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NRL Report 5366

SPACE SURVEILLANCE SYSTEM
OBSERVATIONS OF THE SATELLITE 1958 ZETA

[UNCLASSIFIED TITLE]

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ABSTRACT
[Confidential]

All observations made by the Space Surveillance System on the satellite 1958 Zeta (Atlas) during its lifetime (December 18, 1958 to January 21, 1959) are presented. Only the Eastern Complex consisting of the Jordan Lake (Alabama) transmitting station and the Fort Stewart (Georgia) and Silver Lake (Mississippi) receiving stations were in operation at this time.

About 70 feet long and 10 feet in diameter, this satellite was large enough to give good reflected signals and afforded the first opportunity for the Space Surveillance System to achieve a triangulation height measurement of a satellite. Between December 19 and January 19, reflected signal observations were made on 37 satellite passes including 18 coincident observations with complete information for height triangulation. These observations were obtained with the use of lower transmitter power and smaller antennas than now employed and in spite of considerable downtime resulting from construction work then in progress.

PROBLEM STATUS

This is the first in a series of reports on satellite observations made by the Space Surveillance System. Work is continuing.

AUTHORIZATION

NRL Problem R02-35
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SPACE SURVEILLANCE SYSTEM

OBSERVATIONS OF THE SATELLITE 1958 ZETA

INTRODUCTION

The satellite 1958 Zeta, popularly called Atlas, was launched from the Atlantic Missile Range, Cape Canaveral, Florida and was placed in orbit on December 18, 1958 at 2306Z; its life presumably ended on January 21, 1959. At injection this satellite had a period of 101.5 minutes, inclination of 32.3 degrees, perigee height of 113 statute miles, and apogee height of 916 statute miles.

This satellite provided the first good opportunity for evaluating the performance of the Space Surveillance System through observations of a known object. Previously, signals received by the system had been identified only by correlating them with the predicted time of crossing and predicted zenith angle of a known satellite at the receiving station. This correlation was difficult because the predictions could be in error by as much as twenty minutes in time from the observed positions because of errors in existing source data. In the case of 1958 Zeta the certainty of correlation was improved in the following two ways: (a) it was possible in some cases to receive the reflected signal simultaneously at two stations and thus triangulate to obtain the satellite height, (b) it was possible for the station to receive the 107.97-Mc signal radiated by the satellite during most of its life.

No attempt has been made in this report to compare the observations with predictions or post-flight data for several reasons: (a) predictions made during the lifetime of a satellite having a rapidly decaying period are unsatisfactory for comparison since they are frequently several minutes of time in error, (b) the time required for analysis and issue of all the 107.97-Mc observations by the Minitrack system on a post-flight basis by the Vanguard Computing Center would delay the release of this report, and (c) a detailed comparison of all the Space Surveillance System observations with post-flight data is probably not justified since the Eastern Complex was in a development and installation phase, which is not representative of the current capability of the system.

There also has been no effort devoted to an explanation of how the Space Surveillance System observations on this satellite could be used to establish information concerning the orbital elements. For a single Complex, this capability was considered too limited to devote the time to it, since observations on later satellites are much more fruitful in this regard. Nevertheless, it should be pointed out that through the use of all the observations of 1958 Zeta the orbital elements of this satellite could have been established with fair accuracy.

STATION STATUS

During the lifetime of 1958 Zeta, only the Eastern Compex of the Space Surveillance System was in operation, and it was undergoing modifications. The receiving stations of the Eastern Complex at Fort Stewart, Georgia, and Silver Lake, Mississippi, are about 280 statute miles from the transmitting station at Jordan Lake, Alabama. The Western complex consists, similarly, of two receiving stations - one at Elephant Butte, New Mexico,

and one at San Diego, California – with the transmitting station located at Gila River, Arizona. All six stations (Fig. 1) lie along a single great circle from Fort Stewart to San Diego to form part of an east-west "fence." The inclination of this great circle with the equator is 33.4°.

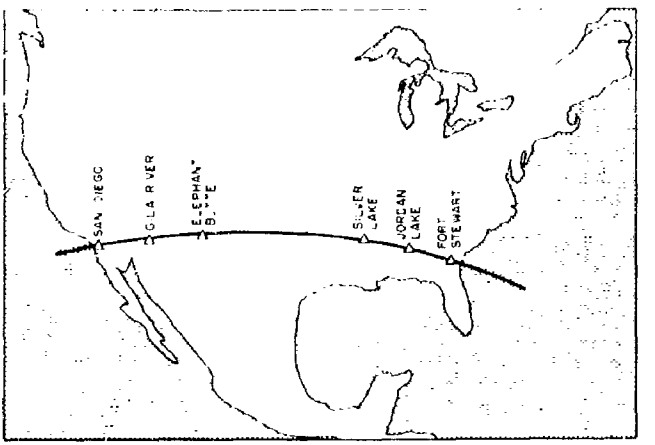

Fig. 1 – Space Surveillance Stations

The antenna layout for the stations of the Eastern Complex during the lifetime of 1958 Zeta is shown in Fig. 2, which also illustrates the electric-vecto · orientation of the dipole elements of the antennas. Each station contains a number of antennas, an antenna consisting of a 400-foot line of dipoles mounted horizontally over a ground screen. Silver Lake, a typical receiving station, consists of five antennas with dipole elements in a collinear array and two antennas with dipoles in a broadside array, thus permitting signal reception for both polarizations. The Fort Stewart installation used the three antennas which were initially installed to check the feasibility of the system. The Jordan Lake transmitting antenna was the 400-foot feasibility antenna which used slot elements whose polarization was east-west. The continuous-wave transmitter at Jordan Lake was operated at a frequency of 108.00 Mc with 40-kw power output. All of the arrays are located so as to produce a vertical fan-shaped beam with the broad portion of the beam in an east-west direction. The beam pattern for the collinear array is about 1.2° by 140° to half-power points, and the pattern for the broadside array and the transmitter slot array is about 1.2° by 120°.

DATA RECORDING SYSTEM

During December 1958 and January 1959 the Silver Lake data were recorded at the station on an eight-channel Sanborn recorder operated at 5 mm per second (Appendix A, Fig. A1). During December and the first half of January, Fort Stewart data were recorded in the form illustrated in Fig. A4. In addition, beginning with January 6, three channels

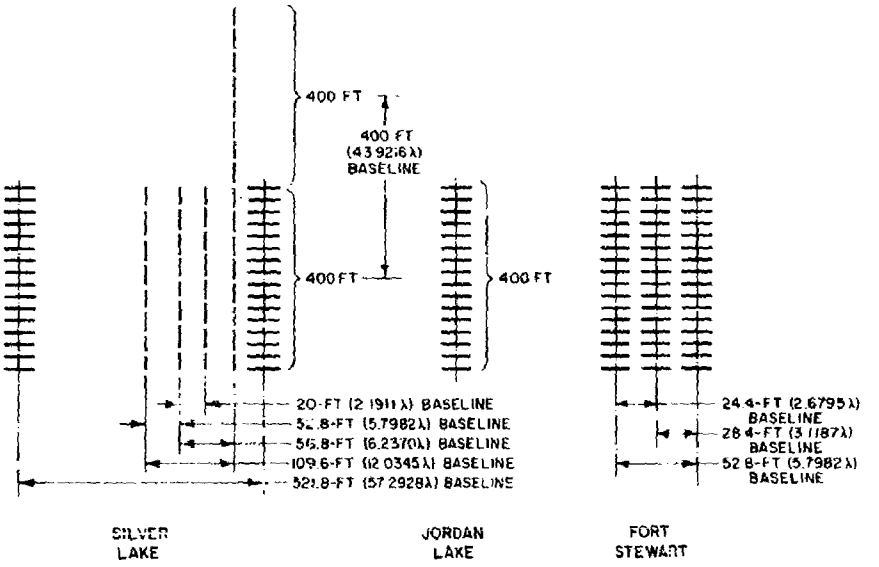

Fig. 2 - Eastern Complex antenna arrays during the lifetime of 1958 Zeta

for phase data and one channel for signal level – all the data available from the three antennas at Fort Stewart – were transmitted in analog form over a data-circuit telephone line to Silver Lake for simultaneous recording with four channels of Silver Lake data. This combined recording was especially useful in establishing the occurrence of coincident observations from both stations so that the satellite height could be determined by triangulation. On January 14, when it was established that all the pertinent phase information from Fort Stewart could be recorded on the combined recording at Silver Lake, the paper speed of the Fort Stewart recorder was changed from 5 mm to 1/4 mm per second for use only in monitoring station operation.

SIGNAL CONDITIONS

The satellite, about 70 feet long and 10 feet in diameter was large enough to give good reflected signals, and it also contained a continuous-wave transmitter which radiated on 107.97 Mc. Until January 11, 1959, when the batteries went dead, the transmitted signal provided an almost positive means of identifying reflected signals as being those from 1958 Zeta. The Silver Lake station could be tuned to receive either the reflected signal at 108.00 Mc or the signal transmitted by the satellite at 107.97 Mc. At Fort Stewart, although it was not possible to tune the station to the satellite-transmitter frequency, the signal level from a communications receiver tuned to receive 107.97 Mc was recorded along with 108.00-Mc phase information.

ORBIT

The orbit of 1958 Zeta was favorable for observations by the Space Surveillance System for the first week, but then became less favorable as the apogee came near the stations, owing to a rather high motion of perigee (about 9 degrees per day). After about another week the orbit had again moved to a more favorable position so that observations were made almost every day until two days before the life of the satellite ended.

Since the inclination of 1958 Zeta was 32.3°, about one degree less than that of the plane through the stations, the satellite could cross the beam of the Eastern Complex only at longitudes less than 85°West, which is east of Jordan Lake. For this inclination, the satellite always enters the southern edge of the beam and passes to the northern edge. These effects are illustrated in Fig. 3 where three typical satellite passes are shown. Passes A through C show a decreasing angle of incidence between the orbital plane and the observing station plane. For incident angles of 14° to 3°, which are typical for an orbit having an inclination such as that of 1958 Zeta, the satellite will take from 4 to 20 times longer to cross the beam than if it crossed perpendicularly. As the orbital inclination increases above that of 1958 Zeta, there is less variation in the incident angle and consequently less variation in signal duration due to this cause. It can be seen from an examination of the observations of 1958 Zeta that, as expected, there is quite a variation in signal duration for this satellite.

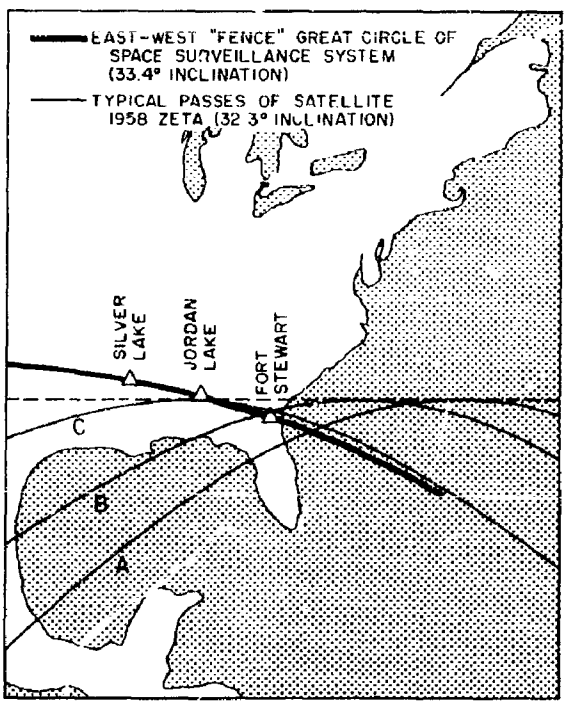

Fig. 3 - Passes of the Satellite 1958 Zeta through Space Surveillance "Fence"

OBSERVATIONS

The term "observations" as used in this report will be used only for reflected signals received by the Space Surveillance System. All observations for 1958 Zeta are shown in Table 1 and in the signal traces reproduced in the Appendix. The heights listed in the table are observed values as determined by triangulation on the vertical plot of Fig. 4, except for single-station observations for which predicted heights have been used.

Reflected signals were received on 37 passes during the 34 days that the satellite was in orbit. There were 18 coincident observations with complete information from both stations, five coincident observations with incomplete phase information from at least one station, seven observations from Silver Lake only and seven observations from Fort Stewart only. Observations with only partial phase readings have been listed as they establish the time at which the satellite crossed the beam.

A summary of observations on a time correlation basis is shown in the day-hour plot of Fig. 4. The time of day is plotted against the date for all observations. Coincident observations from two stations are indicated by a circle and observations from a single station are indicated by a semicircle. A shaded circle or semicircle indicates that a zenith angle was determined from the observation while the unshaded symbols indicate that only the time of the observation could be determined. This type of plot is quite useful in adjusting beam-crossing predictions on a day-by-day basis to take account of the most recent observations for improvement of the correlation in real time as is essential for operational use. The plot shows a stroboscopic effect since the Complex is observing passes at approximately one-day intervals. If the satellite had no decay in its period, the graph would be a series of essentially straight lines. For 1958 Zeta, however, the period of decay is readily noticed in the changing slope.

A summary of all observations is presented on a vertical plot in Fig. 5. This plot presents the positions of the satellite as it crossed a vertical plane which contains the great circle passing through the stations. Where angular information from both stations was available, the plotted point was determined by the intersection of the two angles. If only one angle was available, the point was determined from the observed angle and the predicted height. It will be noted that all of the observations are somewhat east of the Jordan Lake transmitter at longitudes less than 85° West, as had been expected for a satellite with this inclination.

The earliest time at which an observation could have been made on this satellite by the Space Surveillance System was about 20 hours after launch. At this time (Dec 19/190939Z) the Silver Lake receiving station observed it at a zenith angle of 76°E (Appendix A, Fig. A1), when it was at a predicted height of 295 statute miles. Unfortunately, there was no forewarning of this satellite launching, and the Fort Stewart receiving station was inoperative at the time because one of the antenna arrays was being moved to improve the ambiguity resolution of the received signals. The first observation with complete phase information (Fig. A2) made by Fort Stewart was on December 22 at 192640Z, soon after Fort Stewart had been returned to operation. Since an observation was also made at that time by Silver Lake it was possible for the first time to triangulate for the satellite height with this system; the value obtained was 370 statute miles.

During the last pass on December 20, which was at 221320Z, and during the three passes on December 21 at 181130Z, 195920Z, and 214339Z the phase receiver at Silver Lake was tuned to the transmitter frequency of the satellite. Thus phase readings were available, but there was no possibility of receiving a reflected signal. These signals were

Table 1
Space Surveillance System Observations of the Satellite 1958 Zeta (Atlas) for the Eastern Complex

Date	Universal Time (hr-min-sec)	Silver Lake		Fort Stewart		Height (statute miles)
		Zenith Angle (deg)	Signal Duration (sec)	Zenith Angle (deg)	Signal Duration (sec)	
Dec. 1958						
19	190939	76E	5.5			295*
19	205433	#	3.2			230*
20	202838	61E	14.0			255*
22	174156			#	7.0	455*
22	192640	49E	9.5	29W	7.0	370
23	185046	48E	14.0	22W	9.0	425
24	181114	45E	11.0	20W	12.0	475
25	172824	47E	8.5	#	6.0	540*
26	164205			#	1.0	610*
27	.73725	#	34.0	#	43.0	570*
28	145926	56E	9.0	#	2.0	730*
28	164324	38E	16.0	14W	5.0	650
29	154606	40E	15.0	11W	17.0	655
30	163240	62E	3.2	27E	12.0	600
31	152611	#	13.0	14W	12.0	720*
Jan. 1959						
3	133830	35E	16.6			710*
4	122218	53E	14.0			650*
4	140622			4E	29.0	710*
5	110252			40E	5.0	590*
5	124416	37E	25.0	16W	16.0	640
6	112053	#	10.0	#	7.0	585*
6	130338	44E	36.0	7W	27.0	630
7	095406			50E	5.5	530*
7	113439	45E	11.0			570*
8	100332	67E	14.0	31E	5.0	480
8	114427	41E	20.0			535*
9	115042	57E	19.0	9E	6.0	525
10	100806	54E	8.0	12W	11.0	420
11	100216	50E	10.0	27W	11.0	375
12	095031	52E	12.0	11W	12.0	450
13	093246	58E	11.0	27W	11.0	305
14	090728	64E	7.0	25W	16.0	260
15	083718	68E	10.0	29W	12.0	220
16	075819	72E	16.0	43W	16.0	165
17	071007	73E	5.0	28W	7.0	180
18	061148			16W	4.0	140*
19	063804			41W	16.0	105*

* - Predicted height
\# - Some phase readings, but insufficient to obtain zenith angle

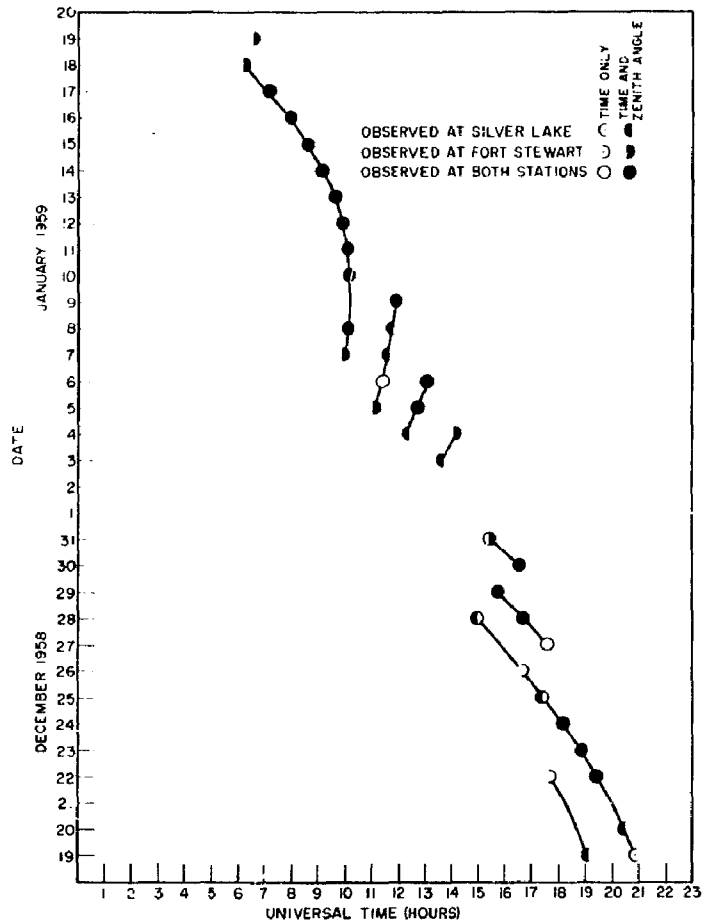

Fig. 4 - 1958 Zeta day-hour plot

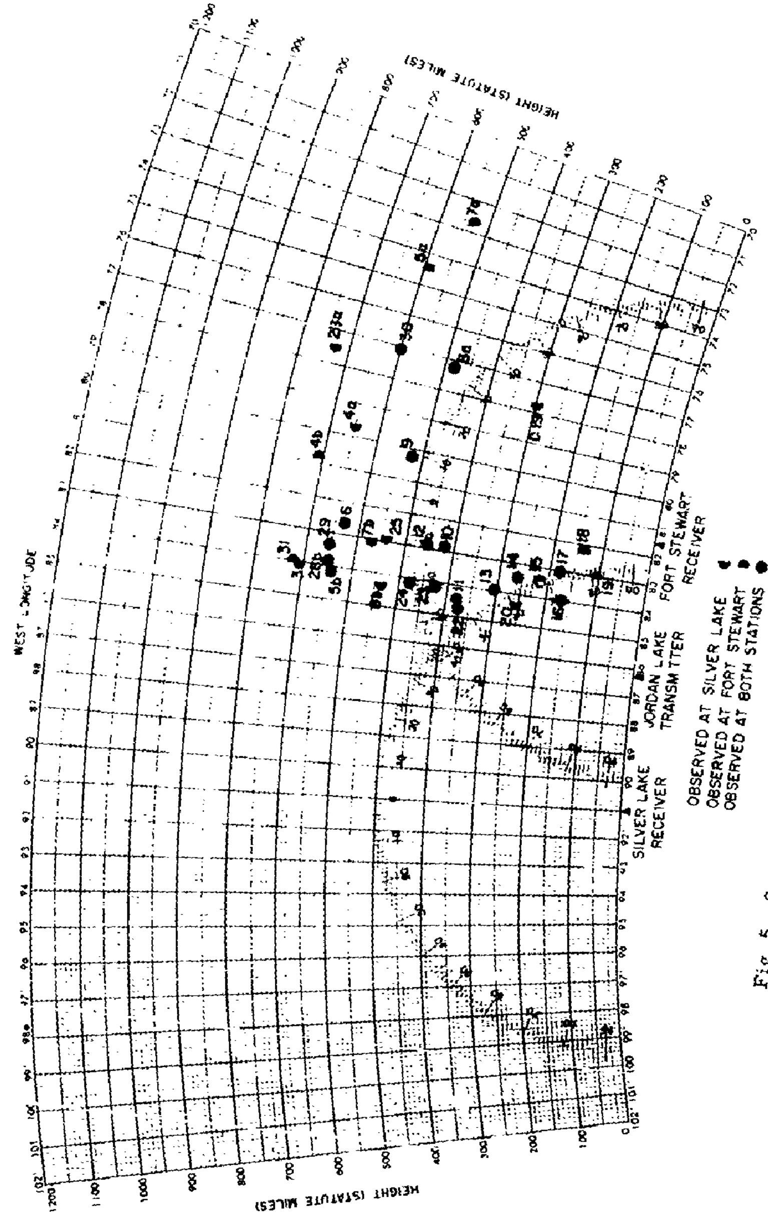

Fig. 5 - Space Surveillance vertical plot (Eastern Complex)

several minutes in length since they were received on side lobes of the antenna as well as on the main lobe. During some passes the Fort Stewart communications receiver was tuned to the 1958 Zeta frequency. On some days the only signal recorded was by this receiver, as occurred for two passes on January 1 and two on January 2.

For some observations, zenith angles could not be obtained because of incomplete phase data. For Fort Stewart, these noisy-signal observations are shown in Figs. A4, A12, A13, A15, A17, and A33 for most of which phase information is present in only the channel for the 5.7982-wavelength baseline. In all cases the reflected signal coincides with the 107.97-Mc signal recorded in the noise correlation channel from the communications receiver.

Since Silver Lake had both collinear and broadside antennas, it could receive signals which were cross-polarized or like-polarized respectively to the transmitted signal. The first reflected signal from 1958 Zeta (Fig. A1) was received only on the collinear antennas and therefore was cross-polarized with respect to the transmitted signal. On the next pass, only a like-polarized signal was received as shown in Fig. A2. Of the 30 observations made at Silver Lake, five (Figs. A2, A14, A17, A24, and A32) had only the same polarization as the transmitted signal and six (Figs. A1, A11, A16, A26, A40, and A55) indicated only a cross-polarized signal.

The greatest slant range achieved on 1958 Zeta was about 1100 statute miles for the observation made at Silver Lake on Dec 28/145926Z (Fig. A16).

SIGNAL CHARACTERISTICS

Studies made subsequent to the publication of Technical Summary Report No. 1* have indicated that about half a dozen of the signals listed for Silver Lake alone in that report were actually not observations on 1958 Zeta. In most cases these signals occurred at very nearly the correct time, but did not have quite the characteristics which experience has indicated the signals should have. For these signals the signal-level response had a spike or jagged shape instead of the rounded shape found associated with signals from satellites. An examination of the records showing the satellite observations indicates that most of them have rounded signal-level responses produced as the satellite enters the beam from one side and exits from the other. This signal in general should trace out a shape similar to the antenna pattern except when it is distorted by tumbling of the satellite or some other disturbance.

ACKNOWLEDGMENTS

The assistance of personnel associated with the Space Surveillance System is gratefully acknowledged. Special mention goes to Mr. J. J. Fleming for assistance in organizing the report. Discussions with Dr. C. E. Cleeton, Mr. R. L. Easton, and Mr. E. W. Peterkin have been very helpful. The assistance of Mr. V. B. Richards in organizing the illustrations for the Appendix and of Mr. B. Richardson in connection with the prediction information is greatly appreciated. Predicted information has been obtained from the Vanguard Computing Center.

