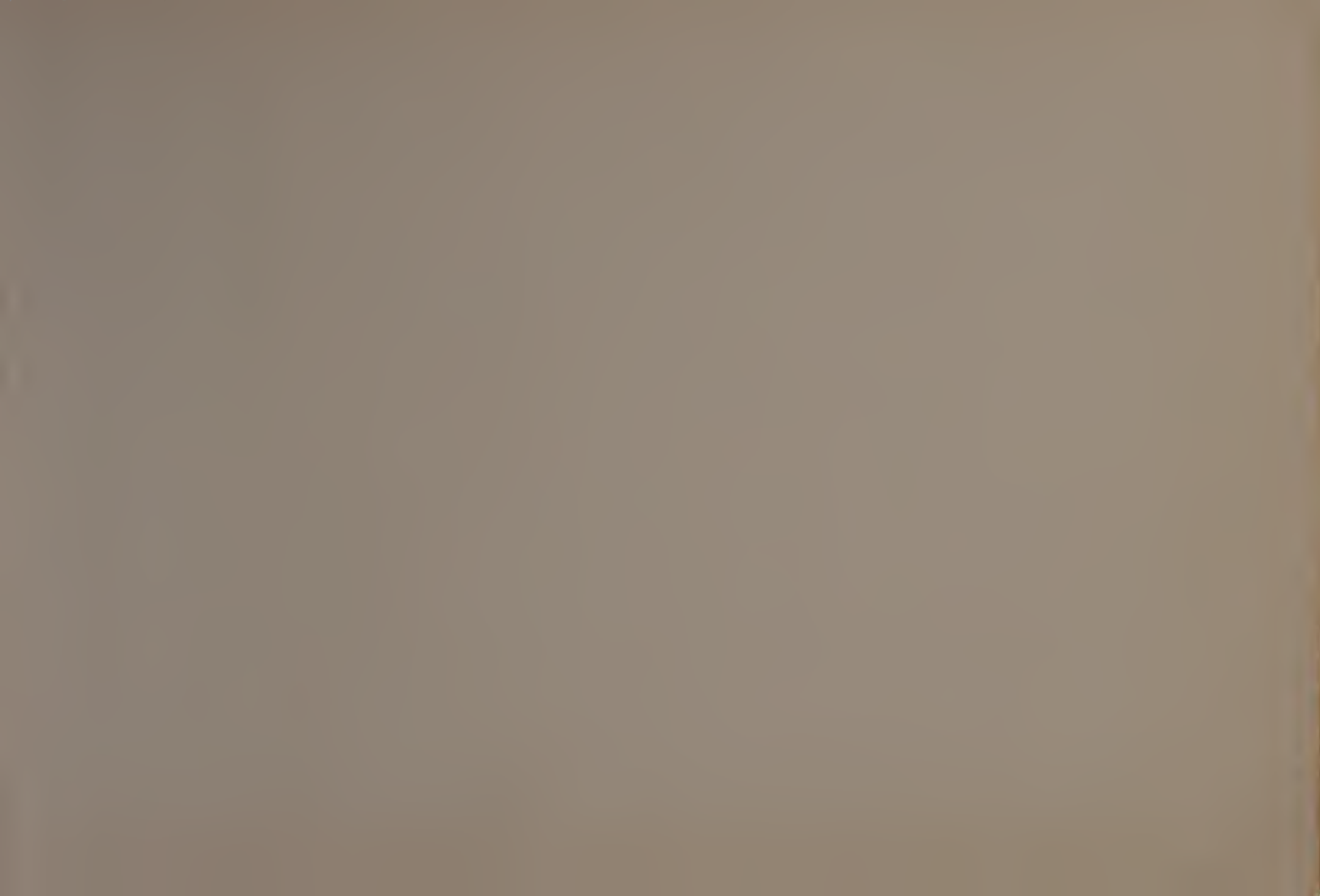
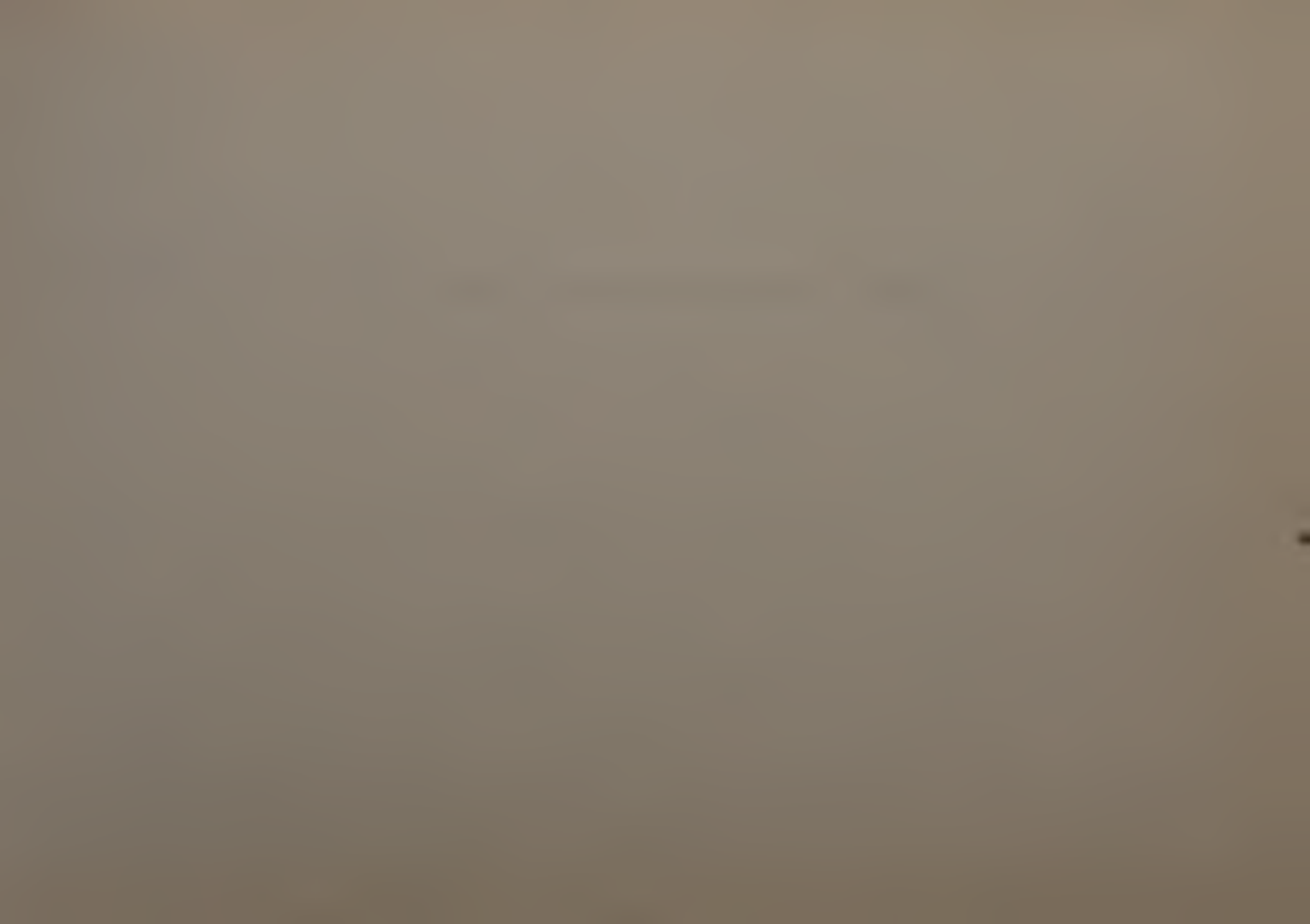


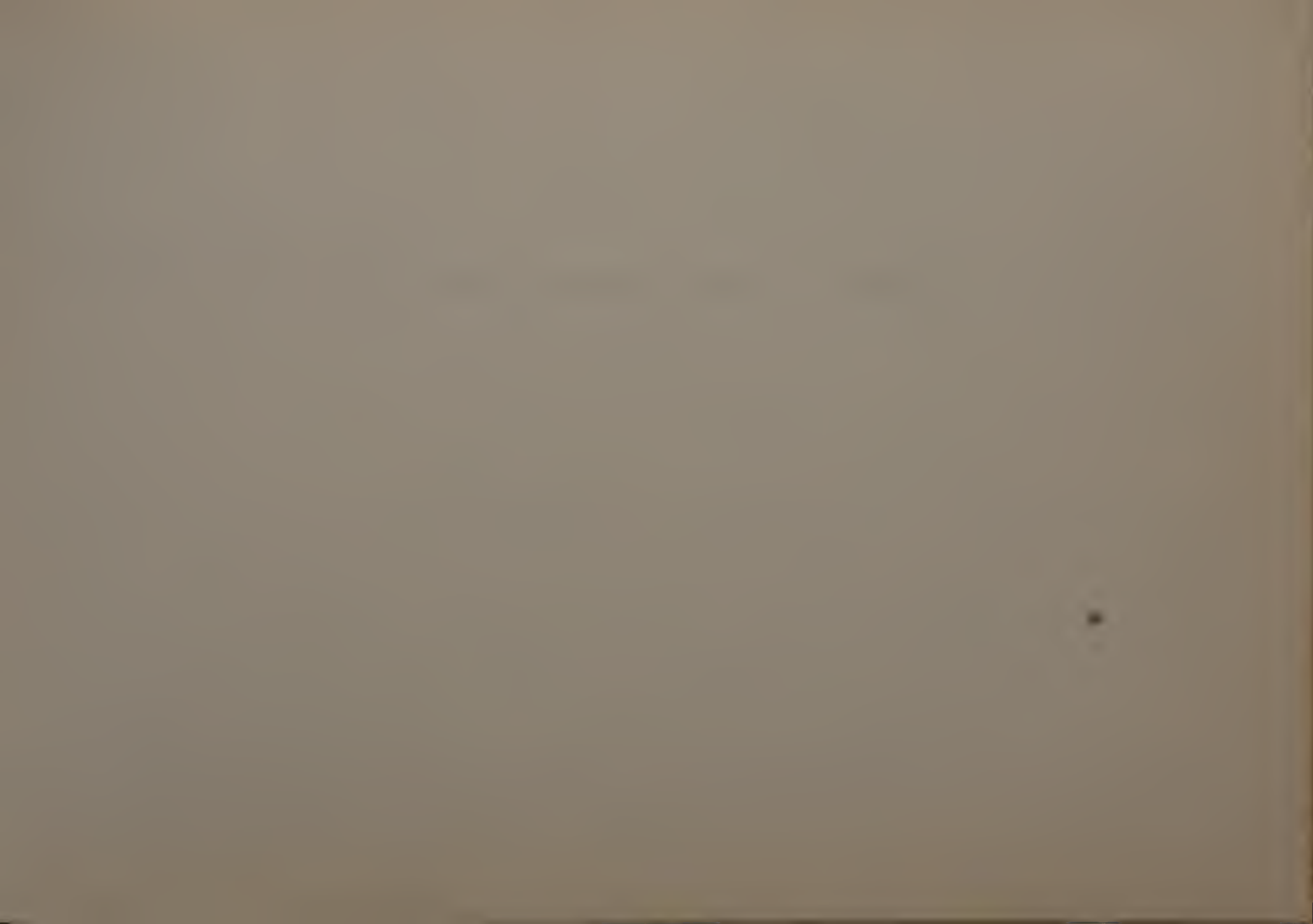
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Technical Note

Boulder Laboratories

PB 181454

No. 166

AN ATLAS OF WHISTLERS
AND VLF EMISSIONS

A SURVEY OF VLF SPECTRA
FROM BOULDER, COLORADO

BY

D. L. JONES, R. M. GALLET,
J. M. WATTS, D. N. FRAZER



U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

AUG 5 1965

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NATIONAL BUREAU OF STANDARDS

Technical Note

166

JANUARY 1963

AN ATLAS OF WHISTLERS AND VLF EMISSIONS
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BY

D. L. JONES, R. M. GALLET, J. M. WATTS, D. N. FRAZER

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AN ATLAS OF WHISTLERS AND VLF EMISSIONS
A SURVEY OF VLF SPECTRA FROM BOULDER, COLORADO

by

D. L. Jones, R. M. Gollet, J. M. Watts, D. N. Frozer
National Bureau of Standards, Boulder, Colorado

ABSTRACT

Naturally occurring VLF noises are classified and spectrograms illustrating each class are presented.

The report is divided into six sections. The first section consists of the systematic classification of VLF noises. Samples of whistlers and VLF emissions are shown in the second and third sections, respectively. The next section gives examples of interactions between these two classes. Section five consists of some exceptionally active periods during magnetic disturbances. The last section is a synoptic survey for the four months, March through June, 1957. A spectrogram is given for every observation period containing any VLF activity.

Most of the data was recorded at the Sunset Field Station of the National Bureau of Standards, Boulder, Colorado, during 1956-1957.

TABLE OF CONTENTS

INTRODUCTION	
SECTION I - SYSTEMATIC CLASSIFICATION OF VLF NOISES	1
VLF Noise Classification	2
Classes of Discrete VLF Emissions	3
SECTION II - WHISTLERS	4
Long Whistler with Twenty-one Separate Echoes	5
Multiple Echo Whistler	6
Whistlers Extending to Low Frequencies	7
Whistler Train with a Very Long Dispersion	8
Nose Whistlers	9
Dispersion Analysis of Whistlers	11
(Distinction made between multiple path and multiple flash)	
SECTION III - VLF EMISSIONS	17
Transition in the Slope of Hooks	18
Rising Tones	19
Rising Tones as Possible Degenerate Forms of Hooks	20
Chorus	21
Falling Tones	22
Quasi-Horizontal Tones	23
Pseudo Noses	24
Complex Events	25
Emission with a Train of Echoes	26
Echoing VLF Emission	27
Hiss	28
Transition from Hiss to Detailed Structure	30
SECTION IV - INTERACTIONS BETWEEN WHISTLERS AND VLF EMISSIONS	31
Risers Following a Whistler	32
Whistlers Followed by VLF Emissions	33
Hiss Triggered by a Whistler	34
Interactions	35
SECTION V - PERIODS SELECTED FOR THEIR VLF ACTIVITY	36
Events of 16-17 May 1956, associated with strong magnetic disturbance. Maximum $K_p = 8+$	37
Events of 16 September 1956, associated with weak magnetic disturbance. Maximum $K_p = 3^{\circ}$	48
Events of 25-26 October 1956, associated with moderate magnetic disturbance. Maximum $K_p = 7-$	50
Events of 9-14 November 1956, associated with moderate magnetic disturbance. Maximum $K_p = 7-$	56
Events of 30 June 1957, associated with strong magnetic disturbance. Maximum $K_p = 8+$	62
Events of 12 February 1958, associated with strong magnetic disturbance. Maximum $K_p = 9^{\circ}$	65
SECTION VI - FOUR-MONTH SYNOPSIS SURVEY OF VLF NOISES	66

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Notional Bureau of Standards, Boulder, Colorado

INTRODUCTION

It is the purpose of this atlas to present a comprehensive survey of the very low frequency (VLF) activity observed at a middle latitude station (Boulder, Colorado--geomagnetic latitude 40° N). The period covered is the year and one-half beginning in January 1956 and ending in June 1957; the period just prior to and in preparation for the International Geophysical Year (IGY). The two major groups of VLF activity, whistlers and VLF emissions, are shown in considerable detail, as well as a third rarer group consisting of whistler-VLF emission interactions. Certain periods of VLF activity associated with disturbances of the earth's magnetic field are also presented. The work which led to the material presented here was probably the first systematic study, with records and spectrograms of sufficiently good quality, of the characteristics of VLF emissions. It was principally on the basis of the data in this atlas that a classification of the types of VLF noises was developed [1,2]. This classification was important for organizing the observational program during the IGY.

A program of observation of whistlers and VLF emissions was initiated at the Boulder Laboratories of the National Bureau of Standards early in 1955. The equipment to detect and record these natural VLF noises was developed and installed in the summer of 1955 at the Sunset Field Site ($40^{\circ} 08' N$, $254^{\circ} 42' E$). The equipment design was similar to that used in the subsequent IGY whistler program [3] with the exception of the antenna which was a loop with an area of approximately $110,000 \text{ m}^2$.

The recording of a single spectrogram takes about five minutes and on the 0-8 kc/s display, represents only 2.4 seconds of data. Thus, if one entire two minute period were printed it would take about five hours. To complete a 24 hour day in this manner would require about one month. While it would be possible to operate a large number of spectrographs and obtain visual records of all the data, such a process would be extremely time-consuming and costly. However, this is not necessary since some recording periods contain no VLF events while others contain several. For instance, in the first half of 1957 a total of 4041 two-minute periods were recorded of which 137 contained discrete VLF emissions, and 255 contained hiss. Whistlers occurred at the average rate of 2.24 per minute throughout the year. Subsequent experience has shown that this does not represent an exceptionally high level of VLF activity.

By January 1956, the observation program was on a regular basis with magnetic tape samples being taken during two minutes of each hour. The magnetic tapes were then monitored aurally and dynamic spectrograms of the selected events were obtained with a sound spectrograph. The data are displayed with frequency in ordinate and time in abscissa. Normally, the frequency range 0-8 kc/s is examined, but in some special cases, the ranges 0-4 kc/s, 0-16 kc/s, and 0-32 kc/s are studied (in this atlas, the respective frequency and time scales are indicated for each spectrogram).

A large fraction of the present material was already available



early in 1957, and a preliminary atlas was assembled and distributed in limited circulation to groups actively engaged in the preparation of VLF programs for the coming IGY. The present atlas is a more complete version of that earlier work, containing nearly three times as much data. That early period was very fruitful. As a propagation phenomenon the whistlers disclosed the extension of the outer atmosphere of the earth, and later permitted to give a reasonably accurate model of the electron density distribution to distances as large as four or five earth's radii. The VLF emissions disclosed the presence of bunches and streams of high energy electrons producing electromagnetic waves of well-defined VLF frequencies far out in the exosphere of the earth. The theory of the emission mechanism, combined with the observed characteristics, gave the first quantitative indication of the velocities and energies of the high energy particles. These discoveries were made prior to the era of direct measurements by means of the satellites and space probes which revealed the existence and structure of the Van Allen radiation belts. Using more recent and sophisticated techniques, the experimental work has uncovered a wealth of more complex VLF phenomena than those presented here, and the present authors intend to produce a specialized complementary publication dealing with these phenomena. Notwithstanding the newer developments, it is felt that this atlas can serve as a useful reference for the basic VLF phenomena.

The atlas is divided into six sections. The first section consists of the systematic classification of VLF noises. The next three sections follow the outline of the classification of VLF emissions presented in Section 1. Section 2 on whistlers contains: whistlers with multiple echoes, nose whistlers, and dispersion measurements of the several types of whistlers. Section 3, on VLF emissions illustrates in detail, various classes of discrete VLF emissions. Whistler-VLF emission interactions are presented in Section 4. Periods selected for their VLF

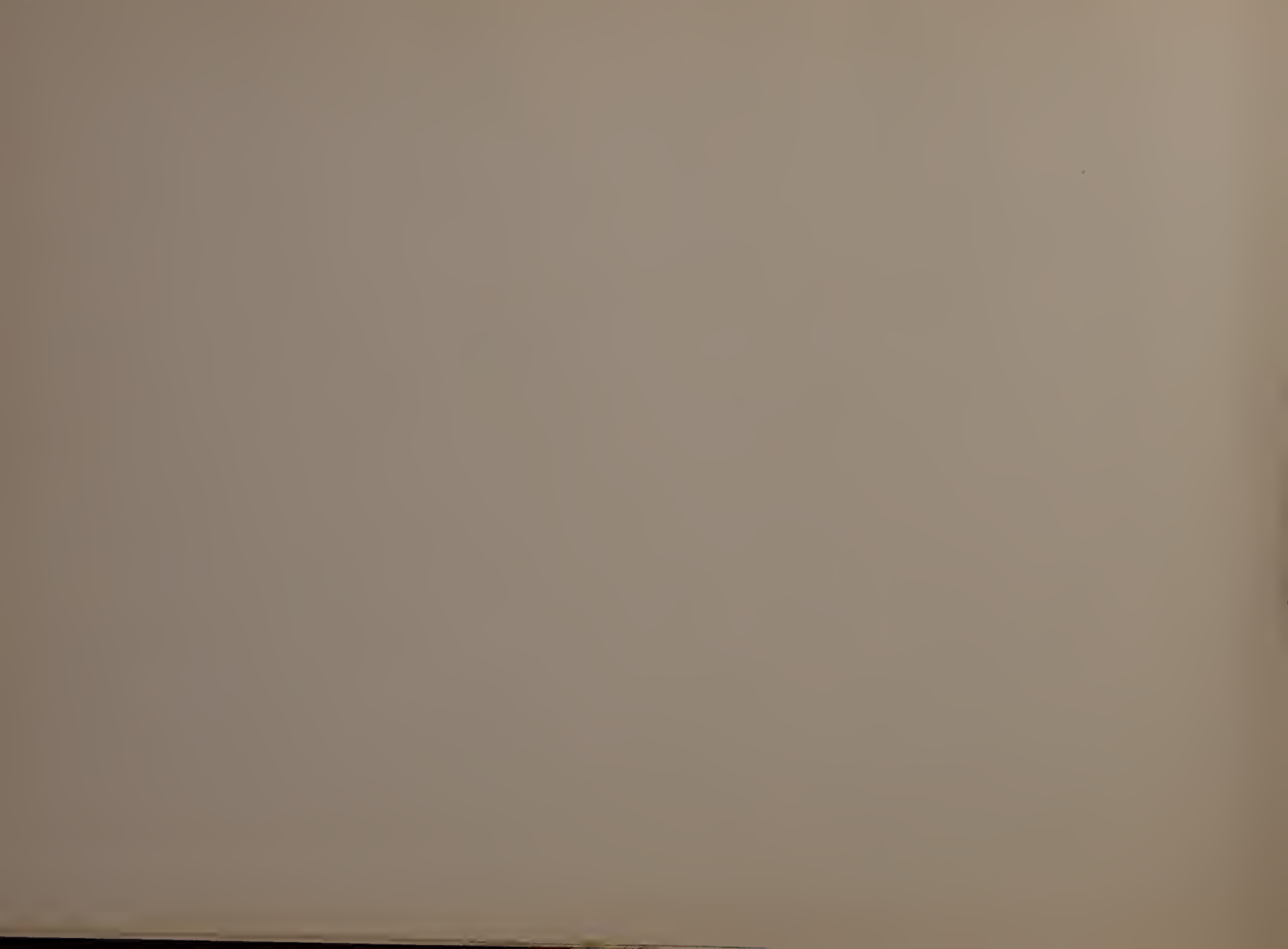
activity which also coincide with magnetic disturbances are presented in Section 5. Section 6 gives a four-month synoptic survey of both whistlers and VLF emissions. Beginning March 2, 1957, at least one sonagram is shown for each period that contains an audible VLF noise. In addition to the samples previously classified, this section shows the typical evolution of the VLF activity over a considerable period of time.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the valuable assistance of Miss Jean Koch in the preparation of this atlas.

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1. Gallet, R. M., and D. L. Jones, A systematic classification of natural VLF noises other than whistlers, presented at URSI Spring meeting, Washington, D. C. (May 1957).
2. Gallet, R. M., The very low frequency emissions generated in the earth's exosphere, Proc. IRE, 47, No. 2, pp. 211-231 (Feb. 1959).
3. Helliwell, R. A., and D. L. Carpenter, Whistlers-West IGY-IGC synoptic program, Final Report prepared under NSF Grants IGY 6.10/20 and G-8839, Stanford Univ. (Mar. 20, 1961).



SECTION I

SYSTEMATIC CLASSIFICATION OF VLF NOISES

SYSTEMATIC CLASSIFICATION OF OBSERVED VLF NOISES

Two Major Groups:

I. WHISTLERS - Cause: Lightning Discharges

All frequencies emitted at once; shape due to dispersion along the path.

II. VLF EMISSIONS - Not caused by lightning.

Strongly associated with magnetic perturbations.

TWO PRINCIPAL TYPES:

1. Continuous in both time and frequency.

Steady state situation. Hiss

2. Discrete, but often with repetition tendency

Transient situation Many classes recognized.

A Third Rarer and More Complex Group Exists

III. Interactions between Whistlers and VLF emissions

1. Continuous

a. Enhancement of whistler echoes with hiss




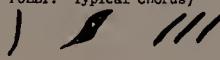






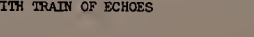
b. Whistler triggering hiss

2. Discrete

a. VLF emission preceding whistler

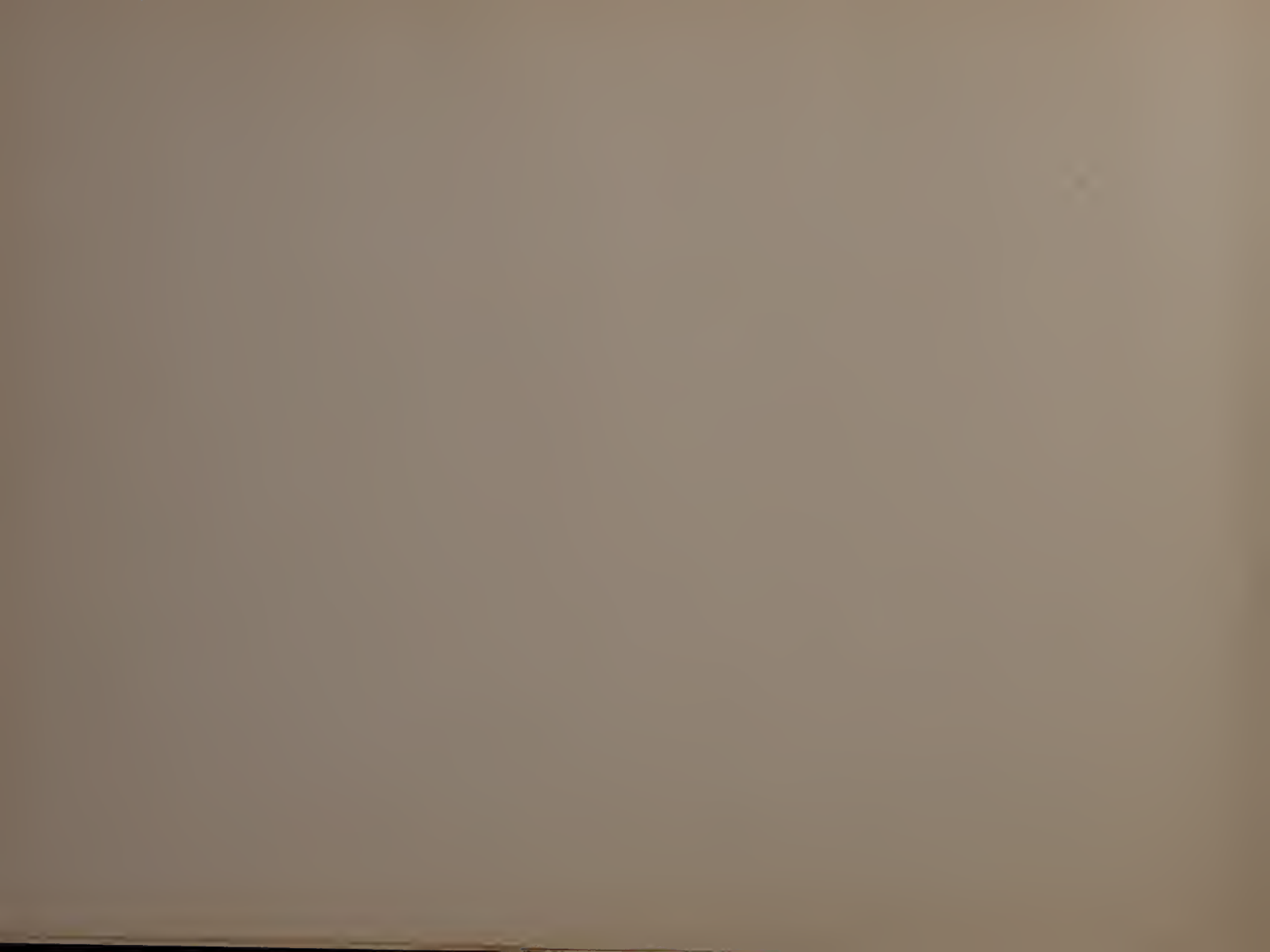
b. VLF emission following whistler

II. 2. CLASSES OF DISCRETE VLF EMISSIONS:

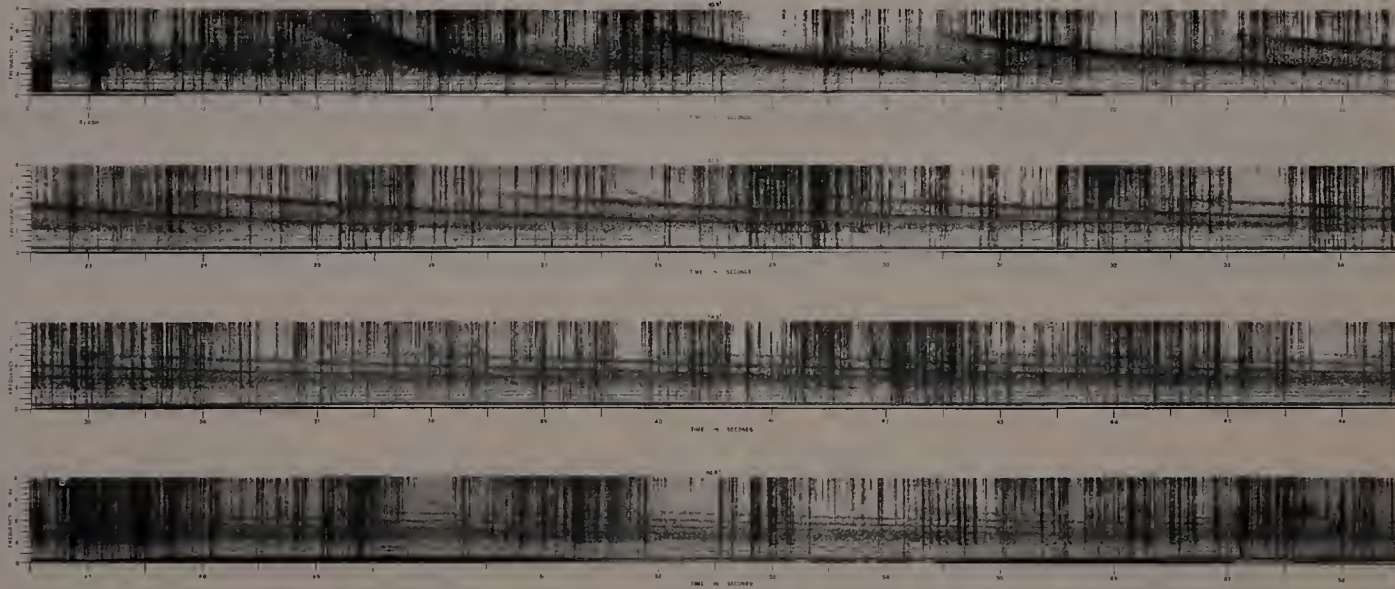
1. HOOKS 
2. RISERS 
- 2B. HOOK WITH EXTENDED RISING TAIL 
3. QUASI VERTICAL (Generally FUZZY. Typical Chorus) 
4. FALLING TONES 
- 4B. PSEUDO WHISTLERS 
5. QUASI HORIZONTAL 
- 5B. COMBINATION OF 4 AND 5 
6. PSEUDO NOSES (by analogy with nose whistlers) 
7. TOO COMPLEX FOR THE PRECEDING CLASSES 
8. EXCEPTIONAL STRONG NOISES WITH TRAIN OF ECHOES 

SECTION II

WHISTLERS



LONG WHISTLER WITH TWENTY-ONE SEPARATE ECHOES
6 APRIL 1957
0435 UT



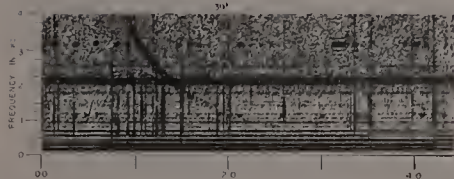
MULTIPLE ECHO WHISTLER

3 MARCH 1956
0440 UT

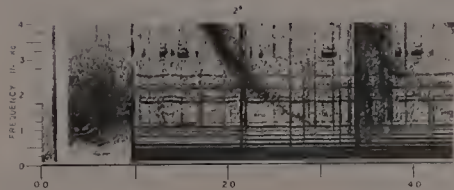


WHISTLERS EXTENDING TO LOW FREQUENCIES

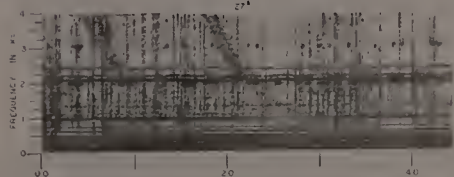
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0435 UT



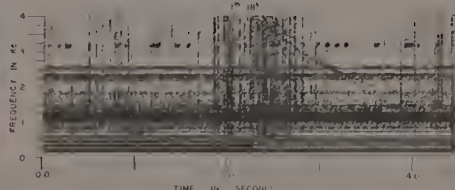
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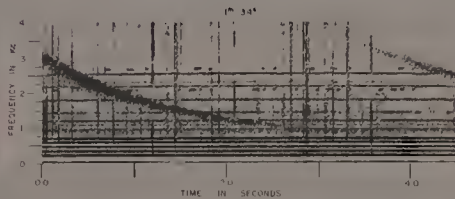
9 FEBRUARY 1957
1035 UT



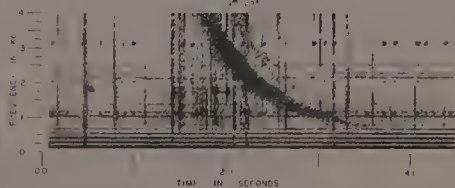
22 JANUARY 1957
2115 UT



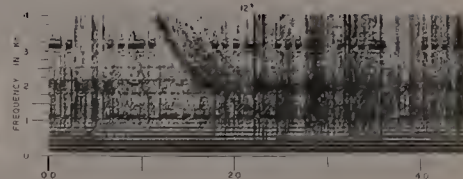
5 FEBRUARY 1957
0335 UT



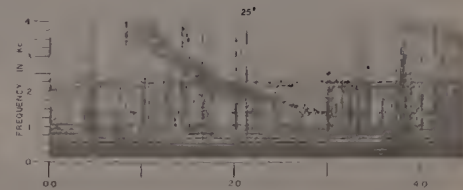
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0435 UT



28 JANUARY 1957
0835 UT



6 FEBRUARY 1957
0935 UT

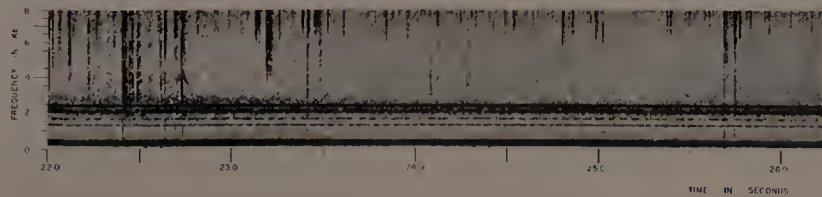
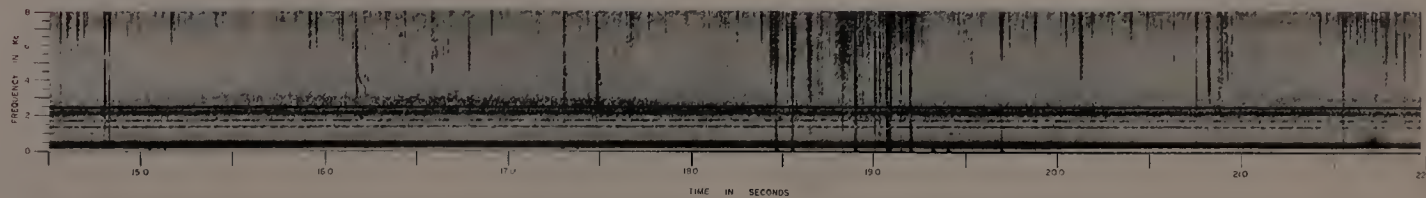
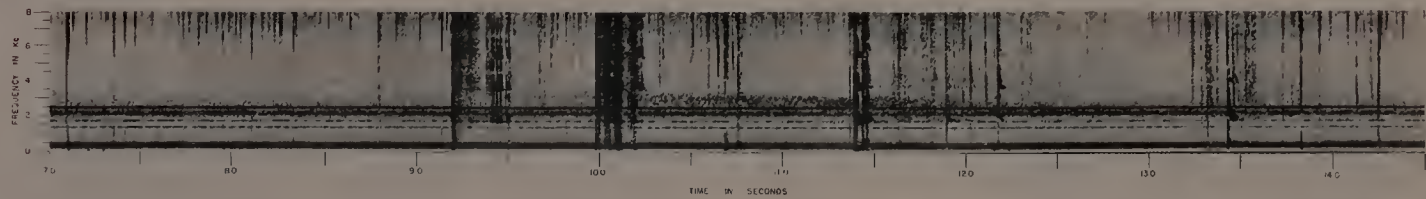
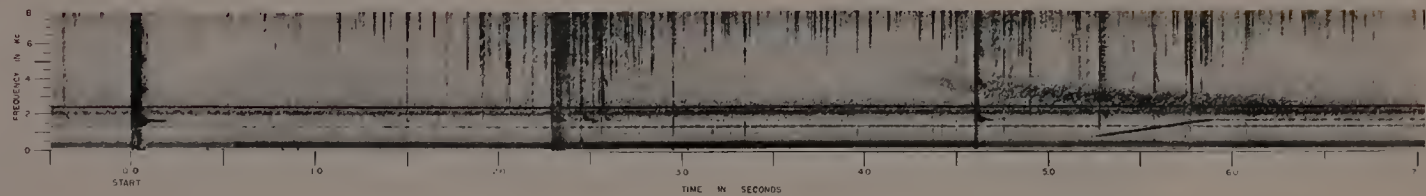


22 FEBRUARY 1957
1135 UT



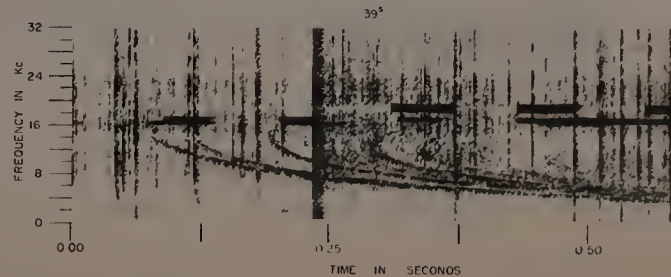
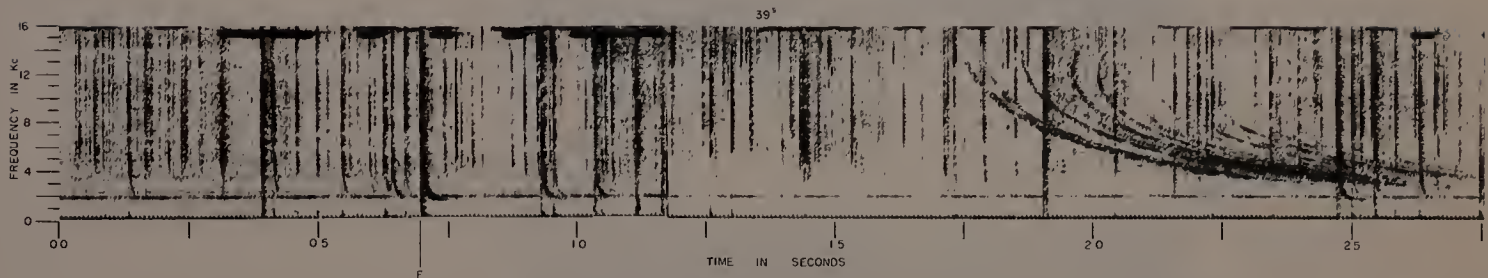
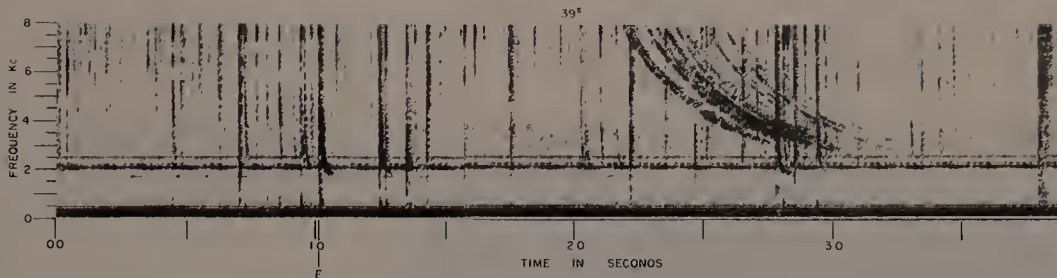
WHISTLER TRAIN WITH A VERY LONG DISPERSION ($D=150$)

