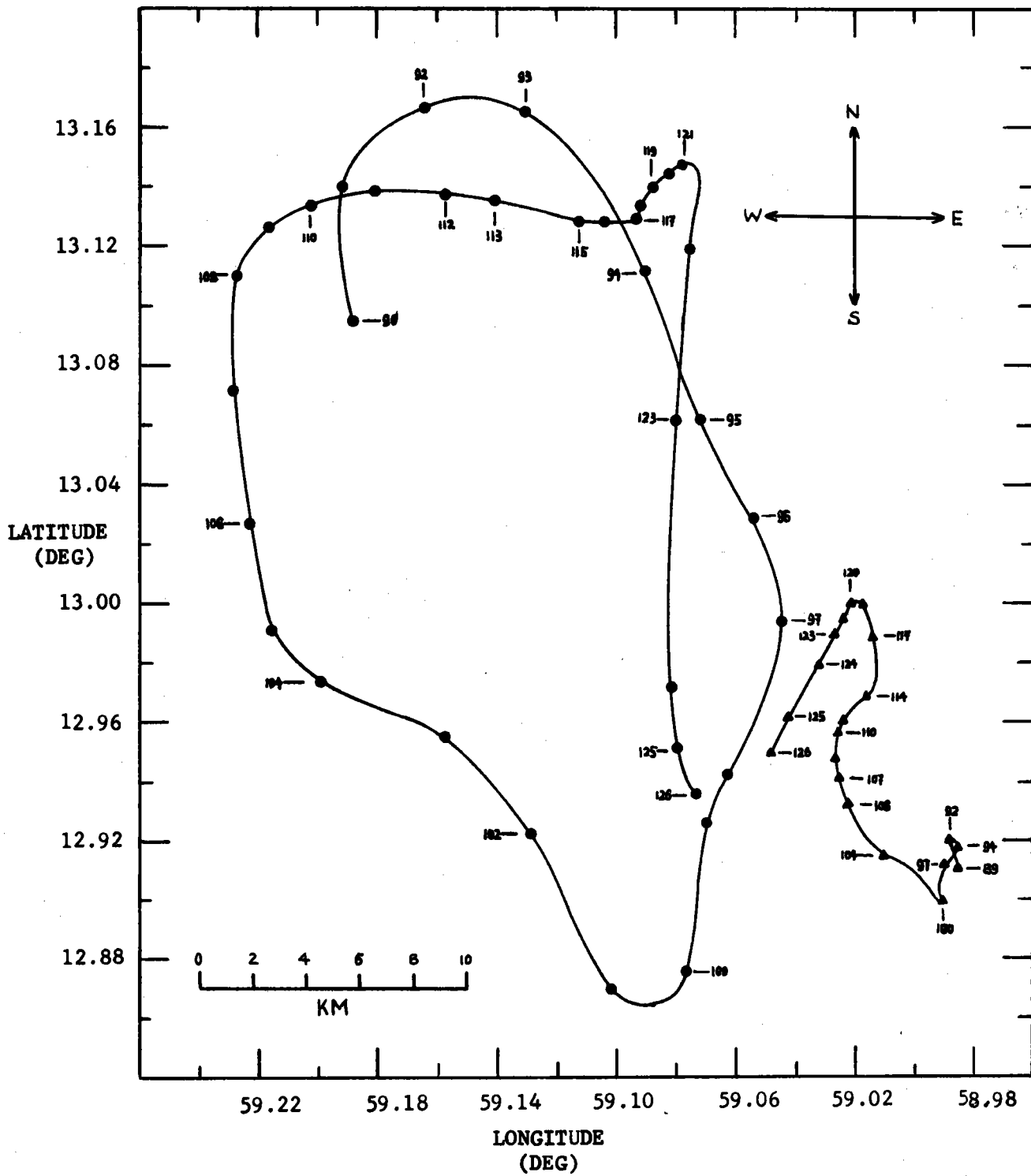


GROUND PLOT
T + 262

H.A.R.P. BARBADOS
TRAIL NO. B-57 THETA
20 SEPTEMBER 1966
04:03:00 A.S.T.