*NRL Memorandum Report 896, "Space Surveillance System, Technical Summary Report No. 1" (Confidential Report, Unclassified Title), Dec. 31, 1958.

APPENDIX A

RECORDINGS MADE AT FORT STEWART AND SILVER LAKE SHOWING ALL SIGNALS RECEIVED FOR THE SATELLITE 1958 ZETA

Since the equipment was in a development and installation stage during the life of 1958 Zeta, many of the following records are incomplete. All are however included to provide a complete permanent record of the observations made on this satellite. In the information given as part of the title for each figure, an asterisk (*) has been printed wherever predicted information has been used; otherwise, the information has been observed by the Space Surveillance System.

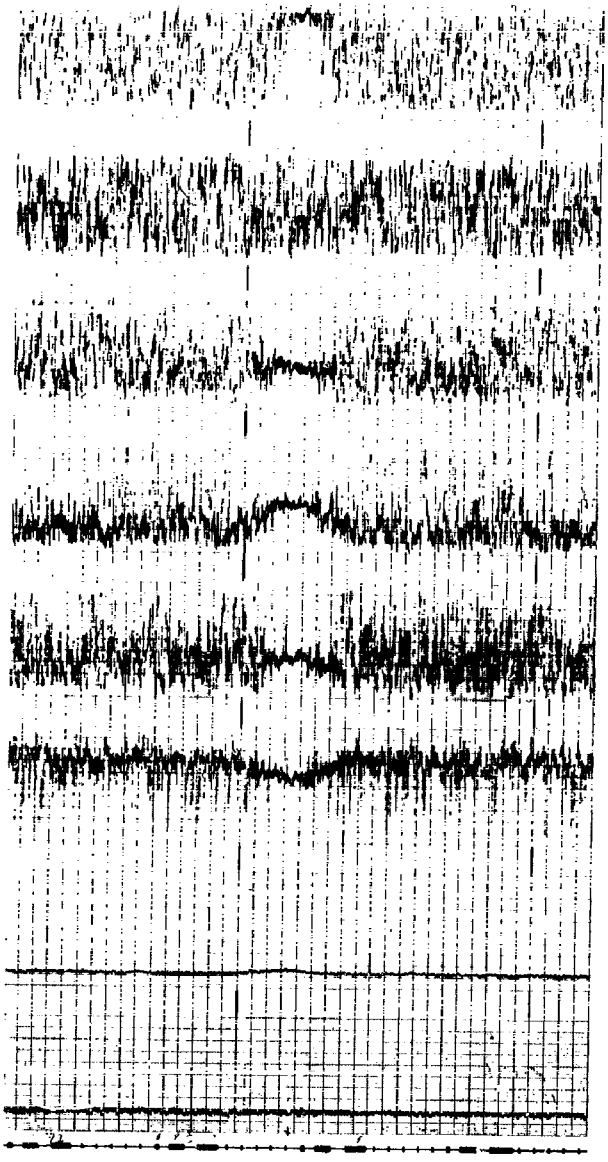

Figure A1 - Silver Lake, 1958 Dec 19/190939Z,
*Height: 295 miles, Zenith Angle: 76°E

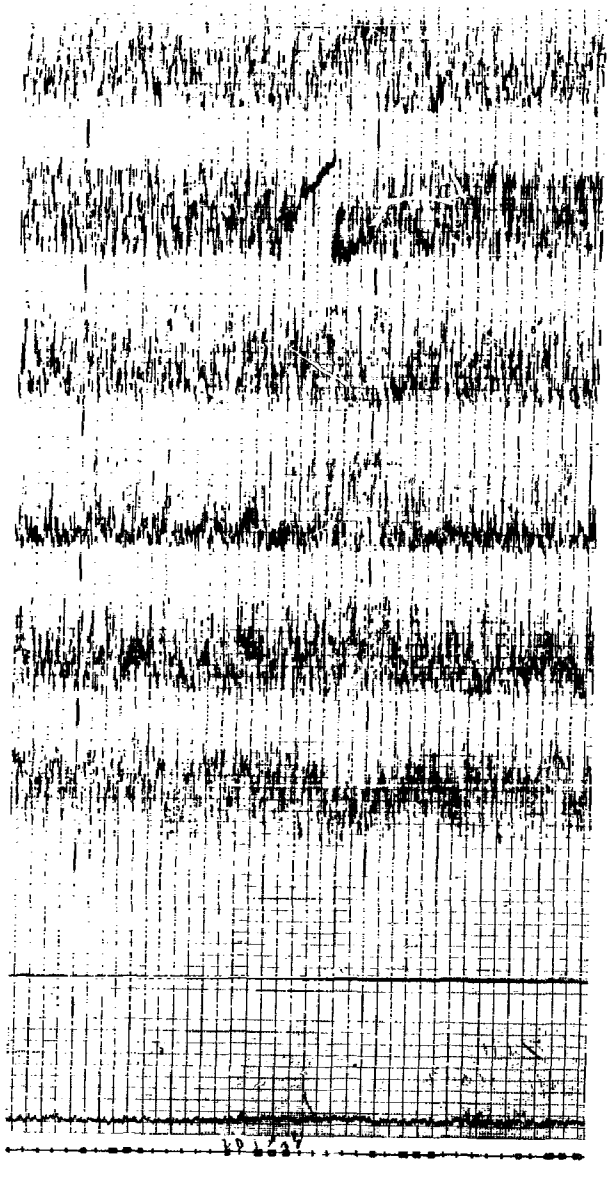

Figure A2 - Silver Lake, 1958 Dec 19/205433Z,
*Height: 230 miles, *Zenith Angle: 70°E

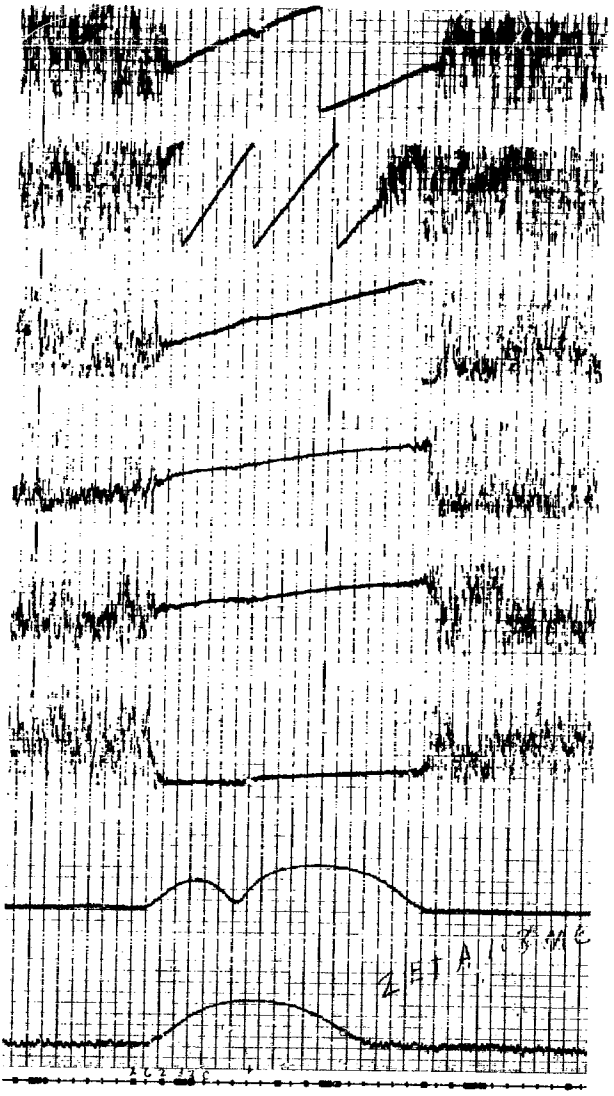

Figure A3 - Silver Lake, 1958 Dec 20/202838Z,
*Height: 255 miles, Zenith Angle: 61°E

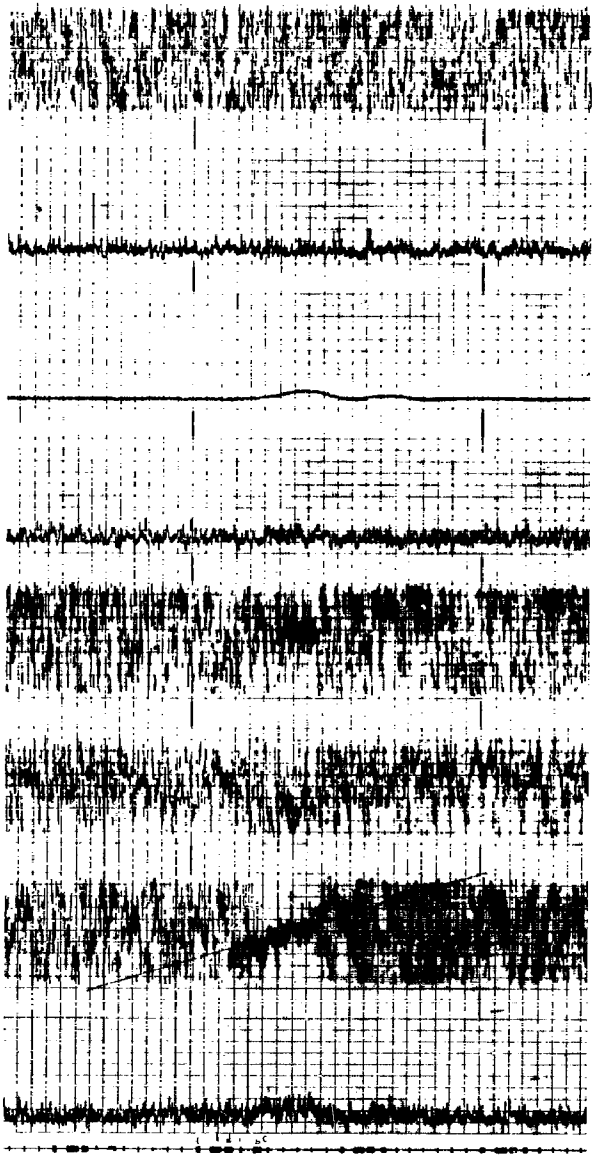

Figure A4 - Fort Stewart, 1958 Dec 22/174156Z,
*Height: 465 miles, *Zenith Angle: 34°E

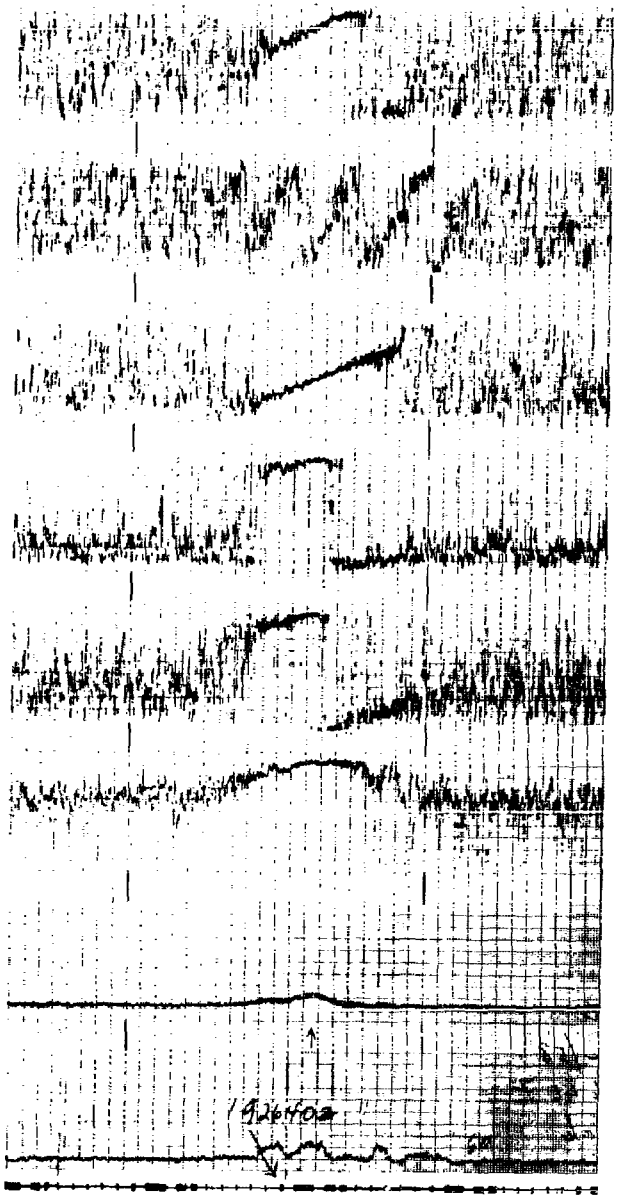

Figure A5 - Silver Lake, 1958 Dec 22/192640Z,
Height: 370 miles, Zenith Angle: 49°E

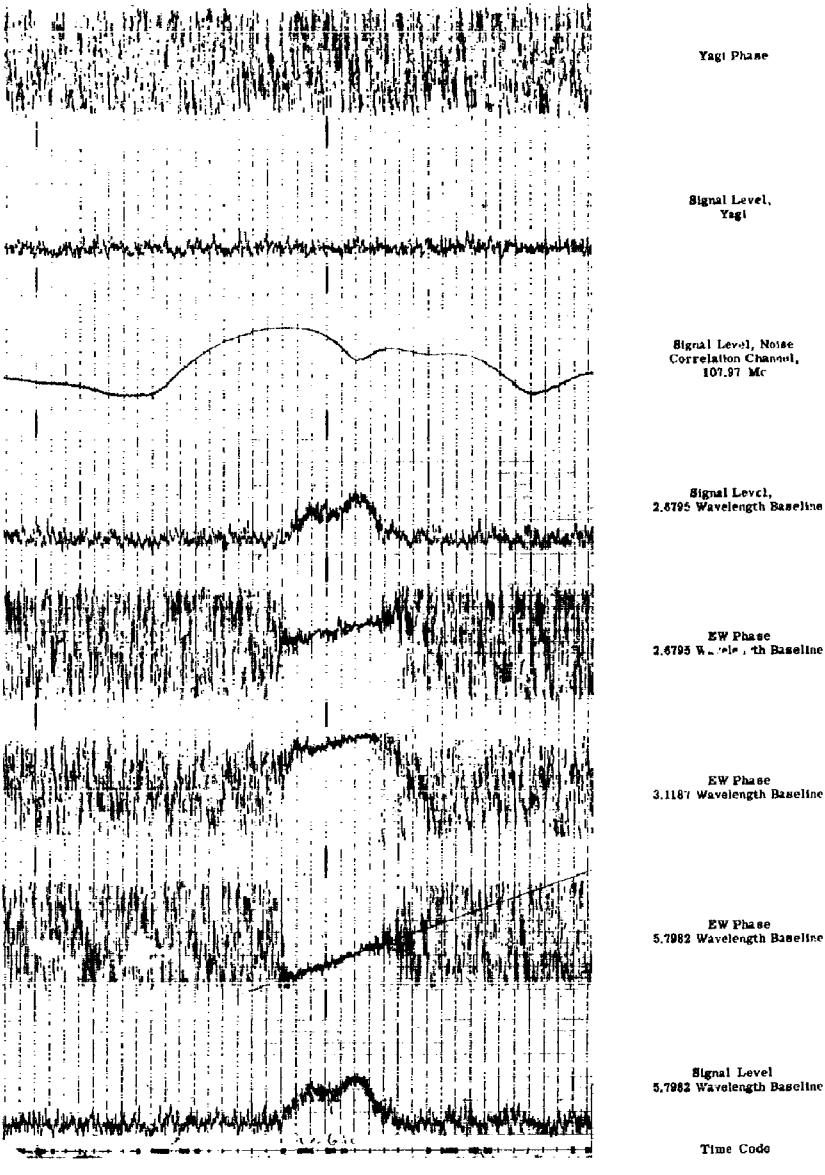

Figure A6 - Fort Stewart, 1958 Dec 22/192640Z,
Height: 370 miles, Zenith Angle: 29°W

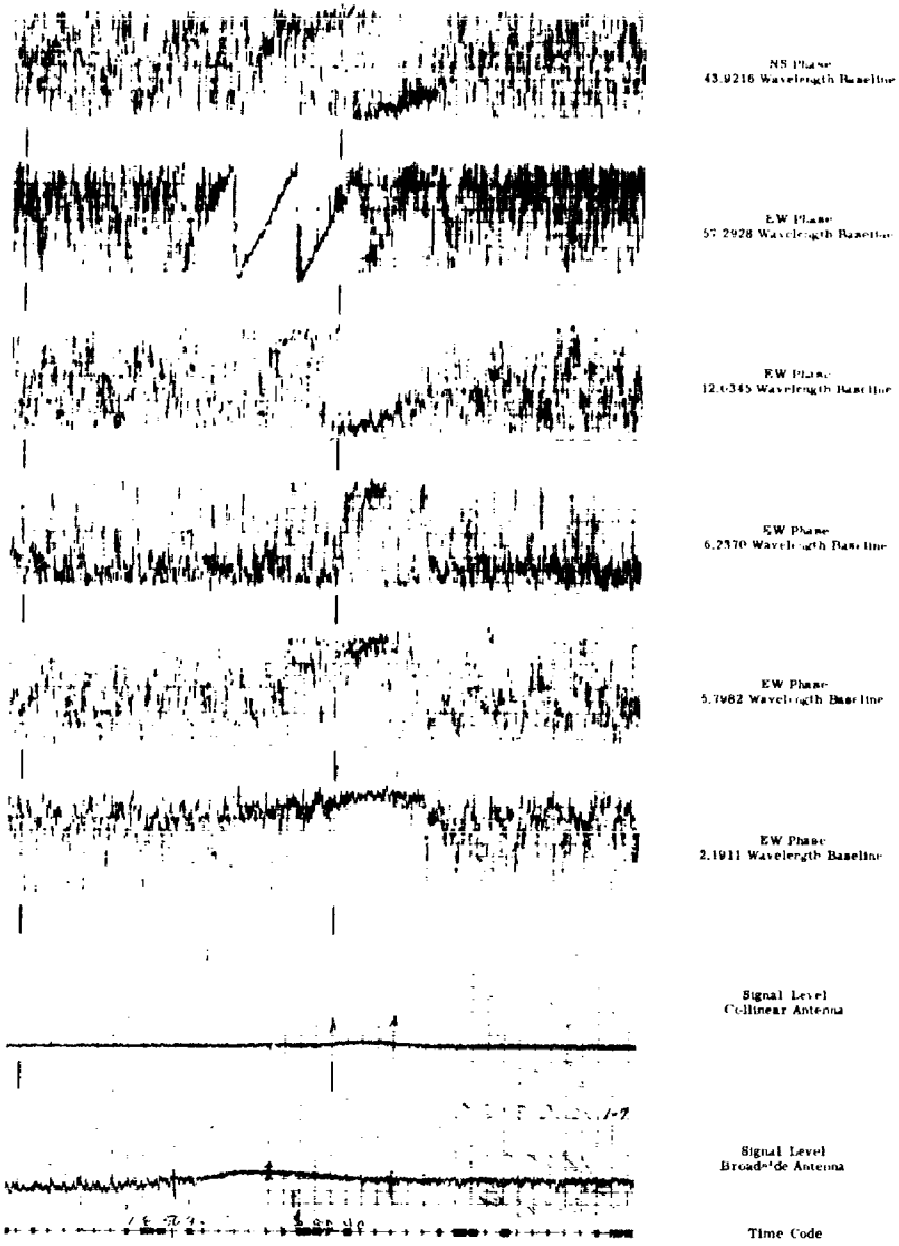

Figure A7 - Silver Lake, 1958 Dec 23/185046Z,
Height: 425 miles, Zenith Angle: 48° E

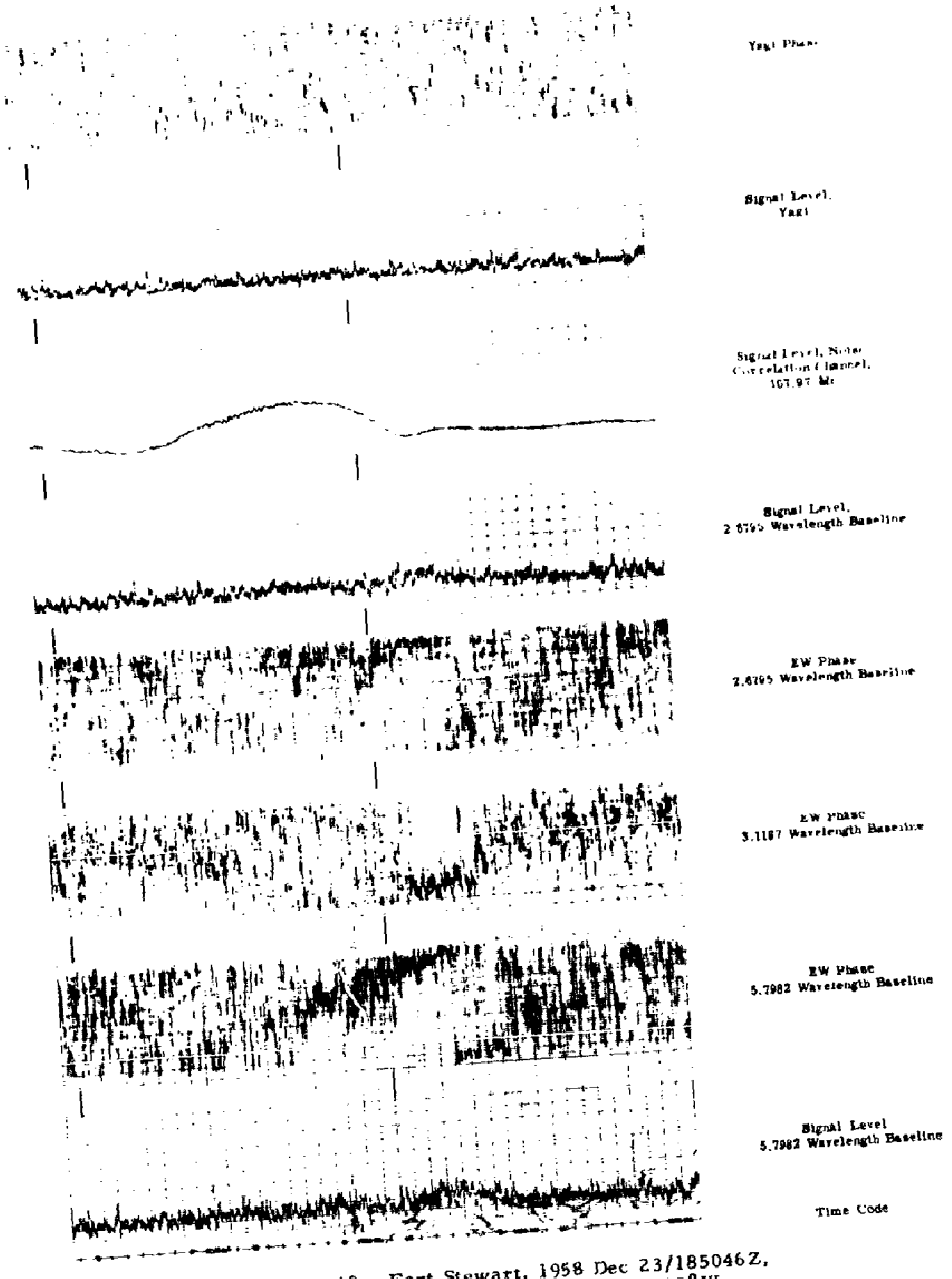

Figure A8 - Fort Stewart, 1958 Dec 23/185046Z,
Height: 425 miles, Zenith Angle: 22°W