8 DECEMBER 1956 0435 UT



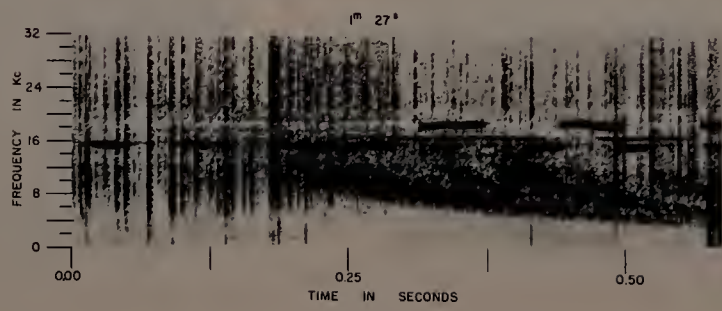
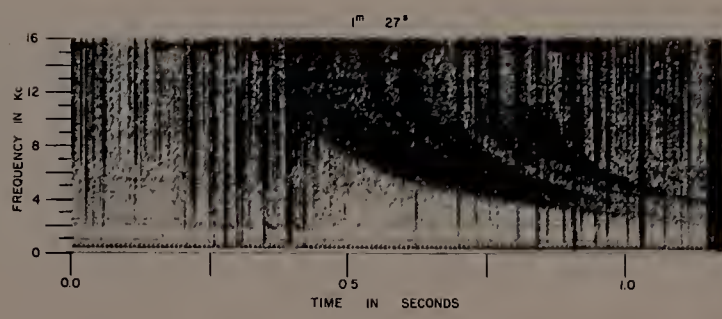


NOSE WHISTLER
20 JANUARY 1957
0535 UT



NOSE WHISTLER

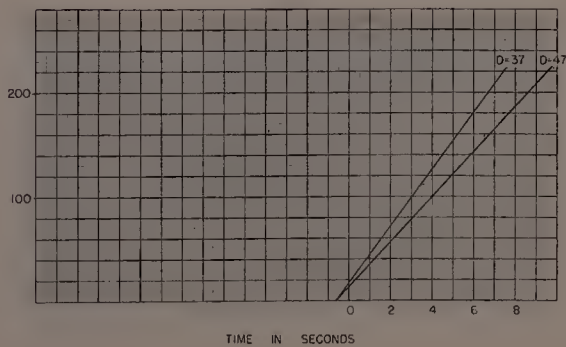
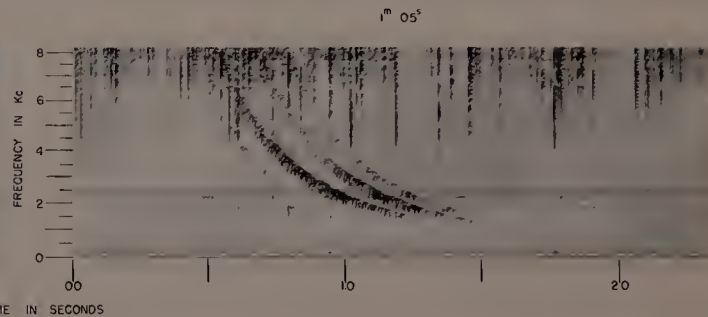
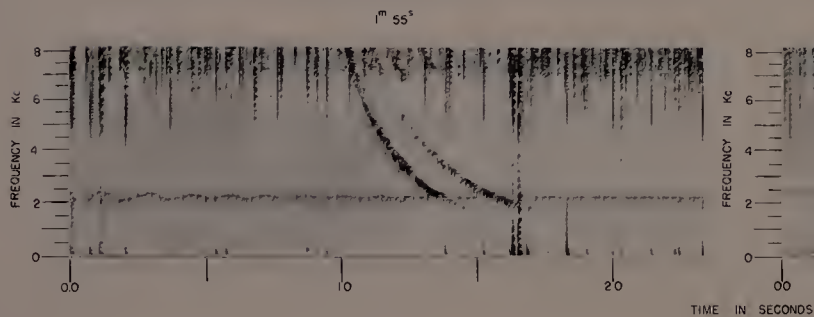
25 JANUARY 1957
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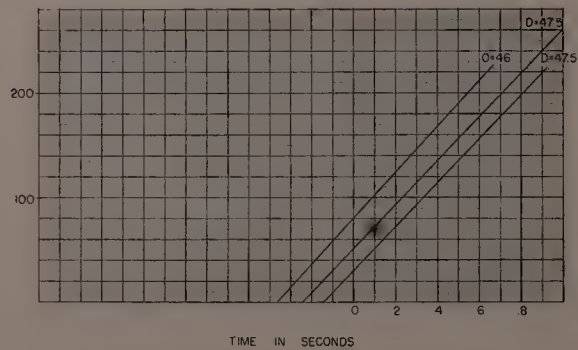
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17 MAY 1956
2235 UT

18 MAY 1956
0035 UT



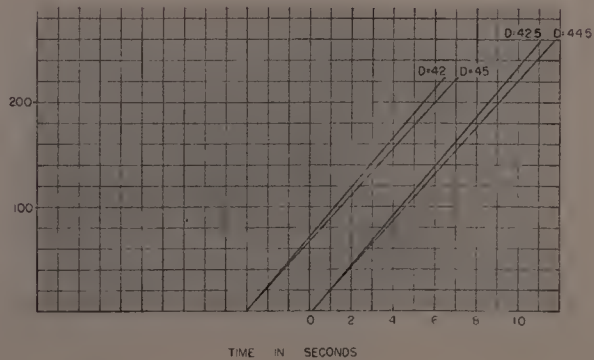
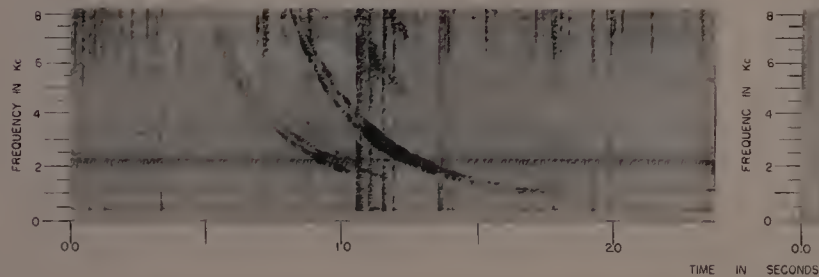
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TYPE SHORT MF

18 MAY 1956
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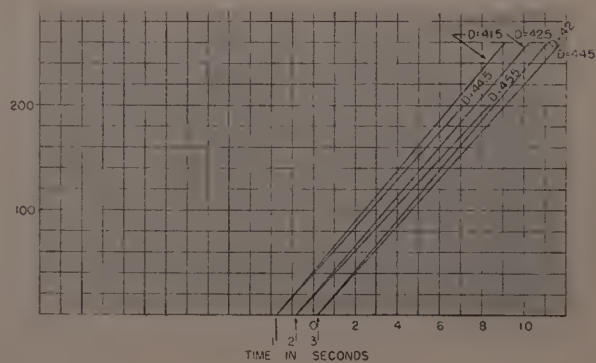
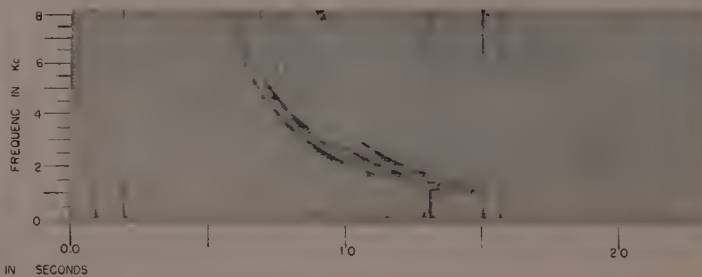
54°



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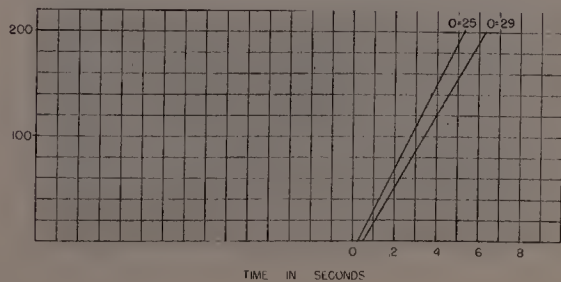
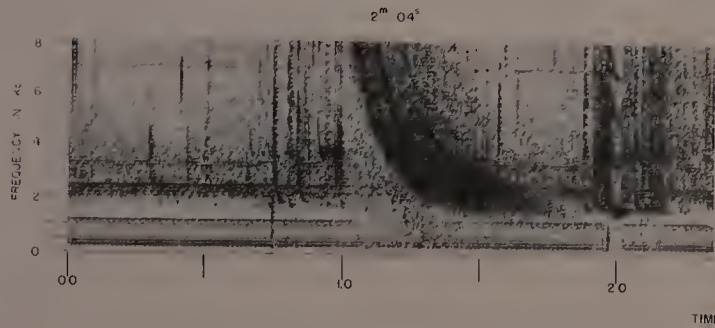
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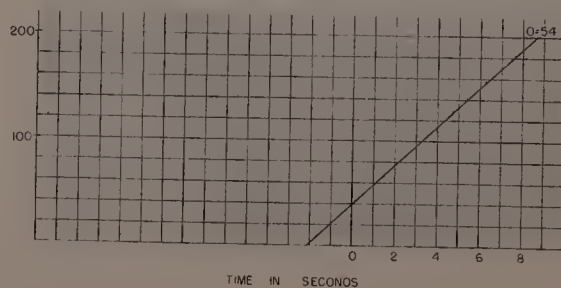
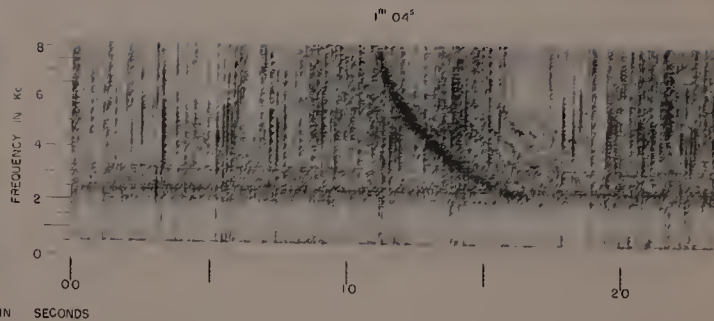


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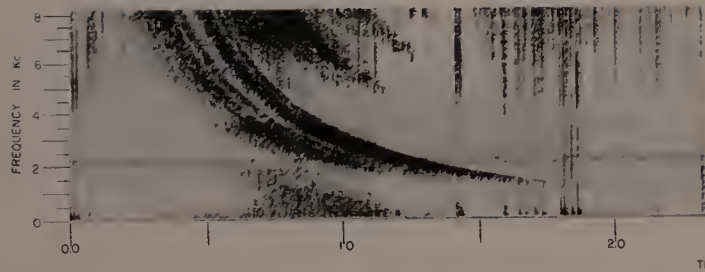
21 MAY 1956
1235 UT



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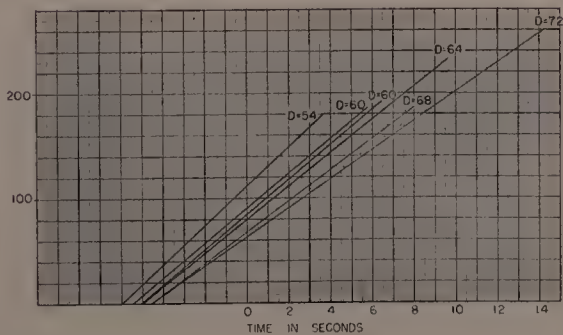
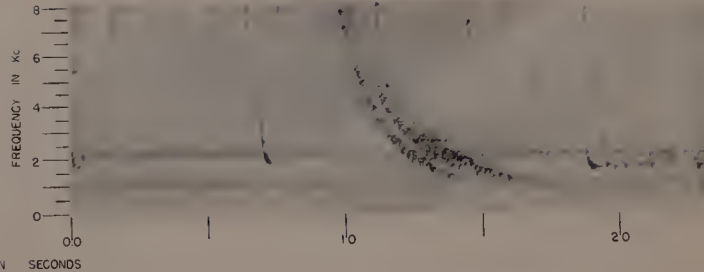
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0140 UT

23°

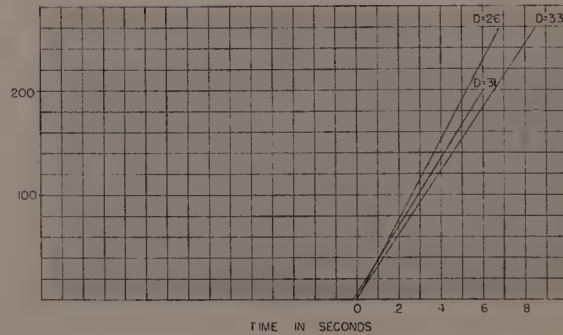


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20°



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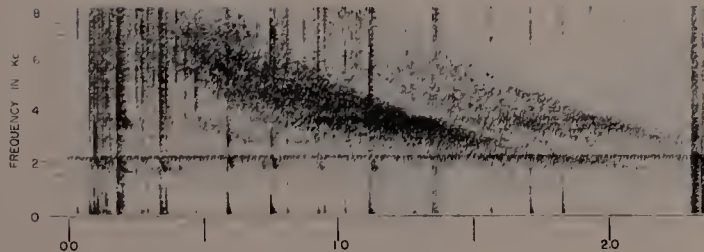


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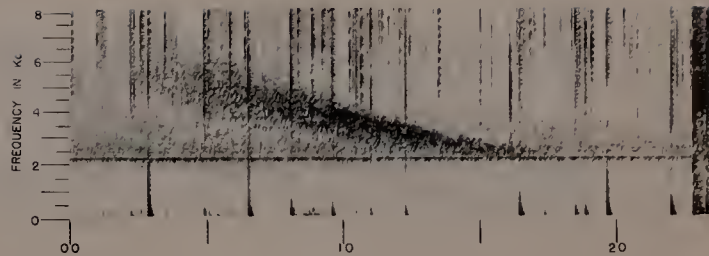
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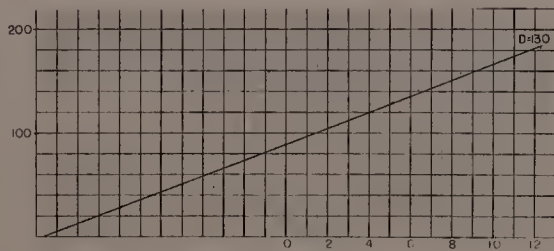


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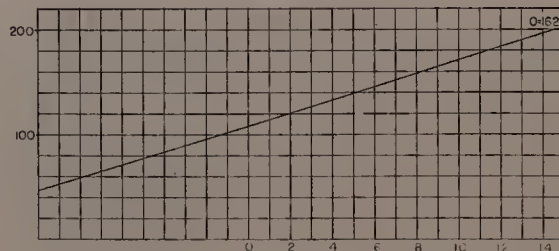


TIME IN SECONDS



TIME IN SECONDS

TYPE LONG

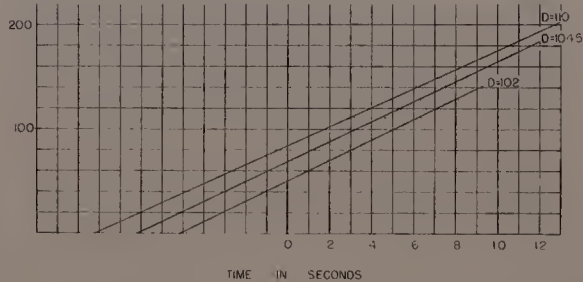
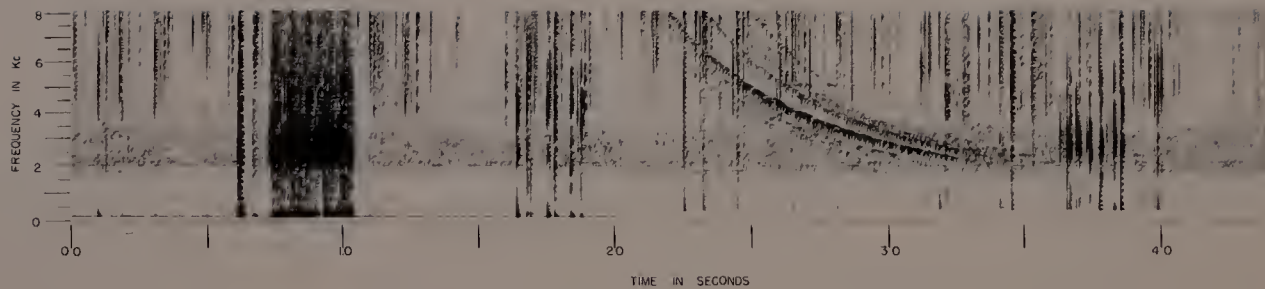


TIME IN SECONDS

TYPE LONG

25 JUNE 1956
1735 UT

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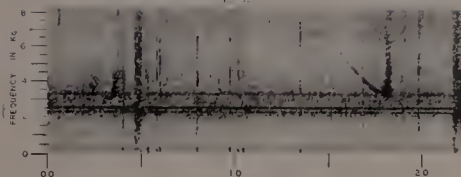
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SECTION III

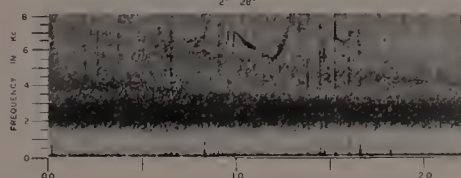
VLF EMISSIONS

TRANSITION OF THE SLOPES IN HOOKS

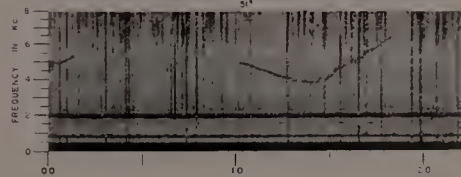
16 MAY 1956
1335 UT



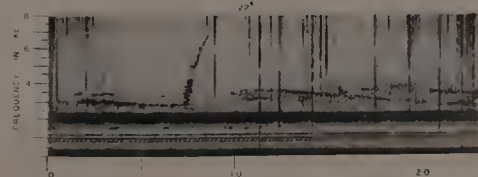
17 MAY 1956
0135 UT



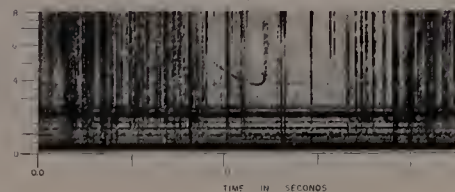
16 SEPTEMBER 1956
1835 UT



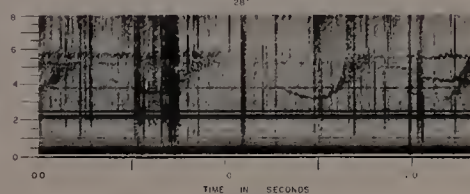
26 OCTOBER 1956
2230 UT



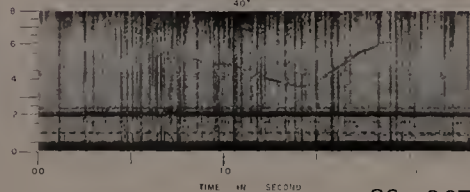
10 NOVEMBER 1956
1235 UT



29 OCTOBER 1956
1135 UT



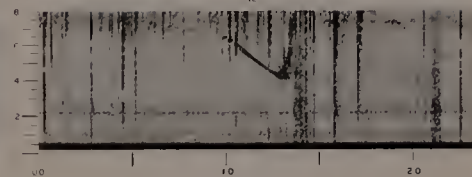
16 SEPTEMBER 1956
1835 UT



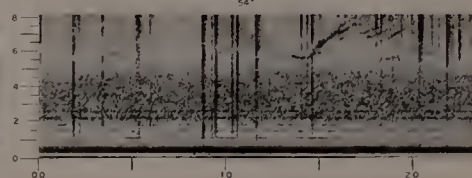
26 OCTOBER 1956
2230 UT



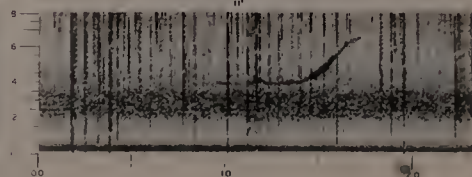
12 NOVEMBER 1956
2335 UT



24 NOVEMBER 1956
1135 UT

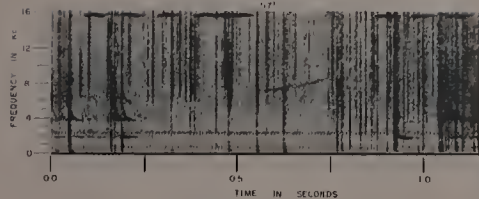


25 NOVEMBER 1956
0435 UT

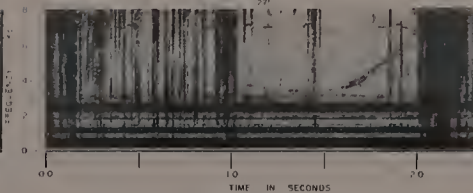


RISING TONES

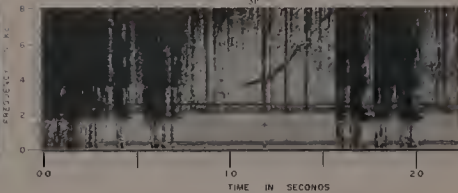
27 OCTOBER 1956
0735 UT



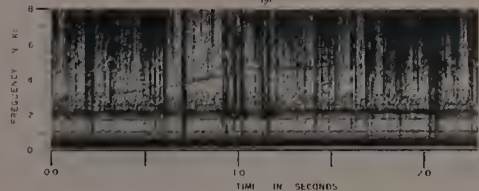
8 OCTOBER 1956
2235 UT



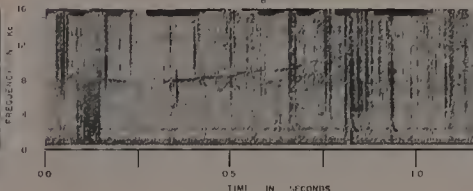
13 DECEMBER 1956
0735 UT



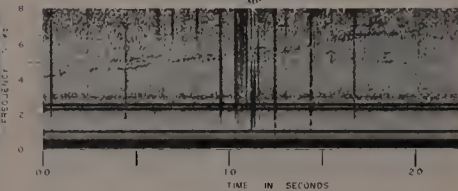
1 FEBRUARY 1957
0735 UT



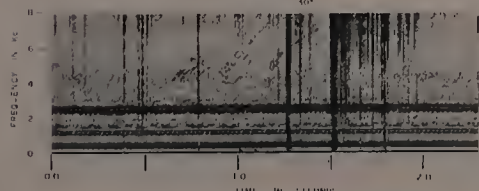
12 NOVEMBER 1956
2335 UT



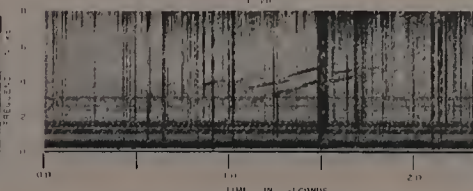
25 DECEMBER 1956
2235 UT



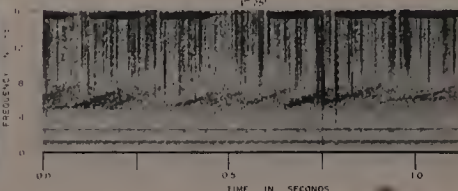
13 DECEMBER 1956
2135 UT



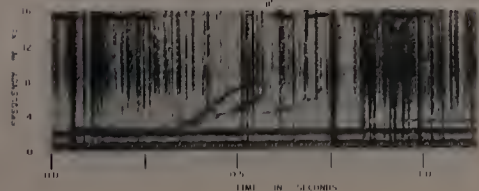
9 NOVEMBER 1956
2035 UT



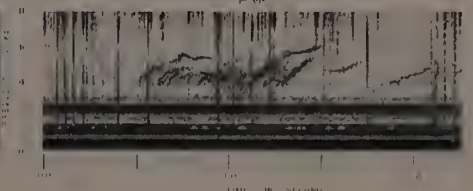
21 JANUARY 1957
1635 UT



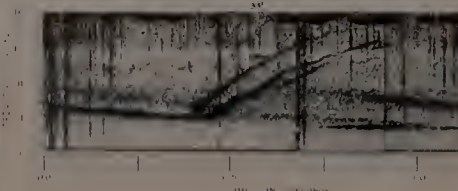
26 OCTOBER 1956
2230 UT



16 NOVEMBER 1956
2135 UT

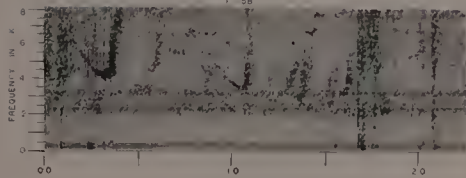


14 NOVEMBER 1956
2335 UT

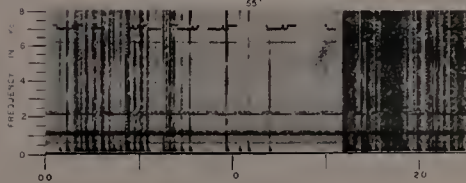


RIISING TONES AS POSSIBLE DEGENERATE FORMS OF HOOKS

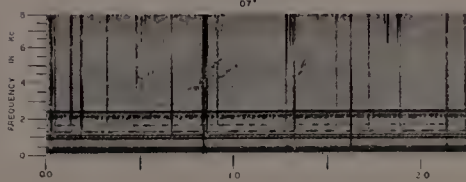
16 MAY 1956
1335 UT



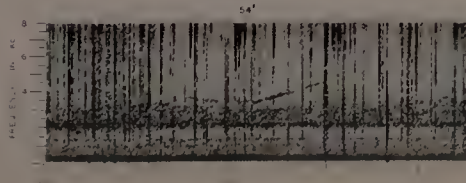
8 SEPTEMBER 1956
1435 UT



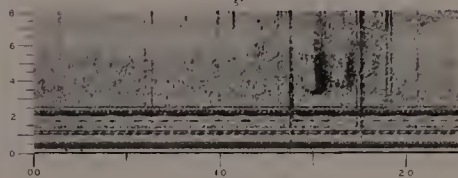
12 NOVEMBER 1956
1935 UT



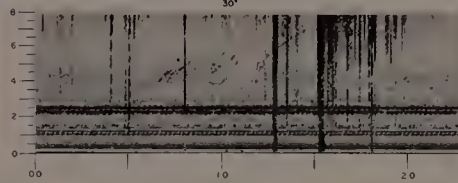
24 NOVEMBER 1956
0635 UT



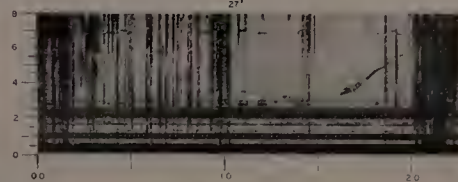
12 NOVEMBER 1956
1535 UT



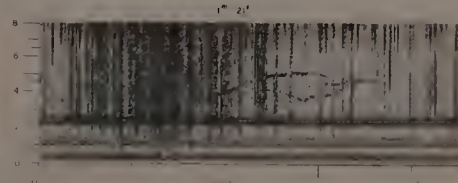
13 DECEMBER 1956
2135 UT



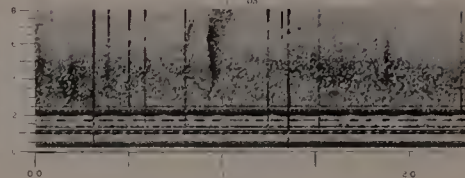
8 OCTOBER 1956
2235 UT



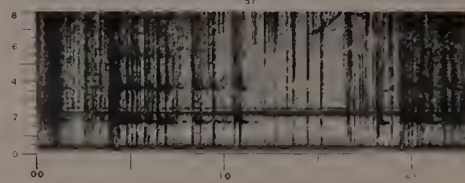
20 NOVEMBER 1956
1935 UT



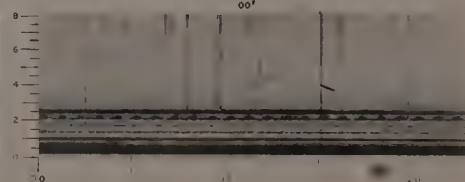
12 NOVEMBER 1956
1535 UT



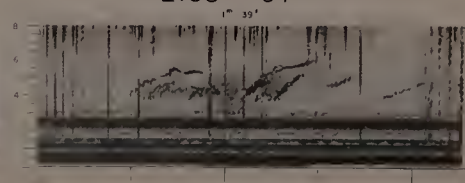
27 OCTOBER 1956
0735 UT



25 OCTOBER 1956
1535 UT

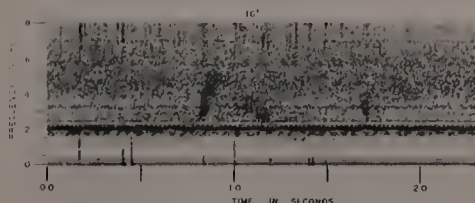


13 NOVEMBER 1956
2135 UT

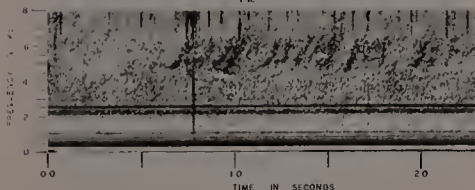


CHORUS

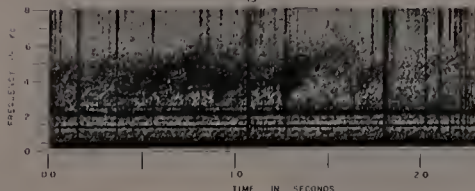
16 MAY 1956
1835 UT



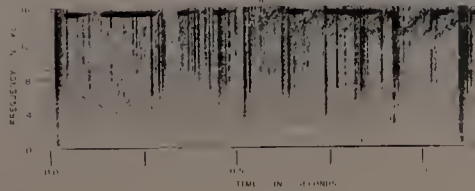
10 MARCH 1957
1235 UT



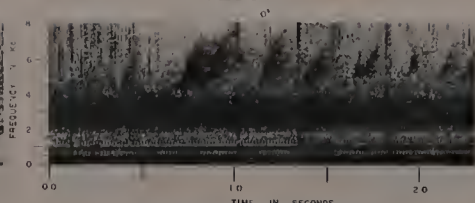
10 NOVEMBER 1956
1335 UT



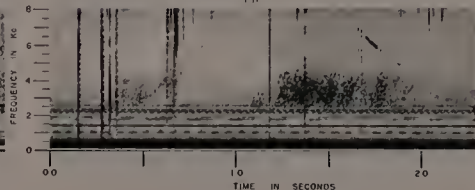
5 FEBRUARY 1957
1335 UT



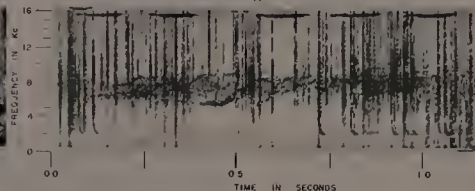
15 MAY 1956
1235 UT



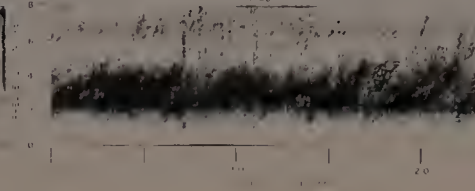
21 OCTOBER 1956
1335 UT



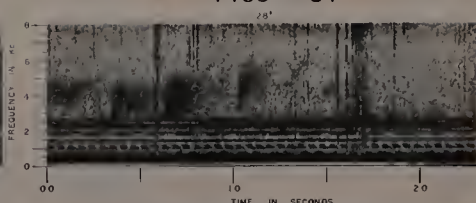
6 APRIL 1957
0135 UT



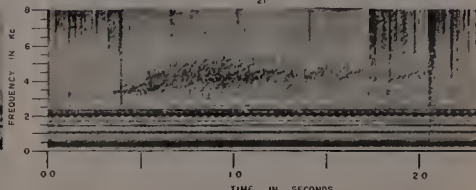
25 MAY 1957
1235 UT



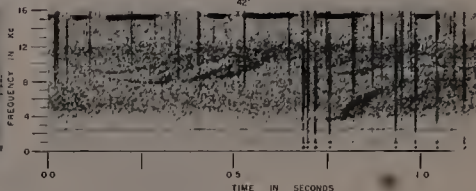
28 OCTOBER 1956
1435 UT



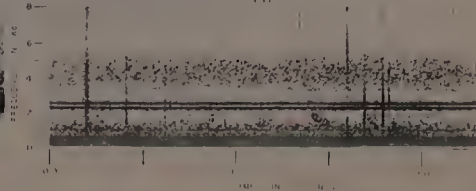
6 APRIL 1957
2335 UT



10 MARCH 1957
1435 UT

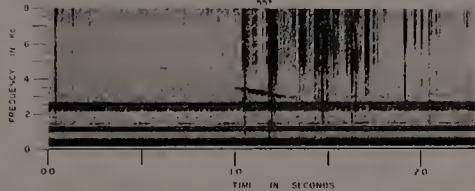


22 SEPTEMBER 1956
1635 UT

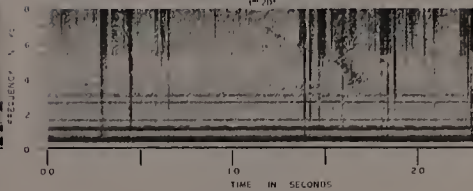


FALLING TONES

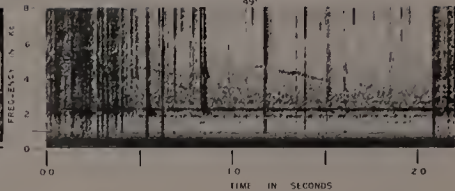
2 JANUARY 1957
2235 UT



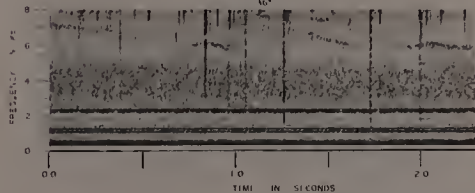
6 FEBRUARY 1957
2235 UT



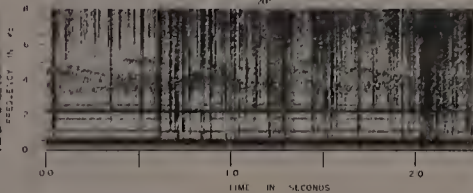
16 MARCH 1957
0535 UT



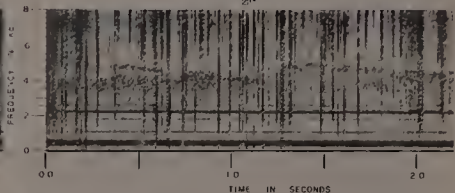
13 FEBRUARY 1957
1935 UT



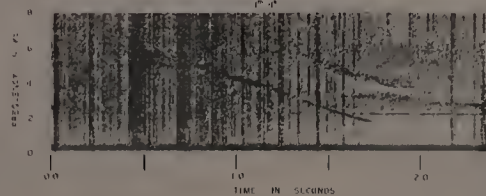
23 FEBRUARY 1957
2135 UT



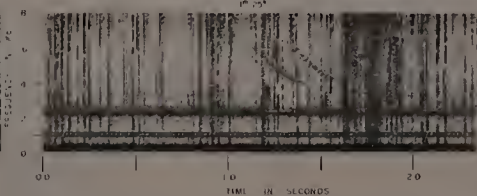
23 FEBRUARY 1957
2135 UT



14 NOVEMBER 1956
2335 UT

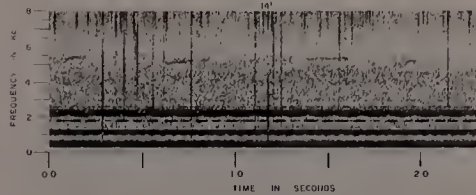


20 SEPTEMBER 1956
2035 UT

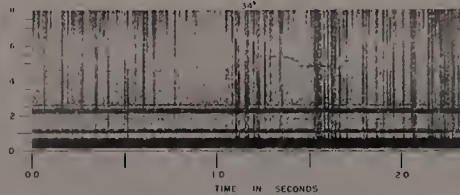


QUASI-HORIZONTAL TONES

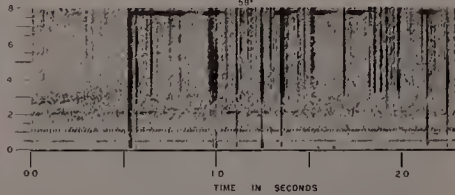
7 FEBRUARY 1957
1735 UT



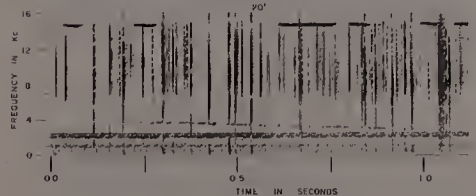
16 SEPTEMBER 1956
1835 UT



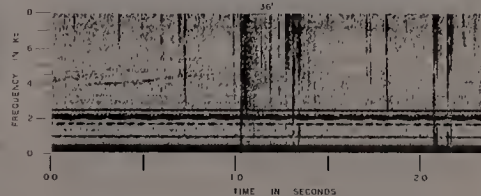
24 NOVEMBER 1956
1435 UT



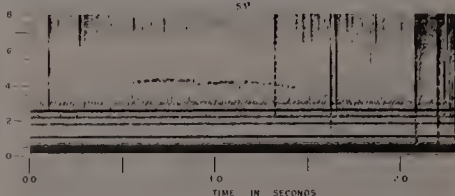
26 OCTOBER 1956
2235 UT



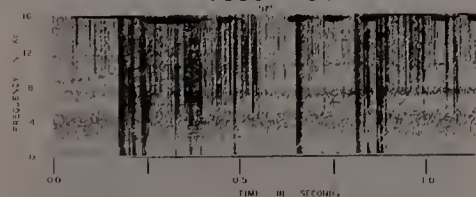
26 DECEMBER 1956
0135 UT



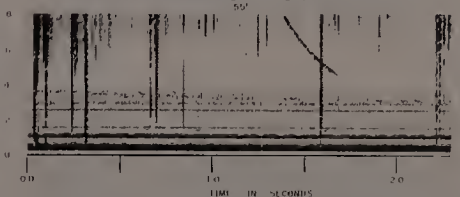
27 JANUARY 1957
2235 UT



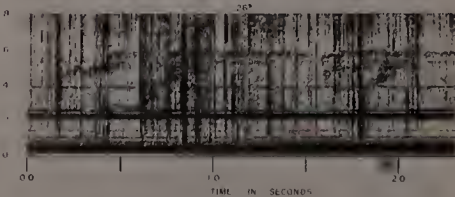
24 NOVEMBER 1956
1035 UT



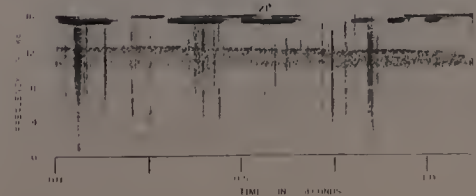
6 FEBRUARY 1957
2235 UT



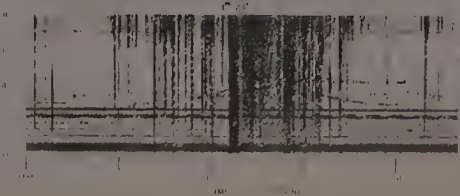
29 OCTOBER 1956
1135 UT



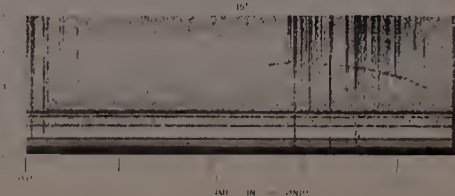
5 FEBRUARY 1957
0035 UT



20 NOVEMBER 1956
1835 UT



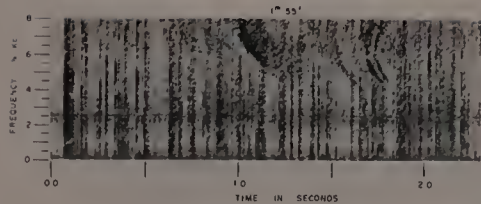
25 DECEMBER 1956
2335 UT



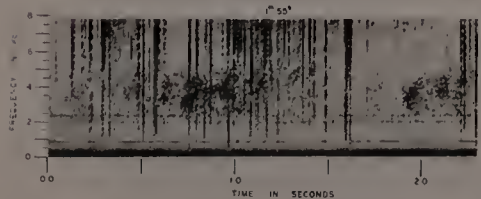


PSEUDO-NOSES

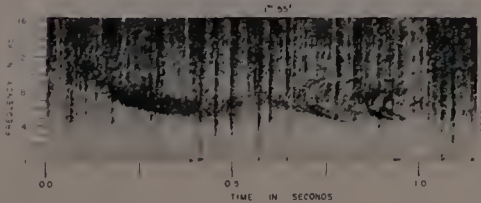
14 AUGUST 1956
1435 UT



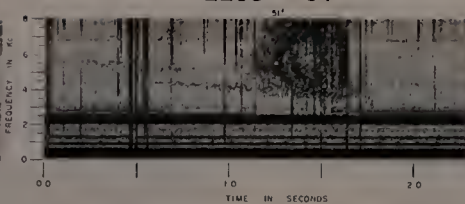
25 MARCH 1957
1235 UT



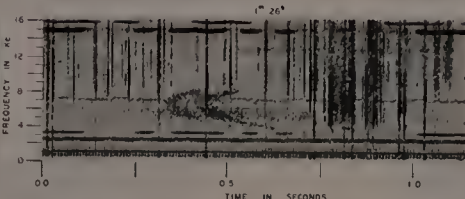
14 AUGUST 1956
1435 UT



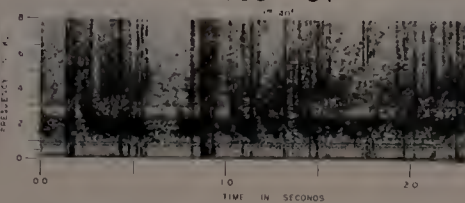
26 OCTOBER 1956
2235 UT



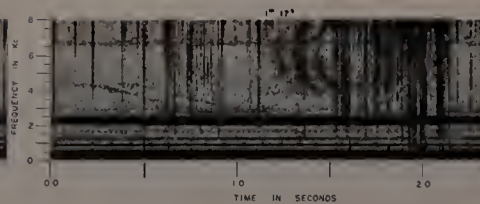
26 OCTOBER 1956
2235 UT



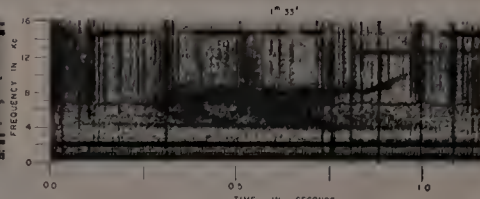
16 MAY 1956
0735 UT



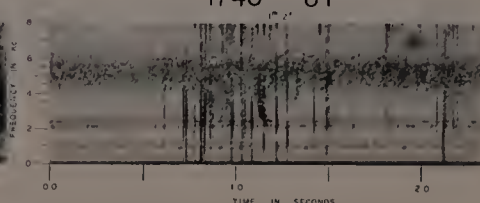
26 OCTOBER 1956
2235 UT



26 OCTOBER 1956
2235 UT

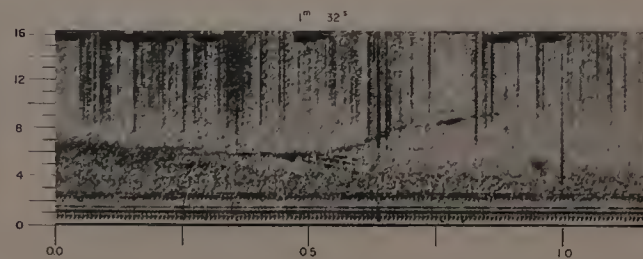
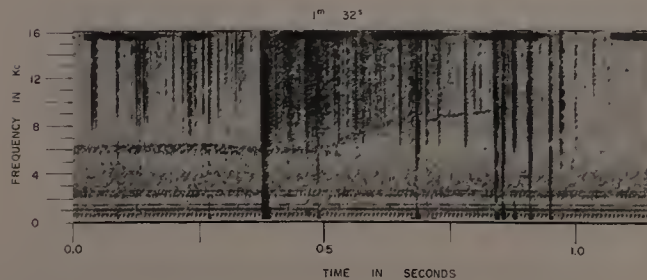
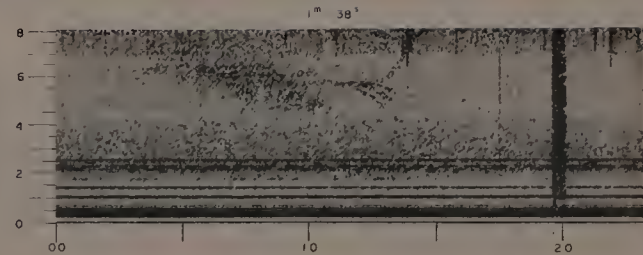
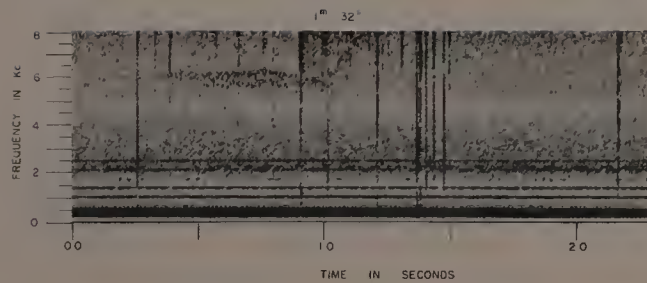


