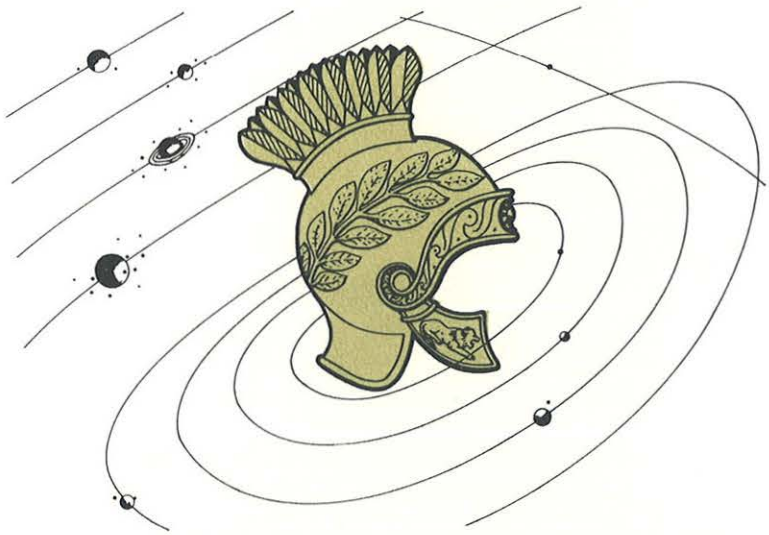
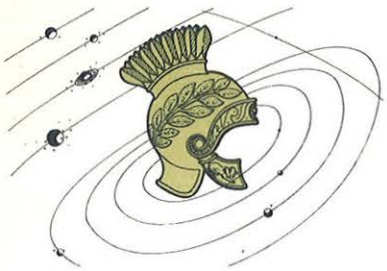


MT. PRINCETON, COLO.

for: AMAX Exploration, Inc.

SENTURION SCIENCES, INC.
TULSA, U.S.A.



SENTURION SCIENCES, INC.

6945 EAST 11TH STREET, TULSA, OKLAHOMA
P.O. BOX 15447, TULSA, OKLAHOMA 74115
PHONE (918) 836-6746

IMAGINEERING for EXPLORATION, ENGINEERING and ENVIRONMENT

SEISMIC GROUNDNOISE SURVEY IN

THE MT. PRINCETON, COLO. AREA

I INTRODUCTION

Location: Chaffee Co., SW of Buena Vista, Colorado. Survey area covered approximately 80 square miles. T14S, 15S, R78W, 79W.

Dates: March 31 through April 6, 1974.

Conditions: Terrain - Valley, foothills, mountainous.
Elevations: 7900 to 10500 feet.

Seismic groundnoise is due to a combination of cultural, atmospheric, and geological disturbances. The resultant microseisms propagate primarily as surface waves with a log normal type of distribution in their power versus frequency plot (Figure A).

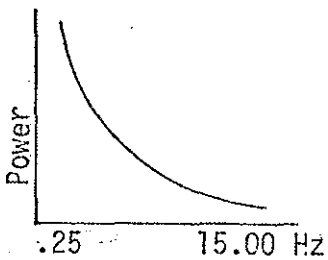


FIGURE A

Microseism power may vary from region to region, but for a given locale it can be considered as originating at a distant source. If the impedance sequence, coupling, and response of seismometers in an array are the same, then the measured power spectrum of the groundnoise would be identical from seismometer station to seismometer station. Since instrument response is identical and ground coupling is good, measured variation of power and frequency may be associated with varying impedance sequences beneath each station, or may be due to a local noise generator.

The recorded time series (24 hrs) at each station is searched for a "quiet" interval (3 hrs or more); and this is spectrally analyzed for the true ground beat at that station.

The data from all stations is statistically evaluated for each specified parameter (Integrated Power, Mean Frequency, etc.) and the parameter (s) tabulated and contoured. Based on the statistical analysis, parameters exhibiting more than 1 standard deviation above the mean can be considered anomalous. In groundnoise surveys an anomaly is defined as an area in which two or more parameters exhibit values greater than 1 standard deviation, Figure 3, Anomalous Areas Map.

