#243

ALOUETTE 1 62-049A-01Q

ALOUETTE 2 65-098A-01N

ISIS 1 69-009A-01E

ISIS 2 71-024A-01E

INDEX OF DUCTED ECHOES

Table of Contents

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1. INTRODUCTION:

The documentation for this data set was originally on paper, kept in NSSDC's Data Set Catalogs (DSCs). The paper documentation in the Data Set Catalogs have been made into digital images, and then collected into a single PDF file for each Data Set Catalog. The inventory information in these DSCs is current as of July 1, 2004. This inventory information is now no longer maintained in the DSCs, but is now managed in the inventory part of the NSSDC information system. The information existing in the DSCs is now not needed for locating the data files, but we did not remove that inventory information.

The offline tape datasets have now been migrated from the original magnetic tape to Archival Information Packages (AIP's).

A prior restoration may have been done on data sets, if a requestor of this data set has questions; they should send an inquiry to the request office to see if additional information exists.

2. ERRATA/CHANGE LOG:

NOTE: Changes are made in a text box, and will show up that way when displayed on screen with a PDF reader.

When printing, special settings may be required to make the text box appear on the printed output.

Version	Date	Person	Page	Description of Change
01				
02				

3 LINKS TO RELEVANT INFORMATION IN THE ONLINE NSSDC INFORMATION SYSTEM:

http://nssdc.gsfc.nasa.gov/nmc/

[NOTE: This link will take you to the main page of the NSSDC Master Catalog. There you will be able to perform searches to find additional information]

4. CATALOG MATERIALS:

a. Associated Documents — To find associated documents you will need to know the document ID number and then click here. http://nssdcftp.gsfc.nasa.gov/miscellaneous/documents/

b. Core Catalog Materials

ALOUETTE 1	62-049A-01D
ALOUETTE 2	65-098A-01N
ISIS 1	69-009A-01E
ISIS 2	71-024A-01E

CRC INDEX OF DUCTED ECHOES

ARC N(H) INT. PROFILES

THIS DATA SET HAS BEEN RESTORED. THERE WAS ORIGINALLY ONE 9-TRACK, 800 BPI TAPE, WRITTEN IN EBCDIC. THERE IS ONE RESTORED TAPE. THE DR TAPE IS A 3480 CARTRIDGE AND THE DS TAPE IS 9-TRACK, 6250 BPI. THE ORGINAL TAPE WAS CREATED ON AN IBM 360 COMPUTER. THE DR AND DS NUMBERS ALONG WITH THE CORRESPONDING D NUMBER AND TIME SPAN IS AS FOLLOWS

DR#	DS#	DD#	FILES	TIME SPAN
DR002716	DS002716	D012316	1	12/01/62 - 12/31/68

*I/O ERROR ON RECORD #2911

REQ. AGENT	RASH NO.	ACQ. AGENT
WTJ	RB4544	LLD

INDEX OF DUCTED ECHOES

ALOUETTE 1 62-049A-01Q

ALOUETTE 2 65-098A-01N

ISIS 1 69-009A-01E

ISIS 2 71-024A-01E

These data sets contained on 1 800 BPI, EBCDIC, 9-track tape that was produced on an IBM 360 computer. The data is contained in 1 file where each satellite is distinguised by a satellite number found in character position 1-2.

D-12316 C-09639

SATELLITE	START	STOP
ALOUETTE 1	12/01/62	12/31/68
ALOUETTE 2	11/29/65	10/30/71
ISIS 1	02/01/69	12/27/71
ISIS 2	04/09/71	06/22/72

CONJUGATE ECHO DATA

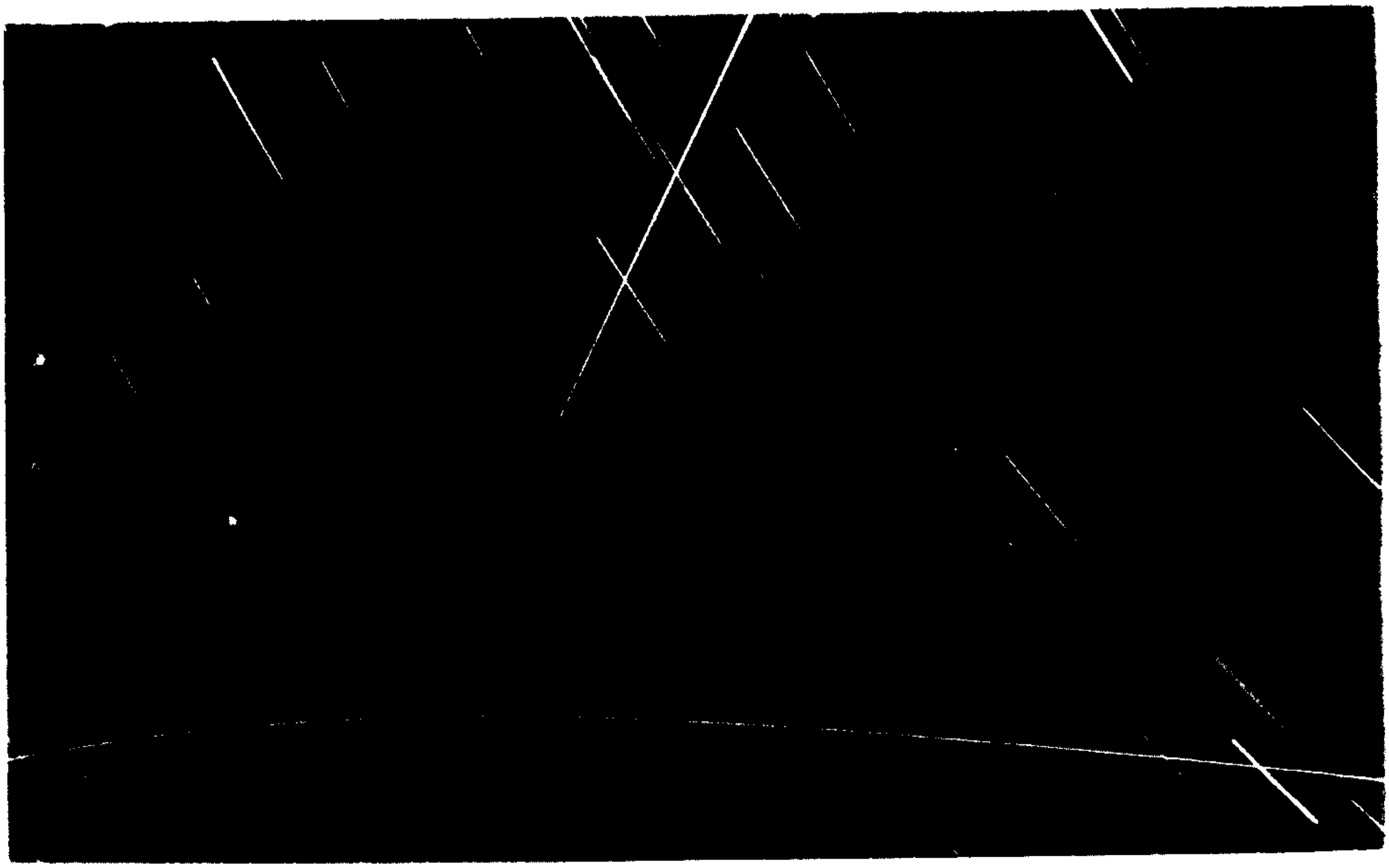
Conjugate echo data scaled from Topside Sounder Ionograms recorded by Satellites Alouette 1 & 2 and ISIS 1 & 2 are available on a digital magnetic tape. The very first record on the tape is a 42 character record containing English language text describing the contents of the tape.

The data (after first record) have the format described below:

CHARACTER POSITION	FORMAT	DESCRIPTION
1-2	I2	Satellite number 1 (Alouette 1) 2 (Alouette 2) 3 (ISIS 1) 4 (ISIS 2)
3-5	I3	Station number
6-8	I3	Year
9-12	I4	Day number
13-17	I5	Hours and minutes (GMT) (Beginning of Pass)
18-20	I3	Number of ionograms with ducted echoes
21-23	I3	Number of ionograms without ducted echoes

Number of Records for Individual Satellites:-

SATELLITE		NUMBER OF RECORDS (PASSES)	5	8	3	21	48
Alouette 1		209	62-65, 67-68				
Alouette 2	65-68 (43)	4452	65-68	65-68	65-67	65-68	65-6[illegible]
ISIS 1	69-71	3050	69-71	69-71	69-71	69-7[illegible]	69-71
ISIS 2		524	71-[illegible]				71
TOTAL Records on Tape		8235					



B05106-000A

DATA USERS' NOTE

NSSDC 67-29

ALOUETTE 1 (1962 BETA ALPHA 1)

TOPSIDE SOUNDER

JULY 1967

NATIONAL SPACE SCIENCE DATA CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION · GODDARD SPACE FLIGHT CENTER, GREENBELT, MD.

DATA USERS' NOTE
NSSDC 67-29

ALOUETTE 1 (1962 BETA ALPHA 1) TOPSIDE SOUNDER

INVESTIGATORS

G. L. B. Nelms
E. Warren
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J. E. Jackson

JULY 1967

FOREWORD

This Data Users' Note is specifically designed to help potential data users decide if they can make use of the data obtained in the Alouette 1 (1962 Beta Alpha 1) topside sounder experiment. Once a data user decides that he requires the data, it will serve as the unifying element – the key – in the actual use of the data available at the National Space Science Data Center (NSSDC). To achieve these goals, the Note briefly describes the experiment, including the instrumentation and measurements, the telemetry, and the operational experience. All available details are then provided on the actual reduction techniques and format of recorded data. For those desiring more details, names and addresses of the investigators are provided to facilitate direct contact. As a further aid, detailed references (and bibliography) are also included. When available, NASA accession numbers* are given. The primary purpose of these references is to identify the sources containing complete information concerning the subject under discussion. Most of these references are physically available at NSSDC – those that are not are readily obtainable.

*For example, N64-2243 is an accession number for an article reported in the *Scientific and Technical Aerospace Reports* (STAR), and A63-5921 refers to an entry in the *International Aerospace Abstracts* (IAA).

CONTENTS

LIST OF FIGURES

ALOUETTE 1 (1962 BETA ALPHA 1) TOPSIDE SOUNDER

BACKGROUND

The Alouette 1 topside sounder satellite was launched on September 29, 1962, from the Pacific Missile Range. The Canadian Defence Research Telecommunications Establishment (DRTE) of Ottawa, Canada, proposed and constructed the satellite in cooperation with NASA. The orbital period of Alouette 1 was 105.5 min and the inclination was 80.5 deg to the equatorial plane. The spacecraft achieved a nearly circular orbit having an apogee of approximately 1030 km and a perigee of 998 km.[1,2]

The topside sounder instrumentation was one of the four experiments on Alouette 1, as shown in Figure 1. The primary data collected from the topside sounder underwent several different methods of reduction by DRTE scientists, as well as by scientists at Ames Research Center (ARC), Goddard Space Flight Center (GSFC), the Institute for Telecommunication Sciences and Aeronomy (ITSA), and the Radio and Space Research Station (RSRS). These data are grouped according to the arrangement shown in Figure 1.

INVESTIGATORS

G. L. B. Nelms – Defence Radio Telecommunications Establishment*
E. Warren – Defence Radio Telecommunications Establishment*
R. Fitzenreiter – Goddard Space Flight Center**
J. E. Jackson – Goddard Space Flight Center**

See the "Data" section for the names and current addresses of other investigators.

EXPERIMENT

Instrumentation and Measurements

The topside sounding technique used in Alouette 1 was an extension of the sounding method used for routine ionospheric sounding observations from the ground. In general, this equipment consists of a low frequency radar system

*Address: Defence Radio Telecommunications Establishment, Shirley Bay, Ottawa 4, Ontario, Canada.

**Address: Goddard Space Flight Center, Code 615, Greenbelt, Maryland 20771.

FIGURE 1

ALOUETTE 1 EXPERIMENTS

No.	Experiment	Investigator(s)	Affiliation
01	Topside Sounder	G. L. B. Nelms E. Warren R. Fitzenreiter J. Jackson	DRTE[a] DRTE[a] GSFC[b] GSFC[b]
	A – Ionograms (Primary Data)	G. L. B. Nelms	DRTE[a]
	B – Alosyn	E. L. Hagg	DRTE[a]
	C – Synoptic Data	W. Calvert	ITSA[c]
	D – Electron (Number) Density Profiles	G. L. B. Nelms G. E. K. Lockwood	DRTE[a] DRTE[a]
	E – Electron Density Profiles	W. Calvert T. E. Van Zandt J. W. King	ITSA[c] ITSA[c] RSRS[d]
	F – Electron Density Profiles and Scale Height Profiles	J. O. Thomas M. J. Rycroft L. Colin K-L. Chan	ARC[e] ARC[e] ARC[e] ARC[e]
02	Energetic Particle Counters	D. C. Rose I. B. McDiarmid	NRC[f] NRC[f]
03	VLF Receiver	J. S. Belrose R. Barrington	DRTE[a] DRTE[a]
04	Cosmic Noise	T. R. Hartz	DRTE[a]

a – Defence Research Telecommunications Establishment (Canada)
b – Goddard Space Flight Center
c – Institute for Telecommunication Sciences and Aeronomy (formerly known as Central Radio Propagation Laboratories, CRPL)
d – Radio and Space Research Station (formerly known as Radio Research Station, Great Britain)
e – Ames Research Center
f – National Research Council (Canada)

NOTE: Some of the affiliations have changed since the time of the Alouette 1 experiments. Current addresses are provided in the descriptions of the individual data sets.

in which the carrier frequency is swept from 1 Mc/s to about 20 Mc/s. The transmitted Ordinary wave signals propagate downward in the ionosphere and are subsequently reflected when they reach a region of electron density, N, which is given by[3]

$$N = 1.2388 \times 10^4 f^2$$

where

N = electron density per cm^3, and

f = frequency in Mc/s of the Ordinary ray†

The topside sounding instrument in Alouette 1 is basically a pulsed transmitter and receiver tuned to the transmitter wave frequency in order to obtain echo returns from the ionosphere. The wave frequency is continuously varied from 0.5 to 11.5 Mc/s at a rate of 1 Mc/s^2. The time required for one complete sweep is approximately 12 sec, during which time the satellite traveled a distance of about 80 km. The time interval between ionograms is about 18 sec, which corresponds to a distance of about 125 km.[3]

Telemetry

The output of the receiver was telemetered to the ground via a two-watt transmitter which operated in the 136-Mc/s band. The system operated on command from the ground, obtaining and telemetering data for a 10-min period after which it turned off automatically.