27 APRIL 1956
1740 UT

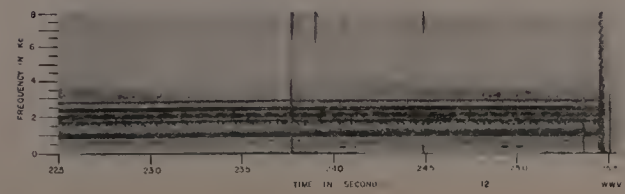
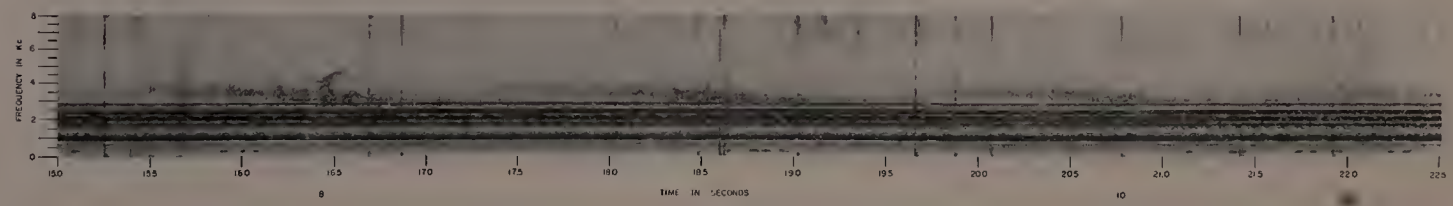
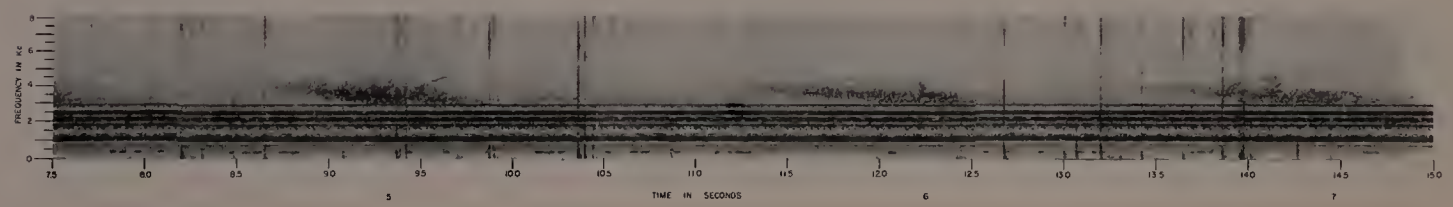
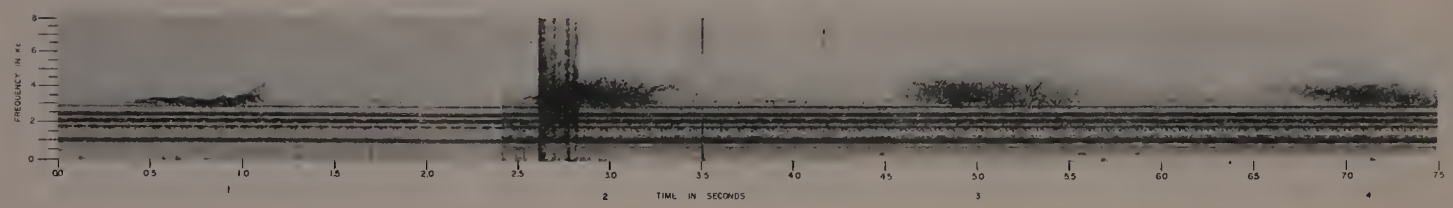


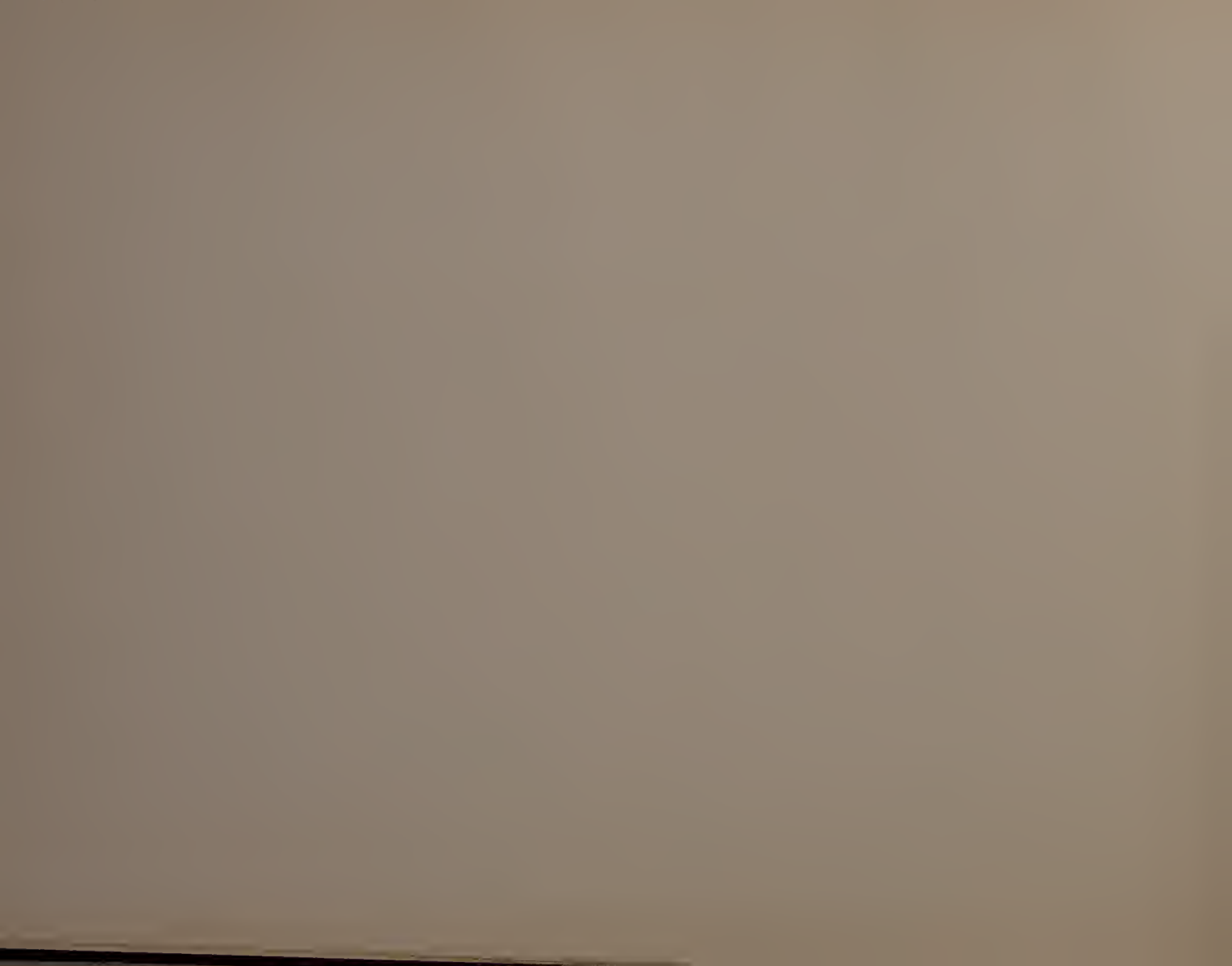
COMPLEX EVENTS

17 NOVEMBER 1956
1535 UT



STRANGE EMISSION WITH TRAIN OF ECHOES
27 FEBRUARY 1956 2102.22 UT (SECOND TRAIN) BOULDER, COLORADO

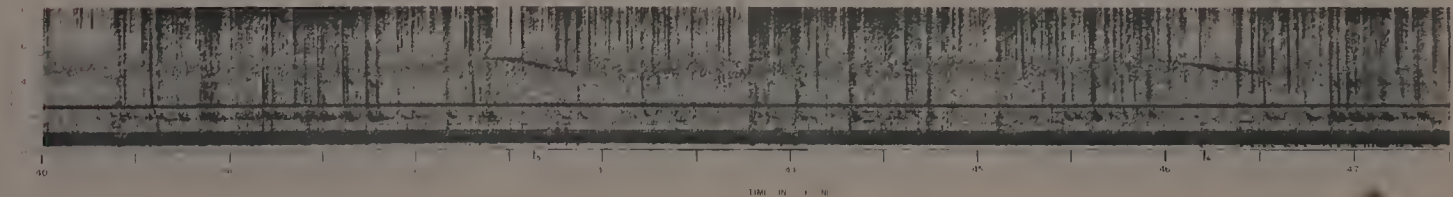
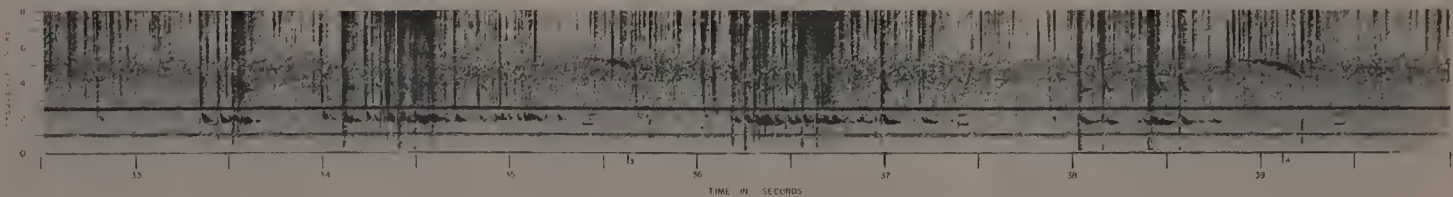
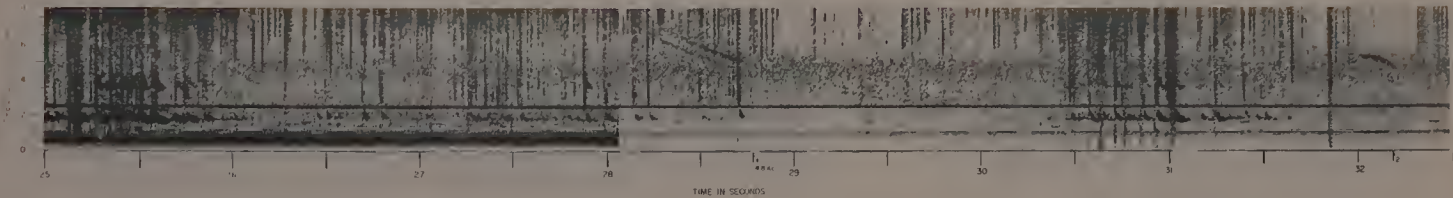




ECHOING VLF EMISSION

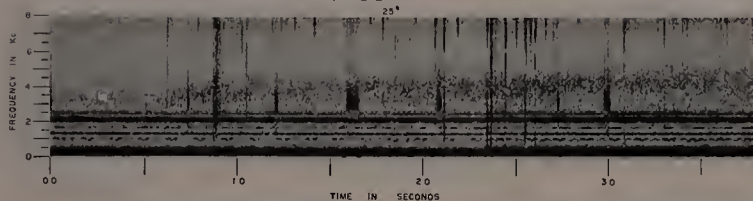
27 NOVEMBER 1957

0335 UT

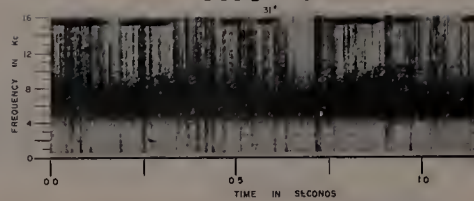


HISS

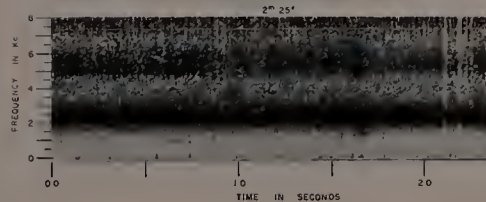
28 OCTOBER 1956
1535 UT



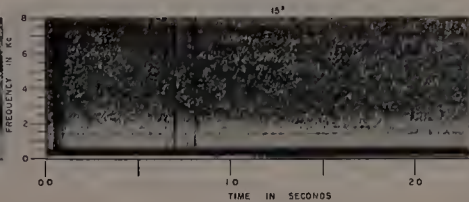
2 MARCH 1957
0635 UT



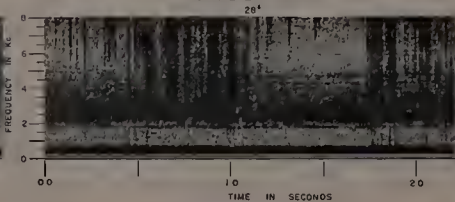
16 MAY 1956
2035 UT



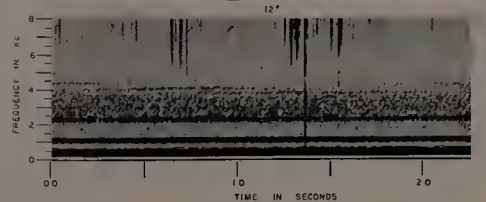
22 JANUARY 1957
0335 UT



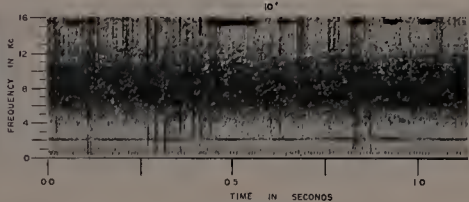
20 FEBRUARY 1957
0435 UT



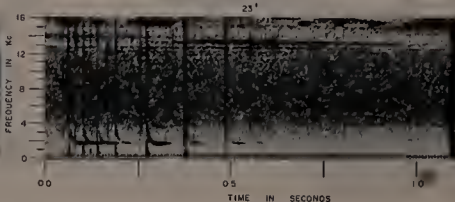
10 JANUARY 1957
2235 UT



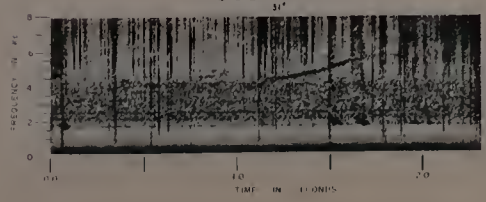
12 NOVEMBER 1956
1335 UT



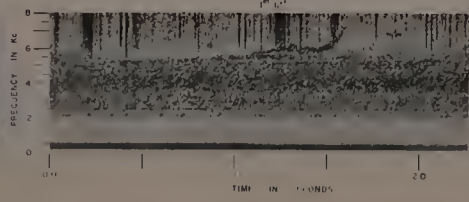
12 NOVEMBER 1956
0235 UT



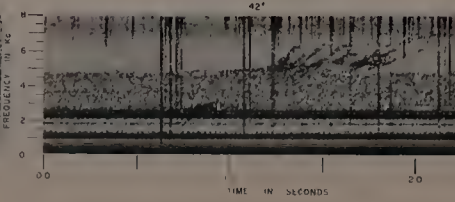
1 FEBRUARY 1957
0935 UT



13 FEBRUARY 1957
2335 UT

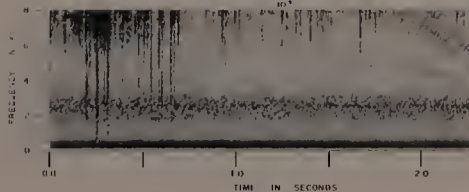


28 DECEMBER 1956
2035 UT

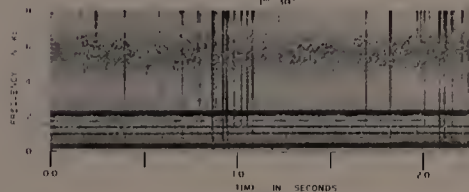


HISS

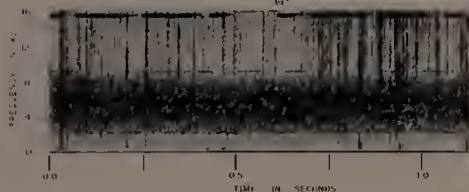
22 JANUARY 1957
2255 UT



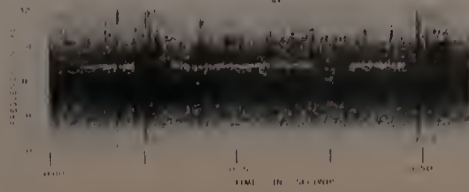
10 NOVEMBER 1956
1635 UT



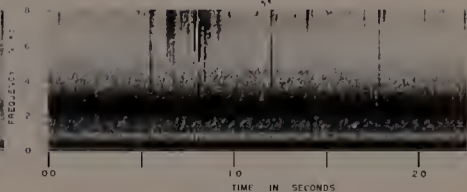
17 NOVEMBER 1956
1235 UT



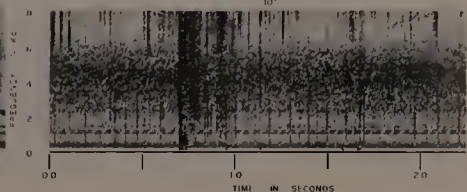
2 MARCH 1957
0835 UT



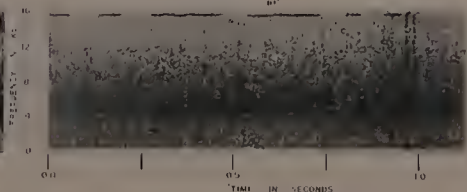
27 DECEMBER 1956
2135 UT



15 NOVEMBER 1956
1935 UT



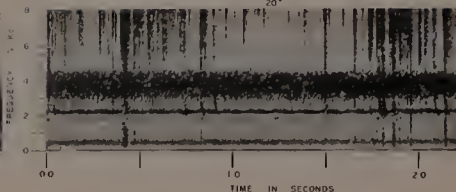
13 OCTOBER 1956
0435 UT



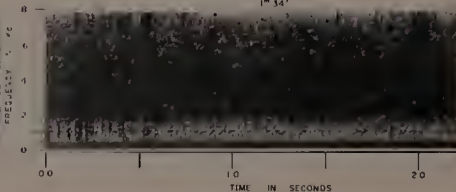
2 APRIL 1957
0535 UT



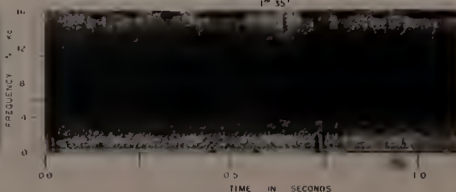
27 MARCH 1957
0135 UT



12 NOVEMBER 1956
0135 UT



12 NOVEMBER 1956
0335 UT



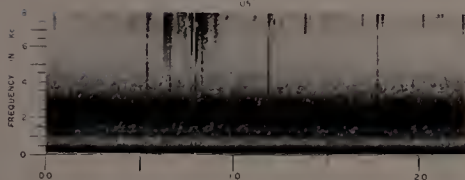
7 APRIL 1957
0235 UT



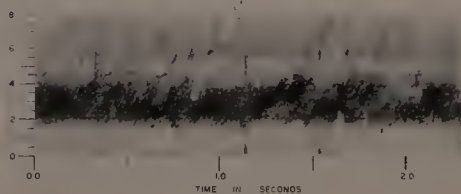


TRANSITION FROM HISS TO DETAILED STRUCTURE

27 DECEMBER 1956
2135 UT



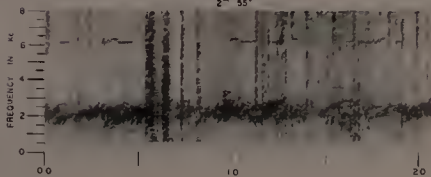
25 MAY 1956
1235 UT



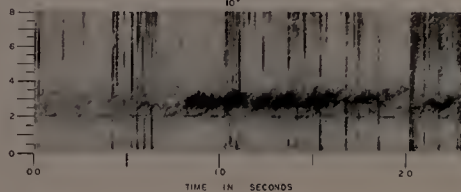
25 MAY 1956
1135 UT



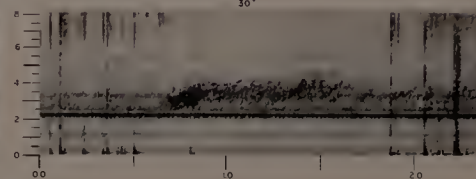
26 JULY 1956
1235 UT



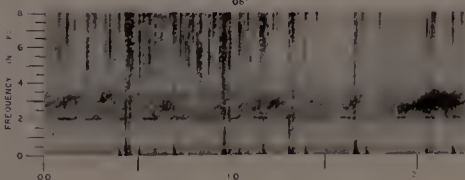
24 JUNE 1956
1535 UT



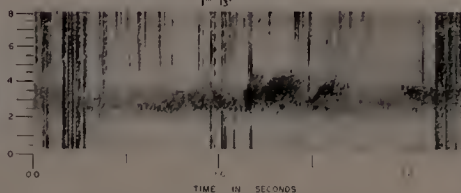
25 MAY 1956
1535 UT



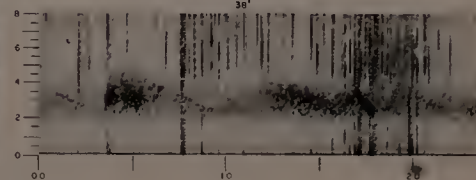
24 JUNE 1956
1535 UT



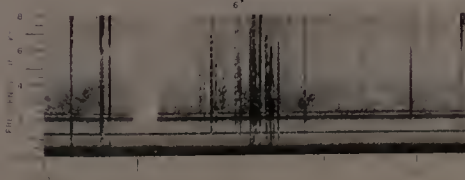
24 JUNE 1956
1635 UT



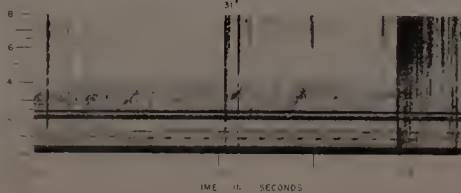
24 JUNE 1956
1635 UT



21 OCTOBER 1956
1335 UT



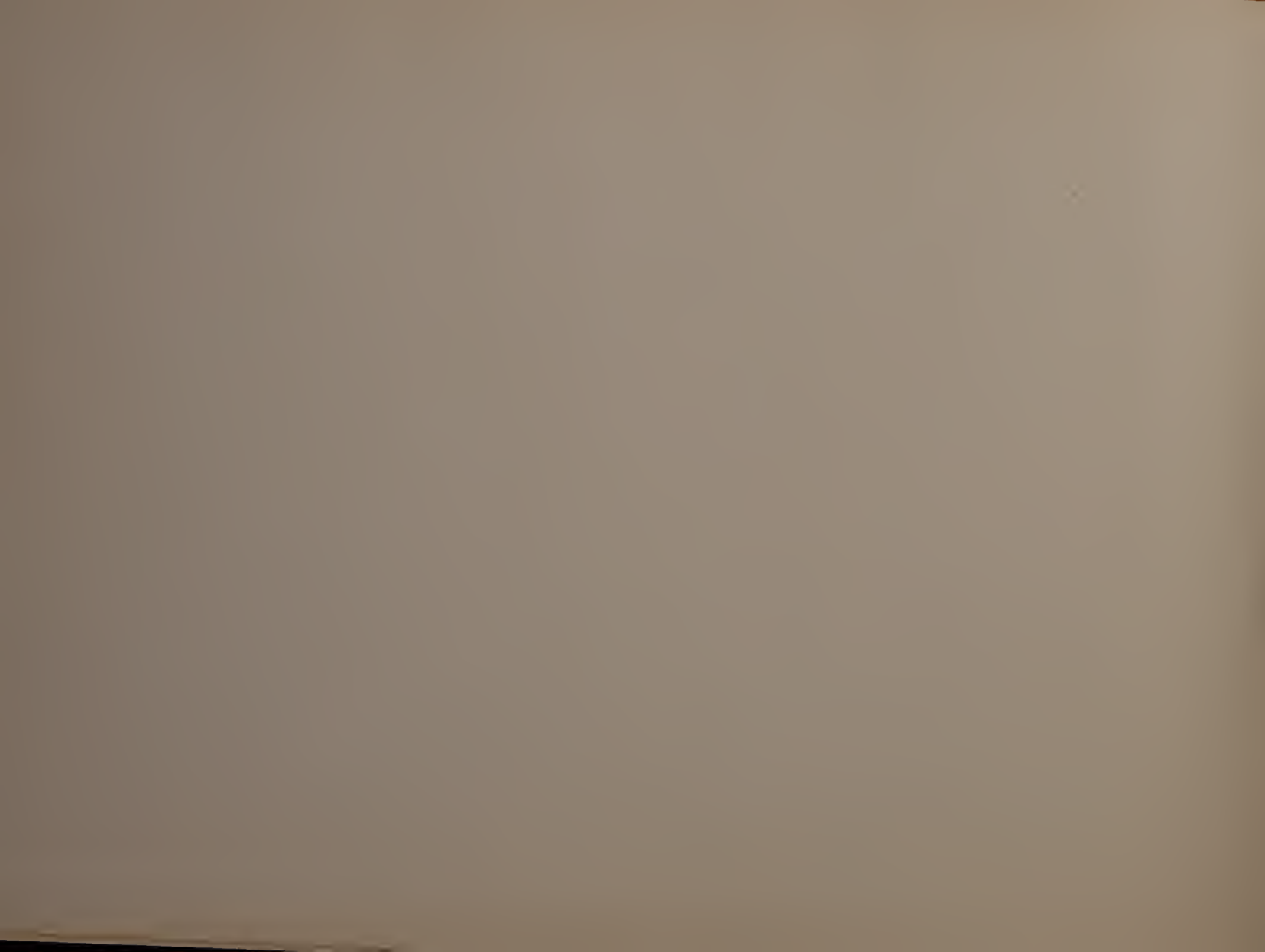
21 NOVEMBER 1956
1435 UT



21 SEPTEMBER 1956
1435 UT



TIME IN SECONDS

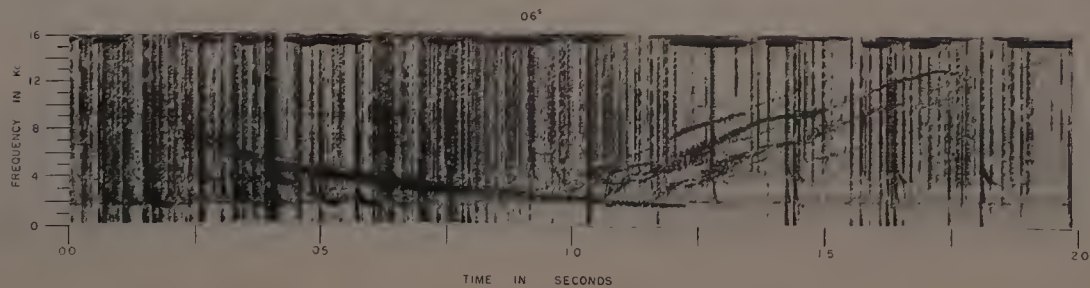
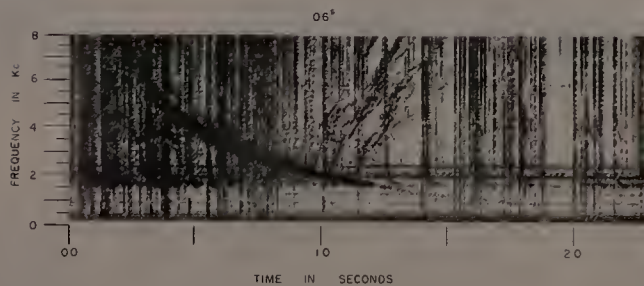
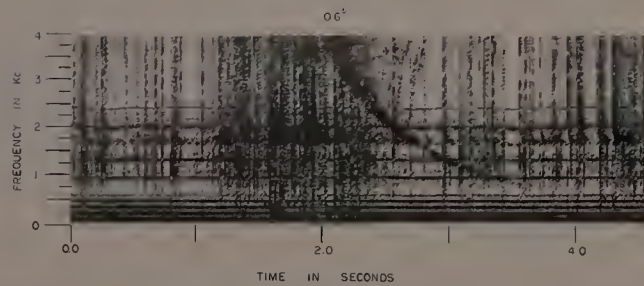


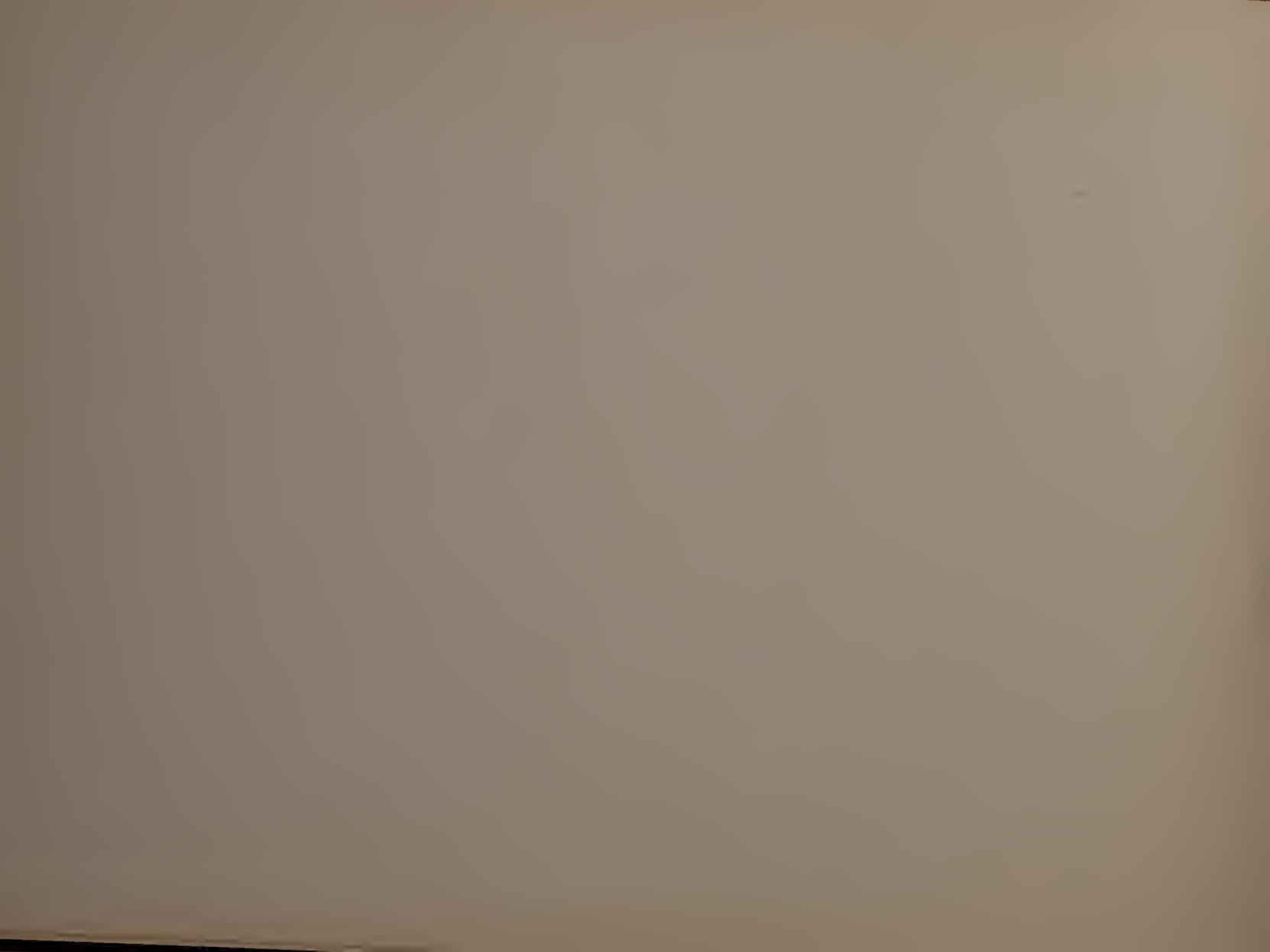
SECTION IV

INTERACTIONS BETWEEN WHISTLERS AND
VLF EMISSIONS



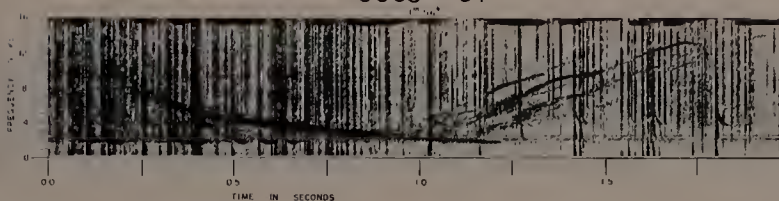
20 NOVEMBER 1956
0036 UT



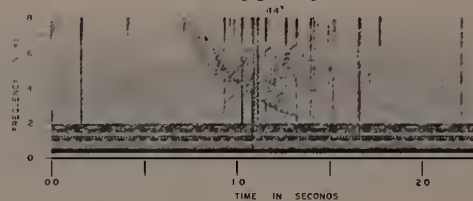


WHISTLER FOLLOWED BY VLF EMISSION

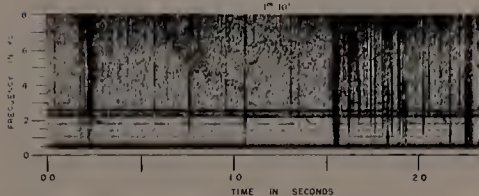
20 NOVEMBER 1956
0035 UT



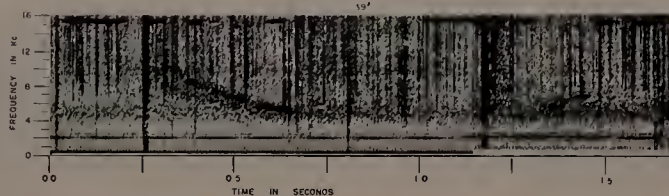
10 APRIL 1957
1635 UT



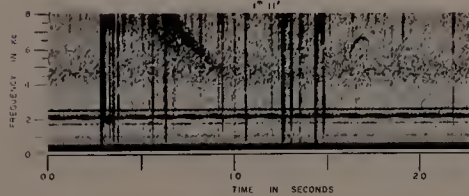
23 JANUARY 1957
0935 UT



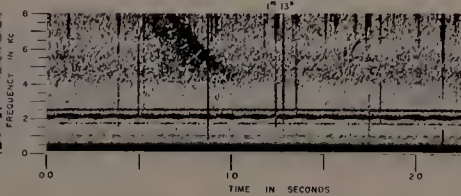
2 JANUARY 1957
1335 UT



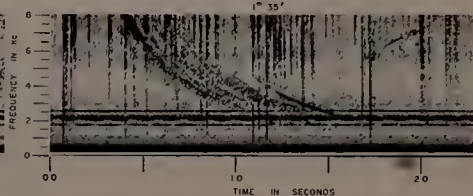
2 JANUARY 1957
1335 UT



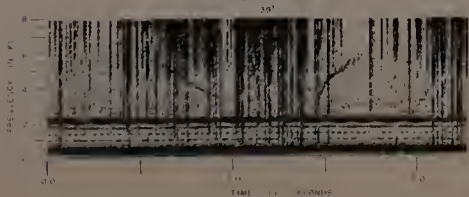
2 JANUARY 1957
1335 UT



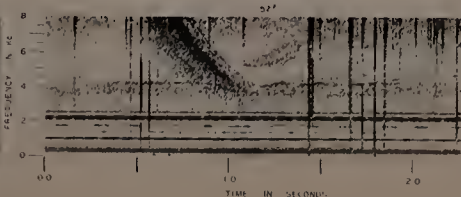
9 FEBRUARY 1957
0535 UT



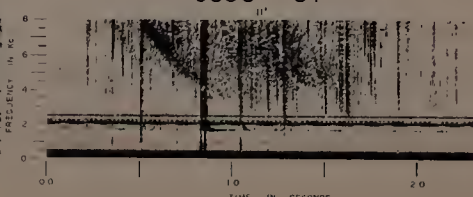
13 MARCH 1957
1435 UT



24 NOVEMBER 1956
1435 UT



2 JANUARY 1957
0535 UT

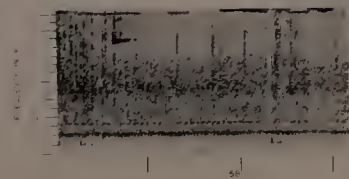
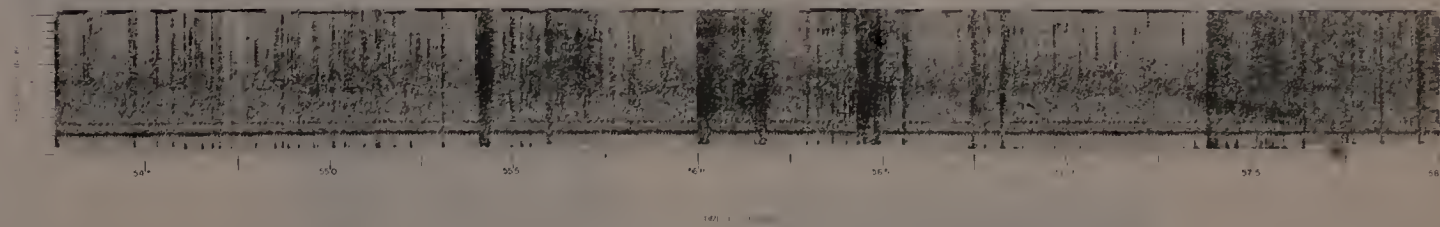
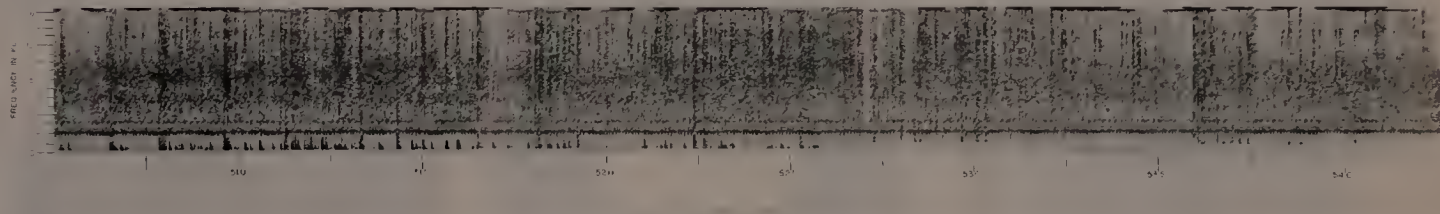
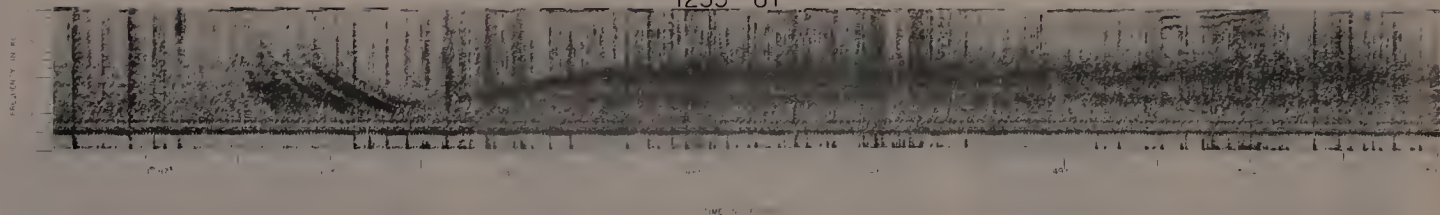


