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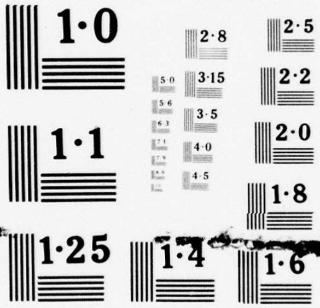
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NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

HIGH FREQUENCY IONOSPHERIC
PROPAGATION PHENOMENA

by

Richard Robert Rowe

December 1976

Thesis Advisor: S. Jauregui, Jr.

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HIGH FREQUENCY IONOSPHERIC PROPAGATION PHENOMENA

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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

PROJECT BRIGHAM was a Department of Defense data collection effort wherein 890 kHz wide samples of the HF spectrum were acquired using a 25 Hz sampling rate with 2.8 kHz resolution for a period of up to 2.4 minutes. The main thrust of this paper has been the visual examination of the data on a graphics display with the idea of identifying drastic and unexpected changes in either individual signals or the entire wavefront; those changes being due, at least in part, to signal transformation resulting from various ionospheric phenomena. In addition, an in-depth statistical study was conducted on several of the specific signals with the hope of aiding in the formulation of an algorithm to efficiently automate the receiving system's sensitivity settings.

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I. OBJECTIVES

The objectives of the project were: (1) to continue the visual, or graphical, analysis of the BRIGHAM data (the initial effort of which was reported in Ref. 1) in an attempt to verify anomalous signal behavior already documented and to discover any new anomalies which might be present; (2) toward that end, to make whatever changes were necessary in both the programs and data handling procedures to meet either new system constraints or to enhance over-all project efficiency; and (3) to analyze the data from a statistical standpoint (via two entirely new computer programs) in an effort to determine how often and by what amount (in decibels) several different classes of signals change.

The format of the data, particularly that of the 2.4 minute time duration limitation (although there were several time-wise contiguous data sets), made long term analysis, both visual and statistical, impossible. In addition, the daily intercept times for the data sets precluded any significant effort being made to correlate signal characteristics from even approximately the same time of the day.

II. INTRODUCTION

It is well documented that as radio signals traverse the ionosphere (including signals bounced off of one of its layers) they are often changed in a manner that goes beyond simple attenuation due to the distance travelled. Both the make-up of the ionosphere itself (how many ions are present at any one time, the elusive Sporadic-E phenomenon, night-day asymmetry and the geomagnetic non-reciprocity to name but a few) and the more dramatic disruptions of ionospheric behavior (solar flare caused magnetic storm activity, polar cap absorption and the auroral displays are three) team with the more common, every day phenomena of "Faraday Rotation" and noise-producing lightning storms to alter any signal with which any or all of them come in contact. The results can be severe attenuation, pronounced amplification, "ducting", "whistlers", and fading (sometimes called the Dellinger Effect). References 2 - 6 were excellent sources for ionospheric phenomena information.

It was felt that the application of graphical techniques to signals which had traversed the ionosphere might add some insight into the problem of exactly what happens to these signals.

For the most part, the visual presentation techniques, shown in various stages in Fig. 1, used in this study were the same as those presented in Ref. 1. However, some changes have been made and will be discussed in detail in the appropriate section. As in Ref. 1, interesting sets of scans have been reproduced as graph plots (using the VERSATEC plotter) for further analysis and presentation in

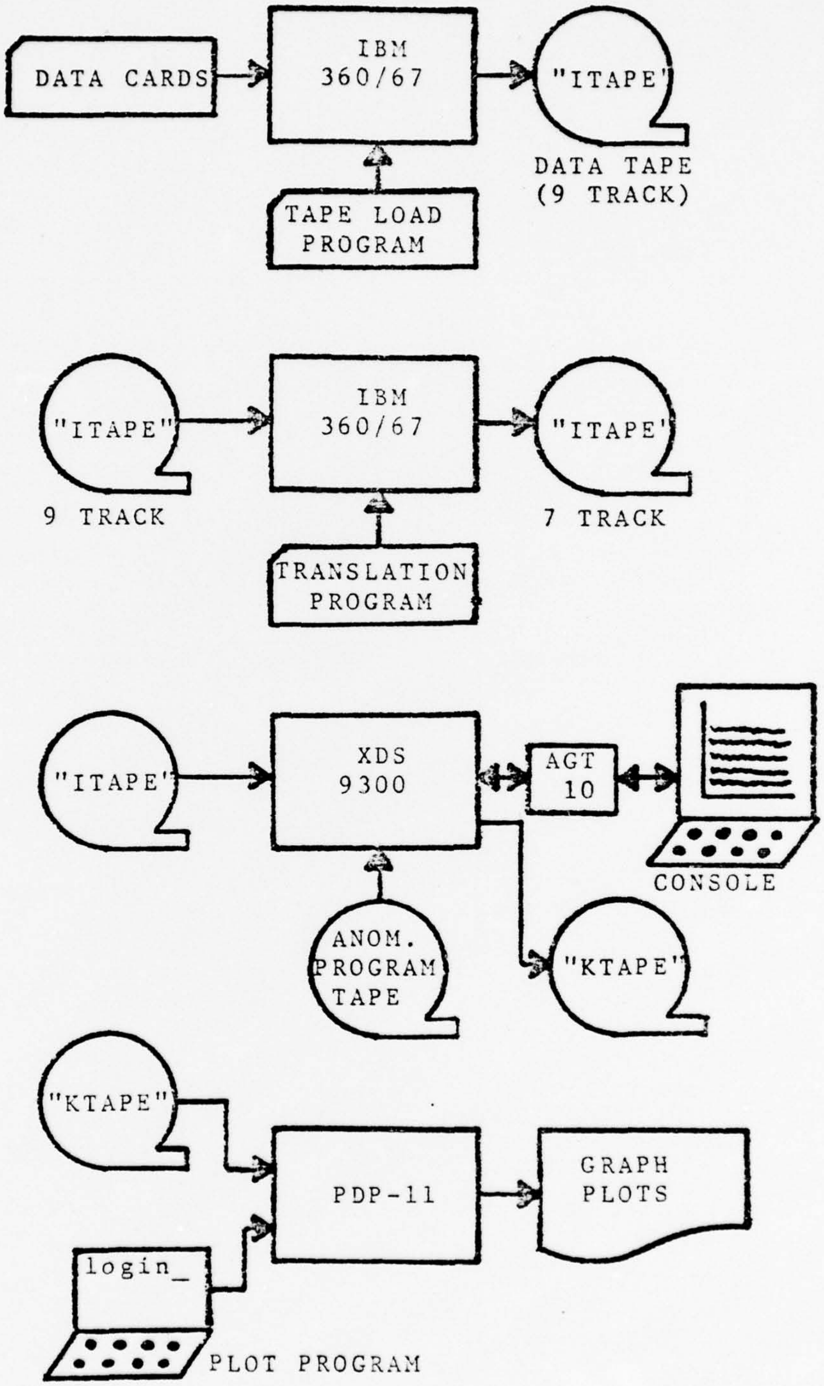


Figure 1 - ANOMALY DATA PROCESSING STAGES

this paper. All thirty-four of the previously unanalyzed complete data sets were studied with varying degrees of success concerning anomalies (or, least, perceived to be so) found therin.

The swept-tuned receiver and associated equipment used to acquire and record the data sets is an operational receiver equipment used for other than experimental data gathering. Its proper operation requires frequent tuning of numerous sensitivity adjustments. How often and by what amount these attenuators and thresholds are changed have a profound effect on the performance of the equipment. Therefore, programs MIN/MAX 1 and MIN/MAX 2 were written in an effort to accumulate enough statistical data from the sets to warrant the recommendation of some appropriate algorithm for controlling the attenuator adjustments. Section IV of this paper will address itself to that topic.

A. NATURE OF THE DATA

The data was gathered using a swept-tuned receiver with either an omnidirectional or 12 degree beam antenna. The data sets were produced by sampling the receiver output at a 25 Hz sampling rate as it scanned downward through an 890 kHz band. Each data set consists of, at most, 3597 scans (each scan being composed of 318 contiguous 2.8 kHz wide bins moving down in frequency as the bin number increases) placed on 7194 cards. Card one gives amplitude information, in 2 dB high quantization levels, for bins 1 through 160 while information on bins 161 through 318 is found on card two. The quantization levels are given in 5-bit binary words with even numbered bin information found in rows 11 through 3 while odd numbered bin information is in rows 5 through 9. In addition, each card has the card number and set number punched in row 12 for accounting purposes. With each set there is a parameter card which delineates the date and time of signal acquisition, base frequency, antenna configuration and attenuation applied.

Of approximately 150 data sets recorded, forty-four were made available for this study. Figure 2 is a table of pertinent information concerning the forty-two complete sets analyzed in Ref. 1 and this paper.

B. CHANGES IN THE GRAPHICAL ANALYSIS PROCEDURE

Equipment reconfigurations since the graphical analysis procedure was formulated and reported in Ref. 1 and efforts to make the data handling more efficient demanded several changes both in procedure and in the two main analysis programs, Anomaly A and Anomaly B. Specific information concerning the workings of the two programs may be found in Ref. 1, particularly in section II B.

First of all, the sheer number of binary cards to be transcribed onto magnetic tape (nearly a quarter of a million) obviated the card-to-tape technique used previously. A much faster and far more reliable procedure was initiated wherein the IBM 360/67 system, belonging to the W. R. Church Computer Center, was used after normal working hours. The cards were first read onto 9-track tapes (800 BPI, even parity) and then transcribed to the 7-track tapes (556 BPI, odd parity) required for the XDS-9300 computer. Partial dumps were made of all sets from both the 9- and 7-track tapes to ensure that the cards read onto the tapes properly and that the tape-to-tape translation was successful. The programs used to read the cards onto tapes, translate the 9- to 7-track and dump the tapes for

SET	DATE/TIME	FREQUENCY	ANTENNA	ATTENUATION
3	100522Z MAR 70	03501	OMNI	8 DB
4	101030Z MAR 70	18000	OMNI	0 DB
5	120555Z MAR 70	06000	OMNI	10 DB
7	121205Z MAR 70	11000	OMNI	8 DB
8	130505Z MAR 70	05000	OMNI	18 DB
9	131018Z MAR 70	13000	OMNI	10 DB
15	181036Z MAR 70	12000	OMNI	10 DB
16	181705Z MAR 70	10000	OMNI	10 DB
18	191105Z MAR 70	14000	OMNI	10 DB
20	191715Z MAR 70	04000	OMNI	4 DB
21	020400Z APR 70	05000	OMNI	20 DB
22	020400Z APR 70	05000	BEAM	20 DB
24	031400Z APR 70	11000	OMNI	10 DB
25	031400Z APR 70	11000	BEAM	10 DB
31	051400Z APR 70	11000	OMNI	0 DB
32	051407Z APR 70	11000	BEAM	4 DB
33	060400Z APR 70	05000	OMNI	24 DB
34	060400Z APR 70	05000	BEAM	24 DB
35	061400Z APR 70	11000	OMNI	0 DB
36	061406Z APR 70	11000	BEAM	4 DB
37	070400Z APR 70	05000	BEAM	10 DB
38	070400Z APR 70	05000	OMNI	10 DB
39	071409Z APR 70	11000	BEAM	4 DB
40	071400Z APR 70	11000	OMNI	0 DB
41	080412Z APR 70	05000	BEAM	14 DB
51	132113Z APR 70	07000	OMNI	14 DB
52	142100Z APR 70	07000	OMNI	14 DB
53	142109Z APR 70	07000	BEAM	14 DB
54	161030Z APR 70	13650	OMNI	2 DB
61	291005Z APR 70	15000	OMNI	0 DB
63	050830Z MAY 70	14600	OMNI	0 DB
67	060955Z MAY 70	14000	OMNI	4 DB
72	MORSE TEST - PARAMETERS UNAVAILABLE			
73	MORSE TEST - PARAMETERS UNAVAILABLE			
80	100000Z MAY 70	10000	OMNI	10 DB
81	100005Z MAY 70	04000	OMNI	10 DB
91	121100Z MAY 70	13616	BEAM	4 DB
126	221230Z MAY 70	08200	OMNI	0 DB
138	261210Z MAY 70	22000	OMNI	4 DB
139	261215Z MAY 70	18000	OMNI	4 DB
147	272045Z MAY 70	16000	OMNI	13 DB
148	272100Z MAY 70	10000	OMNI	18 DB

Figure 2 - DATA SET INFORMATION

quality control can be found at the end of this paper.

This new system of data loading resulting in the requirement to change the sections of the Anomaly A and Anomaly B programs refering to data read-in. This was accomplished with little difficulty.

Next, a metasymbol subprogram was added to each of the analysis programs to enable entire files (data sets) to be skipped when a specific file required was located other than first on a tape. By calling the routine "FORSCN" a keyboard-entered number of files (NFILE =) would be passed over. This proved to be extremely valuable as a time and labor saving device. The routine "BAKSCN" was also available for backing over entire files but chronic tape drive malfunctions negated the use of this even more valuable tool.

One final major program change was dictated by a computer center equipment reconfiguration wherein the CALCOMP 563 plotter was no longer available. The new system to be used was the PDP-11 computer in conjunction with a VERSATEC plotter. This change required modifications of the analysis program sections dealing with the processing of the output data (desired plots from the AGT-10 screen), found at the very end of the main program, and the generation of a new subroutine , called the Header Subroutine, which packs the header data into the proper format for the plotting unit. In addition, a PDP-11 plot package (used to interface the data tape with the plotter) had to be extensively modified to meet the demands of this anomaly data. Listings of the revised Anomaly A and B programs, the metasymbol program for calling "FORSCN" and "BAKSCN" and the PDP-11 plot routine (called "aa.c" for Anomaly A plots - this routine alone is listed since the one utilized for the Anomaly B graph plots differs only in a few of the approximately 400 lines comprising "aa.c") can be found at the back of this paper. Subroutines GINP, GINPUT , FNS and VCD were not changed and, hence, are not listed in this paper but may be found in Ref. 1.

C. ANOMALY A AND B PLOTS

The plots which have resulted from the graphical analysis portion of this study require some prior explanation. Due to the data handling restrictions imposed by the XDS-9300 computer, only a small portion of the data in each set could be viewed at any one time. This resulted in some difficulty in visualizing what could be long-term (time wise) or wide (frequency wise) phenomena and demanded that each set be analyzed several times before the entire set had been viewed.

The Anomaly A plots consist of twenty scans (signal wavefronts sampled 0.04 seconds apart - or further if scans were deliberately skipped to view long-term effects) with the most recent scan in time falling at the bottom of the picture. The scans could be brought onto the screen in any number up to, and including, twenty at a time. As shown in Fig. 3, the vertical axis is marked off in 5 dB increments which apply only to the bottom scan (called "base scan"). The horizontal axis is divided into ten 28 kHz wide sections each composed of ten frequency bins 2.8 kHz wide for a total of 100 frequency bins and 280 kHz. This width can be varied to other than 100 bins if desired. The leftmost bin (termed the "base bin") is selected by keyboard input, thus allowing the analyst to slide up and down the data set (frequency-wise) at will. The scale along the horizontal axis, then, consists of increments of ten bins starting with the "base bin" number at the origin. The term "base freq" refers to the base frequency of the data set and decreases in 2.8 kHz increments as the bin number increases. Shading has been provided on some of the plots to highlight the suggested anomaly.

The Anomaly B plots are a combination of the Anomaly A plot technique and a modification which enables the analyst to view selected bins (signals) in the time vs. amplitude domain. At the bottom of each plot are five scans (Anomaly A style) used to aid in the selection of the bins to be plotted in the upper traces (see Fig. 4). In addition to the restricted number of scans to be seen at one time (only 5), computer limitations required that the number of frequency bins presented be reduced to eighty. Other than those changes, discussion of the Anomaly A plots is also valid for the lower set of Anomaly B plots. The upper set of Anomaly B plots is a collection of five keyboard-selected signals chosen from among the scans below. The traces are numbered one to five, from top to bottom respectively. The horizontal axis is a time line composed of eighty data points at least 0.04 seconds apart (depending upon the number of scnas skipped, if any) with the oldest point at the extreme right side of the trace) with the hash marks on the vertical axis refering to 10 dB amplitude levels.

As seen to some extent in the Anomaly A plots and, more markedly, in the Anomaly B plots, the scans look fractured in appearance. This was not the result of intentional programming, rather it was the product of the new PDP-11/VERSATEC plot routine combination.

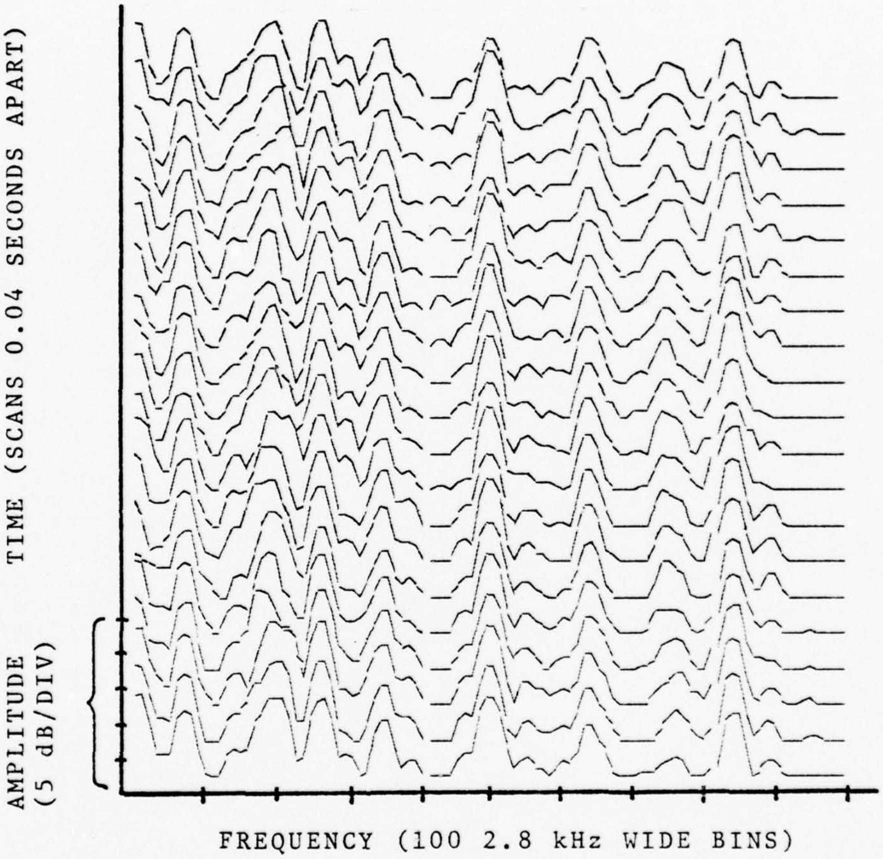


Figure 3 - SAMPLE ANOMALY A PLOT

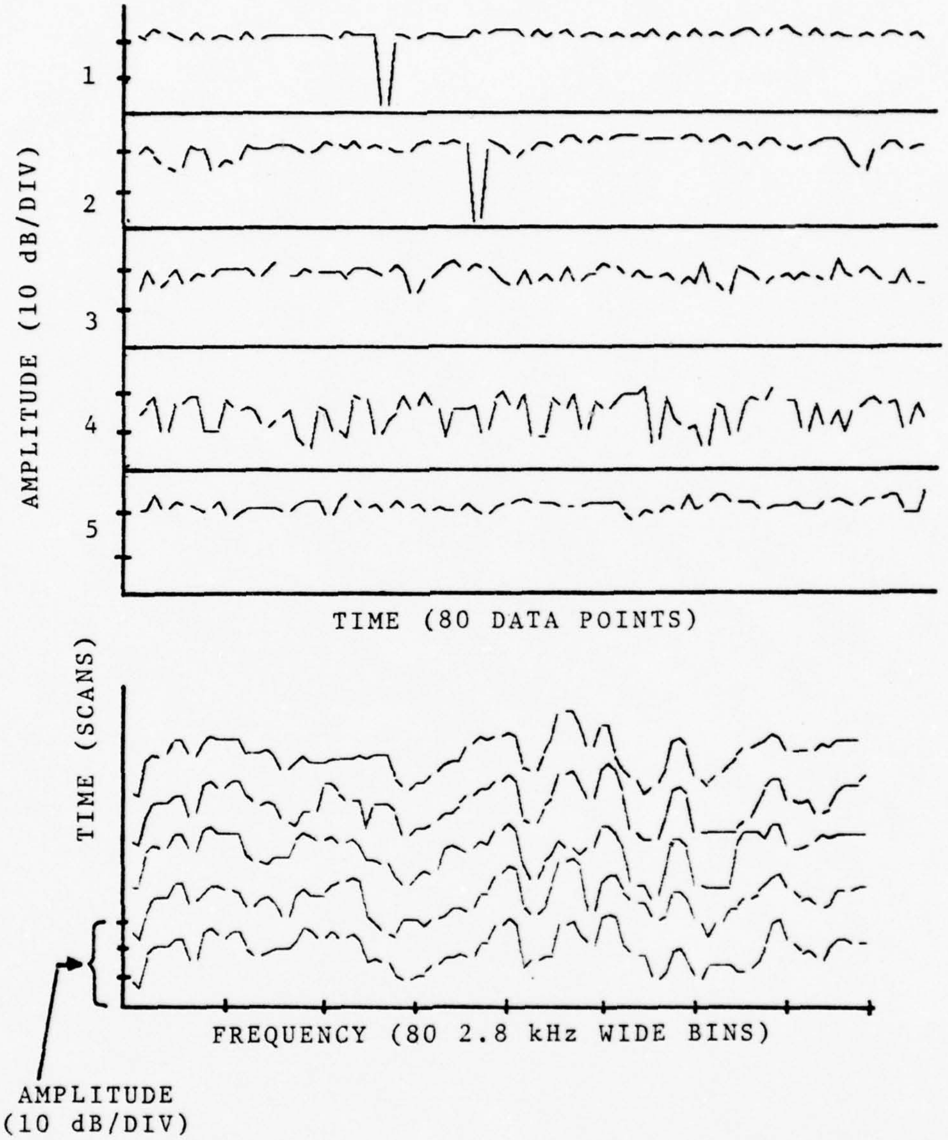


Figure 4 - SAMPLE ANOMALY B PLOT

III. GRAPHICAL ANALYSIS

A. DISCUSSION

Prior to initiation of the graphical analysis process via programs Anomaly A and B, an enumeration of many of the possible "anomalies" expected was made. This was not to imply either that signals which had been markedly affected by the ionosphere would only exhibit these graphical manifestations of anomalous performance or that all forms of signal anomalies would be seen by the analyst. This enumeration procedure was merely an attempt to 'visualize" what effects those signal-changing ionospheric phenomena discussed in the introduction might have on the data sets yet to be analyzed. Although no attempt was made to make this study's "anomalies" conform with those identified in Ref. 1, there has been an attempt to verify any previously seen.

The graphical effects on the signal waveforms expected were:

1. a sudden enhancement/depression of one or more signals (long or short term);

2. an abrupt discontinuity across an entire wavefront or portion thereof;

3. a signal "bump" or "valley" moving either up or down in frequency as the wavefront

progresses (Fig. 4, Ref. 1 refers);

4. a shift in frequency of one or more signals (either short term, long term or aperiodic in nature);

5. an unexplainable enhancement of one or more signals with a concomitant depression of one or more signals at the same time in the same data set;

6. a complete loss of continuity of the signal wavefront for variable periods of time;

7. unexpected variations in one or more signal contours as the wavefront progresses;

8. any out-of-the-ordinary graphical implication of anomalous performance.

Effects 1, 2, 4, 6, and 8 were discerned in the present study while several of these, plus effects 3, 5, and 7, were reported in Ref. 1.

B. ANOMALY A ANOMALIES

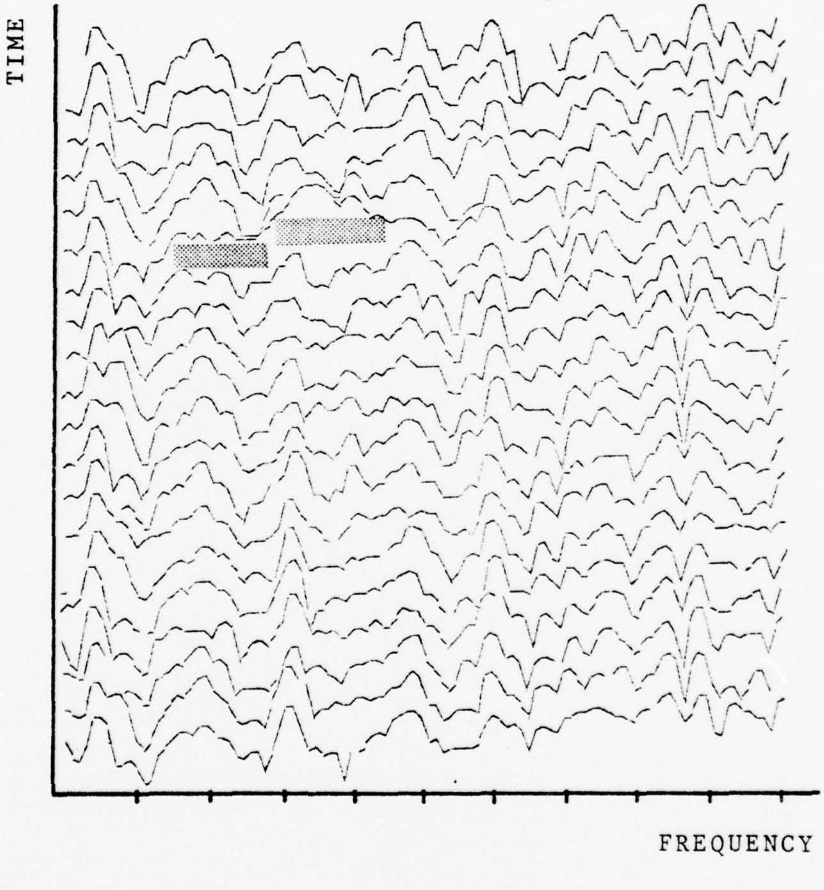
As shown in Ref. 1 and verified in this paper, most of the data sets (when viewed on the graphics terminal) exhibited a great measure of uniformity in signal makeup in the time domain and did not yield any obvious graphical anomalies. In fact, fully fifty per cent of the BRIGHAM data sets failed to provide any reportable irregularities in signal pattern with the other fifty per cent giving fairly uniform signal wavefronts for most of the time recorded.