UPTRAIL ●

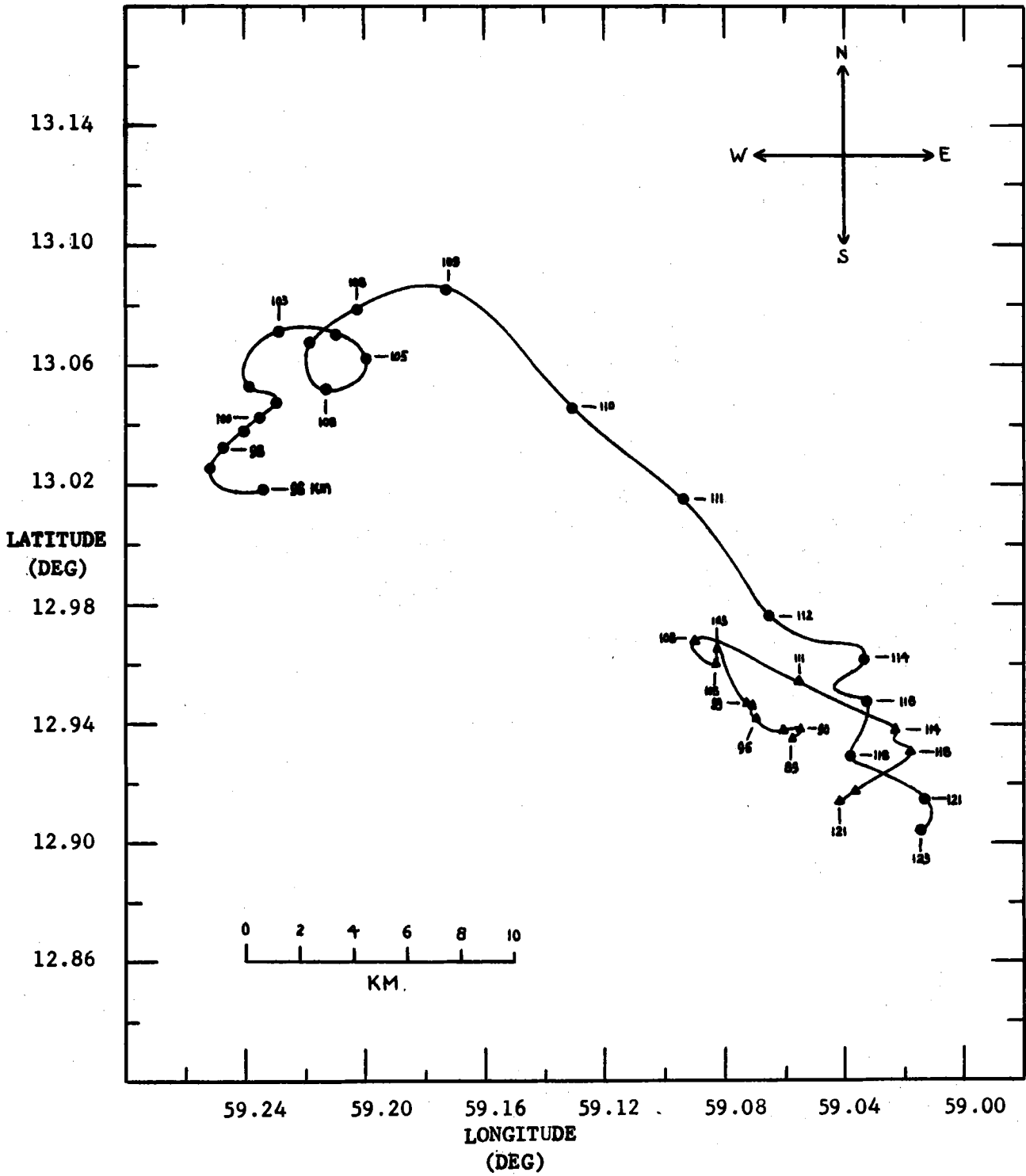
DOWNTRAIL ▲



GROUND PLOT
T + 262

H.A.R.P. BARBADOS
TRAIL NO. B-59 BELFAST
15 FEBRUARY 1967
21:17:00 A.S.T.