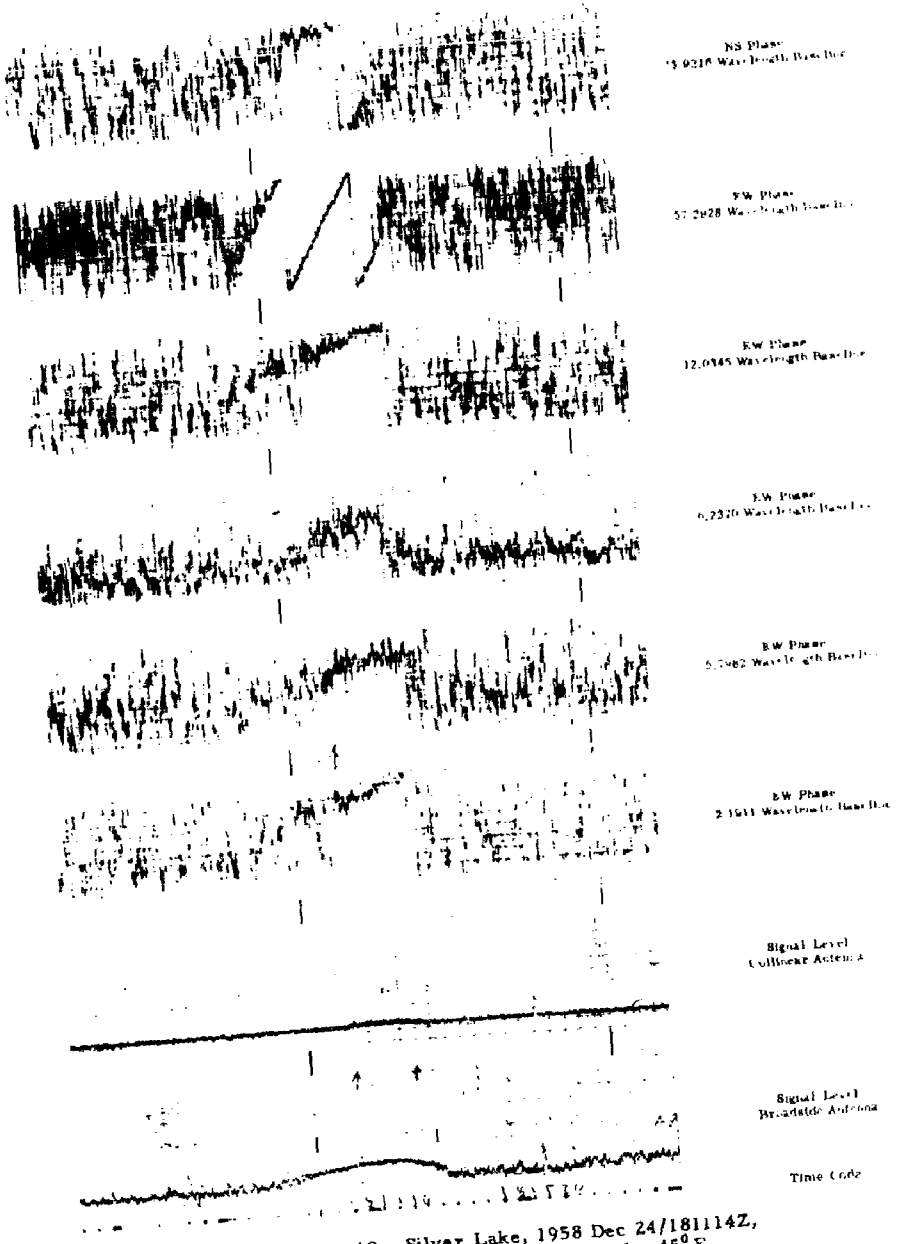

Figure A9 - Silver Lake, 1958 Dec 24/181114Z,
Height: 475 miles, Zenith Angle: 45° E

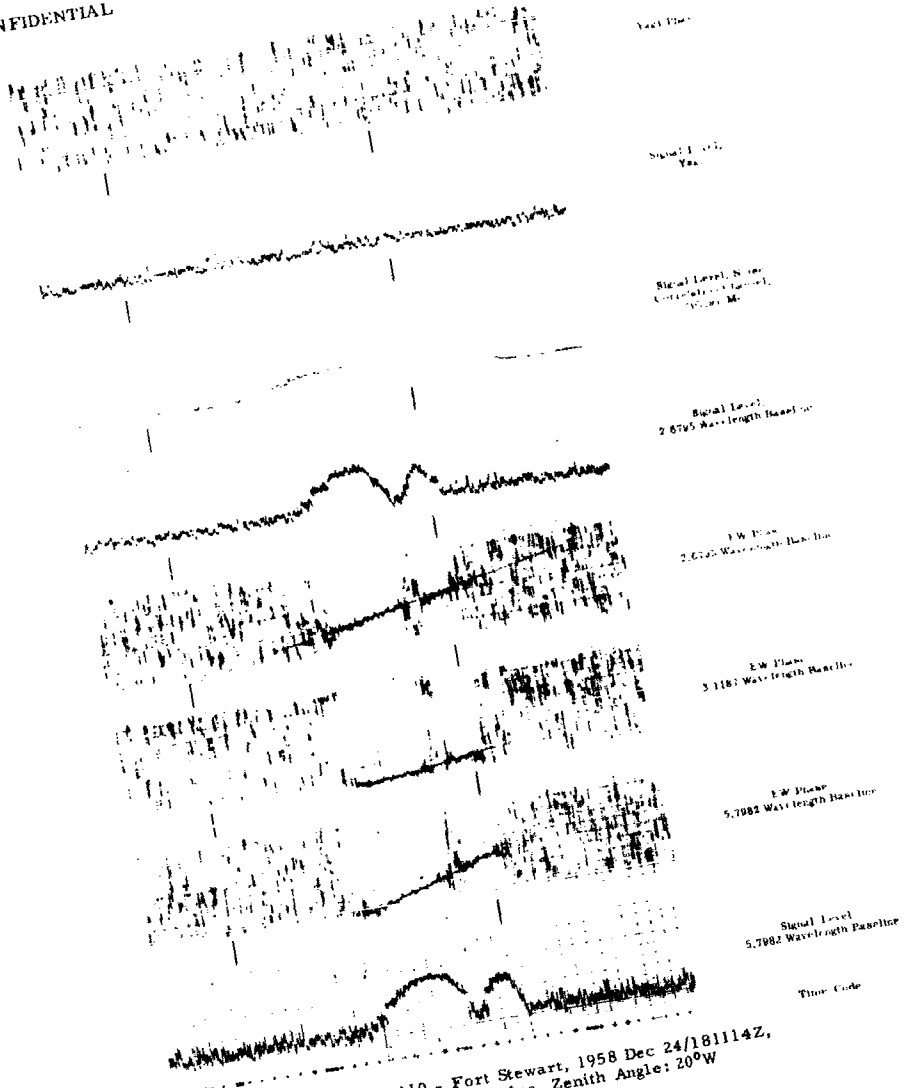

Figure A10 - Fort Stewart, 1958 Dec 24/181114Z,
Height: 475 miles, Zenith Angle: 20°W

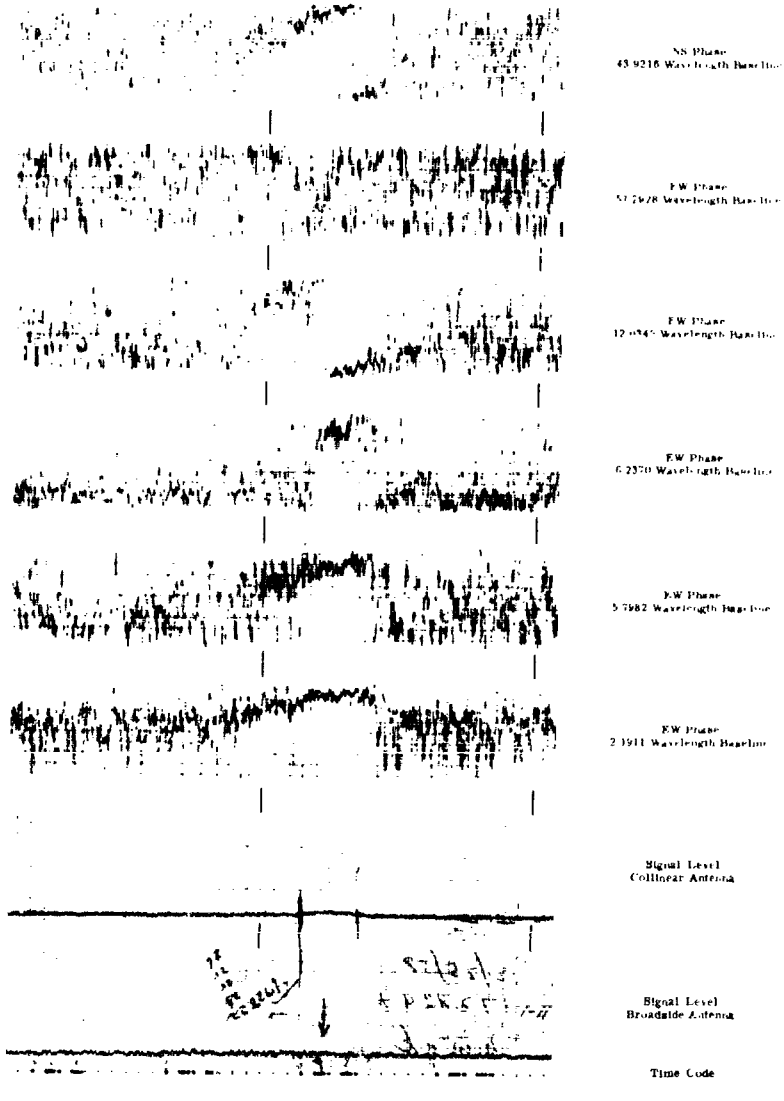

Figure A11 - Silver Lake, 1958 Dec 25/172824Z,
*Height: 540 miles, Zenith Angle: 47°E

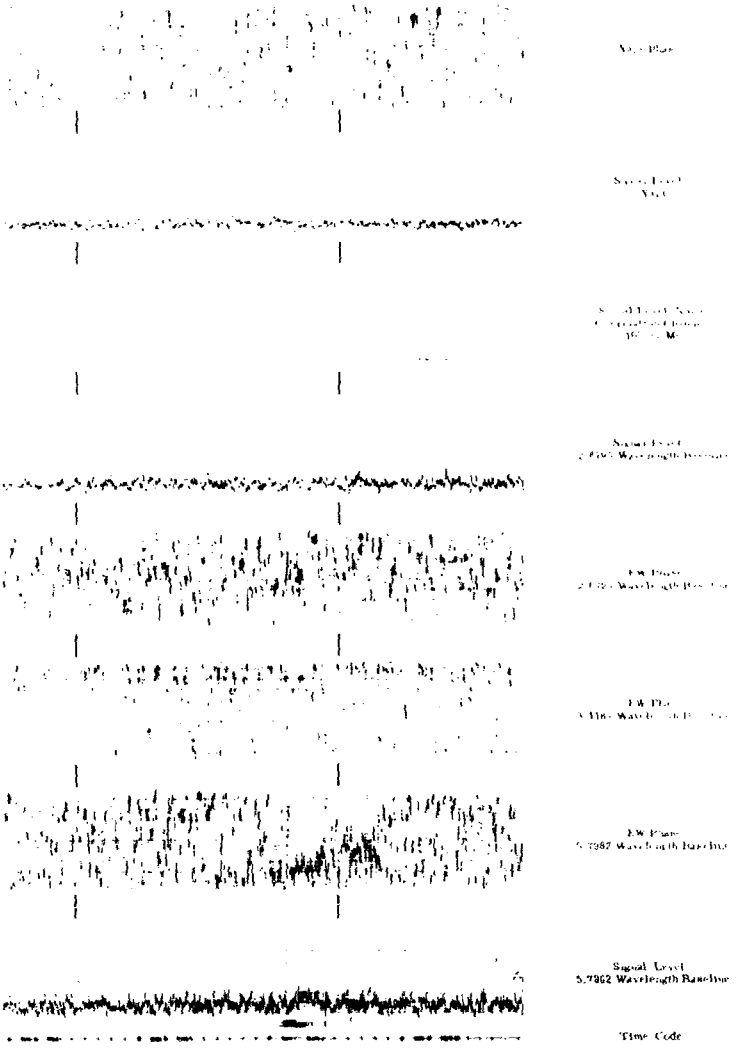

Figure A12 - Fort Stewart, 1958 Dec 25/172824Z,
*Height: 540 miles, *Zenith Angle: 9°W

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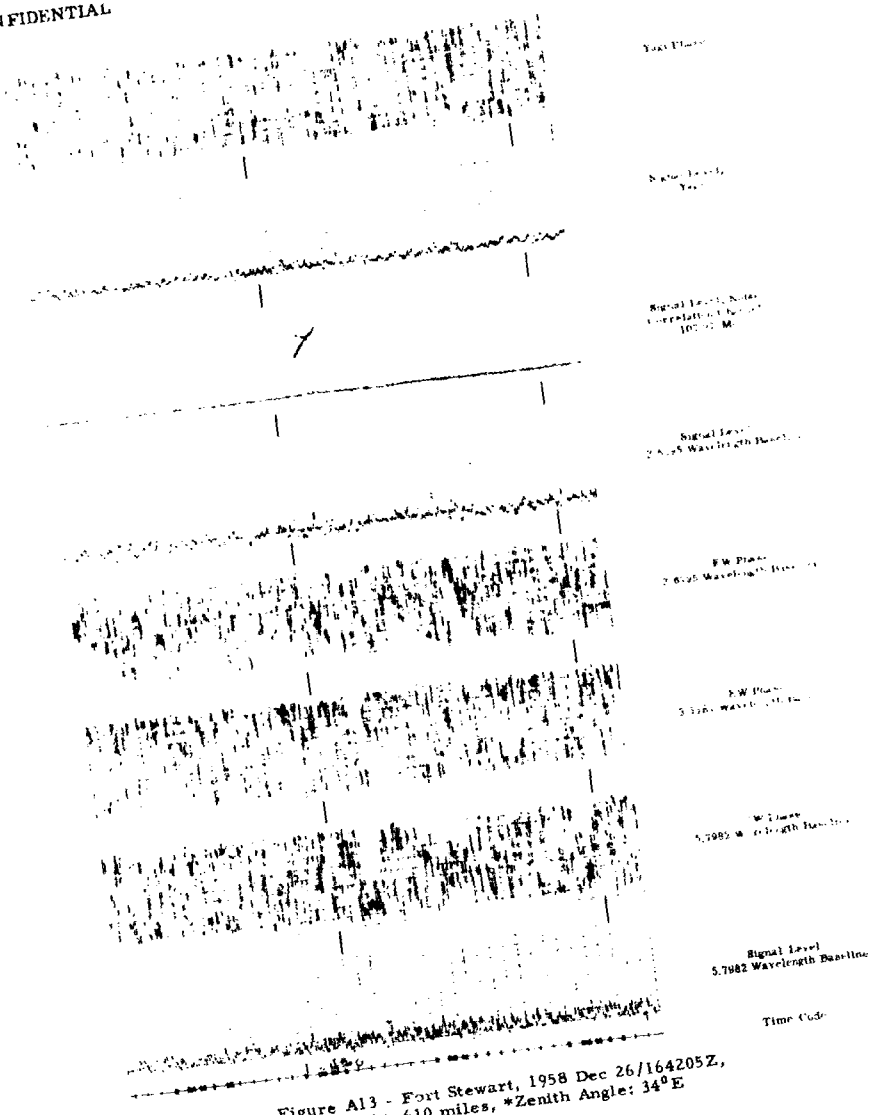

Figure A13 - Fort Stewart, 1958 Dec 26/164205Z,
*Height: 610 miles, *Zenith Angle: 34°E

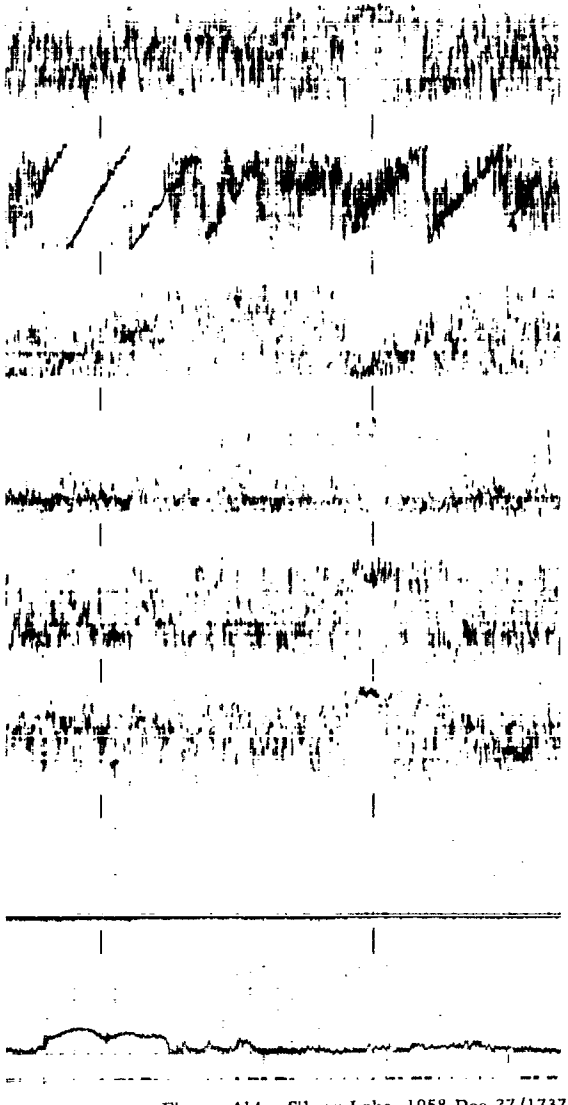

Figure A14 - Silver Lake, 1958 Dec 27/173725Z,
*Height: 570 miles, *Zenith Angle: 40°E

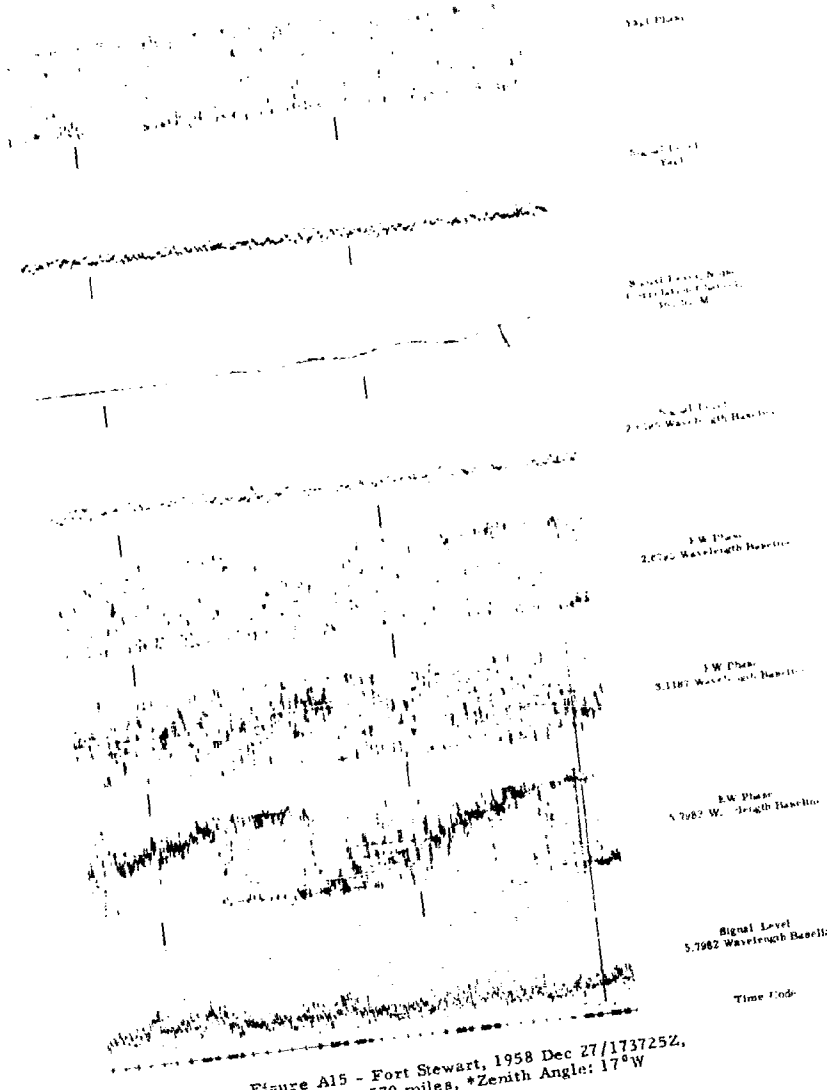

Figure A15 - Fort Stewart, 1958 Dec 27/1737252,
*Height: 570 miles, *Zenith Angle: 17°W

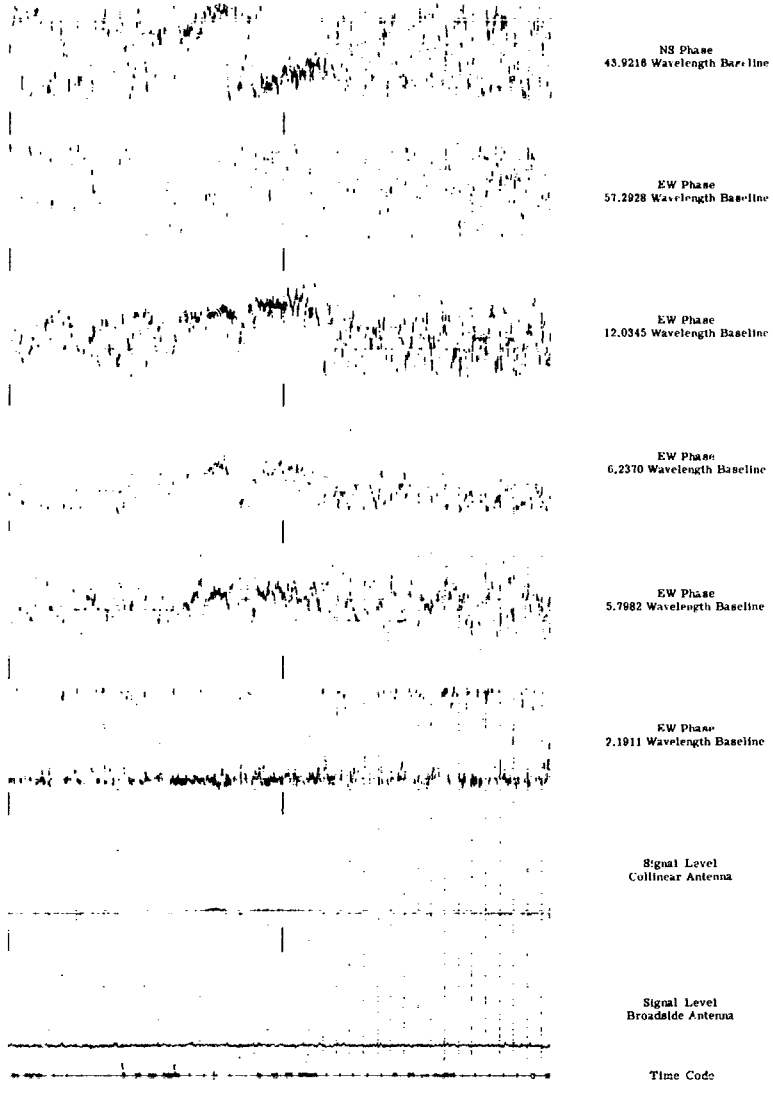

Figure A16 - Silver Lake, 1958 Dec 28/145926Z,
*Height: 730 miles, Zenith Angle: 56°E