The telemetry signals were recorded on magnetic tape and were subsequently transcribed onto 35-mm film. In this manner, a photographic record was provided showing the variation of the virtual depth of reflection beneath the satellite, P', as a function of the frequency, f, of the transmitted radio waves.[1]

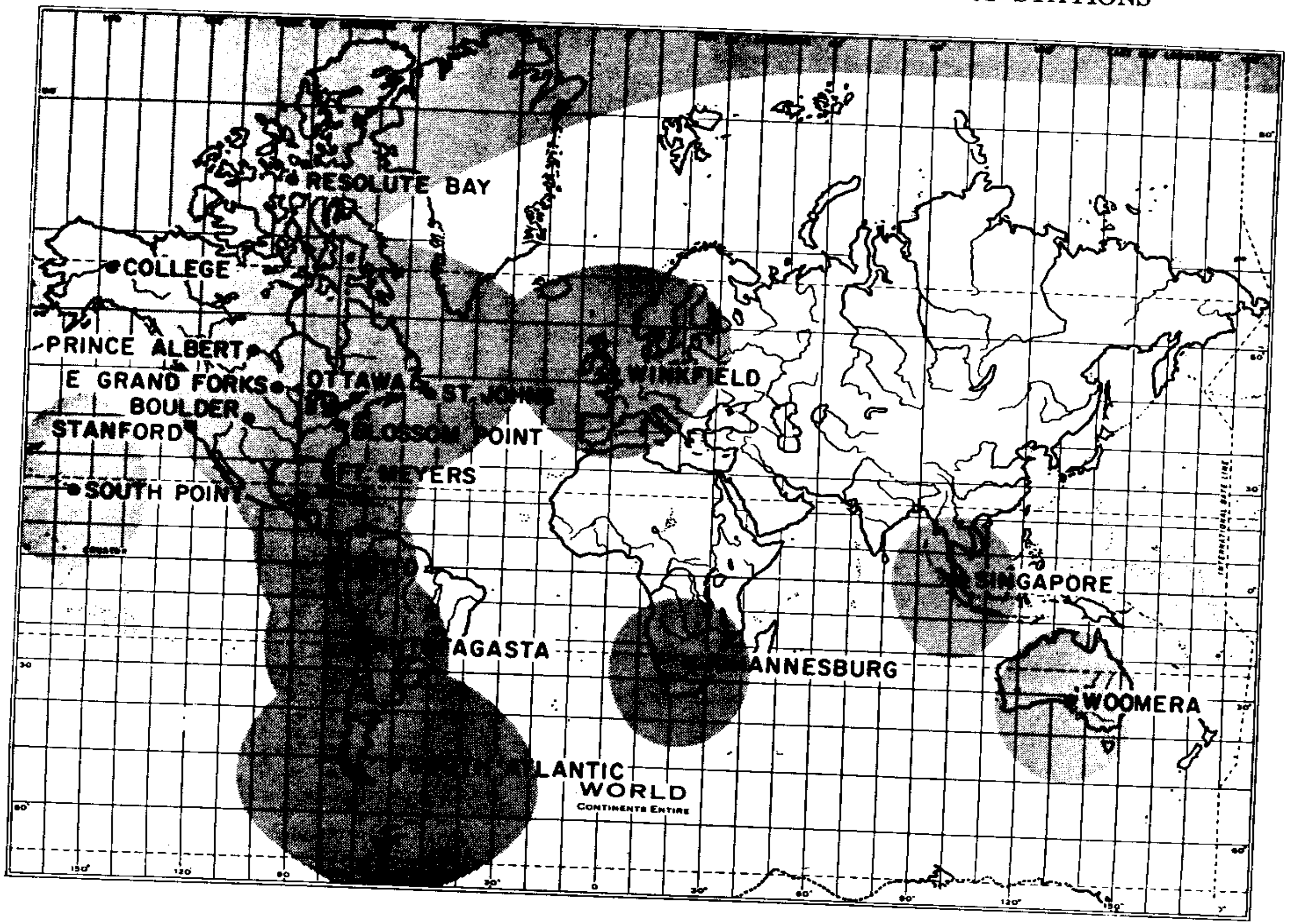
Operational Experience

The Alouette tracking stations, as shown in Figure 2, are situated in locations which provided for successive monitoring from 80°N to 80°S.[4] Since the satellite orbit rotated only 0.99° per day, three months were required to sample all local times at the equator.[5] Ionograms are still being recorded at the time of publication of this Note.

†By agreement, all investigators use 1.24×10^4 as the multiplicative constant.

FIGURE 2

LOCATION AND COVERAGE OF ALOUETTE 1 TELEMETRY STATIONS



DATA

Introductory Remarks

As stated earlier in this Note, the variable depths of reflection below the satellite, P', of radio pulses vertically incident on the topside ionosphere were measured as a function of frequency, f. The frames of 35-mm film showed traces of the P'(f) data. From these traces, or ionograms, various methods of data reduction were used to obtain the data sets listed in Figure 1.

The virtual depth of reflection below the satellite, P', is defined by $P' = 1/2\ ct$, where c is the speed of light and t is the travel time. Since the radio pulse did not travel in a vacuum, but in a plasma, the actual distance traveled differed from the virtual depth. If h is the real depth of reflection below the satellite, then for the Extraordinary trace:

$$P'(f) = \int_{f_{os}}^{f_{Nr}} M' \frac{dh}{df_N} df_N$$

where

f = the measured Extraordinary wave frequency on the ionogram trace

$f_{Nr} = (f^2 - ff_H)^{1/2}$ = plasma frequency at the reflection point

f_H = the gyrofrequency for an electron in the earth's magnetic field for the position corresponding to h

fos = $(f_{xs}^2 - f_{xs}\ f_{Hs})^{1/2}$ where the s denotes the frequencies at the position of the satellite. fos is the plasma frequency at the satellite.

f_{xs} = the frequency at which the Extraordinary trace had zero range

M' = the group refractive index of the Extraordinary ray, which may be calculated from the Appleton-Hartree Magneto-ionic equation, and,

f_N = the plasma frequency (considered as a variable dependent upon the altitude).[1]

The following pages include a brief description of the primary data set (ionograms) and the derived data sets, as well as a summary of the reduction techniques involved for each set. These descriptions are arranged in the order in which they appear in Figure 1.

A – Ionograms

Investigator

G. L. B. Nelms – Defence Radio Telecommunications Establishment

The Alouette ionograms exhibit plasma resonances, echoes from Ordinary, Extraordinary and Z plasma modes, and echoes from below the F2 maximum atmospheric layer reflections. The ionograms, on 35-mm film, were directly recorded from the analog record. The analog record contained time, frequency versus virtual depth signals, and frequency markers. These markers occurred at 0.5, 1.5, 2.0, 2.5, 3.5, and 7.0 Mc/s and were generated on board the satellite. The vertical lines, showing frequency (see sample in Figure 3), were constructed from the frequency markers at the time of filming.

The frequency lines began at any point and moved downward to the bottom of the ionogram, and once again moved from top to bottom. The beginning point, or the left extreme of the frequency lines, gives the exact frequency values as shown in Figure 3.

Several methods of time coding appear on the filmed ionograms. These are shown in Figures 4-7.* In each of these figures, an actual photograph of an ionogram containing a certain type of code is shown along with a schematic representation of the coded ionogram. Figure 4 shows a Horizontal Binary Dot Coding. The time code is represented along the lower edge of the ionogram in binary code. The code is formed by representing each character by a vertical grouping of dots representing various powers of 2 with decreasing magnitude found in the forward direction. The code beds are located as follows:

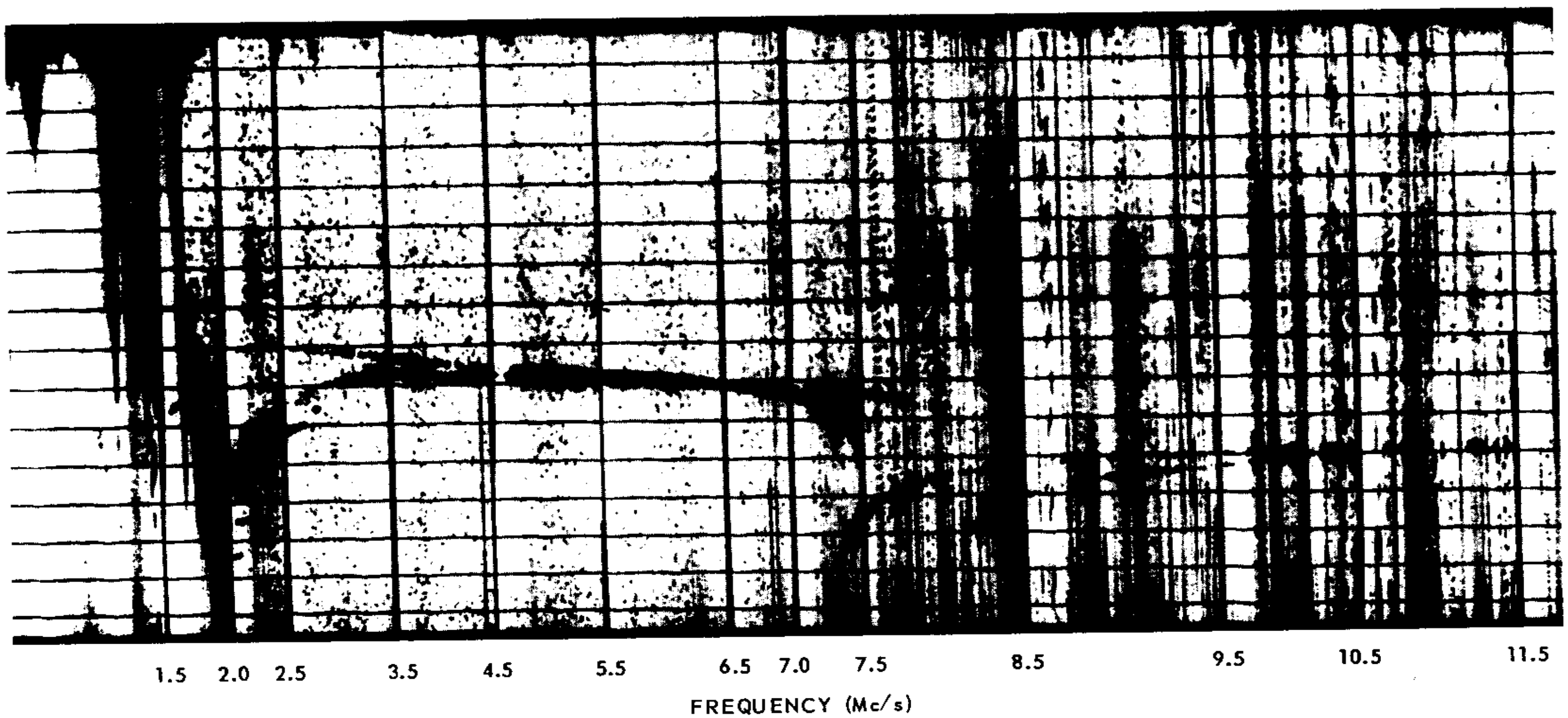
the first three vertical dot groupings representing the day,
the fourth and fifth groupings representing the hour,
the sixth and seventh representing the minutes,
the eighth and ninth representing the seconds, and
the tenth and last vertical group of dots representing the station number.

Figure 5 illustrates a display of Vertical Binary Dot Coding. This system of coding is identical to the horizontal coding except that the code groupings run vertically upward from the bottom left of the ionogram. This code is most easily read with the ionograms in the vertical position with the frequency markers

*At times, the identification is not complete. For example, Figures 4 and 5 do not indicate the year—complete identification can be obtained from the film log sheets.