UPTRAIL ●
DOWNTRAIL ▲

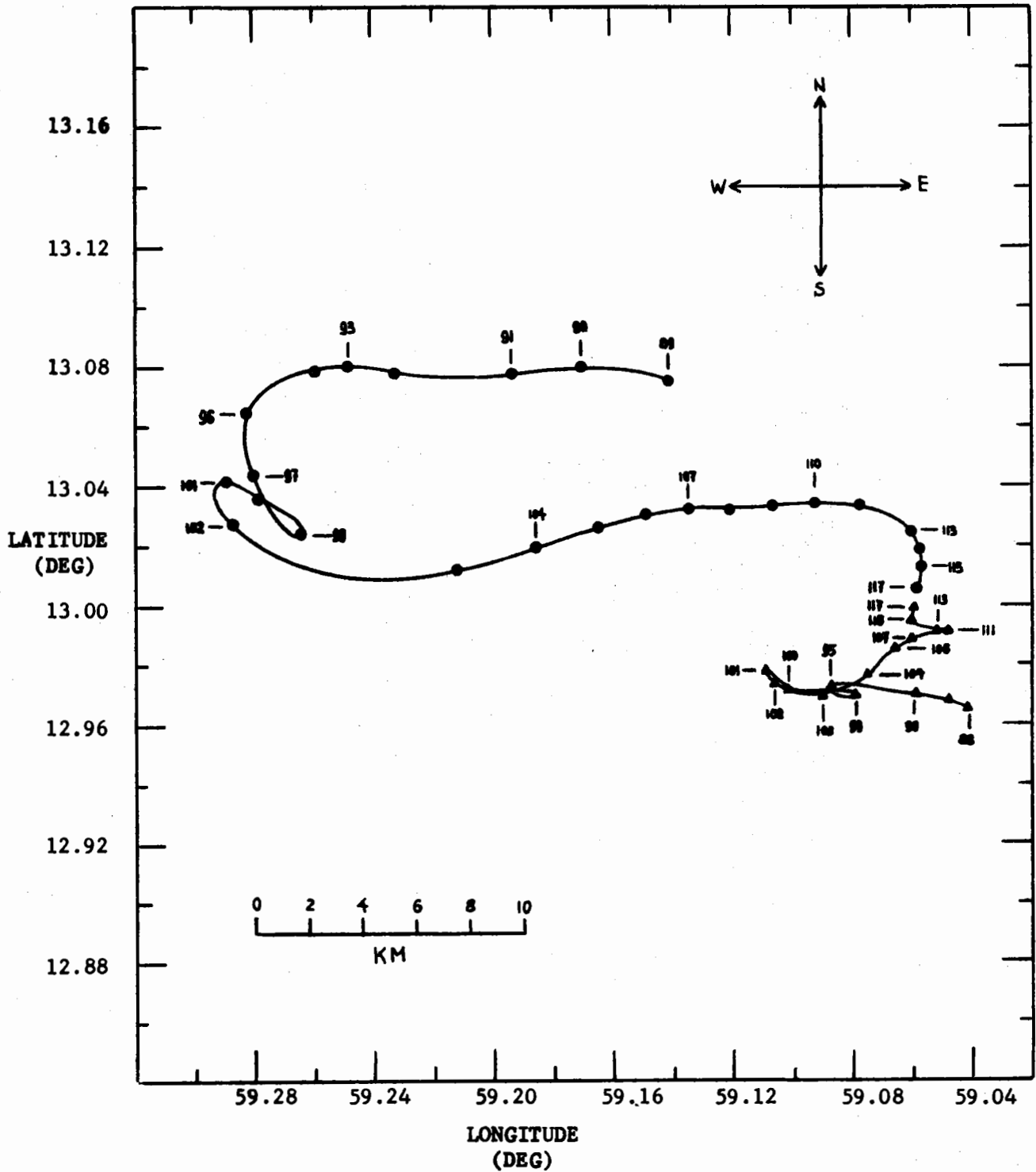


GROUND PLOT
T+ 252

H.A.R.P. BARBADOS
TRAIL NO. B-61 DUBLIN
15 FEBRUARY 1967
23:56:00 A.S.T.

UPTRAIL ●

DOWNTAIL ▲

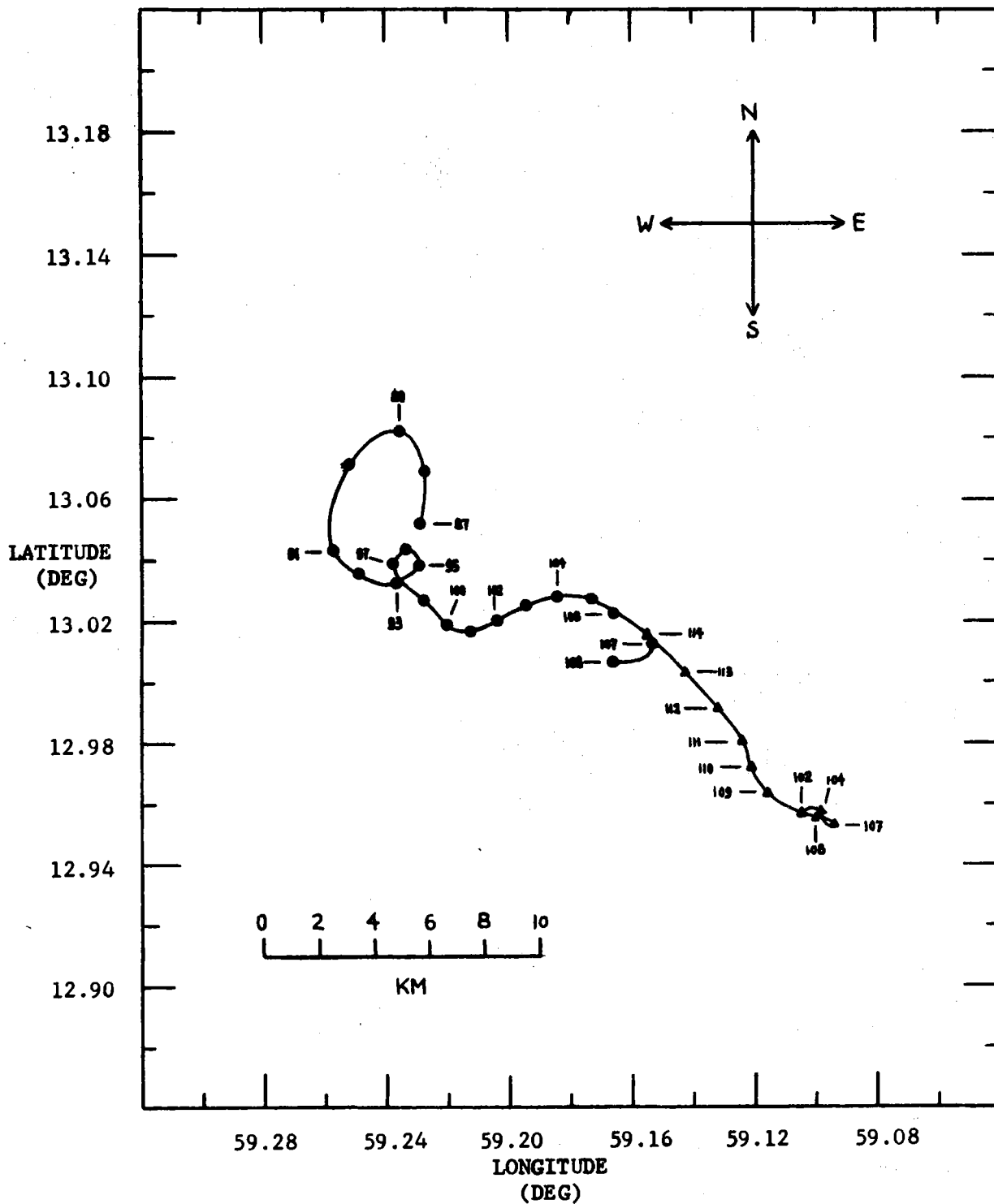


GROUND PLOT
UPTRAIL T + 172
DOWNTRAIL T + 252

H.A.R.P. BARBADOS
TRAIL NO. B-63 HOLLYWOOD
16 FEBRUARY 1967
22:45:00 A.S.T.