HISS OF COMPLEX STRUCTURE TRIGGERED BY A WHISTLER

(whistler type: short MP, $D \approx 40$)

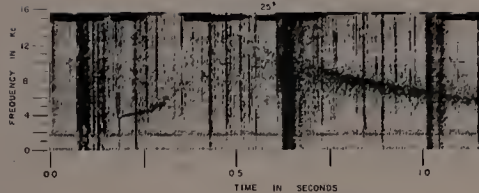
18 MAY 1956

1235 UT

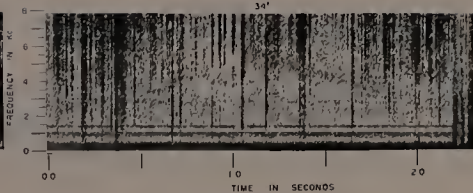


INTERACTIONS

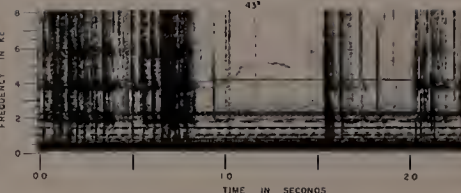
13 NOVEMBER 1956
0135 UT



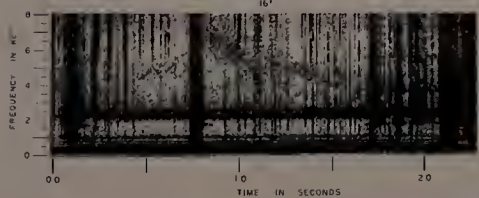
22 MARCH 1957
0035 UT



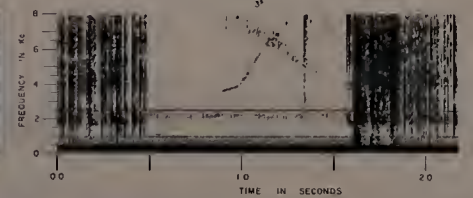
24 OCTOBER 1956
1035 UT



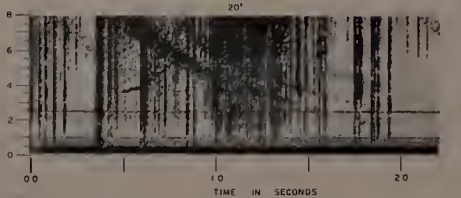
21 OCTOBER 1956
0935 UT



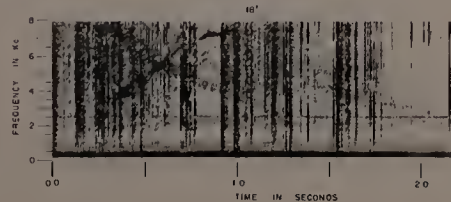
17 MARCH 1957
1035 UT



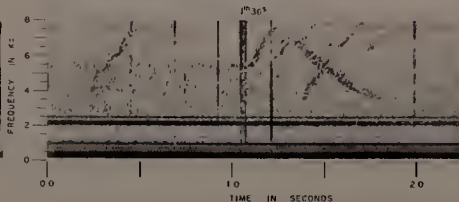
17 MARCH 1957
1235 UT



17 MARCH 1957
1135 UT



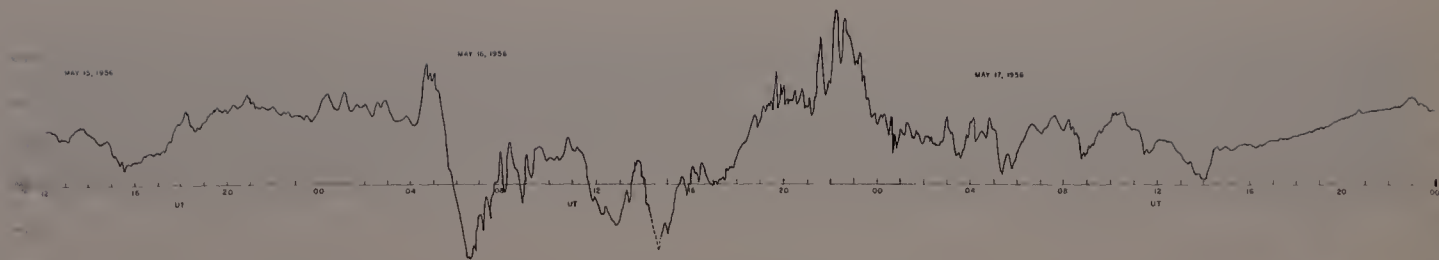
10 NOVEMBER 1956
1435 UT



SECTION V

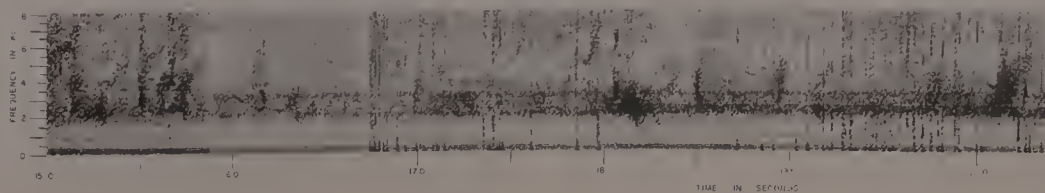
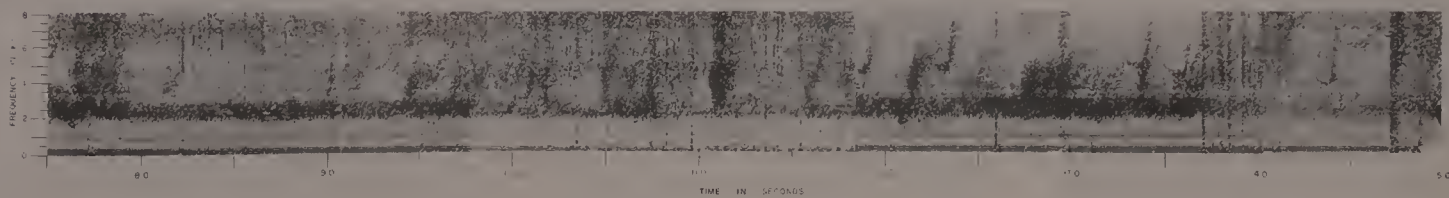
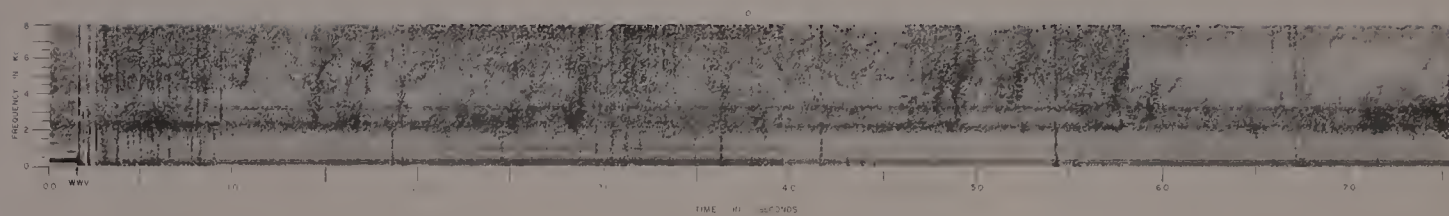
PERIODS OF SPECIAL INTEREST SELECTED
BY THEIR VLF ACTIVITY

MAGNETOGRAM FROM CHELTENHAM OBSERVATORY
HORIZONTAL COMPONENT



UNUSUAL VLF ACTIVITY
ASSOCIATED WITH A STRONG MAGNETIC DISTURBANCE

16 MAY 1956
1335 UT

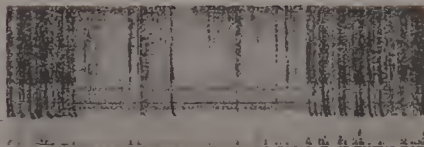


16 MAY 1956

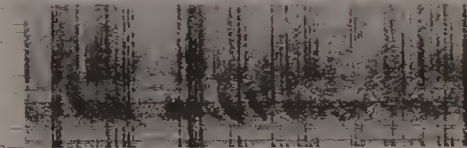
01:15 UT



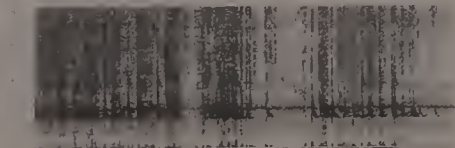
16 MAY 1956
0635 UT



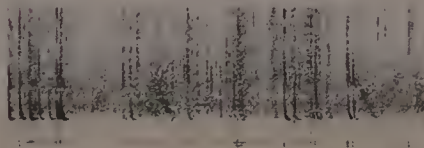
0735 UT



0835 UT

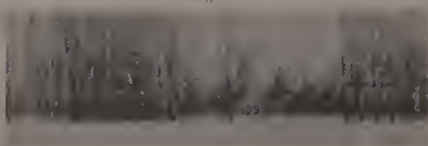
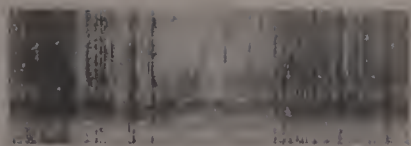


0935 UT

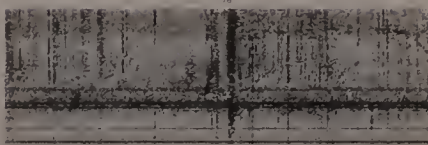
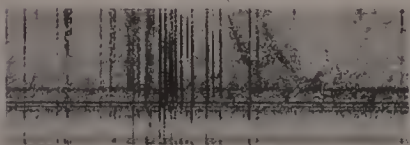
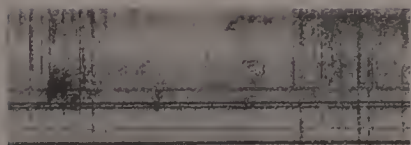


16 MAY 1956

1035 UT



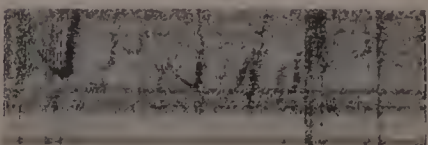
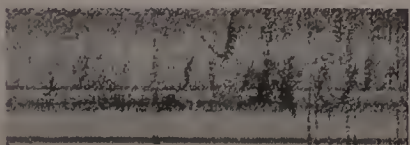
1155 UT



1235 UT



1355 UT

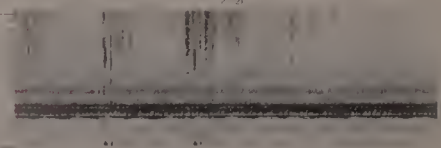
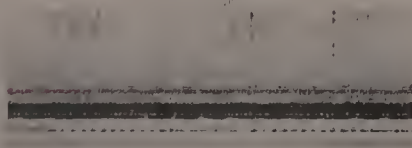
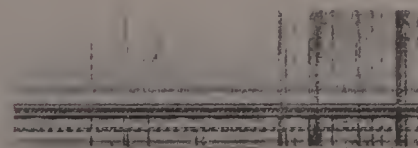


16 MAY 1956

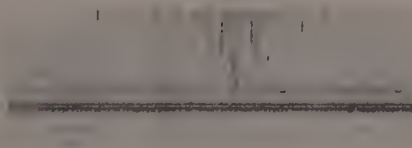
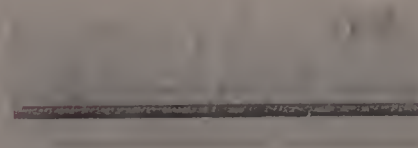
1435 UT



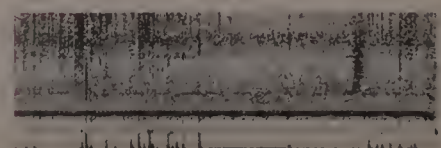
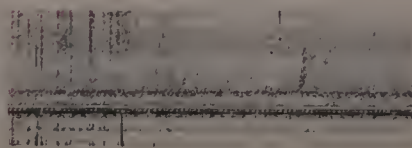
1535 UT



1635 UT

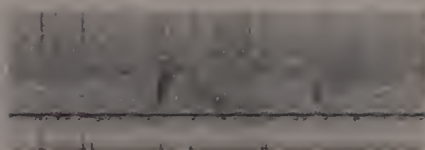


1735 UT



16 MAY 1956

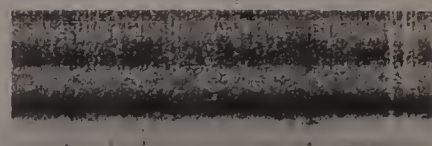
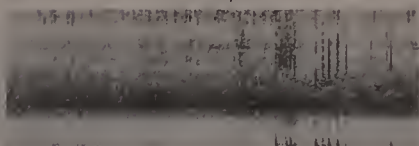
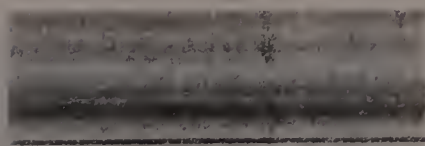
1835 UT



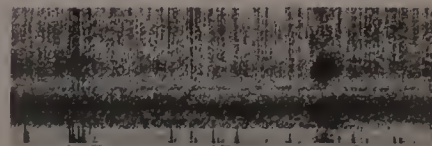
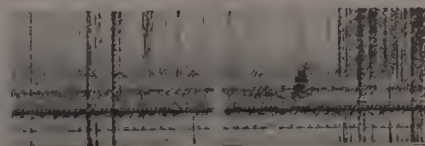
1935 UT



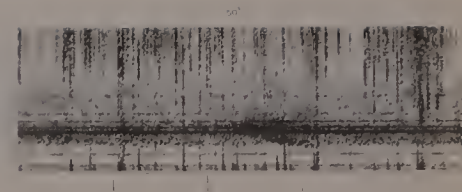
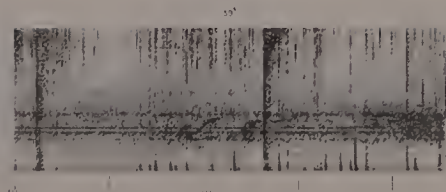
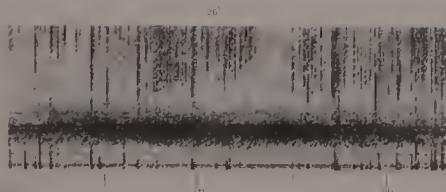
2035 UT



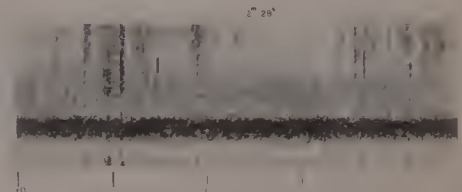
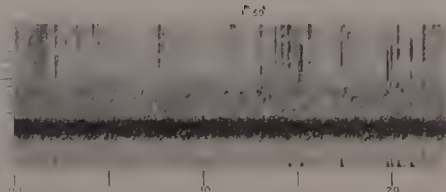
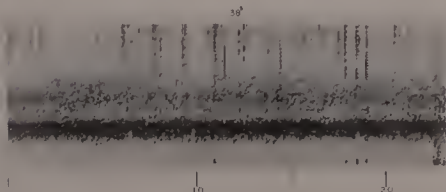
2135 UT



16 MAY 1956
2235 UT

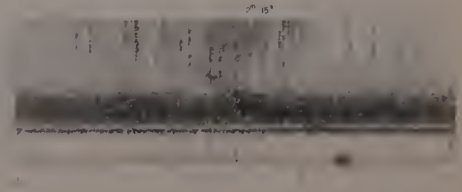
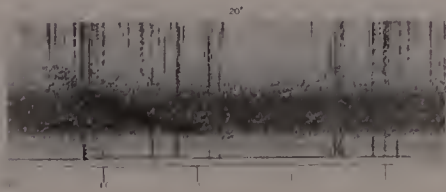


TIME IN SECONDS
2335 UT



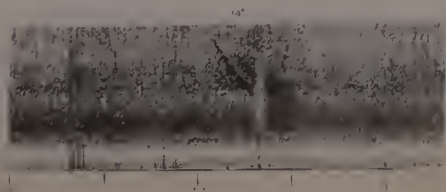
TIME IN SECONDS

0035 UT



TIME IN SECONDS

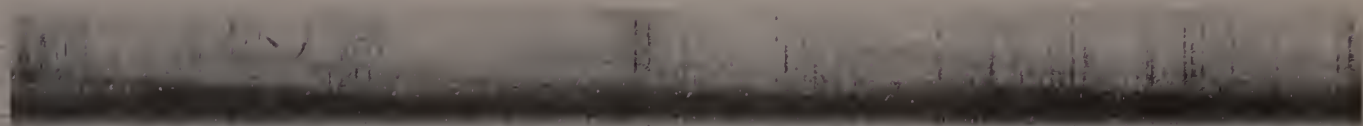
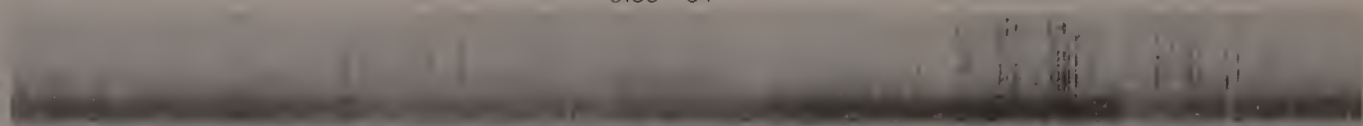
0135 UT



HISS IN CONJUNCTION WITH A WHISTLER TRAIN AND A TRIPLE ISOLATED HOOK

17 MAY 1956

0135 UT



17 MAY 1956

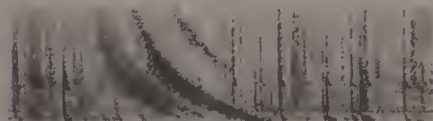
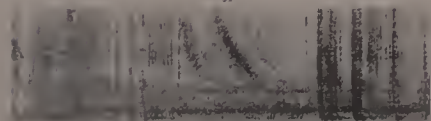
0235 UT



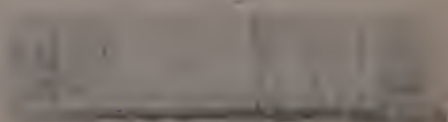
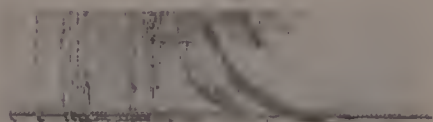
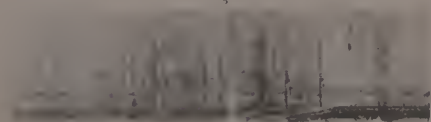
0335 UT



0435 UT

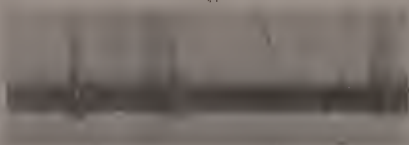
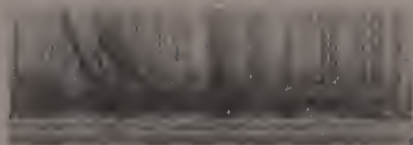


0535 UT

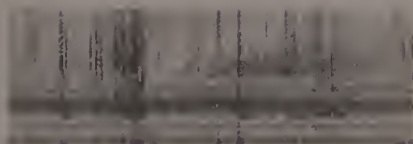


17 MAY 1956

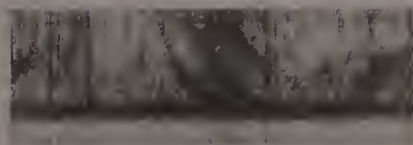
0635 UT



0735 UT



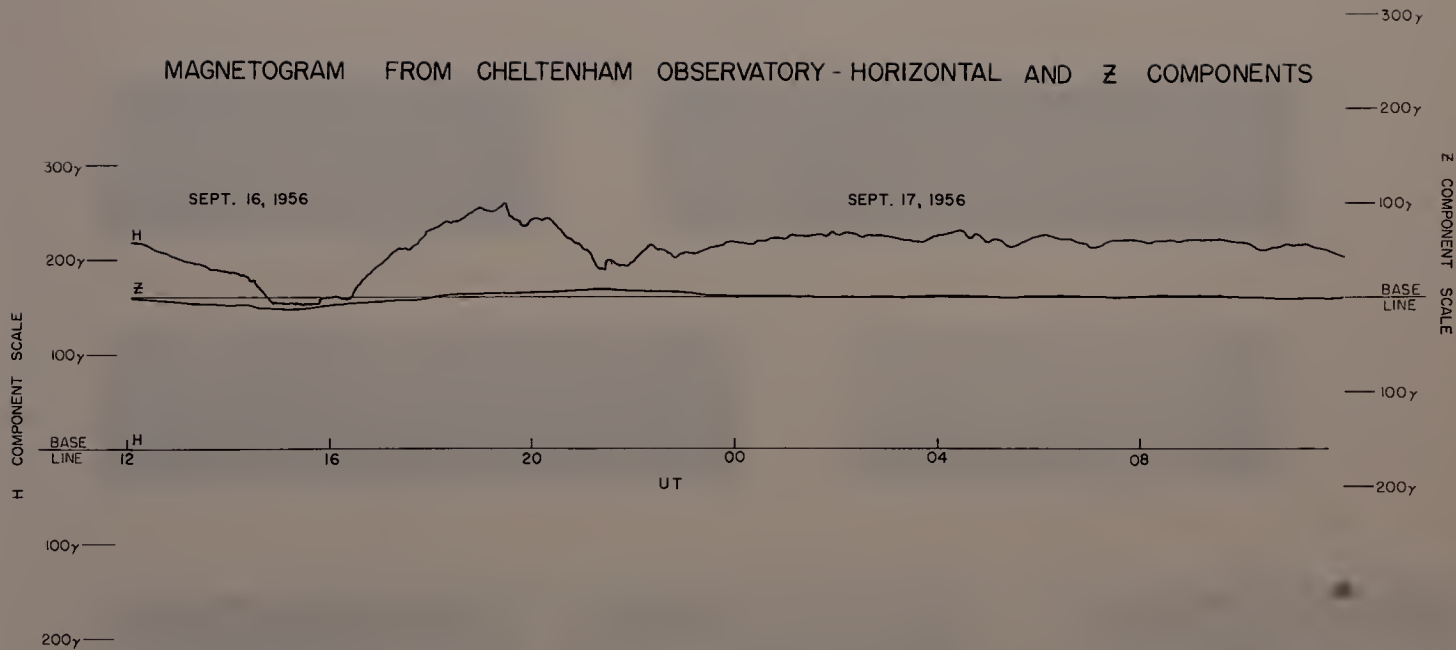
0835 UT



0935 UT



MAGNETOGRAM FROM CHELTENHAM OBSERVATORY - HORIZONTAL AND Z COMPONENTS





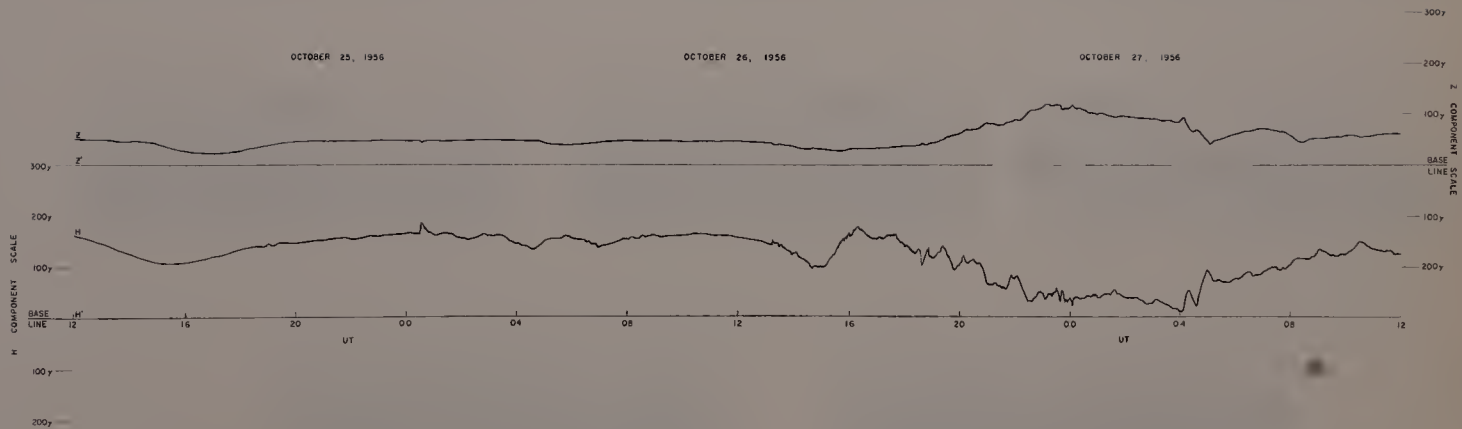
AN ISOLATED PERIOD OF VLF EMISSIONS
ASSOCIATED WITH A WEAK MAGNETIC DISTURBANCE

16 SEPT 1956

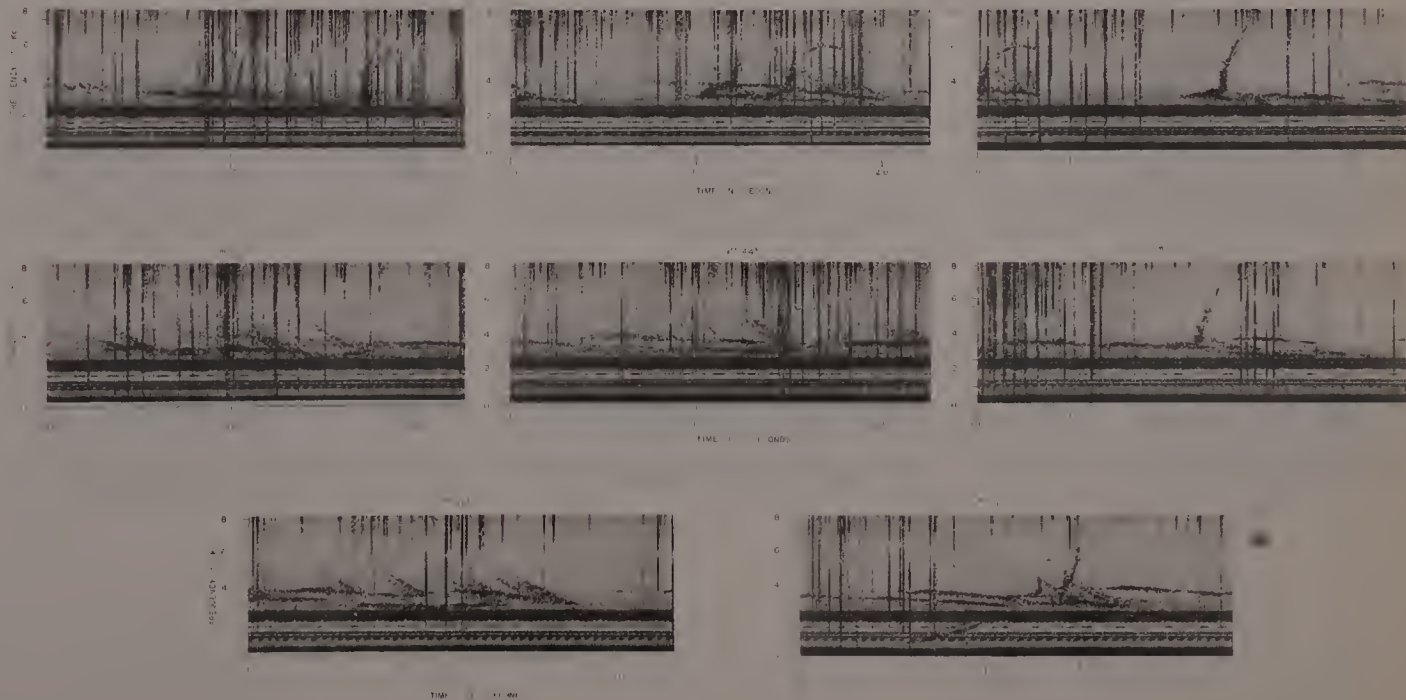
1835 UT



MAGNETOGRAM FROM FREDERICKSBURG OBSERVATORY HORIZONTAL & Z COMPONENTS

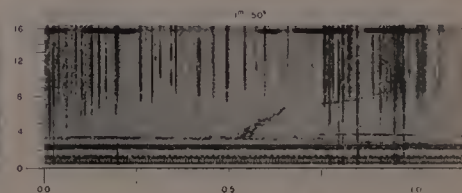
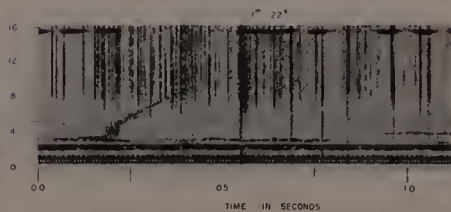
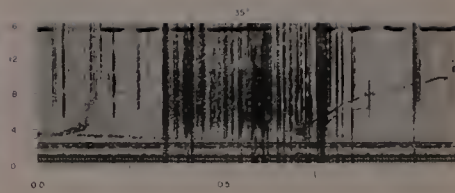
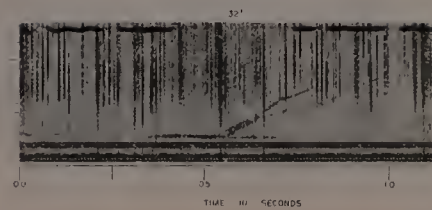
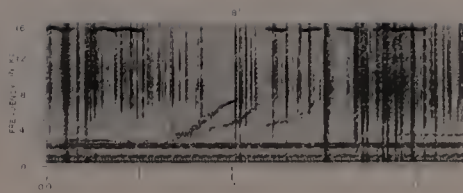


VLF EMISSIONS ASSOCIATED WITH A MODERATE MAGNETIC DISTURBANCE

26 OCTOBER 1956
2230 UT

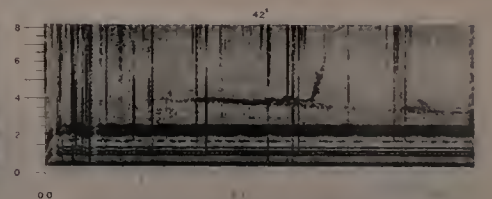
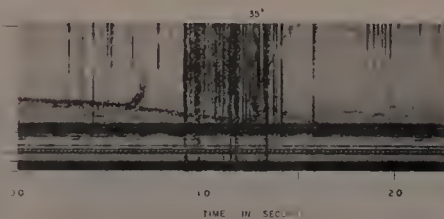
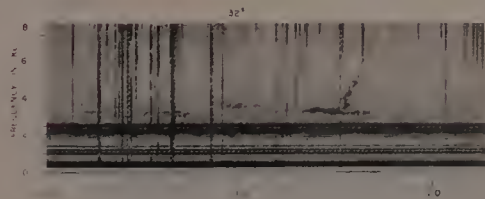
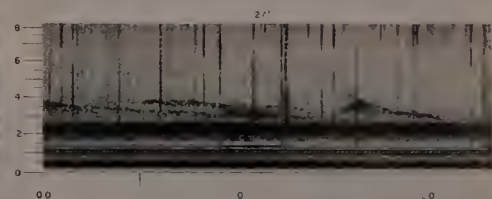
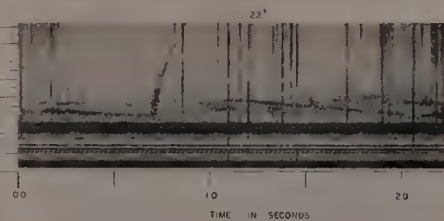
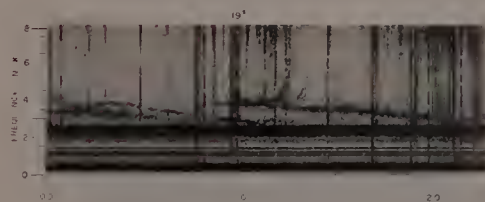
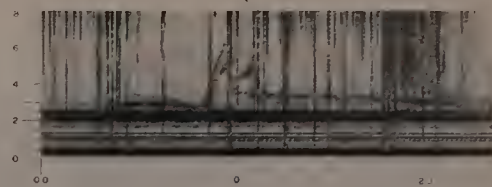
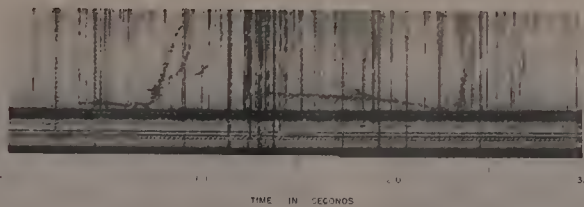
HOOKS

26 OCTOBER 1956
2230 UT

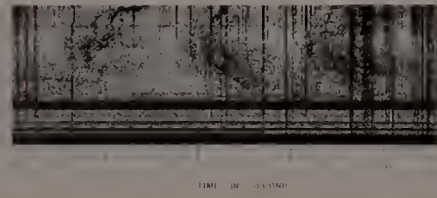
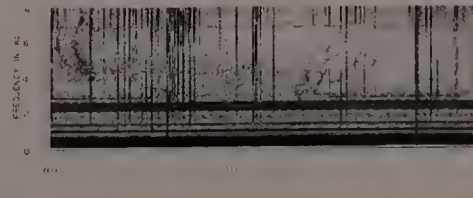
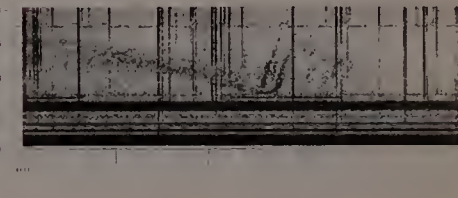
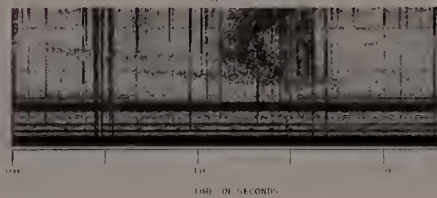


HOOKS
26 OCTOBER 1956
2230 UT

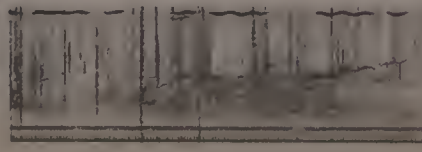
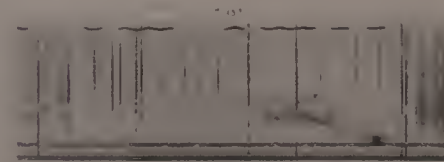
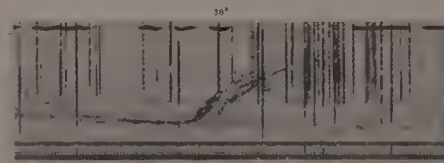
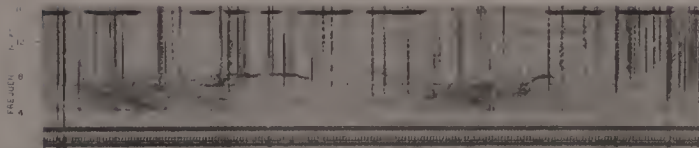
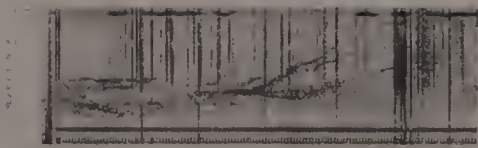
72



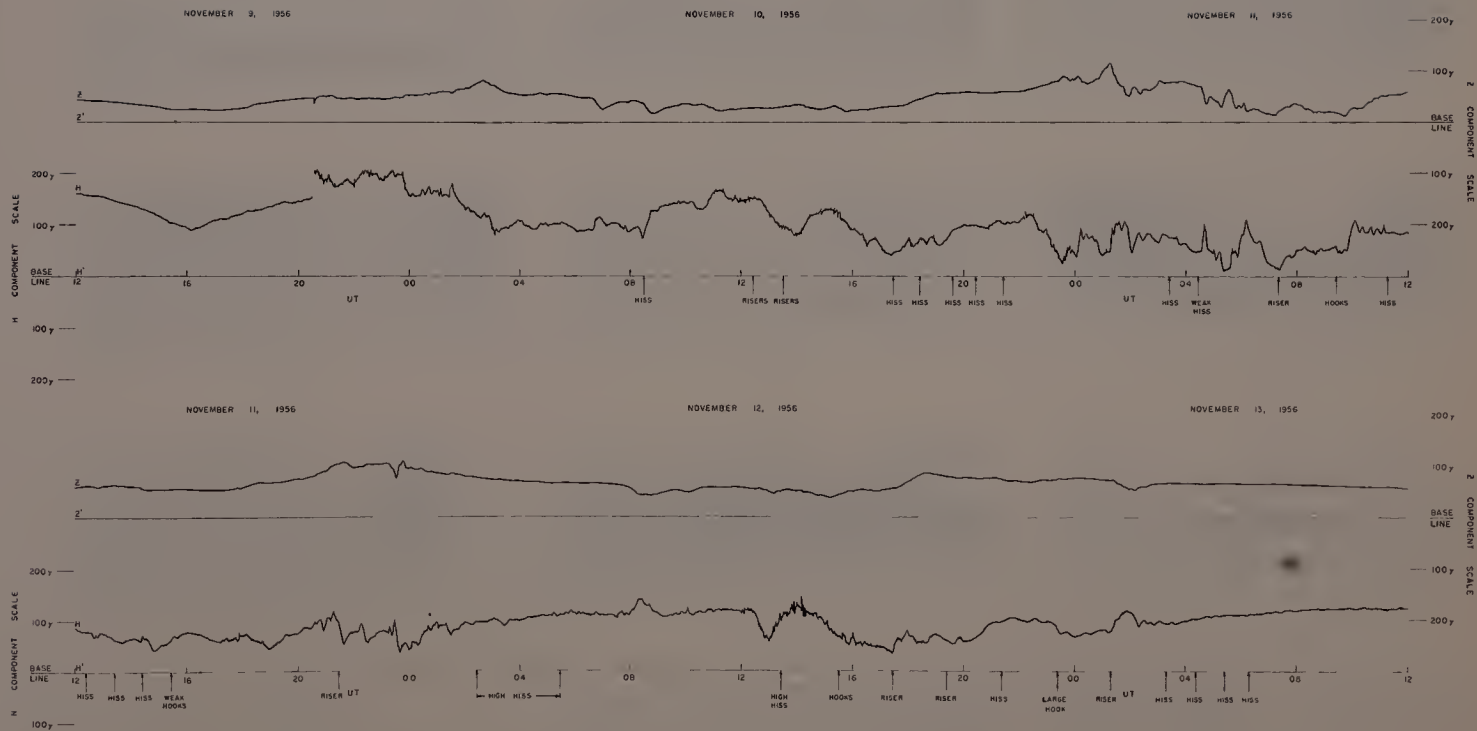
26 OCTOBER 1956
2235 UT



26 OCTOBER 1956
2235 UT



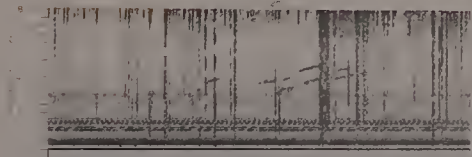
MAGNETOGRAM FROM FREDERICKSBURG OBSERVATORY HORIZONTAL & Z COMPONENTS



VLF ACTIVITY ASSOCIATED WITH A MODERATE MAGNETIC DISTURBANCE
S. C.-9 NOVEMBER 1956 AT 20:30 U.T.