The latter group did, however, exhibit anomalous (or, at least, assumed to be so) characteristics which were verifications of performance reported in Ref. 1 or were newly discovered. The uniformity mentioned above aided immeasureably in the detection of anomalies since even a slight wavefront variation could be discerned in the midst of otherwise uniform signal progression.

Figures 5 and 6 are two examples of minor discontinuities (affecting 30 to 40 bins - approximately 100 kHz) which appear to be the result of a multi-signal amplitude enhancement for a very short period of time. This effect was found scattered through almost half of the thirty-four data sets viewed via Anomaly A. Figure 7 is an example of aperiodic discontinuities which ran across almost all of the entire data set bandwidth. This change did not occur over the entire time duration of the set and, as mentioned above, could not be traced over its entire frequency spectrum. This type of discontinuity was also found in data sets 33 and 80. Both of the discontinuity examples were anticipated although the latter form holds the most promise, anomaly-wise.

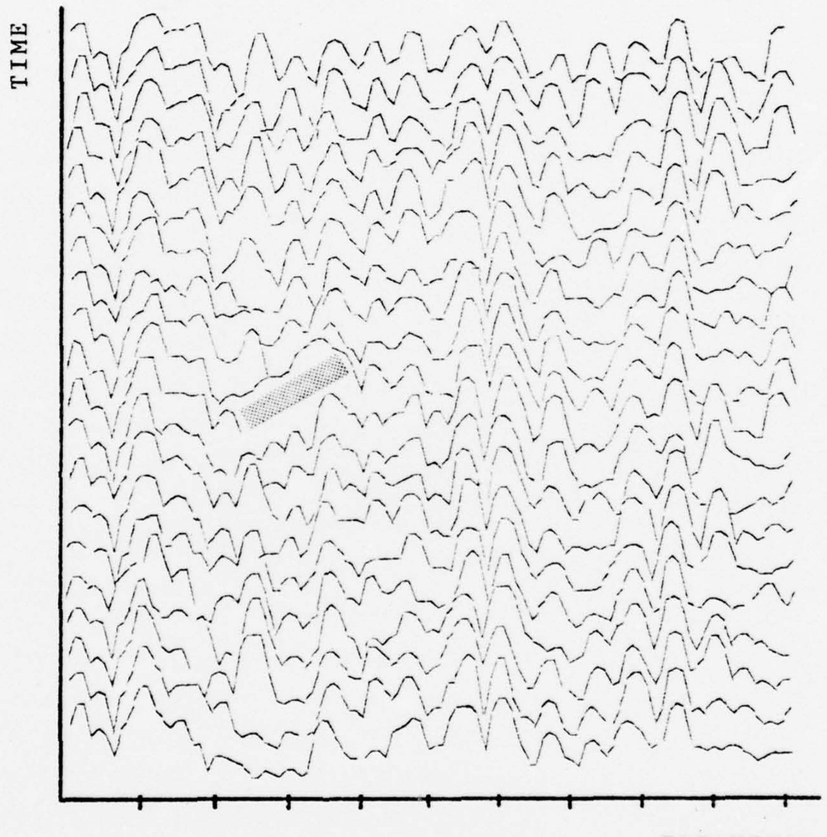
Fading was another effect expected but the examples found were somewhat surprising in that it was anticipated that the entire frequency bandwidth of a signal wavefront (890 kHz) would be affected. This proved not to be the case, with all of the examples of fading implicating at most 20 frequency bins at a time. Figure 8 shows the signal centered on bin 148 fading in and out, a process which lasted several seconds. Figure 9 shows a much smaller time-duration fading centered on bin 24.

A third type of possible anomalous activity is that of the shifting, up or down in frequency, of either a single signal or entire 890 kHz wide signal scans. The precise



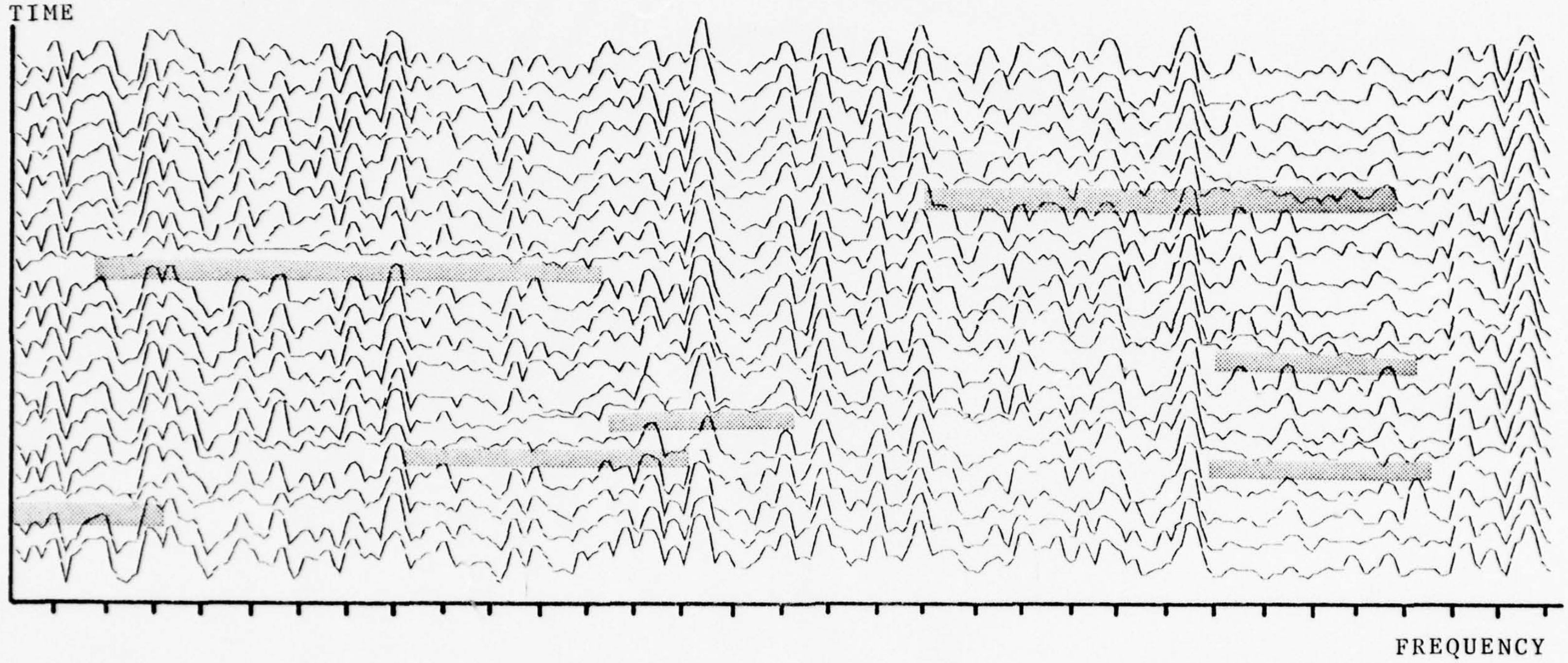
Set 3, Base Scan 141, Base Freq 3.5 MHz, Base Bin 1

Figure 5 - NARROW DISCONTINUITY EXAMPLE #1



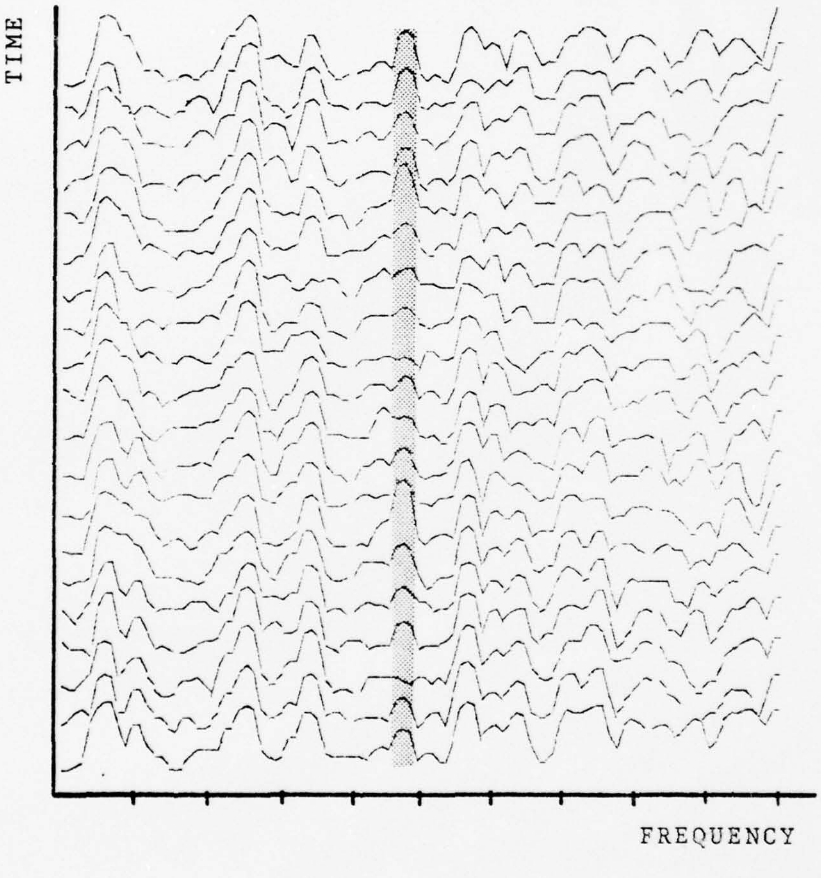
Set 3, Base Scan 1023, Base Freq 3.2 MHz, Base Bin 100

Figure 6 - NARROW DISCONTINUITY EXAMPLE #2



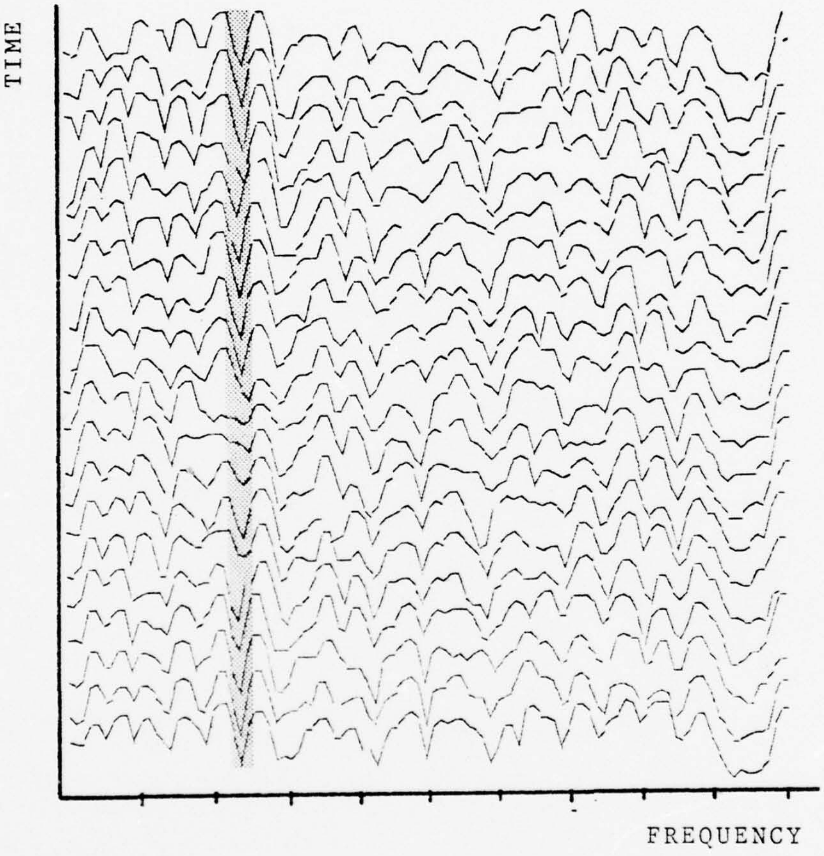
Set 67, Base Scan 690, Base Freq 14 MHz, Base Bin 1

Figure 7 - WIDE DISCONTINUITY EXAMPLE



Set 53, Base Scan 544, Base Freq 6.7 MHz, Base Bin 100

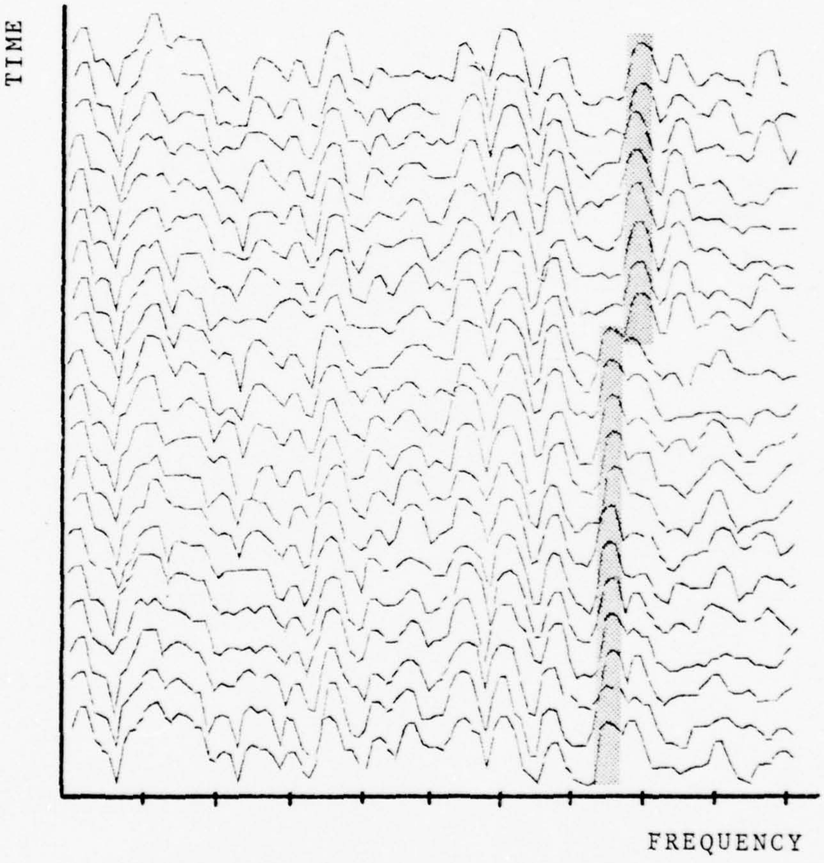
Figure 8 - FADING EXAMPLE #1



Set 33, Base Scan 270, Base Freq 5 MHz, Base Bin 1

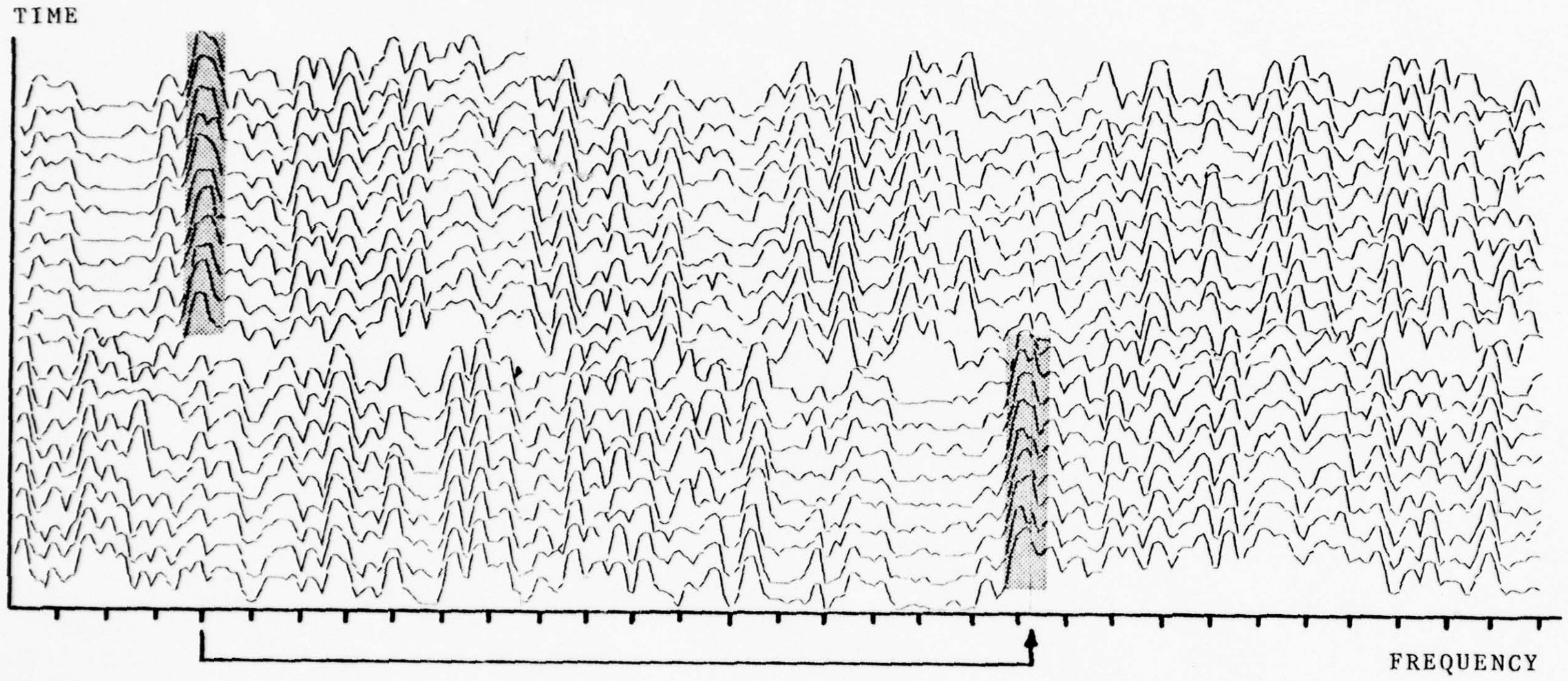
Figure 9 - FADING EXAMPLE #2

explanation of this phenomenon is not available but it must be kept in mind that malfunctions in the receiver system itself could be the cause rather than some ionosphere-related activity. Figure 10 shows a possible left shift (approximately 3 bins) and distortion of two side-by-side signals. Figures 11 and 12 are examples of apparent frequency shifts of 160 bins both of which turned out to be data set problems. Since each scan is composed of two data cards of binary coded amplitudes (bins 1 - 160 on card one and bins 161 - 318 on card two), the order in which the two cards appear and, as importantly, the existence of both cards for each scan are absolutely vital to the correct representation of the signal wavefront. For example, if card one of a scan is missing, then card one of the next scan is taken as card two of the former. This has a domino effect which will graphically manifest itself as an apparent shift of 160 bins in all subsequent scans. Figure 11 illustrates precisely this effect. A manual search of the missing from the set. Figure 12 is an interesting twist on this problem in that the signal apparently shifted 160 bins to the right (or, down in frequency) and then, three scans later, shifted right back again. Another search of the cards showed that ,as expected, two cards were missing, one to cause the initial 160 bin right shift and a second to return the data cards to their correct sequence three scans later. One last example of signal shifting is by far the most interesting of the lot. As illustrated by Fig. 13, there is a shift down in frequency of approximately 12 bins (34 kHz) affecting the entire 318 bins (890 kHz bandwidth) of aperiodically spaced scans. This phenomenon was seen over the entire length of the data set at apparently random intervals. Data sets 138 and 143 also exhibited this aperiodic frequency shifting, although the number of bins by which the scans were shifted varied slightly over the three sets.



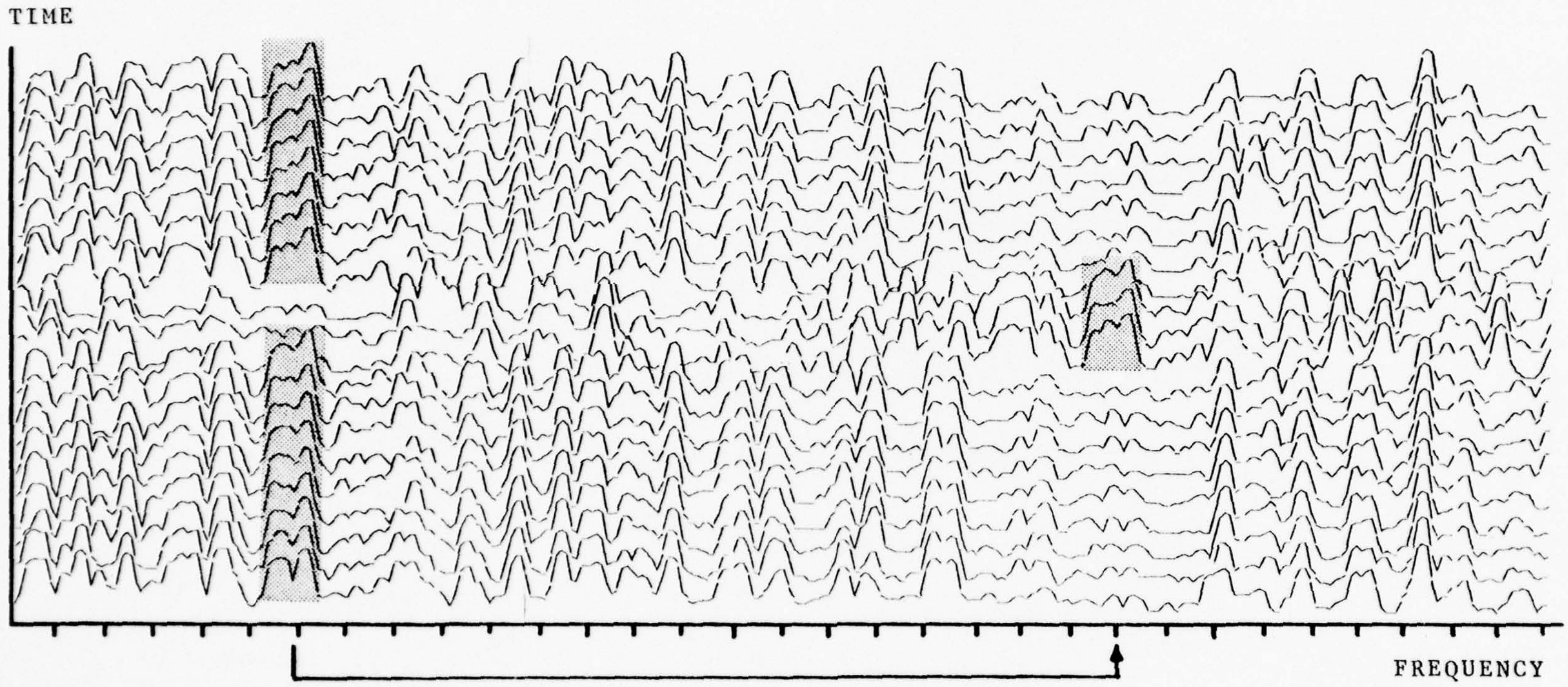
Set 3, Base Scan 336, Base Freq 3.2 MHz, Base Bin 100