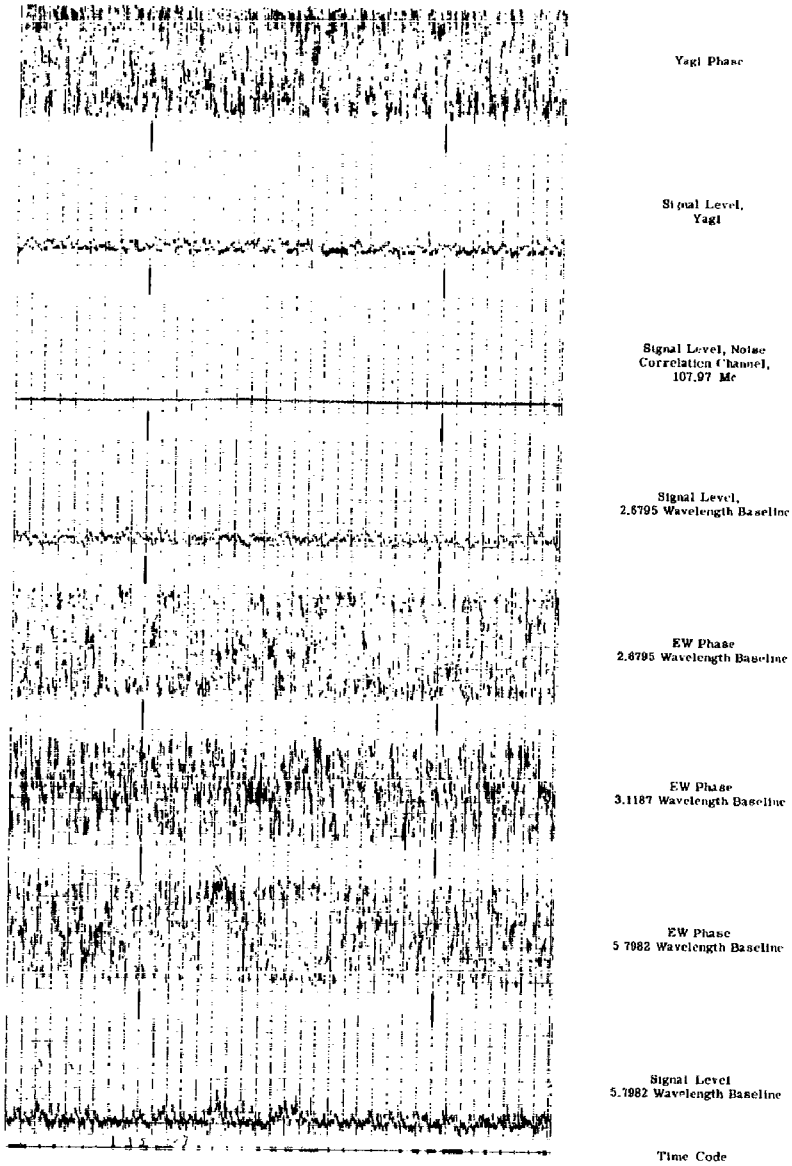

Figure A17 - Fort Stewart, 1958 Dec 28/145926Z,
*Height: 730 miles, *Zenith Angle: 24°E

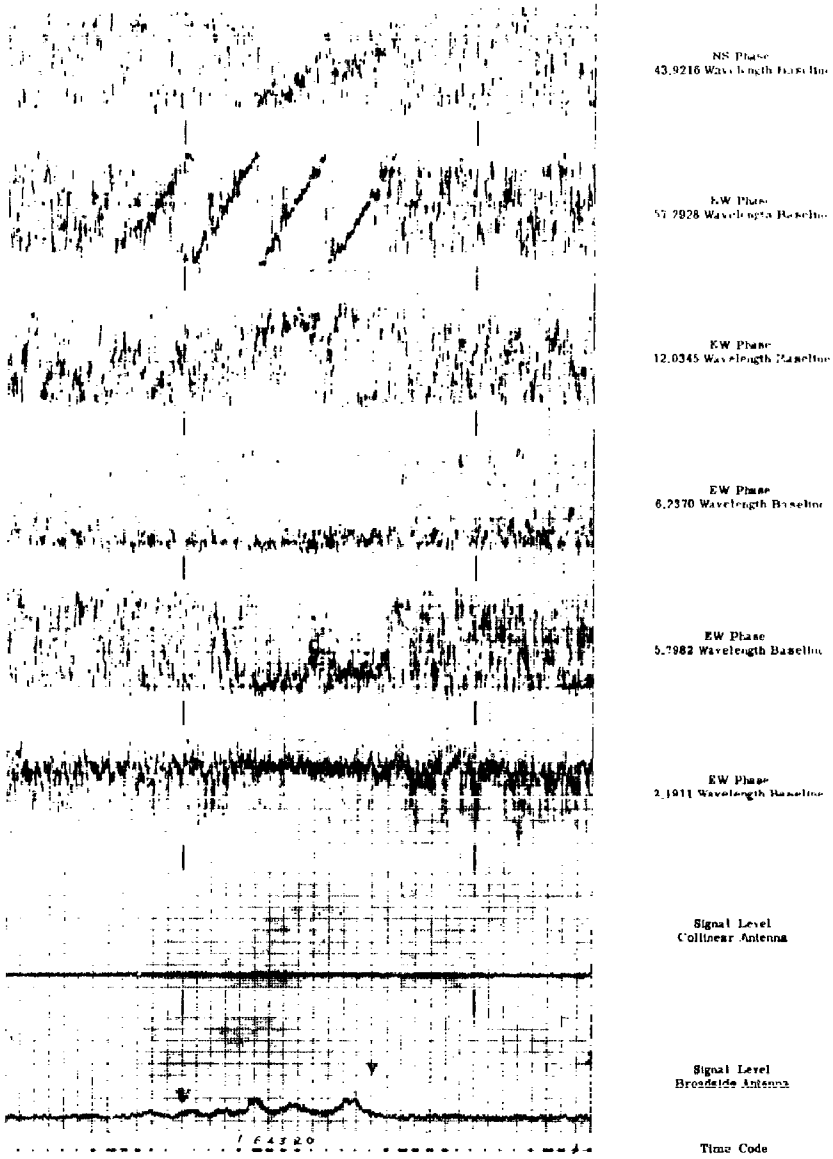

Figure A18 - Silver Lake, 1958 Dec 28/164324Z,
Height: 650 miles, Zenith Angle: 38°E

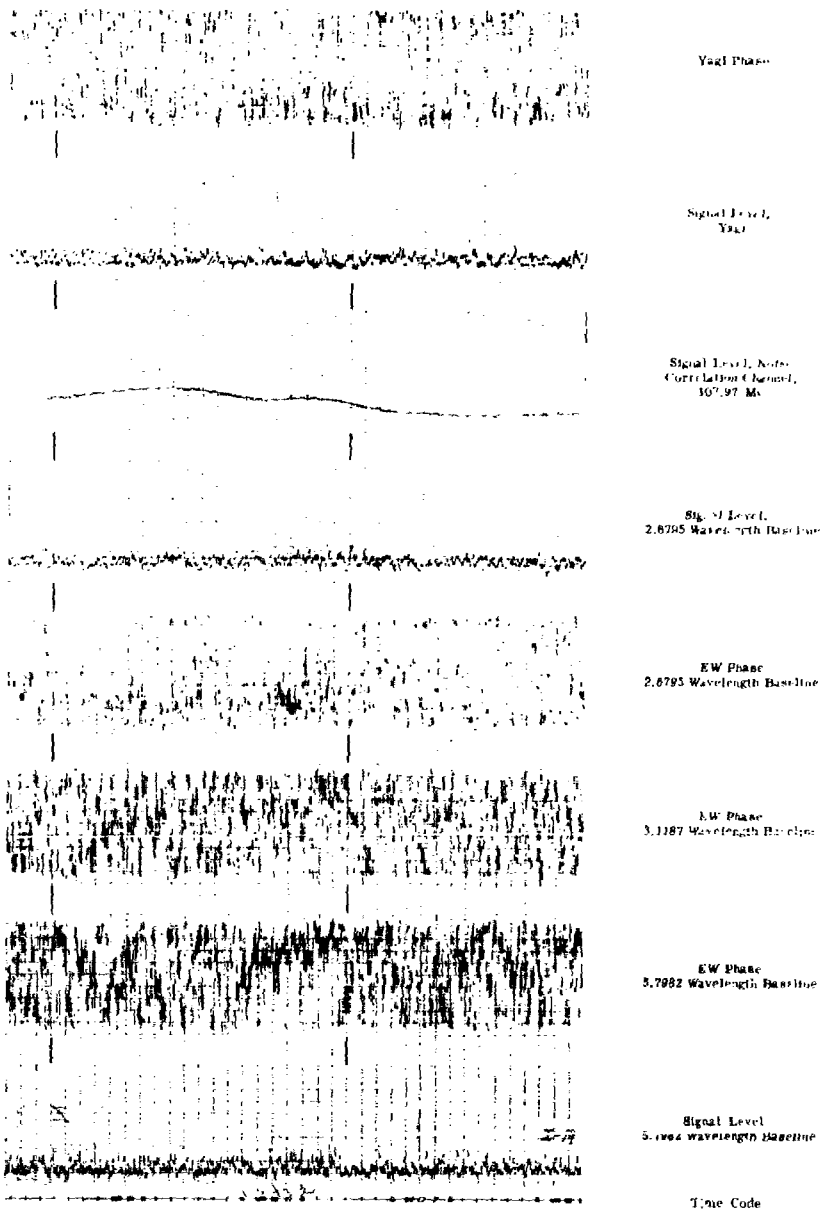

Figure A19 - Fort Stewart, 1958 Dec 28/1643242,
Height: 650 miles, Zenith Angle: 14° W

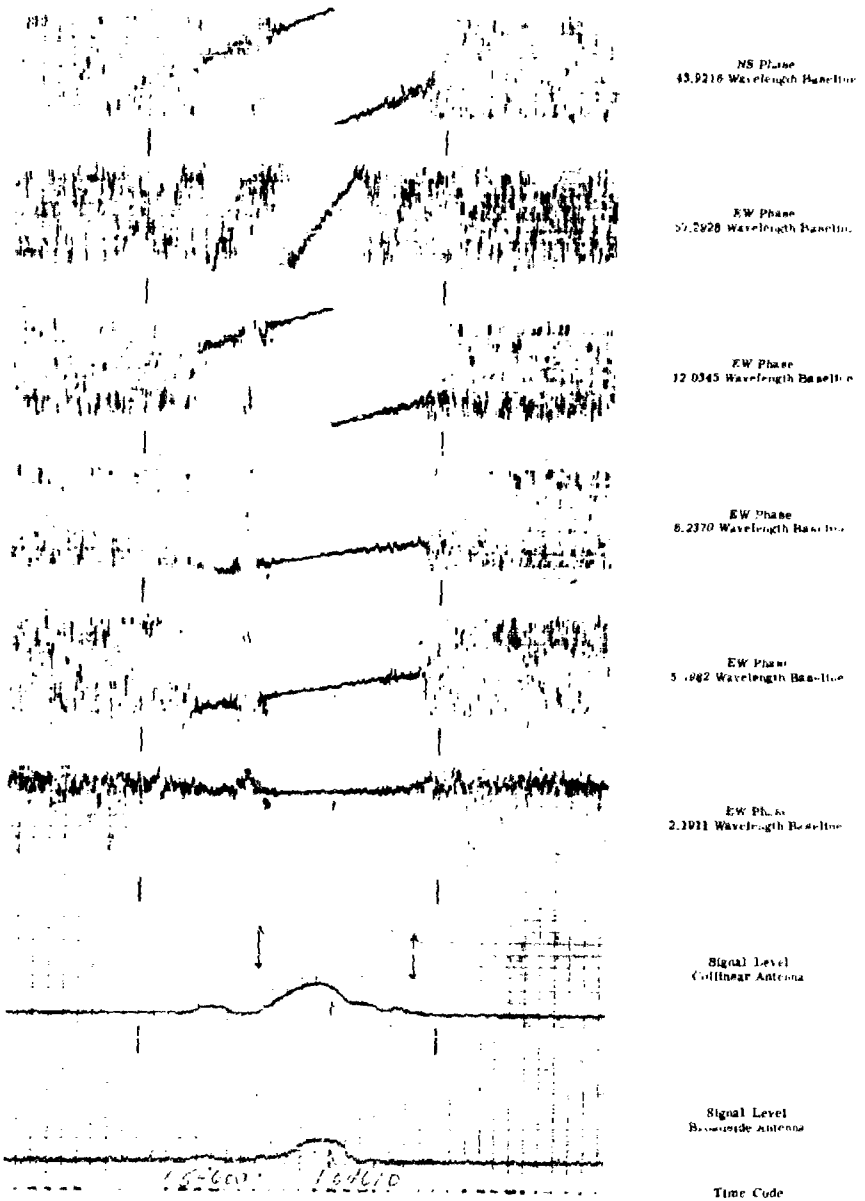

Figure A20 - Silver Lake, 1958 Dec 29/154606Z,
Height: 655 miles, Zenith Angle: 40° E

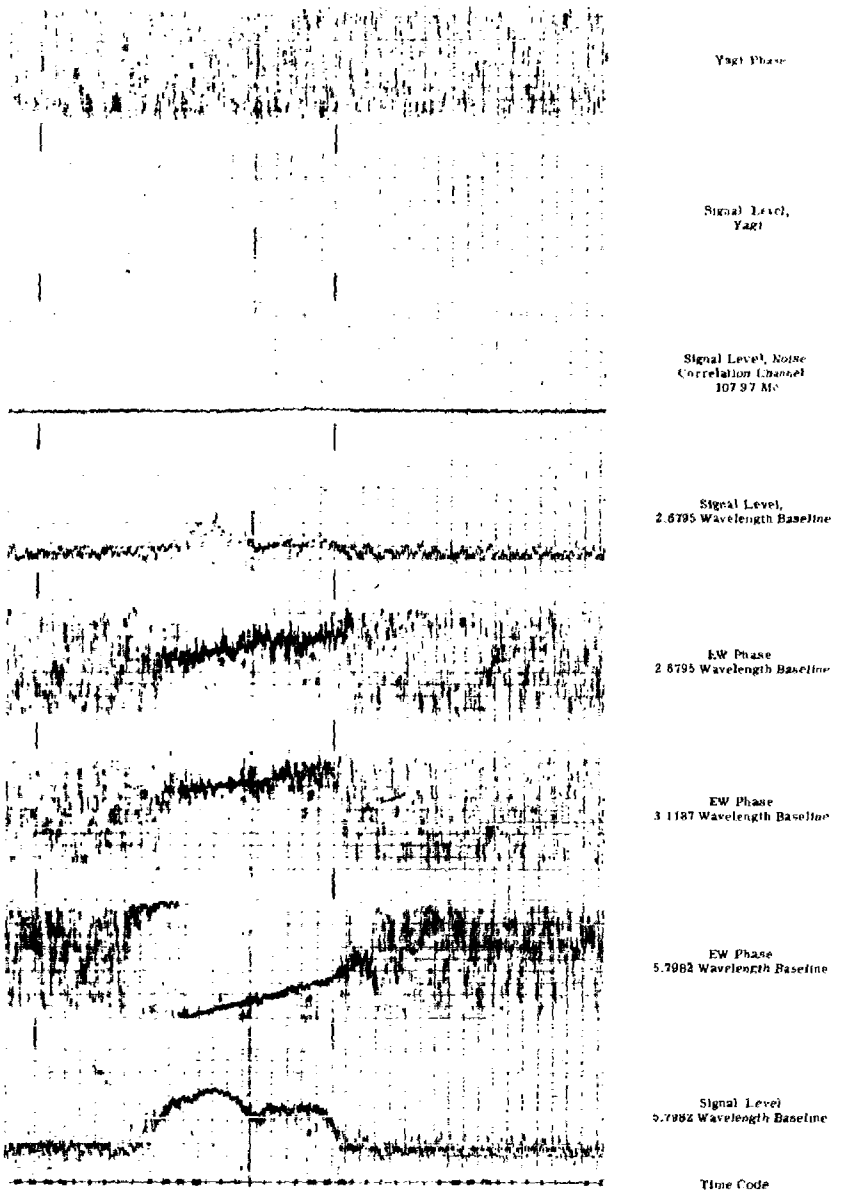

Figure A21 - Fort Stewart, 1958 Dec 29/154606Z,
Height: 655 miles, Zenith Angle: 11°W

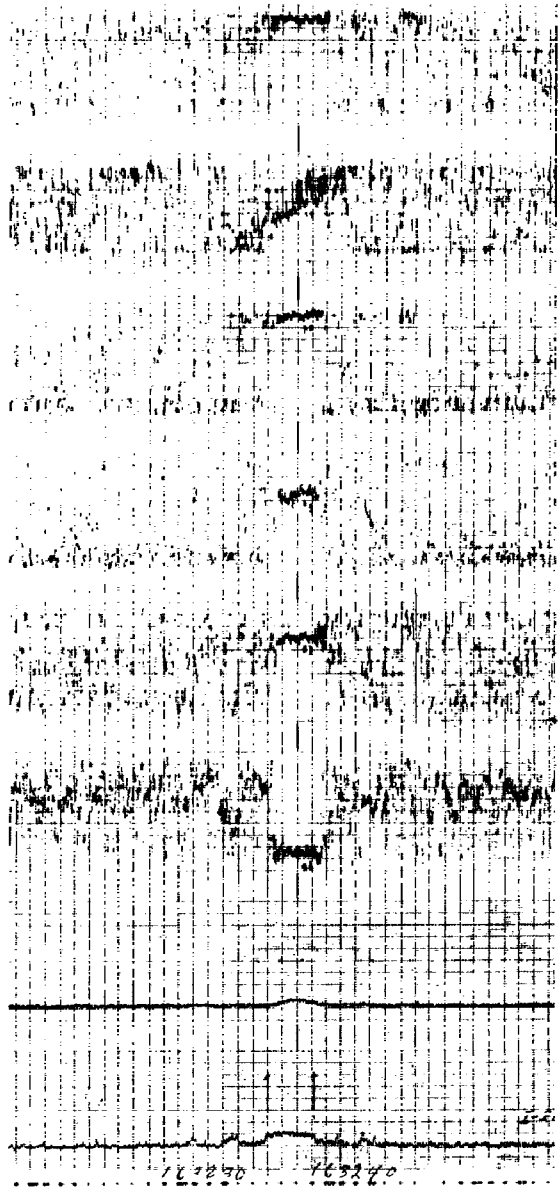

Figure A22 - Silver Lake, 1958 Dec 30/163240Z,
Height: 600 miles, Zenith Angle: 62°E

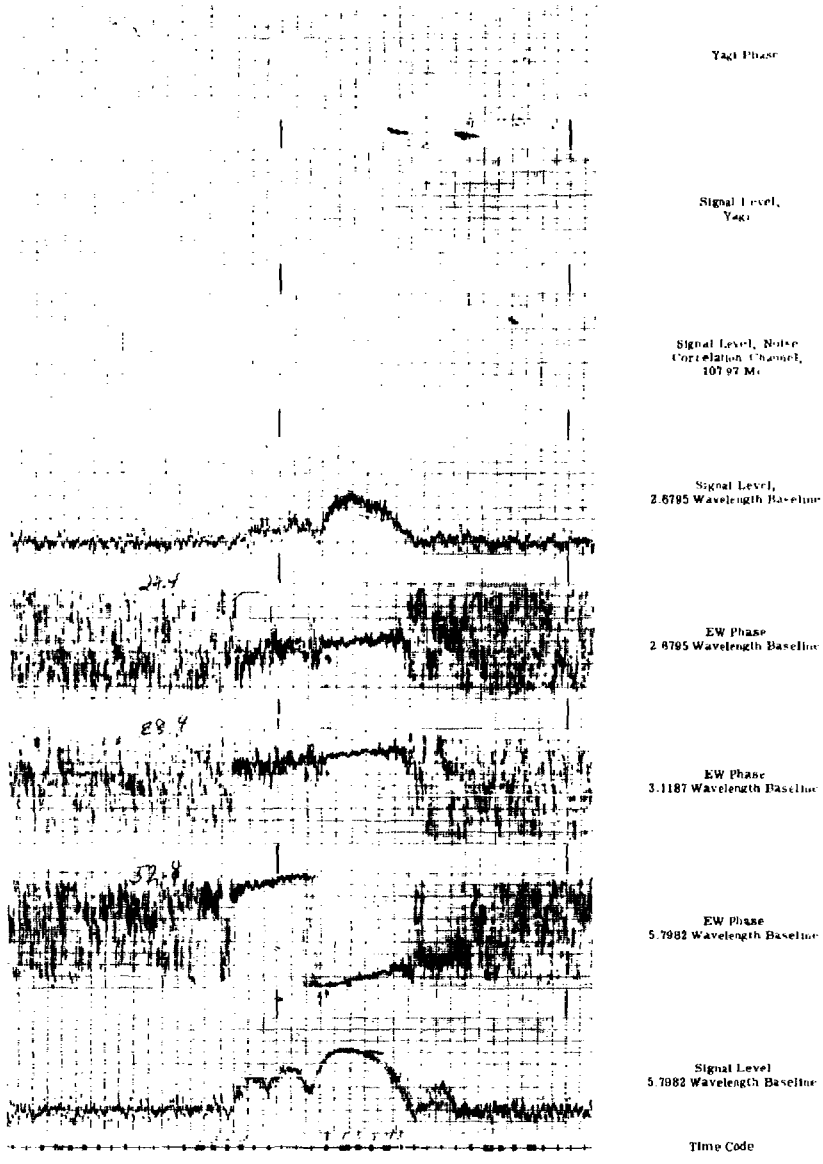

Figure A23 - Fort Stewart, 1958 Dec 30/163240Z,
Height: 600 miles, Zenith Angle: 27°E

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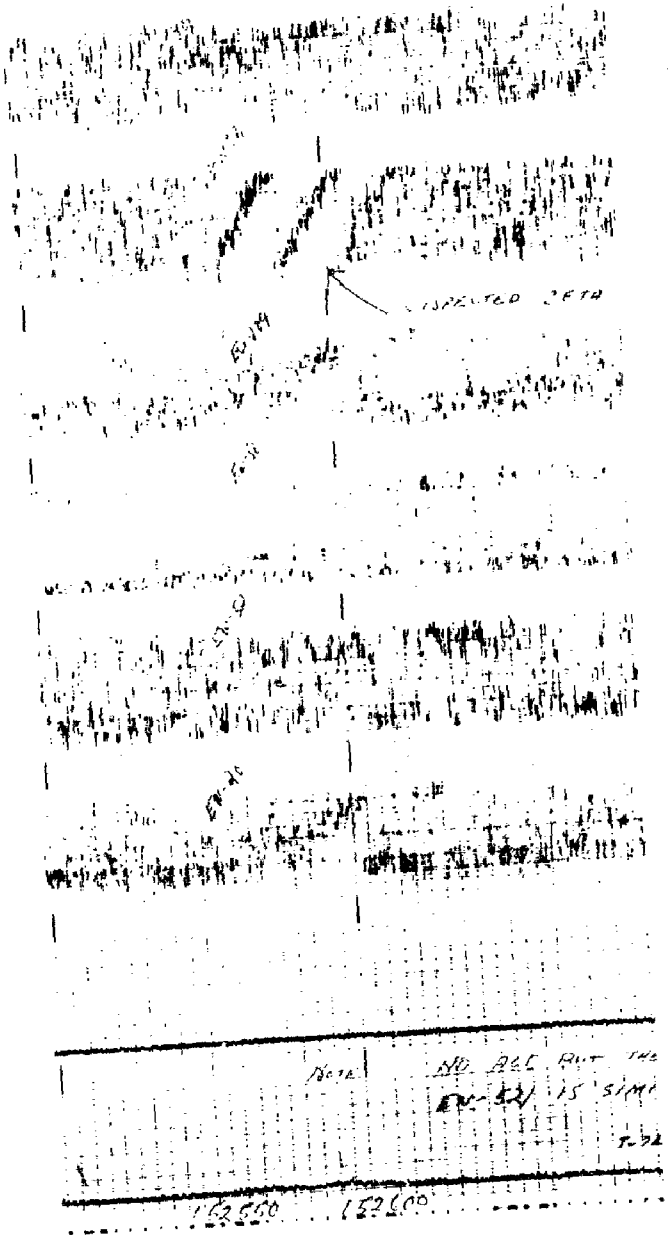

Figure A24 - Silver Lake, 1958 Dec 31/1526117,
*Height: 720 miles, *Zenith Angle: 28° E

