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13 January 1965

Headquarters
National Aeronautics and Space Administration
Washington, D C 20546

Attention: Geophysics and Astronomy Programs
Division, Code SGM

Subject: Contract No. NASw-1083

Gentlemen:

With reference to Article XIV, Paragraph B of the subject contract, enclosed are ten (10) copies of our First Quarterly Report covering the period 24 July 1964 through 31 October 1964.

Very truly yours,

Original Signed By
T. L. SEXTON
Thomas L. Sexton
Senior Contract Administrator

TLS/edb
1 Enclosure
Quarterly Rpt (10 cys)

cc: NASA/Code ATU (w/1 cy rpt)
Tech. Utilization Division

NASA/Code BCA (w/1 cy rpt)
Contracts Division

Measurement of Upper Atmospheric Ionization and Winds with a Combined Payload

First Quarterly Report

Covering the Period

24 July 1964 - 31 October 1964

Contract No. NASw-1083

Project Managers

L. G. Smith
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Bedford, Massachusetts

Prepared for

National Aeronautics and Space Administration
Headquarters
Washington, D. C.

Measurement of Upper Atmospheric Ionization and Winds with a Combined Payload

INTRODUCTION

The purpose of this contract is to develop and utilize a combined payload consisting of a Langmuir probe for the measurement of upper atmospheric ionization and a sodium vaporizer or trimethylaluminum (TMA) dispenser to furnish a trail from which winds may be determined. Descriptions of the experimental and analytical methods employed in the probe measurements are given in reports covering Contract NASw-98, NASw-489 and NASw-500. Similar information concerning the sodium vapor method of determining winds may be found in reports covering Contract NAS5-215 and NASw-396. The analytical methods employed to determine winds from a TMA trail are the same as for a sodium vapor trail, but the TMA dispenser was designed, tested, and constructed in this contract.

The work statement of this contract contains five tasks. Briefly these tasks are as follows:

A. Design and construct one each of the following payloads for Nike Apache Rockets:

1. Combined Langmuir Probe - Alkali Vapor.
2. Combined Langmuir Probe - TMA.

B. Make necessary preparation for and participate in test launching of each payload at Wallops Island.

C. Construct eight (8) combined payloads.

D. Make necessary preparation for and participate in launching of these payloads at Fort Churchill, Canada, during two different field trips.

E. Collect, prepare, analyze and study the data.

Tasks A and B were successfully completed during the period covered by this report. Both of the combined payloads were tested at GSFC and then flown successfully from Wallops Island. Good data were obtained from both firings and the measurements of electron densities and winds are included in this report.

PAYLOAD DESIGN

Several methods of obtaining both the electron density profile with the Langmuir probe and the wind profile with a vapor trail using the same rocket vehicle were considered. The most desirable situation is that both height profiles be obtained simultaneously at the same position in space. However, a method of obtaining exact simultaneity was not found. This is primarily due to the contaminating effect of the alkali-vapor. The operation of both the probe and telemetry are seriously compromized by the vapor. To avoid this contamination, the probe must operate at either a time or place which is different from that at which the vapor trail is present. Various methods of separating either or both of the packages from the vehicle were not satisfactory due primarily to the large impulses required or to instability, or unpredictable altitude and/or attitude of the separated packages. The only system which does not require extensive design, development, and testing is one using the normal rocket trajectory to produce the required separation by operating the Langmuir probe on the ascent and releasing the alkali vapor on the descent. This method has other advantages also. Since minimum design changes and modification of the individual payloads were required, the proven reliability of these payloads could be retained in the combination. Costs and time of development could also be minimized. The time and space separation of the measurements may be greater with a combined payload than could be achieved by other methods. The effect of the time and space separations of the value of the data cannot positively be determined at the present.

Langmuir Probe Section

The nose tip of the rocket is insulated from the rest of the vehicle and is programmed with a sweep voltage alternating with a fixed voltage. The sweep (-2.7 to +2.7 volt, duration 0.5 sec) is the conventional Langmuir mode and is used to obtain electron temperature and electron density by measuring probe current as a function of voltage. The fixed voltage mode (+2.7 volt, duration 1.5 sec) is used to obtain fine structure of the electron density profile and is particularly suited to the observation of Sporadic E layers.

The payload also contains an aspect magnetometer, which is primarily used to monitor the vehicle motion, and a baroswitch which is used to determine rocket trajectory by a time of flight method. The magnetometer and baroswitch signals are telemetered on one channel of the FM/FM system and the probe data on a second channel. The power supply for the probe section of the payload is independent of that for the vapor section.

Alkali-Vapor Section

The alkali-vapor payload has been completely described elsewhere.* Only the major modifications will be included here. The instrumentation rack was shortened and made a little lighter by relocating components and deck plates. The completely isolated dual ignition system was retained. This system utilizes two mechanical timers, two battery packs and two igniters. The timers had previously been started at take-off by a built-in inertia switch. The longer time to vapor ejection on the down trail required the use of an explosive switch start on the timer. Provisions were made to start the timers after take-off with an aneroid switch. The only other major change in the alkali-vapor payload was the relocation of the arming plugs. These plugs were originally located on the forward end of the instrumentation rack and the vaporizer was armed by removing the nose cone. In the combined payload, the probe instrumentation rack was mounted to the forward end of the vapor rack and, thus, arming at that point was inconvenient. The arming plugs were moved to the side of the rack and are accessable through a removable door in the skin.

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* Contract No. NAS5-215, GCA Technical Report No. 62-13-N.
Contract No. NASw-396, GCA Technical Report No. 63-16-N.