FIGURE 3

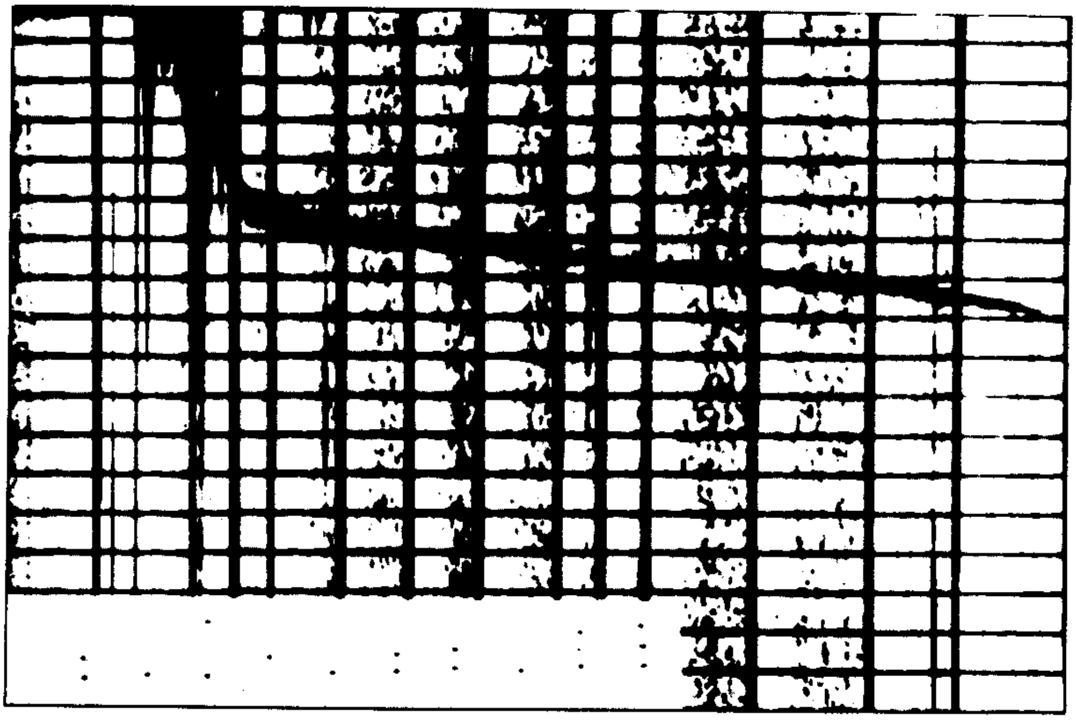
SAMPLE OF TYPICAL IONOGRAM



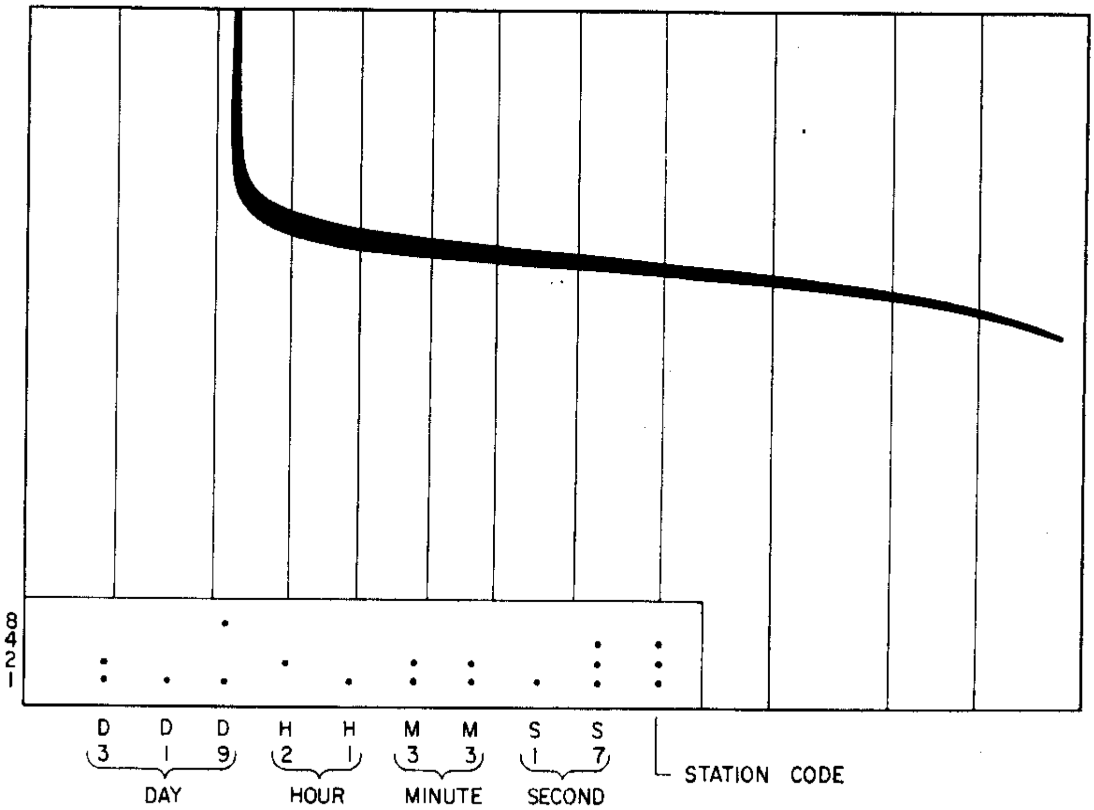
NOTE: The frequency lines and lines of virtual depth are not labelled on the 35-mm frames. The lines have essentially the same values on all frames.