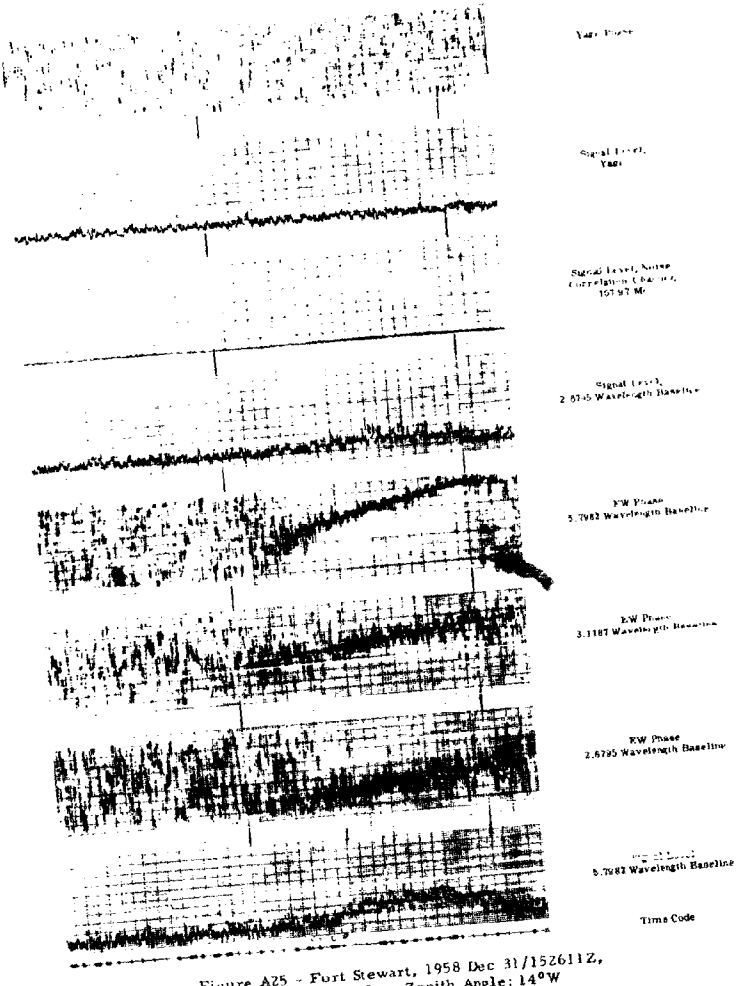

Figure A25 - Fort Stewart, 1958 Dec 31/1526Z11Z,
*Height: 720 miles, Zenith Angle: 14°W

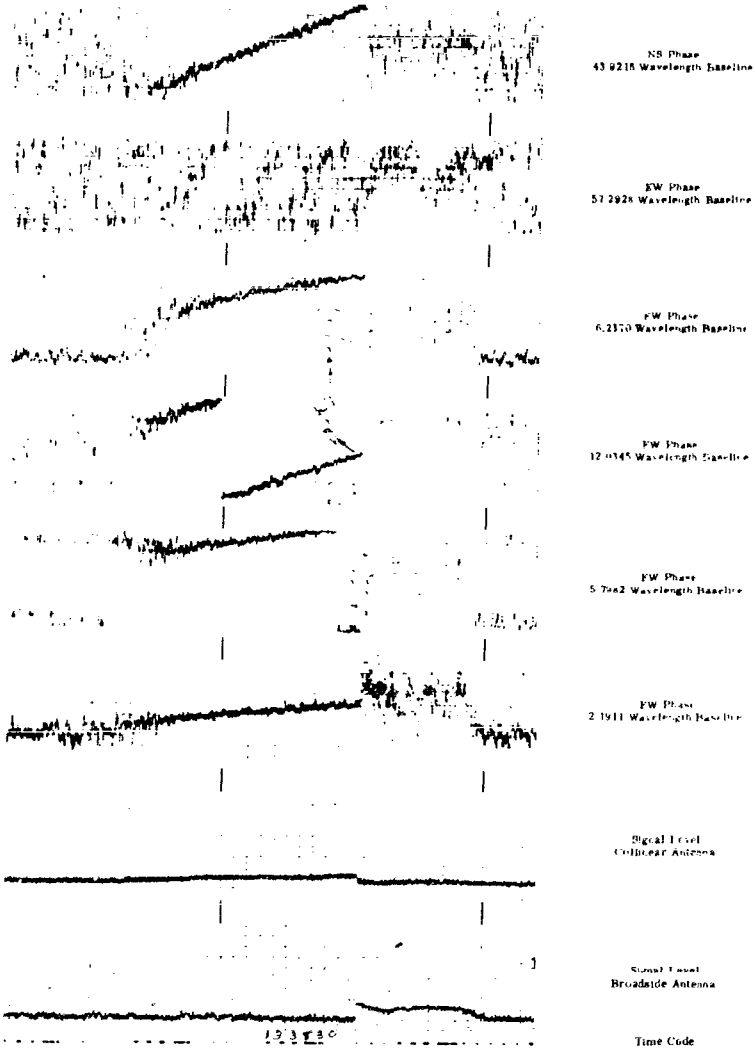

Figure A26 - Silver Lake, 1959 Jan 3/133830Z,
*Height: 710 miles, Zenith Angle: 35°E

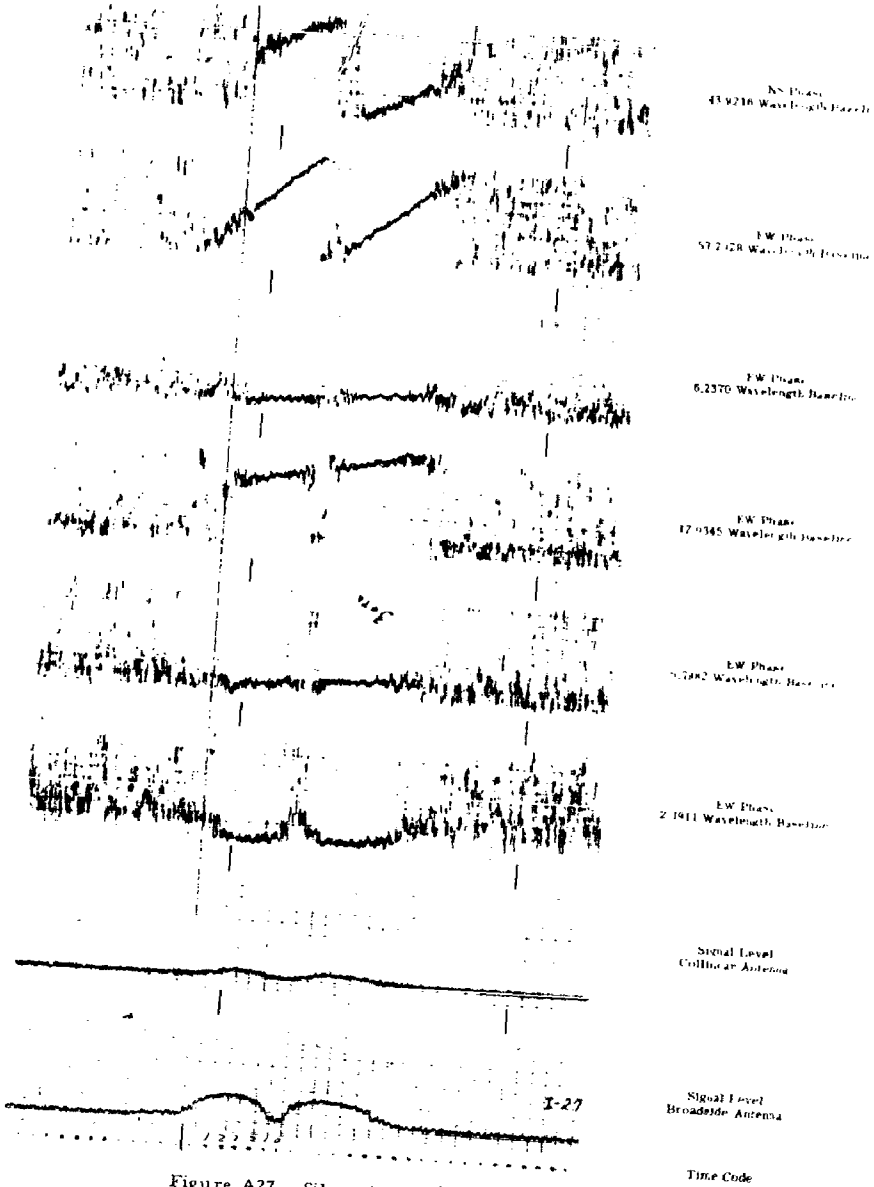

Figure A27 - Silver Lake, 1959 Jan 4/122218Z,
*Height: 650 miles, Zenith Angle: 53°E

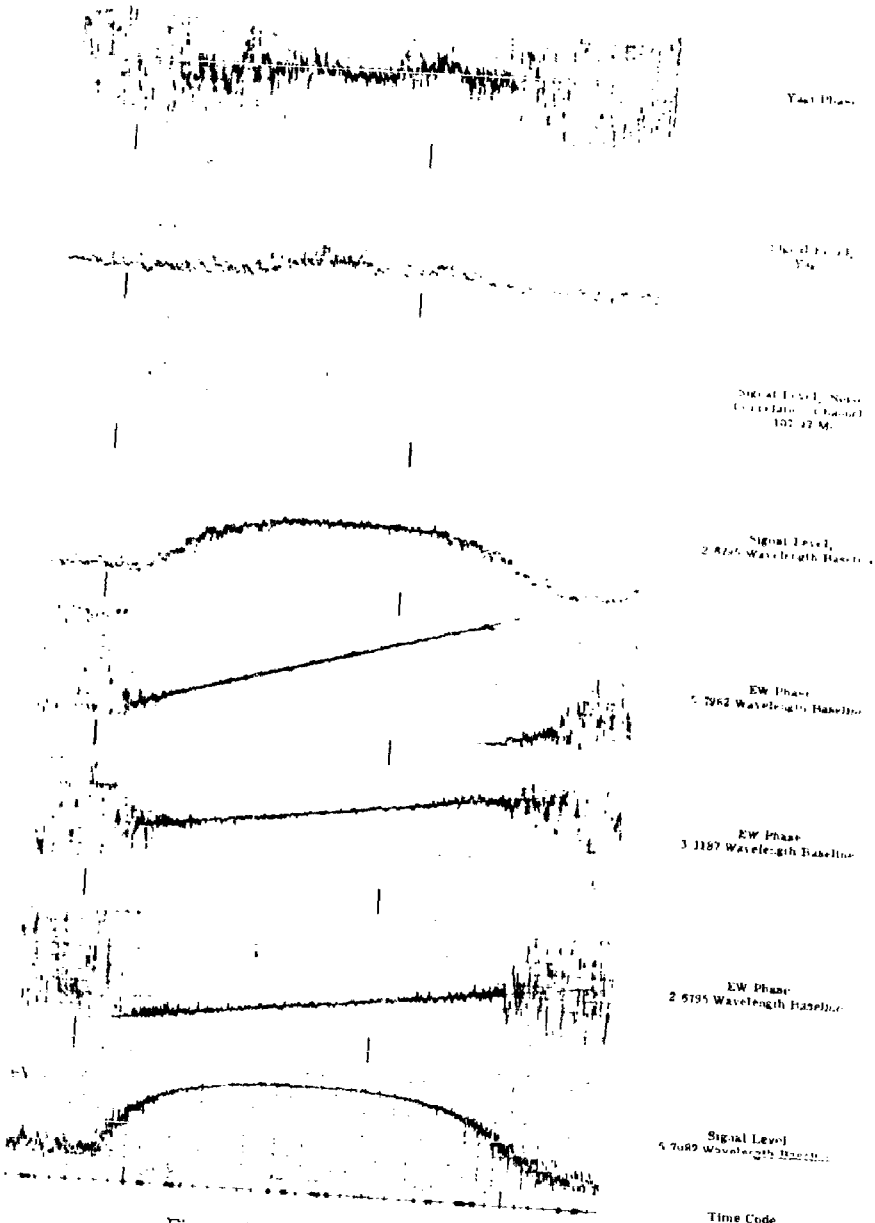

Figure A28 - Fort Stewart, 1959 Jan 4/140622Z,
*Height: 665 miles, Zenith Angle: 4°E

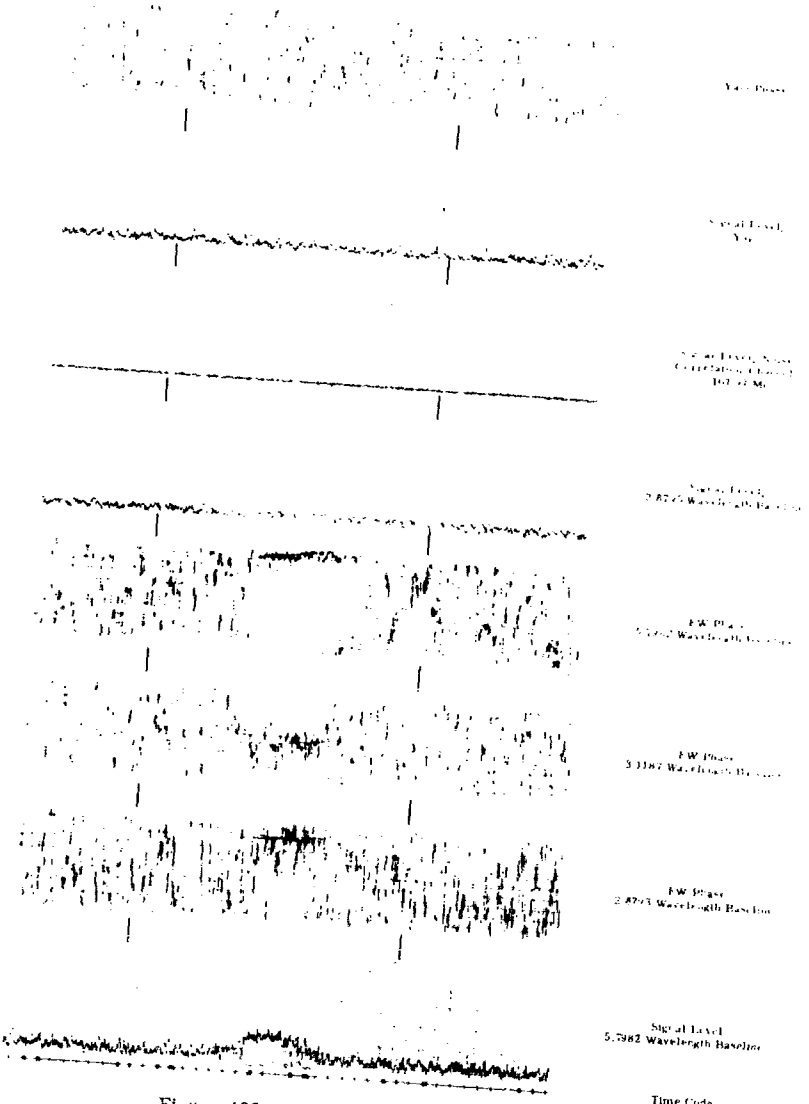

Figure A29 - Fort Stewart, 1959 Jan 5/1102522,
*Height: 590 miles, Zenith Angle: 40°E

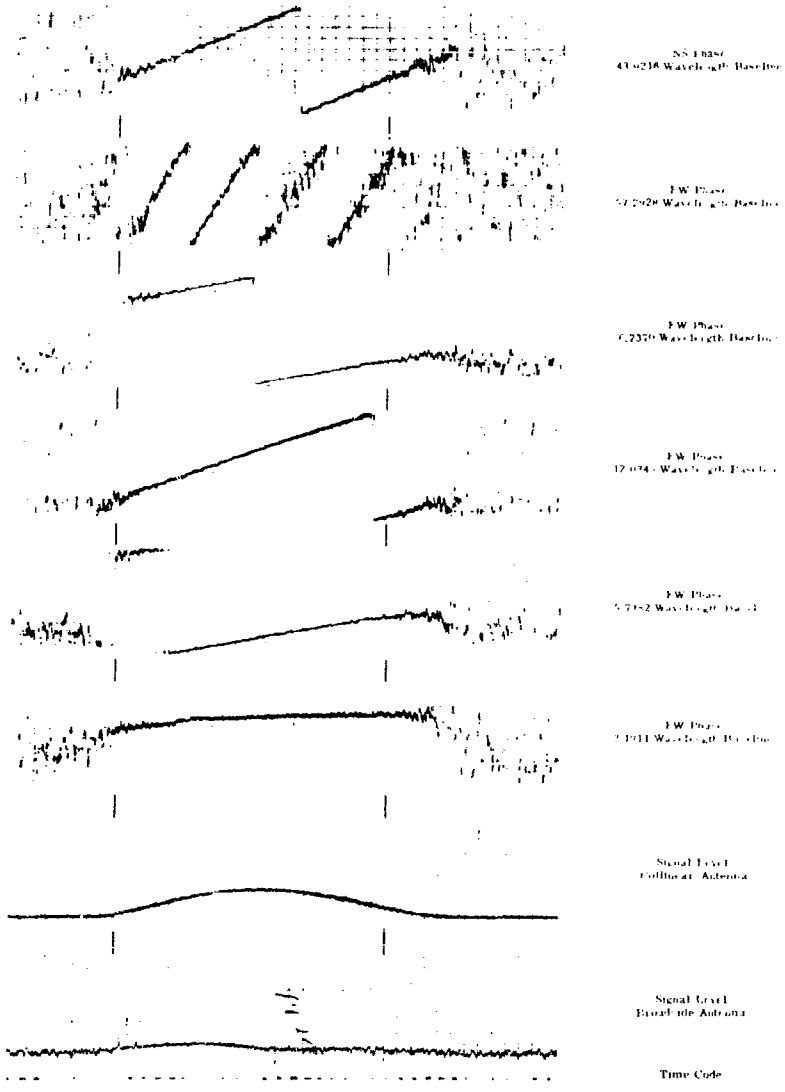

Figure A30 - Silver Lake, 1959 Jan 5/124416Z,
Height: 640 miles, Zenith Angle: 37°E

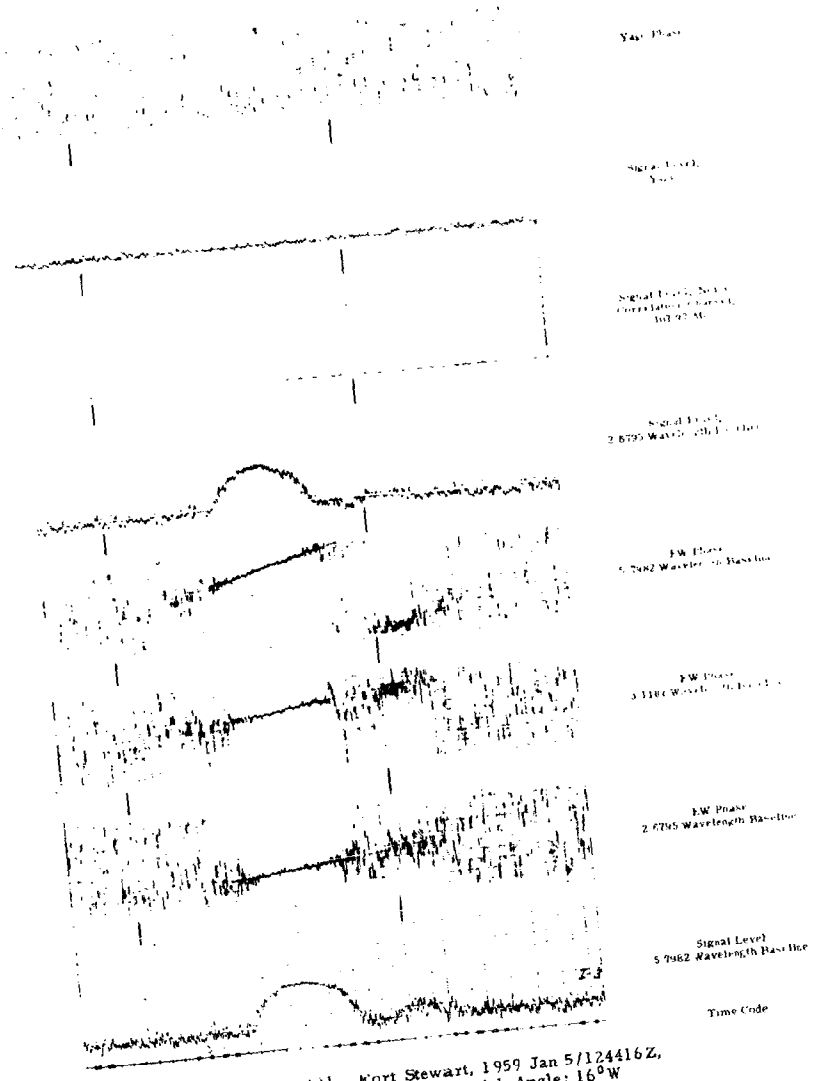

Figure A31 - Fort Stewart, 1959 Jan 5/124416Z,
Height: 640 miles, Zenith Angle: 16°W

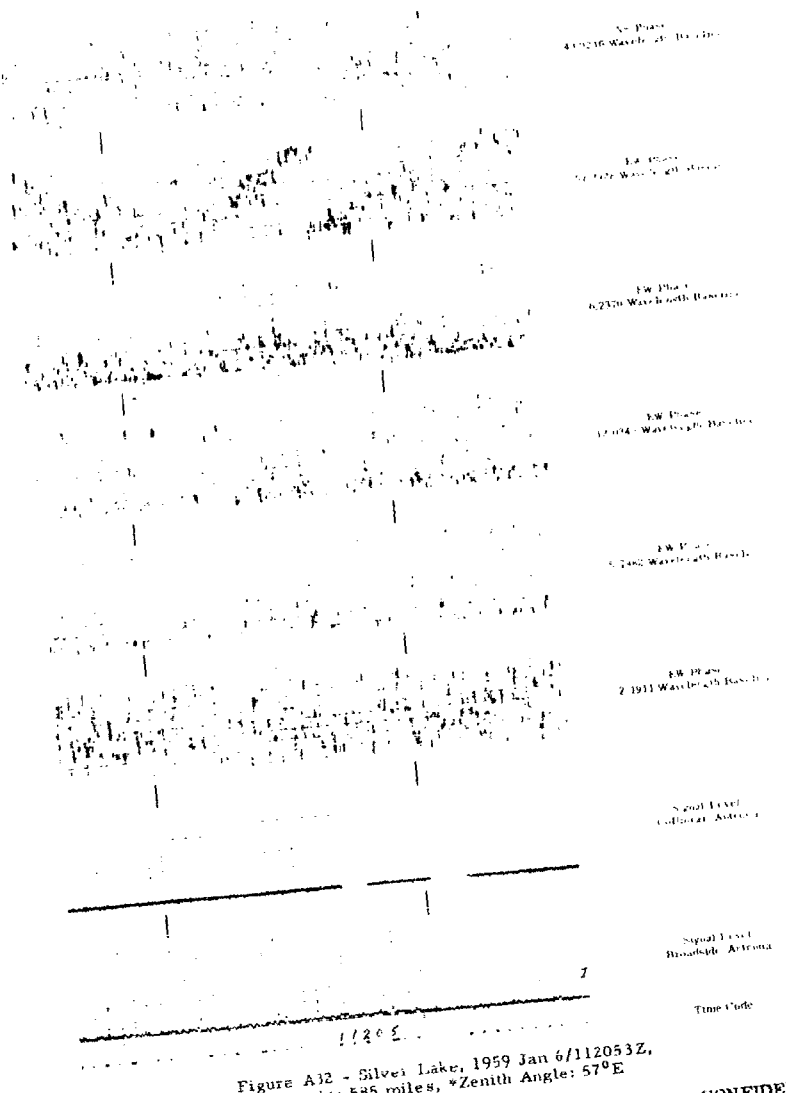

Figure A32 - Silver Lake, 1959 Jan 6/112053Z,
*Height: 585 miles, *Zenith Angle: 57°E