TMA Section

The method of dispensing TMA is an entirely new design. The basic features of the design are as follows:

(1) The TMA dispenser attaches to the same instrumentation rack as alkali-vapor canister.

(2) The TMA canister is filled at the manufacturer's plant and shipped to the launch site in the flight container.

(3) The rate of ejection of TMA may be controlled.

Basically the operation of the TMA dispenser is simple. The TMA is contained in a specially designed flexible teflon bladder which is carefully mounted in an internally fitted aluminum canister. The bladder has an exit port through a valve system and the canister is also fitted with a port and valve. When the valves to the bladder and canister are both opened and dry nitrogen under pressure is forced into the canister, the bladder is compressed, forcing the TMA out of the bladder valve. During flight, these valves are operated by electrically initiated controlled explosives. The initiation circuits and safety monitors are very similar to those for the alkali metal vaporizer.

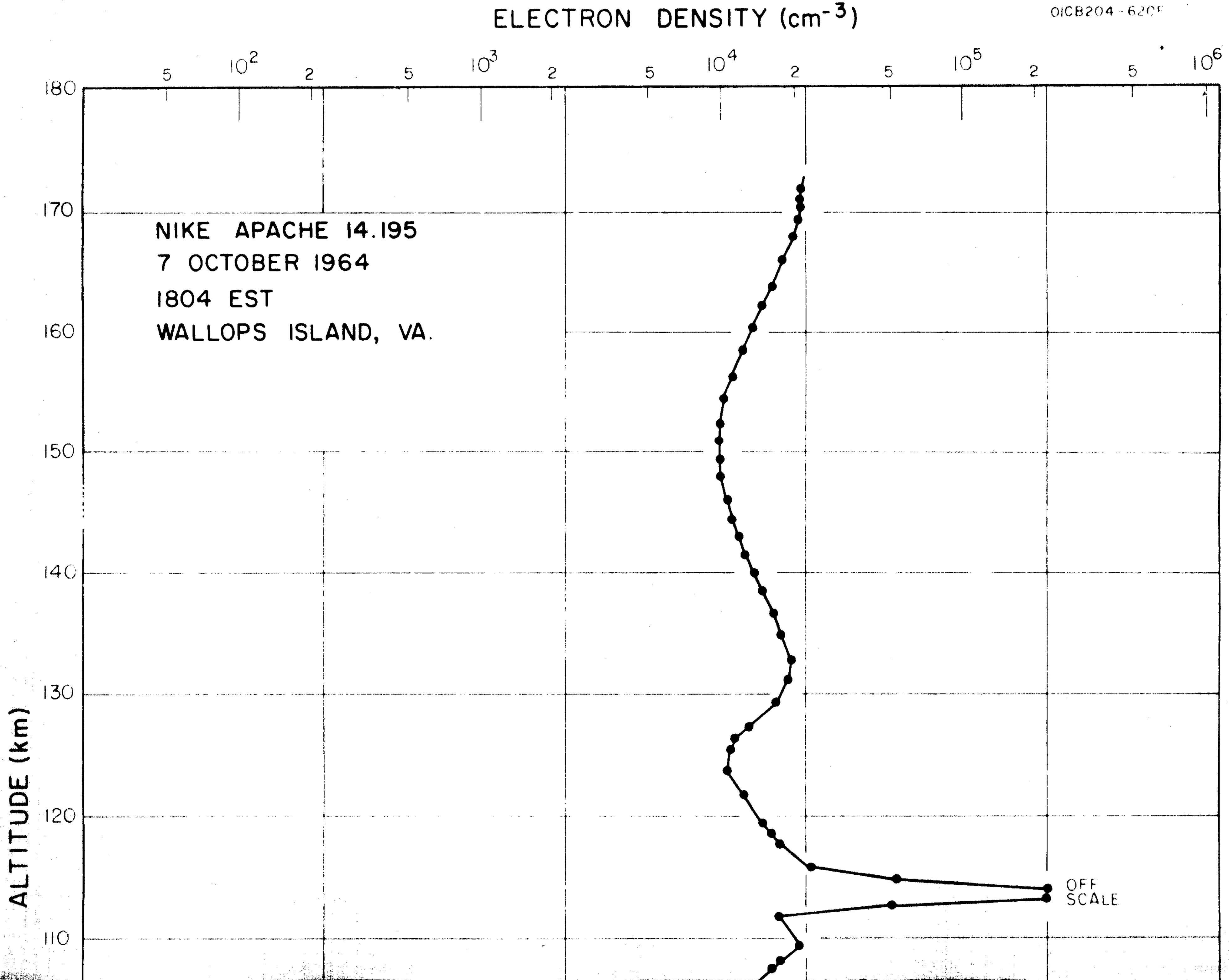
The rate of ejection of the TMA is controlled by the size of the exit port. In ground tests, the time required to uniformly empty the bladder was controlled over the range 60 to 240 seconds.

Two prototype combined payloads have been constructed. The probe-alkali payload weighs 86 lb and is 69 inches in length. The probe-TMA payload weighs 69.5 lb and is 73 inches long. Both of these payloads have been subjected to environmental tests at GSFC and performed satisfactorily in test flights from Wallops Island. The results of the test flights are given in the following section of this report.