9 NOVEMBER 1956

2036 UT



10 NOVEMBER 1956

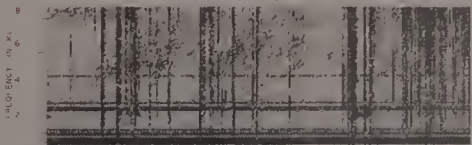
0830 UT



0835 UT



1035 UT



1130 UT



1230 UT



1236 UT



1335 UT



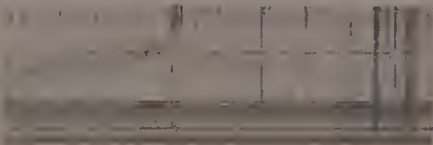
1435 UT



1436 UT

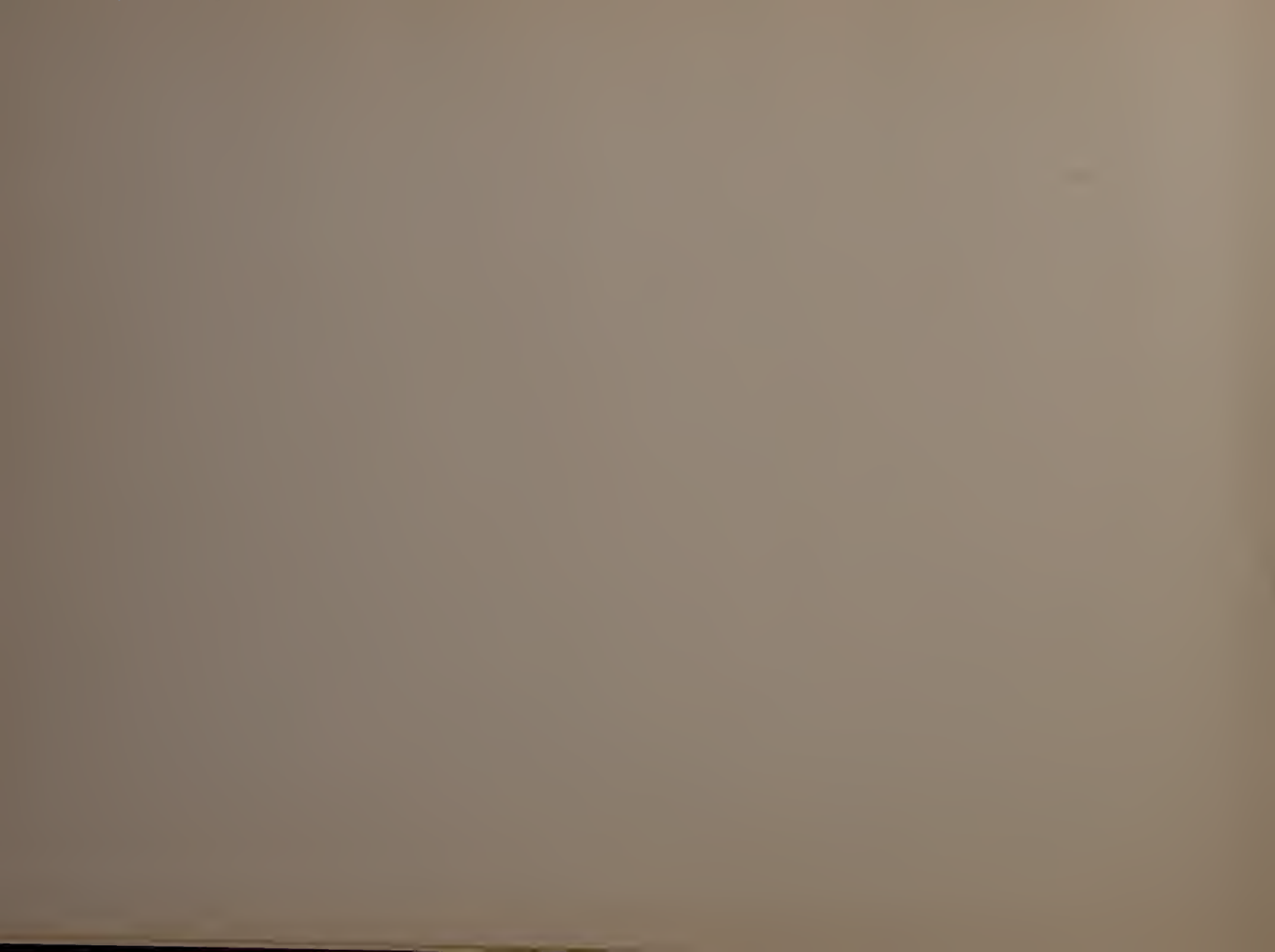


1535 UT

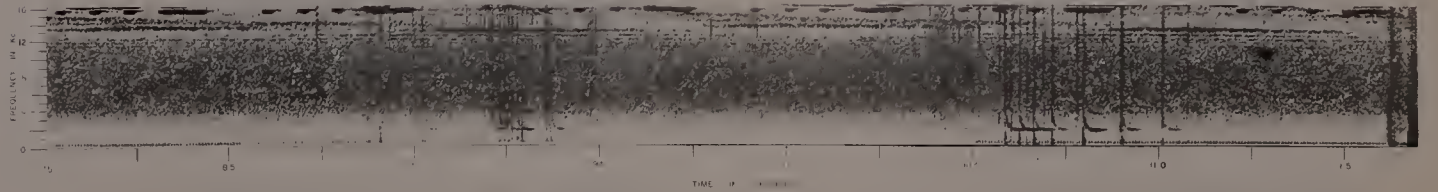
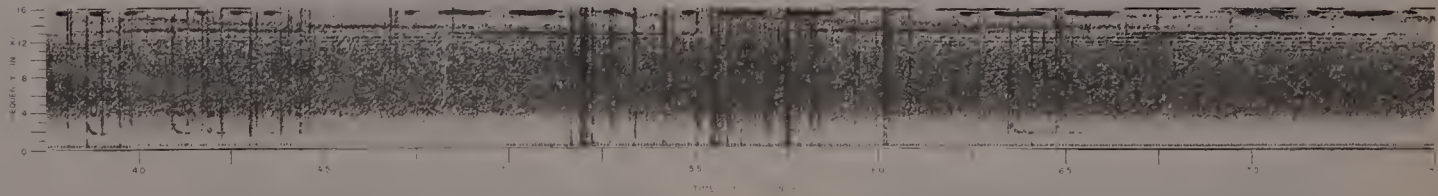
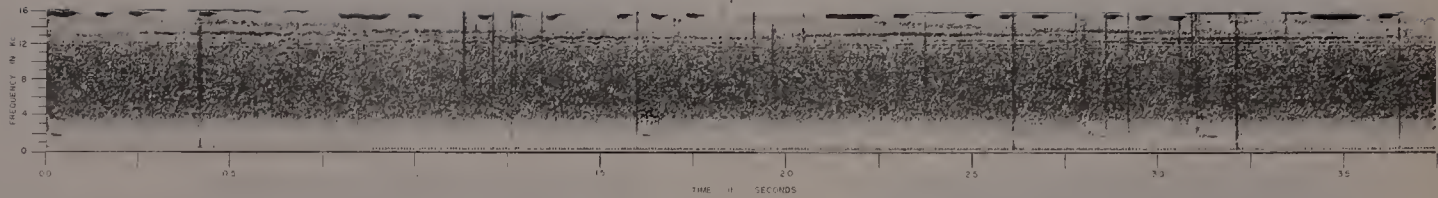


1630 UT





PERIOD OF STRONG HISS

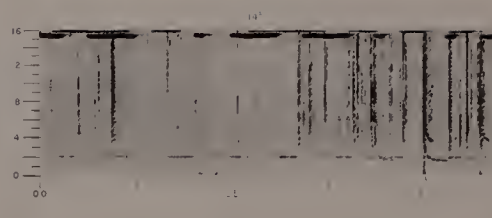
12 NOVEMBER 1956
0235 UT

12 NOVEMBER 1956

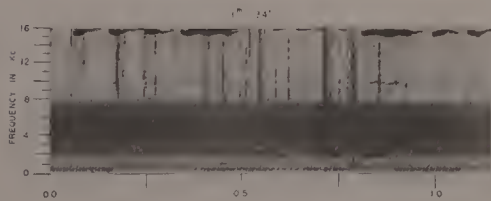
2335 UT



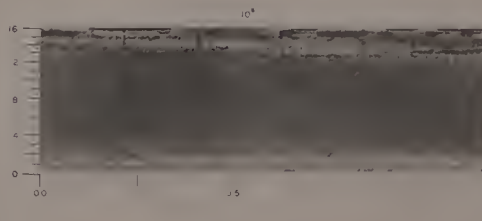
0035 UT



0135 UT



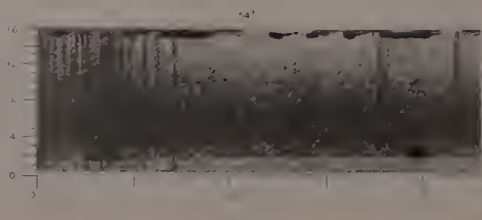
0235 UT



0335 UT



0435 UT



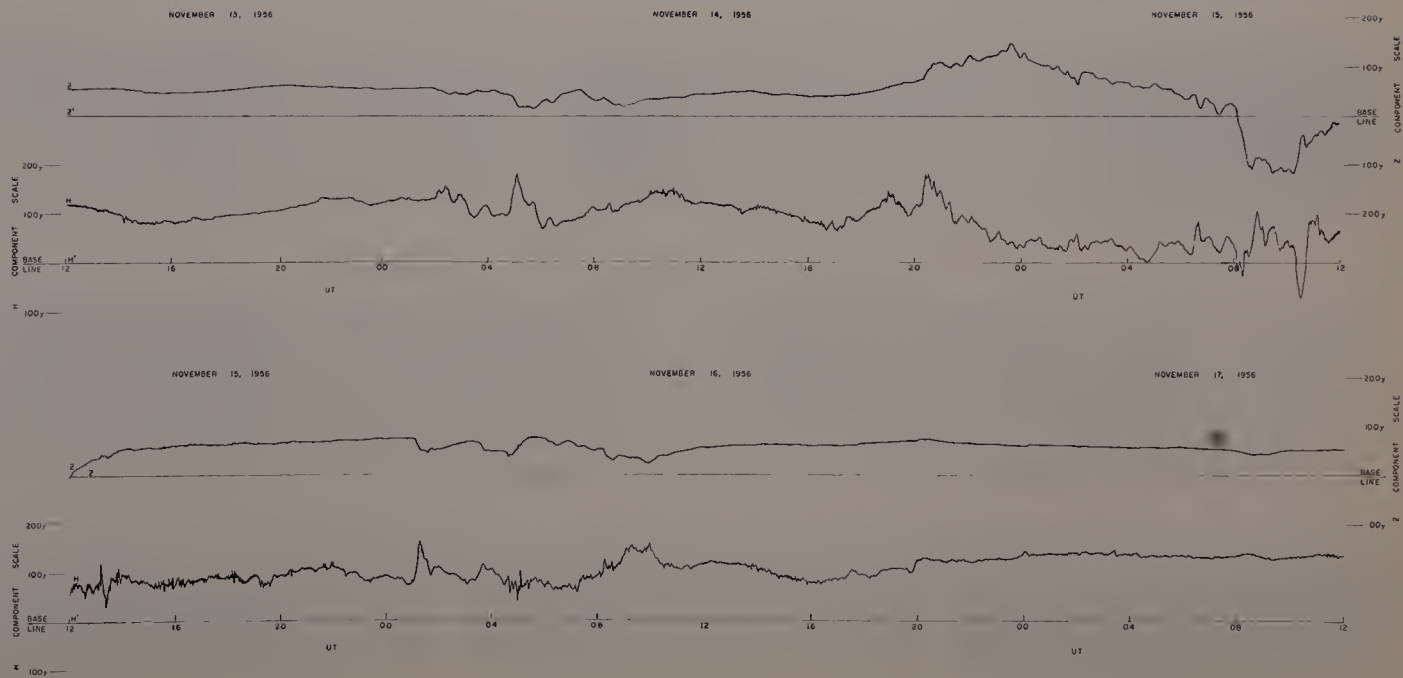
0535 UT



0635 UT



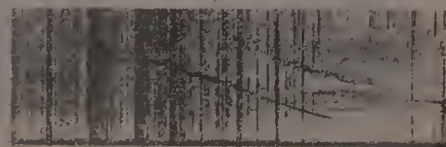
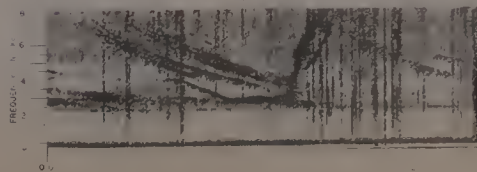
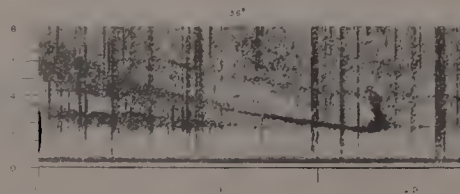
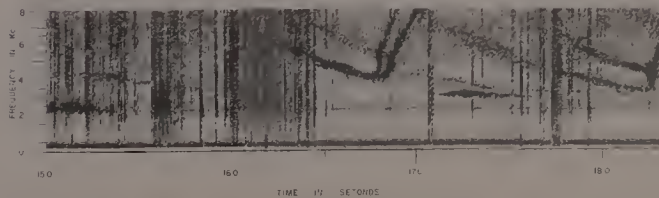
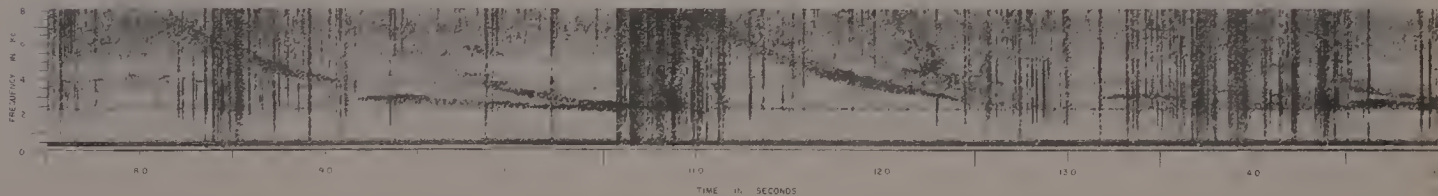
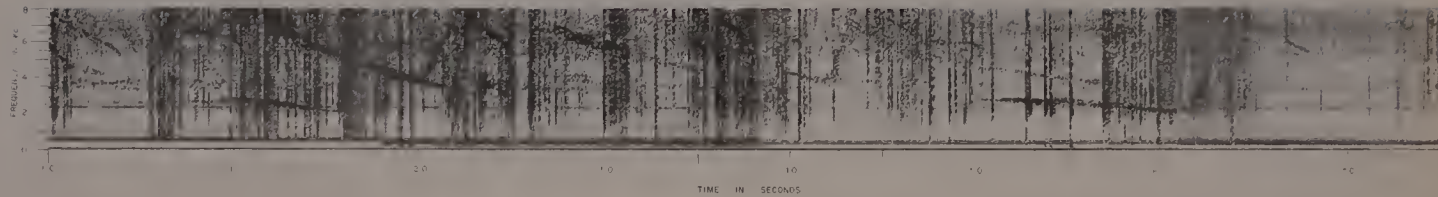
MAGNETOGRAM FROM FREDERICKSBURG OBSERVATORY
HORIZONTAL & Z COMPONENTS



WHISTLERS AND HOOKS

14 NOVEMBER 1956

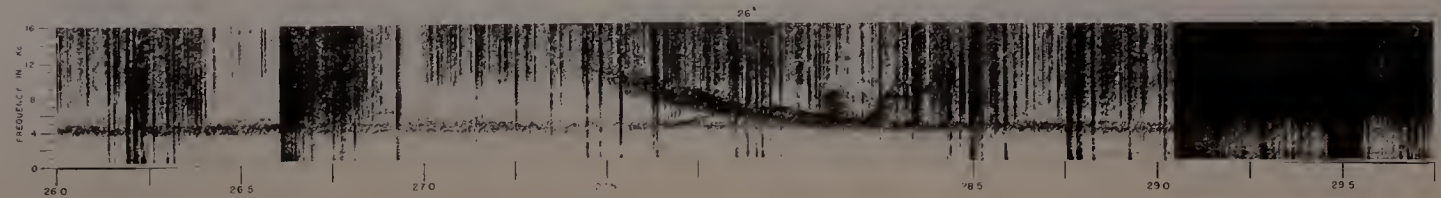
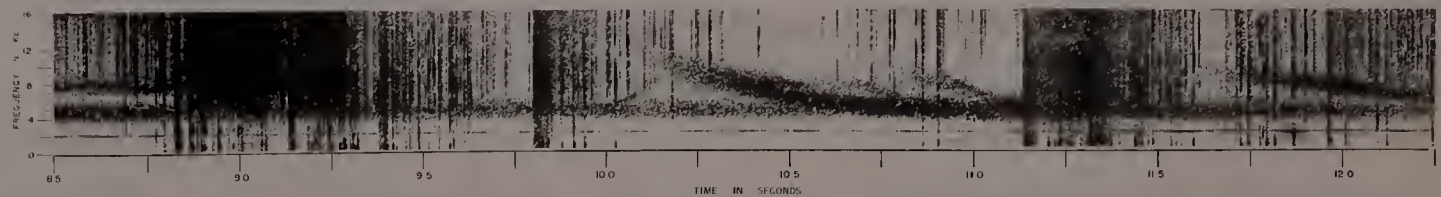
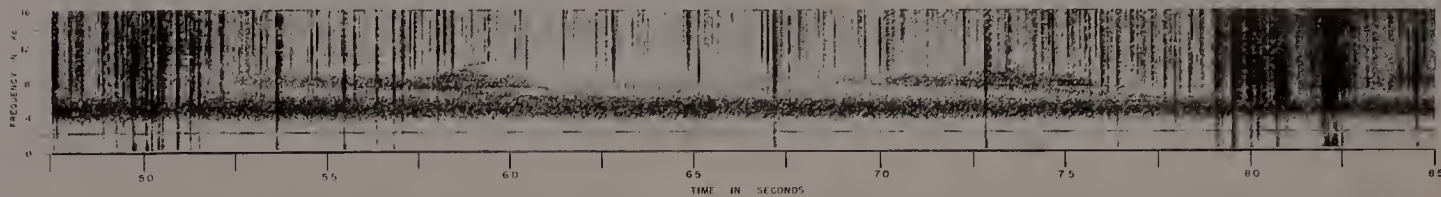
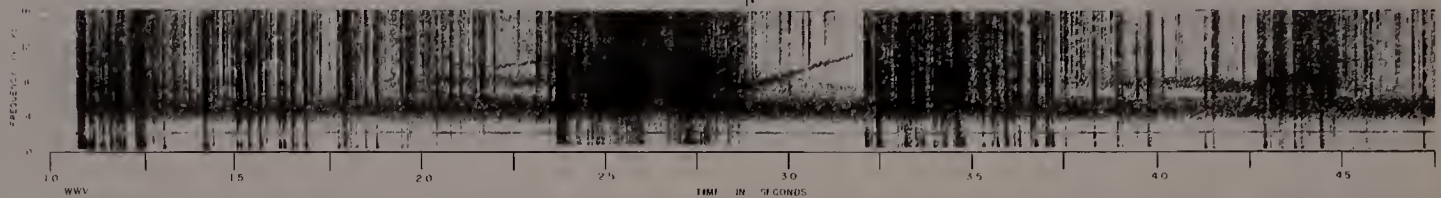
2335 UT



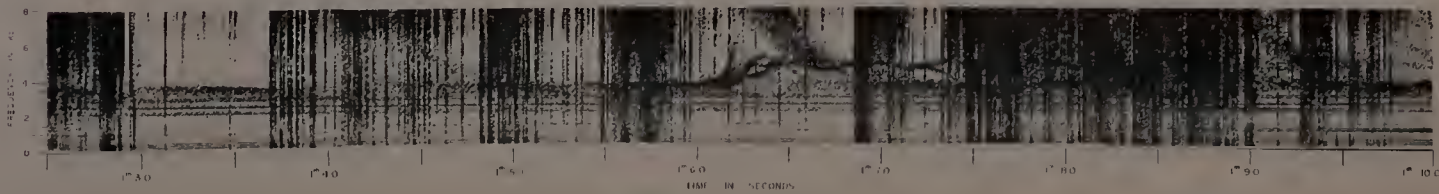
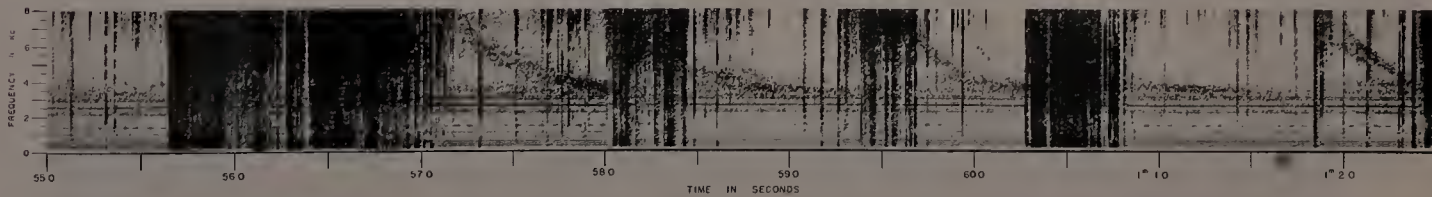
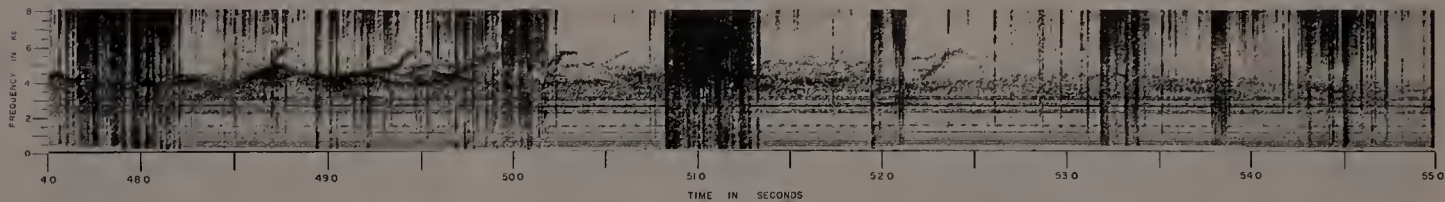
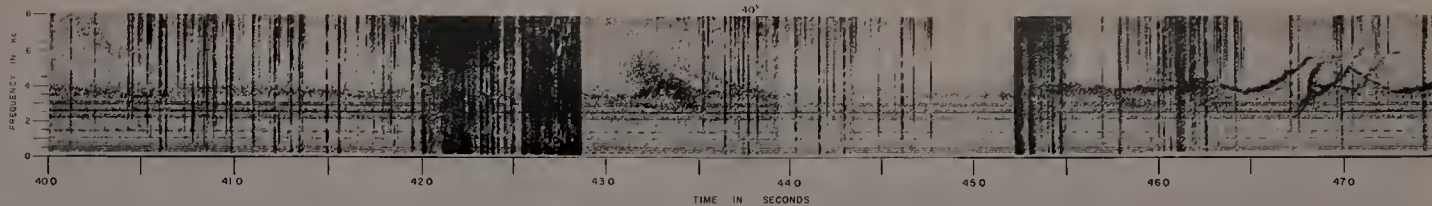
S. C. 30 JUNE 1957, AT 04:00 UT

30 JUNE 1957

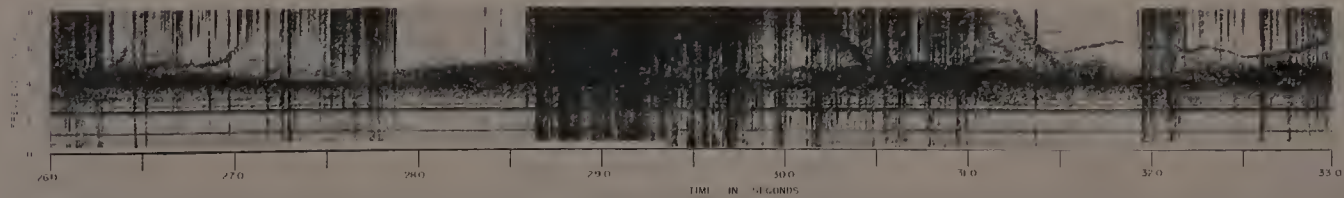
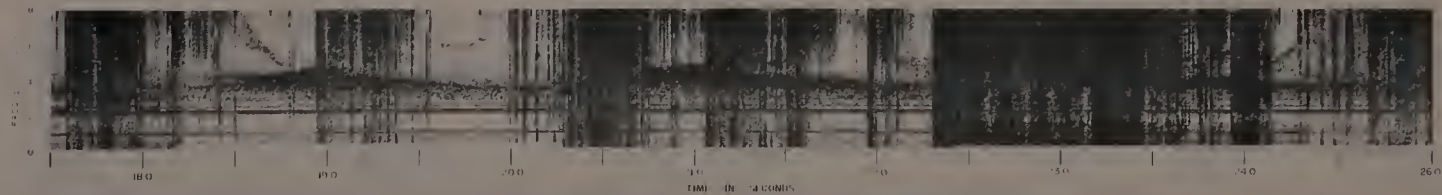
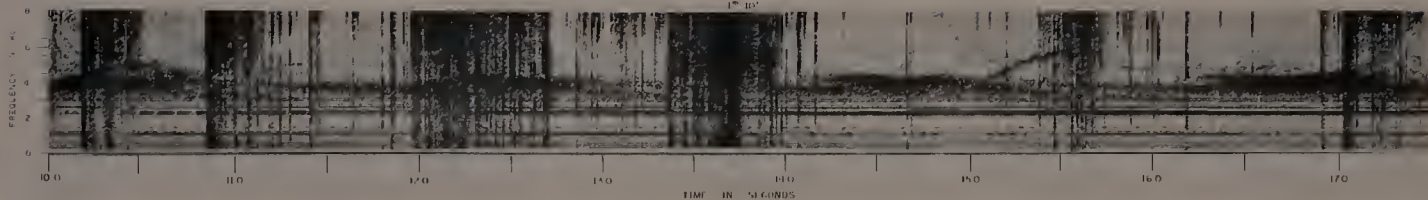
1735 UT



30 JUNE 1957
1735 UT (PLATE 1)

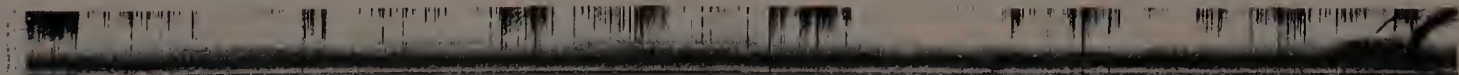


30 JUNE 1957
1735 UT (PLATE II)



UNUSUAL VLF EMISSIONS ASSOCIATED WITH STRONG MAGNETIC DISTURBANCE
S. C. 11 FEBRUARY 1958 AT 01:26 U.T.

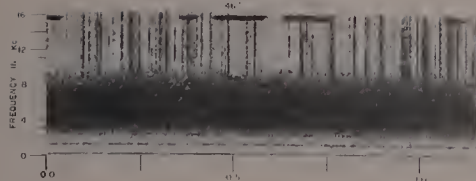
FEBRUARY 12, 1958
1835 UT



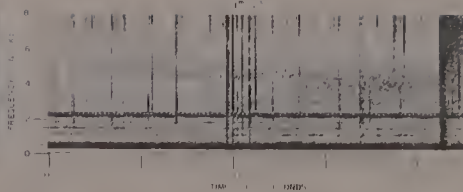
SECTION VI

FOUR MONTH SYNOPTIC SURVEY
OF VLF NOISES

2 MARCH 1957
1735 UT



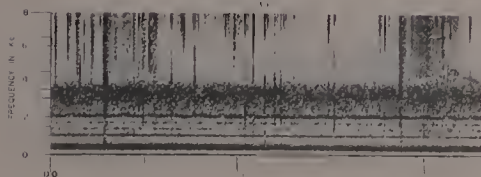
1835 UT



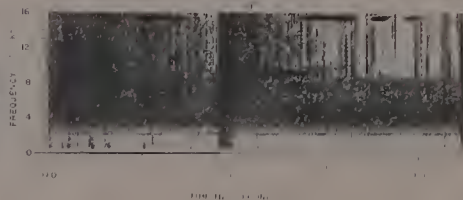
1935 UT



2035 UT



2135 UT



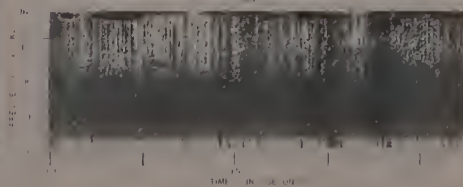
2235 UT



3 MARCH 1957
0035 UT



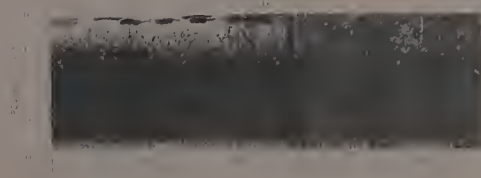
0135 UT



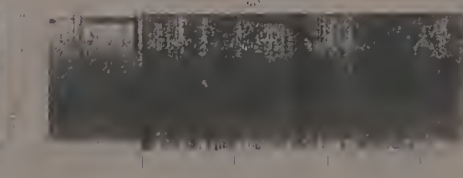
0235 UT



0335 UT

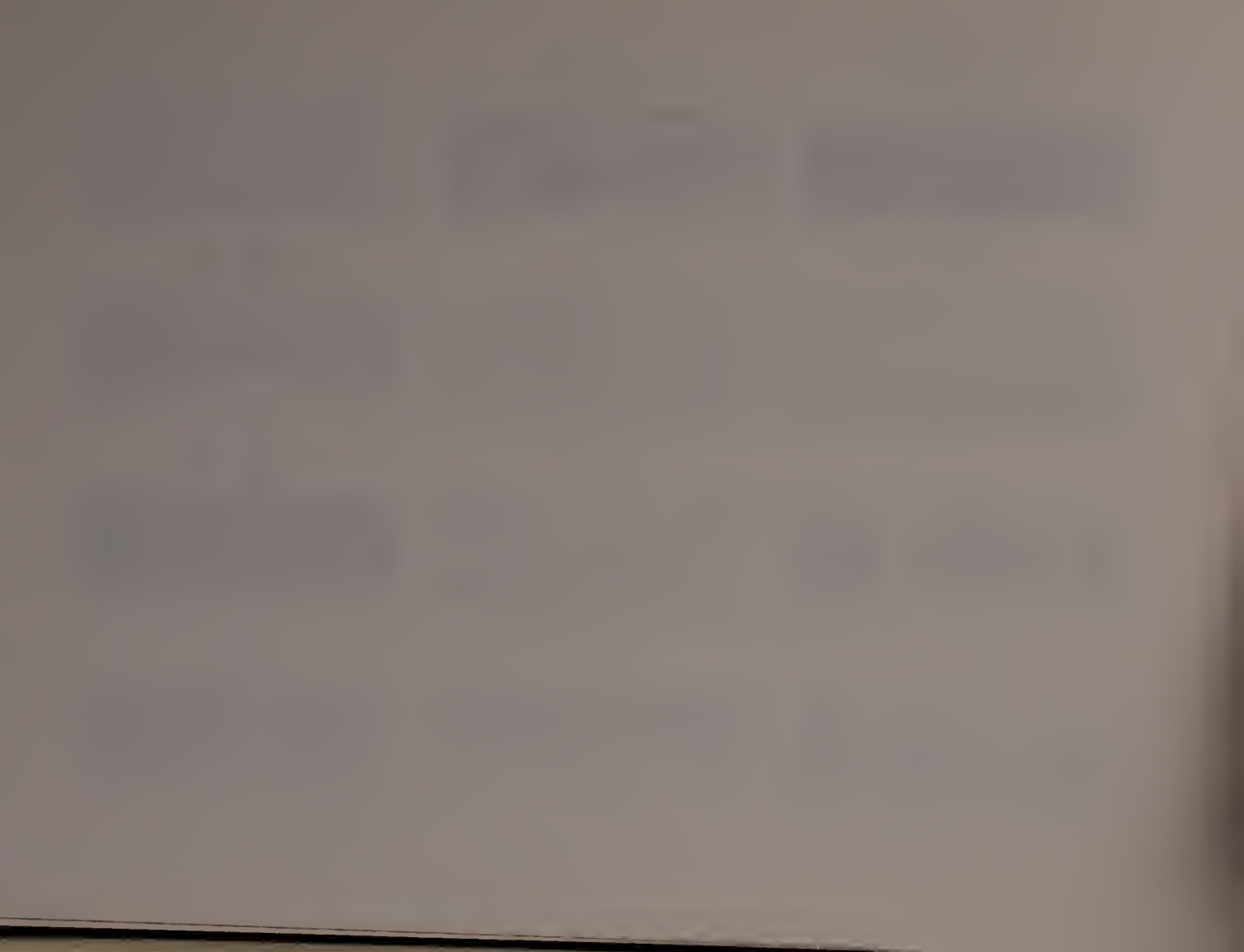


0435 UT

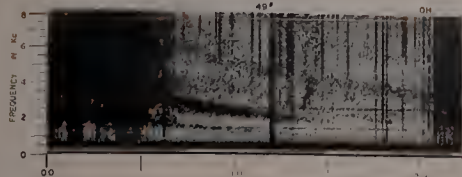


0535 UT

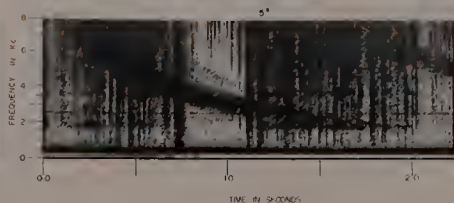




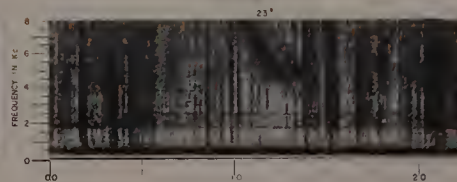
3 MARCH 1957
0635 UT



0835 UT



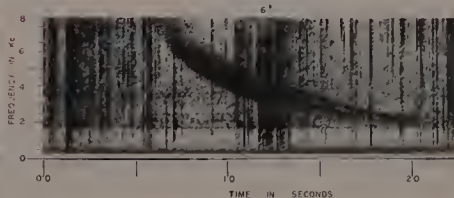
0935 UT



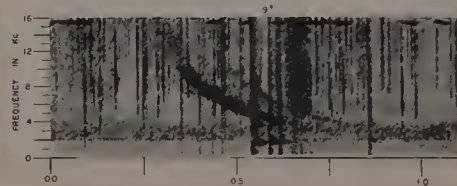
1035 UT



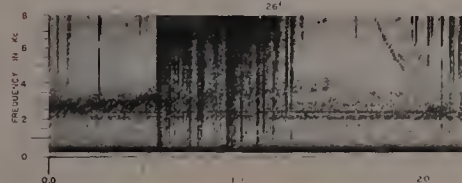
1135 UT



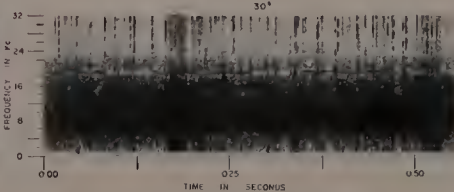
1235 UT



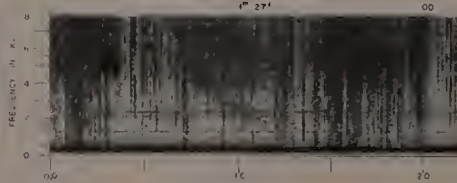
1435 UT



2235 UT



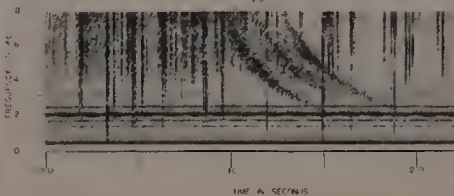
4 MARCH 1957
1235 UT



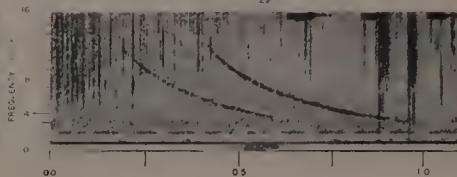
5 MARCH 1957
0535 UT



6 MARCH 1957
1235 UT



1435 UT

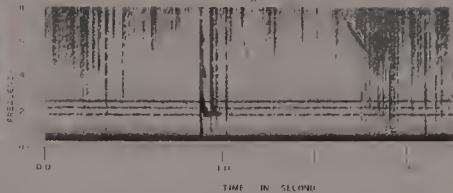




7 MARCH 1957
0535 UT



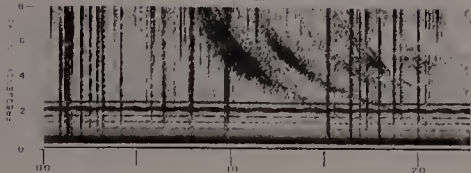
1235 UT



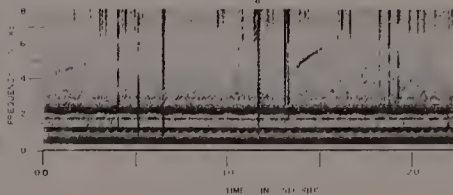
8 MARCH 1957
0935 UT



1235 UT



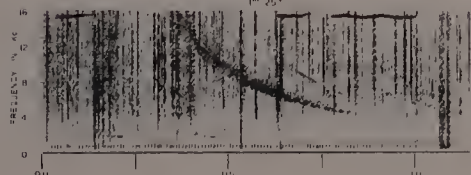
2235 UT



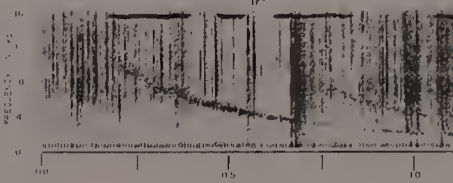
9 MARCH 1957
0435 UT



0635 UT



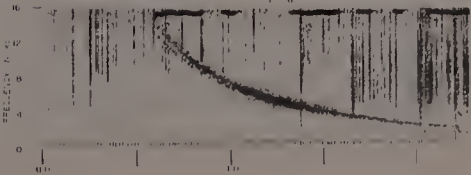
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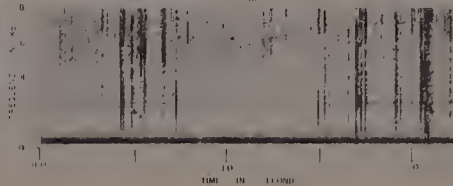
1135 UT