Figure 10 - SHIFTING EXAMPLE #1



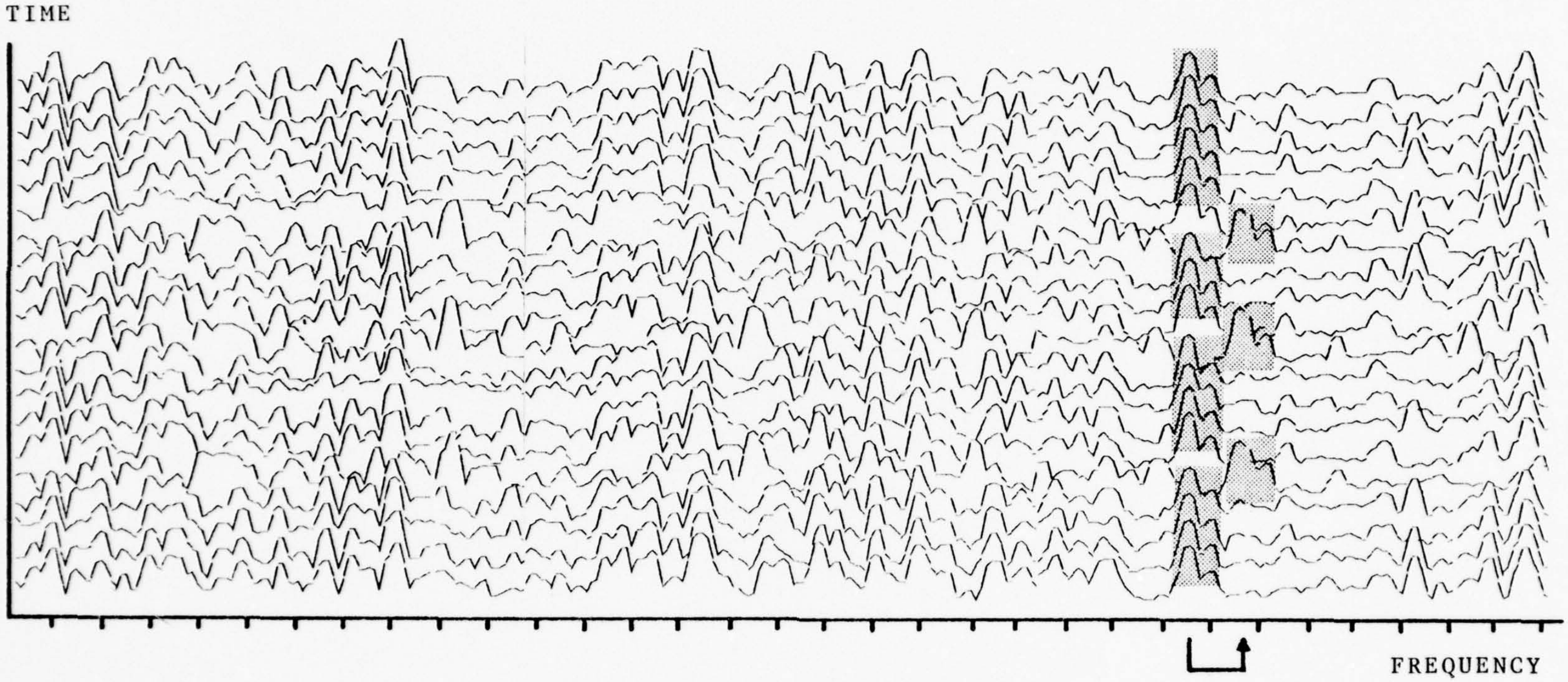
Set 139, Base Scan 3110, Base Freq 18 MHz, Base Bin 1

Figure 11 - SHIFTING EXAMPLE #2



Set 126, Base Scan 2940, Base Freq 8.2 MHz, Base Bin 1

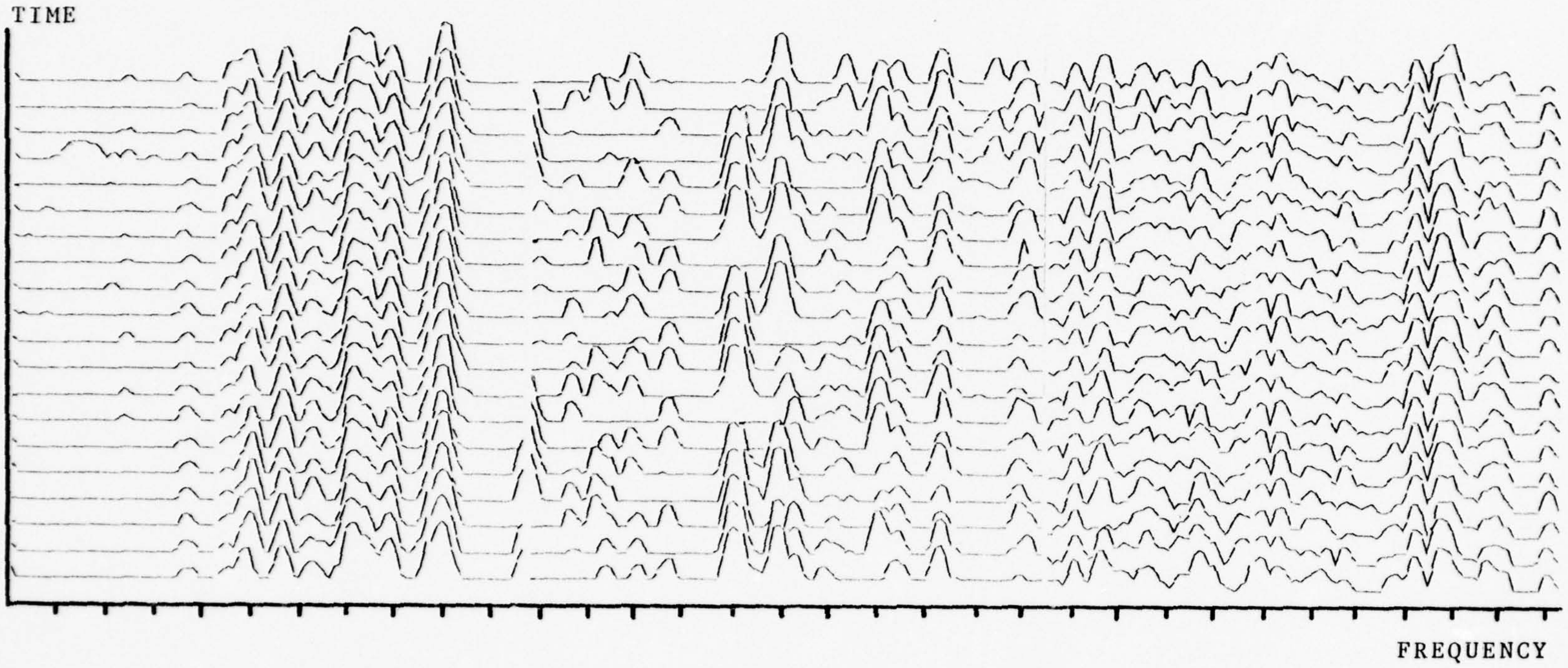
Figure 12 - SHIFTING EXAMPLE #3



Set 67, Base Scan 2860, Base Freq 14 MHz, Base Bin 1

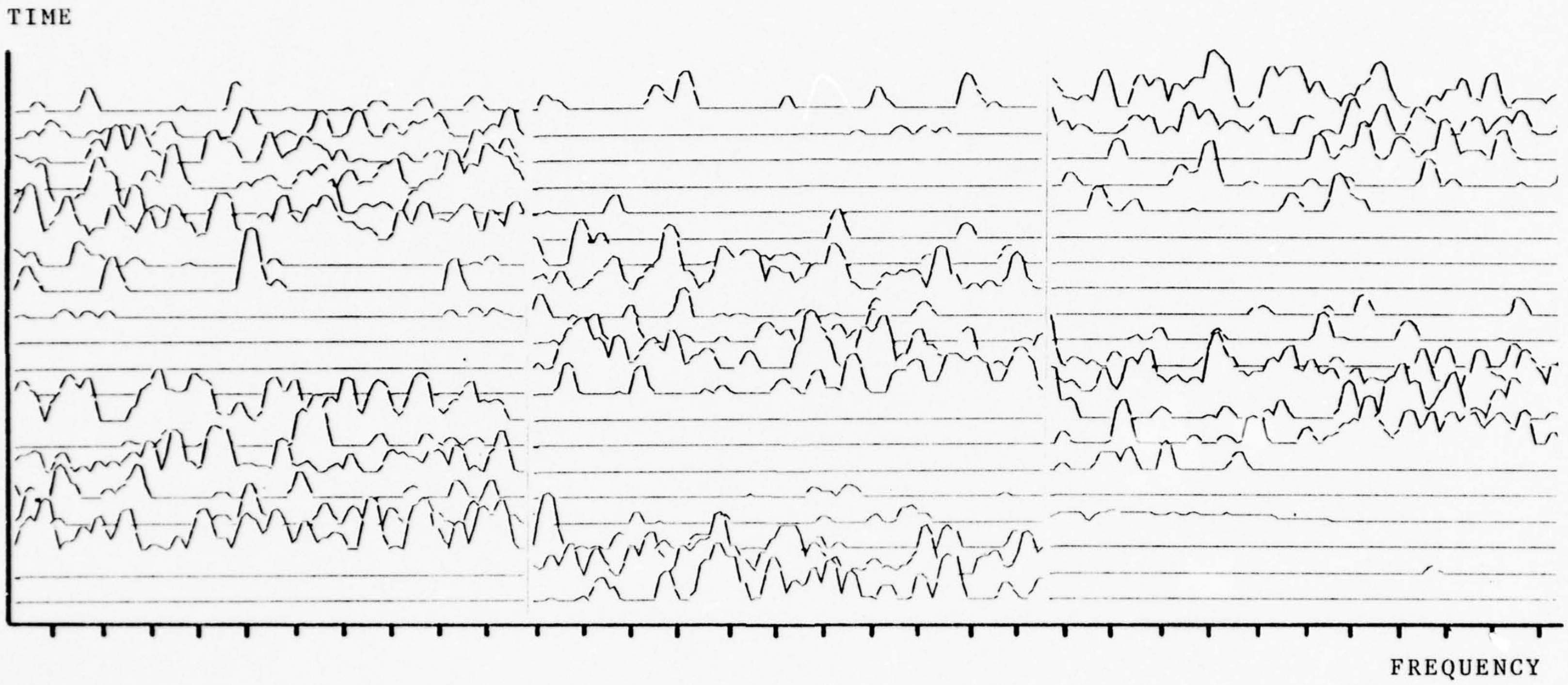
Figure 13 - SHIFTING EXAMPLE #4

One final category for possible signal anomalies consists of five different phenomena each of which occured, with one exception, only once in the thirty-four data sets. Figure 14 is an example wherein three different "anomalies" were present. (It should be noted that base scan = "various" for Figs. 14 and 15 means that each of the three sections of the waveforms in the two figures had different base scans and implies that this in no way detracts from the usefulness of the figures as examples of the affects in question.) Bins 1 through 40 and 88 through 98 exhibit a very high degree of signal attenuation not seen in normal data sets (i.e. data sets not found to have either a receiver malfunction or test signal present). Bins 41 through 87 exhibit normal signal characteristics. Bins 101 through 200 evidence a combination of unusual attenuation and normal signal activity, while bins 201 through 270 show either a general distortion of the signals present or a fairly high amplitude level of ambient noise and/or distorted signals plus noise. None of these phenomena could be explained by receiver malfunction, data card sequencing or special signal characteristics (i.e. test signal, etc.). Figure 15 shows a data set exhibiting no continuity of signal whatsoever. None of the signal "bumps" can be followed in a uniform manner as time progresses. The theory that a serious receiver system malfunction was the cause of the distortion was borne out by a call to the cognizant authority. This malfunction was also verified for data sets 25 and 54. The sawtooth effect seen at the middle, right hand side of Fig. 16 is a pattern not seen elsewhere either in this set or any of the other thirty-three sets analyzed. It shows wild fluctuations in seven adjacent amplitude points (2.8 kHz apart) in one scan, whereas the rest of the scan appears to be normal. No explanation for this phenomenon can be offered. Another unexpected anomaly was the two flat-topped signals, centered at bins 124 and 128,



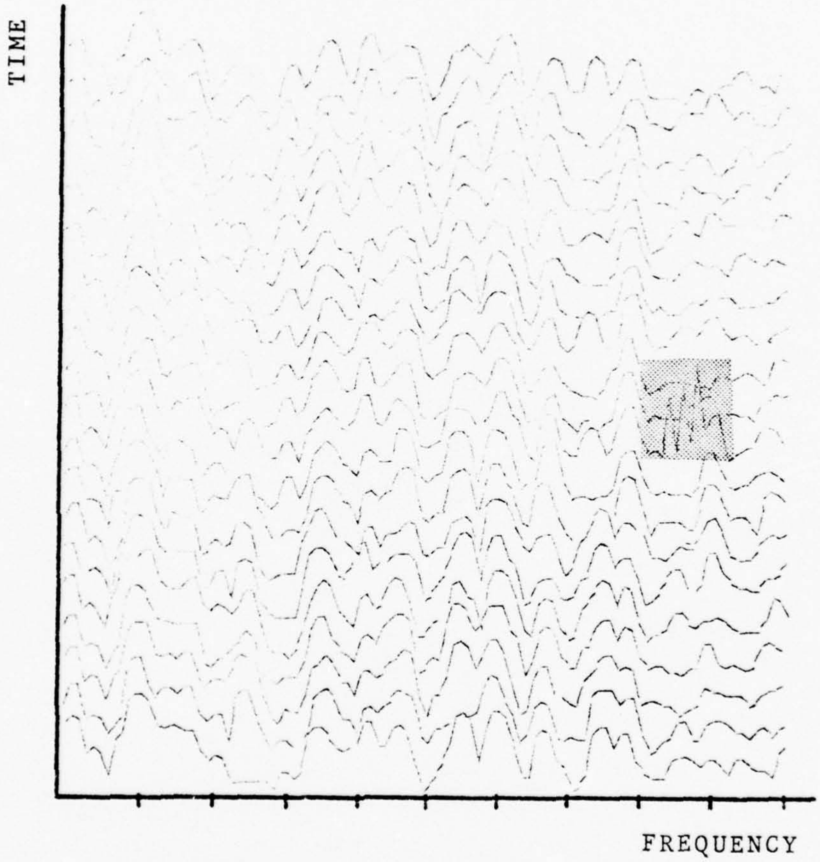
Set 91, Base Scan Various, Base Freq 13.6 MHz, Base Bin 1

Figure 14 - MULTIPLE ANOMALY EXAMPLE



Set 24, Base Scan Various, Base Freq 11 MHz, Base Bin 1

Figure 15 - EQUIPMENT MALFUNCTION EXAMPLE



Set 3, Base Scan 1815, Base Freq 3.2 MHz, Base Bin 100

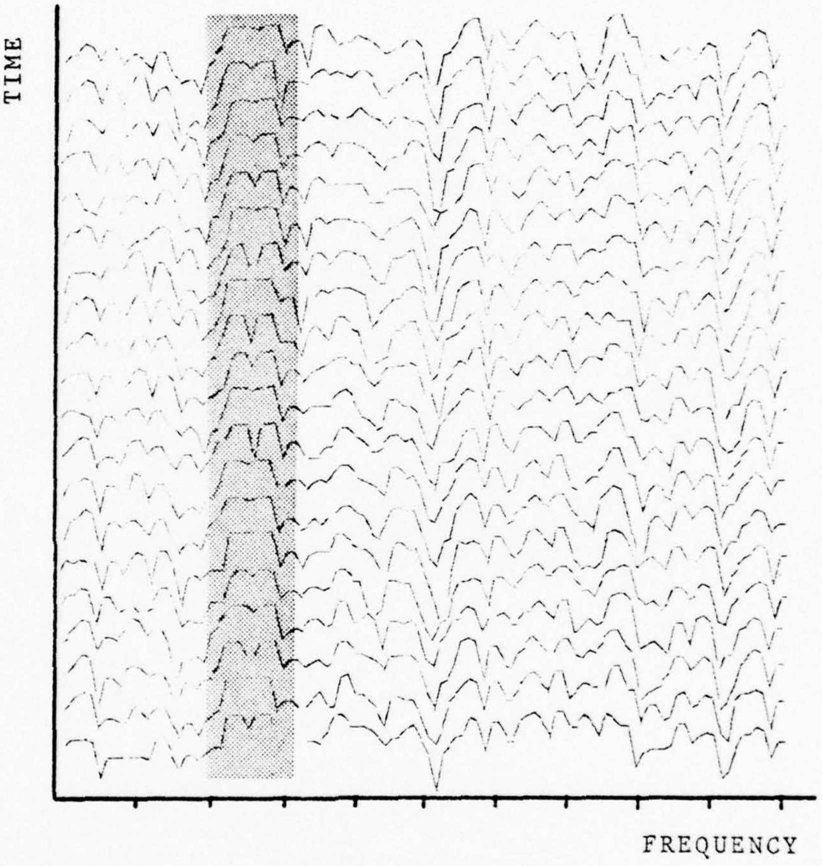
Figure 16 - SAWTOOTH PATTERN EXAMPLE

found in Fig. 17. It appears to be the result of some special attenuation applied to those frequency bins alone, because, as can be seen by the rather "large" signal centered on bin 178, other signals appear not to be affected. The additional attenuation applied to this set during reception , 10 dB, is lower than levels applied to other sets which were not similarly affected. The best phenomenon observed in this final category is found in Fig. 18. For some reason (other than the possibility of a different form of receiver malfunction than seen before) an otherwise normal data set lost total signal continuity across the entire frequency bandwidth with subsequent scans exhibiting a highly distorted nature. While this could not have been caused by a card sequencing problem, its source cannot be identified.

C. ANOMALY B ANOMALIES

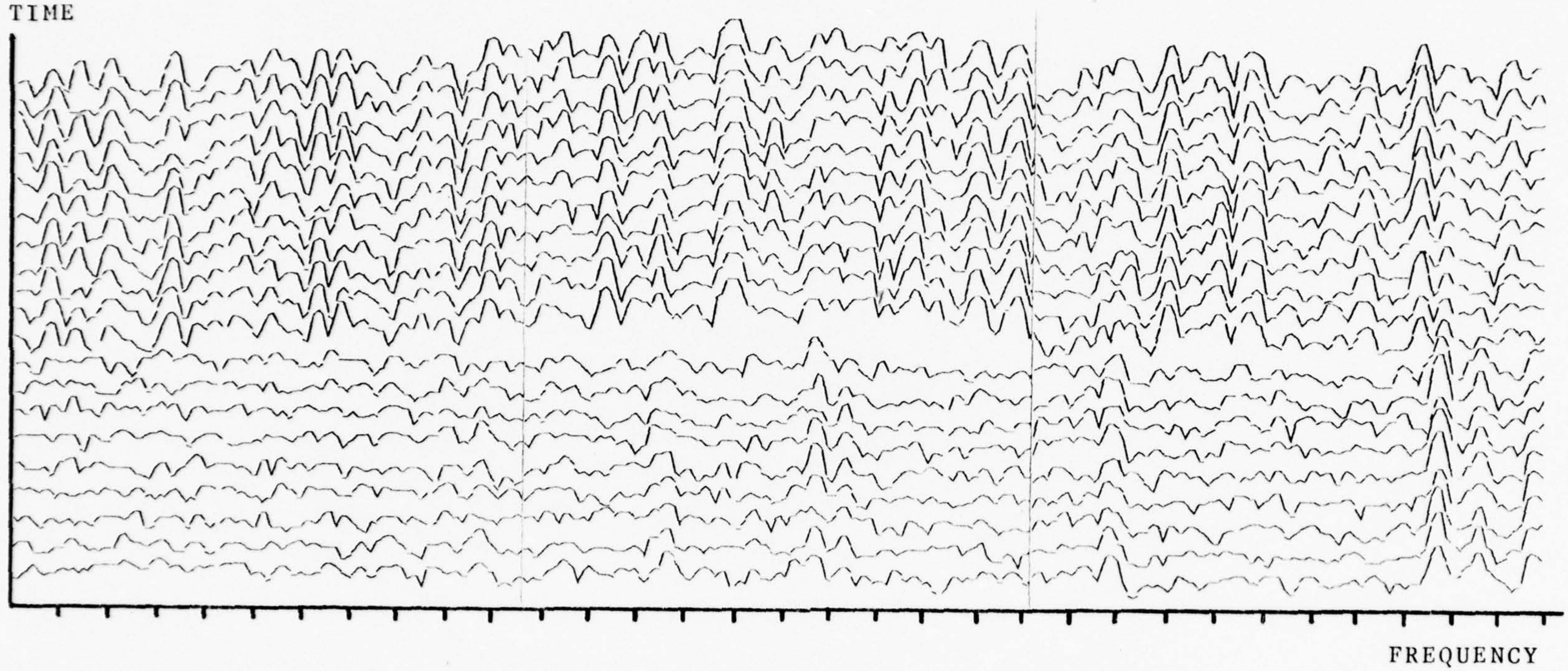
The Anomaly B program provided a different perspective from which to observe the data sets since it presented two dissimilar plots on the screen at the same time. The lower traces consisted of five Anomaly A style three-dimensional plots, this time only eighty points (or bins) wide, while the upper five traces were the two-dimensional time vs. amplitude plots of bins selected from the traces below. It was felt that this different perspective would enhance the anomaly identification effort, that it did not was disappointing.

Of the eighteen data sets analyzed (3, 7, 16, 18, 20, 21, 33, 36, 37, 38, 40, 41, 51, 53, 61, 80, 125, and 139), Anomaly B proved useful in only two instances: (1) to provide a graphic presentation of the three signal types used in the Statistical Analysis Section of this paper; and



Set 16, Base Scan 932, Base Freq 9.7 MHz, Base Bin 100

Figure 17 - ATTENUATED SIGNALS EXAMPLE



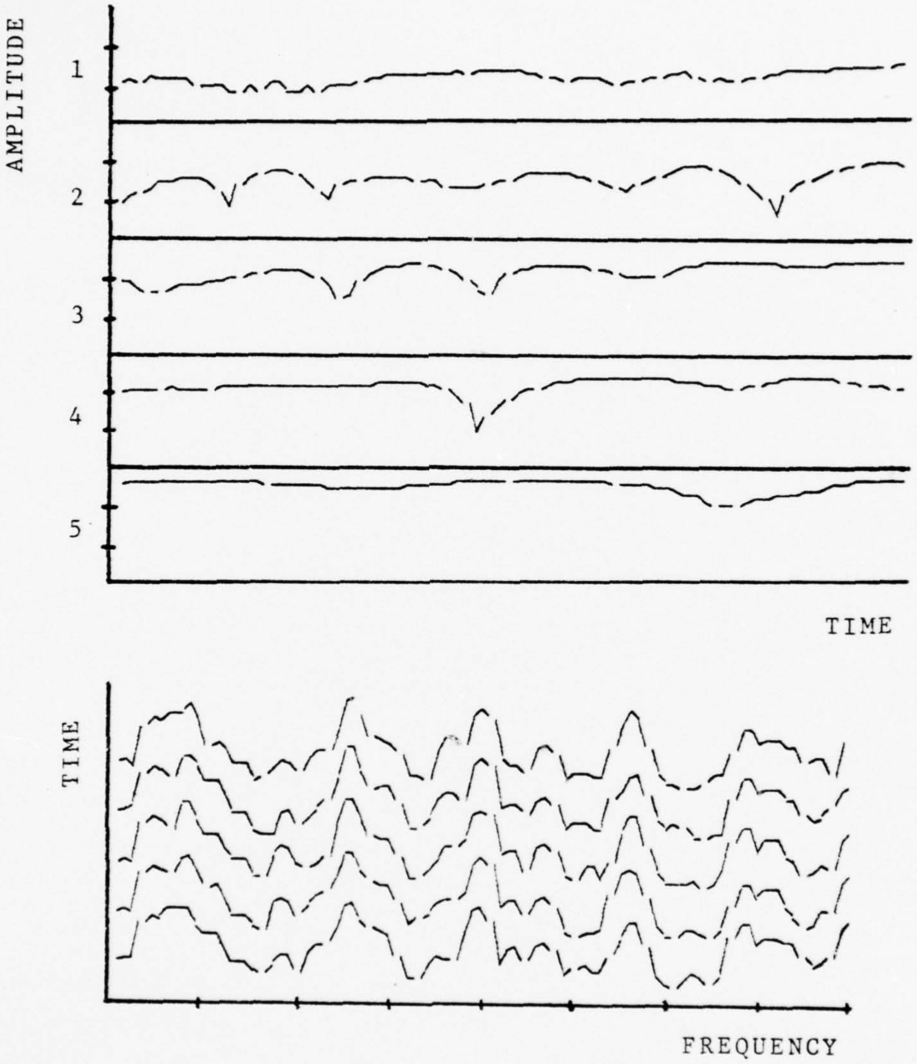
Set 148, Base Scan 210, Base Freq 10 MHz, Base Bin 1

Figure 18 - COMPLETE DISCONTINUITY EXAMPLE

(2) to illustrate one very interesting phenomenon which could not be seen by the Anomaly A presentation. As shown in Fig. 19 this phenomenon consists of an undulation in the amplitude of the five upper traces. This "lazy sinusoidal" variation appears to affect some signals more often than others. The term "lazy sinusoidal" should be used with care since it is not meant to imply that there is any strict periodicity to be found in the undulation or that the traces look exactly like sinusoids. However, many of the signals did evidence the more smooth (and, hence, sinusoidal) variation seen in trace one in the figure.

Although only relatively smooth waveforms are depicted in the figure, this effect was identified over a large range of signal types including those which keyed off and on; however, it was much easier to see this phenomenon on the smooth signals. This variation was seen in every data set analyzed although it occured more frequently and noticeably in some than in others.

The cause of this undulation could be: (1) variations in transmitter output power levels; (2) receiver system processing; or (3) ionosphere-related phenomena including Faraday Rotation, Sporadic-E and fading.