ROCKET FIRINGS AND RESULTS

Following the accelerated development program the first test flights were scheduled for 30 September and 1 October 1964 at Wallops Island but were delayed due to poor weather conditions. The combined payload consisting of a Langmuir probe and TMA dispenser was eventually fired during the evening twilight of 7 October 1964 as Nike Apache 14.195. All instrumentation performed as programmed and the rocket reached a peak altitude of 172 km. A record of the electron density was obtained by the probe over the range 76 km to 172 km and is shown in Figure 1. Winds were obtained from the vapor trail over the range 90 km to 157 km and are shown in Figures 2a and 2b.

The combined Langmuir probe and Alkali-Vapor payload was fired from Wallops Island during the morning twilight of 8 October 1964 as Nike Apache 14.194. Again all instrumentation operated properly and the rocket reached a peak altitude of 160 km. Electron density was observed over the range 78 km to 157 km and is shown in Figure 3. Winds were obtained from 84 km to 160 km and are shown in Figures 4a and 4b.



ELECTRON DENSITY (cm^{-3})
01CB204-620F
5
10^2
2
5
10^3
2
5
10^4
2
5
10^5
2
5
10^6
180
170
160
150
140
130
120
110
ALTITUDE (km)
NIKE APACHE 14.195
7 OCTOBER 1964
1804 EST
WALLOPS ISLAND, VA.
OFF SCALE

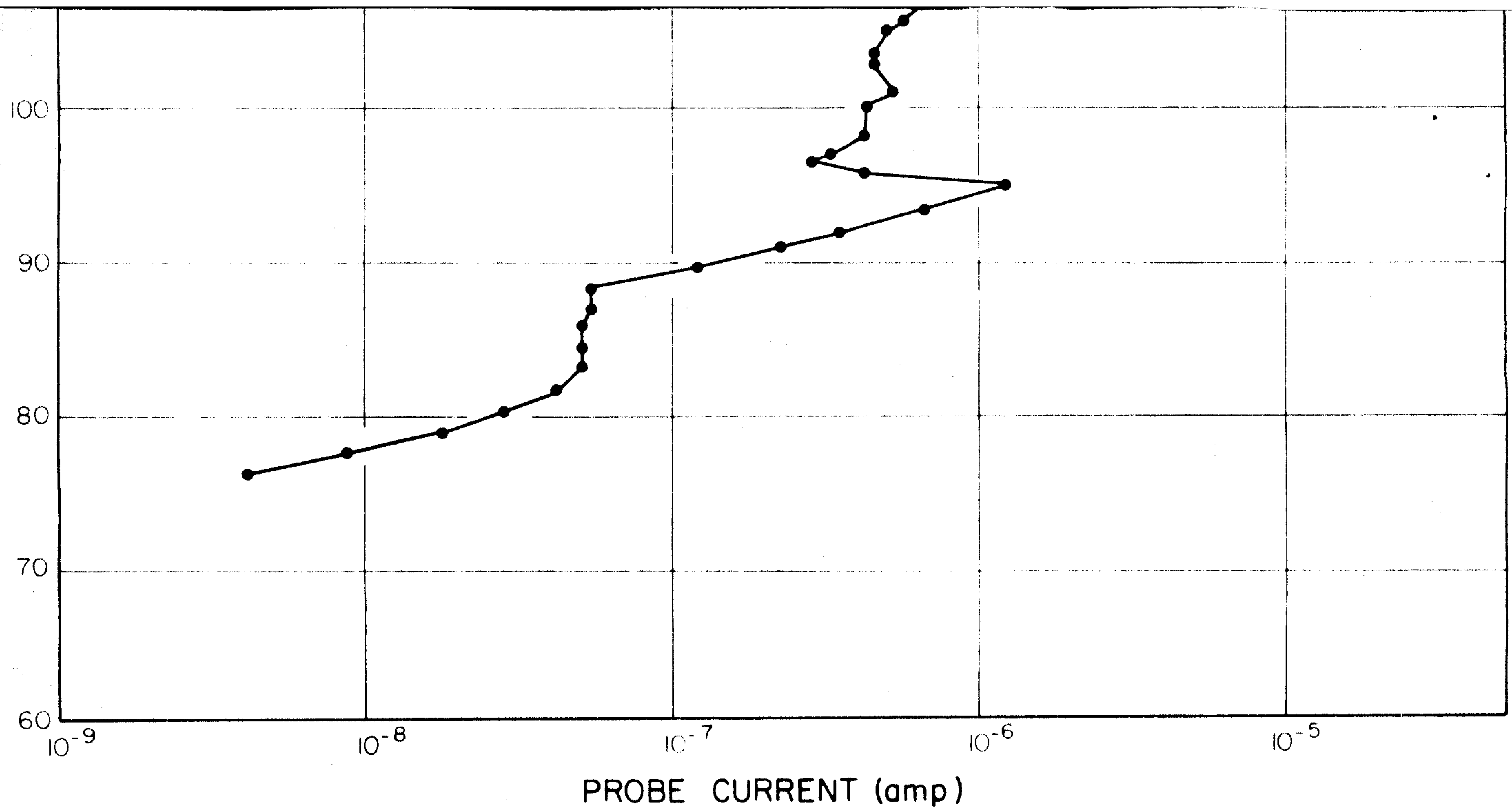


Figure 1.