FIGURE 4

DRTE BINARY DOT CODING - HORIZONTAL DISPLAY



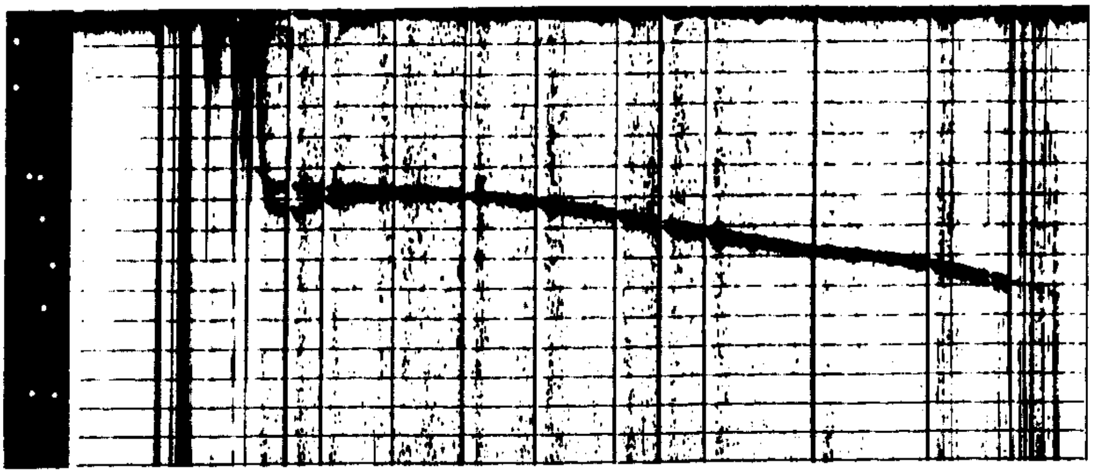
ACTUAL IONOGRAM



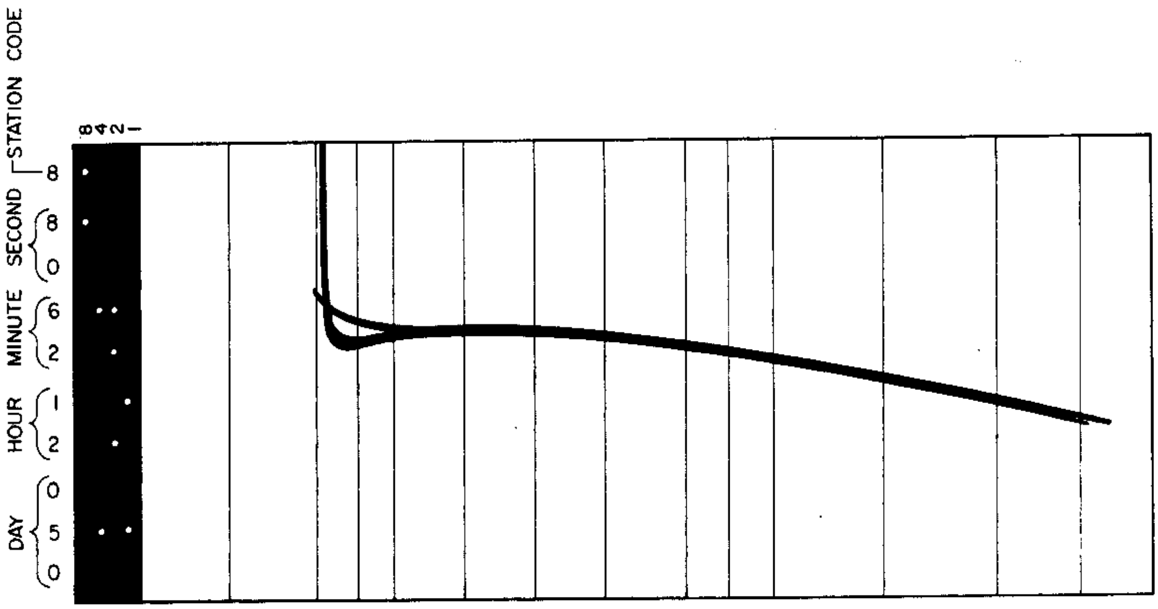
IONOGRAM SCHEMATIC

FIGURE 5

DRTE BINARY DOT CODING – VERTICAL DISPLAY



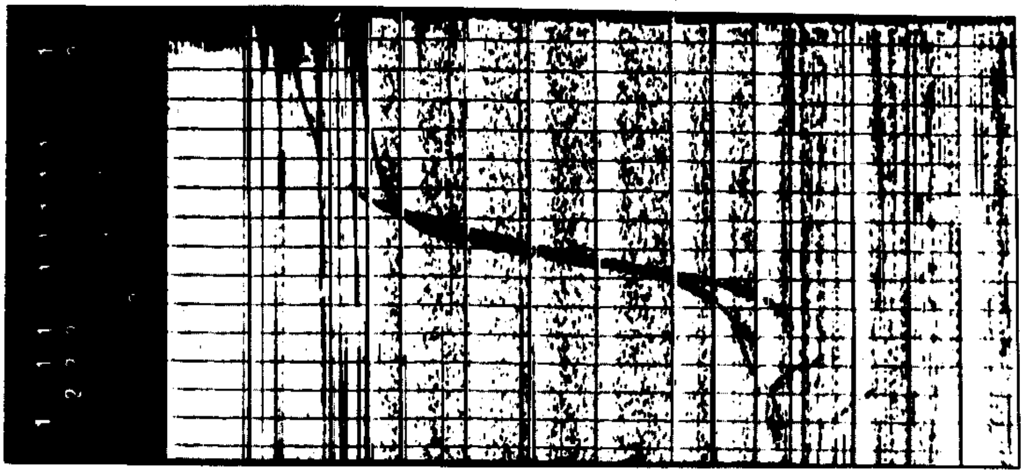
ACTUAL IONOGRAM



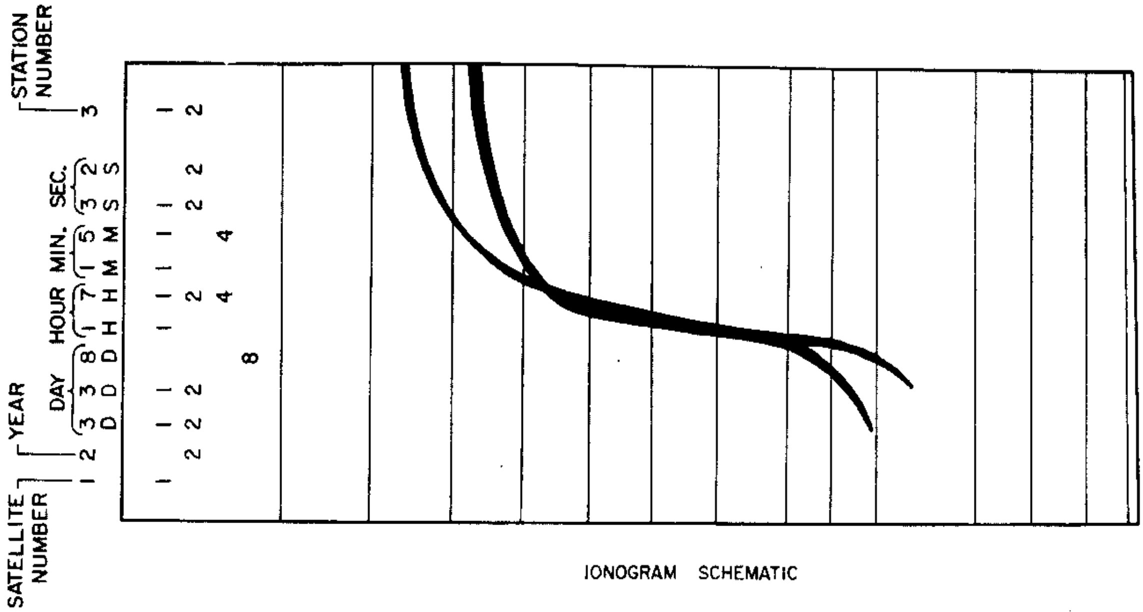
IONOGRAM SCHEMATIC

FIGURE 6

DRTE BINARY DIGITAL CODING



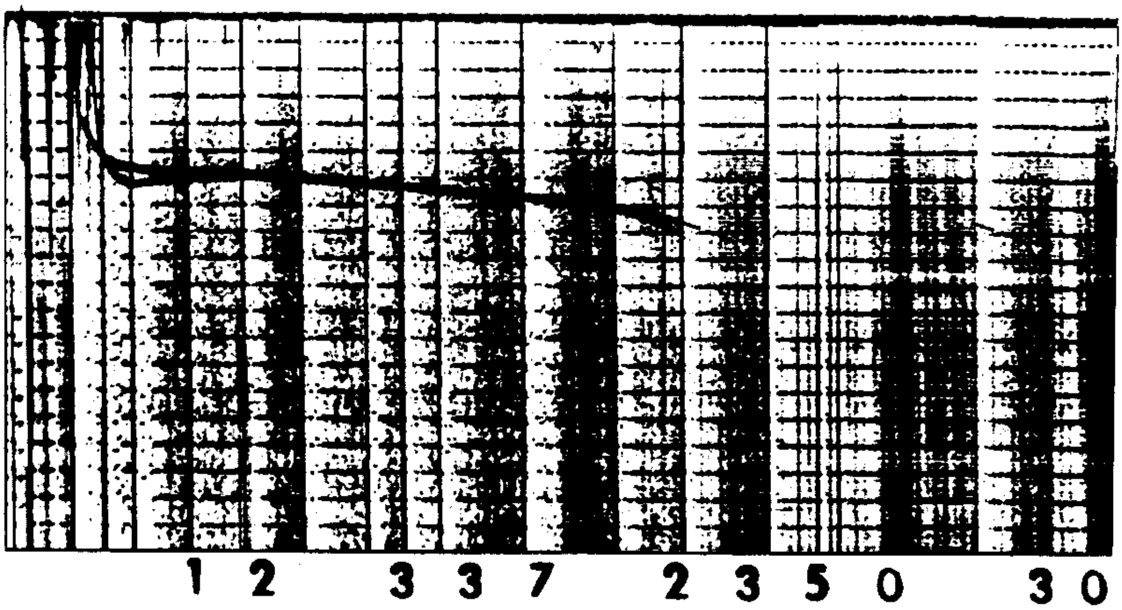
ACTUAL IONOGRAM



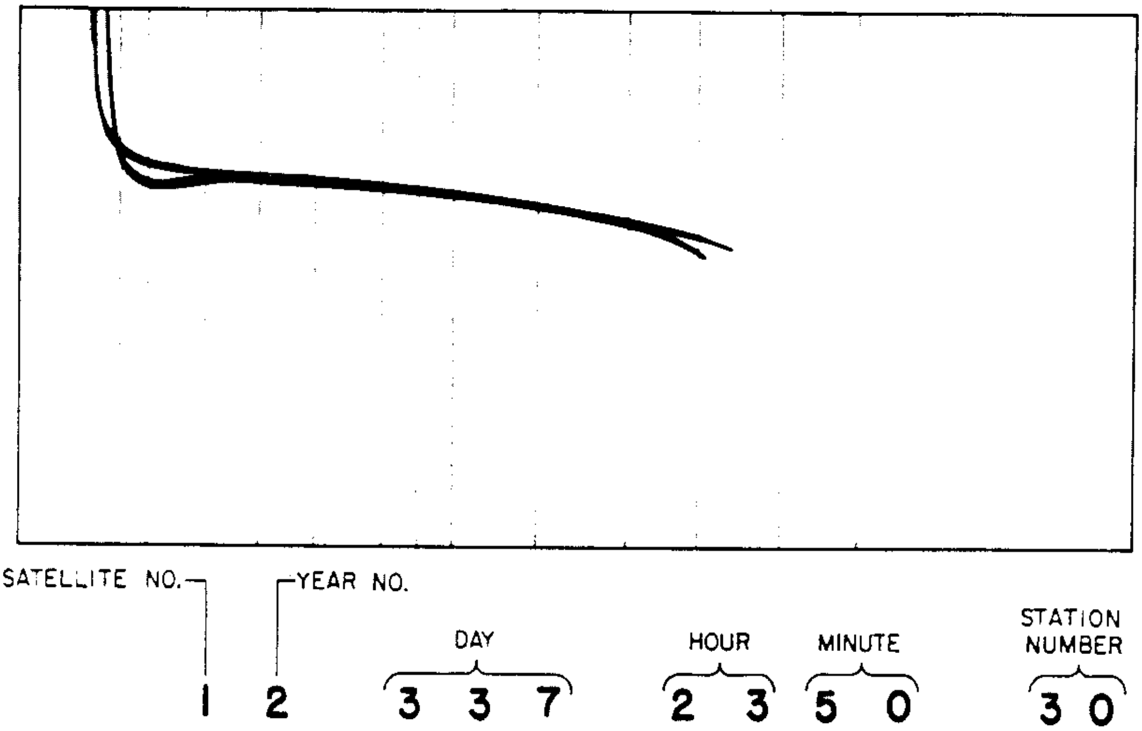
IONOGRAM SCHEMATIC

FIGURE 7

NUMERICAL TIME CODING



ACTUAL IONOGRAM



IONOGRAM SCHEMATIC

increasing in the downward direction. The code is then read with the significance of binary code beds from left to right as follows:

the first three vertical groupings representing the day,
the fourth and fifth groupings representing the hour,
the sixth and seventh representing the minutes,
the eighth and ninth representing the seconds, and
the tenth representing the station code.

When the ionogram is held in the vertical position, the higher powers of two are at the top.

A third method of time coding, shown in Figure 6, is the Binary Digital Coding. This is a vertical display in which arabic numerals are used instead of dots and two extra code groupings are added to give the satellite number and last digit of the year. The coding is located on the left edge of the ionogram and is best read with the numerals in the upright position. The sum of the digits in each vertical code grouping gives the number to be represented. The significance of the code groupings running from left to right is as follows:

the first group gives the satellite number,
the second group gives the last digit of the year,
the third, fourth, and fifth groups give the days since the start of the year,
the sixth and seventh groupings give the hours,
the eighth and ninth groupings give the minutes,
the tenth and eleventh groupings give the seconds, and
the twelfth and thirteenth groupings give the station number.

An additional Numerical Time Coding is given in Figure 7. This code is printed in arabic numerals at the bottom of the ionogram. The significance of the numerals from left to right is as follows:

the first digit is the satellite number,
the second is the last digit of the year,
the third, fourth, and fifth digits are the days of the year,
the sixth and seventh are the hours,
the eighth and ninth are the minutes, and
the last digits are the station code.

The Alouette telemetry station code list is given in Figure 8. The station number, three-letter code, and geographic latitude and longitude are included for each station.

FIGURE 8

CODE LIST FOR ALOUETTE TELEMETRY STATIONS

STATION NAME	STATION NUMBER	3-LETTER CODE	GEOGRAPHIC LAT.	LONG.
Antofagasta, Chile	8*	ANT	23.6S	70.3W
Blossom Point, Maryland	14*, 1	BPT	38.4N	77.1W
Boulder, Colorado	46	BLR	40.1N	105.1W
College, Fairbanks, Alaska	5*, 13	COL	64.9N	147.8W
Darwin, Australia	65	DAR	12.5S	130.8E
East Grand Forks, Minnesota	13*, 14	GRK	48.0N	97.1W
Fort Myers, Florida	6*, 3	FTM	26.6N	81.9W
Gilmore Creek, Fairbanks, Alaska	49	GIL	65.0N	147.5W
Johannesburg, South Africa	16	JOB	25.9S	27.7E
Kano, Nigeria	53	KNO	12.0N	8.5E
Kauai, Hawaii	37	HAW	22.1N	159.7W
Lima, Peru	6	LIM	11.8S	77.2W
Mojave, California	17	MOJ	35.3N	116.9W
Orroral Valley, Australia	21	RAL	35.6S	149.0E
Ottawa, Canada	3*, 50	OTT	45.4N	75.7W
Prince Albert, Canada	2*, 44	PRI	53.2N	105.9W
Quito, Ecuador	7*, 5	QUI	0.6S	78.6W
Resolute Bay, No. W. Territories	1*, 43	RES	74.7N	95.0W
Rosman, No. Carolina	20	ROS	35.2N	82.9W
St. John's, Newfoundland	4*, 12	NEW	47.6N	52.4W
Santiago, Chile	8*, 8	SNT	33.2S	70.1W
Singapore, Malaysia	11*, 48	SNP	1.3N	103.8E
South Atlantic, Falkland Islands	9*, 38	SOL	51.8S	57.9W
South Point, Hawaiian Islands	15*, 55	SPT	18.9N	155.7W
Stanford, California		STN	34.4N	122.2W
Tananarive, Madagascar	63	MAD	19.0S	47.3E
Tromso, Norway	25	TRO	69.7N	18.9E
University of Alaska, Fairbanks, Alaska	19	ULA	65.0N	147.5W
Winkfield, England	10*, 18*, 15	WNK	51.4N	0.4W
Woomera, Australia	12*, 18	WOO	31.1S	136.8E

*Indicates station number used prior to July 1965.

Additional information available for the interpretation and use of the ionograms includes log sheets for the rolls of filmed ionograms and refined world maps (Brouwer).

Each film log sheet includes the film number, the date the film was processed, the station name, the pass time, tape number, and qualitative remarks. A list of abbreviations used in the remarks appears in Figure 9.

FIGURE 9

TERMS USED IN REMARKS ON FILM LOG SHEET

VLF ONLY	– very low freq. transmission only
VLF on	– very low freq. transmission on video
VLF INT.	– very low freq. transmission interference
INT.	– interference
L.L.S.	– loss of line synchronization
L.F.S.	– loss of frame synchronization
L.S.D.	– line synchronization distortion
T.C.R.	– time code rolling
N.T.C.	– no time code
STN.	– station
C.T.O.	– camera turned off
T.S.E.	– tape speed erratic
T.F.	– TELEMETRY FAILURE
d/os	– drop outs
TOBAS	– turned on by another station

The satellite maps are generated from a computer program that computes subsatellite points at specified time intervals of the satellite's orbit. The subsatellite point consists of longitude in degrees ±180 deg, geodetic latitude in degrees ±90, and height above sea level in kilometers. The program also computes ascending node crossing for each pass. The Alouette satellite maps include Brouwer elements. The maps are available on rolls of 16-mm microfilm and usually cover periods of about 10 weeks.

The ionograms that are available at NSSDC at the time of publication of this Data Users' Note are given in Figure 10 according to stations and times. A total of 3140 rolls of 35-mm microfilm ionograms are currently available.

FIGURE 10

IONOGRAM TIMES AND STATIONS

STATION	PASS NUMBER*	PERIOD* START MO			END MO		
		MO	DA	YR	MO	DA	YR
Antofagasta, Chile	18 - 4130	09	30	62	07	28	63
College, Alaska, U.S.A.	1 - 17549	09	29	62	04	07	66
East Grand Forks, Minn., U.S.A.	1940 - 16239	02	18	63	01	01	66
Fort Myers, Florida, U.S.A.	12 - 15980	09	30	62	12	13	65
Kano, Nigeria	9625 - 11735	09	03	64	02	05	65
Kauai, Hawaii, U.S.A.	14274 - 16600	08	10	65	01	27	66
Orroral Valley, Australia	15713 - 16480	11	23	65	01	18	66
Ottawa, Ont., Canada	6 - 18009	09	29	62	05	10	66
Port Stanley, Falkland Islands	12 - 16888	09	30	62	02	17	66
Prince Albert, Sask., Canada	13 - 4473	09	30	62	08	23	63
Quito, Ecuador	20 - 16074	09	30	62	12	20	65
Resolute Bay, N.W.T., Canada	7 - 17787	09	29	62	04	24	66
St. John's, Nfld., Canada	11 - 15545	09	30	62	11	11	65
Santiago, Chile	4246 - 16074	08	06	63	12	20	65
Singapore, Malaysia	12 - 16210	09	30	62	12	30	65
South Point, Hawaii, U.S.A.	531 - 13451	11	07	62	06	10	65
University of Alaska, Alaska, U.S.A.	15793 - 15974	11	29	65	12	12	65
Winkfield, England	9 - 15680	09	29	62	11	21	65
Woomera, Australia	18 - 15395	10	01	62	10	31	65

*Pass numbers and dates are not necessarily inclusive.

B – Alosyn

Investigator

E. L. Hagg – Defence Radio Telecommunications Establishment*

Tabulations of selected ionospheric parameters were compiled from representative ionograms recorded from September 29, 1962, to January 31, 1964. One horizontal row of tabulation was derived from each selected ionogram. These ionograms were recorded at the following tracking stations:

Resolute Bay, N.W.T., Canada
College, Alaska, U.S.A.
Prince Albert, Sask., Canada
East Grand Forks, Minn., U.S.A.
Ottawa, Ont., Canada
St. John's, Nfld., Canada
Winkfield, England
South Point, Hawaii, U.S.A.
Fort Myers, Fla., U.S.A.
Quito, Ecuador
Antofagasta, Chile
Port Stanley, Falkland Islands
Santiago, Chile
Woomera, Australia

Figure 11 is a sample of the Alosyn data. The symbols used in the tabulations are the following:

YR	Year
MO	Month
DY	Day of the month
GMT	GMT at which the record was taken, in hours, minutes, and seconds, with the minutes and seconds separated by a solidus. The time given is for 3.0 ± 1 sec before the occurrence of the 0.5 Mc/s frequency marker.
LMT	Local mean time in hours and minutes
LONG	Longitude (deg); (+) denotes East
LAT	Latitude (deg); (+) denotes North
HGT	Height of satellite in km
CHI	Solar zenith angle, χ
DIP	Angle of dip of earth's magnetic field at the satellite; (+) denotes North

*Address: Defence Radio Telecommunications Establishment, Shirley Bay, Ottawa 4, Ontario, Canada.