1235 UT



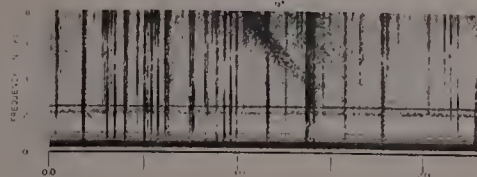
10 MARCH 1957
0735 UT



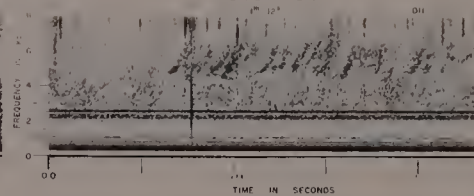
0835 UT



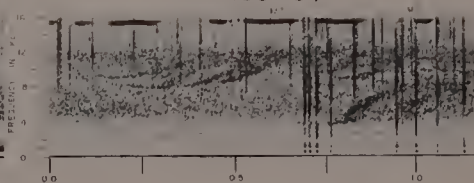
10 MARCH 1957
1135 UT



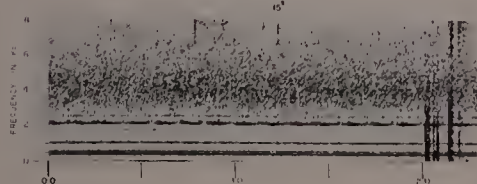
1235 UT



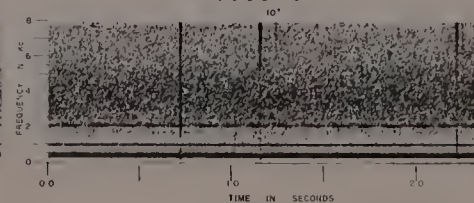
1435 UT



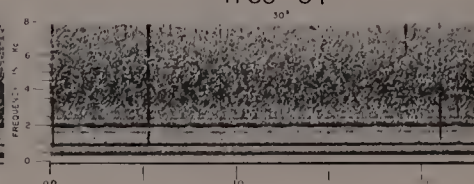
1535 UT



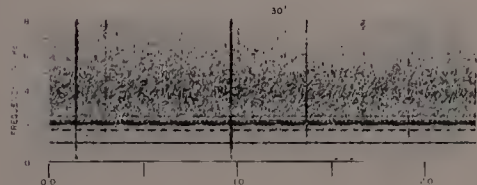
1635 UT



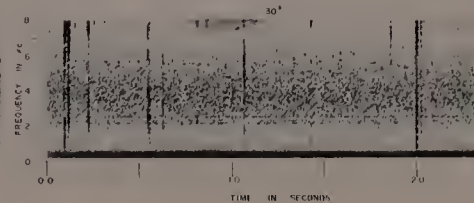
1735 UT



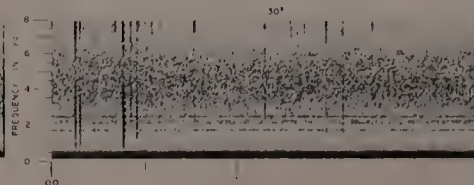
1835 UT



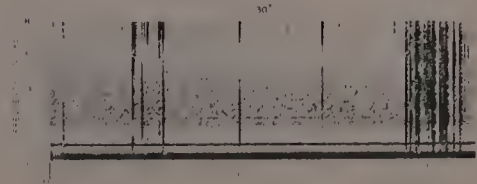
1935 UT



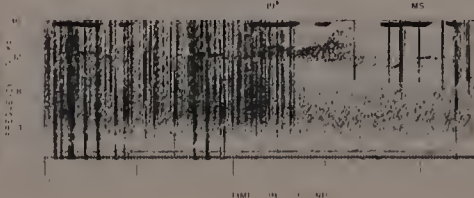
2035 UT



2135 UT



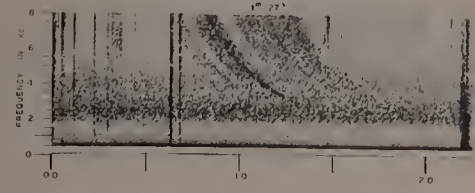
2235 UT



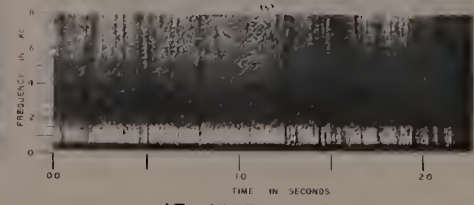
2335 UT



11 MARCH 1957
1235 UT



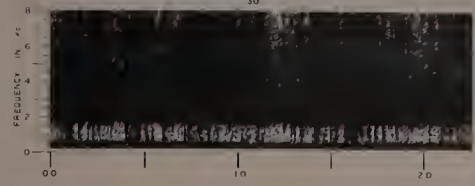
12 MARCH 1957
0335 UT



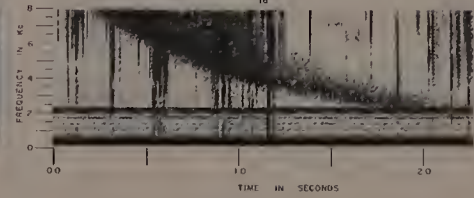
0435 UT



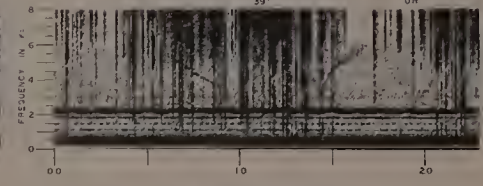
0535 UT



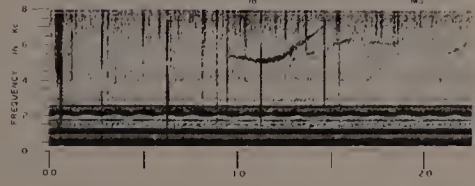
13 MARCH 1957
0035 UT



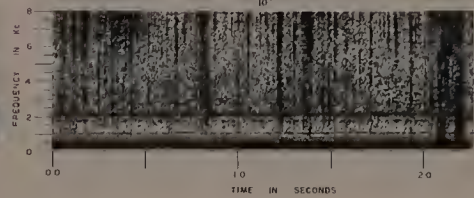
1435 UT



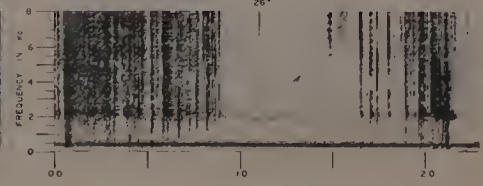
1535 UT



1835 UT



14 MARCH 1957
0335 UT



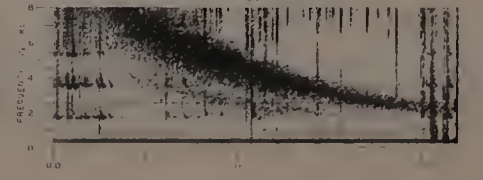
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0735 UT

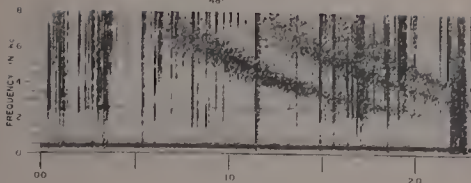


0835 UT



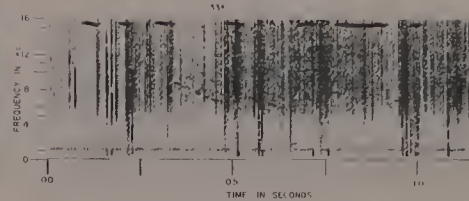
14 MARCH 1957

1235 UT

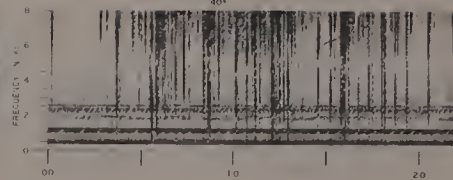


15 MARCH 1957

1635 UT

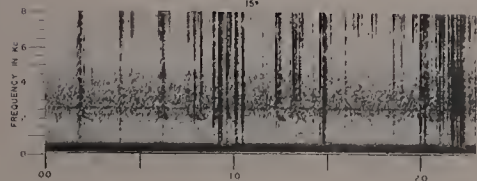


2135 UT

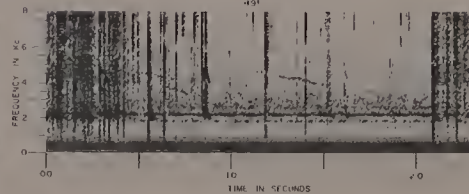


16 MARCH 1957

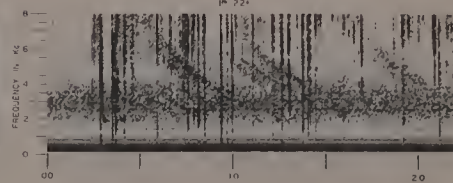
0435 UT



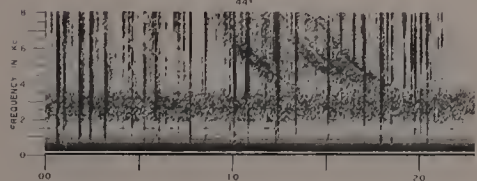
0535 UT



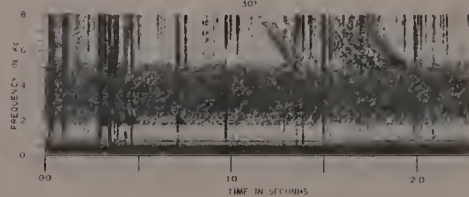
0635 UT



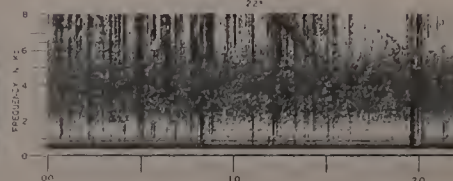
0735 UT



0835 UT



0935 UT



1035 UT



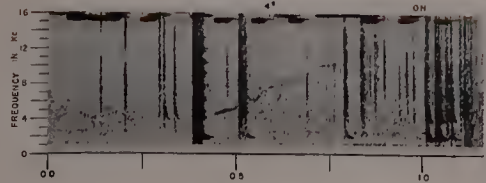
2335 UT



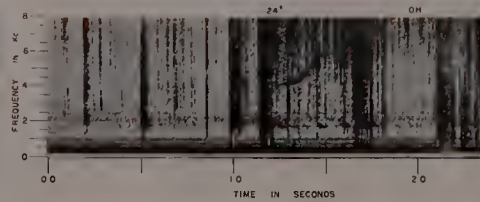
2335 UT



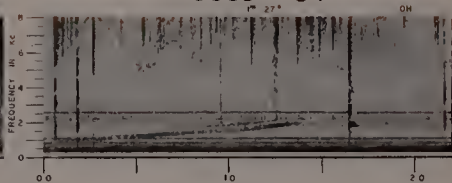
17 MARCH 1957
0435 UT



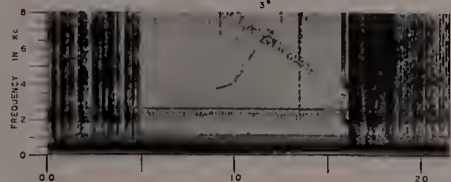
0835 UT



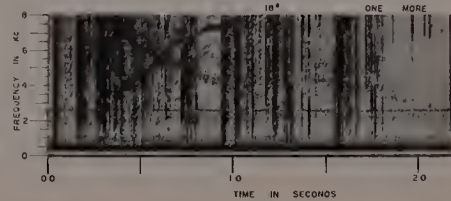
0935 UT



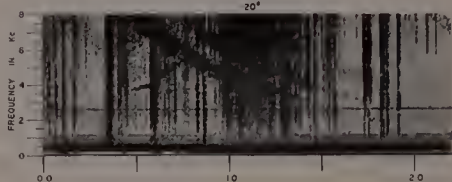
1035 UT



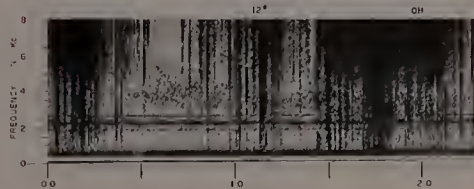
1135 UT



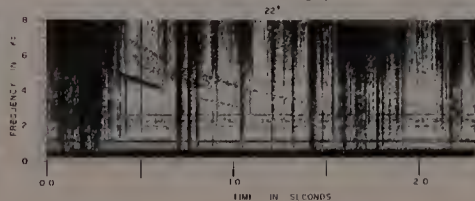
1235 UT



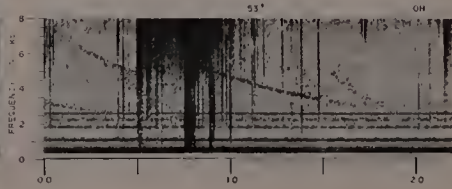
1435 UT



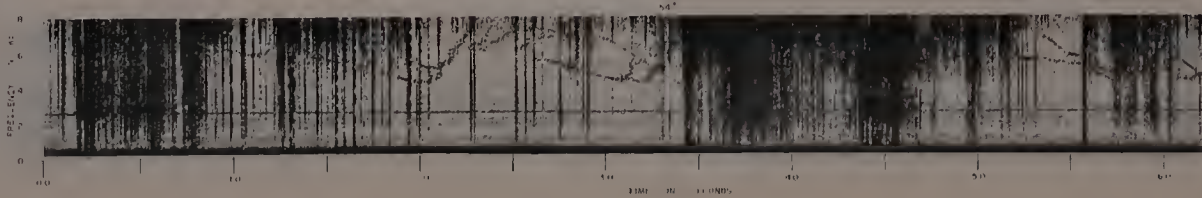
1635 UT



1735 UT

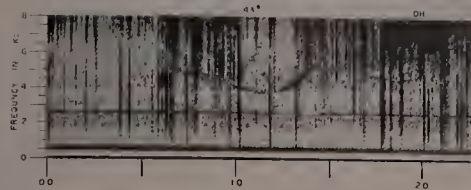


1935 UT

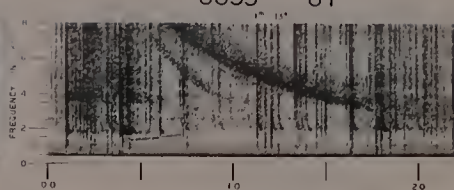




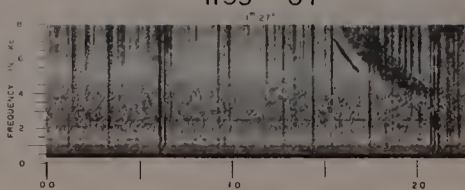
17 MARCH 1957
2035 UT



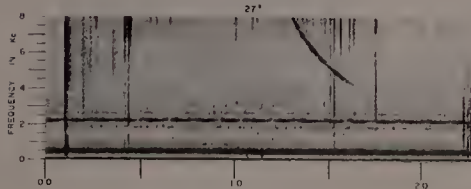
18 MARCH 1957
0635 UT



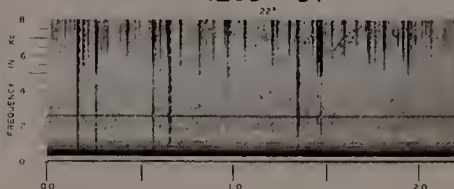
1135 UT



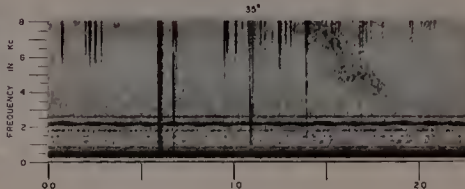
1335 UT



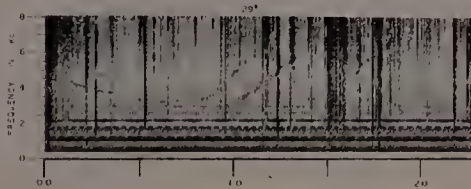
20 MARCH 1957
1235 UT



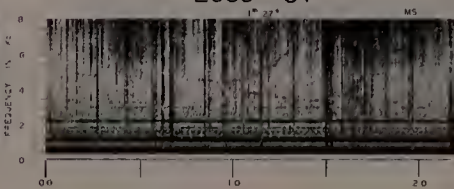
1235 UT



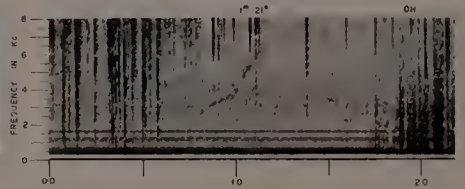
21 MARCH 1957
2035 UT



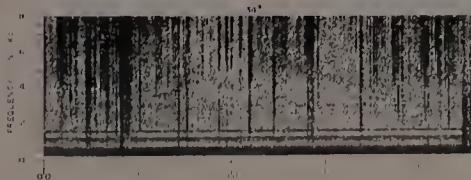
2035 UT



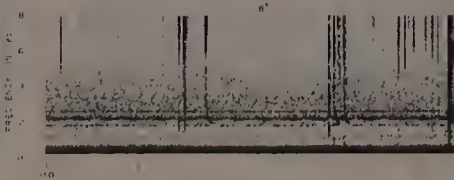
2335 UT



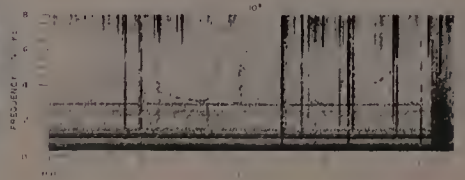
22 MARCH 1957
0035 UT

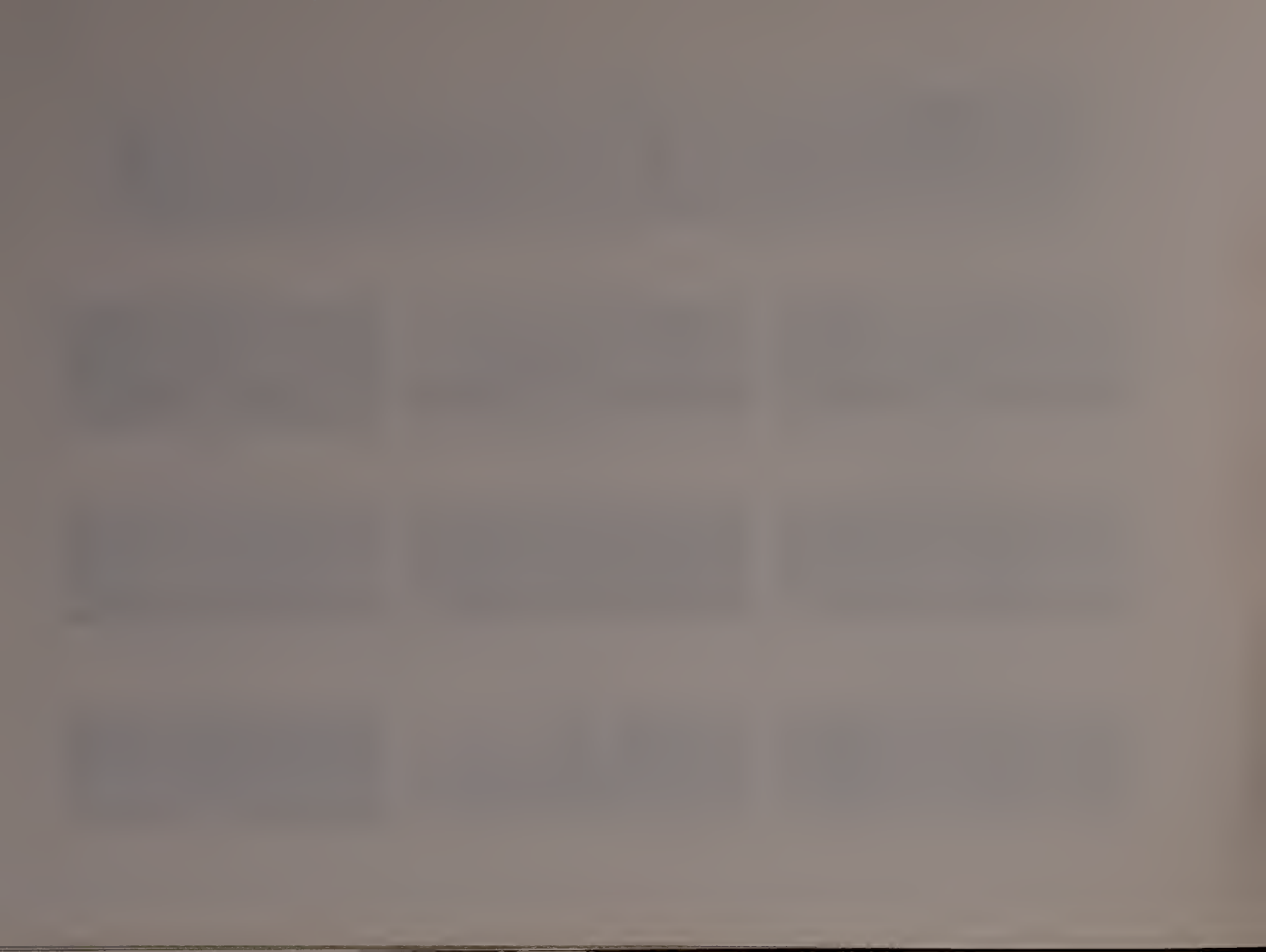


0235 UT

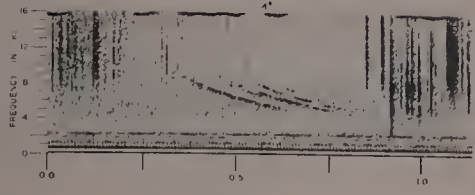


2135 UT

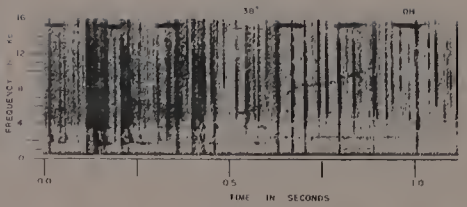




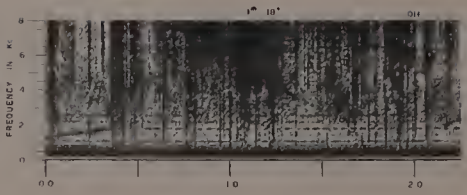
23 MARCH 1957
0135 UT



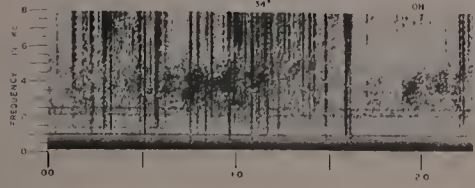
0935 UT



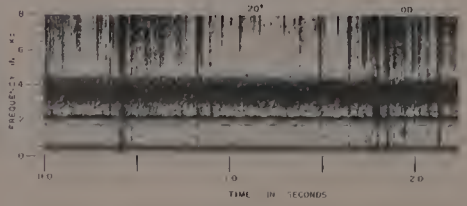
25 MARCH 1957
1135 UT



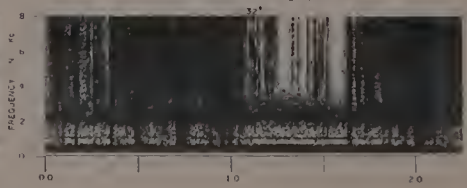
1235 UT



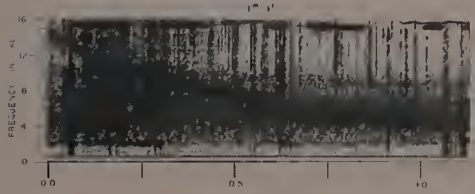
27 MARCH 1957
0135 UT



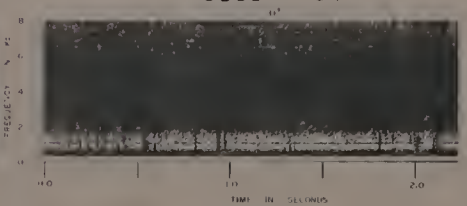
28 MARCH 1957
0135 UT



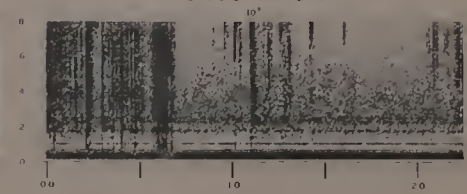
0235 UT



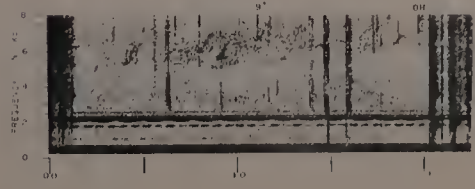
0335 UT



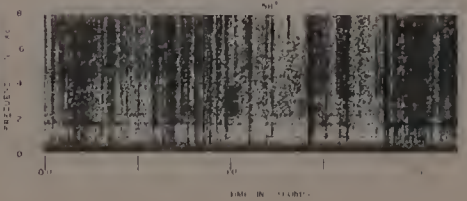
0435 UT



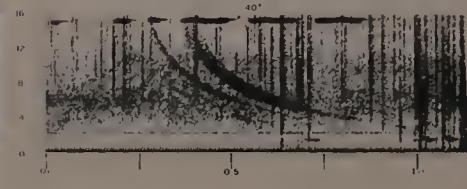
0535 UT



0635 UT



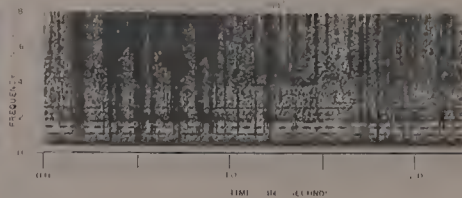
0735 UT



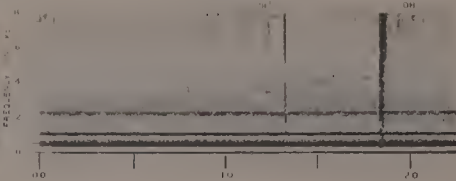
28 MARCH 1957
0835 UT



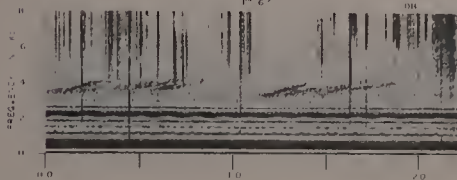
1035 UT



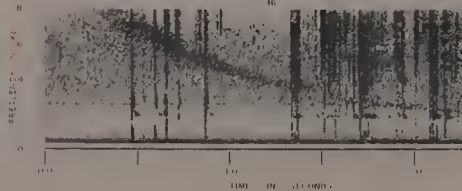
2335 UT



29 MARCH 1957
0035 UT



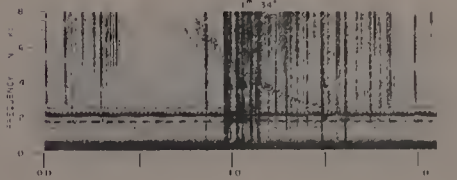
0335 UT



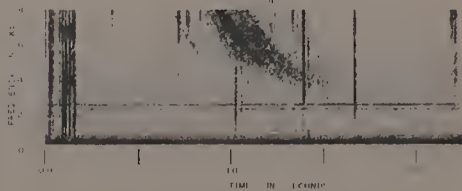
0435 UT



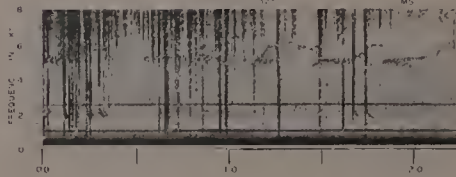
0535 UT



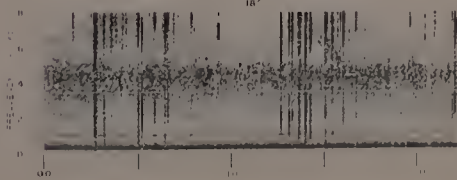
0635 UT



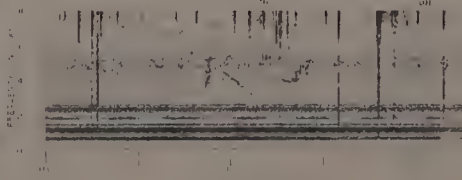
1135 UT



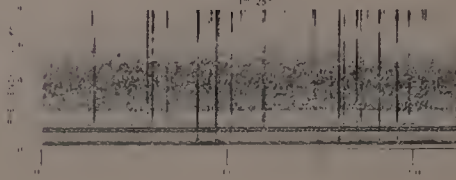
1435 UT



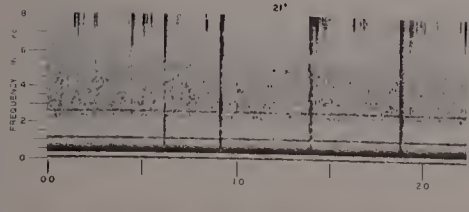
1635 UT



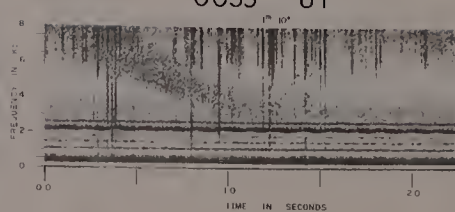
2035 UT



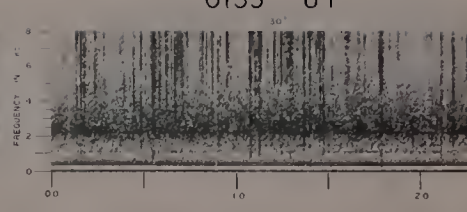
29 MARCH 1957
2335 UT



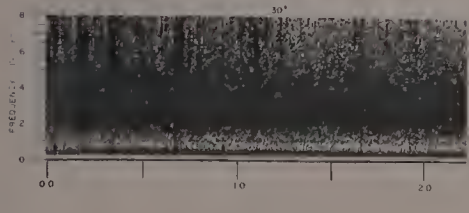
30 MARCH 1957
0035 UT



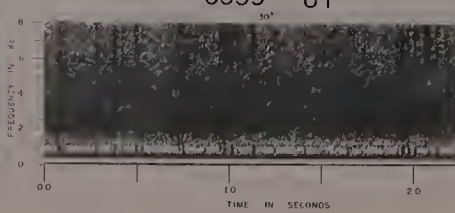
0135 UT



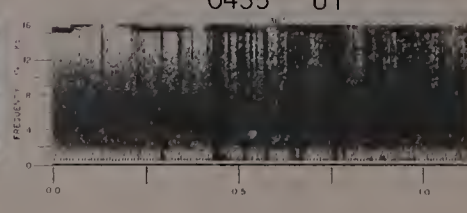
0235 UT



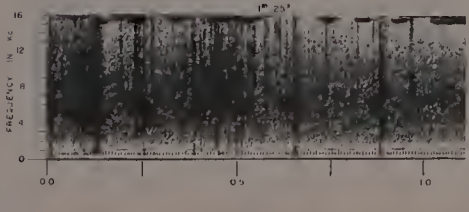
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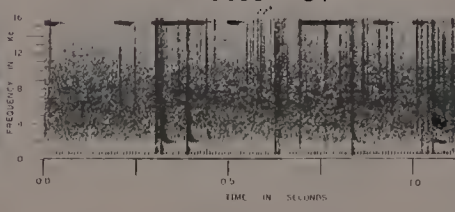
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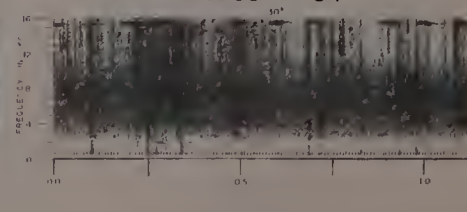
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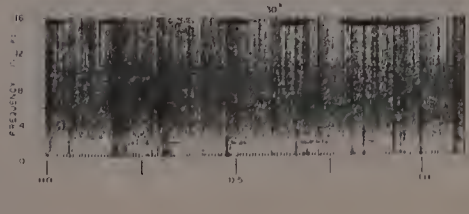
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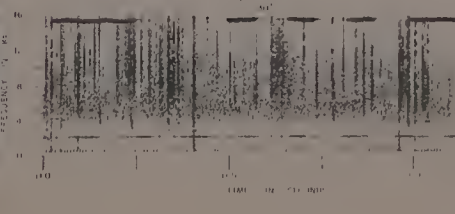
0735 UT



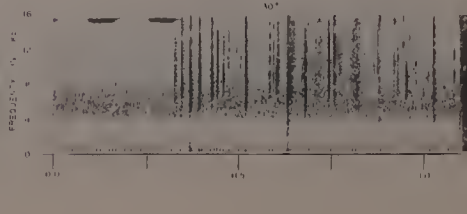
0835 UT



0935 UT

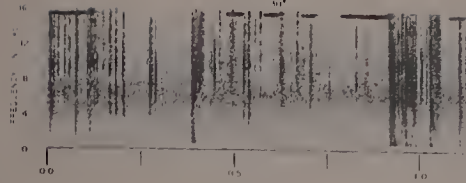


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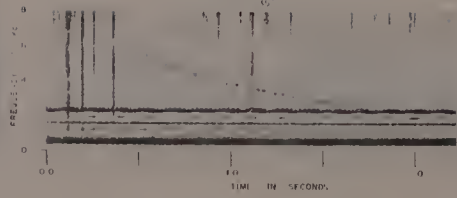




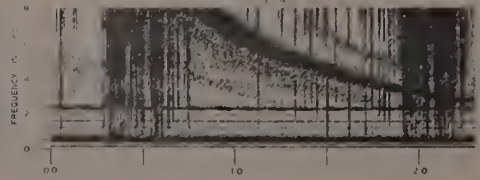
30 MARCH 1957
1135 UT



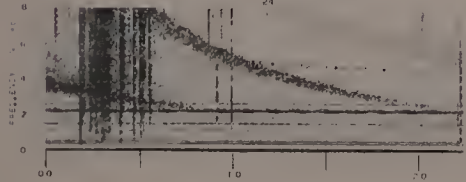
2235 UT



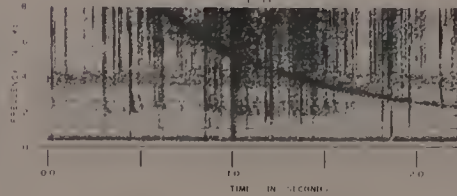
2335 UT



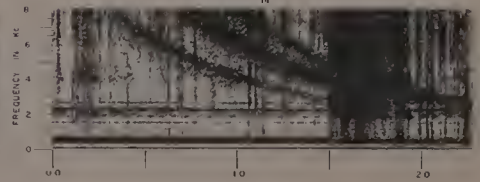
31 MARCH 1957
0035 UT



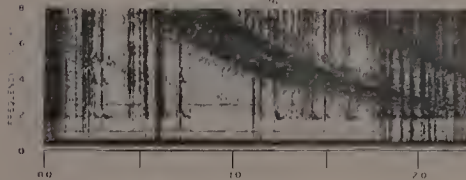
0135 UT



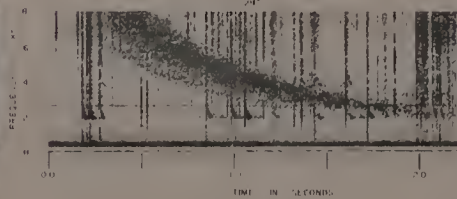
0535 UT



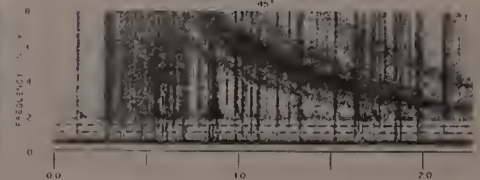
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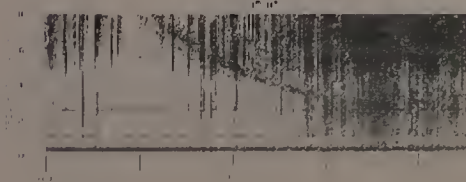
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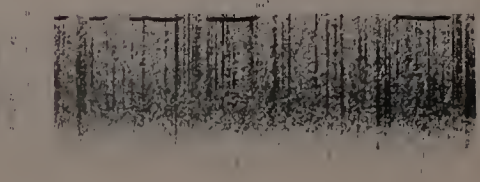
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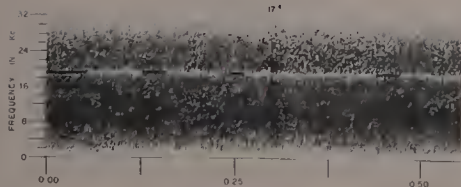
1 APRIL 1957
2335 UT



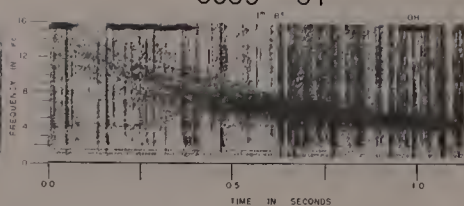
2 APRIL 1957
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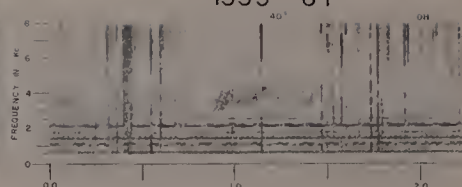
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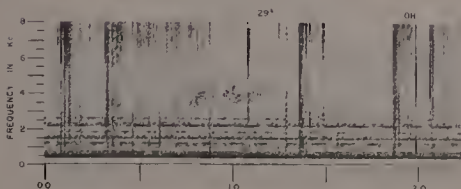
5 APRIL 1957
0535 UT



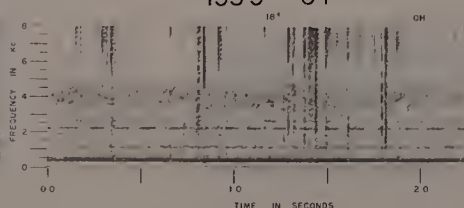
1335 UT



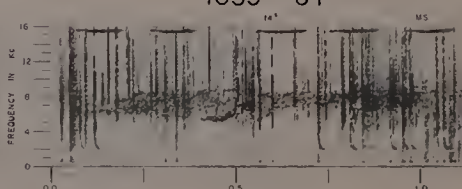
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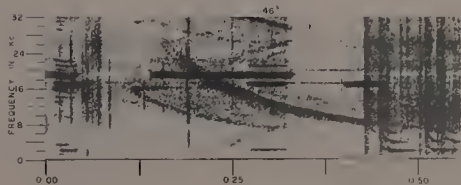
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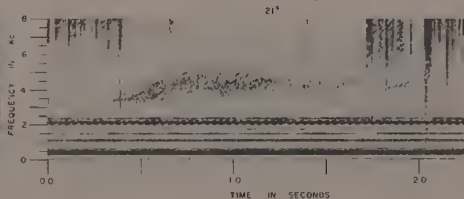
6 APRIL 1957
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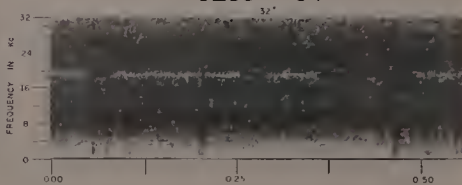
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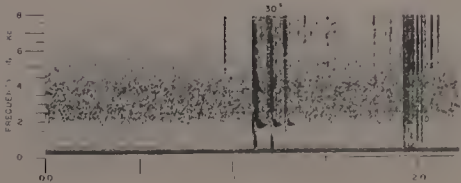
2335 UT



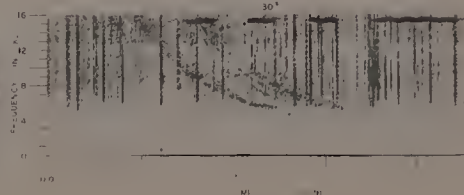
7 APRIL 1957
0235 UT



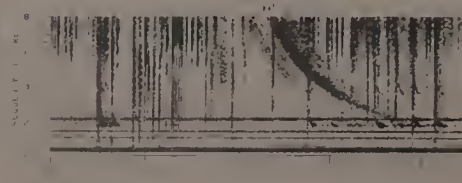
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0835 UT

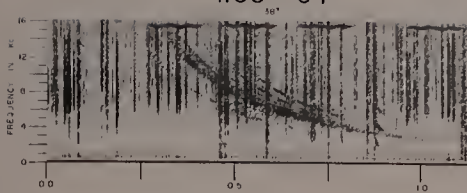


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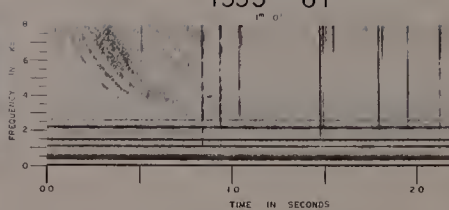




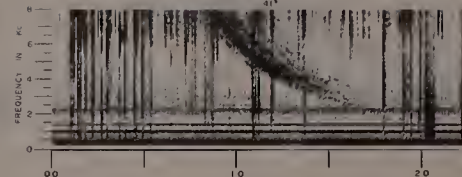
7 APRIL 1957
1135 UT



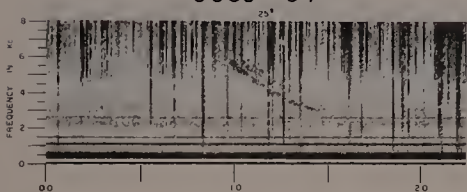
1335 UT



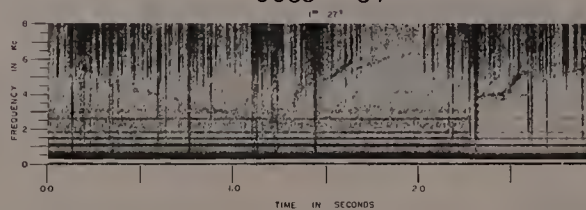
9 APRIL 1957
2335 UT



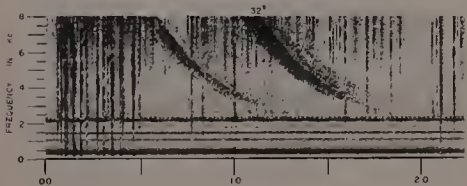
10 APRIL 1957
0035 UT



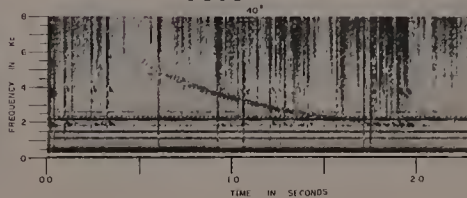
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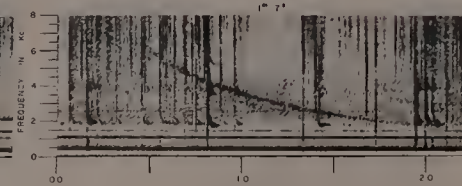
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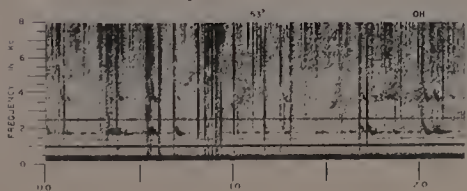
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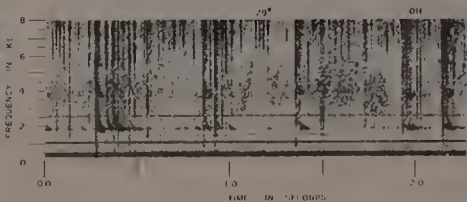
0635 UT



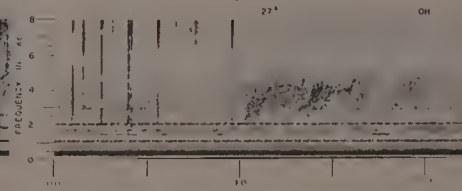
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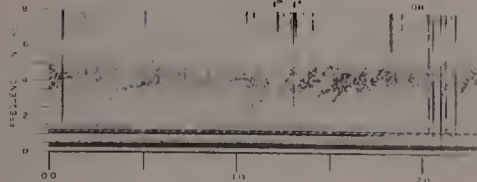


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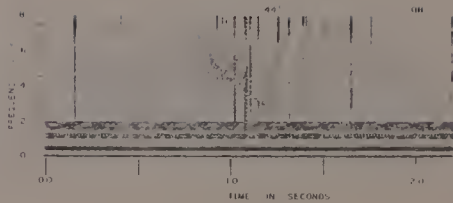