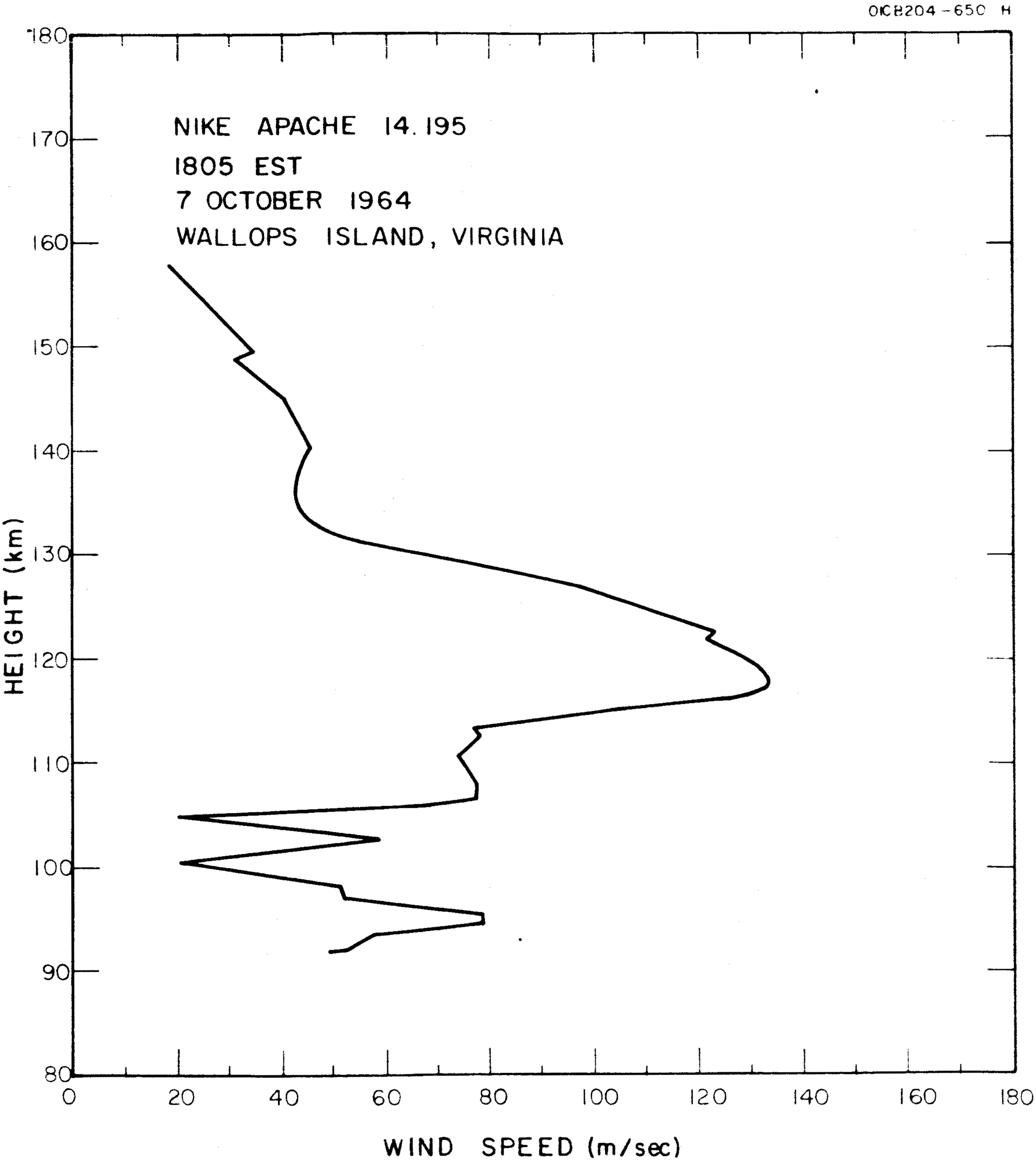
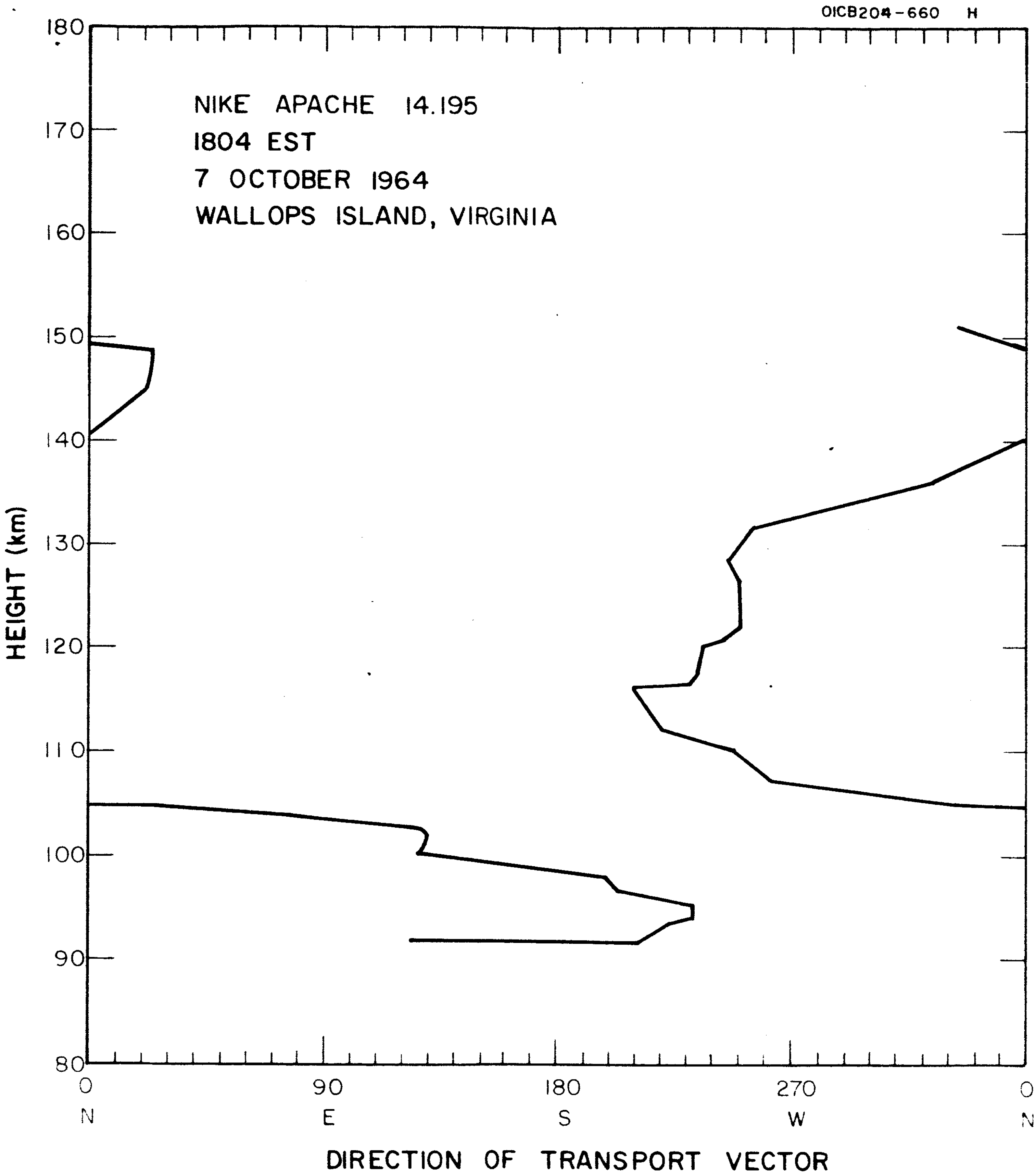