FIGURE 11

ALOSYN DATA (DRTE)

YR	MO	DY	GMT	LMT	LONG	LAT	HGT	CHI	DIP	FH	JFOS	FXS	A	Q	FOF2	A	Q	JFOF2	FXF2	A	Q	FES	Q	G	KP
64	3	3	719/46	318	-60.4	-59.93	1057	104	-56	.72	1.08	1.50	4	D	4.3	3	D	4.09	4.5	3	D	0		1	1+
64	3	3	720/ 3	321	-59.8	-60.83	1058	103	-57	.72	1.08	1.50	4	D	4.0	2	E	4.09	4.5	2	E	0		1	1+
64	3	3	720/18	323	-59.3	-61.62	1058	102	-58	.73	.86	1.30	3	D	4.0	2	E	4.08	4.5	2	E	0		1	1+
64	3	3	720/36	326	-58.6	-62.57	1058	101	-58	.74	.85	1.30	3	D	4.0	3	D	4.08	4.5	2	D	0		2	1+
64	3	3	720/53	329	-57.9	-63.46	1059	100	-59	.75	.79	1.25	2	D	3.8	2	D	3.87	4.3	3	D	0		2	1+
64	3	3	721/11	333	-57.1	-64.40	1059	100	-59	.76	.78	1.25	2	D	3.8	2	D	3.87	4.3	3	D	0		1	1+
64	3	3	822/15	2151	-157.9	79.56	1013	105	85	1.06	.69	1.40	1	D	0	0		4.44	5.2	2	E	0		2	1+
64	3	3	822/33	2210	-153.1	79.09	1013	106	85	1.06	.48	1.25	2	D	0	0		4.44	5.2	1	G	0		2	1+
64	3	3	822/50	2227	-148.9	78.59	1013	107	85	1.06	.32	1.15	2	G	0	0		3.52	4.3	1	H	5.7	D	2	1+
64	3	3	823/ 8	2244	-144.9	77.99	1013	108	85	1.06	.41	1.20	2	G	3.7	2	G	3.67	4.4	1	G	0		2	1+
64	3	3	823/25	2258	-141.4	77.38	1014	109	85	1.06	.20	1.10	2	G	3.7	2	H	3.67	4.4	1	H	0		2	1+
64	3	3	823/43	2311	-138.1	76.68	1014	110	85	1.06	.31	1.15	2	G	3.7	2	G	3.82	4.6	2	G	7.1	D	2	1+
64	3	3	824/ 0	2323	-135.4	75.99	1014	111	85	1.06	.20	1.10	2	G	3.7	2	H	3.82	4.6	1	H	0		2	1+
64	3	3	824/18	2333	-132.7	75.22	1014	111	85	1.07	.40	1.20	2	G	3.8	1	G	3.67	4.4	1	G	0		2	1+
64	3	3	824/35	2343	-130.4	74.47	1014	112	85	1.07	.19	1.10	1	D	3.8	2	H	3.72	4.5	2	H	0		2	1+
64	3	3	824/53	2352	-128.3	73.65	1014	113	85	1.07	0	1.05	1	D	3.7	2	H	3.87	4.7	1	H	0		2	1+
64	3	3	825/10	2359	-126.4	72.86	1014	114	84	1.07	0	1.05	2	D	3.7	2	H	3.82	4.6	1	H	0		2	1+
64	3	3	825/27	6	-124.7	72.05	1014	115	84	1.07	0	1.05	1	D	0	0		2.69	3.5	5	H	0		2	1+
64	3	3	825/44	13	-123.2	71.22	1015	116	84	1.07	0	1.05	1	D	3.7	2	H	3.81	4.6	2	H	0		2	1+
64	3	3	826/ 2	19	-121.7	70.34	1015	117	84	1.07	0	1.05	1	D	0	0		2.16	3.0	2	H	0		2	1+
64	3	3	826/20	25	-120.4	69.44	1015	117	84	1.07	.68	1.40	4	D	2.2	2	H	2.16	3.0	2	H	0		2	1+
64	3	3	826/37	30	-119.2	68.58	1015	118	84	1.07	.68	1.40	4	D	0	0		1.84	2.7	2	G	0		2	1+
64	3	3	826/55	35	-118.0	67.66	1015	119	83	1.07	.68	1.40	4	D	2.0	2	D	1.73	2.6	2	D	0		2	1+
64	3	3	827/12	39	-117.1	66.78	1015	120	83	1.07	.68	1.40	4	D	2.0	2	D	1.73	2.6	2	D	0		2	1+
64	3	3	827/30	43	-116.1	65.85	1015	121	83	1.07	.67	1.40	4	D	2.0	2	D	1.72	2.6	2	D	0		2	1+
64	3	3	827/47	47	-115.2	64.96	1015	122	82	1.07	.67	1.40	4	D	2.0	2	D	1.61	2.5	1	D	0		2	1+
64	3	3	828/ 5	50	-114.4	64.01	1016	123	82	1.08	.67	1.40	4	D	0	0		1.61	2.5	2	G	4.2	D	2	1+
64	3	3	828/22	54	-113.7	63.11	1016	123	82	1.07	.67	1.40	4	D	2.0	2	D	1.99	2.8	1	D	3.8	D	2	1+
64	3	3	828/40	57	-112.9	62.15	1016	124	81	1.07	.54	1.30	4	D	0	0		2.15	3.0	2	E	3.8	D	2	1+
64	3	3	828/57	60	-112.3	61.25	1016	125	81	1.07	.54	1.30	4	D	0	0		1.61	2.5	2	G	3.8	D	3	1+
64	3	3	829/15	103	-111.7	60.28	1016	126	80	1.07	.80	1.50	4	D	2.5	2	D	2.67	3.5	2	F	4.3	D	3	1+
64	3	3	829/32	105	-111.1	59.36	1016	127	80	1.07	.18	1.10	1	D	0	0		3.39	4.2	1	D	0		3	1+
64	3	3	829/50	108	-110.5	58.39	1016	127	80	1.07	.18	1.10	1	D	2.6	1	D	2.78	3.6	1	D	0		3	1+
64	3	3	830/ 7	110	-110.1	57.47	1016	128	79	1.07	.19	1.10	1	D	0	0		2.98	3.8	1	D	0		3	1+
64	3	3	830/24	112	-109.6	56.54	1017	129	79	1.07	.81	1.50	4	D	0	0		3.19	4.0	2	D	0		2	1+
64	3	3	830/42	114	-109.1	55.56	1017	130	78	1.06	0	1.05	1	D	0	0		2.68	3.5	2	D	0		2	1+
64	3	3	830/59	116	-108.7	54.64	1017	131	78	1.06	.75	1.45	4	D	0	0		2.16	3.0	2	E	0		2	1+
64	3	3	831/15	118	-108.3	53.76	1017	131	77	1.06	.81	1.50	4	D	0	0		1.05	2.0	5	D	0		2	1+
64	3	3	832/13	124	-107.1	50.57	1017	134	75	1.05	.82	1.50	4	D	0	0		1.07	2.0	5	E	0		2	1+
64	3	3	832/31	125	-106.8	49.58	1017	135	75	1.04	.83	1.50	4	D	0	0		1.19	2.1	1	E	0		2	1+
64	3	3	832/48	127	-106.5	48.64	1017	135	74	1.04	.26	1.10	1	D	0	0		1.14	2.0	1	E	0		2	1+
64	3	3	833/ 6	128	-106.2	47.65	1017	136	73	1.03	.37	1.15	1	D	0	0		1.65	2.5	5	D	0		2	1+
64	3	3	833/23	130	-105.9	46.70	1017	137	73	1.03	.46	1.20	1	A	0	0		1.77	2.6	5	D	0		3	1+
64	3	3	833/41	131	-105.6	45.71	1017	138	72	1.02	.46	1.20	1	A	0	0		2.20	3.0	5	D	0		3	1+
64	3	3	833/58	132	-105.4	44.76	1017	138	71	1.01	.47	1.20	1	D	0	0		2.20	3.0	5	E	0		2	1+
64	3	3	834/16	134	-105.1	43.76	1017	139	71	1.01	.40	1.15	1	D	0	0		2.21	3.0	5	D	0		2	1+
64	3	3	834/33	135	-104.9	42.82	1017	140	70	1.00	.62	1.30	1	D	3.0	2	A	2.99	3.8	1	A	0		3	1+
64	3	3	834/51	136	-104.7	41.82	1017	140	69	.99	.69	1.35	1	D	3.3	2	D	3.05	3.8	2	F	0		2	1+
64	3	3	835/ 8	137	-104.4	40.87	1017	141	68	.99	.76	1.40	1	A	3.0	2	A	3.06	3.8	2	A	0		2	1+
64	3	3	835/26	139	-104.2	39.87	1017	142	68	.98	.83	1.45	1	D	3.5	2	A	3.47	4.2	1	A	0		3	1+
64	3	3	835/43	140	-104.0	38.92	1017	142	67	.97	.89	1.50	1	A	3.5	2	A	3.68	4.4	2	A	0		3	1+
64	3	3	836/ 0	141	-103.8	37.97	1017	143	66	.96	.90	1.50	1	A	3.7	2	A	3.69	4.4	2	A	0		2	1+
64	3	3	836/18	142	-103.6	36.97	1017	144	65	.95	.91	1.50	1	A	3.7	2	F	3.75	4.4	1	D	0		3	1+
64	3	3	836/35	143	-103.5	36.02	1017	144	65	.95	.91	1.50	1	A	3.8	2	D	3.76	4.4	1	D	0		2	1+
64	3	3	836/53	144	-103.3	35.01	1017	145	64	.94	.98	1.55	1	A	3.5	2	A	3.71	4.4	2	A	0		3	1+
64	3	3	837/10	145	-103.1	34.06	1017	145	63	.93	.98	1.55	1	D	4.0	1	E	3.92	4.6	2	E	0		3	1+
64	3	3	837/28	146	-103.0	33.05	1017	146	62	.92	.99	1.55	1	A	4.0	2	D	3.83	4.5	2	D	0		2	1+
64	3	3	837/45	147	-102.8	32.10	1017	147	61	.91	1.05	1.60	1	A	4.0	2	D	3.84	4.5	2	D	0		2	1+
64	3	3	838/ 3	147	-102.6	31.09	1017	147	60	.90	1.11	1.65	1	A	4.0	2	E	3.85	4.5	2	E	0		3	1+
64	3	3	838/20	148	-102.5	30.14	1017	148	59	.89	1.12	1.65	2	D	3.6	2	E	3.76	4.4	2	E	0		2	1+
64	3	3	838/38	149	-102.4	29.13	1017	148	58	.88	1.50	2.00	4	D	0	0		2.85	3.5	5	D	0		2	1+
64	3	3	838/55	150	-102.2	28.17	1017	149	57	.87	1.19	1.70	1	A	3.5	2	E	3.37	4.0	2	E	0		2	1+
64	3	3	839/12	151	-102.1	27.22	1017	149	56	.86	1.20	1.70	1	D	3.5	2	E	3.38	4.0	2	E	0		2	1+
64	3	3	839/30	152	-101.9	26.21	1017	149	55	.85	1.21	1.70	1	D	0	0		1.32	2.0	5	D	0		2	1+
64	3	3	839/48	153	-101.8	25.20	1018	150	54	.83	1.21	1.70	2	D	3.0	2	E	3.19	3.8	2	E	0		3	1+
64	3	3	840/ 5	153	-101.7	24.24	1018	150	53	.82	1.11	1.60	1	D	3.0	2	E	3.20	3.8	1	E	0		3	1+
64	3	3	840/22	154	-101.6	23.29	1018	151	52	.81	1.02	1.50	1	D	3.0	1	E	3.21	3.8	1	E	0		2	1+
64	3	3	840/40	155	-101.4	22.28	1018	151	51	.80	1.02	1.50	1	D	3.0	2	E	3.02	3.6	1	E	0		3	1+
64	3	3	840/57	156	-101.3	21.32	1018	151	50	.79	1.03	1.50	1	D	3.3	2	E	3.03	3.6	2	E	0		2	1+
64	3	3	841/15	156	-101.2	20.31	1018	151	48	.78	1.04	1.50	1	D	0	0		3.24	3.8	2	E	0		2	1+
64	3	3	1323/15	1442	19.6	40.43	1007	58	56	.81	1.02	1.50	4	D	5.7	2	D	5.41	6.0	5	D	0		3	2-
64	3	3	1323/48	1444	20.0	42.28	1007	60	58	.82	.84	1.35	1	D	0	0		3.89	4.5	5	A	0		3	2-
64	3	3	1324/ 5	1445	20.3	43.22	1007	61	58	.83	1.00	1.50	4	D	0	0		4.89	5.5	5	D	0		3	2-
64	3	3	1324/23	1446	20.5	44.23	1007	62	59	.84	1.00	1.50	4	D	0	0		4.89	5.5	5	D	0		3	2-
64	3	3	1324/40	1448	20.8	45.17	1007	63	60	.84	.77	1.30	1	A	0	0		4.88	5.5	5	D	0		3	2-
64	3	3	1324/58	1449	21.0	46.17	1008	64	61	.85	.99	1.50	4	D	0	0		4.88	5.5	5	D	0		3	2-
64	3	3	1325/15	1450	21.3	47.12	1008	64	62	.86	2.03	2.50	4	D	0	0		4.87	5.5	5	D	0		3	2-
64	3	3	1325/33	1452	21.6	48.12	1008	65	63	.87	.81	1.35	1	A	0	0		4.87	5.5	5	A	0		3	2-
64	3	3	1325/50	1453	21.9	49.06	1008	66	64	.87	.80	1.35	1	A	0	0		4.76	5.4	5	D	0		3	2-
64	3	3	1326/25	1457	22.6	50.99	1008	68	66	.89	.85	1.40	1	A	0	0		4.86	5.5	5	D	0		3	2-

FH Gyrofrequency at the satellite, in Mc/s. The dip and gyrofrequency are calculated by using the set of 48 spherical harmonic coefficients determined by Jensen and Cain (epoch 1960).