Set 7, Base Scan 588, Base Bin 120

Figure 19 - AMPLITUDE UNDULATION EXAMPLE

IV. STATISTICAL ANALYSIS

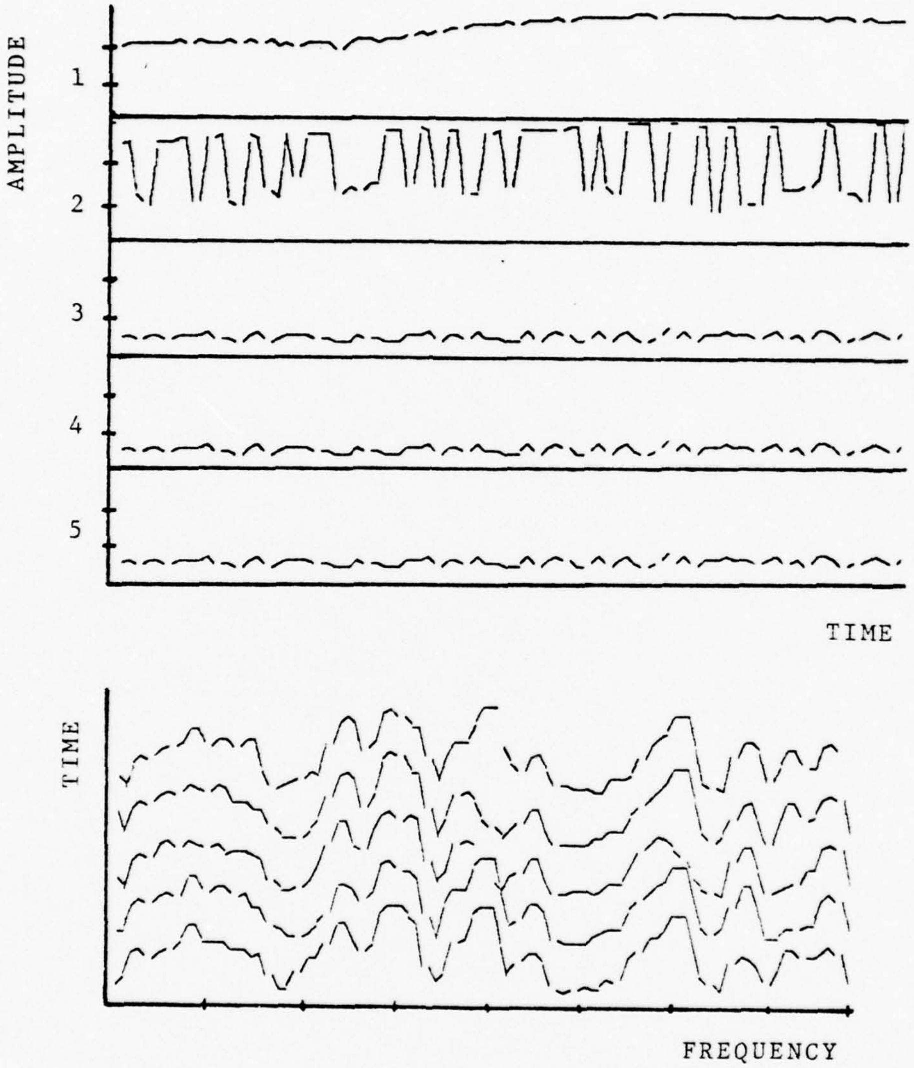
A. DISCUSSION

In conjunction with the graphical analysis approach to identify signal anomalies attributable to ionospheric properties, an attempt was made to glean additional information from the BRIGHAM data by means of statistical algorithms; however, it should be noted that no attempt was made to identify anomalies by this approach. Rather, the programs MIN/MAX 1 and MIN/MAX 2 were developed in an effort to determine how often and by what amount (amplitude in decibels) both signal wavefronts (scans) and individual signals (bins or sets of bins) change. It was hoped that this new data might prove useful in the developement of an algorithm to adjust the myriad sensitivity controls found on the swept-tuned receiving equipment used to acquire and record the BRIGHAM data. Although this effort has nothing directly to do with the signal analysis effort reported previously, it did take considerable time and effort to write the programs and create the desired data base. In addition, this evolution proved extremely helpful in the overall effort of understanding signal characteristics, the primary goal of this study.

For the purposes of this inquiry, three different types of signals (one that stayed "on" through most of the signal duration, one that stayed "off" through most of the signal duration and one that appeared to key on and off throughout most of the signal duration) were chosen from data sets which were collected at various times of the day. The quotation marks are used (here and throughout the rest of the paper) to imply a general trend noted over the life of the signal not some unvarying signal characteristic. Figure 20 is an Anomaly B graph plot presenting classic examples of the three signal types. The "ON" signal (exhibiting that "lazy sinusoidal" amplitude variation mentioned in the graphical analysis section) is trace 1, the "ON/OFF" signal is trace 2 and the "OFF" signal is trace 3. Traces 4 and 5 are merely copies of trace 3 to fill out the plot. A table giving all pertinent data on the twenty-four signals analyzed may be found in Fig. 21. In the figure, set frequency refers to the base frequency of the set when the recording was initiated while TOI means the time of interception for the data set. An attempt was made to analyze two signals from each of four different time categories (interesting from the ionosphere's standpoint) ,those being sunrise, noon, sunset and midnight. With one exception, set 53 - 2109LOCAL, this effort was realized.

B. STATISTICAL ANALYSIS PROGRAMS

The first generation algorithm developed, called MIN/MAX 1, provided for a scan-by-scan (down entire frequency bandwidths - cross sections of many signals - at fixed times) analysis of a variable number of scans within a given set. MIN/MAX 1 identified each of the peaks and valleys along the scans, chose the highest peak and lowest valley and computed the average peak and average valley heights. The quantization levels given on the data cards were changed to decibels and the amount of attenuation applied at the time of acquisition was added back in to give received signal levels accurately. MIN/MAX 1 proved to be of only small value since signal wavefronts vice signals themselves



Set 7, Base Scan 200, Base Bin 40

Figure 20 - THREE MIN/MAX SIGNAL TYPES

```
SET   BIN   SIGNAL TYPE   SET FREQUENCY    SET TOI

  3   136       ON          03501 KHZ       0522Z
      154     ON/OFF
      169       OFF
  7     8       ON          11000 KHZ       1205Z
       81     ON/OFF
       91       OFF
 20   265       ON          04000 KHZ       1715Z
      238     ON/OFF
      259       OFF
 21   150       ON          05000 KHZ       0400Z
      273     ON/OFF
      187       OFF
 53    19       ON          07000 KHZ       2109Z
        8     ON/OFF
       50       OFF
 80    82       ON          10000 KHZ       0000Z
       60     ON/OFF
       73       OFF
 81     4       ON          04000 KHZ       0005Z
       72     ON/OFF
       11       OFF
126    57       ON          03200 KHZ       1230Z
       74     ON/OFF
        8       OFF
```

Figure 21 - MIN/MAX SIGNAL PARAMETERS

were analyzed. A program listing for MIN/MAX 1 may be found at the end of this paper.

The next generation effort, tabbed MIN/MAX 2, focused on specific signals (the three varieties delineated in the discussion section above) and added a number of more valuable statistical features. Like its predecessor, MIN/MAX 2 identified each of the peaks and valleys, chose the highest peak and lowest valley and computed the average peak and average valley heights.

Its next feature was the determination of two different types of signal changes: (1) the comparison of sample point amplitudes with a sliding reference point to determine long-term changes in signal levels; and (2) the comparison of adjacent sample point amplitudes to determine short-term changes. The former was initiated with the bin 1 point as the reference point and all subsequent points compared with it until an amplitude was found which differed from the reference by a previously agreed upon number of decibels (for this test, 4, 6, 12 and 18 dB changes were used in succession). That point then became the reference point and the process continued for the entire 2.4 minute length of the signal. The number of such long-term changes and the elapsed time between each change were recorded. This data could then be used to attain the goal of this effort, the gauging of how often and by what amount the various signal types changed.

A further refinement of the procedure was the creation of amplitude histograms of the elapsed times between the changes to illustrate the effect that increasing the level of decibel fluctuation which constituted a change had on both the frequency of changes and the distribution of elapsed times. Since the receiver sampling rate was 25 Hz, the smallest elapsed time possible between X dB fluctuations was 0.04 seconds. A brief analysis of the first set of elapsed times led to the division of the time line (abscissa) into twenty-one time bins with the inclusive boundaries given in Fig. 22 and labeled N1 through N21. As a further refinement, bins N1, N2 and the first segment of N3 were divided into individual 0.04 second bins labeled N1-1 through N1-7, N2-1 through N2-8 and N3-1 respectively. The two histograms gave an excellent perspective from which to watch the changes in signal characteristic as the amount of decibel fluctuation tested was stepped from 4 to 6 to 12 and, finally, to 18 dB.

The final output of MIN/MAX 2 was, in addition to the peak and valley statistics mentioned above, a listing of the number of long-term changes that took place in each of the thirty-seven time bins of interest, the percentage of the number of changes under each time bin as compared with the total number of changes (this allowed for a more valid comparison of the over-all change picture when an increase in decibel deviation required resulted in fewer changes tabulated in the bins), the total number of long-term changes (called NUM in the output) and the total number of changes in adjacent sample points (the short-term changes mentioned above). In addition, the mean and standard deviation for the elapsed times between long-term changes were computed. A listing for MIN/MAX 2 may be found at the end of this paper.

C. OBSERVATIONS AND CONCLUSIONS

There were a number of surprises which resulted from the initial computer output from MIN/MAX 2. First, the high number of both long- and short-term changes identified was not expected. Out of the possible 3597 changes (there were

TIME BIN	START	END
N1	0.04	0.28
N2	0.32	0.60
N3	0.64	0.96
N4	1.00	1.28
N5	1.32	1.60
N6	1.64	1.96
N7	2.00	2.28
N8	2.32	2.60
N9	2.64	2.96
N10	3.00	3.28
N11	3.32	3.60
N12	3.64	3.96
N13	4.00	4.28
N14	4.32	4.60
N15	4.64	4.96
N16	5.00	7.46
N17	7.50	9.96
N18	10.00	14.96
N19	15.00	19.96
N20	20.00	29.96
N21	30.00	NONE
N1-1	0.02	0.06
N1-2	0.06	0.10
N1-3	0.10	0.14
N1-4	0.14	0.18
N1-5	0.18	0.22
N1-6	0.22	0.26
N1-7	0.26	0.30
N2-1	0.30	0.34
N2-2	0.34	0.38
N2-3	0.38	0.42
N2-4	0.42	0.46
N2-5	0.46	0.50
N2-6	0.50	0.54
N2-7	0.54	0.58
N2-8	0.58	0.62
N3-1	0.62	0.66

NOTE: START AND END FIGURES ARE IN SECONDS.

Figure 22 - HISTOGRAM TIME BIN PARAMETERS

at most that many scans, or sample points, available for each signal of interest) the number of changes noted in some cases reached as high as 2000 for the lower decibel fluctuation levels. Second, the elapsed time histograms tabulated showed a marked tendency to be heavily damped exponentials in nature with the 0.04 second bin (N1-1) having the highest number of occurences throughout. And third, there was a high degree of overlap between the statistical characteristics generated for the three signal types chosen indicating that there was no absolute way to categorize a signal as "ON", "ON/OFF" or "OFF" merely by looking at its statistics. What was expected (and did occur) was that, as the number of decibels used for comparison increased, the exponential distributions "flowed" to the right indicating greater elapsed times between larger decibel fluctuations.

Figures 23 - 29 represent the bulk of the meaningful data garnered from the MIN/MAX 2 application to the twenty-four signals of interest. In speaking of the characteristics which differentiate the three arbitrarily chosen and defined signal types, Figs. 23 - 28 provide those statistics which can be of value in coming to a logical conclusion concerning their differences. As would be expected from "ON/OFF" signals, they showed a greater difference between both average peak and valley values and between "maxmax" and "minmin" values than did the other two, implying more signal level fluctuation. The "OFF" signals consistently showed the smallest fluctuations as would be expected from a series of either highly decayed signals or high but fluctuating ambient noise. Based on these statistics alone it would be nearly impossible to distinguish with a high degree of certainty between an "ON" and an "ON/OFF" signal given only the parameters in those figures. Figure 29 provides both a summary of the data concerning the number of changes tabulated for each decibel

```
        SET     BIN     PEAK     VALLEY     MAXMAX     MINMIN

          3     136    54.40      46.78         58          8
          7       8    56.74      52.02         62         34
         20     265    45.65      39.65         54         24
         21     150    55.44      49.19         62         20
         53      19    55.97      52.16         66         28
         80      82    57.83      53.54         68         22
         81       4    68.81      60.75         70         10
        126      57    43.52      38.61         52          0


 PEAK AVG   VALLEY AVG      PVR        PVA      MMR      MMA

  54.54       49.09      3.81-8.06    5.46     28-60    43.25


KEY:     PEAK = AVERAGE OF ALL MAX PTS IN EACH BIN (SIGNAL)
       VALLEY = AVERAGE OF ALL MIN PTS IN EACH BIN (SIGNAL)
       MAXMAX = LARGEST PEAK VALUE
       MINMIN = SMALLEST VALLEY VALUE
          PVR = RANGE OF DIFFERENCES BETWEEN PEAK & VALLEY
          PVA = AVERAGE DIFFERENCE BETWEEN PEAK & VALLEY
          MMR = RANGE OF DIFFERENCES BETWEEN MAXMAX & MINMIN
          MMA = AVERAGE DIFFERENCE BETWEEN MAXMAX & MINMIN
     PEAK AVG = AVERAGE OF ALL PEAKS FOR "ON" SIGNALS
   VALLEY AVG = AVERAGE OF ALL VALLEYS FOR "ON" SIGNALS
```

Figure 23 - "ON" SIGNAL PEAK-VALLEY STATISTICS

```
      SET     BIN     PEAK     VALLEY      MAXMAX      MINMIN

        3     154    52.49     44.69         62            8
        7      81    42.96     16.57         66            8
       20     238    51.69     41.24         62           24
       21     273    57.00     49.16         72           20
       53       8    55.96     48.15         64           26
       80      60    59.84     54.30         70           18
       81      72    40.82     30.44         60           10
      126      74    21.19     16.11         30            0


  PEAK AVG    VALLEY AVG       PVR        PVA       MMR       MMA

   47.74        37.58      5.08-26.57   10.18     30-58     46.50


 KEY:     PEAK = AVERAGE OF ALL MAX PTS IN EACH BIN (SIGNAL)
        VALLEY = AVERAGE OF ALL MIN PTS IN EACH BIN (SIGNAL)
        MAXMAX = LARGEST PEAK VALUE
        MINMIN = SMALLEST VALLEY VALUE
           PVR = RANGE OF DIFFERENCES BETWEEN PEAK & VALLEY
           PVA = AVERAGE DIFFERENCE BETWEEN PEAK & VALLEY
           MMR = RANGE OF DIFFERENCES BETWEEN MAXMAX & MINMIN
           MMA = AVERAGE DIFFERENCE BETWEEN MAXMAX & MINMIN
      PEAK AVG = AVERAGE OF ALL PEAKS FOR "ON/OFF" SIGNALS
    VALLEY AVG = AVERAGE OF ALL VALLEYS FOR "ON/OFF" SIGNALS
```

Figure 24 - "ON/OFF" SIGNAL PEAK-VALLEY STATISTICS

```
        SET     BIN     PEAK      VALLEY      MAXMAX      MINMIN

          3     169    19.19       13.57          46           8
          7      91    11.33        8.05          26           8
         20     259    13.76        8.36          26           4
         21     187    47.97       41.14          56          20
         53      50    28.26       22.69          38          16
         80      73    18.42       12.65          24          10
         81      11    25.02       17.77          54          10
        126       8    14.69       10.64          36           0


PEAK AVG    VALLEY AVG        PVR        PVA       MMR        MMA

 22.33          16.88      3.28-7.25    5.47     14-44      28.75


KEY:      PEAK = AVERAGE OF ALL MAX PTS IN EACH BIN (SIGNAL)
        VALLEY = AVERAGE OF ALL MIN PTS IN EACH BIN (SIGNAL)
        MAXMAX = LARGEST PEAK VALUE
        MINMIN = SMALLEST VALLEY VALUE
           PVR = RANGE OF DIFFERENCES BETWEEN PEAK & VALLEY
           PVA = AVERAGE DIFFERENCE BETWEEN PEAK & VALLEY
           MMR = RANGE OF DIFFERENCES BETWEEN MAXMAX & MINMIN
           MMA = AVERAGE DIFFERENCE BETWEEN MAXMAX & MINMIN
      PEAK AVG = AVERAGE OF ALL PEAKS FOR "OFF" SIGNALS
    VALLEY AVG = AVERAGE OF ALL VALLEYS FOR "OFF" SIGNALS
```

Figure 25 - "OFF" SIGNAL PEAK-VALLEY STATISTICS

SET	BIN	DB	NUM	ADJ	N1	N2	N3	N1-1	N1-2	N1-3	N1-4
3	136	4	1233	1226	94	4	1	50	20	10	7
		6	636	649	87	5	4	44	18	9	7
		12	123	135	67	5	6				
		18	25	27	56	4	4				
7	8	4	1417	1406	95	4	1	48	24	9	7
		6	515	539	81	9	4	34	19	10	7
		12	29	15	52	7	3				
		18	5	5	60	0	0				
20	265	4	1496	1519	95	4	1	55	20	10	5
		6	844	887	88	6	3	45	21	10	5
		12	181	180	67	7	9				
		18	0	0	0	0	0				
21	150	4	1442	1433	96	3	1	54	21	10	5
		6	916	938	93	3	2	51	21	9	7
		12	175	222	36	3	1				
		18	19	27	47	0	0				
53	19	4	329	208	68	12	8	13	21	5	5
		6	192	113	56	15	7	6	21	3	2
		12	61	30	28	11	13				
		18	14	2	7	7	29				
80	82	4	898	929	88	8	3	45	20	9	6
		6	353	324	73	13	4	37	14	6	6
		12	44	34	43	14	7				
		18	6	7	50	0	0				
81	4	4	1932	1932	98	2	0	62	20	9	3
		6	1350	1340	94	5	1	48	22	11	6
		12	281	329	68	10	11				
		18	52	56	50	10	13				
126	57	4	334	61	58	19	12	9	12	10	7
		6	178	14	43	24	9	3	9	5	8
		12	59	2	27	15	5				
		18	19	2	11	11	11				

KEY: DB = DB CHANGE TESTED
NUM = NUMBER OF LONG-TERM CHANGES
ADJ = NUMBER OF SHORT-TERM (ADJACENT POINT) CHANGES
N_ = PERCENTAGE OF LONG-TERM CHANGES IN TIME BIN N__

Figure 26 - "ON" SIGNAL ELAPSED TIME STATISTICS

SET	BIN	DB	NUM	ADJ	N1	N2	N3	N1-1	N1-2	N1-3	N1-4
3	154	4	2101	2130	100	0	0	60	24	9	5
		6	1325	1357	95	5	0	41	22	12	10
		12	252	215	65	15	4				
		18	21	34	48	5	0				
7	81	4	2012	1984	100	0	0	62	19	4	11
		6	1675	1653	99	1	0	52	21	4	16
		12	1225	1214	96	3	0				
		18	1150	1147	96	3	0				
20	238	4	2162	2188	100	0	0	56	28	12	2
		6	1513	1480	97	2	0	39	25	23	5
		12	324	291	59	20	10				
		18	36	27	36	3	8				
21	273	4	1573	1482	97	3	0	49	24	11	7
		6	939	873	87	9	3	37	21	11	8
		12	322	254	75	9	5				
		18	131	115	84	6	5				
53	8	4	1515	1526	96	3	1	53	22	11	5
		6	1059	1113	93	4	2	50	21	12	4
		12	283	374	80	5	4				
		18	60	80	53	3	2				
80	60	4	1430	1434	95	4	1	44	30	11	4
		6	660	818	85	9	2	36	27	7	5
		12	15	25	20	7	0				
		18	4	1	25	0	0				
81	72	4	2312	2322	100	0	0	67	20	7	3
		6	1647	1645	97	2	0	52	25	10	5
		12	615	553	82	9	4				
		18	216	209	70	12	6				
126	74	4	1277	1245	94	5	1	49	20	10	6
		6	577	592	81	11	4	38	15	7	9
		12	80	69	49	20	9				
		18	16	8	31	13	0				

KEY: DB = DB CHANGE TESTED
NUM = NUMBER OF LONG-TERM CHANGES
ADJ = NUMBER OF SHORT-TERM (ADJACENT POINT) CHANGES
N_ = PERCENTAGE OF LONG-TERM CHANGES IN TIME BIN N__

Figure 27 - "ON/OFF" SIGNAL ELAPSED TIME STATISTICS

SET	BIN	DB	NUM	ADJ	N1	N2	N3	N1-1	N1-2	N1-3	N1-4
3	169	4	1630	1609	97	3	0	51	23	11	5
		6	802	748	85	9	3	33	23	11	6
		12	42	37	55	10	12				
		18	4	4	50	0	25				
7	91	4	628	620	79	12	4	46	13	7	5
		6	146	146	66	8	5	38	15	2	5
		12	2	2	50	0	0				
		18	2	2	50	0	0				
20	259	4	1593	1594	97	3	0	51	21	11	6
		6	763	716	82	12	4	33	19	13	6
		12	26	21	38	15	15				
		18	0	0	0	0	0				
21	187	4	1651	1659	96	3	1	57	19	10	5
		6	1008	1009	88	9	2	45	19	10	7
		12	226	208	58	14	8				
		18	20	38	45	10	10				
53	50	4	1690	1679	98	2	0	52	22	10	6
		6	827	818	86	8	4	35	23	10	7
		12	56	21	41	16	9				
		18	2	0	0	0	0				
80	73	4	1785	1792	98	2	0	54	23	10	6
		6	863	883	85	10	3	34	22	11	8
		12	0	0	0	0	0				
		18	0	0	0	0	0				
81	11	4	2077	2089	99	1	0	63	20	9	5
		6	1267	1246	93	6	1	45	20	11	7
		12	156	180	58	12	8				
		18	19	15	47	11	5				
126	8	4	934	912	87	10	3	38	20	10	6
		6	313	249	60	15	11	20	12	7	5
		12	28	5	11	14	11				
		18	2	2	50	0	0				

KEY: DB = DB CHANGE TESTED

NUM = NUMBER OF LONG-TERM CHANGES

ADJ = NUMBER OF SHORT-TERM (ADJACENT POINT) CHANGES

N_ = PERCENTAGE OF LONG-TERM CHANGES IN TIME BIN N__

Figure 28 - "OFF" SIGNAL ELAPSED TIME STATISTICS

"ON" SIGNAL STATISTICS

DB	NUM RANGE	NUM AVG	ADJ RANGE	ADJ AVG
4	329-1932	1135	61-1932	1089
6	178-1350	623	14-1340	600
12	29- 281	119	2- 329	118
18	0- 52	18	0- 56	16

"ON/OFF" SIGNAL STATISTICS

DB	NUM RANGE	NUM AVG	ADJ RANGE	ADJ AVG
4	1277-2312	1798	1245-2322	1789
6	577-1675	1174	592-1653	1192
12	15-1225	390	25-1214	374
18	4-1150	204	1-1147	202

"OFF" SIGNAL STATISTICS

DB	NUM RANGE	NUM AVG	ADJ RANGE	ADJ AVG
4	628-2077	1498	620-2089	1494
6	146-1267	749	146-1246	726
12	0- 226	64	0- 208	64
18	0- 20	6	0- 38	8

Figure 29 - OVER-ALL dB VS. CHANGE DATA

comparison level and a general means of distinguishing between the three types of signals. Although there are definite differences between the average figures for the various dB levels and some differences in the ranges of values, the overlap encountered in the ranges makes signal differentiation by this means risky. In short, what distinguished the "ON" from the "ON/OFF" and "OFF" signals was thoroughly subjective and only loosely corroborated by the statistics generated.

Additional information can be retreived from Figs. 26 - 28 which provide the number of changes (both long- and short-term) found when the decibel differential was "walked" from 4 to 18 dB and the percentage of long-term changes which fell into the most meaningful of the thirty-seven histogram bins (for elapsed times between long-term changes). As is clearly shown, the number of changes, NUM and ADJ, decreased as the dB level increased while the percentage figures in columns N1 and N1-1 evidenced a movement away from the first elapsed time bin. Both of these characteristics imply that the average time between signal level changes at the various dB settings increases as the number of dB increase. To be specific, by taking the data from Fig. 30 it could be calculated that the average time elapsed between 4 and 6 dB fluctuatuions for the three signal types were:

Signal Type	4 dB	6 dB
ON	.195 sec	.362 sec
ON/OFF	.083 sec	.132 sec
OFF	.110 sec	.229 sec

SET	BIN	NDB	MEAN	ALPHA	CHISQ	DF	VARIANCE
3	136	4	0.116	-	-	-	-
3	136	6	0.226	-	-	-	-
3	154	4	0.067	-	-	-	-
3	154	6	0.108	0.93	1.43	1	0.012
3	169	4	0.088	0.87	0.004	1	0.009
3	169	6	0.179	0.34	9.18	5	0.094
7	8	4	0.102	-	-	-	-
7	8	6	0.279	0.18	5.88	5	0.432
7	81	4	0.072	-	-	-	-
7	81	6	0.106	-	-	-	-
7	91	4	0.229	0.34	3.26	5	0.154
7	91	6	0.985	0.18	2.73	5	5.390
20	265	4	0.096	-	-	-	-
20	265	6	0.171	0.16	8.35	5	0.183
20	238	4	0.067	-	-	-	-
20	238	6	0.095	-	-	-	-
20	259	4	0.090	0.94	0.34	1	0.009
20	259	6	0.189	0.50	4.00	5	0.071
21	150	4	0.100	-	-	-	-
21	150	6	0.157	0.045	7.36	5	0.548
21	273	4	0.091	0.85	1.52	1	0.010
21	273	6	0.153	0.49	4.21	5	0.048
21	187	4	0.087	-	-	-	-
21	187	6	0.143	0.44	2.33	5	0.046
53	19	4	0.436	-	-	-	-
53	19	6	0.748	-	-	-	-
53	8	4	0.095	-	-	-	-
53	8	6	0.136	0.065	13.70	5	0.284
53	50	4	0.085	1.05	0.18	1	0.007
53	50	6	0.174	0.28	9.32	5	0.108
80	82	4	0.162	0.18	10.65	5	0.146
80	82	6	0.411	-	-	-	-
80	60	4	0.101	-	-	-	-
80	60	6	0.218	0.18	14.58	5	0.264
80	73	4	0.081	1.05	0.60	1	0.006
80	73	6	0.166	-	-	-	-
81	4	4	0.074	-	-	-	-
81	4	6	0.106	-	-	-	-
81	72	4	0.062	-	-	-	-
81	72	6	0.087	-	-	-	-
81	11	4	0.069	-	-	-	-
81	11	6	0.113	0.76	2.70	5	0.017
126	57	4	0.424	0.72	1.16	5	0.250
126	57	6	0.795	0.62	8.50	5	1.019
126	74	4	0.111	-	-	-	-
126	74	6	0.245	0.28	10.38	5	0.214
126	8	4	0.152	-	-	-	-
126	8	6	0.452	0.51	2.68	5	0.400

KEY:
NDB = MIN/MAX AMPLITUDE CHANGE VARIABLE
ALPHA = VALUE OF ALPHA AT MIN CHI SQUARED
CHISQ = MINIMUM CHI-SQUARED VALUE
DF = DEGREE OF FREEDOM FOR CHISQ

Figure 30 - CURVE-FITTING DATA

This data confirms that the "ON/OFF" signals fluctuated more rapidly than the other two categories while the "ON" signals proved to be more stable than the "OFF".