UPTRAIL ●

DOWNTRAIL ▲

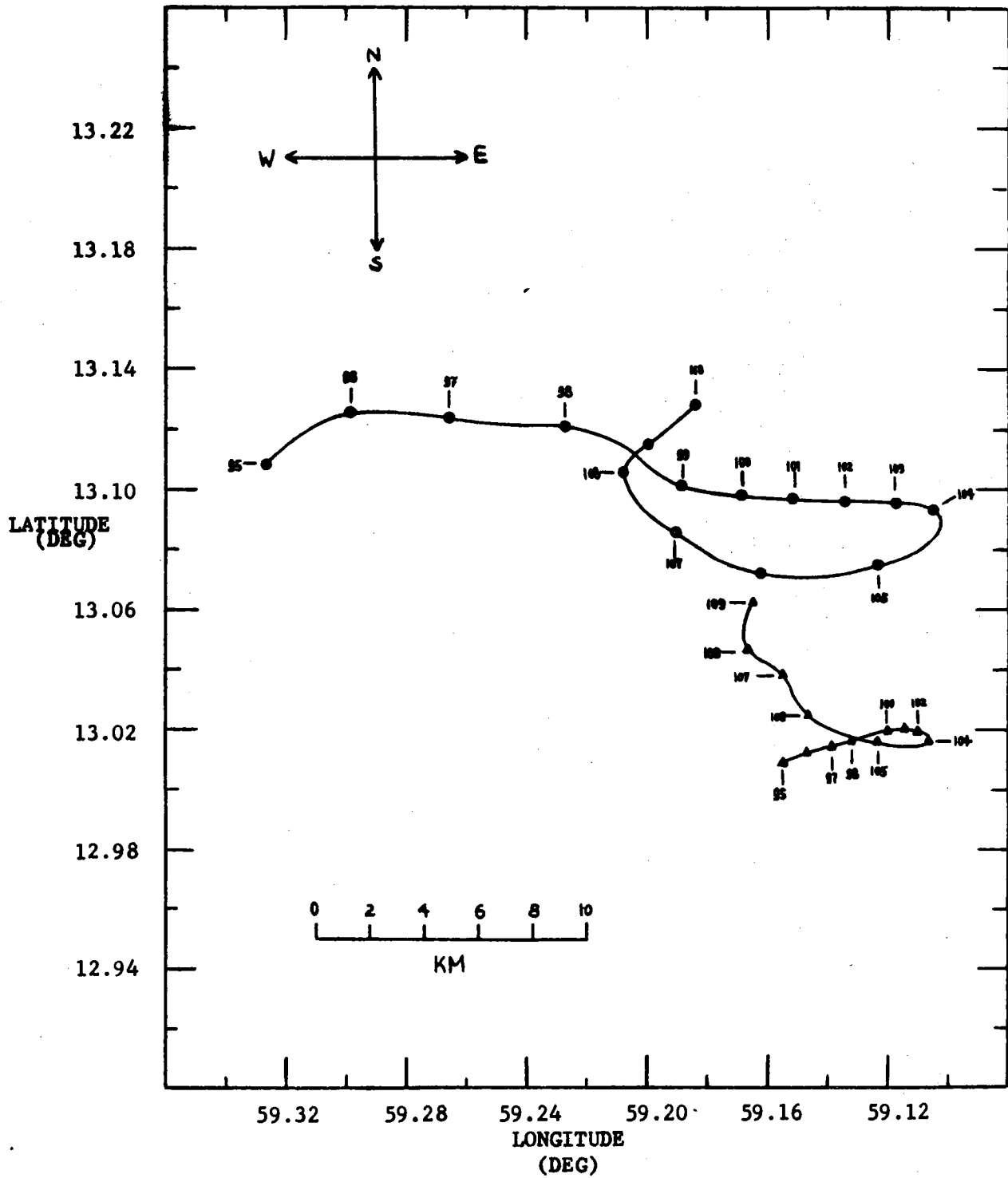


GROUND PLOT
T + 252

H.A.R.P. BARBADOS
TRAIL NO. B-65 LIMERICK
16 FEBRUARY 1967
04:17:00 A.S.T.