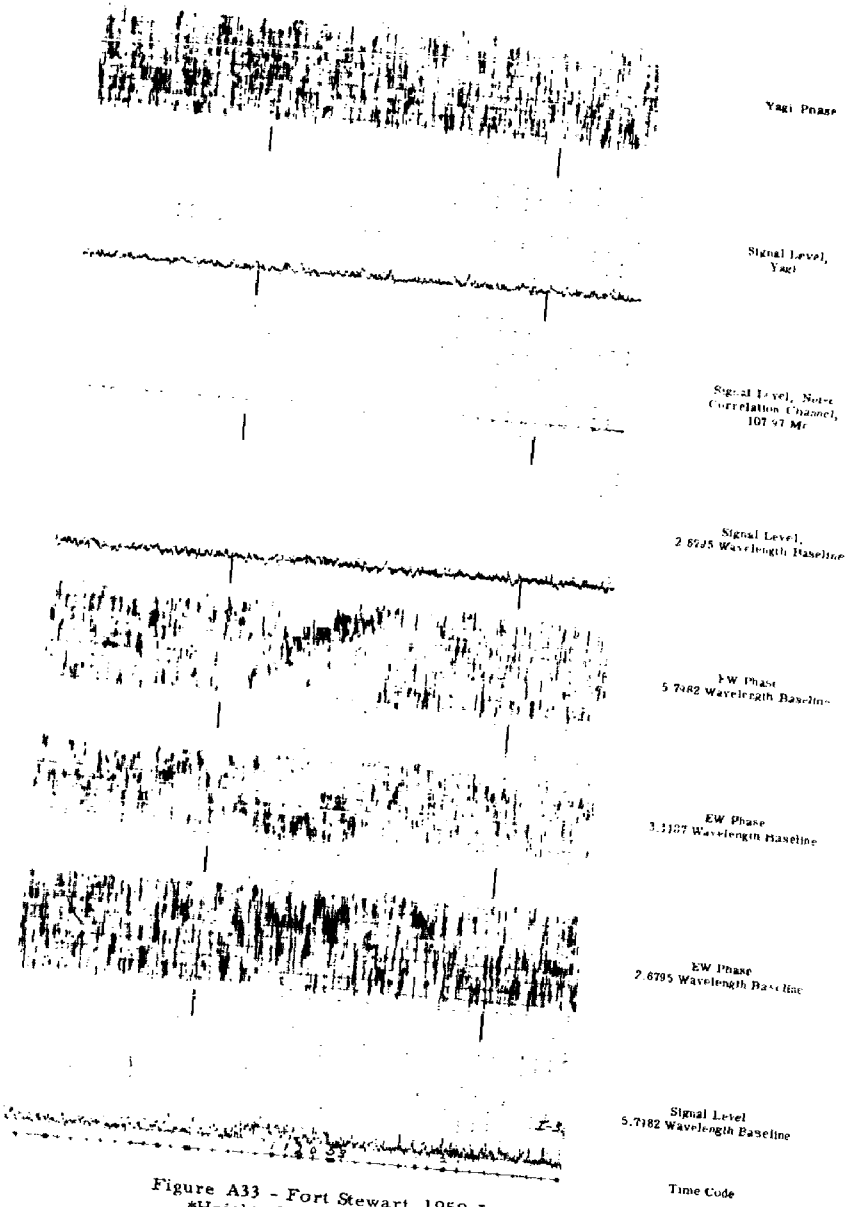

Figure A33 - Fort Stewart, 1959 Jan 5/112053Z,
*Height: 585 miles, *Zenith Angle: 13°E

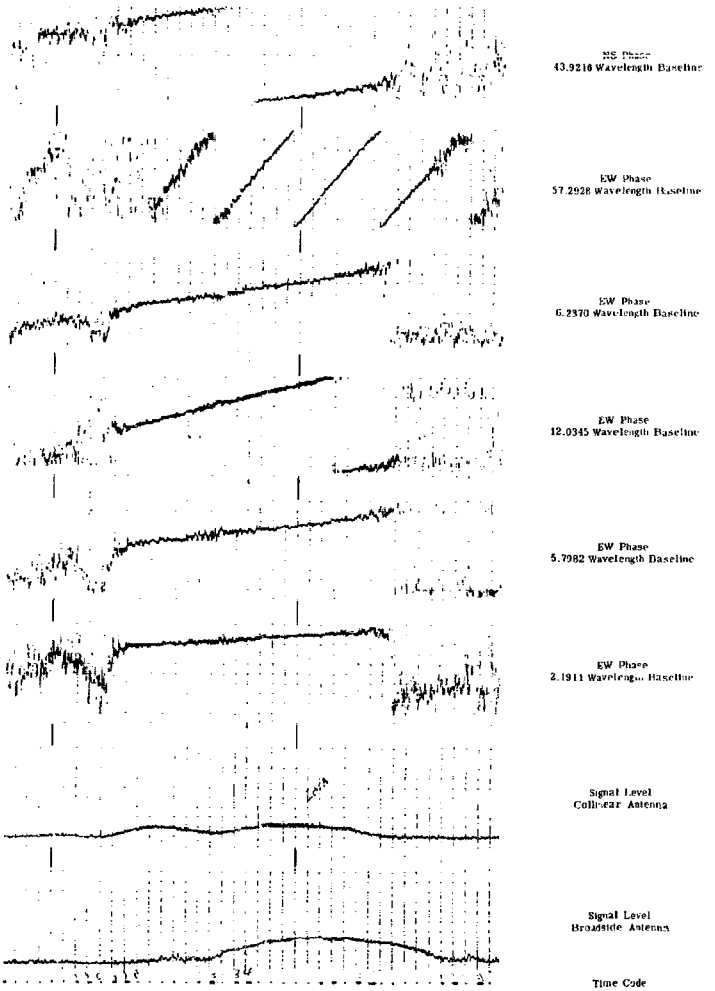

Figure A34 - Silver Lake, 1959 Jan 6/130338Z,
Height: 630 miles, Zenith Angle: 44°E

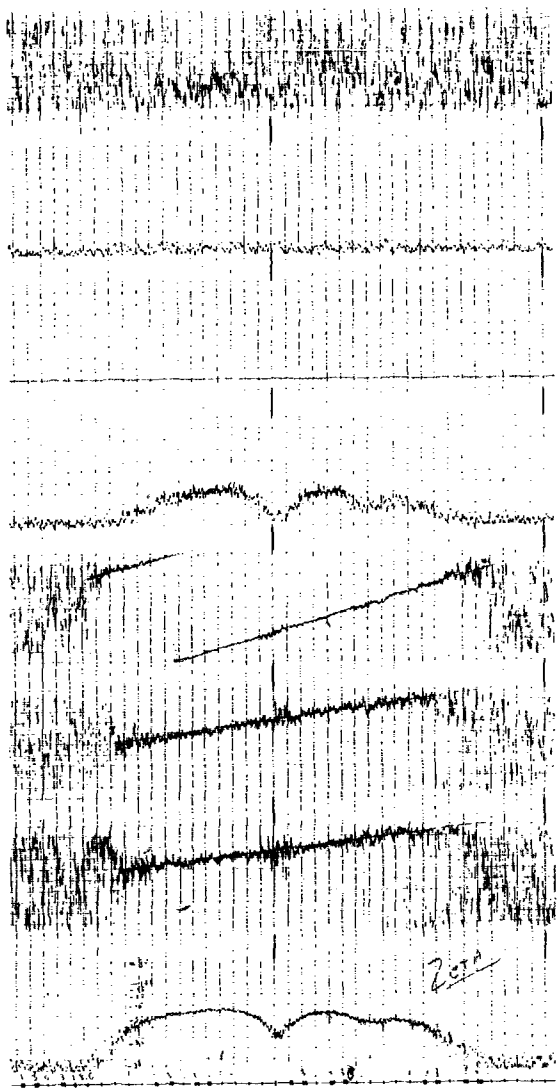

Figure A35 - Fort Stewart, 1959 Jan 6/130338Z,
Height: 630 miles, Zenith Angle: 7°W

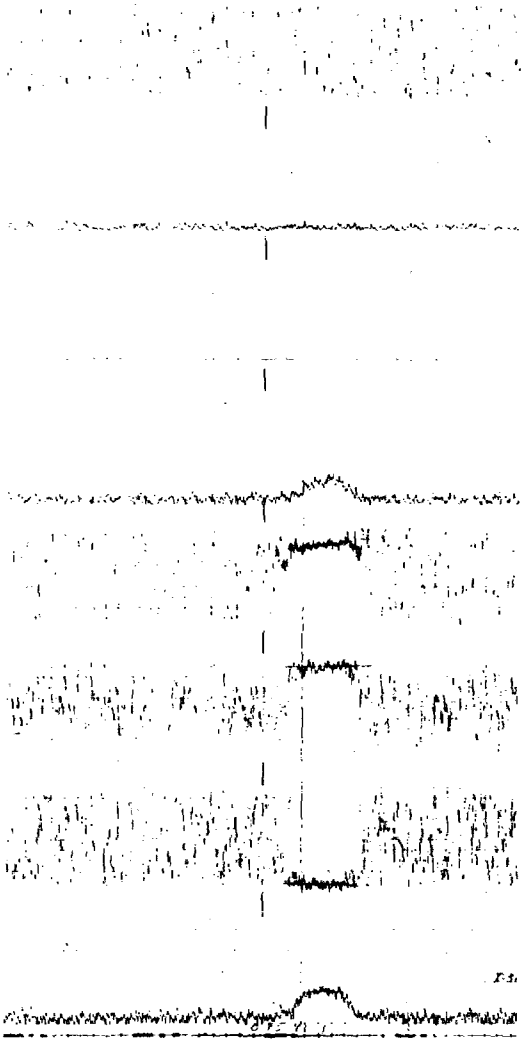

Figure A36 - Fort Stewart, 1959 Jan 7/095406Z,
*Height: 525 miles, Zenith Angle: 50°E

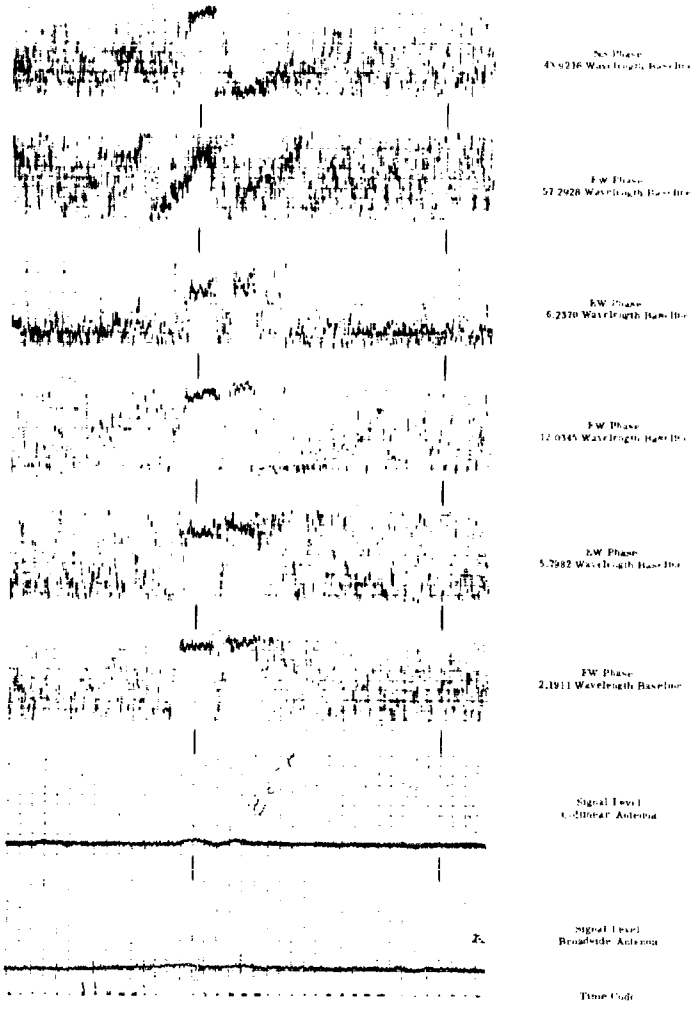

Figure A37 - Silver Lake, 1959 Jan 7/113439Z,
*Height: 570 miles, Zenith Angle: 45° E

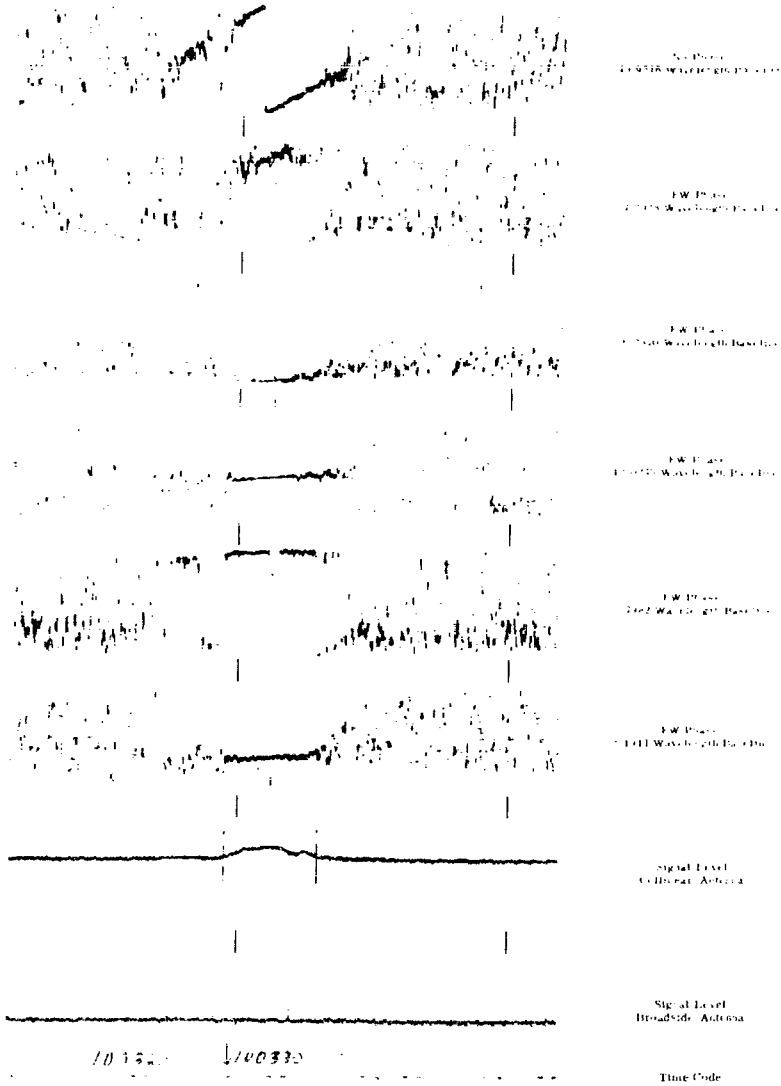

Figure A38 - Silver Lake, 1959 Jan 8/100332Z,
Height: 480 miles, Zenith Angle: 67° E

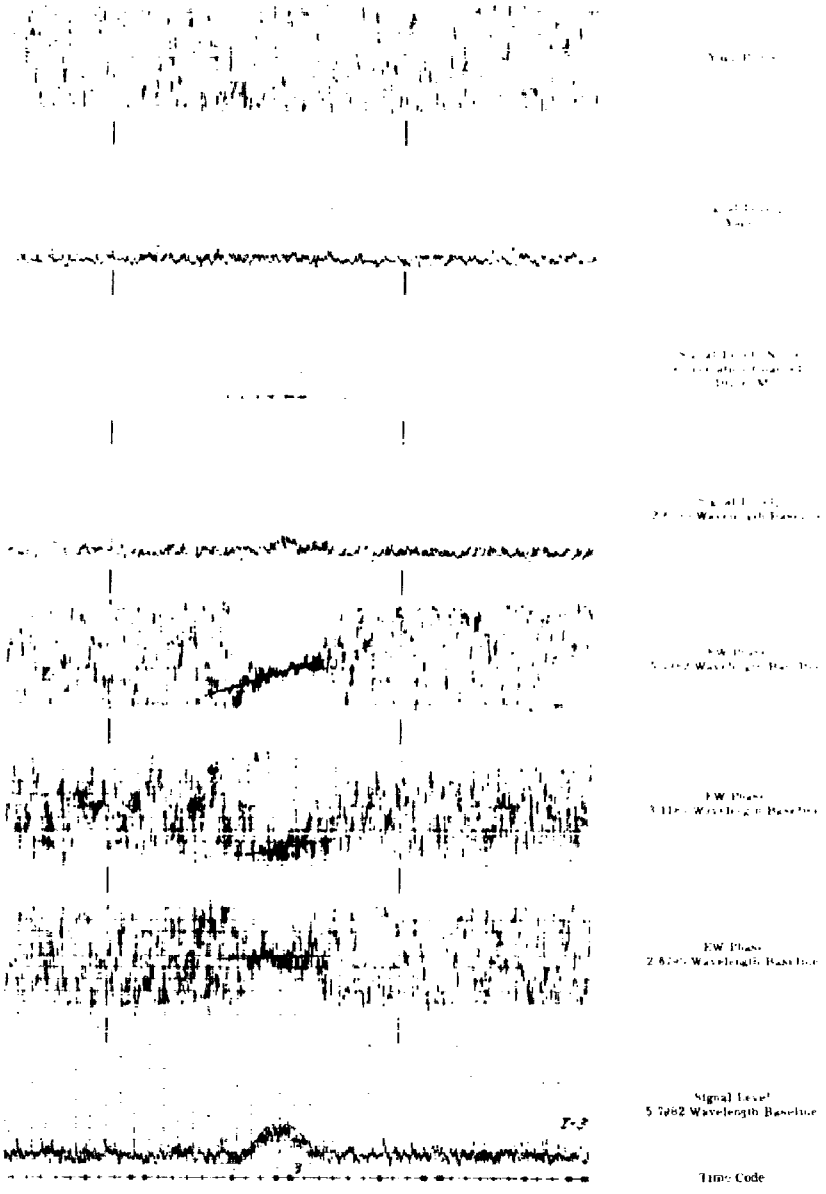

Figure A39 - Fort Stewart, 1959 Jan 8/100332Z,
Height: 480 miles, Zenith Angle: 31° E

No illustration has been printed on this page in order to permit coincident pairs of observations to appear on facing pages.

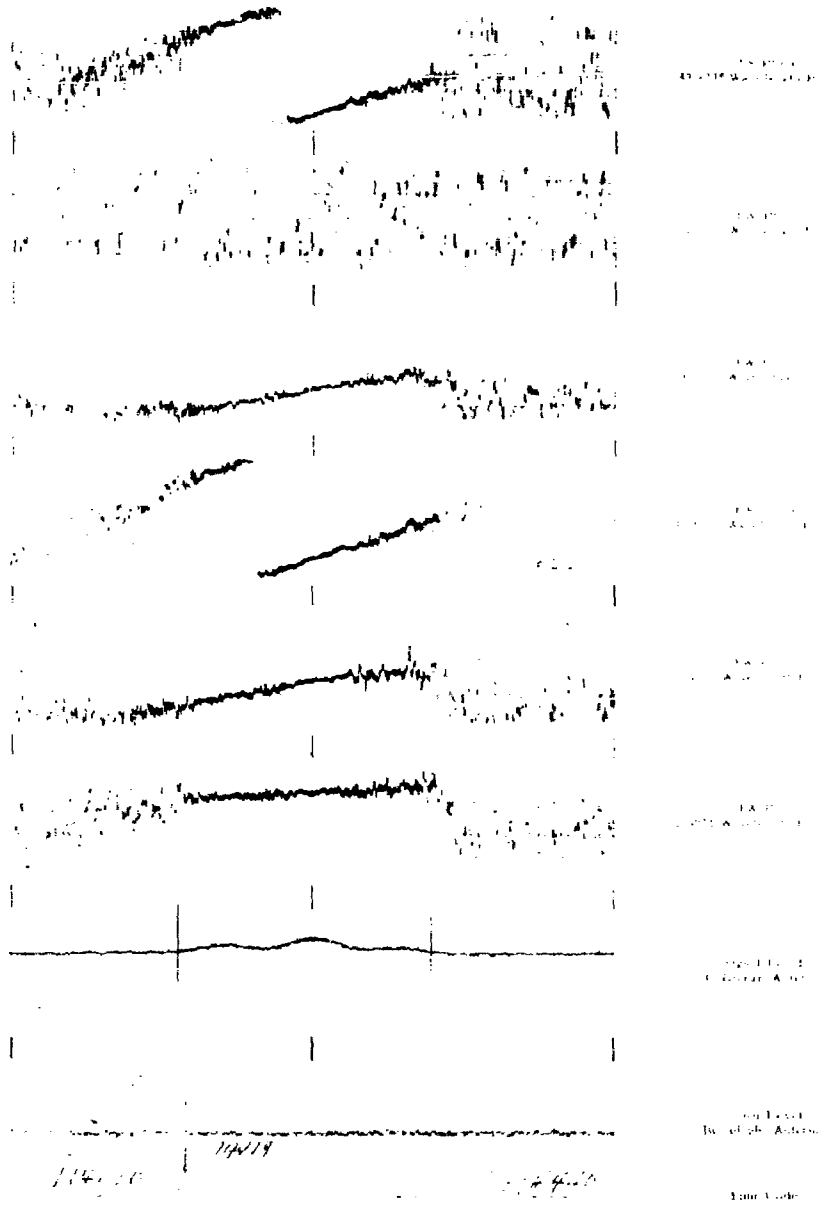

Figure A40 - Silver Lake, 1959 Jan 8/114427Z,
*Height: 535 miles, Zenith Angle: 41° E

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A44

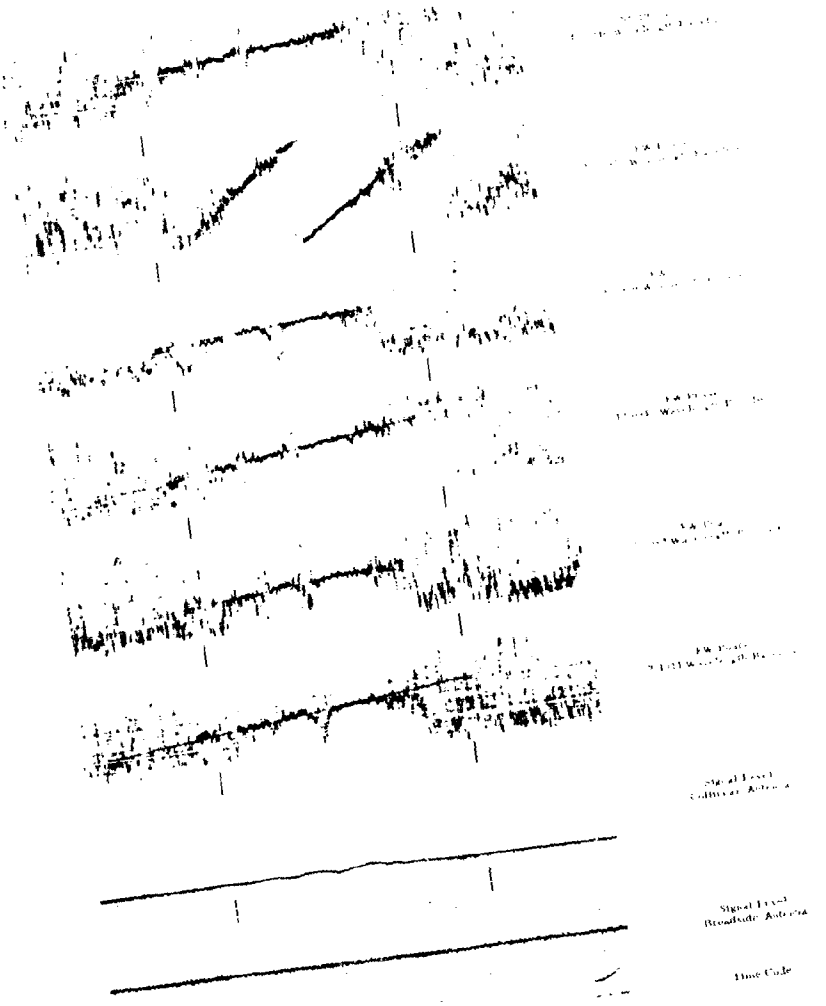

Figure A41 - Silver Lake, 1959 Jan 9/115042Z,
Height: 525 miles, Zenith Angle: 57° E