These results imply that, if the agency that operates the swept-tuned receiving system used to acquire and record the BRIGHAM data desires to acquire FSK-type signals (roughly, the "ON" variety), it could get away with changing the sensitivity adjustments much less frequently than if Morse-type signals (roughly, the "ON/OFF" variety) were desired. This, plus the rough data provided in Fig. 28, could provide a good data base from which a dial controlling algorithm could be adjusted to meet the needs of the signal types of interest at any time.

As was mentioned above, MIN/MAX 2 provided for the calculation of the mean and standard deviation of the elapsed times tabulated for each of forty-eight signals (the twenty-four signals of interest at both 4 and 6 dB comparison levels). Although the mean values were accurate the standard deviation values were not since the formula used in their calculation is valid for only normal (or Gaussian) distributions. Since the elapsed time histograms were apparently exponential in nature, another form of variance determination was required. This effort called for a curve-fitting technique to identify the histograms as being of a particular distribution type, use of the chi-squared test for goodness-of-fit and manipulation of the chosen distribution's mean and variance formulas to derive the information desired. Attempts were made to fit three distribution functions to the histograms (Gamma, Poisson and Geometric) with the Gamma function proving to be the most successful. The Gamma distribution function, with parameters α, β, $0<\alpha<\infty$, $0<\beta<\infty$ is defined as follows:

$$f(x) = \begin{cases} (\Gamma(\alpha)\beta^{\alpha})^{-1} x^{\alpha-1} e^{-x/\beta}, & x>0 \\ 0, & x<0 \end{cases}$$

Where, Mean $= \alpha\beta$, Variance $= \alpha\beta^2$.

An algorithm was written which read in the observed histogram frequencies, calculated the expected Gamma frequencies (using an International Mathematical Subroutine Library subroutine called MDGAM) and calculated the chi-squared value (essentially, the sum of the least squared differences between the observed and expected frequencies) for use in the goodness-of-fit test. The chi-squared value was then compared with the appropriate value found in the chi-squared distribution table (appropriate as to degrees of freedom and significance level); if it fell below that table entry, the fit was considered good, if not the fit was bad. As discussed in Refs. 7 and 8, a good rule of thumb is that the smaller the chi-squared value for a given number of degrees of freedom, the better the fit. As a word of caution, even an excellent fit (extremely small chi-squared value) does not guarantee that the distribution is really the one being tested, it merely states that the data do not present sufficient evidence to contradict the hypothesis that the histograms possess Gamma distributions.

For the curve-fitting at hand, knowledge of the mean and an iterative variation in α permitted an iterative calculation of β thus providing all of the necessary information for the algorithm discussed above. The process was refined until the smallest chi-squared value could be identified. It should be noted that only the N1 through N15 time bins were used since very few elapsed times ever fell beyond five seconds and that, as the individual histogram composition dictated, either seven or three bins were actually used in the algorithm (following a suggestion that bins containing five or fewer counts be combined to enhance the accuracy of the test). The bin limits implied that the degrees of freedom used were five or one respectively.

Of the forty-eight histograms to be fitted, six had counts in too few bins to be useful (would have implied zero degrees of freedom - not found in the table), eighteen were bad fits and the remaining twenty-four provided good fits to the Gamma distribution. Figure 30 gives the results of the curve-fitting effort. Knowledge of α and the mean implies knowledge of β which, in turn, implies (by definition) knowledge of the variance. A combination of the mean and variance values should be useful in the determination of how often the sensitivity dials on the receiving system should be adjusted for the desired signals to be acquired.

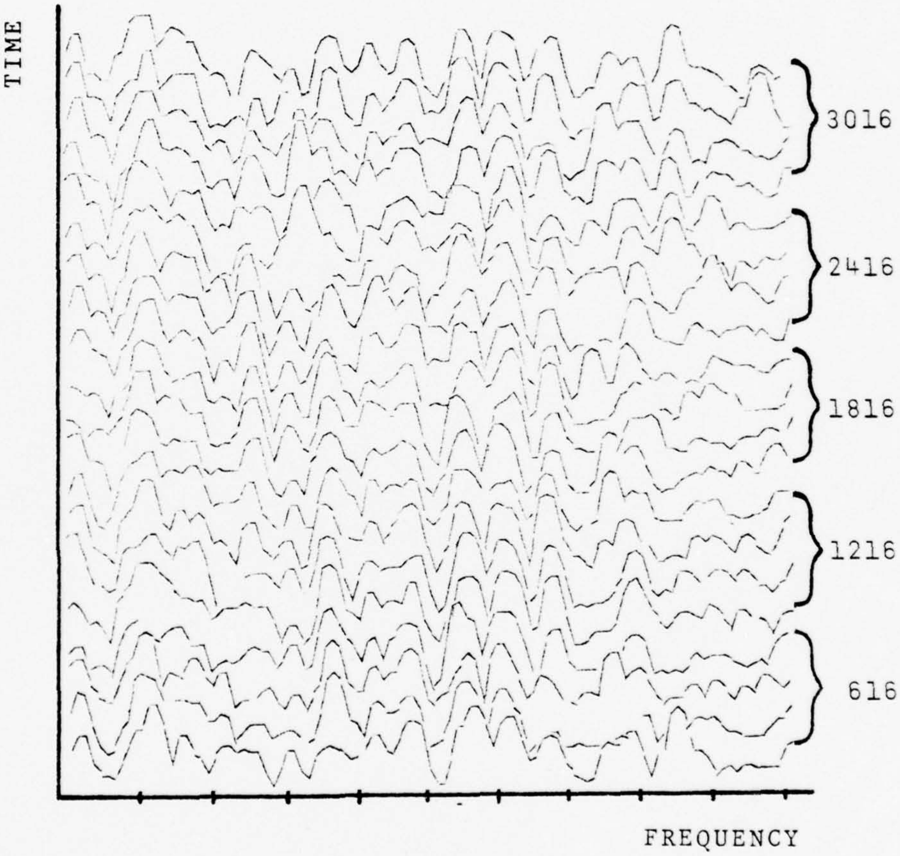
Figure 31 provides a breakdown of the α values vs. signal type and amplitude change variable for the twenty-four histograms which "fit" the Gamma distribution. It was felt that this would permit the grouping of histograms with respect to some combination of the three categories above. The six ranges shown in the figure imply that any grouping by α alone would be tenuous indeed as they overlap quite heavily. The only discernable trend is the apparent lowering of the average α figure as the amplitude change variable increases from 4 to 6 dB. This would seem to contradict the defining equations for the Gamma distribution which imply that a lower α implies a more "damped-exponential" form for the distribution (when, in fact, the more damped case is found at the 4 dB change variable). However, the shape of the distribution is also a function of β which, as defined in Mean = $\alpha\beta$, tends to affect the distribution shape in a more radical fashion

```
                                 4 DB

        "ON"                   "ON/OFF"                 "OFF"

  SET/BIN    ALPHA      SET/BIN    ALPHA      SET/BIN    ALPHA

   80/82     0.18        21/273    0.85         3/169    0.87
  126/57     0.72                                7/91    0.34
                                               20/259    0.94
                                               53/50     1.05
                                               80/73     1.05


RANGE:  0.18-0.72   RANGE:  NONE         RANGE:  0.34-1.05
 MEAN:  0.45         MEAN:  0.85          MEAN:  0.85


                                 6 DB

        "ON"                   "ON/OFF"                 "OFF"

  SET/BIN    ALPHA      SET/BIN    ALPHA      SET/BIN    ALPHA

    7/8      0.18         3/154    0.93         3/169    0.34
   20/265    0.16        21/273    0.49          7/91    0.18
   21/150    0.045       53/8      0.065       20/259    0.50
  126/57     0.62        80/60     0.18        21/187    0.44
                        126/74     0.28        53/50     0.28
                                               81/11     0.76
                                              126/8      0.51


RANGE:  0.045-0.62  RANGE:  0.065-0.93   RANGE:  0.18-0.76
 MEAN:  0.25         MEAN:  0.39          MEAN:  0.43
```

Figure 31 - SIGNAL TYPE VS. ALPHA TABLE

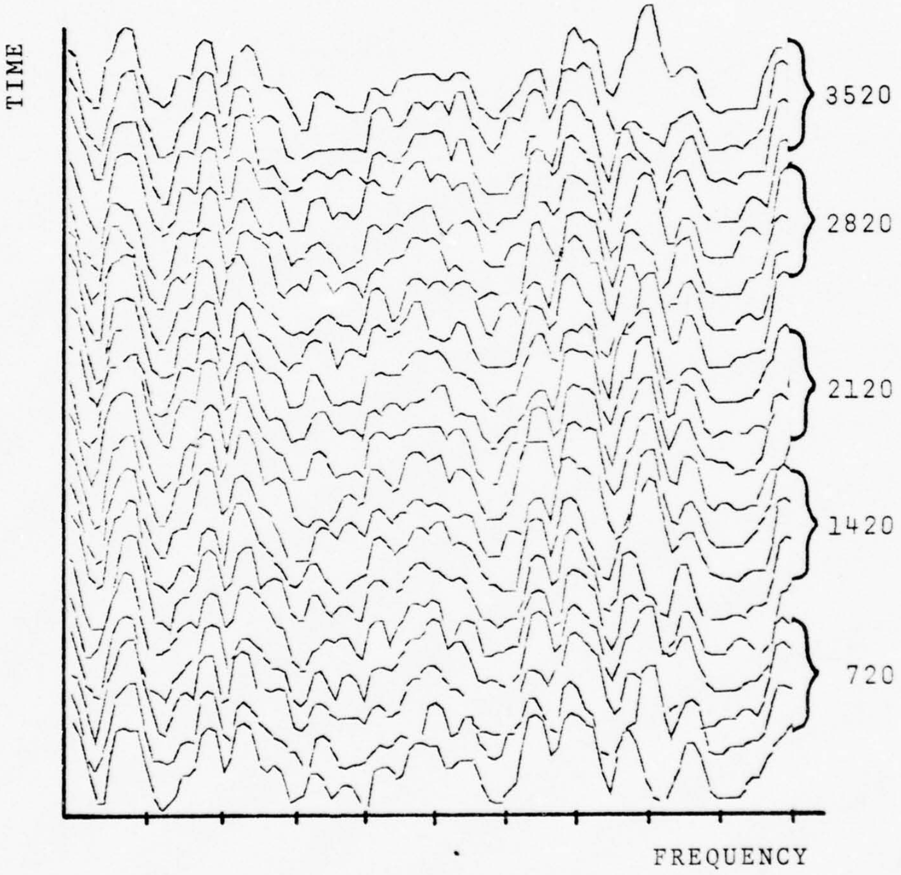
than does α. In fact, as the change variable increases, the mean increases (see Fig. 30) and α seems to decrease (see Fig. 31) implying a very pronounced increase in β which, in the defining equations, is found to be most prominent in the exponential term; but, this implies a distribution shape less heavily dampled in the lower (4 dB) change variable level. This trend of decreasing values, then, was to be expected and appears to be the only meaningful product of the analysis of the Fig. 31 data.

As an aside on the subject of signal continuity during the brief recorded time span of the waveforms (around 2.4 minutes), it should be noted that data set number 7 bins 81 ("ON/OFF") and 91 ("OFF") exhibited very unusual characteristics when compared with the other signals in their classes. As shown on Fig. 27, bin 81 still had over 1000 changes at 18 dB difference while the other "ON/OFF" signals had fallen off to much smaller numbers. In fact, that bin had two changes at 54 dB when ever-increasing numbers were applied. The "OFF" signal, bin 91, evidenced a similar degree of consistency as it had many fewer 4 dB changes than the other "OFF" signals while falling off much more quickly as the number of decibels increased (see Fig. 28). In fact, this signal had only a few more than 1700 2 dB changes implying exceptional amplitude continuity when compared with any of the twenty-three other signals analyzed. To give a more graphic representation of this phenomenon, Figs. 32 and 33 compare the long-term signal changes found in data sets 3 and 7 with the latter proving to be the more consistent of the two, although even set 3 has a good measure of uniformity throughout its 3600 scans. The base scans for each of the five scan sets (which show the beginning, middle and end of each data set - time-wise) are provided at the right of the pictures.



Base Freq 3.2 MHz, Base Bin 100

Figure 32 - LONG-TERM SIGNAL CONTINUITY - SET 3



Base Freq 11 MHz, Base Bin 1

Figure 33 - LONG-TERM SIGNAL CONTINUITY - SET 7

V. COMMENTS AND RECOMMENDATIONS

Of the two signal anomaly identification techniques, Anomaly A proved to be the most fruitful. Narrow and wide wavefront discontinuities, fading, frequency shifting of entire wavefronts, frequency shifting of individual signals and several miscellaneous varieties were seen. Two of the above (discontinuities and shifting) were reported on in Ref. 1 with the rest being unique to this study. Several examples of pseudo-anomalies were included to perform the dual function of warning against the false assumption of anomalous performance simply because the plot seemed to imply it and to provide pictures with the narrative in such cases. Analysis with Anomaly B proved to be relatively unproductive as only the interesting and frequently seen phenomenon of signal amplitude undulation (reported in Ref. 1 and expanded upon herein) being noted. The diverse and amazingly complex nature of the ionosphere and its interaction with its environment precludes the precise assignment of a cause to every effect (i.e., anomaly). Suffice it to say that, except for those anomalies which can be explained away by equipment malfunction, nothing has been found in this effort which will simplify the model of the ionosphere as an ever-changing medium in which literally anything can happen to a radio signal which traverses it.

The statistical analysis work performed, from creation of the MIN/MAX algorithms to the tedious curve-fitting effort, resulted in a wealth of predominantly raw data which, with the mean and variance values, should provide a foundation upon which a receiver system sensitivity dial-controlling algorithm could be refined. It was noted in the curve-fitting section that it is perhaps the weakest link in the statistical study since the chi-squared test guarantees neither that the elapsed time histograms are Gamma distributions nor that there might exist other distributions which would "fit" the histogram data as well as the Gamma function did. However, a statistically reasonable argument can be made that the histograms (at least half of them) are probably Gamma in nature and, hence, the variance values calculated can be accepted as accurate.

Should additional work be done with the BRIGHAM data, the following remarks/recommendations could prove useful:

(1) all of the complete data sets in hand have been thoroughly analyzed with program Anomaly A - additional effort along this line might be a waste of time and energy;

(2) although nearly twenty of the data sets in hand have not been analyzed with program Anomaly B, the disappointing results thusfar might act as a warning as to expected future rewards from additional effort;

(3) if Anomaly A and/or Anomaly B are to be used again, the BAKSCN feature found in the METASYMBOL subroutine (it provides for the backing over of a specified number of files, or data sets) should be made to work as a time/labor saving device - the problem is in the magnetic tape unit, not the program;

(4) the recommendation (made initially in Ref. 1) for the creation of a computer algorithm to search out the anomalies in an automatic and, hence, more rapid manner than the visual approach is guardedly endorsed herein - although the speed at which the data sets could be analyzed would be improved by at least an order of magnitude, the extreme complexity of trying to tell the computer what to look for

as well as the loss of that very intangible but valuable human discretionary power could combine to make this effort a quagmire;

(5) should additional work be done utilizing the MIN/MAX routines, Anomaly B should be used first to enhance the accuracy in selecting the different signal types to be analyzed - that this was not done in the present study may have resulted in the rather large ranges found in the data;

(6) the accuracy of any future curve-fitting work could be enhanced by the inclusion of the Weibull and Lognormal distributions (or any of the level-crossing distributions) to the list of possible curves to which the elapsed time histograms are matched because sets of such data can be fitted to more than one distribution with equal accuracy and validity - this was not done here because the suggested distributions were complex enough and the time remaining short enough that a good effort could not have been put forth.

GLOSSARY

1. Sporadic-E: thin horizontal layer (or patch) of high electron density embedded in the regular E layer resulting in signal deflection and/or absorption.

2. Night-Day Asymmetry: Less attenuation at night than day due to difference in the ionizing effect of the sun resulting in discontinuities during the sunrise/sunset periods.

3. Geomagnetic Non-Reciprocity: different attenuation effects on signals travelling west to east rather than east to west due to the earth's magnetic field lines.

4. Polar Cap Absorption (PCA): absorption of radio signals passing the polar regions - due to a combination of solar flare activity and the shape of the earth's magnetic field lines.

5. Auroral Display: brightly colored northern latitude phenomena disruptive to communications - also as the result of a combination of solar flare activity and the earth's magnetic field lines.

6. Faraday Rotation: any linearly polarized wave travelling in the direction of a magnetic filed results in its two circularly polarized components travelling at different velocities and thus the plane of polarization will rotate with distance.

7. Ducting: if a radio wave comes into contact with a region of inhomogeneous refractive indices the wave could be trapped between two layers and guided, as in a leaky wave guide, away from its intended destination.

8. Fading (Dellinger Effect): sudden ionospheric disturbance (S. I. D.) which produces a complete radio "fade out" lasting from a few minutes to an hour or more - caused by solar flare activity.

LIST OF REFERENCES

1. Stapleton, D. V., High Frequency Propagation Anomalies M.S.EE Thesis, U. S. Naval Postgraduate School, Monterey, 1973

2. Alpert, I. L., Radio Wave Propagation and the Ionosphere, Vol. 1, p. 192 to 397, Consultants Bureau, 1974.

3. Budden, K. G., Radio Waves in the Ionosphere, p. 1 to 542, University Press, 1961.

4. Gerson, N. C., Editor, Radio Absorption in the Ionosphere, p. 1 to 29, 106 to 317, Pergamon Press, 1962.

5. Jordan, E. C. and Balmain, K. G., Electromagnetic Waves and Radiating Systems, p. 567 to 699, Prentice-Hall, Inc., 1968.