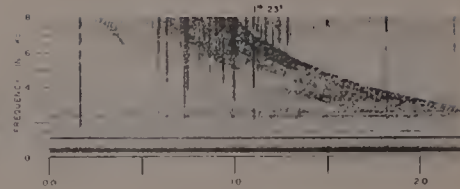
10 APRIL 1957
1535 UT



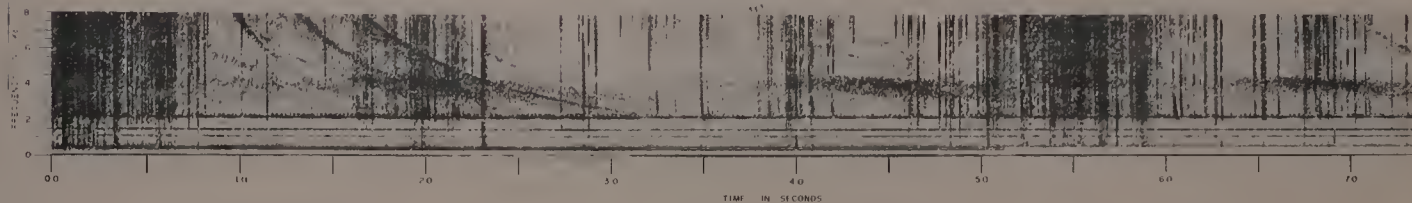
1635 UT



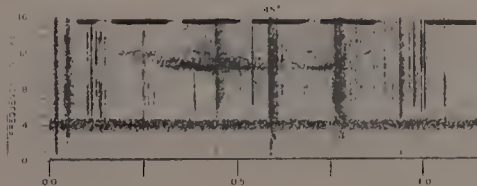
11 APRIL 1957
0335 UT



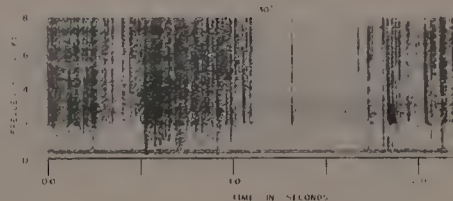
0135 UT



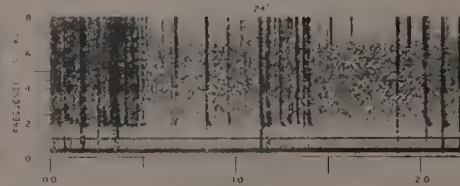
0235 UT



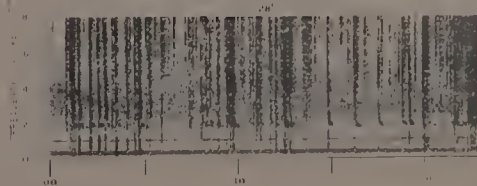
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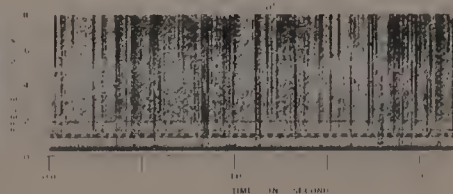
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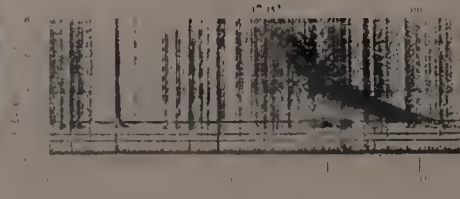
0735 UT



1935 UT

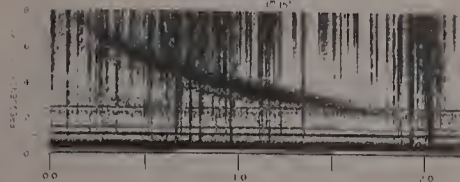


12 APRIL 1957
0535 UT

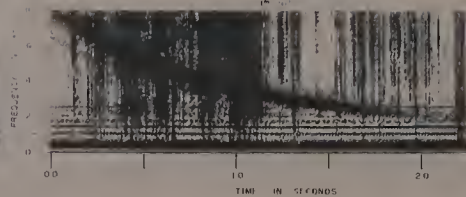




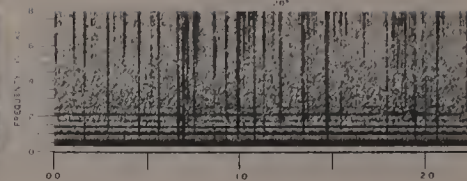
13 APRIL 1957
0035 UT



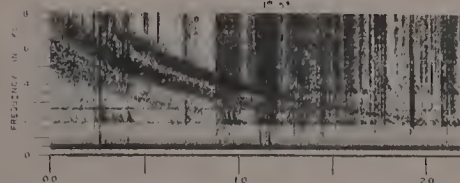
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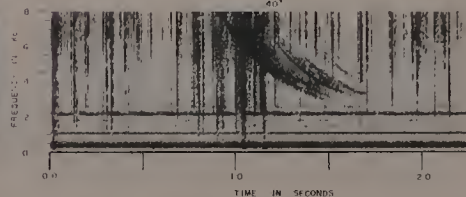
1235 UT



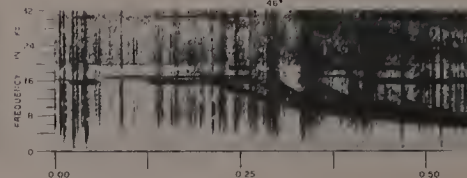
17 APRIL 1957
0535 UT



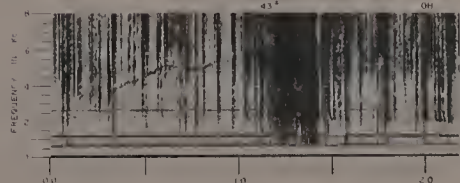
2335 UT



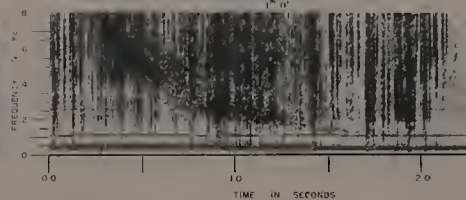
18 APRIL 1957
0035 UT



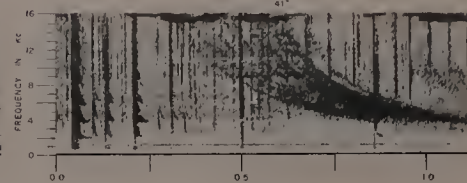
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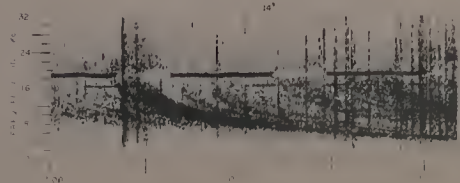
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0335 UT



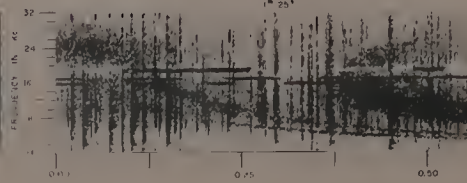
0435 UT



0635 UT

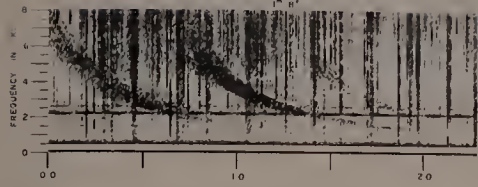


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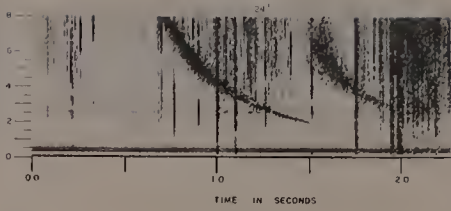




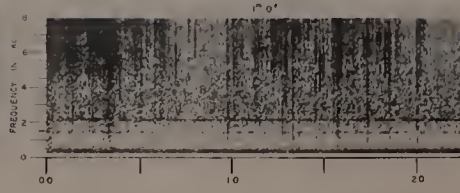
18 APRIL 1957
1335 UT



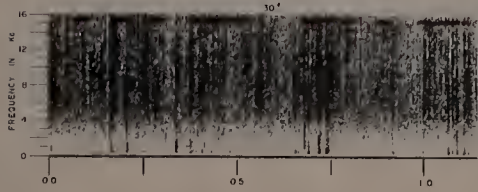
1435 UT



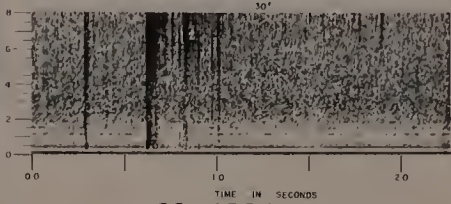
19 APRIL 1957
1335 UT



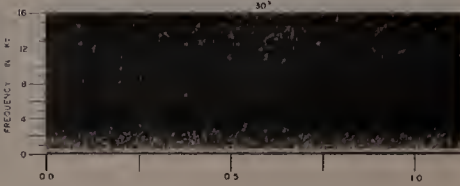
1435 UT



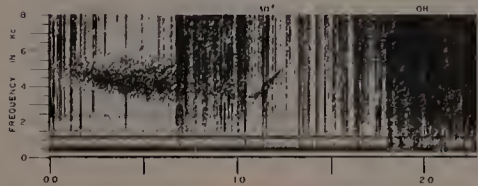
1635 UT



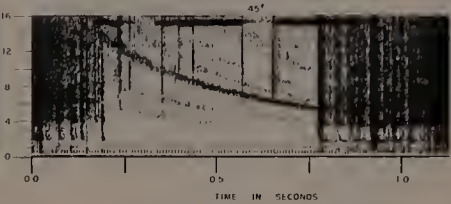
1735 UT



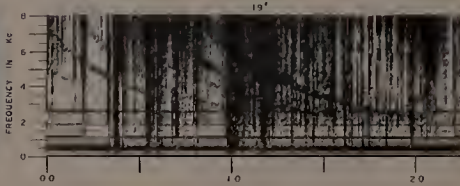
2235 UT



20 APRIL 1957
1035 UT



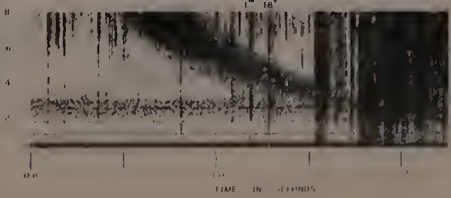
1235 UT



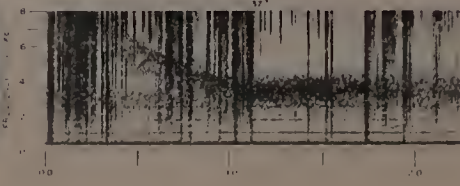
21 APRIL 1957
1335 UT



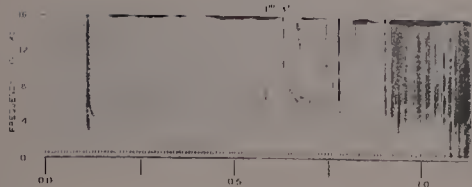
22 APRIL 1957
0935 UT



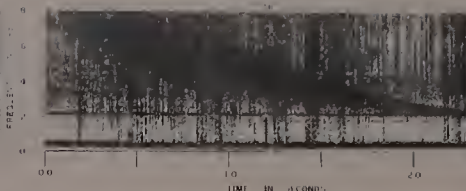
1335 UT



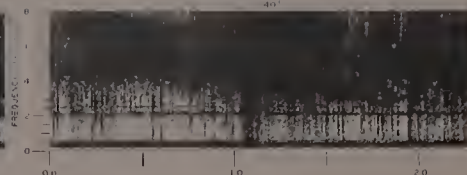
24 APRIL 1957
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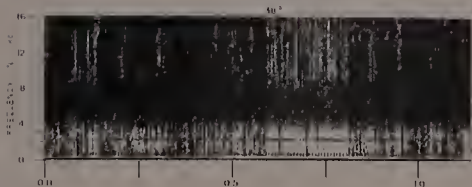
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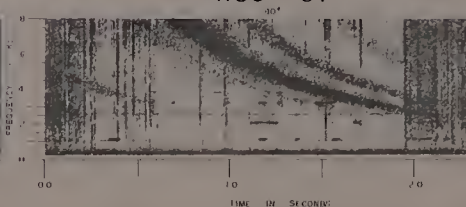
1335 UT



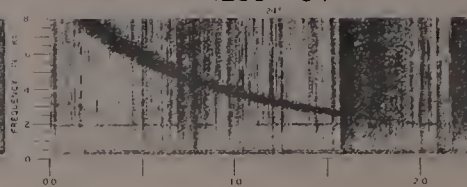
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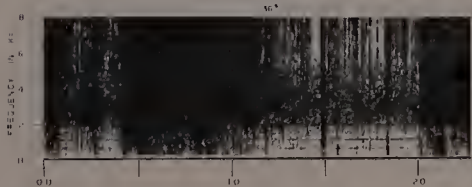
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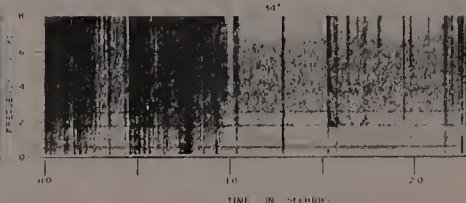
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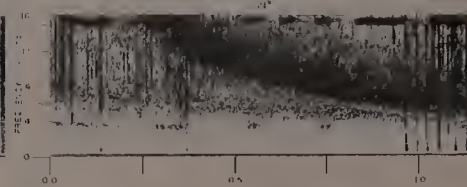
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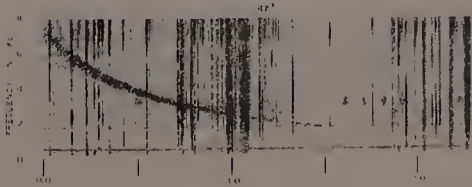
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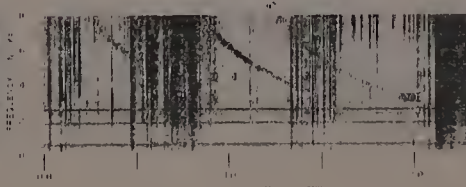
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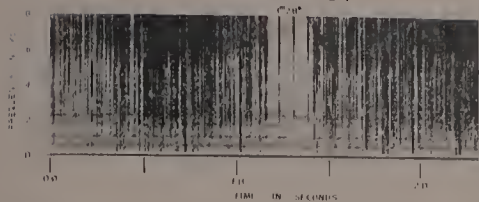
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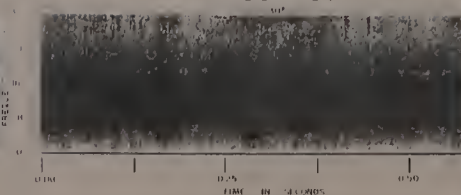
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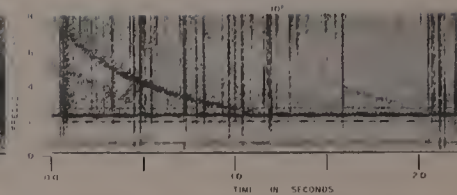
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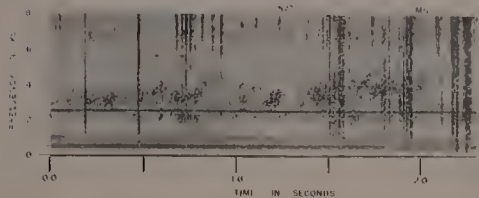
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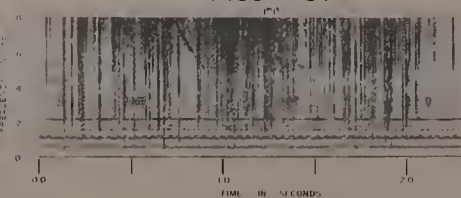
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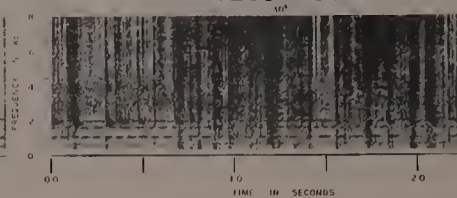
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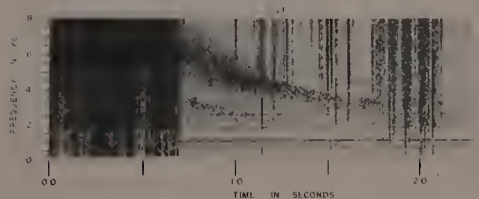
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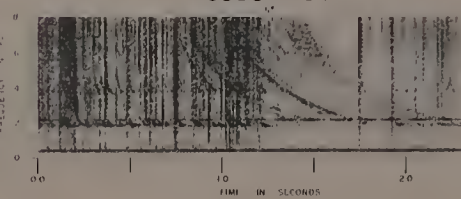
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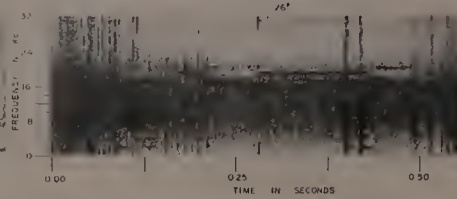
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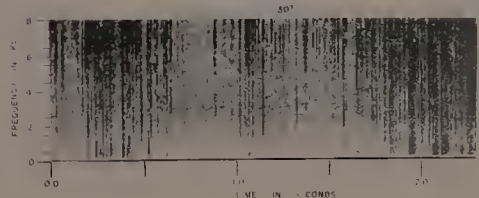
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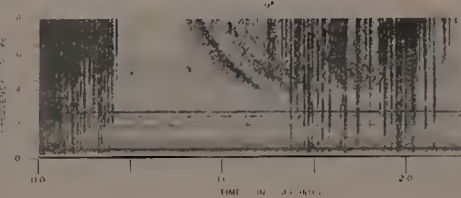
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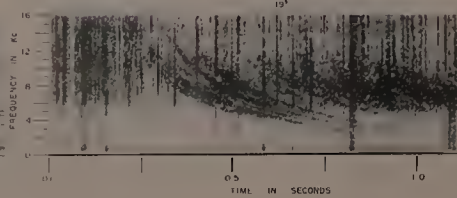
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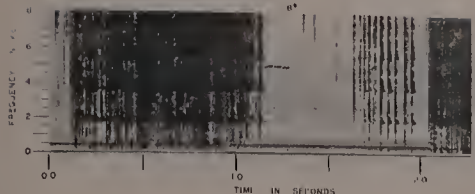
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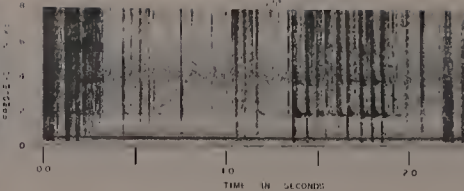
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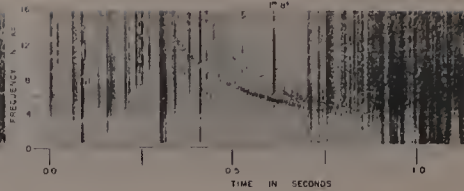
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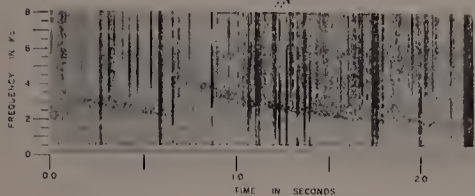


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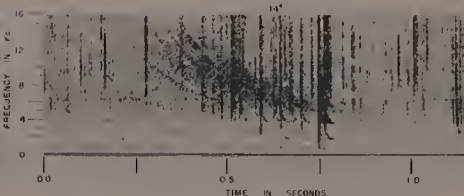


87

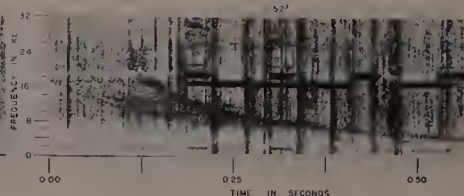
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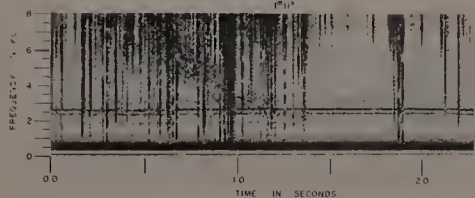
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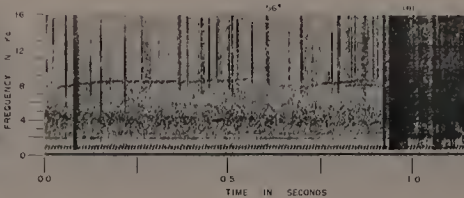
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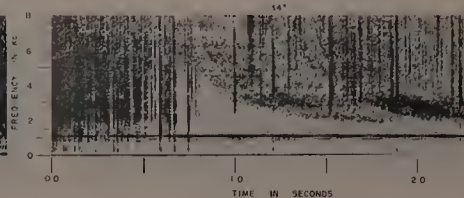
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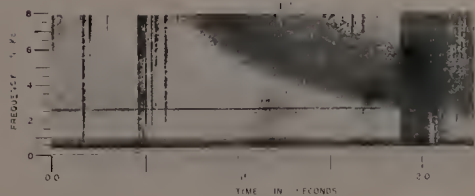
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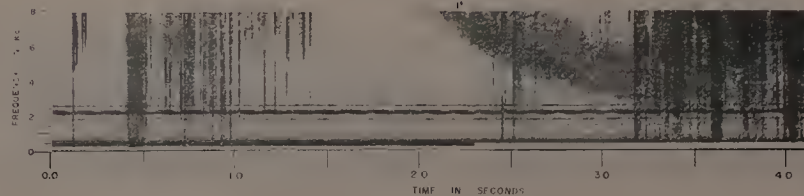
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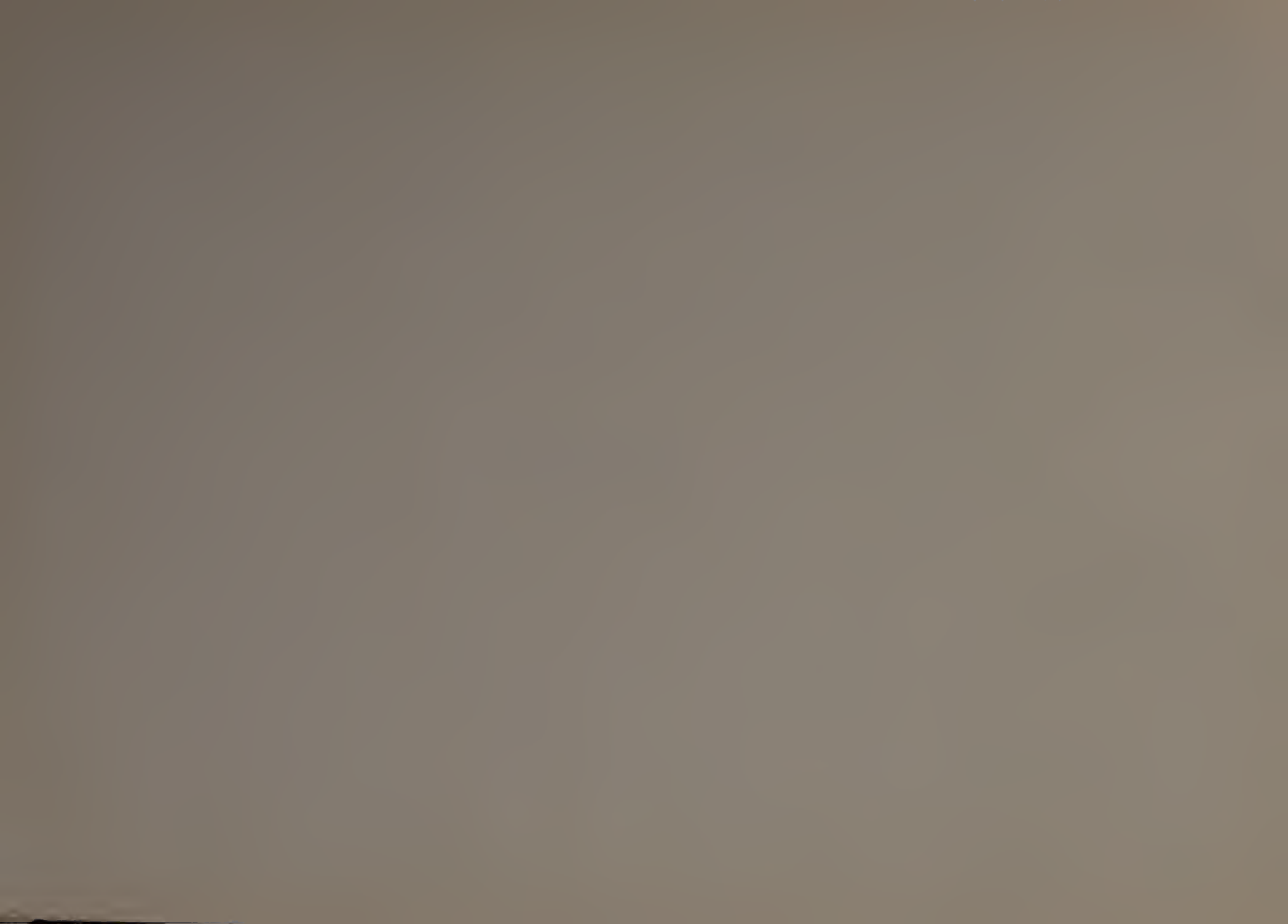


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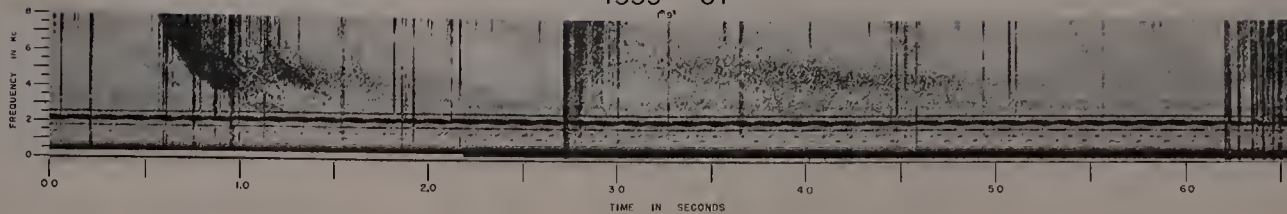
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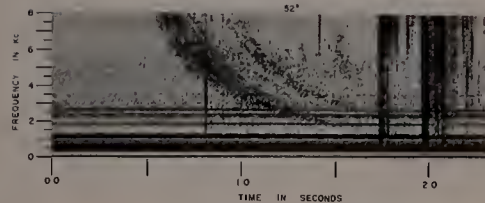


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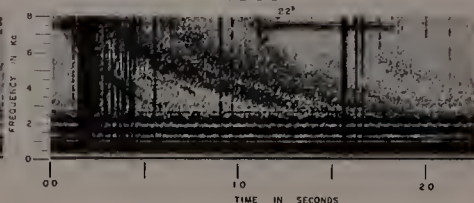
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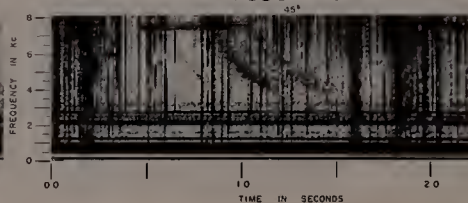
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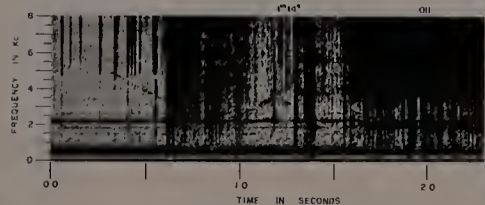


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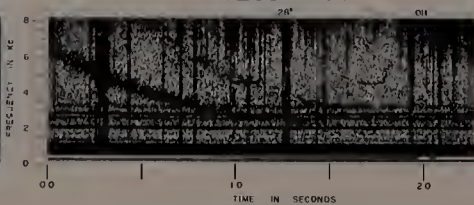


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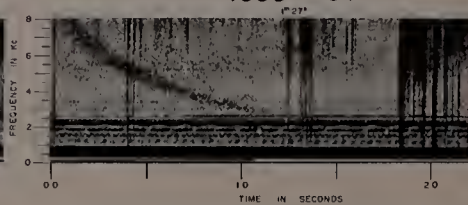
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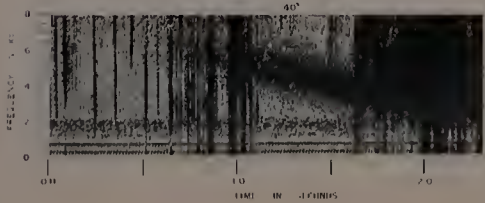


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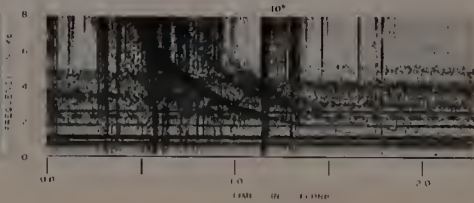


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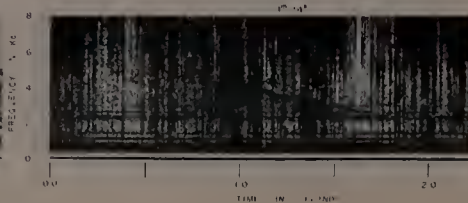
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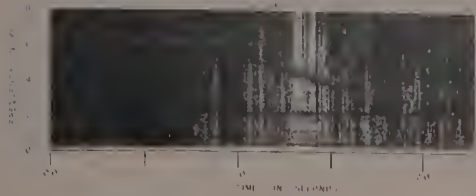
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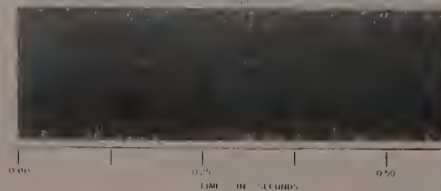
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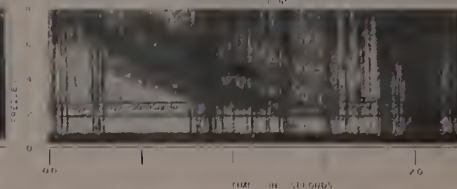
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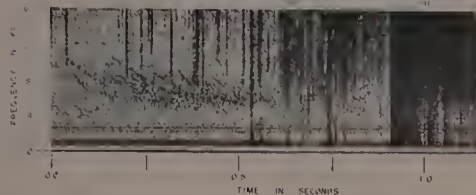
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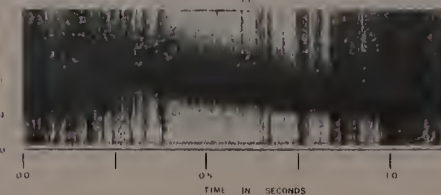
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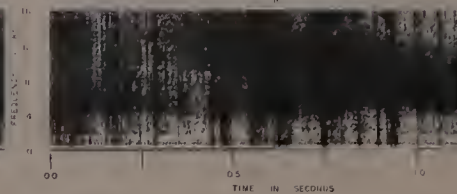
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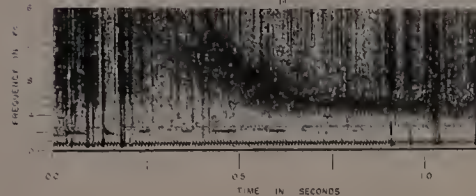
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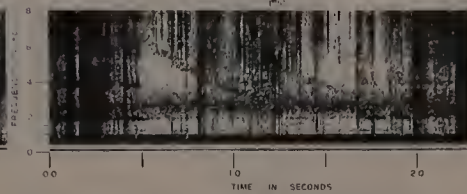
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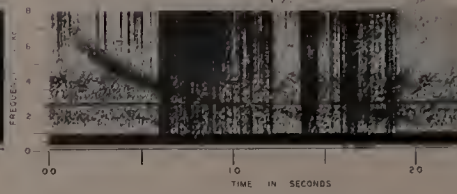
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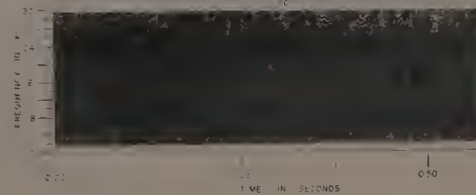
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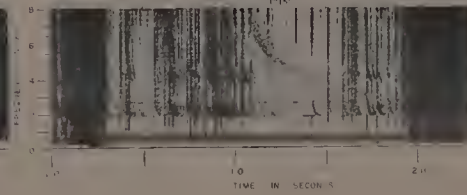
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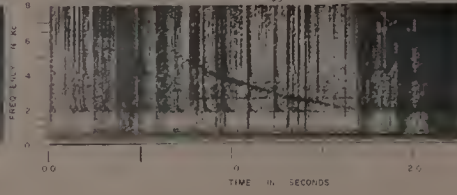
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4 JUNE 1957
0435 UT



0535 UT



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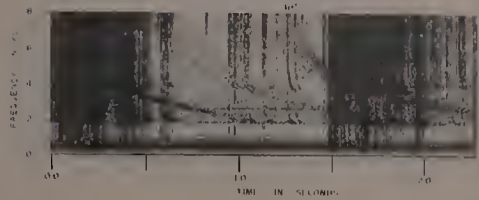
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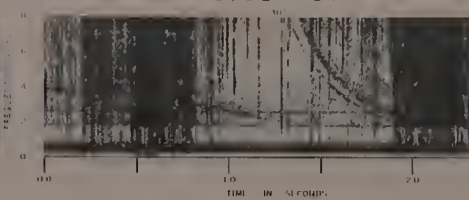
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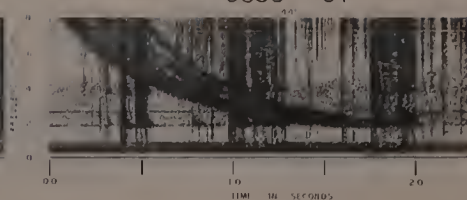
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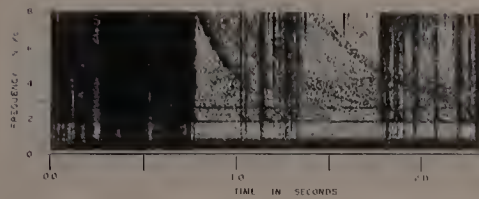
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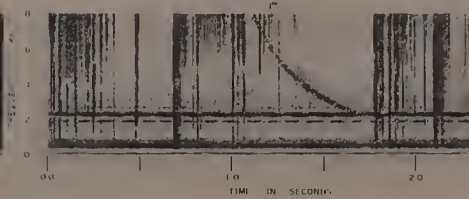
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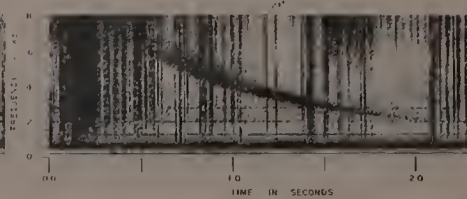


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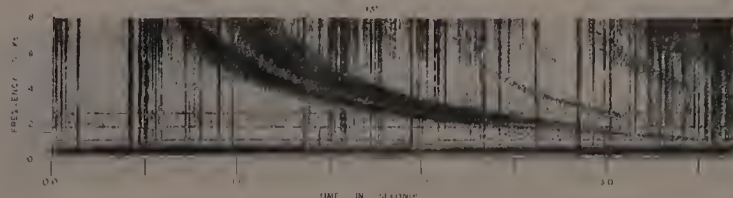


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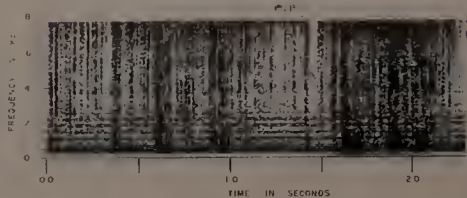
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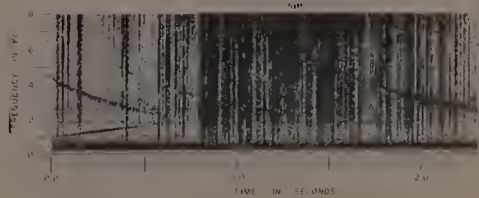


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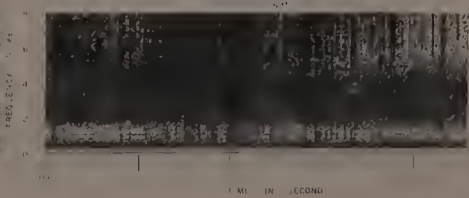
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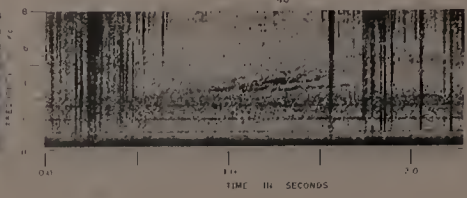


7 JUNE 1957

1035 UT



1135 UT



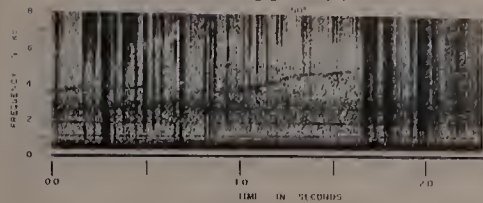
1. The first part of the document discusses the importance of maintaining accurate records of all transactions.

2. It is essential to ensure that all entries are supported by appropriate documentation and receipts.

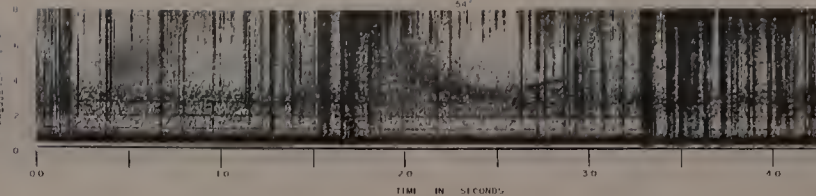
3. Regular audits should be conducted to verify the accuracy of the records and identify any discrepancies.