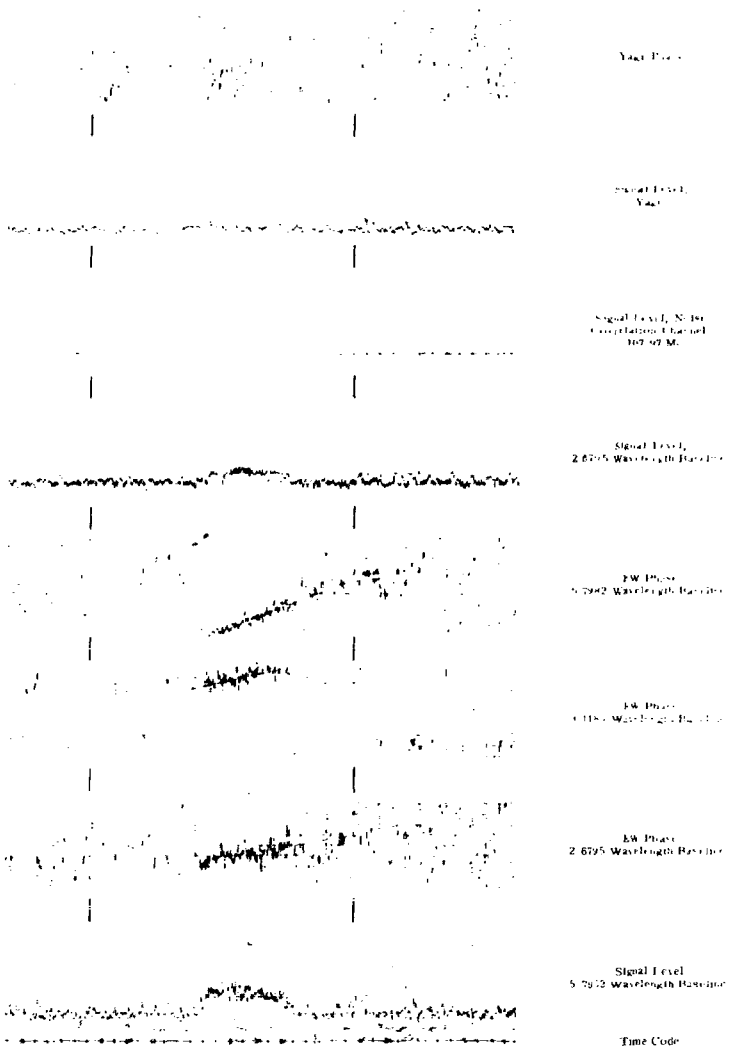

Figure A42 - Fort Stewart, 1959 Jan 9/115042Z,
Height: 525 miles, Zenith Angle: 9^0 E

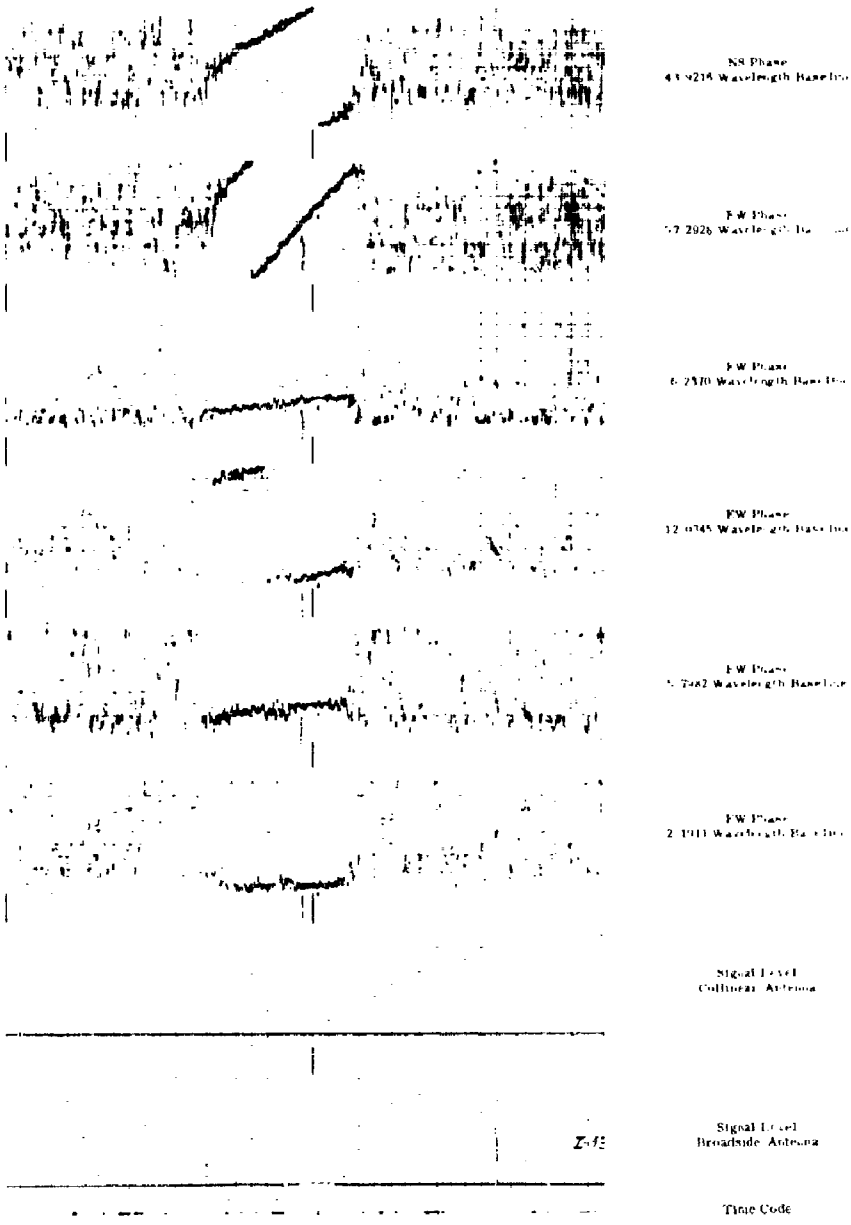

Figure A43 - Silver Lake, 1959 Jan 10/100806Z,
Height: 420 miles, Zenith Angle: 54°E

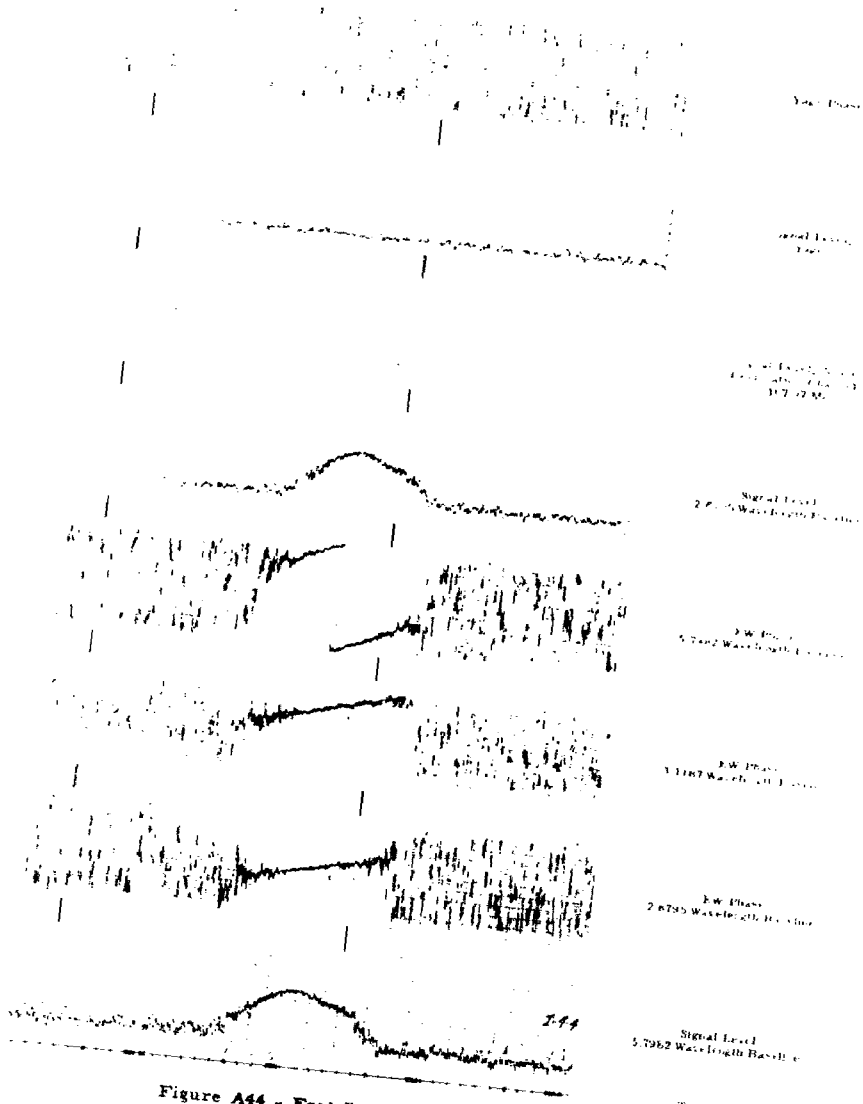

Figure A44 - Fort Stewart, 1959 Jan 10/1008062,
Height: 420 miles, Zenith Angle: 12°W

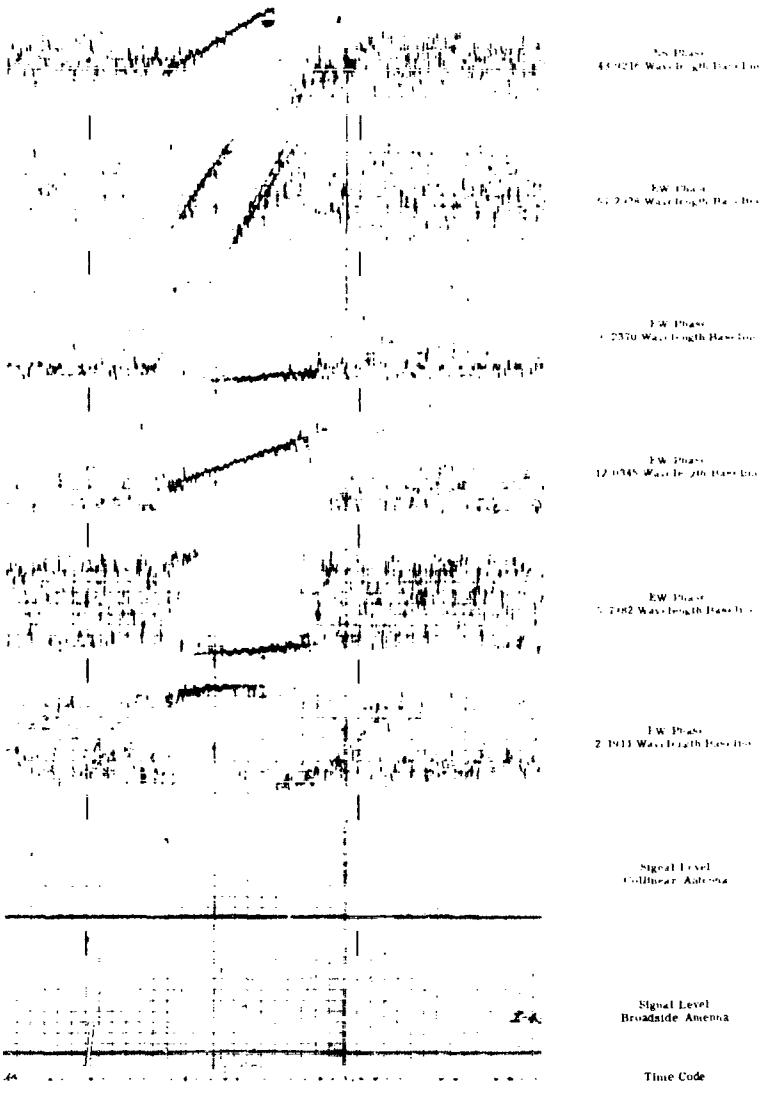

Figure A45 - Silver Lake, 1959 Jan 11/100216Z,
Height: 375 miles, Zenith Angle: 50°E

Figure A46 - Fort Stewart, 1959 Jan 11/100216Z,
Height: 375 miles, Zenith Angle: 27°W

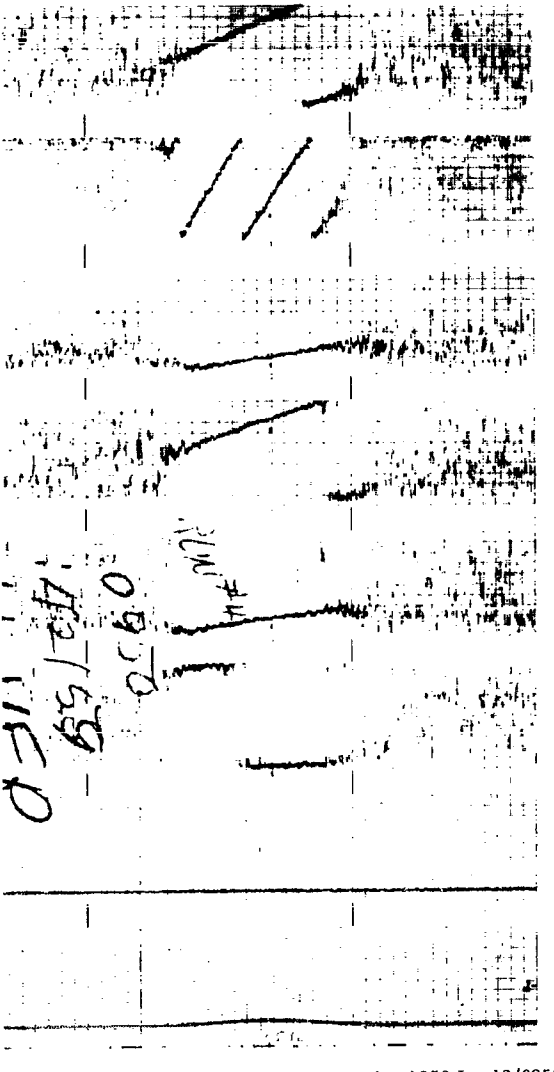

Figure A47 - Silver Lake. 1959 Jan 12/095031Z,
Height: 450 miles, Zenith Angle: 52°E

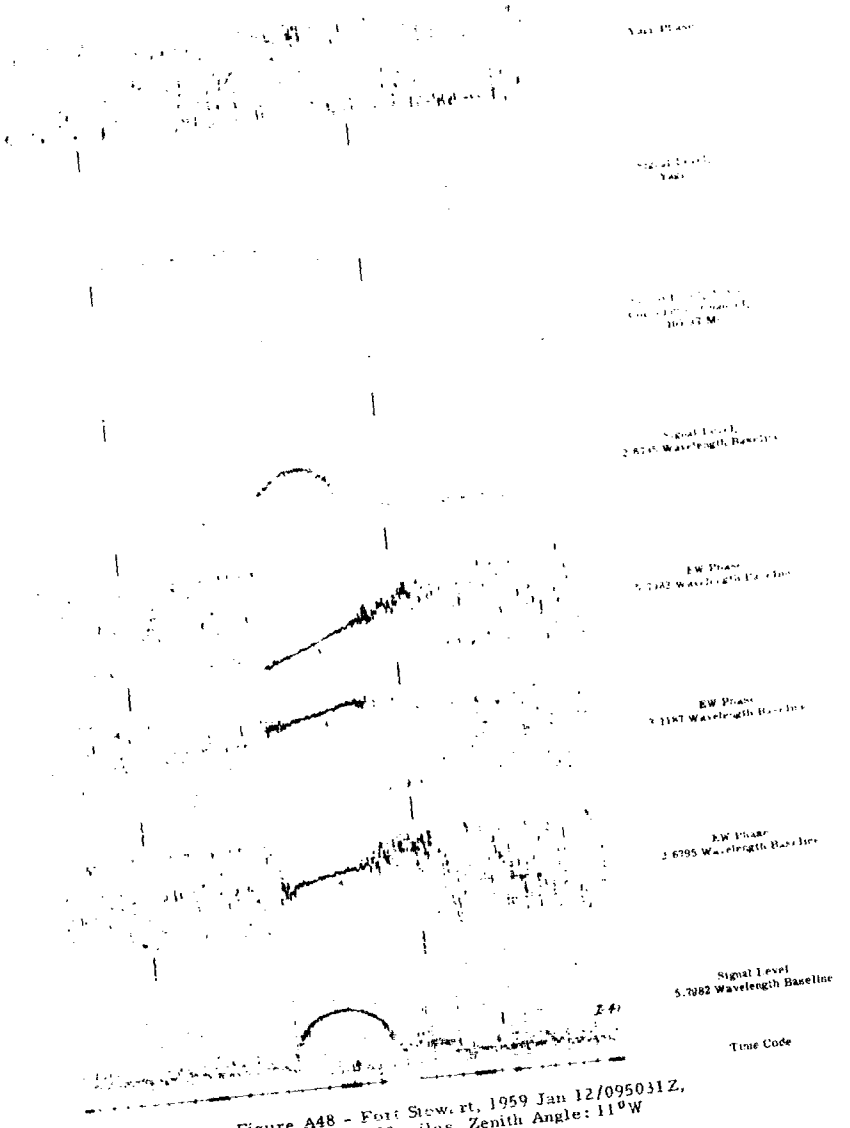

Figure A48 - Fort Stewart, 1959 Jan 12/0950312,
Height: 450 miles, Zenith Angle: 11°W

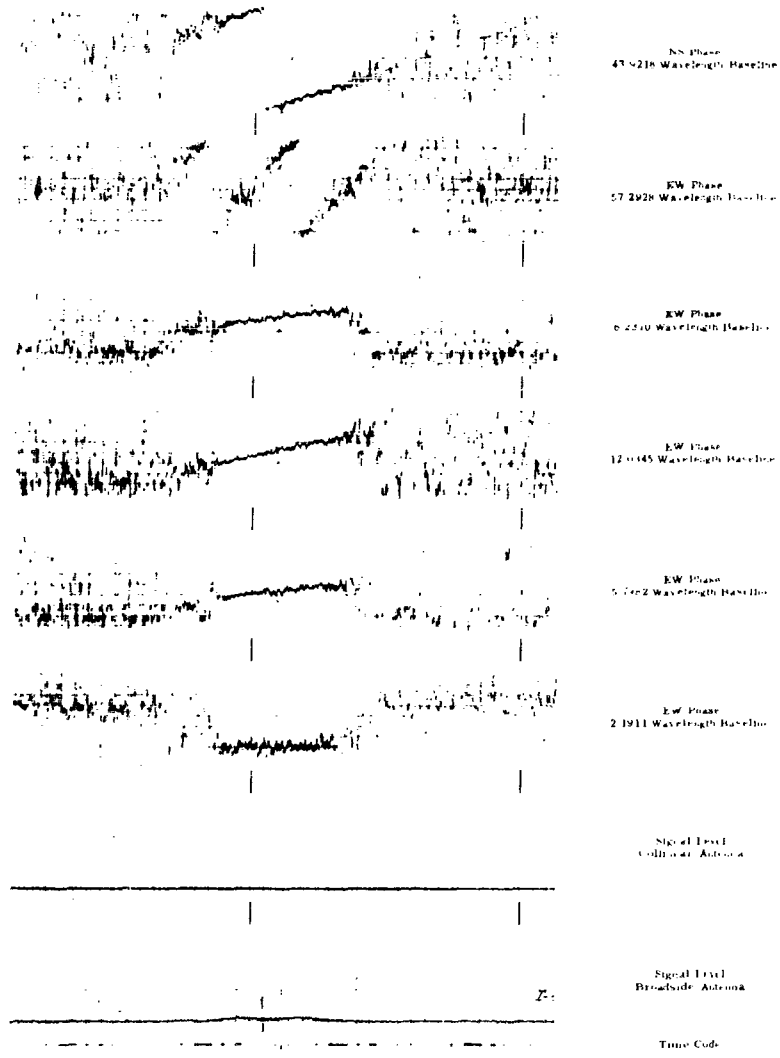

Figure A49 - Silver Lake, 1959 Jan 13/0932462,
Height: 305 miles, Zenith Angle: 58°E

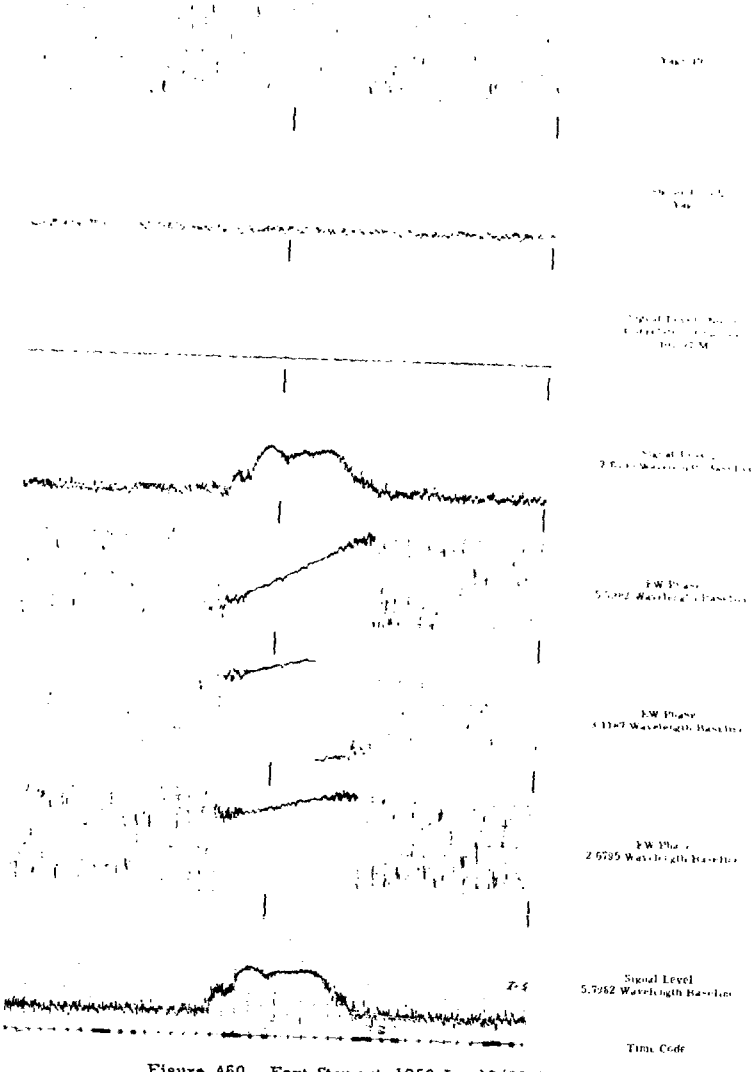

Figure A50 - Fort Stewart, 1959 Jan 13/093246Z,
Height: 305 miles, Zenith Angle: 27° W

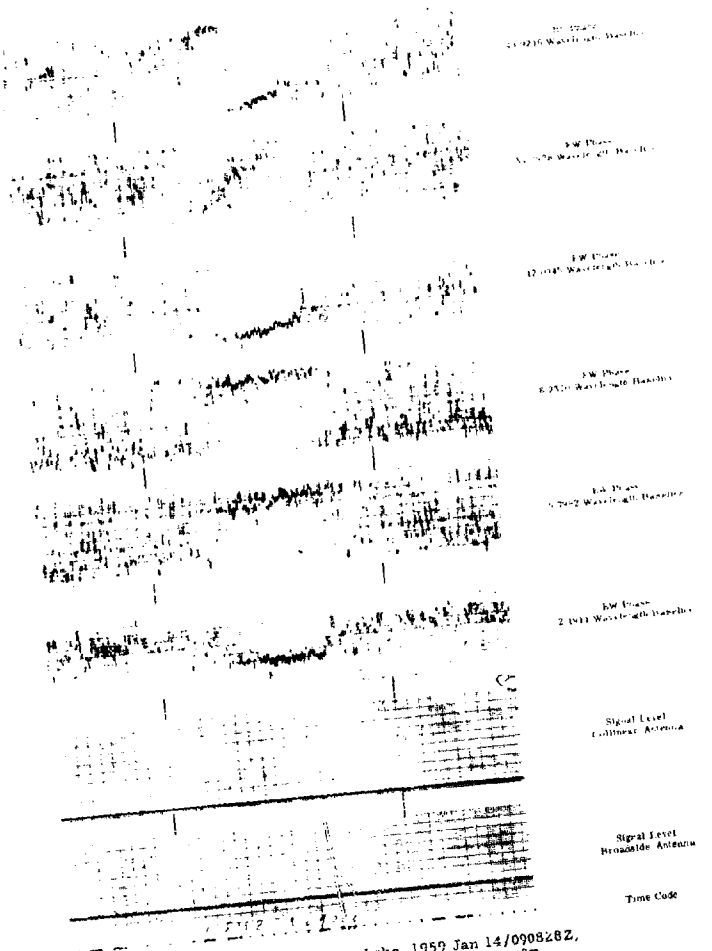

Figure A51 Silver Lake, 1959 Jan 14/0908Z, Height: 260 miles, Zenith Angle: 64°E

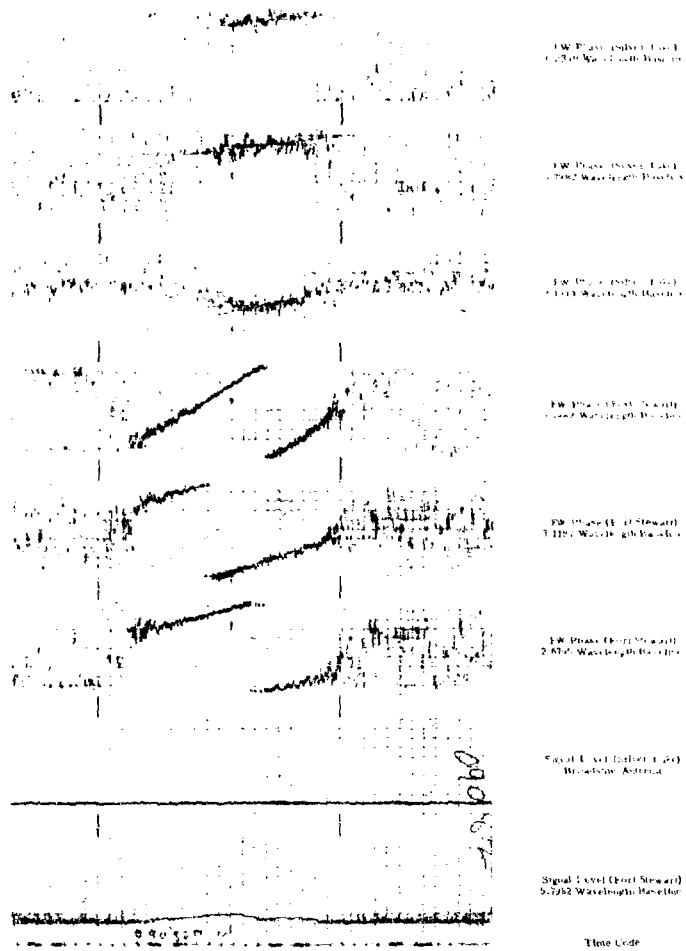

Figure A52 - Silver Lake - Fort Stewart, 1959 Jan 14/090828Z,
Height: 260 miles, Zenith Angle (Ft. Stewart): 25° W