6. Ratcliffe , J. A., An Introduction to the Ionosphere and Magnetosphere, p. 1 to 131, University Press, 1972.

7. Breiman, L., Statistics: With a View Towards Applications, p. 176 to 217, Houghton Mifflin Co., 1973.

8. Freund, J. E., Modern Elementary Statistics, p. 272 to 293, Prentice-Hall, Inc., 1965.

```
C
C
C   PROGRAM TO READ ONE DATA SET (APPROX 7200 CARDS) ONTO A 9-TRACK TAPE
C   -  IN THIS CASE, THE DATA SET WILL OCCUPY LABEL (OR REGION) ONE ON
C   TAPE NPS611 WITH TAPE DENSITY 800 BPI AND EVEN PARITY.
C
C
//  EXEC  FORTCLG
//FORT.SYSIN DD *
      LOGICAL*1 INFO(160)
    5 READ(4,1,END=99) INFO
    1 FORMAT(160A1)
      WRITE(2,1) INFO
      GO TO 5
   99 ENDFILE 2
      STOP
      END
//GO.FT02F001 DD UNIT=3400-4,VOL=SER=NPS611,
// LABEL=(1,SL),DSN=FILE1,DISP=(NEW,KEEP),
// DCB=(RECFM=FB,LRECL=160,BLKSIZE=320,DEN=2)
//GO.FT04F001 DD UNIT=2540,DCB=(MODE=C,BLKSIZE=160)
```

```
C
C
C   PROGRAM TO TRANSFER DATA FROM A 9-TRACK TAPE TO A 7-TRACK TAPE   -  IN
C   THIS CASE, DATA SETS 1 THROUGH 4 FROM 9-TRACK TAPE NPS611 WILL
C   OCCUPY LABELS 1 THROUGH 4 ON 7-TRACK TAPE ROWE08 WITH TAPE DENSITY
C   556 BPI AND ODD PARITY.
C
C
//ONE   EXEC   PGM=IEBGENER
//SYSPRINT   DD   SYSOUT=A
//SYSUT1   DD   UNIT=3400-4,DISP=(OLD,KEEP),LABEL=(1,SL),
//   VOL=SER=NPS611,DSN=FILE1
//SYSUT2   DD   UNIT=2400-1,DISP=(NEW,KEEP),LABEL=(1,NL),
//   VOL=SER=ROWE08,DCB=(RECFM=FB,LRECL=160,BLKSIZE=320,DEN=1)
//SYSIN   DD   DUMMY
//TWO    EXEC   PGM=IEBGENER
//SYSPRINT   DD   SYSOUT=A
//SYSUT1   DD   UNIT=3400-4,VOL=(,RETAIN,REF=*.ONE.SYSUT1),
// DISP=(OLD,PASS),DSNAME=FILE1,LABEL=(2,SL)
//SYSUT2   DD   UNIT=2400-1,VOL=(,RETAIN,REF=*.ONE.SYSUT2),
// DISP=(NEW,PASS),DCB=*.ONE.SYSUT2,LABEL=(2,NL)
//SYSIN   DD   DUMMY
//THREE EXEC   PGM=IEBGENER
//SYSPRINT   DD   SYSOUT=A
//SYSUT1   DD   UNIT=3400-4,VOL=(,RETAIN,REF=*.ONE.SYSUT1),
// DISP=(OLD,PASS),DSNAME=FILE1,LABEL=(3,SL)
//SYSUT2   DD   UNIT=2400-1,VOL=(,RETAIN,REF=*.ONE.SYSUT2),
// DISP=(NEW,PASS),DCB=*.ONE.SYSUT2,LABEL=(3,NL)
//SYSIN   DD   DUMMY
//FOUR   EXEC   PGM=IEBGENER
//SYSPRINT   DD   SYSOUT=A
//SYSUT1   DD   UNIT=3400-4,VOL=(,RETAIN,REF=*.ONE.SYSUT1),
// DISP=(OLD,PASS),DSNAME=FILE1,LABEL=(4,SL)
//SYSUT2   DD   UNIT=2400-1,VOL=(,RETAIN,REF=*.ONE.SYSUT2),
// DISP=(NEW,PASS),DCB=*.ONE.SYSUT2,LABEL=(4,NL)
//SYSIN   DD   DUMMY
```

```
C
C
C   PROGRAM TO PRINT OUT RECORDS FROM A 9-TRACK TAPE  -  IN THIS CASE,
C   THE FIRST RECORDS FROM LABEL 1 OF TAPE NPS611 WILL BE DUMPED TO
C   PERMIT VERIFICATION OF DATA TRANSFER.
C
C
//  EXEC   TAPEOUT,PARM='0,4,,1,320'
//TAPEIN   DD  UNIT=3400-4,VOL=SER=NPS611,LABEL=(2,BLP)
```

```
C
C
C   PROGRAM TO PRINT OUT RECORDS FROM A 7-TRACK TAPE  -  IN THIS CASE,
C   THE FIRST FOUR RECORDS FROM LABEL 1 OF TAPE ROWE1 WILL BE DUMPED
C   TO PERMIT VERIFICATION OF DATA TRANSFER.
C
C
//  EXEC   TAPEOUT,PARM='0,4,,1,320'
//TAPEIN   DD  UNIT=2400-1,VOL=SER=ROWE1,LABEL=(1,BLP)
```

```
*
*
*   ANOMALY A  -  PROGRAM TO DRAW A THREE DIMENSIONAL PLOT (TIME,
*   FREQUENCY, AMPLITUDE) OF HF SIGNALS HAVING TRAVERSED THE IONOSPHERE.
*
*
      MSW(I)=LAND(ISW,LLS(1,23-I))
*   REQUIRES SENSE SW. 2 AND FOL CONTROL CARDS (LEFT JUSTIFIED TO COL 1)
*         $PATCH
*         $>>DATA
*         CC7067  00106711
*         $END
*         -AGT
*         ¬JOB ANOMALY A
*         ¬FORTRAN LS,GO
      JSW(I)=LAND(JW,LLS(1,23-I))
      JON(I)=LIOR(JW,LLS(1,23-I))
      JOFF(I)=LAND(JW,LXOR(-1,LLS(1,23-I)))
      INTEGER AXES(47),PBUF
      DIMENSION DIALS(6),IFILE(321)
      DIMENSION IGDIR(3),ITDIR(7)
      DIMENSION IBUF(80),MASK(4),ISHT(4)
      DIMENSION PBUF(2,130),IHBUF(260)
      EQUIVALENCE(PBUF,IHBUF)
      DATA (MASK(I),I=1,4),(ISHT(I),I=1,4)/37000000B,370000B,3700B,37B,1
     18,12,6,0/
      COMMON /AREA1/FILE(130,20),MOV(20,130),IMAGE(2000)
      COMMON /AREA2/IDEV,XSLNT,YSLNT,X1,Y1,DX,AXES,NMBRJMP,NRSCAN
      NAMELIST IDEV,IDIAL,SCALE,SEP,NSCAN,IWDTH,ISTRT,X1,Y1,ITAPE
      NAMELIST DIALS,NMBRJMP,NSKIP,DX,IBRANCH,IDELAY
      NAMELIST NFILE,NREC,JFILE
      DATA NFILE/0/,NREC/0/,JFILE/0/
*
*     INITIALIZATION OF PARAMETERS
*
*         IDEV:      AGT NUMBER(1 OR 2)
      IDEV=1
*         IDIAL:     DIALS SAMPLED ONLY IF IDIAL=1
*                    IF NOT SAMPLED,MUST SPECIFY VALUE OF DIALS(1)& (2)
      IDIAL=1
*         IBRANCH:   CALCULATES,SCALES DIST BETWEEN FREQ BINS IF IBRANCH=0
      IBRANCH=0
*                    IF IBRANCH.NE.0, MUST SPECIFY WIDTH(DX)
      DX=.024
*         SCALE:     DIVISOR FOR SCALING DOWN SIGNAL AMPLITUDES
      SCALE=75.
*         SEP:       SEPARATION (VERTICAL) BETWEEN SCANS
      SEP=.12
```

```
*         X1,Y1:     LOCATION OF ORIGIN ON SCREEN
      X1=-1.3
      Y1=-1.1
*         ITAPE:     TAPE NUMBER FOR DATA INPUT
      ITAPE=1
*         KTAPE:     TAPE NUMBER FOR OUTPUT OF PICTURE DATA
      KTAPE=2
*         NSCAN:     NR OF SCANS TO BE SHOWN AT ONCE
      NSCAN=20
*         IWDTH:     NR BINS (WIDTH) TO BE SHOWN AT ONCE
      IWDTH=100
*         ISTRT:     NR OF LEFTMOST BIN TO BE DISPLAYED
      ISTRT=1
*         NMBRJMP:   NR NEW SCANS BROUGHT ONTO SCREEN FOR EACH NEW PIC
      NMBRJMP=3
*         NSKIP:     NR SCANS SKIPPED(WHEN=1,DISPLAYS EVERY OTHER SCAN)
      NSKIP=0
*         IDELAY:    NUMBER OF SECONDS EXTRA DELAY BETWEEN PICTURES
      IDELAY=0
      NULL=-1
      PI=3.14159265
*
*
      OUTPUT(102) 'DATA INPUT'
      INPUT(101)
      IF(NFILE.EQ.0) GO TO 100
      CALL FORSCN(ITAPE,NFILE)
      NFILE = 0
      GO TO 100
   75 OUTPUT(102) 'DATA INPUT'
      INPUT(101)
      IF(JFILE.EQ.0) GO TO 13
      CALL BAKSCN(ITAPE,JFILE)
      JFILE=0
      GO TO 13
  100 CONTINUE
      OUTPUT(101)'BEGIN PROGRAM.PUSH SENSESWITCH(3) TO CONTINUE'
1     IF(SENSESWITCH(3)) 2,1
2     IF(SENSESWITCH(4)) 3,4
3     INPUT(5)
4     CALL DGINIT(IDEV,IGDIR,3,IER)
      IF(IER.NE.0) OUTPUT(101)IER,'DGINIT ERR'
      CALL DTINIT(IDEV,ITDIR,7,IER)
      IF(IER.NE.0) OUTPUT(101)IER,'DTINIT ERR'
      CALL TEXTO(IDEV,NULL,1,40,75,2,3,IER)
      IF(IER.NE.0)OUTPUT(101),'NRSCAN NULL ERR'
8     MSCAN=NSCAN
*
```

```
*     SAMPLE FUNCTION SWITCHES
*          JSW(3) = NAMELIST INPUT
*          JSW(4) = LOOP (HOLDS NEXT PICTURE)
*          JSW(5) = LOOP BREAKER (ADVANCE AUTOMATICALLY)
*          JSW(6) = WRITES AXIS AND SCAN DATA ON KTAPE FM CURRENT PICTURE
*          JSW(7) = WRITES END OF FILE (EOF) ON DATA OUTPUT TAPE (#2)
*          JSW(8) = REWINDS DATA TAPE
*
       CALL FNS(IDEV,ISW,IER)
       IF(IER.NE.0)OUTPUT(101)IER,'FNS ERR'
       JW=LXOR(JW,ISW)
*
*     FOL ROUTINE(TO 11) WRITES JSW NRS(3 OR 4) ON SCREEN WHEN ACTIVE
*
       LB=1
       DO 10 I=3,4
       IF(JSW(I).EQ.0)GO TO 10
       ENCODE(4,9,ITXT)I
9      FORMAT(I1)
       CALL TEXTO(IDEV,ITXT,1,LB,1,1,3,IER)
       IF(IER.NE.0)OUTPUT(101)IER,'JSW'
       LB=LB+1
10     CONTINUE
       DO 11 I=LB,2
       CALL TEXTO(IDEV,NULL,1,I,1,1,3,IER)
11     IF(IER.NE.0)OUTPUT(101)IER,'JSW NULL'
       IF(JSW(3).EQ.0)GO TO 12
       IBLK=4
       CALL GINPUT(IDEV,ITDIR,IBLK)
*
*     GINPUT WITH GINP ALLOWS NAMELIST INPUT AT ACT
*
       JW=JOFF(3)
12     IF(JSW(4).EQ.0)GO TO 17
13     CALL FNS(IDEV,ISW,IER)
       IF(IER.NE.0)OUTPUT(101)IER,'FNS1 ERR'
       JW=LXOR(JW,ISW)
       IF(JSW(5).NE.0)JW=JOFF(4);JW=JOFF(5);GO TO 17
15     IF(JSW(6).NE.0)GO TO 95
       GO TO 13
17     IF(JSW(7).NE.0)ENDFILE KTAPE;JW=JOFF(7)
       IF(JSW(8).NE.0)REWIND 1;JW=JOFF(8)
*
*     SAMPLE CONTROL DIALS
*
*          DIAL(1) = ANGLE OF Z AXIS
*          DIAL(2) = CURSOR POSITION
*
```

```
30     IF(IDIAL.NE.1)GO TO 35
       CALL VCD(1,DIALS,IER)
       IF(IER.NE.0)OUTPUT(101)IER,'DIALS'
*
*     EVALUATE DISPLAY PARAMETERS
*
35     CONTINUE
       IF(IDELAY.EQ.0)GO TO 36
       IA=IDELAY*100000
       CALL DELAY
36     ISTOP=ISTRT+IWDTH-1
       WIDTH=IWDTH
       NALFA=NMBRJMP+1
       IF(IBRANCH.EQ.1)GO TO 40
       DX=2.4/WIDTH
40     IANGL=90*DIALS(1)
       ANGL=IANGL*PI/180
       Z=(NSCAN-1)*SEP
       ZX=Z*SIN(ANGL)
       ZY=Z*COS(ANGL)
       XSLNT=SEP*SIN(ANGL)
       YSLNT=SEP*COS(ANGL)
*
*     FORMAT AND PACK AXIS DATA INTO AXES ARRAY
*
       AXES(1)=IHEAD(0,5)
*
*     Y AXIS
*
       AXES(2)=IPACK(X1,Y1+Z,0)
       AXES(3)=IPACK(X1,Y1,1)
*
*     X AXIS
*
       AXES(4)=IPACK(X1+2.45,Y1,1)
       AXES(5)=IPACK(X1,Y1,0)
*
*     Z AXIS
*
       AXES(6)=IPACK((X1+ZX),(Y1+ZY),1)
*
*     X AXIS SCALE MARKS
       DO 45 I=2,26,2
       II=I+5
       IF(I*5.GT.IWDTH)AXES(II)=AXES(II+1)=0;GO TO 45
       AXES(II)=IPACK(X1+I*5*DX,Y1-.03,0)
       AXES(II+1)=IPACK(X1+I*5*DX,Y1+.02,1)
45     CONTINUE
```

```
*
*    Y AXIS SCALE MARKS
*
      DO 46 I=2,12,2
      II=I+31
      AXES(II)=IPACK(X1-.02,Y1+(2.5/SCALE)*I,0)
      AXES(II+1)=IPACK(X1+.01,Y1+(2.5/SCALE)*I,1)
46    CONTINUE
*
*    CURSOR
*
      AXES(47)=0
      DO 50 I=1,NSCAN
50    MOV(I,1)=0
*
*     BRING IN NEW SCANS, MOVE OFF OLD SCANS
*
      DO 60 I=NSCAN,NALFA,-1
      DO 60 J=1,IWDTH
      MOV(I,J)=MOV((I-NMBRJMP),J)
60    FILE(J,I)=FILE(J,(I-NMBRJMP))
      IF(NSCAN.GE.MSCAN)GO TO 65
*
*     ZERO OUT THAT PORTION OF *FILE* NOT BEING USED
*
      DO 61 I=NSCAN+1,MSCAN
      DO 61 J=ISTRT,ISTOP
61    FILE(J,I)=0
*
*     READ DATA FROM TAPE
*
65    DO 72 N=1,NMBRJMP
      IF(NSKIP.EQ.0)GO TO 67
      DO 66 J=1,NSKIP
   67 CALL BUFFERIN(ITAPE,1,IBUF,80,IND)
   20 IF(IND.EQ.1) GO TO 20
      NR=NR+1
      GO TO (20,66,90,66),IND
   66 CONTINUE
      DO 29 K=0,1
      M=K*160
      DO 25 I=1,40
      DO 23 J=1,4
   23 IFILE(M+J+I)=LRS(LAND(IBUF(K*40+I),MASK(J)),ISHT(J))
   25 M=M+4
   29 CONTINUE
      IFILE(1)=NR
71    DO 72 I=ISTRT,ISTOP
```

```
      FILE((I-ISTRT+1),(NALFA-N))=IFILE(I+1)/SCALE
*
*    NRSCAN=SCAN NR TO BE DISPLAYED ON SCREEN
*
72    NRSCAN=IFILE(1)
      CALL REMOVAL(NSCAN,IWDTH)
      CALL DISPLAY(NSCAN,IWDTH)
      GO TO 8
90    OUTPUT(101),'END OF DATA TAPE'
*
      NR=0
      GO TO 75
*
*   PACKS GRAPHICS DATA INTO PROPER FORMAT FOR OUTPUT DATA TAPE..
*
   95 CALL HEADER (KTAPE,IWDTH,NSCAN)
      CALL GRAPHI(IDEV,IMAGE,2,IER)
      IF(IER.NE.0)OUTPUT(101),'GIER'
      DO 98 I=1,NSCAN
      DO 97 J=1,IWDTH
      INDX=(I-1)*IWDTH+J
      CALL UNPACK(IMAGE(INDX),PBUF(1,J),PBUF(2,J),NC)
   97 PBUF(2,J)=LIOR(LAND(PBUF(2,J),77777776B),NC)
      CALL BUFFEROU(KTAPE,1,PBUF,2*IWDTH,IND)
   96 IF(IND.EQ.1) GO TO 96
   98 CONTINUE
      JW=JOFF(6)
      GO TO 13
      END
```

```
      SUBROUTINE REMOVAL(NSCAN,IWDTH)
      INTEGER AXES(47)
      COMMON /AREA1/FILE(130,20),MOV(20,130),IMAGE(2000)
      COMMON /AREA2/IDEV,XSLNT,YSLNT,X1,Y1,DX,AXES,NMBRJMP,NRSCAN
*
*  THIS SUBROUTINE ERASES LINE SEGMENTS HIDDEN BEHIND OTHER LINES
*
      LAST=0
105   NR=NSCAN
      DO 110 I=1,NR
      DO 110 J=2,IWDTH
110   MOV(I,J)=1
130   DO 140 K=NR,2,-1
      DO 140 L=K-1,K-4,-1
      IF(L.LT.1)GO TO 140
      LL=K-L
      HEIGHT=LL*YSLNT
      DO 140 J=1,IWDTH
      IF(MOV(K,J).EQ.0)GO TO 140
      INDX=J+LL*(XSLNT/DX+0.4)
      IF(INDX.GT.IWDTH)GO TO 140
      TEST=FILE(J,K)+HEIGHT
      REF=FILE(INDX,L)
      IF(REF.LT.TEST)GO TO 138
      MOV(K,J)=LAST=0
137   IF(REF-TEST.LT.FILE(J-1,K)-FILE(INDX-1,L))MOV(K,J)=1;GO TO 139
      GO TO 140
138   IF(LAST.NE.0)GO TO 140
      IF(FILE(J,K)-FILE(J-1,K).GT.TEST-REF)MOV(K,J)=LAST=0;GO TO 140
139   LAST=1
140   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE DISPLAY(NSCAN,IWDTH)
      INTEGER AXES(47)
      COMMON /AREA1/FILE(130,20),MCV(20,130),IMAGE(2000)
      COMMON /AREA2/IDEV,XSLNT,YSLNT,X1,Y1,DX,AXES,NMBRJMP,NRSCAN
*
*  THIS SUBROUTINE PACKS DATA INTO PROPER FORMAT FOR GRAPHICS UNIT
*
200   N=1
      IMAGE(1)=IHEAD(0,10)
      DO 210 I=1,NSCAN
      X=X1+XSLNT*(I-1)
      Y=Y1+YSLNT*(I-1)
      DO 210 J=1,IWDTH
      N=N+1
      M=MCV(I,J)
      EX=X+DX*(J-1)
      WYE=Y+FILE(J,I)
      IF(EX.GT.1.3)M=0
210   IMAGE(N)=IPACK(EX,WYE,M)
      DO 211 I=N+1,2000
211   IMAGE(I)=0
      CALL GRAPHC(IDEV,AXES,47,1,IER)
      IF(IER.NE.0)OUTPUT(101)IER,'AXES ERR'
      CALL GRAPHC(IDEV,IMAGE,2000,2,IER)
      IF(IER.NE.0)OUTPUT(101),'IMAGERR'
      ENCODE(4,220,JTXT)NRSCAN
220   FORMAT(I4)
      CALL TEXTO(IDEV,JTXT,1,40,75,2,3,IER)
      IF(IER.NE.0)OUTPUT(101)IER,'NRSCAN ERR'
      RETURN
      END
```

```
      SUBROUTINE HEADER (KTAPE,IWDTH,NSCAN)
      INTEGER PBUF
      DIMENSION PBUF(2,130),IHBUF(260)
      EQUIVALENCE(PBUF,IHBUF)
*
* THIS SUBROUTINE PACKS THE DATA FOR PROPER PLOT FORMAT FOR USE ON THE
* PDP-11 PLOTTER.
*
      DO 10 I=1,2
      DO 10 J=1,IWDTH
   10 PBUF(I,J)=0
      IHBUF(1)=IWDTH
      IHBUF(2)=NSCAN
      CALL BUFFEROU(KTAPE,1,IHBUF,2*IWDTH,IND)
   20 IF(IND.EQ.1) GO TO 20
      RETURN
      END
```

```
*
*
*   ANOMALY B  -  PROGRAM TO DRAW A SERIES OF FIVE SCANS (ANOMALY A STYLE)
*   AND FIVE PRESELECTED BINS PRESENTED AS TIME VS. AMPLITUDE TRACES
*   DIRECTLY ABOVE.
*
*
*   REQUIRES SENSE SW. 2 AND FOL CONTROL CARDS (LEFT JUSTIFIED TO COL 1)
*         $PATCH
*         $>>DATA
*         CC7C67  00106711
*         $END
*         -AGT
*         ¬JOB ANOMALY B
*         -FORTRAN LS,GO
      MSW(I)=LAND(ISW,LLS(1,23-I))
      JSW(I)=LAND(JW,LLS(1,23-I))
      JON(I)=LIOR(JW,LLS(1,23-I))
      JOFF(I)=LAND(JW,LXOR(-1,LLS(1,23-I)))
      INTEGER PBUF
      INTEGER AXES(113)
      DIMENSION DIALS(6),IFILE(321),AVECTR(405)
      DIMENSION IGDIR(4),ITDIR(7)
      DIMENSION IBUF(80),MASK(4),ISHT(4)
      DIMENSION PBUF(2,130),IHBUF(260)
      EQUIVALENCE(PBUF,IHBUF)
      DATA (MASK(I),I=1,4),(ISHT(I),I=1,4)/37000000B,370000B,3700B,37B,1
     18,12,6,0/
      COMMON /AREA1/FILE(318,5),MOV(5,318),IMAGE(1591),AMPHIST(5,81)
      COMMON /AREA2/IDEV,XSLNT,YSLNT,X1,Y1,Y2,DX,AXES,NMBRJMP,NRSCAN
      COMMON /AREA3/JMAGE(406),SCALE2,IBIN1,IBIN2,IBIN3,IBIN4,IBIN5
      EQUIVALENCE (AMPHIST(1,1),AVECTR(1))
      NAMELIST IDEV,IDIAL,SCALE,SEP,NSCAN,IWDTH,ISTRT,X1,Y1,ITAPE,Y2
      NAMELIST DIALS,NMBRJMP,NSKIP,IDELAY,DX,IBRANCH
      NAMELIST IBIN1,IBIN2,IBIN3,IBIN4,IBIN5,SCALE2
      NAMELIST NFILE
      DATA NFILE/0/
*
*     INITIALIZATION OF PARAMETERS
*
*         IDEV:       AGT NUMBER(1 OR 2)
      IDEV=1
*         IDIAL:      DIALS SAMPLED ONLY IF IDIAL=1
*                     IF NOT SAMPLED,MUST SPECIFY VALUE OF DIALS(1)& (2)
      IDIAL=1
*         IBRANCH:    CALCULATES,SCALES DIST BETWEEN FREQ BINS IF IBRANCH=0
      IBRANCH=0
*                     IF IBRANCH.NE.0, MUST SPECIFY WIDTH(DX)
```

```
      DX=.024
*         SCALE:     DIVISOR FOR SCALING DOWN SIGNAL AMPLITUDES
      SCALE=125.
*         SCALE2:    DIVISOR FOR SCALING DOWN AMPHIST TRACES SEPARATELY
      SCALE2=120.0
*         SEP:       SEPARATION (VERTICAL) BETWEEN SCANS
      SEP=.11
*         X1,Y1,Y2:  LOCATION OF ORIGIN ON SCREEN
      X1=-1.3
      Y1=-1.1
      Y2=1.1
*         ITAPE:     TAPE NUMBER FOR DATA INPUT
      ITAPE=1
*         KTAPE:     TAPE NUMBER FOR OUTPUT OF PICTURE DATA
      KTAPE=2
*         NSCAN:     NR OF SCANS TO BE SHOWN AT ONCE
      NSCAN=5
*         IWDTH:     NR BINS (WIDTH) TO BE SHOWN AT ONCE
      IWDTH=318
*         ISTRT:     NR OF LEFTMOST BIN TO BE DISPLAYED
      ISTRT=1
*         NMBRJMP:   NR NEW SCANS BROUGHT ONTO SCREEN FOR EACH NEW PIC
      NMBRJMP=3
*         NSKIP:     NR SCANS SKIPPED(WHEN=1,DISPLAYS EVERY OTHER SCAN)
      NSKIP=0
*         IDELAY:    NUMBER OF SECONDS EXTRA DELAY BETWEEN PICTURES
      IDELAY=0
*         IBIN:      BIN NR OF SIGNAL TO BE VIEWED IN AMPHIST TRACES
      IBIN1=2
      IBIN5=IBIN4=IBIN3=IBIN2=IBIN1
      NULL=-1
*         AVFCTR:    AVERAGING FACTOR,USED TO CALC AMPHIST WHEN NSKIP.GT.1
      AVFCTR6=AVFCTR7=AVFCTR8=AVFCTR9=AVFCT10=0.0
      PI=3.14159265
*
*
      OUTPUT(102) 'DATA INPUT'
      INPUT(101)
      IF(NFILE.EQ.0) GO TO 102
      CALL FORSCN(ITAPE,NFILE)
      NFILE=0
  102 CONTINUE
      OUTPUT(101)'BEGIN PROGRAM.PUSH SENSESWITCH(3) TO CONTINUE'
1     IF(SENSESWITCH(3)) 2,1
2     IF(SENSESWITCH(4)) 3,4
3     INPUT(5)
4     CALL DGINIT(IDEV,IGDIR,3,IER)
      IF(IER.NE.0) OUTPUT(101)IER,'DGINIT ERR'
```

```
          CALL DTINIT(IDEV,ITDIR,7,IER)
          IF(IER.NE.0) OUTPUT(101)IER,'DTINIT ERR'
          CALL TEXTO(IDEV,NULL,1,40,75,2,3,IER)
          IF(IER.NE.0)OUTPUT(101),'NRSCAN NULL ERR'
8         MSCAN=NSCAN
*
*       SAMPLE FUNCTION SWITCHES
*           JSW(3) = NAMELIST INPUT
*           JSW(4) = LOOP (HOLDS NEXT PICTURE)
*           JSW(5) = LOOP BREAKER (ADVANCE AUTOMATICALLY)
*           JSW(6) = WRITES AXIS AND SCAN DATA ON KTAPE FM CURRENT PICTURE
*           JSW(7) = WRITES END OF FILE (EOF) ON DATA OUTPUT TAPE
*           JSW(8) = REWINDS DATA TAPE
*           JSW(9) = ZEROES OUT AMPLITUDE HISTORY DISPLAY
          CALL FNS(IDEV,ISW,IER)
          IF(IER.NE.0)OUTPUT(101)IER,'FNS ERR'
          JW=LXOR(JW,ISW)
*
*       FOL ROUTINE(TO 11) WRITES JSW NRS(3 OR 4) ON SCREEN WHEN ACTIVE
*
          LB=1
          DO 10 I=3,4
          IF(JSW(I).EQ.0)GO TO 10
          ENCODE(4,9,ITXT)I
9         FORMAT(I1)
          CALL TEXTO(IDEV,ITXT,1,LB,1,1,3,IER)
          IF(IER.NE.0)OUTPUT(101)IER,'JSW'
          LB=LB+1
10        CONTINUE
          DO 11 I=LB,2
          CALL TEXTO(IDEV,NULL,1,I,1,1,3,IER)
11        IF(IER.NE.0)OUTPUT(101)IER,'JSW NULL'
          IF(JSW(3).EQ.0)GO TO 12
          IBLK=4
          CALL GINPUT(IDEV,ITDIR,IBLK)
*
*       GINPUT WITH GINP ALLOWS NAMELIST INPUT AT AGT
*
          JW=JOFF(3)
12        IF(JSW(4).EQ.0)GO TO 17
13        CALL FNS(IDEV,ISW,IER)
          IF(IER.NE.0)OUTPUT(101)IER,'FNS1 ERR'
          JW=LXOR(JW,ISW)
          IF(JSW(5).NE.0)JW=JOFF(4);JW=JOFF(5);GO TO 17
15        IF(JSW(6).NE.0)GO TO 95
          GO TO 13
17        IF(JSW(7).NE.0)ENDFILE KTAPE;JW=JOFF(7)
          IF(JSW(8).NE.0)REWIND 1;JW=JOFF(8)
```

```
       IF(JSW(9).EQ.0)GO TO 30
       DO 18 I=1,405
18     AVECTR(I)=0
       JW=JOFF(7)
*
*     SAMPLE CONTROL DIALS
*
*         DIAL(1) = ANGLE OF Z AXIS
*         DIAL(2) = CURSOR POSITION
30     IF(IDIAL.NE.1)GO TO 35
       CALL VCD(1,DIALS,IER)
       IF(IER.NE.0)OUTPUT(101)IER,'DIALS'
*
*     EVALUATE DISPLAY PARAMETERS
*
35     CONTINUE
       IF(IDELAY.EQ.0)GO TO 36
       IA=IDELAY*100000
       CALL DELAY
36     ISTOP=ISTRT+IWDTH-1
       WIDTH=IWDTH
       NALFA=NMBRJMP+1
       IF(IBRANCH.EQ.1)GO TO 40
       DX=2.15/WIDTH
40     IANGL=90*DIALS(1)
       ANGL=IANGL*PI/180
       Z=(NSCAN-1)*SEP
       ZX=Z*SIN(ANGL)
       ZY=Z*COS(ANGL)
       XSLNT=SEP*SIN(ANGL)
       YSLNT=SEP*COS(ANGL)
*
*     FORMAT AND PACK AXIS DATA INTO AXES ARRAY
*
       AXES(1)=IHEAD(0,4)
*     Y AXIS
       AXES(2)=IPACK(X1,Y1+Z,0)
       AXES(3)=IPACK(X1,Y1,1)
*     X AXIS
       AXES(4)=IPACK(X1+2.45,Y1,1)
       AXES(5)=IPACK(X1,Y1,0)
*     Z AXIS
       AXES(6)=IPACK((X1+ZX),(Y1+ZY),1)
*     X AXIS SCALE MARKS
       DO 45 I=2,64,2
       II=I+5
       IF(I*5.GT.IWDTH)AXES(II)=AXES(II+1)=0;GO TO 45
       AXES(II)=IPACK(X1+I*5*DX,Y1-.03,0)
```

```
       AXES(II+1)=IPACK(X1+I*5*DX,Y1+.02,1)
45     CONTINUE
*     Y AXIS SCALE MARKS
       DO 46 I=2,6,2
       II=I+69
       AXES(II)=IPACK(X1-.02,Y1+(5.0/SCALE)*I,0)
       AXES(II+1)=IPACK(X1+.01,Y1+(5.0/SCALE)*I,1)
46     CONTINUE
*     AXES AND SCALE MARKS FOR TRACES AT TOP OF PICTURE
       AXES(77)=IPACK(X1-.02,Y2,0)
       AXES(78)=IPACK(X1+.01,Y2,1)
       L=0
       DO 48 I=2,30,2
       L=L+2
       II=I+77
       AXES(II)=IPACK(X1-.02,Y2-(5.0/SCALE2)*I,0)
       IF(L.EQ.6)L=0;GO TO 47
       AXES(II+1)=IPACK(X1+.01,Y2-(5.0/SCALE2)*I,1)
       GO TO 48
47     AXES(II+1)=IPACK(X1+2.3,Y2-(5.0/SCALE2)*I,1)
48     CONTINUE
       AXES(109)=IPACK(X1,Y2,0)
       AXES(110)=IPACK(X1,Y2-(5.0/SCALE2)*30,1)
*     CLRSCR
       AXES(113)=0
       DO 50 I=1,NSCAN
50     MOV(I,1)=0
*
*     SHIFT SCANS UPWARD NMBRJMP POSITIONS
*
       DO 55 I=1,5
       AMPHIST(I,81)=0
       DO 55 J=80,NALFA,-1
55     AMPHIST(I,J)=AMPHIST(I,J-NMBRJMP)
       DO 60 I=NSCAN,NALFA,-1
       DO 60 J=1,IWDTH
       MOV(I,J)=MOV((I-NMBRJMP),J)
60     FILE(J,I)=FILE(J,(I-NMBRJMP))
       IF(NSCAN.GE.MSCAN)GO TO 65
*
*     ZERO OUT THAT PORTION OF *FILE* NOT BEING USED
*
       DO 61 I=NSCAN+1,MSCAN
       DO 61 J=ISTRT,ISTOP
61     FILE(J,I)=0
*
*     READ DATA FROM TAPE
*
```

```
65     DO 76 N=1,NMBRJMP
       IF(NSKIP.EQ.0)GO TO 67
       DO 66 J=1,NSKIP
    67 CALL BUFFERIN(ITAPE,1,IBUF,80,IND)
    20 IF(IND.EQ.1) GO TO 20
       NR=NR+1
       GO TO (20,66,90,66),IND
    66 CONTINUE
       DO 29 K=0,1
       M=K*160
       DO 25 I=1,40
       DO 23 J=1,4
    23 IFILE(M+J+1)=LRS(LAND(IBUF(K*40+I),MASK(J)),ISHT(J))
    25 M=M+4
    29 CONTINUE
       IFILE(1)=NR
71     DO 72 I=ISTRT,ISTOP
       FILE((I-ISTRT+1),(NALFA-N))=IFILE(I+1)/SCALE
*     NRSCAN=SCAN NR TO BE DISPLAYED ON SCREEN
72     NRSCAN=IFILE(1)
*
*     PICK MAX OF 3 BINS FOR AMPHIST VALUE (CENTER AT IBIN+1)
*
       NN=NALFA-N
       AMPHIST(1,NN)=AMAX(IFILE(IBIN1),IFILE(IBIN1+1),IFILE(IBIN1+2))/SCA
      1LE
       AMPHIST(2,NN)=AMAX(IFILE(IBIN2),IFILE(IBIN2+1),IFILE(IBIN2+2))/SCA
      1LE
       AMPHIST(3,NN)=AMAX(IFILE(IBIN3),IFILE(IBIN3+1),IFILE(IBIN3+2))/SCA
      1LE
       AMPHIST(4,NN)=AMAX(IFILE(IBIN4),IFILE(IBIN4+1),IFILE(IBIN4+2))/SCA
      1LE
76     AMPHIST(5,NN)=AMAX(IFILE(IBIN5),IFILE(IBIN5+1),IFILE(IBIN5+2))/SCA
      1LE
       CALL REMOVAL(NSCAN,IWDTH)
       CALL DISPLAY(NSCAN,IWDTH)
       GO TO 8
90     OUTPUT(101),'END OF DATA TAPE'
       NR=0
       GO TO 13
*
*     OUTPUT DATA FOR PLOTTING GRAPH
*
    95 CALL HEADER (KTAPE,81,10)
       CALL GRAPHI(IDEV,JMAGE,3,IER)
       IF(IER.NE.0)OUTPUT(101),'GIER'
       DO 98 I=1,5
       DO 97 J=1,81
```

```
      INDX=(I-1)*81+J
      CALL UNPACK(JMAGE(INDX),PBUF(1,J),PBUF(2,J),MC)
   97 PBUF(2,J)=LIOR(LAND(PBUF(2,J),77777776B),MC)
      CALL BUFFEROU(KTAPE,1,PBUF,162,INC)
   96 IF(INC.EQ.1) GO TO 96
   98 CONTINUE
      CALL GRAPHI(IDEV,IMAGE,2,IER)
      IF(IER.NE.0)OUTPUT(101),'GIER'
      DO 101 I=1,5
      DO 100 J=1,81
      INDX=(I-1)*IWDTH+J
      CALL UNPACK(IMAGE(INDX),PBUF(1,J),PBUF(2,J),MC)
  100 PBUF(2,J)=LIOR(LAND(PBUF(2,J),77777776B),MC)
      CALL BUFFEROU(KTAPE,1,PBUF,162,INC)
   99 IF(INC.EQ.1) GO TO 99
  101 CONTINUE
      JW=JOFF(6)
      GO TO 13
      END
```

```
      SUBROUTINE REMOVAL(NSCAN,IWDTH)
      INTEGER AXES(113)
      COMMON /AREA1/FILE(318,5),MOV(5,318),IMAGE(1591),AMPHIST(5,81)
      COMMON /AREA2/IDEV,XSLNT,YSLNT,X1,Y1,Y2,DX,AXES,NMBRJMP,NRSCAN
      COMMON /AREA3/JMAGE(406),SCALE2,IBIN1,IBIN2,IBIN3,IBIN4,IBIN5
*
*  THIS SUBROUTINE ERASES LINE SEGMENTS HIDDEN BEHIND OTHER LINES
*
      LAST=0
105   NR=NSCAN
      DO 110 I=1,NR
      DO 110 J=2,IWDTH
110   MOV(I,J)=1
130   DO 140 K=NR,2,-1
      DO 140 L=K-1,K-4,-1
      IF(L.LT.1)GO TO 140
      LL=K-L
      HEIGHT=LL*YSLNT
      DO 140 J=1,IWDTH
      IF(MOV(K,J).EQ.0)GO TO 140
      INDX=J+LL*(XSLNT/DX+.4)
      IF(INDX.GT.IWDTH)GO TO 140
      TEST=FILE(J,K)+HEIGHT
      REF=FILE(INDX,L)
      IF(REF.LT.TEST)GO TO 138
      MOV(K,J)=LAST=0
137   IF(REF-TEST.LT.FILE(J-1,K)-FILE(INDX-1,L))MOV(K,J)=1;GO TO 139
      GO TO 140
138   IF(LAST.NE.0)GO TO 140
      IF(FILE(J,K)-FILE(J-1,K).GT.TEST-REF)MOV(K,J)=LAST=0;GO TO 140
139   LAST=1
140   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE DISPLAY(NSCAN,IWDTH)
      INTEGER AXES(113)
      COMMON /AREA1/FILE(318,5),MOV(5,318),IMAGE(1591),AMPHIST(5,81)
      COMMON /AREA2/IDEV,XSLNT,YSLNT,X1,Y1,Y2,DX,AXES,NMBRJMP,NRSCAN
      COMMON /AREA3/JMAGE(406),SCALE2,IBIN1,IBIN2,IBIN3,IBIN4,IBIN5
*
*  THIS SUBROUTINE PACKS DATA INTO PROPER FORMAT FOR GRAPHICS UNIT
*
      BX=2.3/80.0
200   N=1
      IMAGE(1)=IHEAD(0,10)
      DO 210 I=1,NSCAN
      X=X1+XSLNT*(I-1)
      Y=Y1+YSLNT*(I-1)
      DO 210 J=1,IWDTH
      N=N+1
      M=MOV(I,J)
      EX=X+DX*(J-1)
      WYE=Y+FILE(J,I)
      IF(EX.GT.1.3)M=0
210   IMAGE(N)=IPACK(EX,WYE,M)
      DO 211 I=N+1,1591
211   IMAGE(I)=0
      N=1
      JMAGE(1)=IHEAD(0,10)
      DO 215 I=1,5
      DO 215 J=1,81
      N=N+1
      EX=X1+BX*(J-1)
      WHY=Y2+AMPHIST(I,J)-(30.0/SCALE2)*I
      JMAGE(N)=IPACK(EX,WHY,1)
215   IF(J.EQ.1)JMAGE(N)=IPACK(EX,WHY,0)
      JMAGE(82)=JMAGE(163)=JMAGE(244)=JMAGE(325)=JMAGE(406)=0
      CALL GRAPHC(IDEV,AXES,113,1,IER)
      IF(IER.NE.0)OUTPUT(101)IER,'AXES ERR'
      CALL GRAPHC(IDEV,IMAGE,1591,2,IER)
      IF(IER.NE.0)OUTPUT(101),'IMAGERR'
      CALL GRAPHC(IDEV,JMAGE,406,3,IER)
      IF(IER.NE.0)OUTPUT(101)'AMPHIST ERR'
      ENCODE(4,220,JTXT)NRSCAN
220   FORMAT(I4)
      CALL TEXTO(IDEV,JTXT,1,40,75,2,3,IER)
      IF(IER.NE.0)OUTPUT(101)IER,'NRSCAN ERR'
      RETURN
      END
```

```
      SUBROUTINE HEADER (KTAPE,IWDTH,NSCAN)
      INTEGER PBUF
      DIMENSION PBUF(2,130),IHBUF(260)
      EQUIVALENCE(PBUF,IHBUF)
*
*   THIS SUBROUTINE PACKS THE HEADER DATA INTO A FORMAT FOR USE ON THE
*   PDP-11 PLOTTER.
*
      DO 10 I=1,2
      DO 10 J=1,81
   10 PBUF(I,J)=0
      IHBUF(1)=81
      IHBUF(2)=10
      CALL BUFFEROU(KTAPE,1,IHBUF,162,IND)
   20 IF(IND.EQ.1) GO TO 20
      RETURN
      END
```

```
*
*
*   METASYMBOL PROGRAM USED TO PASS OVER (IN EITHER FORWARD OR REVERSE
*  DIRECTION) ENTIRE FILES OR A SPECIFIED NUMBER OF RECORDS WITHIN ANY
*   FILE.
*
*
*
¬METAS3CC SI,GO
A        EQU       5
B        EQU       4
*
*        FORREC  BAKREC       SPACE THE TAPE EITHER FORWARD OR
*        BACKWARD I RECORDS
*        CALLS      9SETUPN, R/IOPS
*        CALLED BY      MAIN PROGRAM
*        CALL BAKREC(N,I)    N = UNIT, I = NO.OF RECORDS
*
*
$BAKREC PZE        0
         LDA       BAKREC
         STA       FORREC
         BRU       FORREC+1
*
$FORREC PZE        0
         BRM       9SETUPN
         PZE       2
FUNIT    PZE       0                   ;UNIT
FNREC    PZE       0                   ;NO. OF RECORDS
         LDA       *FUNIT
         STA       FUNT
         BRM       ASGN
         PZE       1
FUNT     PZE       0
         LDA       ARFDT
         ADD       =03000000
         STA       FOCAL
         LDA       *FNREC
         SKE       =0
         BRU       RCEND
         LDB       BAKREC
         SKB       =077777             ;GO BACKWARDS
         BRU       $+2
         COPY      (-A,A)
         STA       TFDT+4
$
         BRM       R>IOPS
         PZE       1
```

```
FCCAL   FZE     0
$
        SKN     TFDT
        BRU     $+2
        BRL     $-2
RCEND   STZ     BAKREC
        BRR     FCRREC
```

```
*
*       EAKSCN  FORSCN  SCANS FCRWARD CR BACKWARC CN A TAPE FOR A
*       KEYWORC OR AN ENC FILE MARK
*       CALLS      9SETUPN, R/ICPS, BCDCVT, ASGN
*       CALLEC BY       MAIN PRCGRAM
*
*
*
$EAKSCN FZE     0
        LCA     BAKSCN
        STA     FCRSCN
        ERU     FCRSCN+1
*
*
$FCRSCN FZE     0
        ERM     9SETUPN
        FZE     2
SUNIT   FZE     0
SEOF    FZE     0
        STZ     CCUNT
        LCA     *SUNIT
        STA     SUNT
        ERM     ASGN                ;SEARCH SYMBOL TABLE
        FZE     1
SUNT    FZE     0
        LCA     =0600               ;600 - 4 CHARACTER/WCRD
        STA     MCDE                ;STORE MCDE IN FCT
PLC1    LCA     =017170000          ;PUT ECF KEYWORD IN FDT
        STA     TFDT+4
        LCA     *SEOF               ;GET NO. CF ECF'S
        SKU     =0
        EFU     FEND
        SUB     =1
        STA     CCUNT
PLC2    LCB     EAKSCN
        LCA     ARFDT
        ADC     =02000000
        SKB     =077777             ;SCAN BACKWARDS?
        ERU     $+2                 ;NO
        ADC     =00100000
        STA     SCNCAL
*
CCIC    ERM     R>IOPS
*
        FZE     1
SCNCAL  FZE     0
        SRN     TFDT
        ERU     $+2
```