UPTRAIL ●

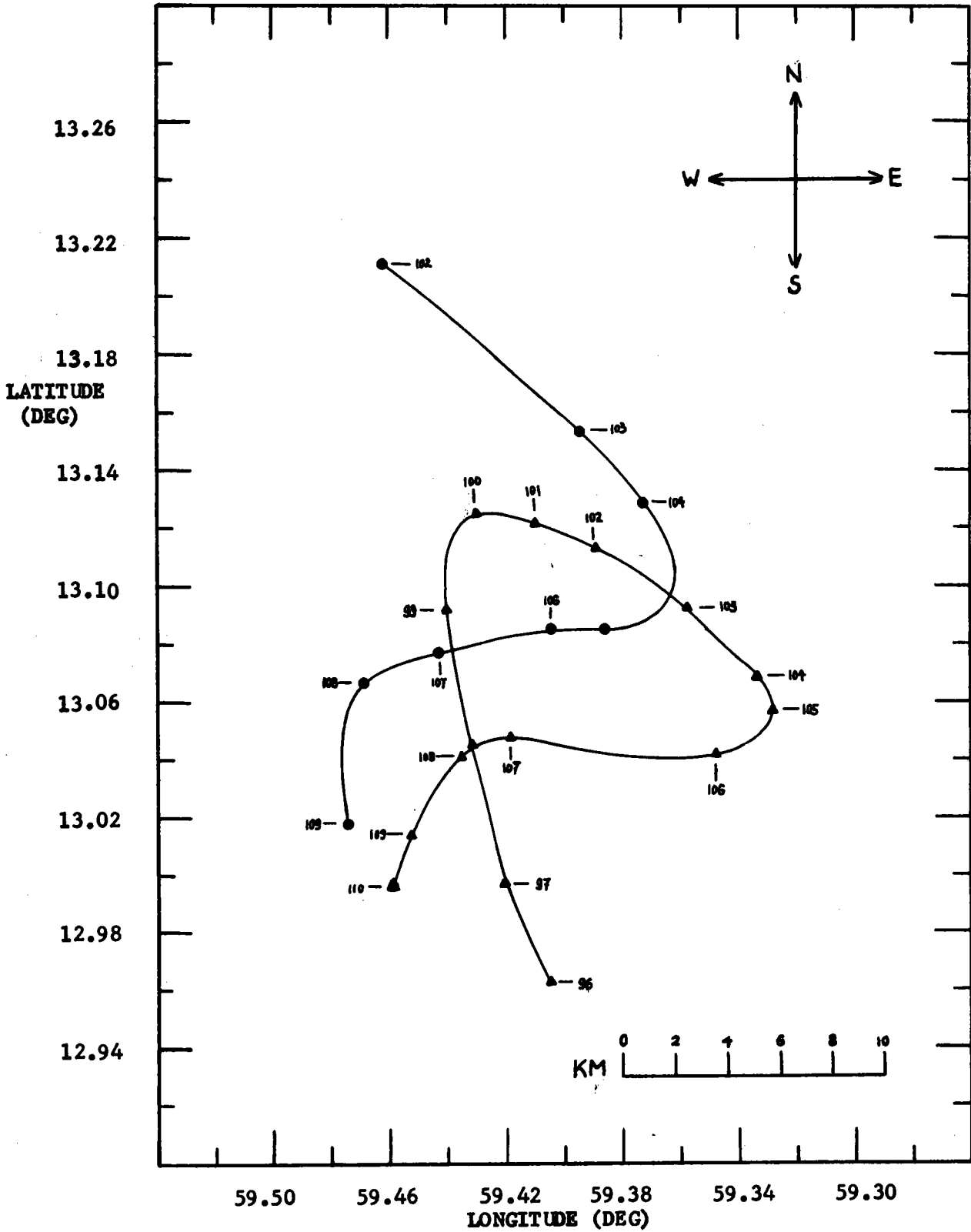
DOWNTRAIL ▲



GROUND PLOT
T + 342 SECONDS

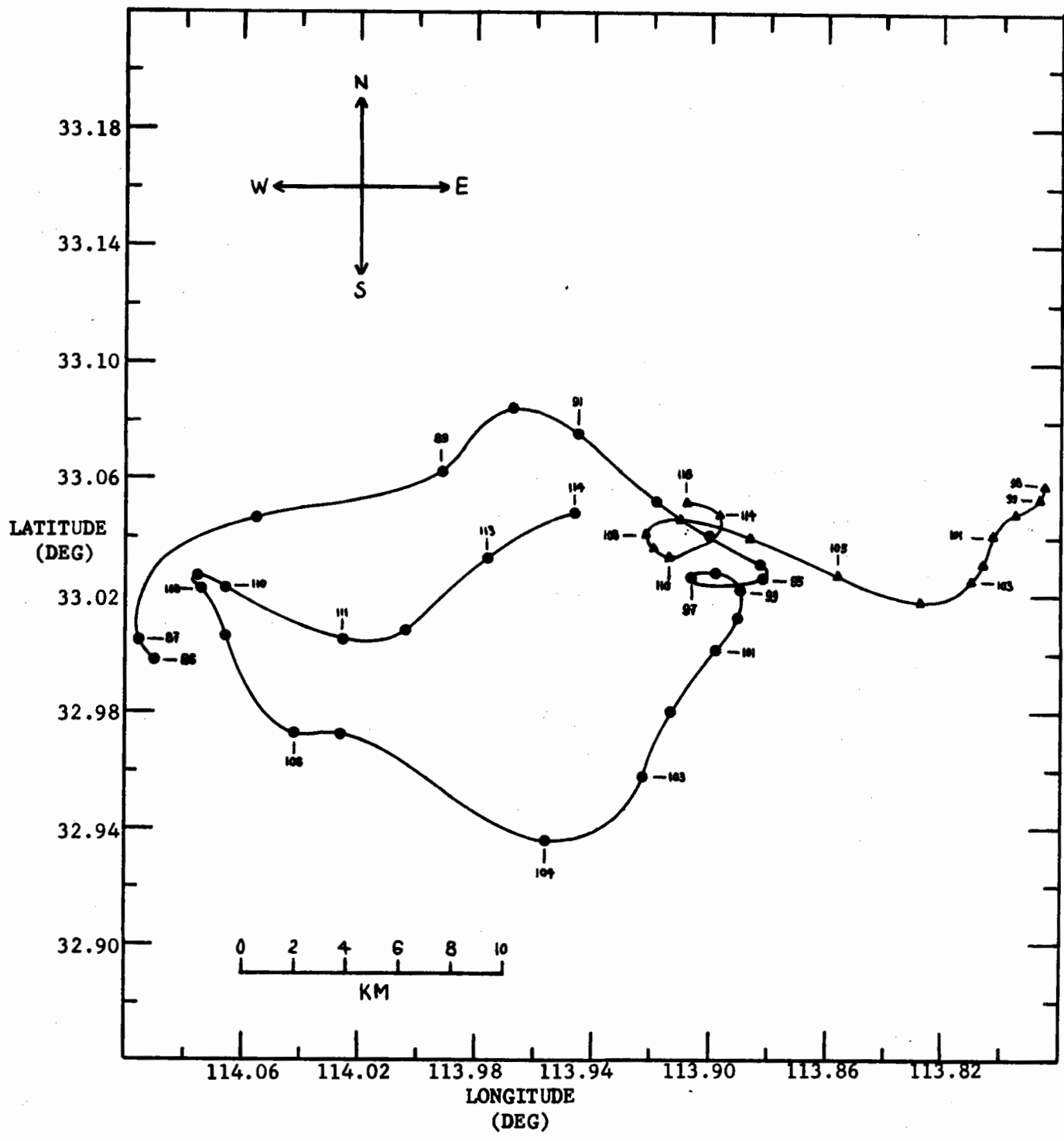
H.A.R.P. BARBADOS
TRAIL NO. B-68 DURBAN
22 JUNE 1967
19:51:00 AST

UPTRAIL ●
DOWNTRAIL ▲



GROUND PLOT
 UPTRAIL T + 262
 DOWNTRAIL T + 272
 UPTRAIL ●
 DOWNTRAIL ▲

H.A.R.P. YUMA
 TRAIL NO. Y-4 Mc CONNELL
 15 JUNE 1966
 01:27:00 A.S.T.