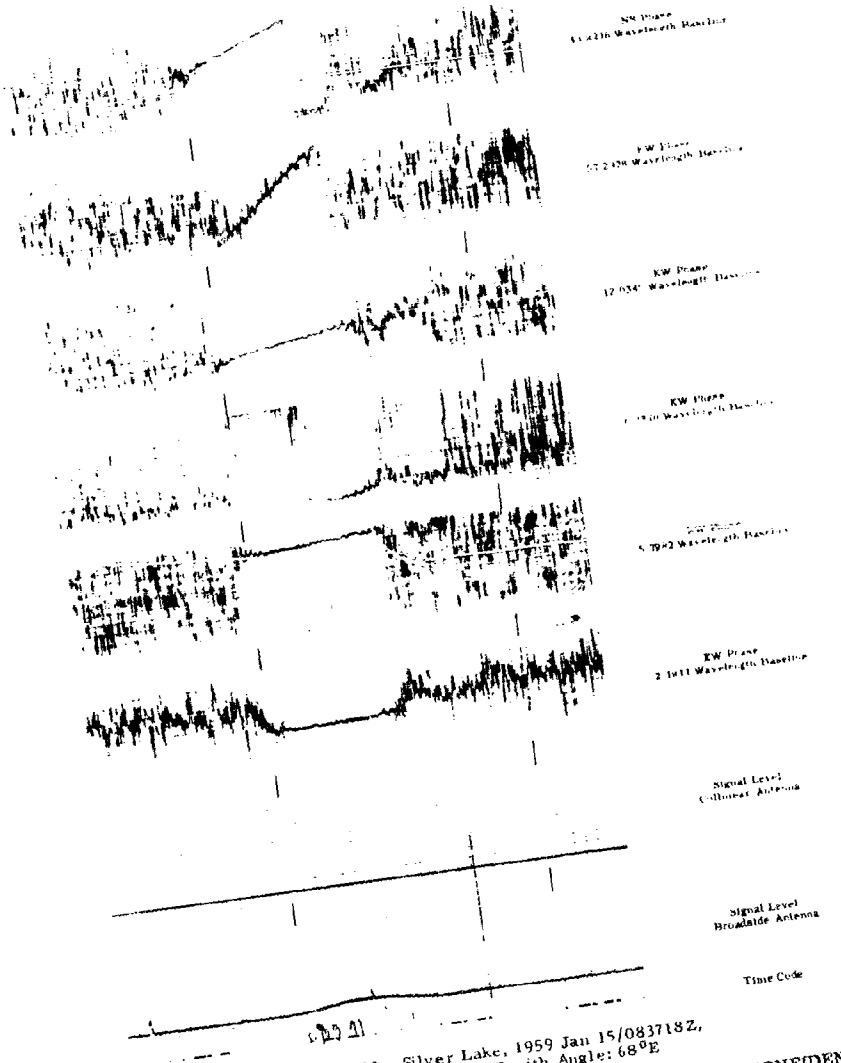

Figure A53 - Silver Lake, 1959 Jan 15/083718Z,
Height: 220 miles, Zenith Angle: 68°E

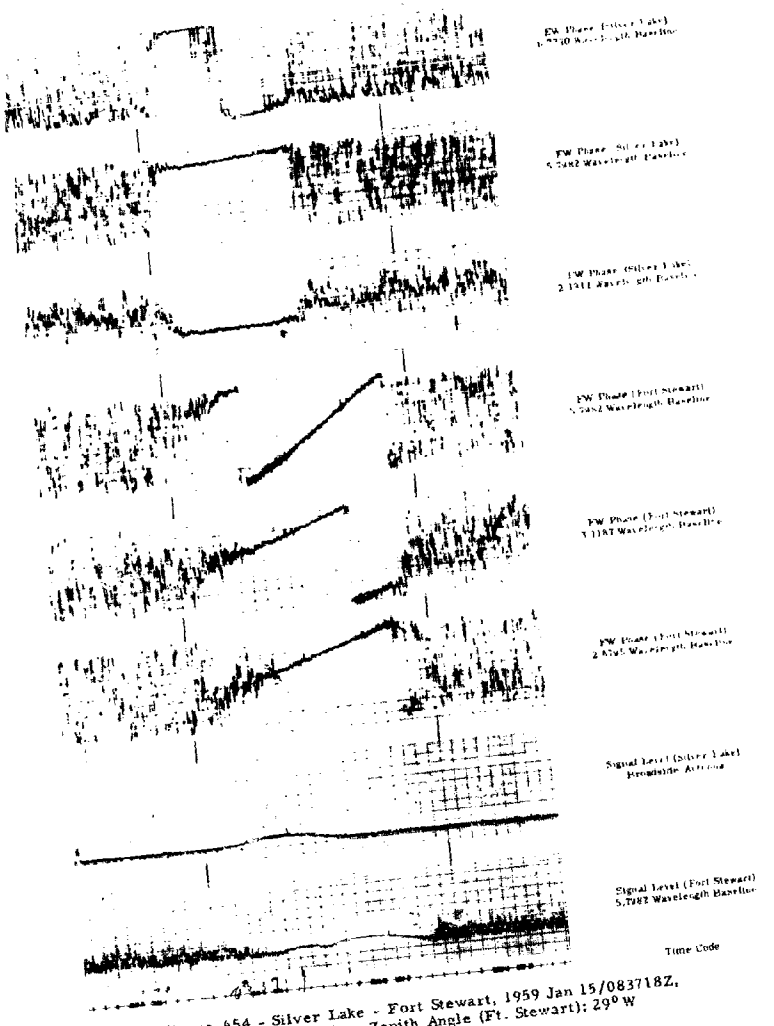

Figure A54 - Silver Lake - Fort Stewart, 1959 Jan 15/083718Z,
Height: 220 miles, Zenith Angle (Ft. Stewart): 29° W

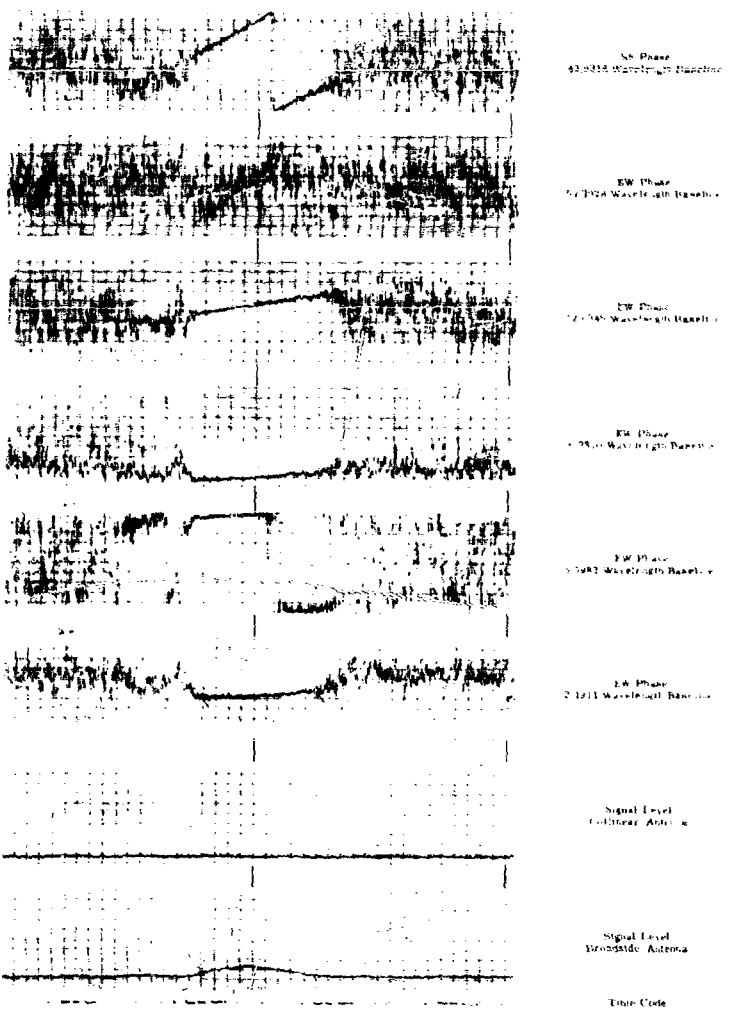

Figure A55 - Silver Lake, 1959 Jan 16/075819Z,
Height: 169 miles, Zenith Angle: 72°E

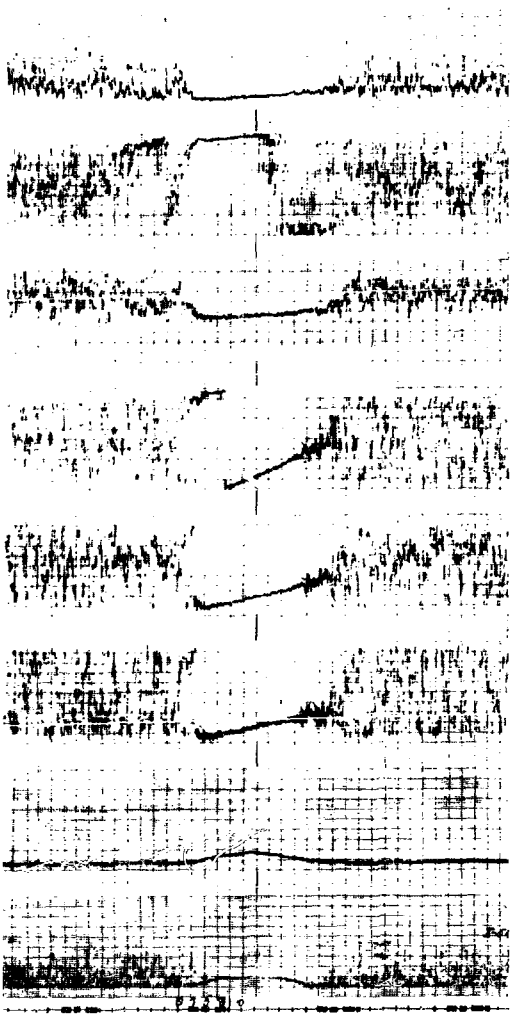

Figure A56 - Silver Lake - Fort Stewart, 1959 Jan 16/0759:19Z,
Height: 165 miles, Zenith Angle (Ft. Stewart): 4x°W

A60

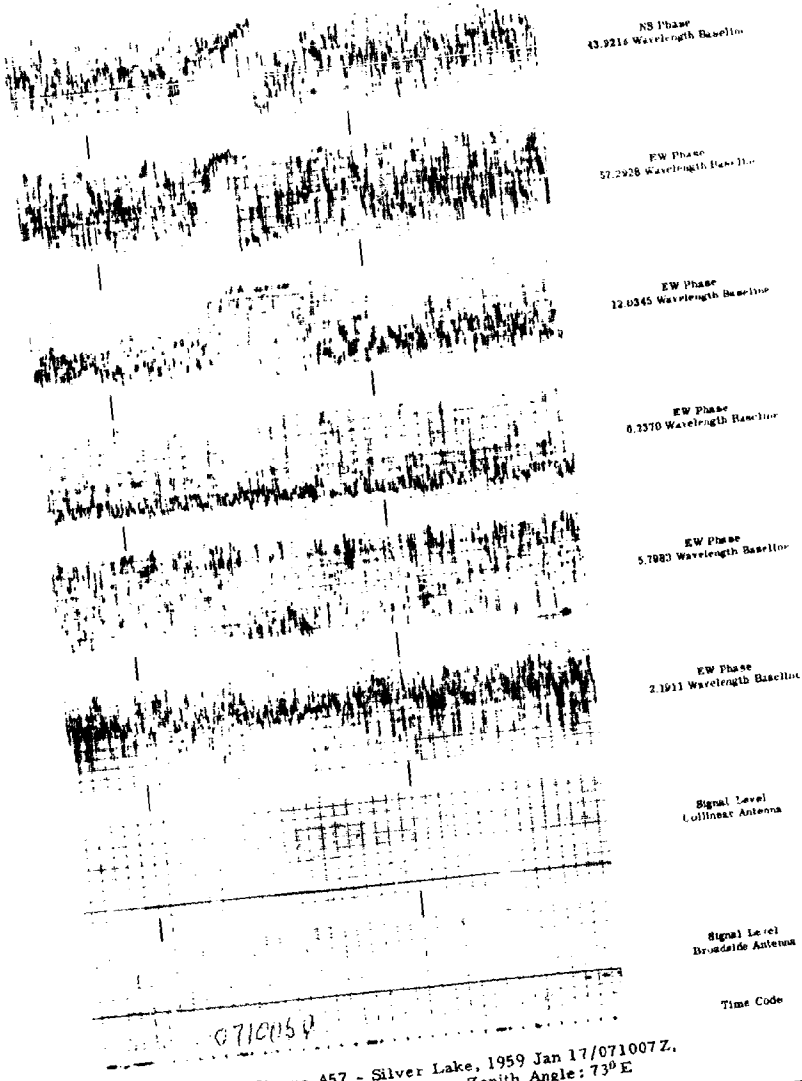

Figure A57 - Silver Lake, 1959 Jan 17/071007 Z,
Height: 180 miles, Zenith Angle: 73° E

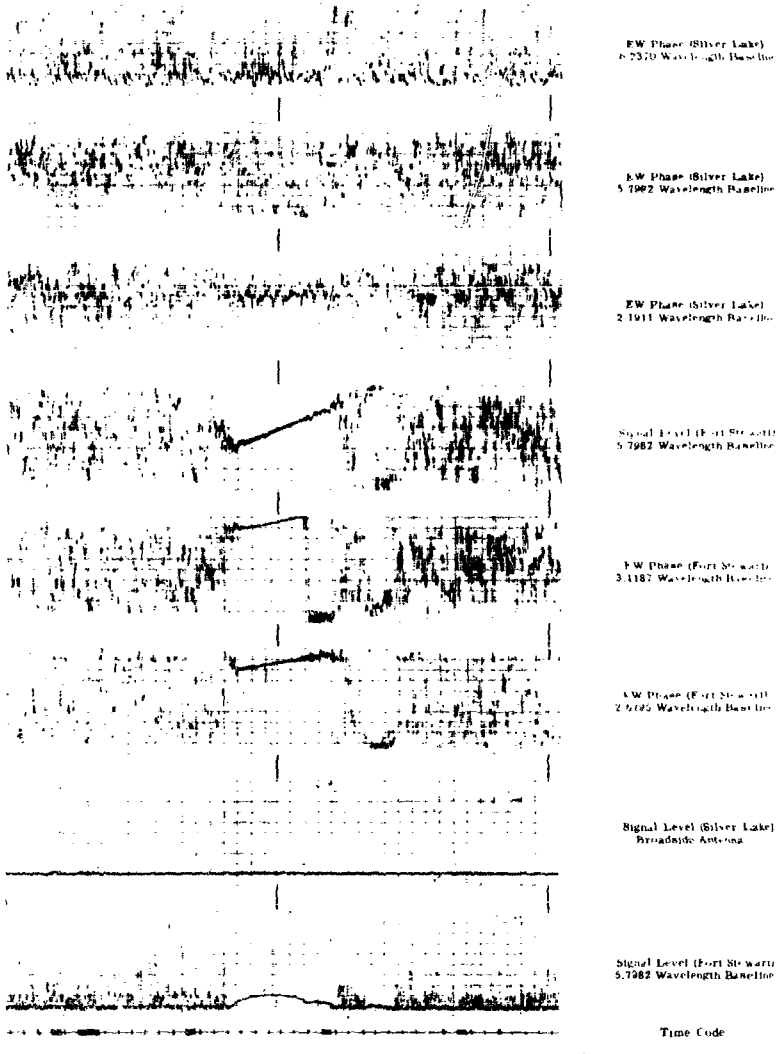

Figure A58 - Silver Lake - Fort Stewart, 1959 Jan 17/071007Z,
Height: 180 miles, Zenith Angle (Ft. Stewart): 28°W

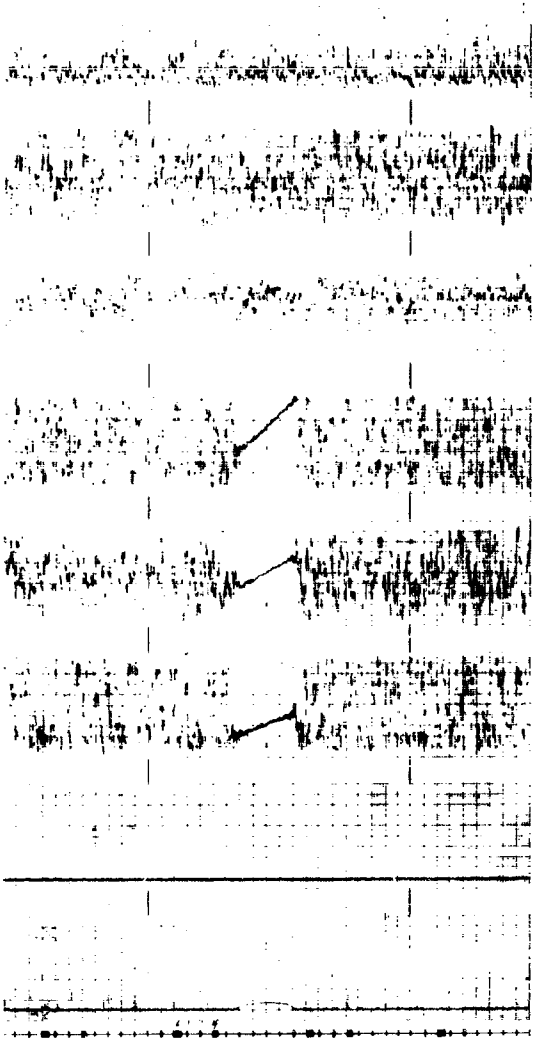

Figure A59 - Silver Lake - Fort Stewart, 1959 Jan 18/061148Z,
*Height: 140 miles, Zenith Angle (Ft. Stewart): 16° W

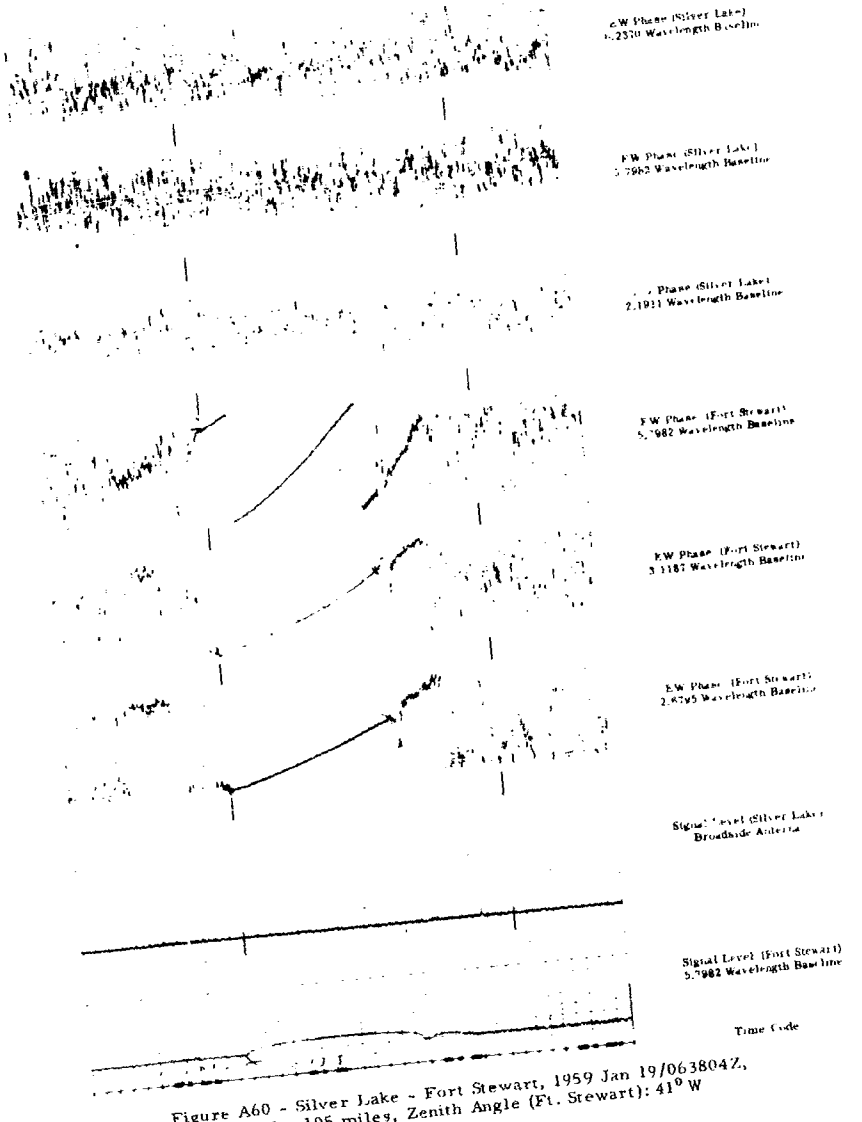

Figure A60 - Silver Lake - Fort Stewart, 1959 Jan 19/063804Z,
*Height: 105 miles, Zenith Angle (Ft. Stewart): 41° W

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March 16, 2000

To: Defense Technical Information Center
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8725 Joh J Kingman Road
Fort Belvior VA 22060-6218

From: Naval Research Laboratory
Attn Code 5227 Mary Templeman
Washington DC 20375-5335

Dear Ms. Kramer,

NRL Formal Report 5366 has been declassified. The downgrading statement was "Downgrade At 3-Year Intervals-Declassify After 12 Years" and made public release on December 2, 1999

Sincerely

Mary Templeman

Mary Templeman

AD- 309598

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Received 3-17-2000

NRL Report 5366

SPACE SURVEILLANCE SYSTEM
OBSERVATIONS OF THE SATELLITE 1958 ZETA
[UNCLASSIFIED TITLE]

C. H. Chrisman, Jr., J. F. Dowd,
and M. P. Anderson

Operational Research Branch
Applications Research Division

June 29, 1959

U. S. NAVAL RESEARCH LABORATORY
Washington, D.C.