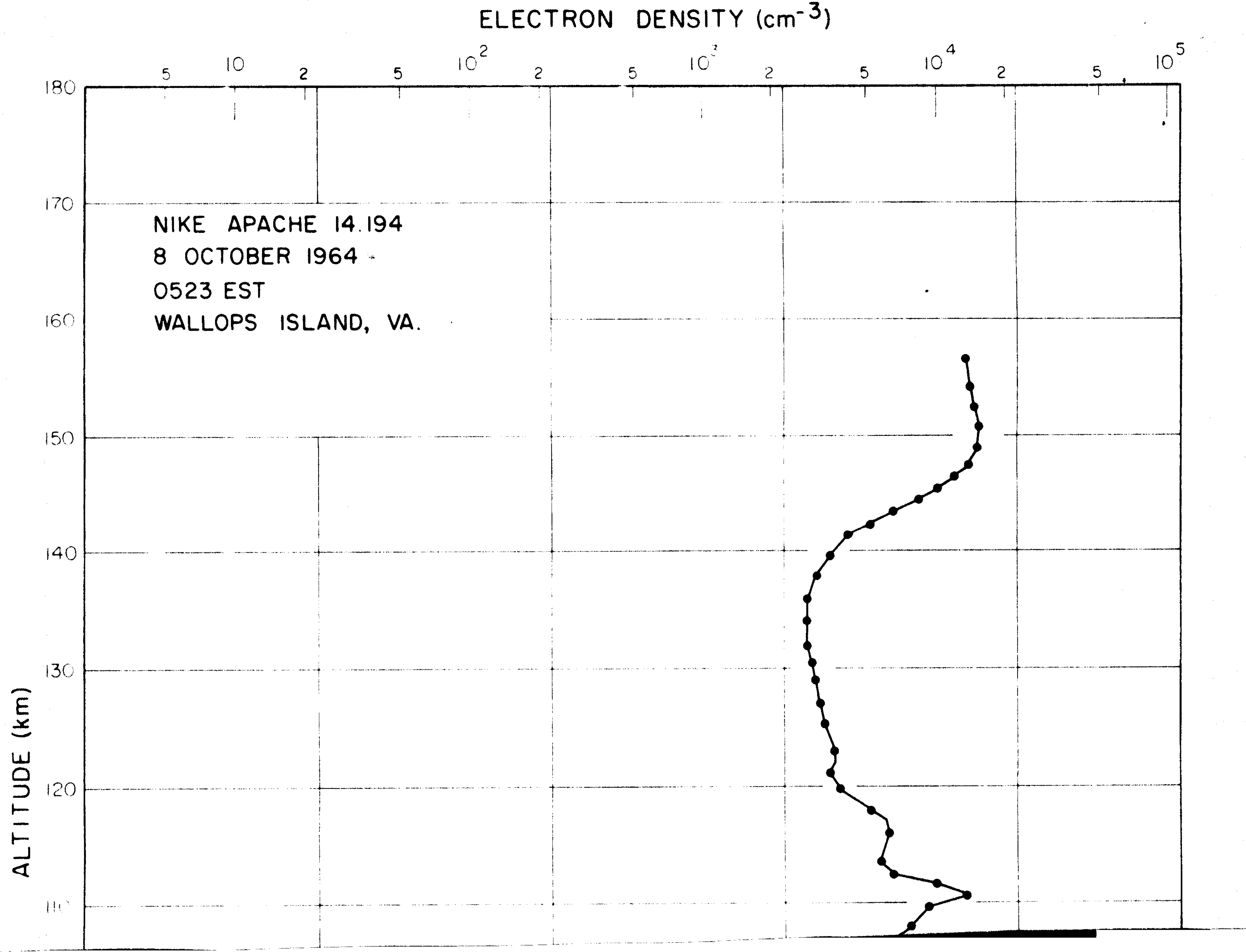