II OVERVIEW

The purpose of the survey was to determine possibility of geothermal reservoir sources through groundnoise anomalies. A complementary objective consisted of delineation of the structural features of the area.

III RESULTS

A total of 38 stations were occupied during the survey. Statistics are presented in Table 1.

PARAMETER	AVERAGE	STANDARD DEVIATION	% STD. DEV.
Integrated Power	33.36	9.37	28.10
Mean Frequency	6.94	.67	9.70

Two groundnoise anomalies defined by high power and high frequency components are established in this survey. The northern anomaly occurs at the intersection of sec. 7,12,13,18, of T15S, R78W-79W and the southern anomaly is located near the intersection of sec. 29,30,31,32, of T15S, R78W.

The northern anomaly may be generated by a thermal cell contiguous to a fault complex. The groundnoise defined and topographically inferred Merriam Creek fault (Y) could extend to this cell at depth and provide the conduits for Hortense and Mt. Princeton Hot Springs. Similarly, Fault G, cross section B-B', could supply this conduit.

The southern anomaly exhibits a very high power component centered in sec. 32. Fault X expressed by Chalk Creek and groundnoise defined on cross-

sections B-B', Figure 5, could also supply the conduit for the Hot Springs Complex. Station density is lacking in this area for detailed resolution.

IV COMMENTS-RECOMMENDATIONS

Two additional features of interest are noted. The NW-SE trend of Mean Frequency anomalies parallel to the Sawatch Range bear out the possibility of a major fault with this trend (Fault A). Higher frequencies are indicative of the dense Pre-Cambrian strata on the west side of the fault.

Sharp gradients in the anomalous areas could indicate separate cells or a deep central source. Statistical analysis and mapping of the lower frequencies would provide additional insight.

The southern anomaly lacks sufficient data point density to presently be highly prospective. Heat flow test holes and/or additional survey stations could contribute pertinent data. Similarly, definition of the fault patterns would also be enhanced.

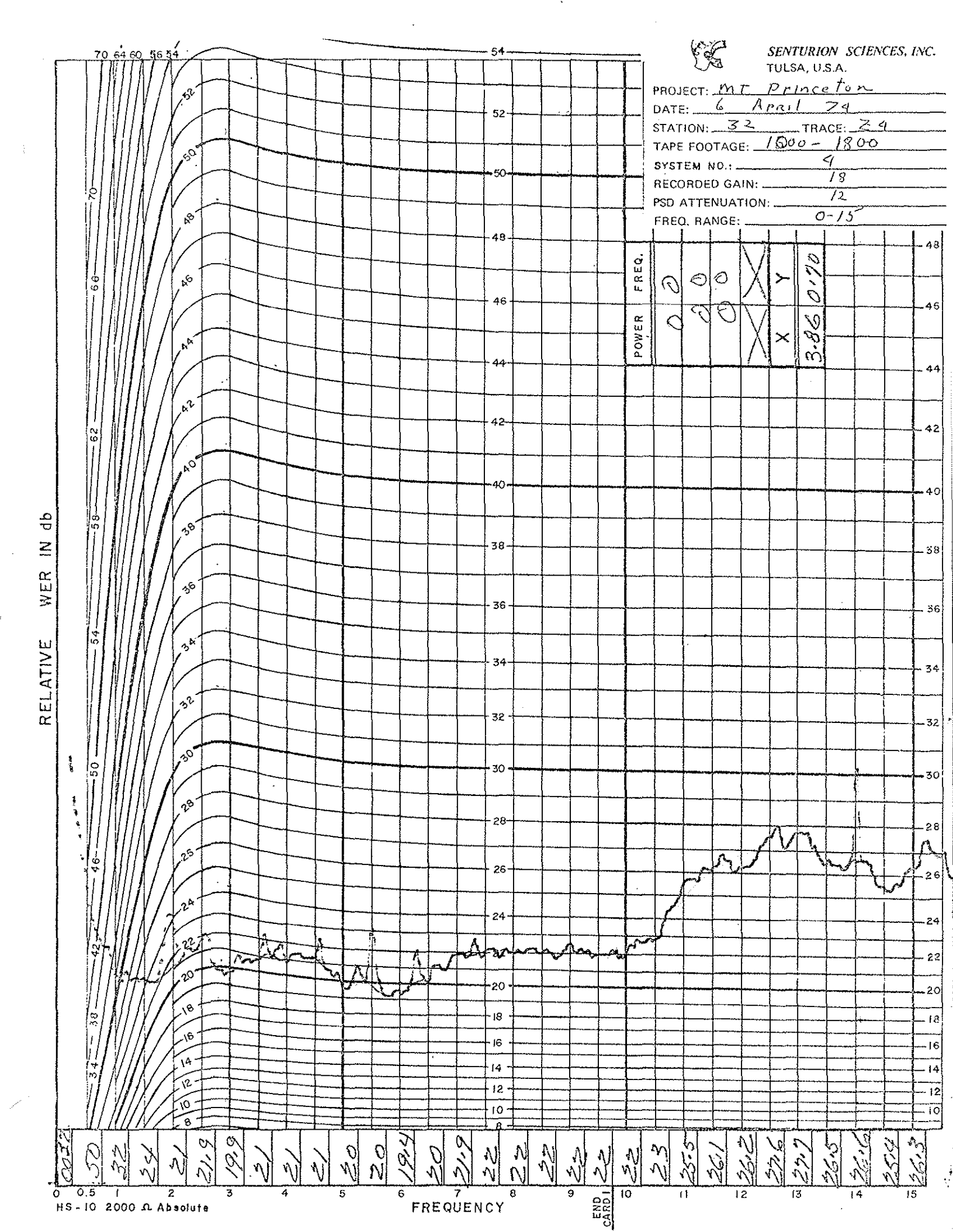
The appendix includes the computer output of Senturion Sciences new groundnoise processing program.