JFOS Ordinary wave frequency at the satellite, calculated from the observed Extraordinary wave frequency. That is, JFOS is the plasma frequency at the satellite in Mc/s.

FXS Observed Extraordinary wave frequency at the satellite in Mc/s

FXS A Accuracy of observation, according to the following code:

1. Estimated error less than .025 Mc/s
2. Estimated error less than .05 Mc/s
3. Estimated error less than .1 Mc/s
4. Magnitude of FXS less than tabulated value
5. Magnitude of FXS greater than tabulated value

FXS Q Quality of the reflection trace near the satellite, according to the following quality table:

	No Spread	Slightly Spread	Moderately Spread	Extremely Spread
Unambiguous records	A	D	G	J
Oblique traces present	B	E	H	K
Cusps and/or forking of the records	C	F	I	L

The classifications of Spread F in this quality table refer to the degree of Spread F at the particular apparent height and frequency at which the parameter was obtained. It is not a classification of Spread F for the ionogram as a whole.

FOF2 Observed Ordinary wave penetration frequency of the F2 layer in Mc/s

FOF2 A Accuracy of observation according to the following code:

1. Estimated error less than .05 Mc/s
2. Estimated error less than .1 Mc/s
3. Estimated error less than .2 Mc/s
4. Magnitude of FOF2 less than tabulated value
5. Magnitude of FOF2 greater than tabulated value

FOF2 Q Quality of the reflection trace at the Ordinary wave penetration frequency according to the quality table

JFOF2	Ordinary wave penetration of the F2 layer, calculated from the observed fxF2. The gyrofrequency appropriate to a height of 300 km is used for this calculation.
FXF2	Observed Extraordinary wave penetration of the F2 layer
FXF2 A	Accuracy of observation, according to the FOF2 accuracy code
FXF2 Q	Quality of the reflection trace at the Extraordinary wave penetration frequency, according to the quality table
FES	Maximum frequency of observation of sporadic E
FES Q	Quality of sporadic E, according to the first row of the quality table
G	Strength of signal returned from the earth, according to the following code: 1. Strong, well-defined echoes 2. Weak and intermittent echoes 3. Echoes not observed
KP	3 hourly Magnetic K_p index

The symbol "-O-" occurring in a column of the tabulations indicates that the parameter was not observed on the ionogram.

It should be noted that one percent of the data recorded at telemetry stations have timing errors greater than 400 sec, and one-fifth percent have timing errors greater than 10 000 sec. Such timing errors can probably be considered systematic over about 30 consecutive ionograms.

C – Synoptic Data

Investigator

W. Calvert – ITSA*

Another tabulation has been compiled by ITSA* for September 29, 1962, to May 30, 1964 (passes 1 - 8318). This listing also includes a partial listing of the ground stations which may have bottomside sounding data to complement the topside data from Alouette 1. The columns in these tabulations are given in Figure 12.

*Address: Institute for Telecommunication Sciences and Aeronomy, ESSA, Boulder, Colorado.

FIGURE 12

DESCRIPTION OF TOPSIDE SOUNDER CATALOG LISTING (ITSA)

TITLE AND IDENTIFICATION

S - 27 - Satellite code

DATE - YYMMDD of the first ionogram

DAY OF THE YEAR

UNIVERSAL TIME - HHMM/SS of the first ionogram

PASS NUMBER - Pass number of the first ionogram

TELEMETRY STATION CODE

SATELLITE DATA

Frame Number of Ionogram

Correspondence between film and catalog should exist.

The number of frames is approximated from the command schedule (based on a 10-minute readout) and may not correspond with the time and number of frames on the film.

An * alone denotes data computed at a given special time interval. No one-to-one correspondence will exist between catalog and film.

UT	Universal time (HHMM) at the satellite
LMT	Local mean time (HHMM) at the satellite
LT	Latitude (deg); (+) denotes North
LN	Longitude (deg); (+) denotes East
HT	Height above the geoid (km)
FH	Gyrofrequency at satellite (Mc/s)
I	Dip of magnetic field at satellite (deg); (+) denotes North
X	Zenith angle of the sun at the satellite (deg)
GLT	Geomagnetic latitude (deg); (+) denotes North

BOTTOMSIDE GROUND STATION DATA

Station Code

GND	Ground distance from subsatellite point to station (km)
ISO	Distance from subsatellite point to isocline passing through station (km); (+) denotes subsatellite point north of isocline
AZ	Azimuth of satellite as seen from station (deg)
LMT	Local mean time (HHMM) at the station
CHI	Zenith angle of the sun at the station (deg)

GAP

Denotes re-timing and often corresponds to obvious gaps in the film

The pertinent telemetry stations and their code descriptions are given in Figure 13.

FIGURE 13

TELEMETRY STATION CODE AND LOCATION (ITSA)

STATION	CODE	STATION LOCATION
BOULDR	Q-19	Boulder, Colorado
BPOINT	P-14	Blossom Point, Maryland
COLEGE	E-05	College, Alaska
FTMYRS	F-06	Fort Myers, Florida
GFORKS	N-13	East Grand Forks, Minnesota
HAWAII	R-15	Naalehu, Hawaii
NEWFLD	D-04	St. John's, Newfoundland
OTTAWA	C-03	Ottawa, Canada
PRINCE	B-02	Prince Albert, Canada
QUITOE	G-07	Quito, Ecuador
RESLUT	A-01	Resolute Bay, Canada
SNPORE	L-11	Singapore, Malaysia
SNTAGO	H-08	Santiago, Chile
SOLANT	J-09	South Atlantic (Falkland Islands)
WNKFLD	K-10	Winkfield, England
WOMERA	M-12	Woomera, Australia

D – Electron Density vs Real Height

Investigators

G. L. B. Nelms – Defence Research Telecommunications Establishment*
G. E. K. Lockwood – Defence Research Telecommunications Establishment*

These data consist of tabulations of electron (number) density profiles derived from ionograms selected from the period of September 29, 1962, to December 31, 1964. The ionograms were reduced under the assumption that the echoes are received from the area vertically beneath the satellite. When more than one set of reflections was present on the ionogram, the number density was computed from the reflection trace at the shortest apparent range. An exception occurred

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when the reflections from the earth were found to be associated with the longer range echoes. The ionograms were reduced by the method of laminations[7] using a matrix:

$$\Delta h_i = \frac{p_i' - \sum_{j=2}^{i-1} B_{ij}\, \Delta h_j}{B_{ii}}$$

where p_i' is the virtual range at the wave frequency f_i

$\Delta h_j = |h_j - h_{j-1}|$ and the point (f_{xs}, h_{sat}) is considered point 1

B_{ij} = the average group refractive index, at the wave frequency f_i, for the lamination from h_{j-1} to h_j.

About 20 laminations were used for each trace, with a linear change of plasma frequency with real height assumed within each lamination. The magnetic dip angle and gyrofrequency, which were based upon the 48-term spherical harmonic representation of the earth's magnetic field (Jensen and Cain-epoch 1960), were used to derive the matrix elements B_{ij}.[8]

For the calculation of the matrix elements for points below the satellite, the gyrofrequency was obtained by means of an inverse cube extrapolation from the value at the satellite. When the Extraordinary trace was used, each wave frequency was converted to an electron density, N(h), by using the gyrofrequency determined from the spherical harmonic coefficients evaluated at the height involved.[8]

Figure 14 is a sample of the data held at NSSDC, and the following are the symbols used in the tabulations:

4	The data are N(h) profiles	
X or O	X appears when an Extraordinary wave was used O appears when an Ordinary wave was used	
T or B	Topside or Bottomside sounder	
YR	Year	
DAY	Day of the year	
GMT	Universal time at which the ionogram was recorded in hours, minutes, and seconds. (The time given is for 3.0 ± 1 sec before the occurrence of the 0.5 Mc/s frequency marker.)	
LONG	Longitude	$\left.\right\}$ calculated from the orbital elements
LAT	Latitude	
CHI	Solar zenith angle, χ	
DIP	Angle of dip of the earth's magnetic field at the satellite	

FIGURE 14

ALOUETTE 1 REAL HEIGHT PROFILES (DRTE)

```
                                                         v
 YR DAY   GMT     LONG    LAT    CHI  DIP   FH    Q   FOF2*    TOTALN    P

4XT 63 123 2305/ 5  -68.9 -30.29  105  -28  0.51  9   5.36   46.119E11  21
     1.17 1022.      1.26  984.     1.50  873.     1.76  792.     2.06  732.     2.36  684.     2.72  646.
     3.10  615.      3.50  589.     4.34  550.     5.31  520.     6.39  498.     7.57  479.     8.84  463.
    12.46  427.     16.70  397.    21.46  371.    26.93  345.    33.02  319.    34.31  314.    35.49  310.

4XT 63 123 2305/23  -68.7 -31.30  105  -30  0.51  9   6.26   69.245E11  22
     1.05 1023.      1.24  924.     1.47  822.     1.73  749.     2.03  694.     2.36  651.     2.68  615.
     3.06  586.      3.46  562.     4.34  525.     5.31  498.     6.39  477.     7.57  459.     8.77  443.
    12.38  410.     16.61  378.    21.46  350.    26.93  321.    32.89  293.    39.58  265.    46.90  238.
    48.44  232.

4XT 63 123 2305/41  -68.6 -32.30  105  -31  0.52  9   5.31   49.835E11  21
     1.05 1023.      1.24  923.     1.47  816.     1.73  740.     2.03  684.     2.33  640.     2.68  607.
     3.06  580.      3.46  557.     4.34  522.     5.26  496.     6.33  475.     7.50  458.     8.77  443.
    12.38  409.     16.61  377.    21.46  346.    26.81  316.    32.89  282.    34.18  276.    34.83  273.

4XT 63 123 2305/59  -68.4 -33.31  106  -32  0.52  9   5.31   50.466E11  20
     1.00 1024.      1.22  879.     1.45  780.     1.70  710.     2.00  657.     2.33  617.     2.64  586.
     3.42  543.      4.29  512.     5.26  486.     6.33  467.     7.50  450.     8.77  434.    12.38  396.
    16.52  361.     21.36  329.    26.81  296.    32.89  264.    34.05  258.    34.83  255.

4XT 63 123 2306/17  -68.3 -34.32  106  -33  0.53  9   4.95   47.384E11  24
     1.03 1025.      1.22  887.     1.45  783.     1.70  709.     2.00  656.     2.29  616.     2.64  585.
     3.02  560.      3.42  538.     4.29  507.     5.26  484.     6.33  463.     7.50  446.     8.71  430.
    10.07  414.     11.54  399.    13.10  384.    14.76  369.    16.52  354.    21.36  318.    26.70  280.
    27.86  273.     29.05  265.    30.26  256.

4XT 63 123 2306/34  -68.1 -35.27  107  -35  0.53  9   4.15   30.794E11  23
     0.98 1026.      0.98 1009.     1.19  859.     1.42  759.     1.67  689.     1.97  637.     2.29  597.
     2.61  568.      2.98  544.     3.38  524.     4.24  491.     5.21  469.     6.28  451.     7.44  434.
     8.71  417.     10.07  401.    11.54  385.    13.10  371.    14.76  357.    16.52  342.    18.28  327.
    20.24  312.     21.25  305.

4XT 63 123 2306/52  -67.9 -36.27  107  -36  0.54  9   3.98   30.880E11  22
     1.22 1027.      1.22  988.     1.45  837.     1.70  750.     1.97  691.     2.29  645.     2.64  610.
     3.02  582.      3.38  559.     4.24  525.     5.21  497.     6.28  473.     7.44  454.     8.71  436.
    10.07  420.     11.54  403.    13.10  387.    14.67  371.    16.43  356.    18.28  338.    19.25  329.
    19.54  326.

4XT 63 123 2307/10  -67.7 -37.27  107  -37  0.54  9   3.76   24.119E11  23
     0.94 1027.      0.96  976.     1.17  831.     1.39  732.     1.64  663.     1.94  617.     2.26  581.
     2.57  553.      2.94  531.     3.34  512.     4.20  483.     5.16  460.     6.22  442.     7.38  425.
     8.64  409.     10.00  394.    11.46  381.    13.02  367.    14.67  354.    15.54  347.    16.43  339.
    17.34  330.     17.44  329.

4XT 63 123 2307/28  -67.5 -38.28  108  -38  0.55  9   4.02   44.061E11  23
     0.94 1028.      0.96  989.     1.14  820.     1.37  717.     1.64  656.     1.91  611.     2.23  574.
     2.57  546.      2.94  524.     3.34  506.     4.20  477.     5.16  454.     6.22  435.     7.38  418.
     8.64  402.     10.00  387.    11.46  373.    12.94  358.    14.59  342.    16.34  325.    18.19  304.
    19.15  292.     19.94  239.

4XT 63 123 2307/46  -67.3 -39.28  108  -39  0.55  9   3.91   41.916E11  23
     0.94 1029.      0.96 1001.     1.14  834.     1.37  722.     1.61  654.     1.91  607.     2.23  570.
     2.54  545.      2.90  524.     3.29  506.     4.15  478.     5.11  454.     6.17  434.     7.32  417.
     8.58  400.      9.93  383.    11.38  368.    12.94  353.    14.59  337.    16.34  320.    17.25  310.
    18.09  298.     18.96  244.

4XT 63 123 2308/ 3  -67.1 -40.22  108  -40  0.56  9   3.93   38.706E11  24
     0.94 1030.      0.94 1012.     1.14  837.     1.34  722.     1.61  649.     1.88  603.     2.19  566.
     2.54  538.      2.90  517.     3.29  499.     4.15  471.     5.11  447.     6.17  426.     7.32  407.
     8.58  391.      9.93  376.    11.31  361.    12.86  347.    14.50  333.    16.25  318.    17.16  308.
    18.09  297.     19.05  281.    19.15  266.

4XT 63 123 2308/21  -66.9 -41.22  108  -41  0.57  9   3.98   42.772E11  23
     0.98 1031.      1.14  886.     1.34  760.     1.61  677.     1.88  623.     2.19  581.     2.54  551.
     2.90  528.      3.25  510.     4.11  480.     5.06  456.     6.11  435.     7.26  417.     8.51  400.
     9.86  383.     11.31  367.    12.86  351.    14.50  336.    16.25  319.    17.16  310.    18.09  301.
    18.96  288.     19.64  243.

4XT 63 123 2308/39  -66.7 -42.22  109  -42  0.57  9   3.88   74.544E11  22
     0.98 1031.      1.12  875.     1.29  772.     1.47  709.     1.70  664.     1.94  626.     2.19  598.
     2.43  573.      2.72  553.     3.50  512.     4.38  479.     5.36  452.     6.45  429.     7.63  409.
     8.91  390.     10.29  373.    11.69  356.    13.26  340.    14.93  324.    15.80  316.    16.70  307.
    17.53  246.
```