AD-A039 355 NAVAL POSTGRADUATE SCHOOL MONTEREY CALIF F/G 20/14
HIGH FREQUENCY IONOSPHERIC PROPAGATION PHENOMENA.(U)
DEC 76 R R ROWE
UNCLASSIFIED NL

2 OF 2
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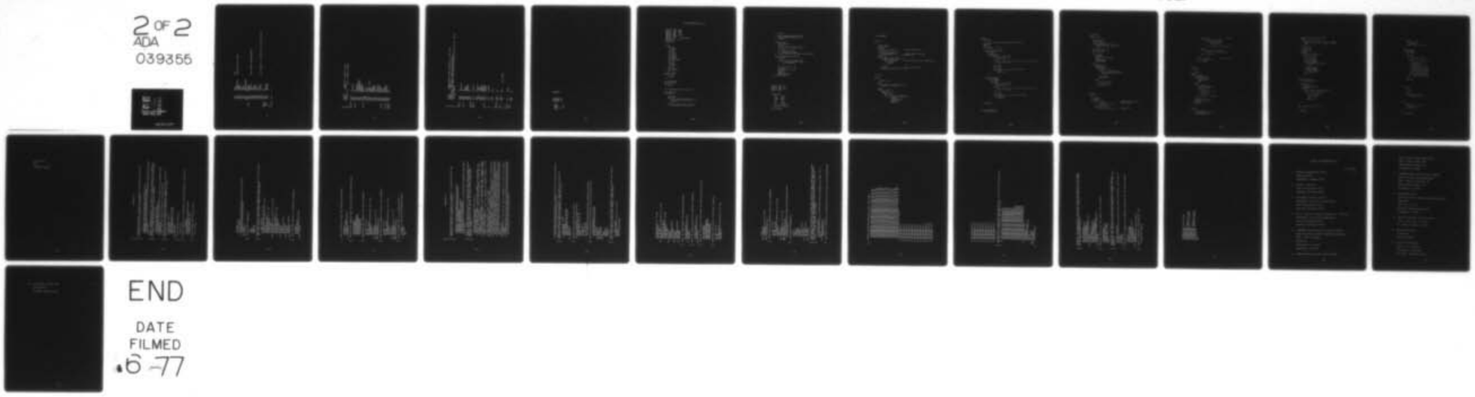

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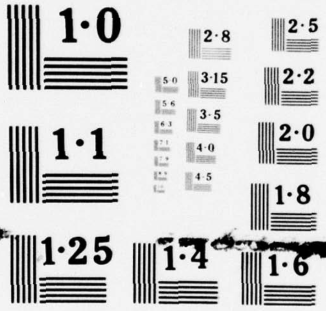

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MICROCOPY RESOLUTION TEST CHART

```
          BRU     $-2                 ;NO
          LDA     TFDT
          SKU     =06000000           ;BEGIN OR END TAPE?
          BRU     FEND
          LDA     *SEOF
          SKU     =0
          BRU     CNTR
          LDA     TFDT
          SKE     =010000000
         BRU     DOIO
CNTR      SKR     COUNT
          BRU     DOIO
          LDA     BAKSCN              ;WAS THERE BACKSCANNING?
          SKU     =0
          BRU     FEND
          LDA     SUNIT
          STA     PLC3
          LDA     1
          STA     PLC4
          BRM     FORREC              ;GO FORWARD 1 RECORD TO GET PAST THE EOF
          PZE     2
PLC3      PZE     0
PLC4      PZE     0
FEND      STZ     BAKSCN
          BRR     FORSCN
*
*
COUNT     PZE     0
```

```
*
*        BCDCVT      CONVERTS A WORD TO BCD
*        CALLS      NONE
*        CALLED BY       ASGN, FORSCN, BAKSCN
*
*
$BCDCVT PZE      0
        BRM      9SETUPN
        PZE      1
WORD    PZE      0
        STX      STORE,1
        LDX      =0200000-4,1
        LDA      =060606060
        STA      NAMTAB
        STA      NAMTAB+1
CLOOP   LDB      WORD
        ALSB     1
        COPY     (0,A)
        DIV      =10
        COPY     (A,B),(B,A)
        STB      WORD
        LDB      MASK
        STS      NAMTAB
        LDA      NAMTAB
        CRSA      6
        STA      NAMTAB
        BRX      DLOOP,1
        BRU      ELOOP
DLOOP   LDA      WORD
        SKE      =0
        BRU      CLOOP
ELOOP   LDX      STORE,1
        BRR      BCDCVT
STORE   PZE      0
MASK    PZE      077
```

```
*
*       ASGN      FINDS SYMBOL TABLE ADDRESS CF TAPE UNIT
*       CALLS        R/RSTS
*      CALLED BY    ALL TAPE HANDLING SUBRCUTINES
*       WILL CAUSE AN ABCRT IF AN ADDRESS CORRESPCNDING TC THE  UNIT
*       IS NOT FCUND
*
*
*
$ASGN   FZE       0
        ERM       9SETUPN
        FZE       1
TUNT    FZE       0
        LCA       TUNT
        STA       ASGN1
        ERM       BCDCVT
        FZE       1
ASGN1   FZE       0
$
ASGN2   ERM       R>RSTS
$
        FZE       1
        FZE       NAMTAB
         SKU       =0
        ERL       TERR
        STA       TFDT+5
        ERR       ASGN
TERR    LCA       NAMTAB
        STA       MSG+1
$
        ERM       R>ABRT
$
        FZE       1
        FZE       MSG
*
*
NAMTAB  TEXT      8,
        FZE       3
*
MSG     FZE       4
        TEXT      16,     NCT FCUND
*
*
*
ARFCT   FZE       TFDT
*
TFDT    FZE       0
        FZE       0
```

```
        PZE     0
MODE    PZE     0
DIRECT  PZE     0
FCB     PZE     0
        PZE     0
*
        END
¬EOF
```