4. The final section provides a summary of the key findings and recommendations for improving record-keeping practices.

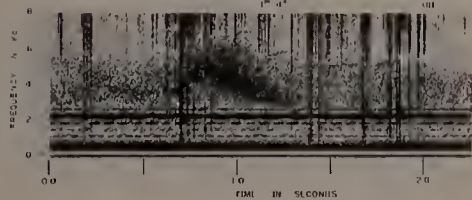
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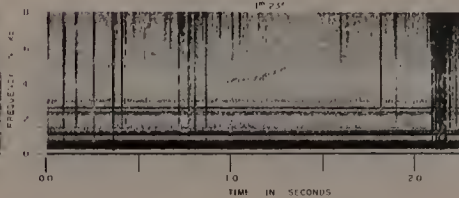
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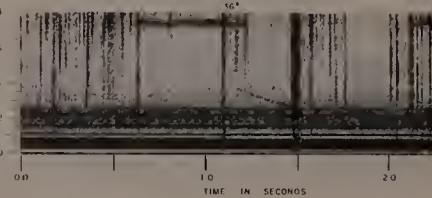
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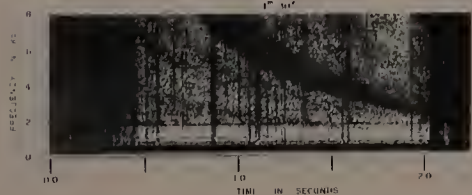
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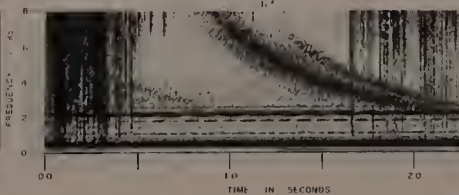
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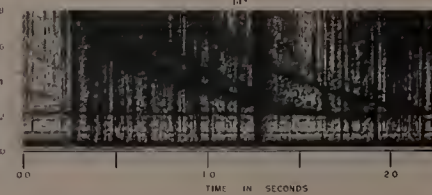
8 JUNE 1957
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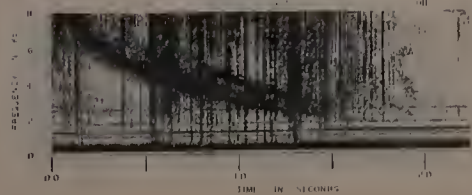
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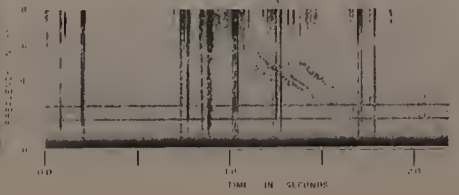
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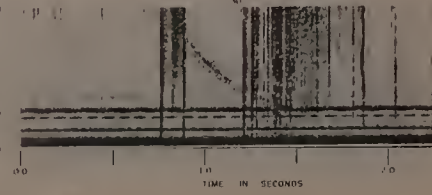
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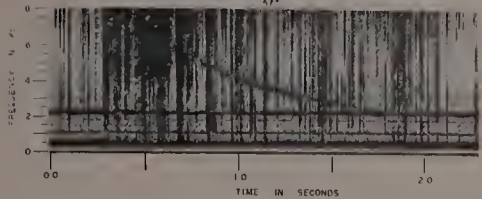
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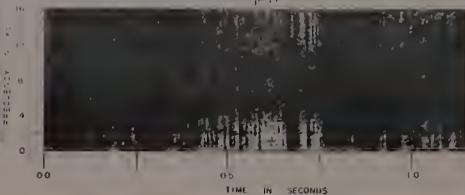
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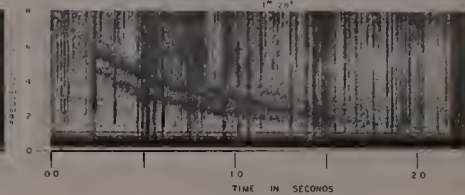
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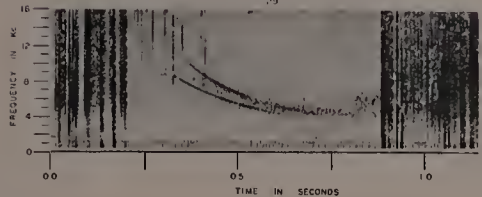
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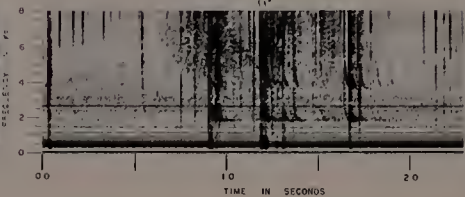
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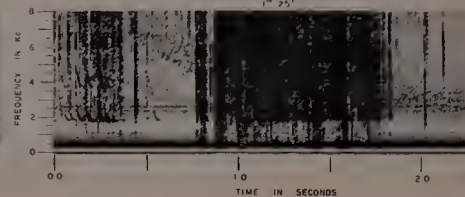
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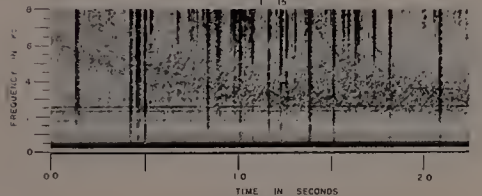
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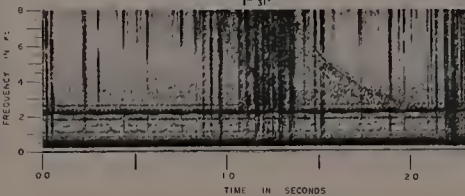
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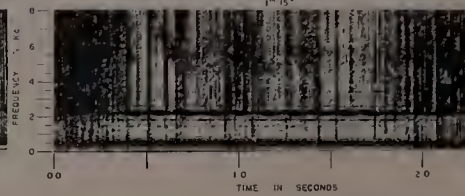
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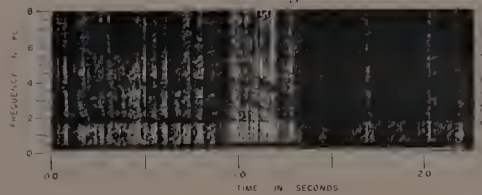
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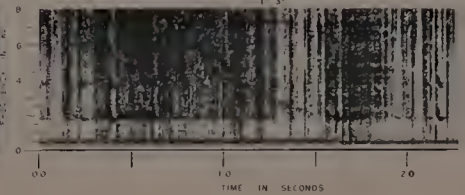
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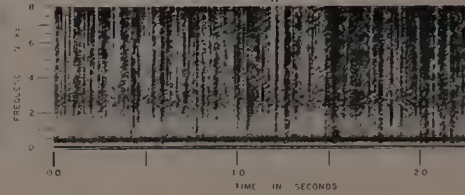
13 JUNE 1957
0835 UT



1035 UT

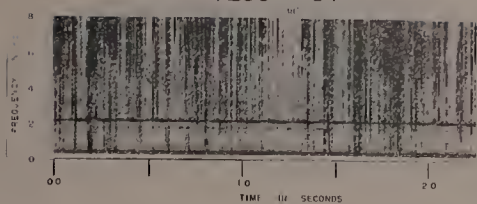


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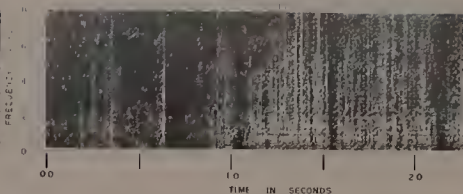


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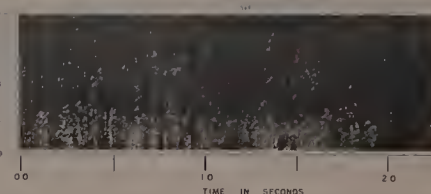
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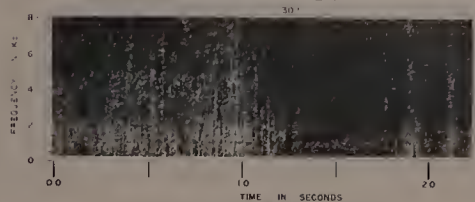
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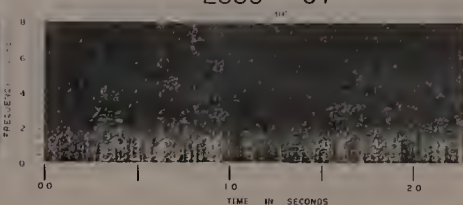
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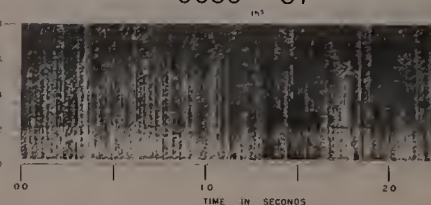
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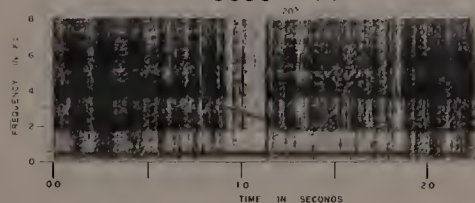
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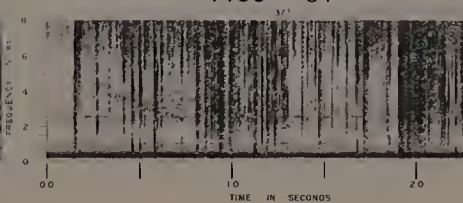
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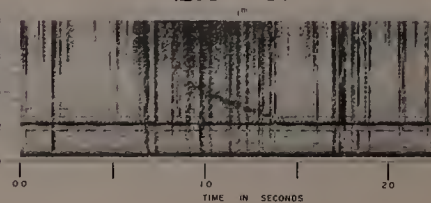
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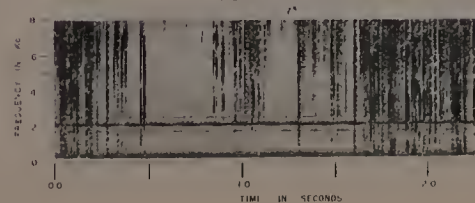
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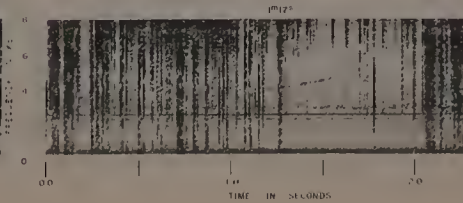
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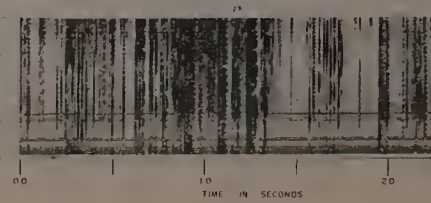
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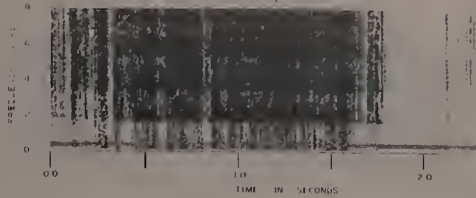
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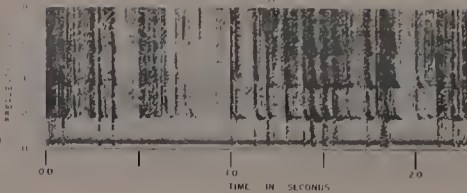
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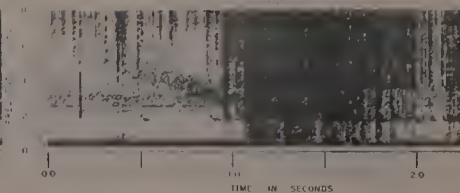
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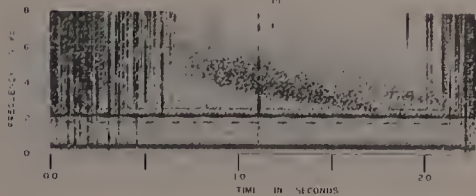
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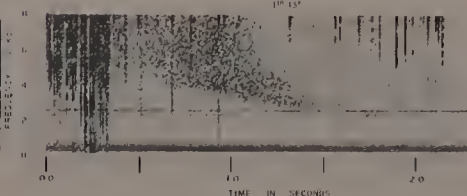
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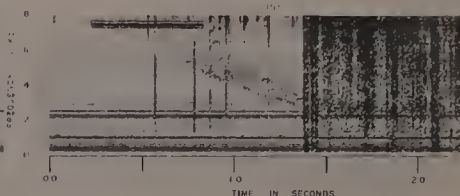
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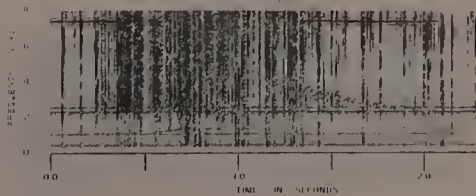
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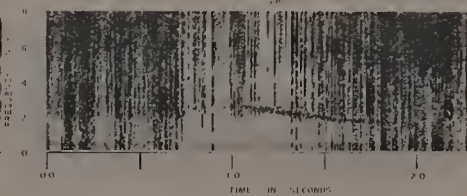
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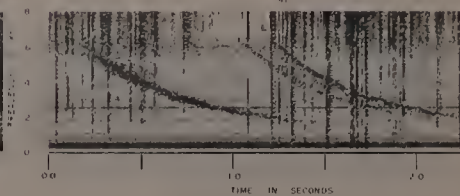
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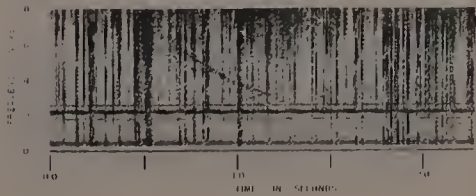
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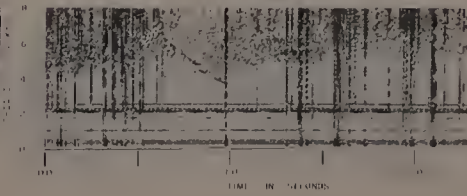
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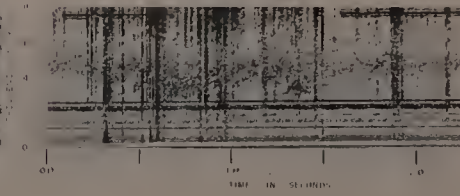
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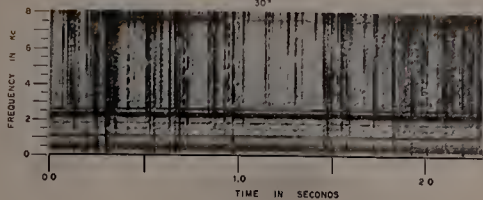


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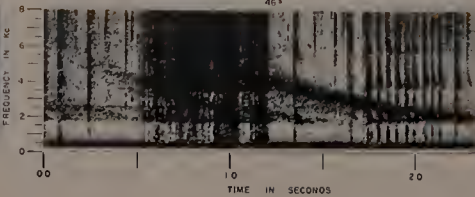


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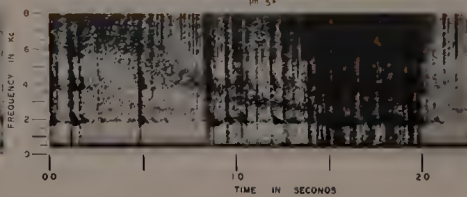
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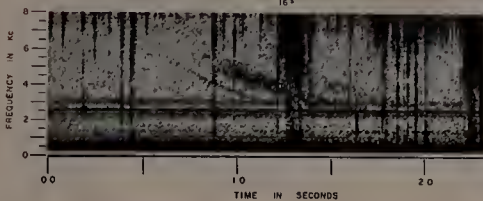
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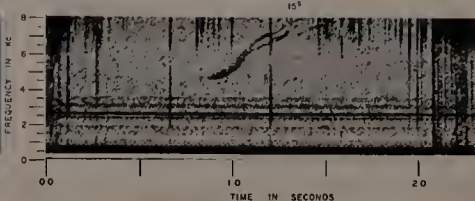
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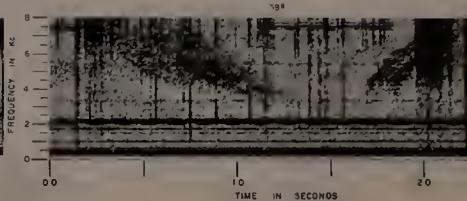
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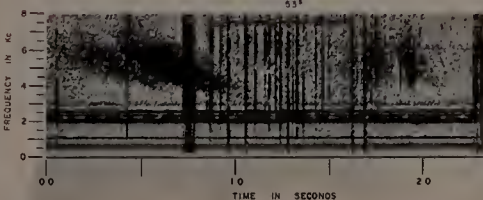
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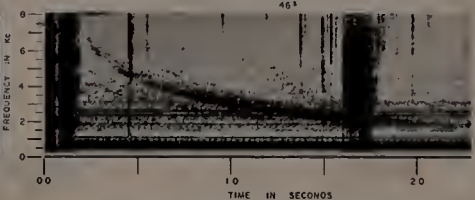
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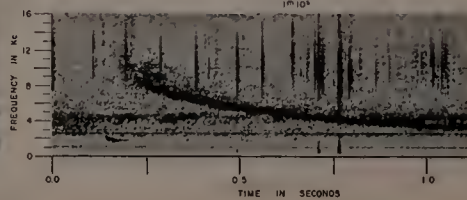
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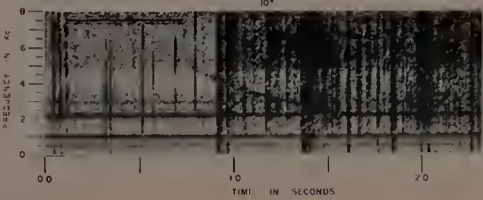
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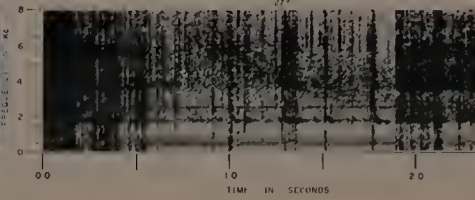
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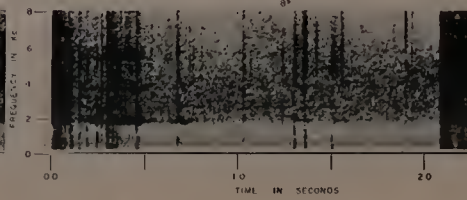
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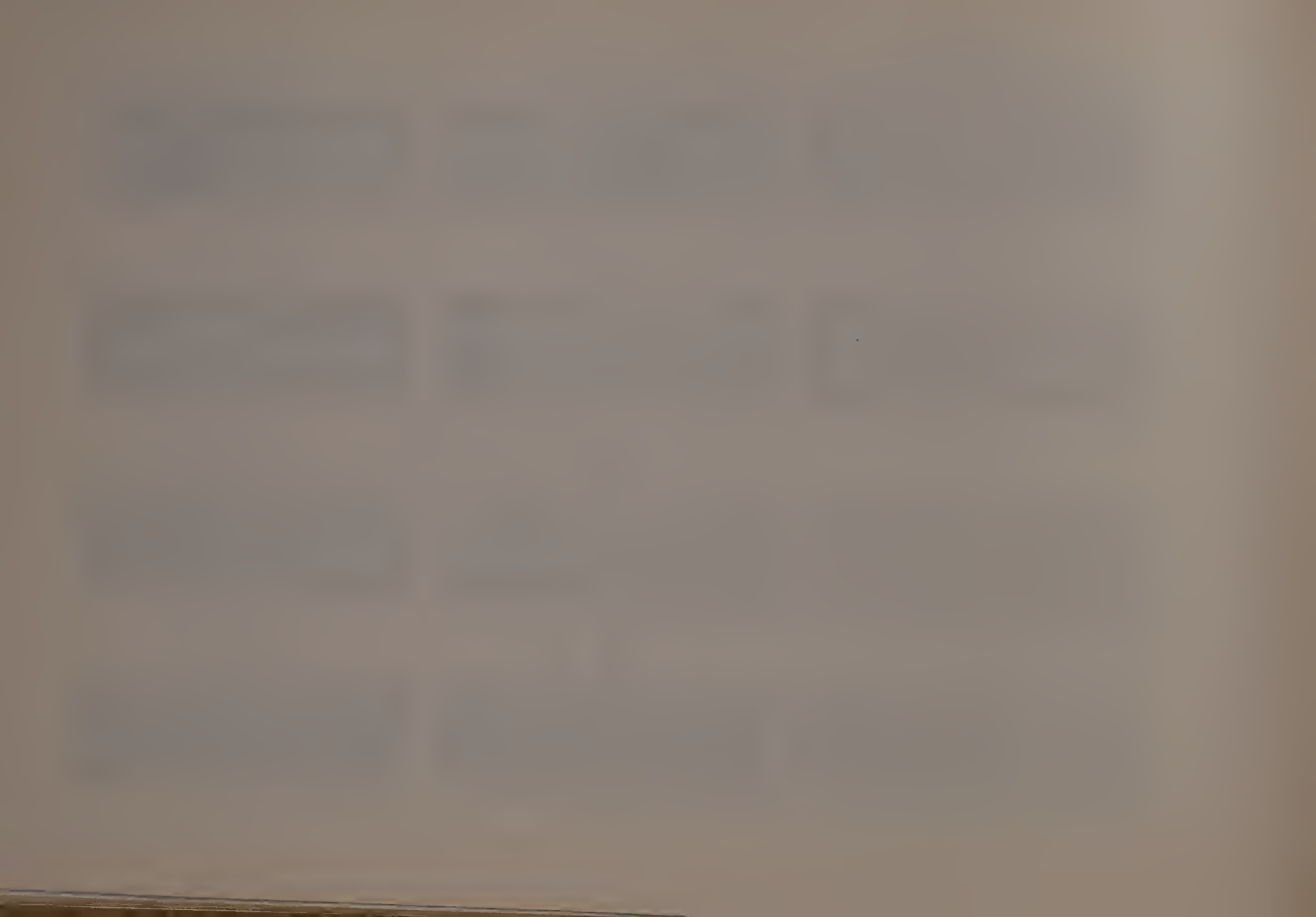


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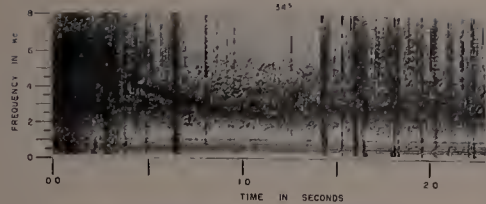
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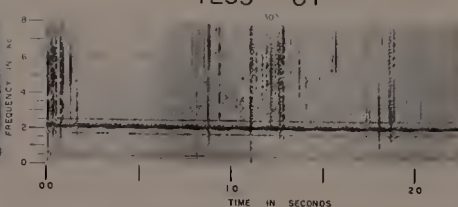


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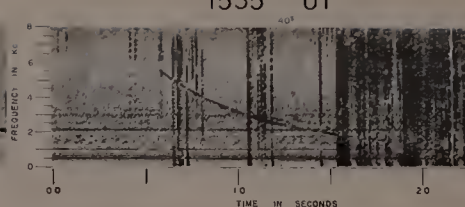
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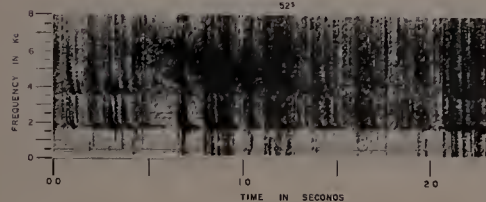


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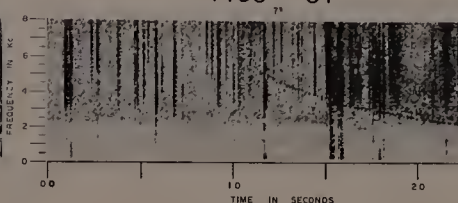


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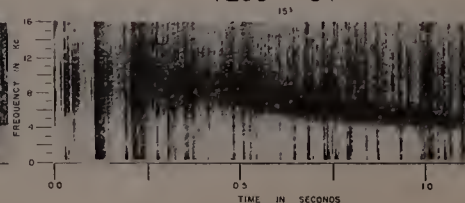
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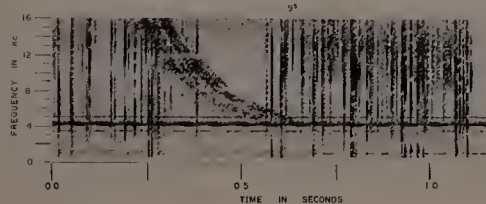
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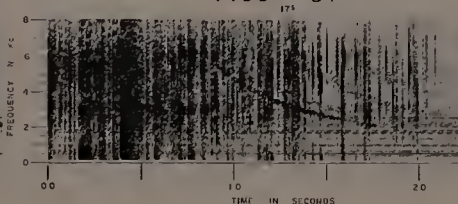


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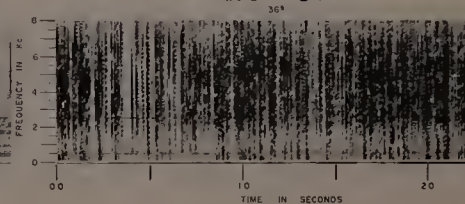


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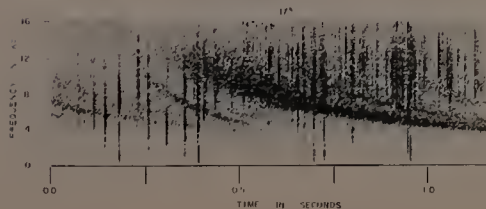
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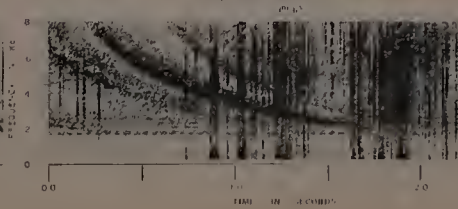
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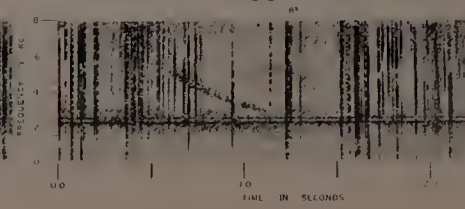
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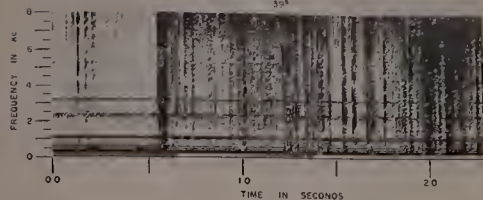
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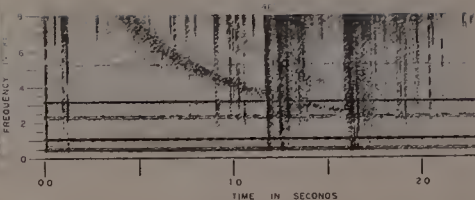
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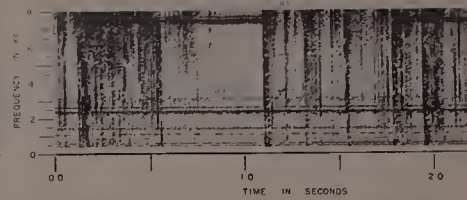
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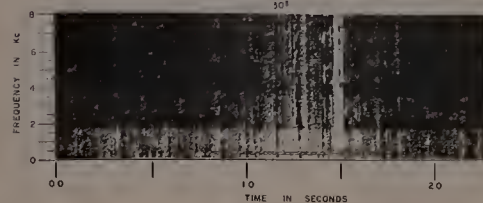
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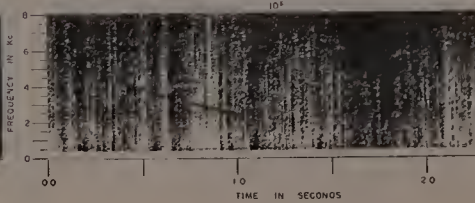
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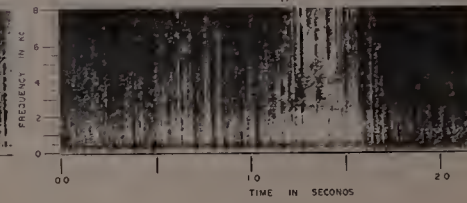
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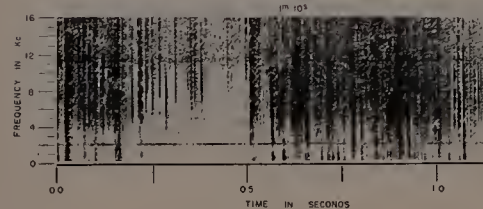
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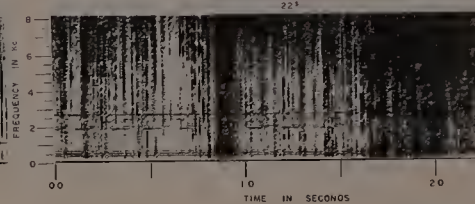
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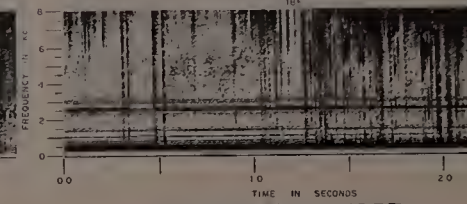
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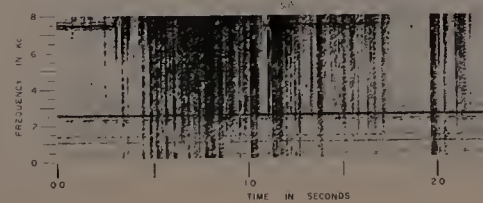
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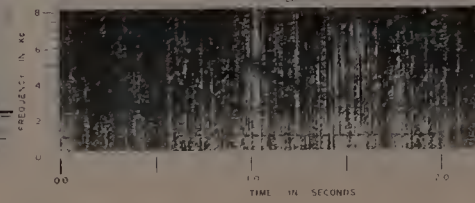
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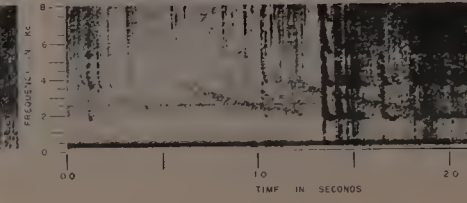
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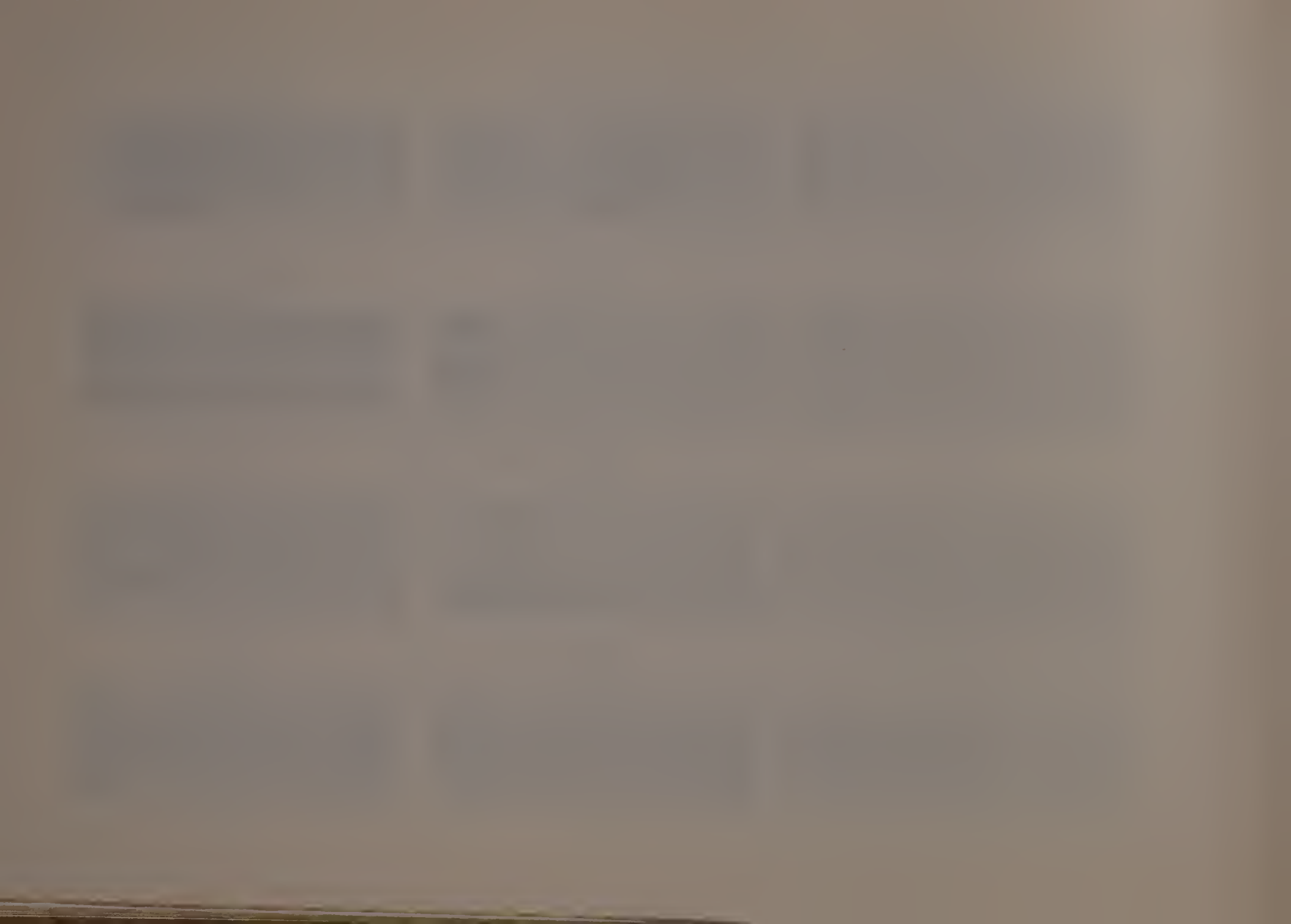


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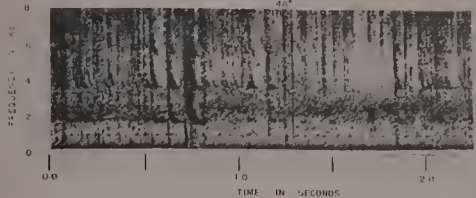


28 JUNE 1957
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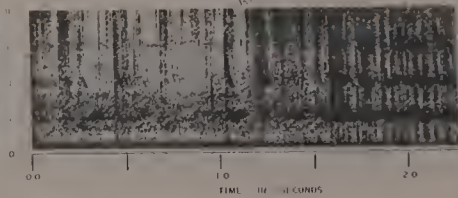




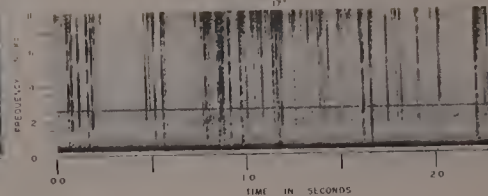
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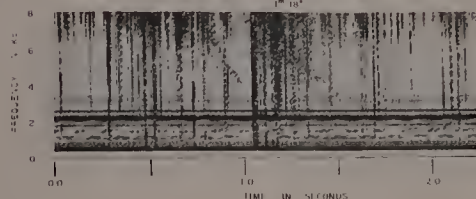
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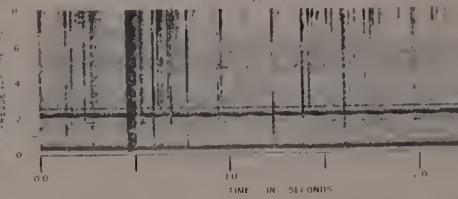
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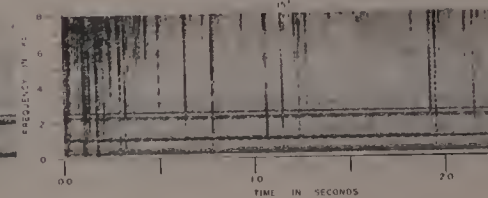
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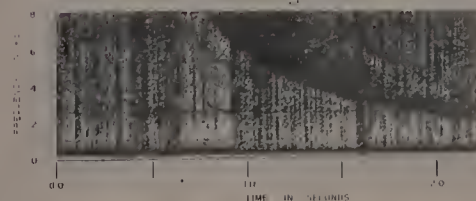
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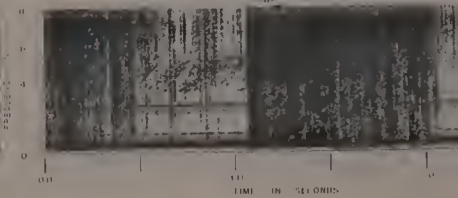
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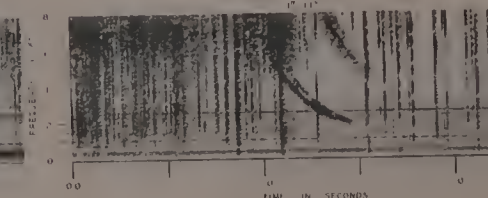
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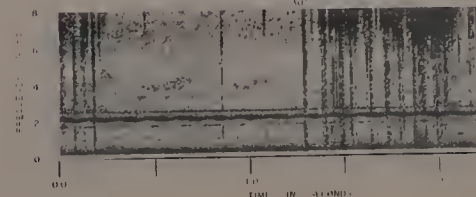
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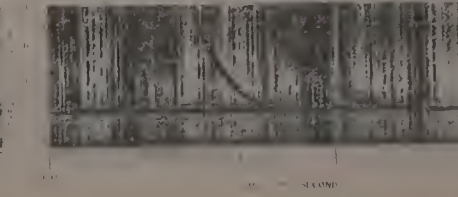
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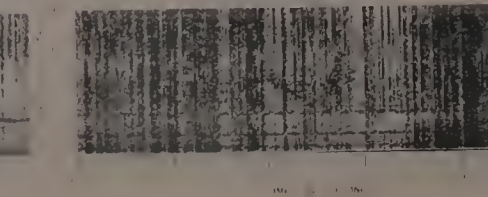
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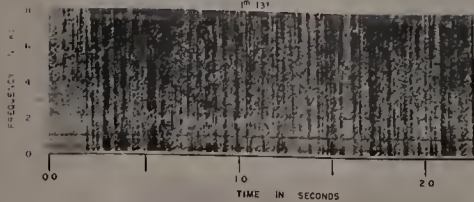
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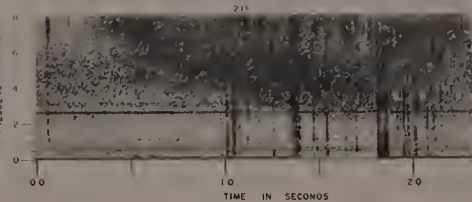
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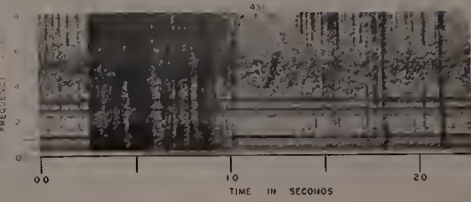
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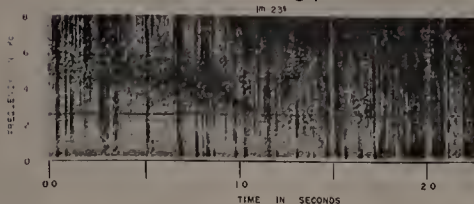
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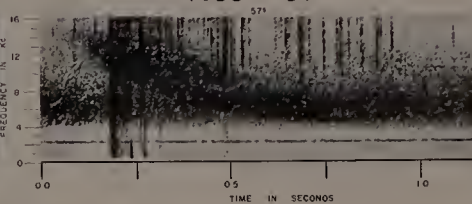
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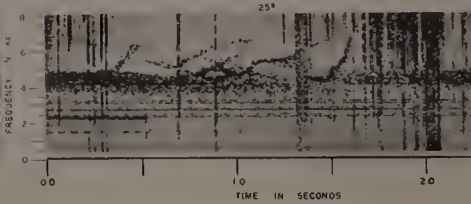
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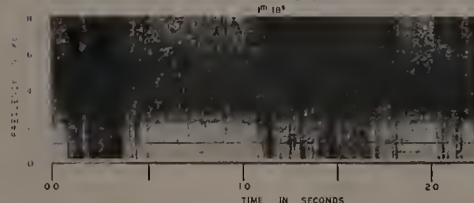
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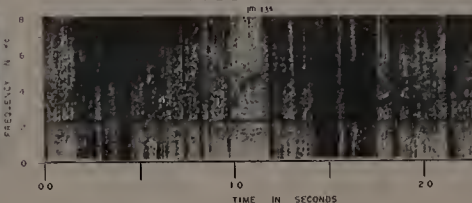
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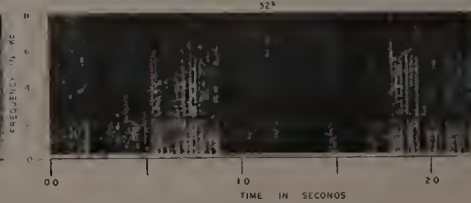
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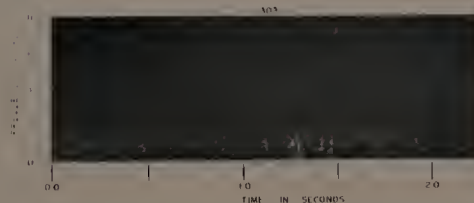
1935 UT



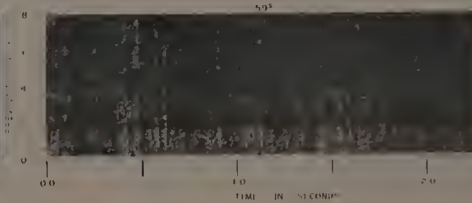
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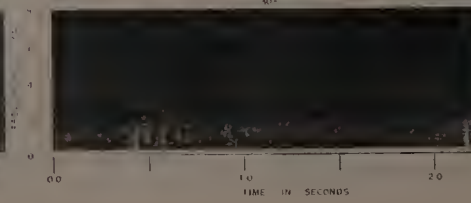
1 JULY 1957
0535 UT



0635 UT



0735 UT





THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D. C.

Electricity. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics. High Voltage.

Metrology. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

Heat, Temperature Physics. Heat Measurements. Cryogenic Physics. Equation of State. Statistical Physics.

Radiation Physics. X-ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

Analytical and Inorganic Chemistry. Pure Substances. Spectrochemistry. Solution Chemistry. Standard Reference Materials. Applied Analytical Research. Crystal Chemistry.

Mechanics. Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. Rheology. Combustion Controls.

Polymers, Macromolecules: Synthesis and Structure. Polymer Chemistry. Polymer Physics. Polymer Characterization. Polymer Evaluation and Testing. Applied Polymer Standards and Research. Dental Research.

Metallurgy. Engineering Metallurgy. Microscopy and Diffraction. Metal Reactions. Metal Physics. Electrolysis and Metal Deposition.

Inorganic Solids. Engineering Ceramics. Glass. Solid State Chemistry. Crystal Growth. Physical Properties. Crystallography.

Building Research. Structural Engineering. Fire Research. Mechanical Systems. Organic Building Materials. Codes and Safety Standards. Heat Transfer. Inorganic Building Materials. Metallic Building Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics. Operations Research.

Data Processing Systems. Components and Techniques. Computer Technology. Measurements Automation. Engineering Applications. Systems Analysis.

Atomic Physics. Spectroscopy. Infrared Spectroscopy. Far Ultraviolet Physics. Solid State Physics. Electron Physics. Atomic Physics. Plasma Spectroscopy.

Instrumentation. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Physical Chemistry. Thermochemistry. Surface Chemistry. Organic Chemistry. Molecular Spectroscopy. Elementary Processes. Mass Spectrometry. Photochemistry and Radiation Chemistry.

Office of Weights and Measures.

BOULDER, COLO.

Cryogenic Engineering Laboratory. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Cryogenic Technical Services.

CENTRAL RADIO PROPAGATION LABORATORY

Ionosphere Research and Propagation. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services. Vertical Soundings Research.

Radio Propagation Engineering. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation-Terrain Effects. Radio-Meteorology. Lower Atmosphere Physics.

Radio Systems. Applied Electromagnetic Theory. High Frequency and Very High Frequency Research. Frequency Utilization. Modulation Research. Antenna Research. Radiodetermination.

Upper Atmosphere and Space Physics. Upper Atmosphere and Plasma Physics. High Latitude Ionosphere Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.

RADIO STANDARDS LABORATORY

Radio Physics. Radio Broadcast Service. Radio and Microwave Materials. Atomic Frequency and Time-Interval Standards. Radio Plasma. Millimeter-Wave Research.

Circuit Standards. High Frequency Electrical Standards. High Frequency Calibration Services. High Frequency Impedance Standards. Microwave Calibration Services. Microwave Circuit Standards. Low Frequency Calibration Services.