FH	Gyrofrequency at the satellite in Mc/s
Q	Quality of the ionogram, according to a code in which 4 refers to best and 9 refers to minimal information. (Use 7 to 9 with caution.) 0 refers to tabulations made before code was established.
FOF2*	The Ordinary wave frequency (in Mc/s) corresponding to the highest number density computed for the ionogram. This is always less than, or equal to, the Ordinary wave penetration frequency of the F layer.
TOTALN	Integral of N, the number of electrons in a column 1 cm^2 in horizontal cross section extending from the satellite to the height corresponding to FOF2*. This number is expressed in units of 10^{11} electrons per square centimeter column.
P	Number of frequencies used for computing the N(h) profile

In Figure 14, the line which is introduced by symbols such as 4 XT contains the values identified by the symbols, as listed in the previous paragraph. The horizontal lines directly following consist of pairs of numbers representing the electron density and the real height at which the number density occurs, computed for a single ionogram. The first number in each pair is the electron density, expressed in 10^4 electrons per cm^3. The second number in the pair is the real height expressed in km above the surface of the oblate spheroid which best approximates the surface of the earth. The number density and the height at the satellite are given by the first pair of points for each ionogram. The electron densities listed correspond to the frequencies used for the real height calculation.

The reading errors are such that, for the best quality ionograms, the real heights are reproducible to an accuracy of about one percent. The systematic error introduced by the assumptions on which lamination methods of computation are based has not yet been adequately investigated. Such systematic error in the computed real height is probably less than five percent.[8]

One percent of data recorded at telemetry stations have timing errors greater than 400 sec; one-fifth percent have time errors greater than 10 000 sec. Such timing errors will probably be systematic over 30 consecutive ionograms.[8]

E – Electron Density Profiles

Investigators

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The Institute for Telecommunication Sciences and Aeronomy (ITSA) in the United States and the Radio and Space Research Station (RSRS) of the Science Research Council in England used selected ionograms to make electron density profiles of the ionosphere. The Radio and Space Research Station selected ionograms from the passes indicated by an asterisk at the Port Stanley and Singapore tracking stations, while ITSA selected ionograms from all the other tracking stations shown in Figure 15.

The ionograms were converted to curves showing the electron density as a function of height. This was accomplished by the reduction of the Extraordinary trace with the method of laminations described in Section D.[9]

Figure 16 is a sample of the RSRS data. The universal time is given in hours, minutes, and seconds for the time when the sounder frequency was 2.0 Mc/s. The electron densities, listed at 10-km intervals of real height, are multiplied by 10^{-5} and given in electrons per cm^3. The plot in Figure 16 shows the variation of electron density with geopotential height, H', where $1/H' = 1/h + 1/R$ and R represents the mean radius of the earth.

The electron density profiles produced by CRPL are in the form of computer plots and listings. The real height is plotted against the electron density (i.e., plasma frequency) on semilogarithmic paper. The computer listing for each reduced ionogram includes the following:

1. Indication of the type of trace – Extraordinary or Ordinary
2. Magnetic dip angle and gyrofrequency at the satellite
3. Latitude, longitude, and height of the satellite
4. Date and universal time
5. Date and place of reduction

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FIGURE 15

STATIONS AND TIMES FOR SELECTED IONOGRAMS (ITSA, RSRS)

Station/Pass No.	Date Mo	Da	Yr	Begin Time (UT)	Station/Pass No.	Date Mo	Da	Yr	Begin Time (UT)
Antofagasta, Chile					Ottawa (Cont'd)				
26	10	01	62	0408	2577	04	06	63	0228
100	10	06	62	1450	2598	04	07	63	1448
1823	02	09	63	2114	2672	04	13	63	0152
1864	02	12	63	2126	2903	04	27	63	2340
1877	02	13	63	2010	2911	04	28	63	1320
1891	02	14	63	2049	2916	04	28	63	2236
1918	02	16	63	2017	2924	04	29	63	1212
1932	02	17	63	2053	2938	04	30	63	1254
1959	02	19	63	2025	3066	05	09	63	2228
2081	02	28	63	1859	3907	07	10	63	1331
2597	04	07	63	1428	Port Stanley,				
3527	06	14	63	1732	Falkland Islands				
3568	06	17	63	1741	370	10	26	62	0930
Blossom Point,					588	11	11	62	0856
Maryland, U.S.A.					609	11	12	62	2140
501	11	04	62	2307	* 1626	01	26	63	1012
989	12	10	62	1728	* 1660	01	28	63	2221
1933	02	17	63	2112	* 1667	01	29	63	1017
2096	03	01	63	1957	1817	02	09	63	1006
2191	03	08	63	1902	* 1836	02	10	63	1953
2286	03	15	63	1808	Quito, Ecuador				
2571	04	05	63	1522	26	10	01	62	0355
2787	04	19	63	1245	623	11	13	62	2153
2957	05	03	63	2240	637	11	14	62	2231
College, Alaska,					650	11	15	62	2122
U.S.A.					677	11	17	62	2048
26	10	01	62	0335	691	11	18	62	2129
472	11	02	62	1952	1342	01	05	63	1434
503	11	05	62	0238	1932	02	17	63	2103
542	11	07	62	2304	2041	02	25	63	2041
553	11	08	62	1815	2597	04	07	63	1438
579	11	10	62	1557	3527	06	14	63	1722
850	11	30	62	1237	3568	06	17	63	1728
1465	01	14	63	1425	4375	08	15	63	2139
Fort Myers,					4565	08	29	63	1950
Florida, U.S.A.					4592	08	31	63	1919
26	10	01	62	0348	4613	09	02	63	0729
Ottawa, Ont.,					6133	12	22	63	1640
Canada					7441	03	27	64	1545
26	10	01	62	0337	7463	03	29	64	0355
1464	01	14	63	1255	7510	04	01	64	1521
1817	02	09	63	0944	7530	04	03	64	0330
2218	03	10	63	1833	7536	04	03	64	1449

FIGURE 15 (CONT'D)

STATIONS AND TIMES FOR SELECTED IONOGRAMS (ITSA, RSRS)

Station/Pass No.	Date Mo	Da	Yr	Begin Time (UT)	Station/Pass No.	Date Mo	Da	Yr	Begin Time (UT)
Quito (Cont'd)					Santiago (Cont'd)				
7604	04	08	64	1425	8291	05	28	64	2011
7632	04	10	64	1355	8549	06	16	64	1757
7653	04	12	64	0203	8576	06	18	64	1725
8196	05	21	64	2104	8644	06	23	64	1702
8223	05	23	64	2026	8671	06	25	64	1630
8277	05	27	64	1932	8766	07	02	64	1535
8291	05	28	64	2002	8834	07	07	64	1511
8481	06	11	64	1818	9641	09	04	64	1905
8549	06	16	64	1754	10191	10	15	64	0144
8644	06	23	64	1659	10211	10	16	64	1334
8671	06	25	64	1628	10666	11	18	64	2111
8739	06	30	64	1603	10761	11	25	64	2012
8766	07	02	64	1532	10951	12	09	64	1822
8834	07	07	64	1506	11114	12	21	64	1701
8861	07	09	64	1436	11141	12	23	64	1631
8956	07	16	64	1334	11703	02	02	65	2138
9044	07	23	64	0114	11704	02	02	65	2318
9641	09	04	64	1910	12681	04	15	65	1338
9654	09	05	64	1810	12702	04	17	65	0155
10191	10	15	64	0142	12708	04	17	65	1304
10204	10	16	64	0035	13557	06	18	65	1734
10211	10	16	64	1339	Singapore, Malaysia				
10666	11	18	64	2100	643	11	15	62	0902
10679	11	19	64	1958	657	11	16	62	0941
10951	12	09	64	1821	670	11	17	62	0832
10964	12	10	64	1711	684	11	18	62	0909
10978	12	11	64	1743	* 792	11	26	62	0707
11704	02	02	65	2324	* 1952	02	19	63	0811
12681	04	15	65	1340	* 2292	03	16	63	0609
12702	04	17	65	0143	* 2346	03	20	63	0508
12708	04	17	65	1310	* 2414	03	25	63	0443
13557	06	18	65	1724	* 2706	04	15	63	1323
13563	06	19	65	0455	* 2801	04	22	63	1228
Resolute Bay, N.W.T., Canada					* 4164	07	31	63	1034
26	10	01	62	0332	South Point, Hawaii, U.S.A.				
2598	04	07	63	1458	612	11	13	62	0226
Santiago, Chile					626	11	14	62	0304
4375	08	15	63	2133	639	11	15	62	0155
7510	04	01	64	1519	653	11	16	62	0233
7632	04	10	64	1352	666	11	17	62	0131
8196	05	21	64	2106	680	11	18	62	0203
8223	05	23	64	2036					