PLOT ROUTINE "aa.c"

```
#define  XINT   320
#define  YINT  8000
#define  DELY   3200
#define  DELX    16
#define  AMPY   8000
#define  NLINE    1
#define  PI       3.141596525
#define  NPT    150
int zero 0;
int one 1;


struct{
     int npt;
     int line;
     int ldx;
     int ldy;
     int cptr;
     int nspt;
     int spot1;
     int spot2;
     int spot3;
     int hr,min,sec;
     int nft;
     int lag;
     int sr;
     int id[3];
     int lp;
     int scl;
     int mo,day,yr;
}  head,  *h;

int hbuf[300];
struct  data    {
     int x;
     int yd;
};

struct data *d;
int dbuf[4000];
int np;
int nip 8;


int idev,pdev,sclx,scly,biasx,tdev;

main(argc,argv)
int **argv;
{
     int i,j,n;
     char *cs;
     if((tdev = open("/dev/spp",1)) < 0){
          printf("cannot open spp #");
          exit();
     }
     if((pdev = open("/dev/rvp",1))<0){
          printf("cannot open rvp #");
```

```
        exit();
    }
    if((idev = open("/dev/rmt6",0))<0){
        printf("cannot open rmt6 #");
        exit();
    }

    if(argc > 1){
        cs = argv[1];
        n = 0;
        while ( *cs >= '0' && *cs <= '9')
            n = n * 10 + *cs++ - '0';
        n =* 11;
        for ( i=0; i<n; i++)
            inp(idev, dbuf,800);
        printf ("number of records skipped, %d#",n);
    }
    while((inp(idev,hbuf,800))>0){
        h = hbuf;
        j = 0;
        for(i = 0; i< h -> line; i++){
            n = inp(idev,&dbuf[j], 800);
            j  =+ 2*(h->npt);
        }

        sclx = 030; scly = 03;
        biasx=50;
        np = h->npt * h->line;
        scale();
        plot();
        cvers(pdev,020);
    stty(pdev,&one);
    }
}



#define  NBYT  264
#define  NBLK   0
#define  NSL  1250
#define  DRAW      1


struct ipt{
    int     y;
    char    *xpb;
    char    yinc;
    char    xdir;
    int     yf;
    int     cxp;
    int     *flink;
    int     *blink;
} itab[7*NBYT],*ip,*ia;

char pb[NBYT];
```

```
int *dp[2000];


plot()
{

    struct ipt *s;
    int i,j,ie;
    sort();
    for(i = 0; i < NBYT; i++)        //clear plot buffer
        pb[i] = 0;
    for(i = 0; i < NBLK; i++)
        write(pdev,pb,NBYT);         //move to top of plot area
    ip = 0; ia = itab;           //plot scan line
    j = 0;
    for(i = NSL; i > -1; i--){
        while(j < np && *dp[j] == i){
            ie = sip(dp[j]);         //set up plot point for interpolation
            if(ie == 1)
                return;
            j++;
        }
        nib(i);                      //set up plot buffer
        write(pdev,pb,NBYT);//plot line
    }
}


int jsort;

sort()
{
    register i,k,t;

    i=0;
    for(d = dbuf; d < &dbuf[np*2]; d++)
        dp[i++] = &(d -> yd);

    k=np;
    while ( k =>> 1 ){
        jsort++;
        while ( jsort ){
            jsort = 0;
            for ( i=0; i< (np-k); i++)
                if ( *dp[i] < *dp[i+k] ){
                    t=dp[i];
                    dp[i]=dp[i+k];
                    dp[i+k]=t;
                    jsort++;
                }
        }
    }

}
```

```
sip(dpi)
    int *dpi;
{
    int xi,yi,xl,yl,xr,yr,incy,fy,dirx,cx,*s,lcx,inc;
    int i,ie;
    s=dpi;
    lcx = 1;
    yi = *dpi--; xi = *dpi;

    if(++s < &(dbuf[2*np])){
        xr = *s++;
        yr = *s;
        if(yr & DRAW){
            if((inc = yi - yr) >= 0){
                if((incy = inc) == 0)
                    dirx = nip;
                else{
                    for(i = 0; ((incy = (inc/(nip >> i))) == 0); i++);
                    dirx = (1 << i);
                }
                fy = yr;
                cx = 0200;
                lcx = 0;
                ie = stack(yi-incy,incy,fy,xi,dirx,cx);
                if(i == 1)
                    return(1);
            }
        }
    }
    if(--dpi >= dbuf){
        if(yi & DRAW){
            yl = *dpi--;
            xl = *dpi;
            if((inc = yi - yl) >= 0){
                if((incy = inc) == 0)
                    dirx = -nip;
                else{
                    for(i =0; ((incy = (inc/(nip >> i))) == 0); i++);
                    dirx = -(1 << i);
                }
                fv = yl;
                cx = lcx;
                ie = stack(yi-incy,incy,fy,xi-1,dirx,cx);
                if(ie == 1)
                    return(1);
            }
        }
    }
    return(0);
}


stack(a,b,c,dd,e,f)
    int a,b,c,dd,e,f;
```

```
{
    int *s;
int i;
struct ipt *z;

    ia -> y = a;
    ia -> yinc = b;
    ia -> yf = c;
    if(dd >= NBYT && dd < 0){
        printf("bad scale x=%d#",dd);
        exit();
    }
    ia -> xpb = dd + pb;
    ia -> xdir = e;
    ia -> cxp = f;

    if(ip == 0){
        ip=itab;
        ip->flink=ip->blink=0;
        ia++;
        ia->blink=ip;
        ia->flink=0;
    }
    else{
        s=ia->blink;
        s->flink=ia;
        if(ia->flink == 0){
            s = ia;
            if(++ia >= &itab[7*NBYT]){
                printf("itab overflow #");
                return(1);
            }
            ia->blink=s;
            ia->flink=0;
        }
        else{
            s = ia -> flink;
            s -> blink = ia;
            ia -> flink = 0;
            ia = s;
        }
    }
}


nib(sl)
    int sl;
{
    int i,j,n;
    int *s; s = ip;
    while(s){                                   //setup plotting buffer
        if(s -> yf <0)                          //delete point
            if((s=free(s)) == 0)
                return;
        *s -> xpb =s -> cxp;
        if(sl == s -> y){                       //line break
            i = ((n = s -> xdir) > 0 ? n : -n);
```

```
            if( n < 0 )                             //left
                for(j = 0; j < i; j++){
                    if(s -> cxp == 0){
                        *s -> xpb =+ 1;
                        s -> cxp = 1;
                    }
                    *s -> xpb =| (s -> cxp =<< 1);
                }
            else
                for(j = 0; j < i; j++){
                    *s->xpb =| (s->cxp =>> 1);
                }
            s->y =- s->yinc;

        }
        if(s] <= s->yf)                     //end of point
                s->yf = -1;
        s = s->flink;
    }
}


free(s)
    int *s;
{
    int *t;
int i;
struct ipt *z;
    *s -> xpb = 0;
    if(s->blink == 0){
        ip = s->flink;
        ip->blink = 0;
        t=ip;
    }
    else{
        t = s->blink;
        t->flink = s->flink;
        t = s -> flink;
        if(t == 0){
            s -> flink = ia;
            ia = s;
            return(t);
        }
        t -> blink = s -> blink;
    }
    s->flink = ia;
    s->blink = ia->blink;
    ia = s;
    return(t);
}


scale()
{
    struct data *s;
    int dm,i,j,c,minx,miny;
    int dx[20],dy[20];
```

```
     s = dbuf; minx = miny = 077777;
     d=s;
     for(i = 0; i < np; i++){
          minx = ((c = s -> x) < minx? c : minx);
          miny = ((c = s -> yd) < miny? c : miny);
          s++;
     }
     if(minx > 0)
          minx = 0;
     if(miny > 0)
          miny = 0;
     s=dbuf;
     for(i = 0; i < np; i++){
          dm = s -> yd & 1;
          s -> x =- minx;
          s -> yd =- miny;
          s -> x =/ sclx;
          s ->x =+ biasx;
          if(s->x >= NBYT){
               printf("overflow pb #");
               exit();
          }
          s -> yd =/ scly;
          if(s->yd > NSL)
               s->yd = NSL-1;
          s -> yd =& 0177776;
          s -> yd =| dm;
          s++;
     }
}

inp(idf,buf,nbyte)
     int idf,*buf,nbyte;
{
     int i,t,n,c;
     struct{
          char c1,c2,c3,c4;
     } cf[1200], *s;
     s = cf;
          if((n = read(idf,cf,nbyte)) > 0){
          for(i = 0; i < nbyte/4; i++){
               c = s -> c2 << 2;
               t = c << 10;
               t =| s -> c3 << 6;
               t =| s -> c4;
               s++;
               buf[i] = t;
          }
     }
}

char *cbp,*loc,tl[132],ch[10];


conv(val)
     int val;
```

```
{
     int a;
     if(a = val/10)
          conv(a);
     *cbp++ = val % 10 + '0';
}


conc(c1,c2,n)
     char *c2;
     int n,*c1;
{
     int i,m;
     for(i = 0; i < n; i++){
          if(i == 0)
               m = (*c1 & 07700) >> 6;
          else
               m = *c1 & 0077;
          if(m == 012)
               *c2 = '0';
          if(m >= 01 && m <= 011)
               *c2 = '1' + m - 1;
          if(m >= 021 && m <= 031)
               *c2 = 'A' + m - 021;
          if(m >= 041 && m <= 051)
           *c2 = 'J' + m -041;
          if(m >= 062 && m <= 071)
               *c2 = 'S' + m - 062;
     c2++;
     }
     return(i);
}



skip(cnt)

     int cnt;
{
     int i;
     for(i = 0; i < cnt; i++)
          write(pdev,pb,2);
}


clr()
{
     int i;
     for(i = 0; i < 132; i++)
          t1[i] = ' ';
     t1[131] = '#';
}


mov(to,from,n)
```

```
    char *to,*from;
    int n;
{
    int i;
    for(i = 0; i < n; i++)
        *to++ = *from++;
}
```

```
C
C                                "MIN/MAX 1"
C
C
C
C
C     PROGRAM TO PERFORM A SERIES OF STATISTICAL CALCULATIONS WITH THE
C     "ANOMALY" DATA ON A SCAN BY SCAN BASIS.
C
C
      DIMENSION IFILE(320),IBUF(80),MASK(4),ISHT(4)
      DIMENSION JPT(320),MINPT(160),MAXPT(160)
      DATA (MASK(I),I=1,4),(ISHT(I),I=1,4)/37000000B,370000B,3700B,37B,1
     18,12,6,0/
C
C     PERMITS IDENTIFICATION OF THE NUMBER OF SCANS (NREC) TO BE INVESTI-
C     GATED, ATTENUATION APPLIED TO THE SET IN QUESTION (NATTN) AND NUMBER
C     OF FILES TO BE SKIPPED UNDER "FORSCN" (NFILE).
C
      NAMELIST NREC,NATTN,NFILE
      DATA NFILE/0/,NREC/0/,ITAPE/1/
    2 FORMAT(//25X,'SCAN',10X,'PEAK',10X,'VALLEY',10X,'MAXMAX',10X,
     1'MINMIN'/)
    3 FORMAT(25X,I4,10X,F5.2,10X,F5.2,11X,I3,14X,I3)
C
C     PERMITS INPUT OF NAMELIST VARIABLES, INCLUDING THE CALLING OF
C     "FORSCAN" TO SKIP OVER AN ARBITRARY NUMBER OF FILES.
C
    5 OUTPUT(102) 'DATA'
      INPUT(101)
      IF(NFILE.EQ.0) GO TO 100
      CALL FORSCN(ITAPE,NFILE)
      NFILE = 0
  100 CONTINUE
C
C     PRINTS COLUMN HEADINGS.
C
      WRITE(6,2)
C
C     PERMITS ANALYSIS OF PREVIOUSLY DELINEATED NUMBER OF SCANS ONLY.
C
      DO 40 N=1,NREC
      CALL BUFFERIN(1,1,IBUF,80,IND)
    7 IF(IND.EQ.1) GO TO 7
      IF(IND.EQ.3) GO TO 5
C
C     UNPACKS DATA FROM THE DATA TAPE.
C
      DO 29 K=0,1
```

```
      M=K*160
      DO 25 I=1,40
      DO 23 J=1,4
   23 IFILE(M+J)=LRS(LAND(IBUF(K*40+I),MASK(J)),ISHT(J))
      JPT(M+J)=(2*IFILE(M+J))+NATTN
   25 M=M+4
   29 CONTINUE
C
C  INITIALIZES PARAMETERS
C
      KZ=0
      LZ=0
      MXCNT=0
      MNCNT=0
C
C  IDENTIFIES ALL OF THE SIGNAL WAVEFORM PEAKS AND VALLEYS AND PLACES
C  THEM INTO ARRAYS "MAXPT" AND "MINPT" RESPECTIVELY.
C
      DO 400 I=1,317
      IF(JPT(I).EQ.0) GO TO 400
      IF(JPT(I+1).LE.JPT(I)) GO TO 150
      MXCNT=1
      KOUNT=MXCNT+MNCNT
      IF(KOUNT.NE.0) GO TO 400
      MINTEM=JPT(I)
      GO TO 200
  150 IF(JPT(I+1).GE.JPT(I)) GO TO 400
      MNCNT=-1
      JOUNT=MXCNT+MNCNT
      IF(JOUNT.NE.0) GO TO 400
      MAXTEM=JPT(I)
      GO TO 300
  200 MNCNT=0
      KZ=KZ+1
      MINPT(KZ)=MINTEM
      GO TO 400
  300 MXCNT=0
      LZ=LZ+1
      MAXPT(LZ)=MAXTEM
  400 CONTINUE
C
C  SUMS THE PEAK VALUES FOR AVERAGING PURPOSES.
C
      MXPEAK=0
      DO 500 I=1,LZ
      MXPEAK=MXPEAK+MAXPT(I)
  500 CONTINUE
C
```

```
C  SUMS THE VALLEY VALUES FOR AVERAGING PURPOSES.
C
      MINVAL=0
      DO 600 I=1,KZ
      MINVAL=MINVAL+MINPT(I)
  600 CONTINUE
C
C  COMPUTES THE AVERAGE PEAK VALUE AND AVERAGE VALLEY VALUE.
C
      XKZ=FLOAT(KZ)
      XLZ=FLOAT(LZ)
      XVAL=FLOAT(MINVAL)
      XPEAK=FLOAT(MXPEAK)
      PEAK=XPEAK/XLZ
      VALLEY=XVAL/XKZ
C
C  IDENTIFIES THE LARGEST PEAK VALUE (MAXMAX).
C
      DO 777 I=1,LZ
      NON=0
      DO 700 J=1,LZ
      IF(MAXPT(I).LT.MAXPT(J)) GO TO 700
      NON=NON+1
      IT=I
  700 CONTINUE
      IF(NON.EQ.LZ) GO TO 799
  777 CONTINUE
  799 MAXMAX=MAXPT(IT)
C
C  IDENTIFIES THE SMALLEST VALLEY VALUE (MINMIN).
C
      DO 888 I=1,KZ
      MON=0
      DO 800 J=1,KZ
      IF(MINPT(I).GT.MINPT(J)) GO TO 800
      MON=MON+1
      JT=I
  800 CONTINUE
      IF(MON.EQ.KZ) GO TO 899
  888 CONTINUE
  899 MINMIN=MINPT(JT)
C
C  PRINTS OUTPUT DATA IN COLUMNAR FORMAT.
C
      WRITE(6,3) N,PEAK,VALLEY,MAXMAX,MINMIN
   40 CONTINUE
      GO TO 5
      END
```

```
C
C                            "MIN/MAX 2"
C
C
C
C     PROGRAM TO PERFORM A SERIES OF STATISTICAL CALCULATIONS WITH THE
C     "ANOMALY" DATA ON A SELECTED BIN BASIS.
C
C
      DIMENSION IFILE(320),IBUF(80),MASK(4),ISHT(4)
      DIMENSION JPT(3600),MINPT(1800),MAXPT(1800)
      DIMENSION XTIME(2500)
      DIMENSION MM(20),KMM(20),XM(20)
      DIMENSION NM(25),X(25),KM(25)
      DATA (MASK(I),I=1,4),(ISHT(I),I=1,4)/37000000B,370000B,3700B,37B,1
     18,12,6,0/
C
C     PERMITS IDENTIFICATION OF THE SET (NSET) AND BIN (NBIN) BEING INVEST-
C     IGATED, SIGNAL LEVEL CHANGE TO  BE DETECTED (NDB), ATTENUATION
C     APPLIED TO NSET (NATTN) AND NUMBER OF FILES TO BE SKIPPED UNDER
C     "FORSCN" (NFILE).
C
      NAMELIST NSET,NBIN,NDB,NATTN,NFILE
      DATA NFILE/0/,ITAPE/1/
    2 FORMAT(///5X,'SET NUMBER ',I3,5X,'BIN NUMBER ',I3,5X,'PEAK = ',
     1F5.2,' DB',5X,'VALLEY = ',F5.2,' DB',5X,'MAXMAX = ',I2,' DB',5X,
     2'MINMIN = ',I2,' DB'/)
    3 FORMAT(37X,'CHANGE NUMBER = ',I4,5X,'ELAPSED TIME = ',F6.2,' SEC')
   13 FORMAT(/32X,'MEAN ELAPSED TIME = ',F7.3,' SEC',5X,'STANDARD DEVIAT
     1ION = ',F6.3,' SEC')
    4 FORMAT(/37X,'NUMBER OF ',I2,' DB CHANGES IN ADJACENT POINTS = ',I4
     1//)
    6 FORMAT(62X,'ELAPSED TIME = ',F6.2,' SEC')
   16 FORMAT(64X,'TOTAL TIME = ',F6.2,' SEC')
   17 FORMAT(10X,'FREQUENCY DISTRIBUTION OF ELAPSED TIMES IN VARIABLE WI
     1DTH TIME BINS (ROW 1 = NUMBER, ROW 2 = PERCENT)')
   18 FORMAT (/7X,'N1',3X,'N2',3X,'N3',3X,'N4',3X,'N5',3X,'N6',3X,'N7',3
     1X,'N8',3X,'N9',3X,'N10',3X,'N11',3X,'N12',3X,'N13',3X,'N14',3X,'N1
     25',3X,'N16',3X,'N17',3X,'N18',3X,'N19',3X,'N20',3X,'N21')
   19 FORMAT (5X,I4,2X,I3,2X,I3,2X,I3,2X,I3,2X,I3,2X,I3,2X,I3,2X,I3,2X,I
     13,3X,I3,3X,I3,3X,I3,3X,I3,3X,I3,3X,I3,3X,I3,3X,I3,3X,I3,3X,I3,3X,I
     23)
   20 FORMAT(//)
   30 FORMAT(//32X,'TIME BINS N1 AND N2 EXPANDED TO 16 BINS .04 SECONDS
     1WIDE')
   31 FORMAT(/8X,'N1-1',3X,'N1-2',3X,'N1-3',3X,'N1-4',3X,'N1-5',3X,'N1-6
     1',3X,'N1-7',3X,'N2-1',3X,'N2-2',3X,'N2-3',3X,'N2-4',3X,'N2-5',3X,'
     2N2-6',3X,'N2-7',3X,'N2-8',3X,'N3-1')
```

```
   32 FORMAT(8X,I4,3X,I4,3X,I4,3X,I3,3X,I4,3X,I4,3X,I4,3X,I4,3X,I4,3X,I4
     1,3X,I4,3X,I4,3X,I4,3X,I4,3X,I4,3X,I4)
C
C     PERMITS INPUT OF NAMELIST VARIABLES, INCLUDING THE CALLING OF
C     "FORSCN" TO SKIP OVER AN ARBITRARY NUMBER OF FILES.
C
    5 OUTPUT(102) 'DATA'
      INPUT(101)
      IF(NFILE.EQ.0) GO TO 100
      CALL FORSCN(ITAPE,NFILE)
      NFILE = 0
  100 CONTINUE
      N=0
C
C     UNPACKS DATA FROM THE DATA TAPE.
C
   10 CALL BUFFERIN(1,1,IBUF,80,IND)
    7 IF(IND.EQ.1) GO TO 7
      IF(IND.EQ.3) GO TO 45
      N=N+1
      DO 29 K=0,1
      M=K*160
      DO 25 I=1,40
      DO 23 J=1,4
      IFILE(M+J)=LRS(LAND(IBUF(K*40+I),MASK(J)),ISHT(J))
C
C     PERMITS ANALYSIS OF PREVIOUSLY DELINEATED BIN(S) ONLY.
C
      IF((M+J).NE.NBIN) GO TO 23
      JPT(N)=(2*IFILE(M+J))+NATTN
      GO TO 40
   23 CONTINUE
   25 M=M+4
   29 CONTINUE
   40 GO TO 10
   45 KZ=0
      LZ=0
      MXCNT=0
      MNCNT=0
      NRE=N-1
C
C     IDENTIFIES ALL OF THE SIGNAL WAVEFORM PEAKS AND VALLEYS AND PLACES
C     THEM INTO ARRAYS "MAXPT" AND "MINPT" RESPECTIVELY.
C
      DO 400 I=1,NRE
      IF(JPT(I+1).LE.JPT(I)) GO TO 150
      MXCNT=1
      KCNT=MXCNT+MNCNT
```

```
      IF(KOUNT.NE.0) GO TO 400
      MINTEM=JPT(I)
      GO TO 200
  150 IF(JPT(I+1).GE.JPT(I)) GO TO 400
      MNCNT=-1
      JOUNT=MXCNT+MNCNT
      IF(JOUNT.NE.0) GO TO 400
      MAXTEM=JPT(I)
      GO TO 300
  200 MNCNT=0
      KZ=KZ+1
      MINPT(KZ)=MINTEM
      GO TO 400
  300 MXCNT=0
      LZ=LZ+1
      MAXPT(LZ)=MAXTEM
  400 CONTINUE
      MXPEAK=0
C
C   SUMS THE PEAK VALUES FOR AVERAGING PURPOSES.
C
      DO 500 I=1,LZ
      MXPEAK=MXPEAK+MAXPT(I)
  500 CONTINUE
      MINVAL=0
C
C   SUMS THE VALLEY VALUES FOR AVERAGING PURPOSES.
C
      DO 600 I=1,KZ
      MINVAL=MINVAL+MINPT(I)
  600 CONTINUE
C
C   COMPUTES THE AVERAGE PEAK VALUE AND AVERAGE VALLEY VALUE.
C
      XKZ=FLOAT(KZ)
      XLZ=FLOAT(LZ)
      XVAL=FLOAT(MINVAL)
      XPEAK=FLOAT(MXPEAK)
      PEAK=XPEAK/XLZ
      VALLEY=XVAL/XKZ
C
C   IDENTIFIES THE LARGEST PEAK VALUE (MAXMAX).
C
      DO 777 I=1,LZ
      NCN=0
      DO 700 J=1,LZ
      IF(MAXPT(I).LT.MAXPT(J)) GO TO 700
      NCN=NCN+1
```

```
      IT=I
  700 CONTINUE
      IF(MCN.EQ.LZ) GO TO 799
  777 CONTINUE
  799 MAXMAX=MAXPT(IT)
C
C  IDENTIFIES THE SMALLEST VALLEY VALUE (MINMIN).
C
      DO 888 I=1,KZ
      MCN=0
      DO 800 J=1,KZ
      IF(MINPT(I).GT.MINPT(J)) GO TO 800
      MCN=MCN+1
      JT=I
  800 CONTINUE
      IF(MON.EQ.KZ) GO TO 899
  888 CONTINUE
  899 MINMIN=MINPT(JT)
      WRITE(6,2) NSET,NBIN,PEAK,VALLEY,MAXMAX,MINMIN
      KSAVE=JPT(1)
C
C  INITIALIZES PARAMETERS.
C
      NUM=0
      NTL=0
      TTIME=0
      CTIME=0
      CCTIME=0
      TAVE=0
      DO 900 I=1,21
      NM(I)=0
  900 CONTINUE
      DO 901 I=1,16
      MM(I)=0
  901 CONTINUE
C
C  IDENTIFIES THE NUMBER OF TIMES THE DISCRETE SIGNAL SAMPLES IN A GIVEN
C  BIN DEVIATE FROM A "SLIDING" REFERENCE VALUE (KSAVE) BY "NDB" DECI-
C  BELS OR MORE; COMPUTES THE NUMBER OF SUCH CHANGES (NUM) AND THE
C  LENGTH OF TIME BETWEEN THEM (TIME).
C
      DO 222 KL=1,NRE
      IF((JPT(KL+1)-NDB).LT.KSAVE.AND.(JPT(KL+1)+NDB).GT.KSAVE) GO TO
     1223
  225 KSAVE=JPT(KL+1)
      TIME=(NTL+1)*.04
C
C  CONSTRUCTS A FREQUENCY DISTRIBUTION FOR THE ELAPSED TIMES BETWEEN NDB
```

```
C   CHANGES UTILIZING VARIABLE WIDTH TIME BINS.
C
      IF((TIME.GE..04).AND.(TIME.LT..32)) GO TO 61
      IF((TIME.GE..32).AND.(TIME.LT..64)) GO TO 62
      IF((TIME.GE..64).AND.(TIME.LT.1.0)) GO TO 63
      IF((TIME.GE.1.0).AND.(TIME.LT.1.32)) GO TO 64
      IF((TIME.GE.1.32).AND.(TIME.LT.1.64)) GO TO 65
      IF((TIME.GE.1.64).AND.(TIME.LT.2.0)) GO TO 66
      IF((TIME.GE.2.0).AND.(TIME.LT.2.32)) GO TO 67
      IF((TIME.GE.2.32).AND.(TIME.LT.2.64)) GO TO 68
      IF((TIME.GE.2.64).AND.(TIME.LT.3.0)) GO TO 69
      IF((TIME.GE.3.0).AND.(TIME.LT.3.32)) GO TO 71
      IF((TIME.GE.3.32).AND.(TIME.LT.3.64)) GO TO 72
      IF((TIME.GE.3.64).AND.(TIME.LT.4.0)) GO TO 73
      IF((TIME.GE.4.0).AND.(TIME.LT.4.32)) GO TO 74
      IF((TIME.GE.4.32).AND.(TIME.LT.4.64)) GO TO 75
      IF((TIME.GE.4.64).AND.(TIME.LT.5.0)) GO TO 76
      IF((TIME.GE.5.0).AND.(TIME.LT.7.5)) GO TO 81
      IF((TIME.GE.7.5).AND.(TIME.LT.10.0)) GO TO 82
      IF((TIME.GE.10.0).AND.(TIME.LT.15.0)) GO TO 83
      IF((TIME.GE.15.0).AND.(TIME.LT.20.0)) GO TO 84
      IF((TIME.GE.20.0).AND.(TIME.LT.30.0)) GO TO 85
      IF(TIME.GE.30.0) GO TO 86
      GO TO 78
   61 NM(1)=NM(1)+1
      GO TO 77
   62 NM(2)=NM(2)+1
      GO TO 77
   63 NM(3)=NM(3)+1
      GO TO 77
   64 NM(4)=NM(4)+1
      GO TO 78
   65 NM(5)=NM(5)+1
      GO TO 78
   66 NM(6)=NM(6)+1
      GO TO 78
   67 NM(7)=NM(7)+1
      GO TO 78
   68 NM(8)=NM(8)+1
      GO TO 78
   69 NM(9)=NM(9)+1
      GO TO 78
   71 NM(10)=NM(10)+1
      GO TO 78
   72 NM(11)=NM(11)+1
      GO TO 78
   73 NM(12)=NM(12)+1
      GO TO 78
```

```
   74 NM(13)=NM(13)+1
      GO TO 78
   75 NM(14)=NM(14)+1
      GO TO 78
   76 NM(15)=NM(15)+1
      GO TO 78
   81 NM(16)=NM(16)+1
      GO TO 78
   82 NM(17)=NM(17)+1
      GO TO 78
   83 NM(18)=NM(18)+1
      GO TO 78
   84 NM(19)=NM(19)+1
      GO TO 78
   85 NM(20)=NM(20)+1
      GO TO 78
   86 NM(21)=NM(21)+1
      GO TO 78
C
C     CONSTRUCTS A FREQUENCY DISTRIBUTION FOR 16 (.04 SEC WIDE) BINS COM-
C     PRISING TIME BINS N1,N2 AND PART OF N3.
C
   77 IF(TIME.EQ..04) MM(1)=MM(1)+1
      IF(TIME.EQ..08) MM(2)=MM(2)+1
      IF(TIME.EQ..12) MM(3)=MM(3)+1
      IF(TIME.EQ..16) MM(4)=MM(4)+1
      IF(TIME.EQ..20) MM(5)=MM(5)+1
      IF(TIME.EQ..24) MM(6)=MM(6)+1
      IF(TIME.EQ..28) MM(7)=MM(7)+1
      IF(TIME.EQ..32) MM(8)=MM(8)+1
      IF(TIME.EQ..36) MM(9)=MM(9)+1
      IF(TIME.EQ..40) MM(10)=MM(10)+1
      IF(TIME.EQ..44) MM(11)=MM(11)+1
      IF(TIME.EQ..48) MM(12)=MM(12)+1
      IF(TIME.EQ..52) MM(13)=MM(13)+1
      IF(TIME.EQ..56) MM(14)=MM(14)+1
      IF(TIME.EQ..60) MM(15)=MM(15)+1
      IF(TIME.EQ..64) MM(16)=MM(16)+1
   78 CTIME=CTIME+TIME
      NUM=NUM+1
      XTIME(NUM)=TIME
      WRITE(6,3) NUM,TIME
      NTL=0
      GO TO 222
  223 NTL=NTL+1
  222 CONTINUE
      XX=FLOAT(NUM)
C
```

```
C  COMPUTES THE PERCENTAGE OF EACH TIME BIN'S DEVIATIONS TO THE TOTAL
C  NUMBER OF DEVIATIONS FOR THAT SIGNAL WAVEFORM (FREQ BIN) AND ROUNDS
C  UP OR DOWN AS APPROPRIATE.
C
      DO 910 I=1,21
      X(I)=(NM(I)/XX)*100
      KM(I)=IFIX(X(I))
      U=X(I)-FLOAT(KM(I))
      IF(U.GE..5) KM(I)=KM(I)+1
  910 CONTINUE
      DO 920 I=1,16
      XM(I)=(MM(I)/XX)*100
      KMM(I)=IFIX(XM(I))
      UM=XM(I)-FLOAT(KMM(I))
      IF(UM.GE..5) KMM(I)=KMM(I)+1
  920 CONTINUE
C
C  COMPUTES TOTAL DATA SET ELAPSED TIME (CCTIME).
C
      TTIME=NTL*.04
      CCTIME=CTIME+TTIME
      WRITE(6,6) TTIME
      WRITE(6,16) CCTIME
      NX=0
C
C  IDENTIFIES THE NUMBER OF TIMES DISCRETE ADJACENT SIGNAL SAMPLES
C  DIFFER BY "NDB" DECIBELS OR MORE AND COMPUTES THE NUMBER OF SUCH DEV-
C  IATIONS.
C
      DO 333 JL=1,NRE
      IF((JPT(JL+1)-NDB).LT.JPT(JL).AND.(JPT(JL+1)+NDB).GT.JPT(JL)) GO
     1TO 333
      NX=NX+1
  333 CONTINUE
C
C  COMPUTES THE AVERAGE AND STANDARD DEVIATION FOR THE ELAPSED TIMES.
C
      TSAVE=0
      TAVE=CCTIME/NUM
      DO 444 J=1,NUM
      XT=(XTIME(J)-TAVE)**2
      TSAVE=TSAVE+XT
  444 CONTINUE
      STDDEV=(TSAVE/(NUM-1))**0.5
C
C  PRINTS FREQUENCY DISTRIBUTION DATA.
C
      WRITE(6,4) NDB,NX
```

```
WRITE(6,13) TAVE,STDDEV
WRITE(6,17)
WRITE(6,18)
WRITE(6,19) (NM(J),J=1,21)
WRITE(6,19) (KM(J),J=1,21)
WRITE(6,30)
WRITE(6,31)
WRITE(6,32) (MM(J),J=1,16)
WRITE(6,32) (KMM(J),J=1,16)
WRITE(6,20)
GO TO 5
END
```

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