0ICB204-650 H
NIKE APACHE 14.195
1805 EST
7 OCTOBER 1964
WALLOPS ISLAND, VIRGINIA
HEIGHT (km)
WIND SPEED (m/sec)
180
170
160
150
140
130
120
110
100
90
80
0
20
40
60
80
100
120
140
160
180

Figure 2a.



OICB204-660 H
NIKE APACHE 14.195
1804 EST
7 OCTOBER 1964
WALLOPS ISLAND, VIRGINIA
HEIGHT (km)
180
170
160
150
140
130
120
110
100
90
80
0
N
90
E
180
S
270
W
0
N
DIRECTION OF TRANSPORT VECTOR

Figure 2b.


ELECTRON DENSITY (cm^{-3})
5
10
2
5
10^2
2
5
10^3
2
5
10^4
2
5
10^5
180
170
160
150
140
130
120
110
ALTITUDE (km)
NIKE APACHE 14.194
8 OCTOBER 1964
0523 EST
WALLOPS ISLAND, VA.

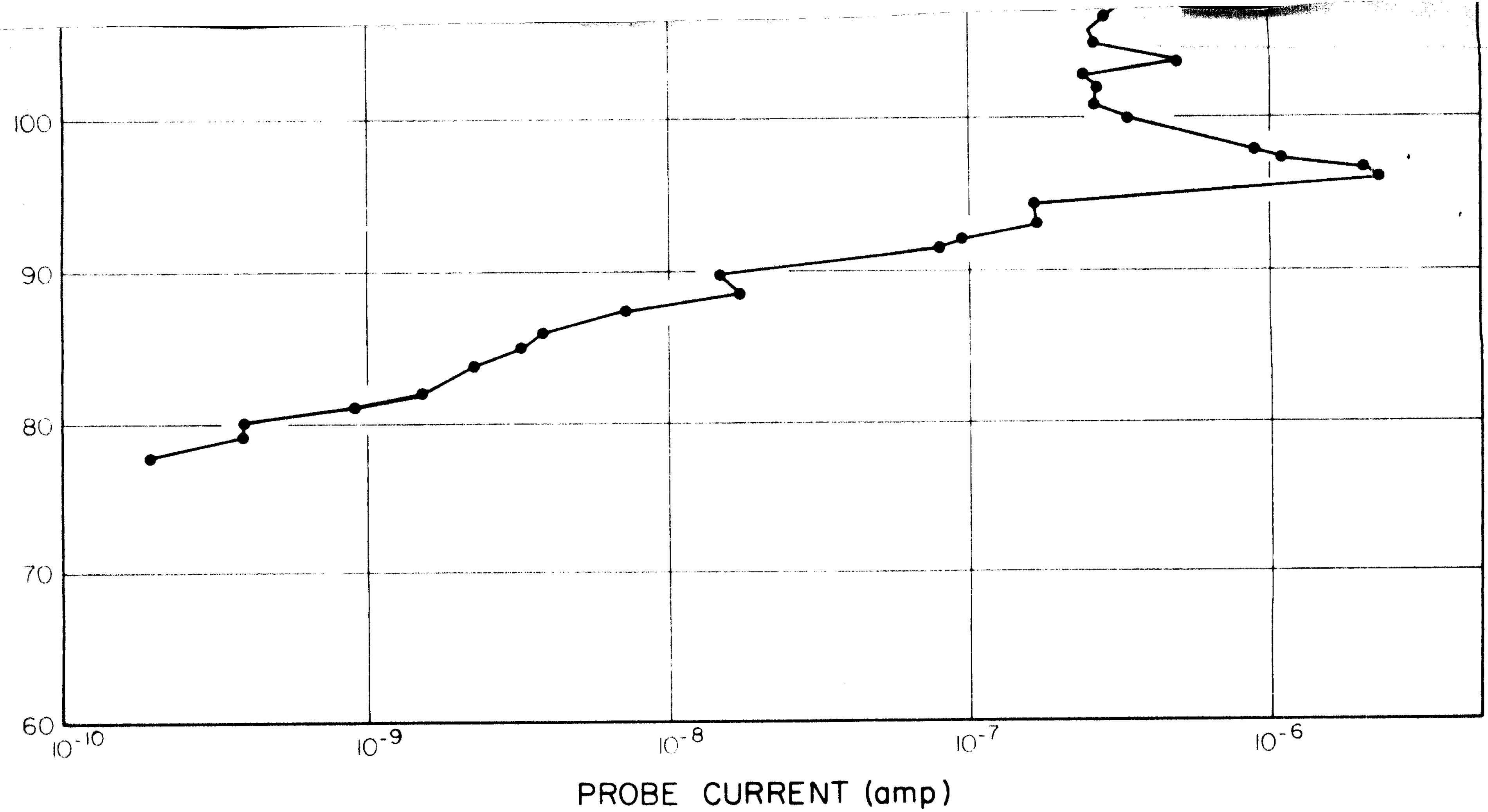
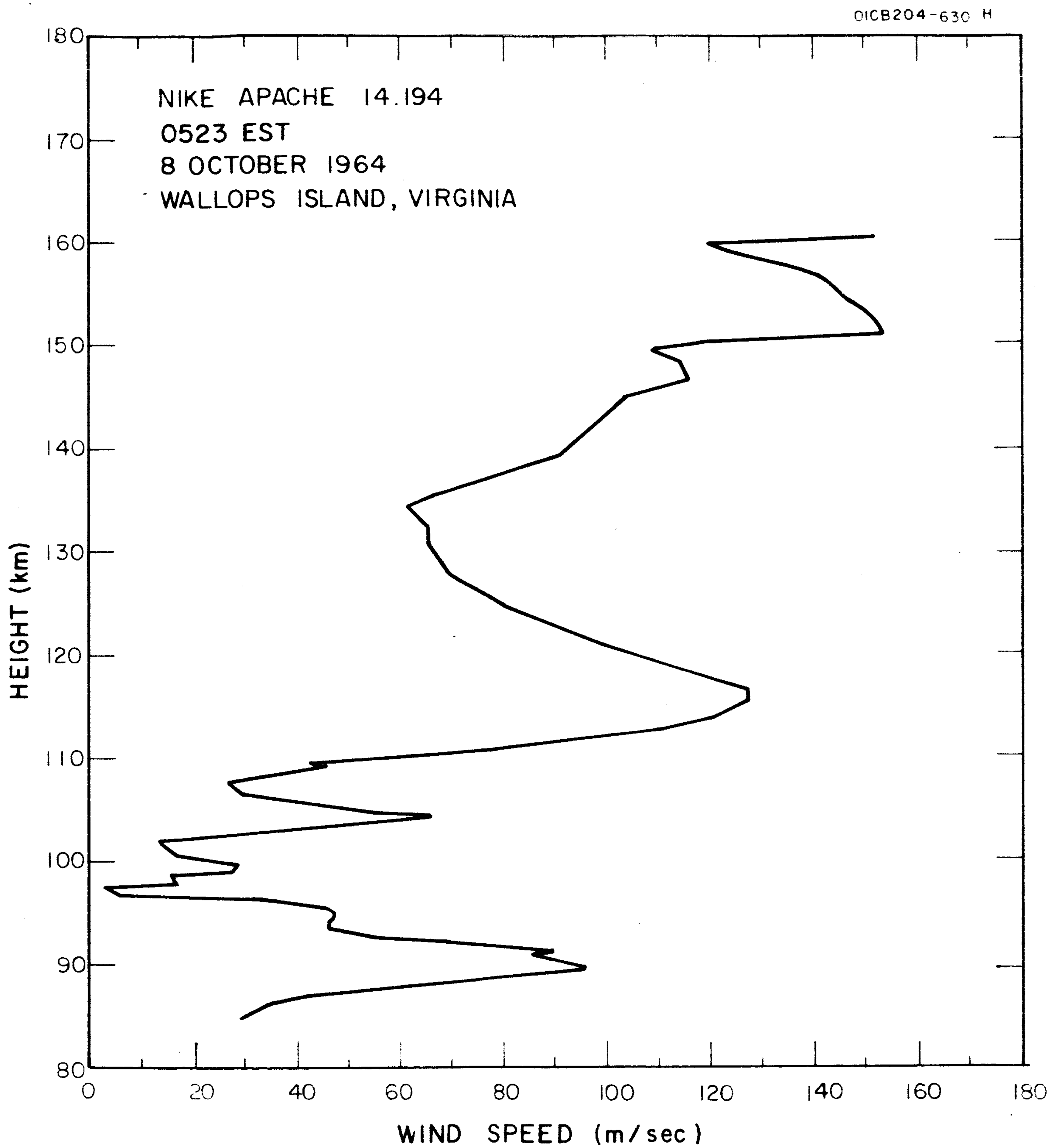
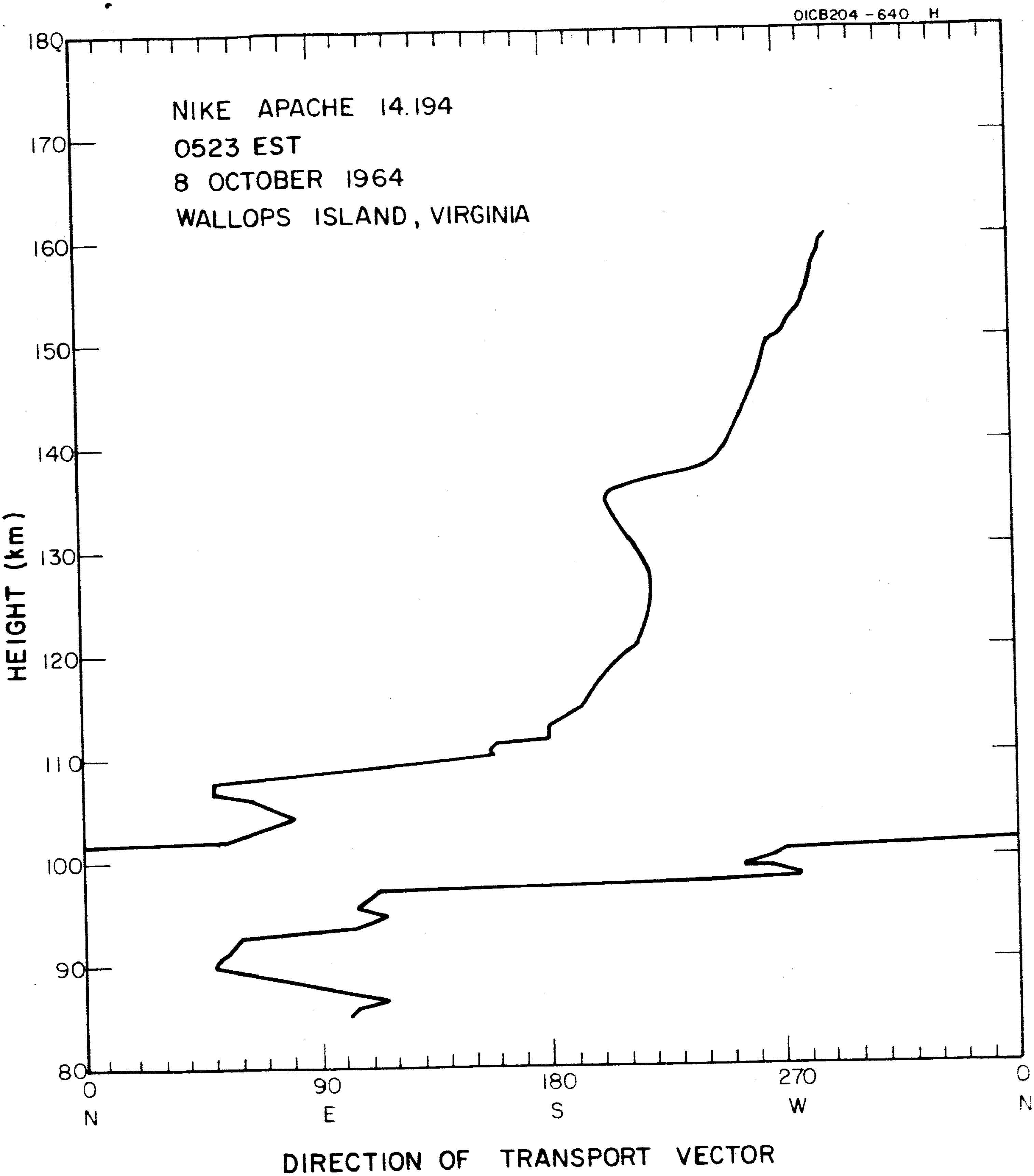