FIGURE 16

SAMPLE OF RSRS DATA

SINGAPORE 26 NOV 1962 REV 792 FRAME 29

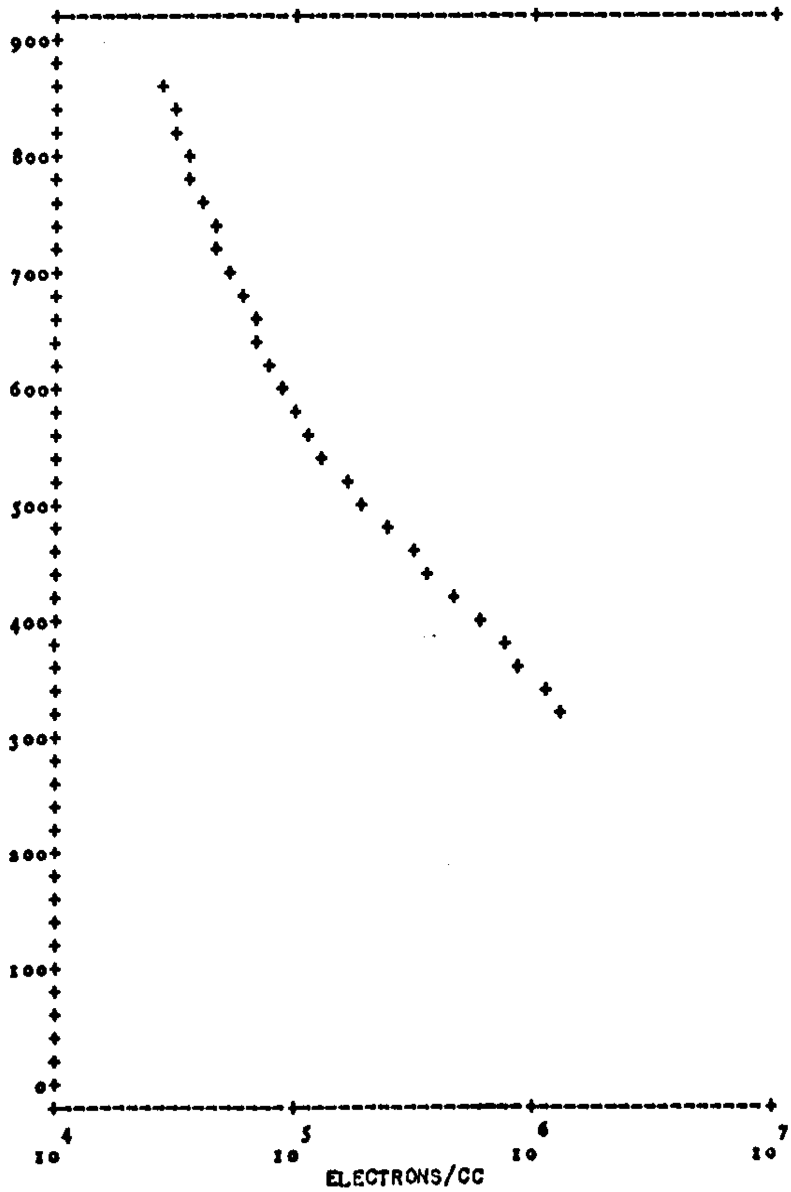
0715.40 UT +117.5 LONG -13.8 LAT

HT	0	10	20	30	40	50	60	70	80	90
1000	0.265									
900	0.362	0.351	0.341	0.331	0.322	0.313	0.304	0.296	0.287	0.277
800	0.504	0.487	0.469	0.453	0.438	0.424	0.410	0.397	0.385	0.373
700	0.757	0.721	0.692	0.664	0.636	0.609	0.586	0.563	0.543	0.523
600	1.294	1.225	1.159	1.094	1.031	0.970	0.923	0.877	0.833	0.795
500	2.860	2.608	2.371	2.173	2.004	1.841	1.707	1.592	1.481	1.374
400	7.762	7.081	6.444	5.858	5.299	4.774	4.298	3.880	3.501	3.171
300				12.70	12.08	11.42	10.71	9.975	9.238	8.487

N GEOPOTENTIAL HEIGHT

(10^5)/CC

0.272
0.298
0.321
0.346
0.374
0.407
0.443
0.484
0.530
0.583
0.646
0.717
0.807
0.912
1.043
1.198
1.374
1.635
1.961
2.393
2.990
3.779
4.793
6.044
7.475
9.120
10.767
12.271



6. Receiving station, pass number, and frame number
7. Digitization of the measured frequency vs virtual height
8. Tabulation of electron density and the corresponding altitude
9. FOF2 – the Ordinary wave frequency corresponding to the highest density computed for the ionogram
10. TOTALN – the number of electrons in a column 1 cm^2 in horizontal cross section extending from the satellite to the height of reflection corresponding to the FOF2
11. The scale height
12. Tabulation of interpolated values of electron density at fixed heights
13. Tabulation of interpolated values of height at fixed electron densities

F – Electron Density and Scale Height vs Real Height

Investigators

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Six volumes of data are available; they consist of tabulations and/or graphs of electron density vs real height and scale height vs real height. Scale height, H, is defined by

$$H = \frac{-N}{\frac{dN}{dh}}$$

where N is the electron density and h is the real height.

The data included in one volume were computed from Alouette 1 ionograms recorded at Stanford University. These ionograms were recorded during the periods of May 1 to July 23, 1963, and November 1, 1963, to January 28, 1964. Plots of average electron density versus dip latitude, and average scale height versus dip latitude, are included.

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Another volume contains data computed from all Alouette 1 ionograms recorded at South Point, Hawaii. These ionograms were recorded during the months of November and December 1962, and May, June, October, and November 1963. Graphs of average electron density and average scale height versus local time and dip latitude are also included.

A series of four volumes contains data chosen primarily for nearly complete latitudinal coverage over the American continents during an epoch of solar minimum. The ionograms were recorded at the following tracking stations, which are listed with their codes:

Antofagasta, Chile	AGASTA
College, Alaska, U.S.A.	COLEGE
Fort Myers, Fla., U.S.A.	FTMYRS
East Grand Forks, Minn., U.S.A.	GFORKS
Ottawa, Ont., Canada	OTTAWA
Prince Albert, Sask., Canada	PRINCE
Quito, Ecuador	QUITOE
Resolute Bay, N.W.T., Canada	RESLUT
South Atlantic Station (U.K.)	SOLANT
St. John's, Nfld., Canada	STJOHN

The first of these four volumes covers the period from November 1, 1962, to January 29, 1963; the second covers the periods from March 1 to March 31 and from May 3 to May 31, 1963; and the third covers the periods June 1 to July 31, from September 1 to September 30, and the day of October 31, 1963. The fourth volume of the series contains the summary graphs of electron density and scale height for the data presented in the first three volumes. The graphs are grouped into three main categories:

1. Variations along the individual satellite orbits
2. Latitudinal variations of the seasonal average at fixed altitudes vs local time
3. Diurnal variations of the seasonal average at fixed altitudes vs dip latitude

The data in all six volumes were reduced by the method of overlapping polynomials. Details of this method of reduction are given in references 1 and 7. The computations were based upon digitizations of the leading edge of the ionograms. The number of points used varied from 8 for smooth traces to 20 or more for curves with severe cusps.[1]

The reduction method assumed that, over small ranges of plasma frequency, the real height profile can be approximated by a polynomial,

$$\Delta h = \sum_{j=1}^{n} \alpha_j \left(f_N - f_{N_s} \right)^j$$

where f_{N_s} is the plasma frequency at the satellite and n is the number of points to which the polynomial was fit. Since several polynomials were used over a series of small frequency ranges, a polynomial representing the exact shape near the designated frequency only was required when the real depth was calculated. The polynomial was chosen to give the correct virtual depth at frequencies just above and below, as well as at the frequency under consideration. The polynomial was also joined to an already determined part of the curve, so that a smooth continuation of the real depth curve with the correct gradient is assured. The coefficients, α_j, were evaluated by using the known real depths and the integral relation between virtual and real height.[1,7]

Since this procedure required known values, the previously described technique of laminations was used for the section of the trace near the satellite. Both f_{xs} and f_H at the satellite were needed because the method of laminations started with the plasma frequency for that position. The required positional data were obtained by linear interpolation of the orbital information listed at 1-min intervals in the Alouette 1 World Maps of the Goddard Space Flight Center. The 48-term spherical harmonic expansion of the earth's magnetic field (Jensen and Cain, epoch 1960) was then used to calculate the gyrofrequency at the satellite. Since the gyrofrequency was a function of height, an inverse cube approximation was applied to obtain the gyrofrequency for a given real height. This value was used to get the plasma frequency and, hence, the electron density.[1]

Possible sources of error were the digitization of the ionograms, the location of the zero range frequency, and the use of linear interpolations in evaluating positions. For a good ionogram, the height at which a given electron density was found is probably correct to ±10 kilometers. The accuracy increases with an increase in height. Scale heights are probably correct to ±10 percent at heights below 800 km, and the accuracy decreases with increasing height.[10]

Data users are further cautioned that, in the reduction from ionograms to electron density profiles, the radio signals were always assumed to be propagated vertically beneath the satellite. Any error introduced by this assumption is a function of how far the signal deviated from the vertical path. This error, if any, cannot be readily estimated unless a complicated computer program of ray tracing is used. The scale height data were computed from the vertical electron density profiles. If the scale height of interest is along a magnetic field line, the value of the scale height in the volumes has to be modified. The method for accomplishing this is illustrated in references 4 and 11 and is especially needed for the low latitudinal region.

A sample of the data appears in Figure 17. The symbols and units appearing in the tabulations are as follows:

N	Electron density, 10^5 per cm^3
h	Real height above the ground, km
Pass	Pass number of Alouette 1
UT	Universal time for the occurrence of the frequency at which the Extraordinary trace had zero range for the particular ionogram
Date	Given as $\frac{XX}{year,}\ \frac{XX}{month,}\ \frac{XX}{day}$; all zeros are suppressed
Time	Given as $\frac{XX}{hour,}\ \frac{XX}{minute,}\ \frac{XX}{second}$; all zero digits on extreme left are suppressed
LONG	Geographic longitude, deg; positive longitude is east of Greenwich, and negative is west of Greenwich
LAT	Geographic latitude, deg; positive indicates northern latitude, and negative indicates southern latitude
QUAL	Quality factor for the ionogram, coded in two-digit numbers (11, 21, 31, 12, 22, 32, 13, 23, and 33) and defined as follows:

First Digit

1. Excellent quality ionogram. Extraordinary trace is narrow, of high contrast, easily identifiable, possesses only small gaps, and cannot be confused with Ordinary trace, spreading or resonances anywhere along its extent. No spurious responses.

2. Good quality ionogram. Extraordinary trace is not too spread, of good contrast, fairly easily identifiable along most of its extent; any large gaps are easily interpolated, and no major confusion exists with the Ordinary trace, spreading or resonances, or spurious responses.

3. Poor quality ionogram, but readable. Considerable spreading, lack of contrast, overlapping traces and resonances, spurious traces, etc., which cause somewhat questionable scaling accuracies.

FIGURE 17

SAMPLE OF ELECTRON DENSITY
AND SCALE HEIGHT DATA VS REAL HEIGHT (ARC)

PASS 2164 AT OTTAWA, 63 3 6

ELECTRON DENSITY IN ELECTRONS PER CC (X10-5)

HEIGHT	TIME (UT)							
	193201	193236	193311	193346	193421	193456	193531	193606
1000	0.160	0.162	0.150	0.149	0.153	0.146	0.134	0.130
950	0.181	0.186	0.168	0.170	0.173	0.166	0.152	0.150
900	0.206	0.212	0.194	0.194	0.198	0.191	0.176	0.174
850	0.236	0.241	0.222	0.223	0.226	0.220	0.203	0.201
800	0.271	0.279	0.257	0.257	0.260	0.253	0.234	0.232
750	0.320	0.328	0.306	0.304	0.308	0.300	0.279	0.275
700	0.386	0.389	0.366	0.362	0.367	0.358	0.332	0.328
650	0.469	0.471	0.441	0.438	0.437	0.427	0.395	0.399
600	0.583	0.588	0.546	0.537	0.544	0.529	0.492	0.495
550	0.748	0.759	0.703	0.701	0.688	0.676	0.617	0.642
500	0.998	1.013	0.938	0.920	0.921	0.903	0.826	0.851
450	1.383	1.411	1.292	1.260	1.279	1.240	1.129	1.163
400	1.964	2.014	1.841	1.769	1.826	1.757	1.593	1.651
350	2.842	2.954	2.735	2.583	2.661	2.577	2.344	2.438
300	4.219	4.325	4.140	3.925	3.993	3.803	3.531	3.708
HEIGHT	SCALE HEIGHT, KM							
950	384.1	372.4	394.7	361.3	387.2	374.2	370.5	335.1
900	366.2	371.2	358.0	359.9	366.4	351.2	346.9	334.4
850	346.5	348.0	334.5	342.0	344.0	335.2	330.6	326.3
800	326.8	326.0	313.8	323.8	322.8	319.2	314.4	317.7
750	301.9	305.3	298.0	304.0	305.4	303.0	298.9	296.1
700	274.4	284.6	282.1	284.1	288.0	286.8	283.3	274.5
650	246.9	256.5	260.7	252.6	270.5	268.7	267.5	246.6
600	219.6	219.8	221.0	213.1	230.9	225.4	232.9	214.7
550	192.1	189.8	192.5	197.0	195.0	194.1	199.8	194.0
500	166.2	165.5	172.0	181.0	170.1	175.0	176.4	177.7
450	153.5	149.2	153.2	159.7	150.1	154.6	156.5	157.7
400	138.7	135.9	132.9	138.6	135.2	135.5	137.6	134.1
350	128.8	129.6	123.1	125.8	128.3	129.6	124.9	124.7
300	138.7	145.8	125.3	125.3	127.9	129.9	130.4	125.9
LONG	-79.72	-79.33	-78.93	-78.50	-78.03	-77.53	-76.95	-76.35
LAT	36.41	38.35	40.30	42.24	44.18	46.11	48.03	49.96
QUAL	13	13	13	13	13	13	13	13

Second Digit

1. f_xF_2 clearly visible and read.
2. f_xF_2 not quite visible, but highest visible frequency close to f_xF_2 or presence of ground reflections would allow an estimate of f_xF_2.
3. f_xF_2 not visible.

The volume of data from Hawaii has the following additional parameters:

SPOINT	Tracking station at South Point, Hawaii
SAT	Electron density at the altitude of the satellite
NT	Integrated electron density in units of 10^{13} per cm^2
HS	Satellite altitude in km
DIPL	Magnetic dip latitude, deg; positive sign indicates northern magnetic latitude, and negative sign indicates southern magnetic latitude
INVL	Magnetic invariant latitude in deg
L	Magnetic L shell number
DIP	Magnetic dip angle in deg; positive sign indicates northern magnetic latitude, and negative sign indicates southern magnetic latitude
FHS	Electron gyrofrequency at the satellite in Mc/s
KP	Planetary magnetic activity index
SNL	Sunlight indicator; 1 = satellite solar illuminated 0 = satellite not solar illuminated

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LAST FEW records of File 1

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