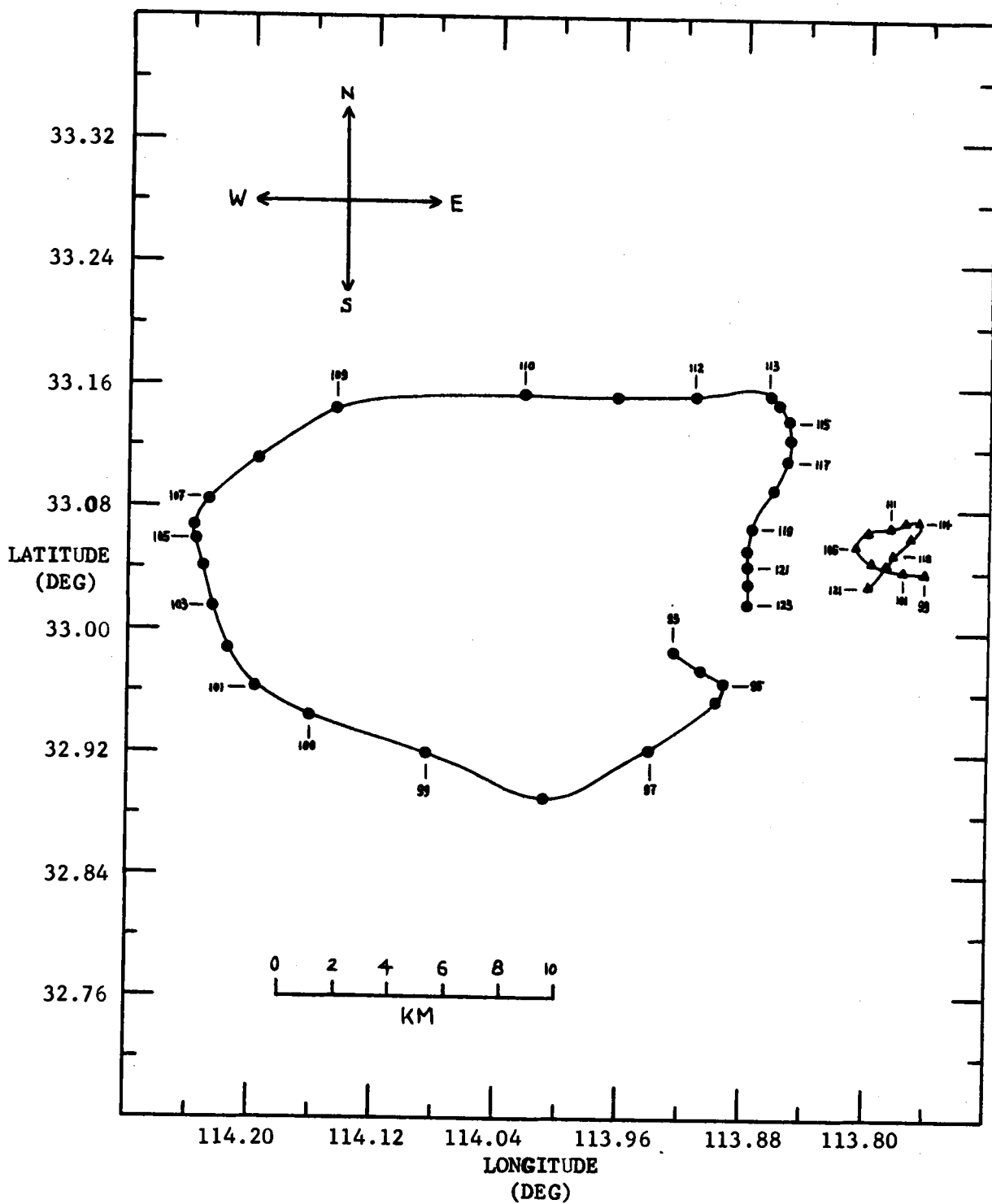


GROUND PLOT
T + 252

H.A.R.P. YUMA
TRAIL NO. Y-13 SHOT# 20
17 NOVEMBER 1966
00:16:13 A.S.T.

UPTRAIL ●

DOWNTAIL ▲

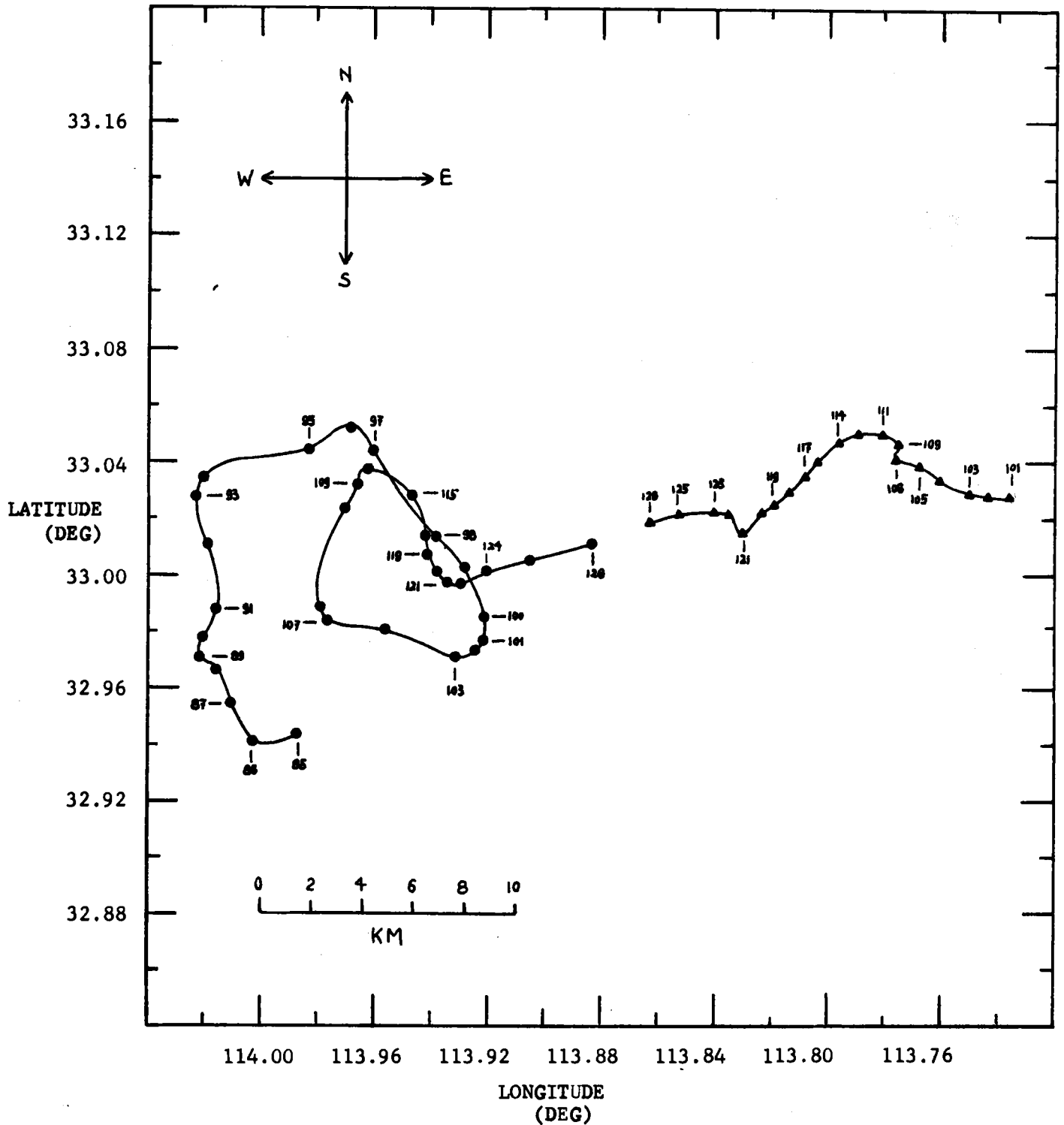


GROUND PLOT
T + 262

H.A.R.P. YUMA
TRAIL NO. Y-15 SHOT # 23
18 NOVEMBER 1966
20:12:21 A.S.T.