Figure 3.



01CB204-630 H
NIKE APACHE 14.194
0523 EST
8 OCTOBER 1964
WALLOPS ISLAND, VIRGINIA
HEIGHT (km)
WIND SPEED (m/sec)
180
170
160
150
140
130
120
110
100
90
80
0
20
40
60
80
100
120
140
160
180

Figure 4a.



01CB204 - 640 H
NIKE APACHE 14.194
0523 EST
8 OCTOBER 1964
WALLOPS ISLAND, VIRGINIA
HEIGHT (km)
180
170
160
150
140
130
120
110
100
90
80
0
N
90
E
180
S
270
W
0
N
DIRECTION OF TRANSPORT VECTOR

Figure 4b.

No detailed study of the data has yet been made. However, some preliminary observations may be made. The ejection of sodium vapor caused temporary loss of the telemetry signal as was expected. The TMA release did not affect the quality of the telemetry signal but did cause some disturbance of the probe current. However, the probe data could be compared on both the up and down portion of the trajectory and measurements of electron density were made in exactly the same place as the winds were measured. Although the disturbance on the down leg measurements obscures detailed structure, major variations from the up leg measurements are easily detected. The most outstanding feature of both of the ionization profiles is the layer of greatly enhanced ionization at 113 km during the evening of 7 October 1964.

A photograph of the TMA trail is shown in Figure 5. It is interesting to note that the trail is more narrow than a corresponding alkali-vapor trail due to the slower diffusion of the heavier vapor. The upper part of the trail had a blue-green color, which probably was due to resonance scattering in aluminum oxide bands. Some spectral observations of the trail were made by W. Fastie at John Hopkins University, but the results are not known. The lower portion of the trail showed an increase brightness and appeared white to the eye. The reason for this is not understood at present, but it may be related to the nighttime emission from TMA which is reported to be a continuum. It is desirable that more complete spectral observations be made of future TMA trails.

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Figure 5.

PROJECT STATUS

Concurrently with the final part of the development phase plans were made for the first field trip to Fort Churchill, Manitoba. It was planned to launch four combined payloads in one night, starting at evening twilight with a sodium-probe payload, followed by another sodium-probe payload four hours later. Then a TMA-probe payload after midnight to be followed by a second TMA-probe at morning twilight. The first attempt was scheduled for the night of 28-29 October 1964 but no rockets were launched due to extensive cloud cover. Due to continuing poor weather, this field trip was terminated on 15 November 1964, only one rocket of the series (Nike Apache 14.197) having been launched. This flight was successful and will be described in the next quarterly report. It is planned to again attempt the four launches in one night in February or March of 1965.

The personnel engaged on the project and their hours for the reporting period (24 July 1964 - 31 October 1964) are given below:

L. G. Smith	Project Manager	241 hours
J. F. Bedinger	Project Manager	130 hours
N. J. Guarino	Project Engineer	85 hours
P. J. McKinnon	Engineer	379 hours
C. G. Arouchon	Engineer	158 hours
S. A. Sapuppo	Engineer	241 hours
A. Corman	Engineer	459 hours
T. Trovato	Engineer	323 hours

W. Aman	Engineer	433 hours
W. Burke	Engineer	356 hours
E. Yavner	Engineer	28 hours
J. Campos	Engineer	264 hours
R. Minzner	Scientist	162 hours
Camera operators, and	Technicians	3,446 hours
	Machinists	804 hours
	Drafting	751 hours
	Clerical	110 hours