UPTRAIL ●

DOWNTRAIL ▲

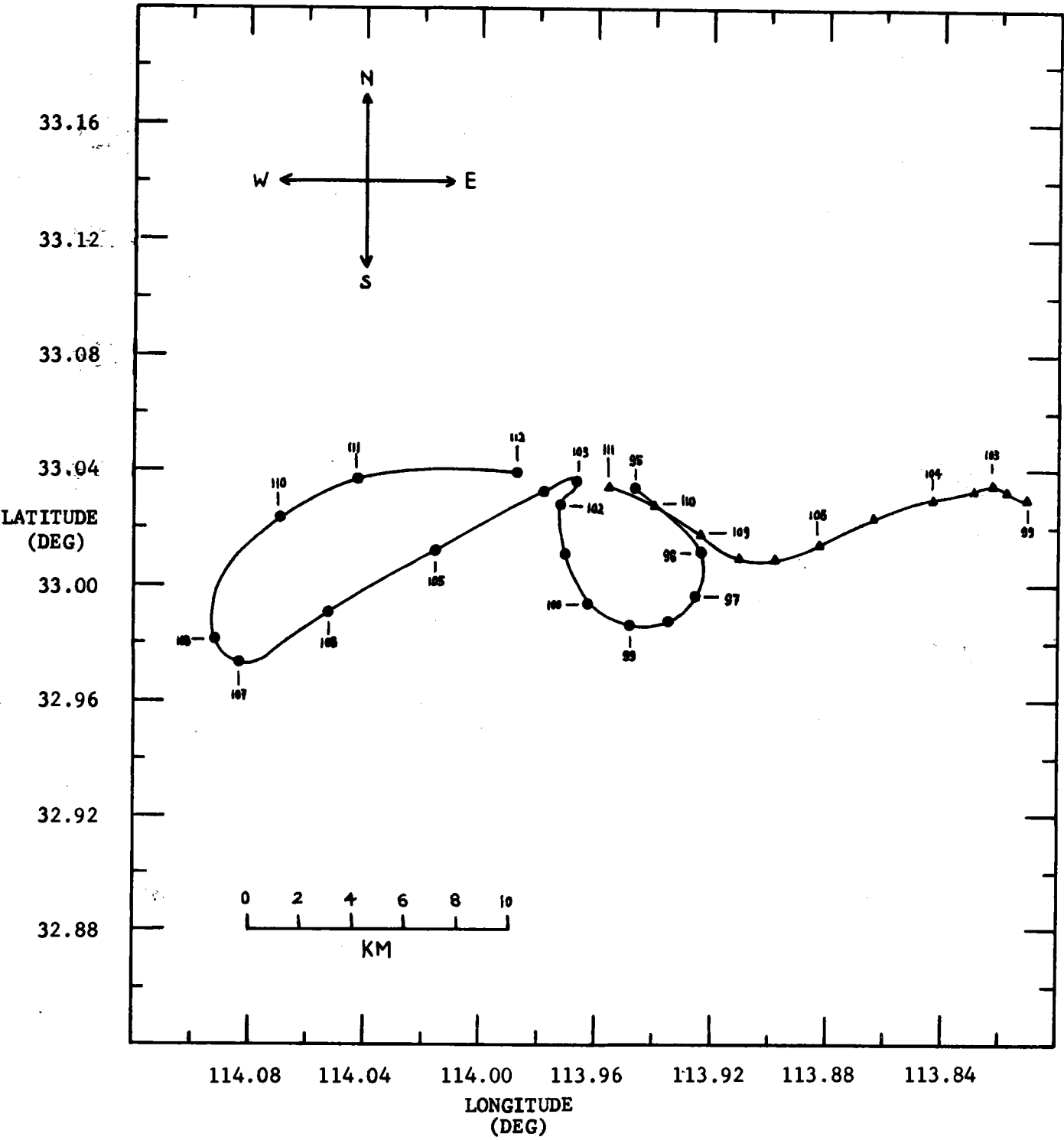


GROUND PLOT
T+ 222

H.A.R.P. YUMA
TRAIL NO. Y-22 SHOT # 31
19 NOVEMBER 1966
21:21:29 A.S.T.

UPTRAIL ●

DOWNTAIL ▲



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(Includes Barbados, 21-22 June 1967 and Yuma, 12 June 1967)**

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

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13. ABSTRACT

During the nights of 21-22 June 1967, two luminous trails were produced between 89 and 110km by the release of trimethyl aluminum from projectiles fired from a smoothbore sixteen-inch gun located on the West Indian island of Barbados (57.5°W, 13.1°N) and on the night of 12 June 1967 an additional trail was produced by a projectile fired from a similar sixteen-inch gun located at Yuma, Arizona (114.3°W, 32.9°N). These trails were photographed from neighboring sites and analyzed to yield wind profiles. This report contains the tabulated wind data from all three trails together with plots versus altitude of wind components, wind speed, and wind heading. Included in this report are ground plots of trails for all previous shots that had both an up trail and a down trail.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
HARP HIGH ALTITUDE RESEARCH PROJECT IONOSPHERIC WINDS						