V LIST OF FIGURES AND TABLES

VI APPENDIX

Power Spectral Density Plots.

Computer Printout.


SENTURION SCIENCES, INC.
TULSA, U.S.A.
PROJECT: Mt Princeton
DATE: 6 April 79
STATION: 32 TRACE: Z 9
TAPE FOOTAGE: 1600 - 1800
SYSTEM NO.: 9
RECORDED GAIN: 18
PSD ATTENUATION: 12
FREQ. RANGE: 0-15
POWER FREQ.
0 00
0 00
X
Y
3.86 0.10
RELATIVE WER IN db
70 64 60 56 54
54 52 50 48 46 44 42 40 38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8
70 66 62 58 54 50 46 42 38 34
DATA 30 32 34 21 21.9 19.9 21 21 21 20 20 19.4 20 21.9 22 22 22 22 22 23 25.5 26.1 26.2 27.6 27.7 26.5 26.6 25.6 26.3
0 0.5 1 2 3 4 5 6 7 8 9 END CARD 10 11 12 13 14 15
HS-10 2000 Ω Absolute
FREQUENCY

33

SENTURION SCIENCES, INC.
TULSA, U.S.A.

PROJECT: NJT Princeton
DATE: 30-March 79
STATION: 1-E033 TRACE: Z1
TAPE FOOTAGE: 3000-3800
SYSTEM NO.: 9
RECORDED GAIN: 12
PSD ATTENUATION: 18
FREQ. RANGE: 0-15

	FREQ.	POWER	
Y	0	0	0
X	0	0	0

±0.40 0.15

RELATIVE POWER IN db

70 64 60 56 54

54 52 50 48 46 44 42 40 38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8

70 66 62 58 54 50 46 42 38 34

32.0	35.0	32.0	24.0	21.0	20.0	18.0	18.0	18.5	19.0	19.0	19.0	19.0	17.0	19.0	17.0	17.0	17.0	18.3	19.0	18.0	19.2	19.0	19.0	18.6	19.0	18.0	19.0	19.5	20.0	21.0	22.0	

0 0.5 1 2 3 4 5 6 7 8 9 END CARD 10 11 12 13 14 15

FREQUENCY

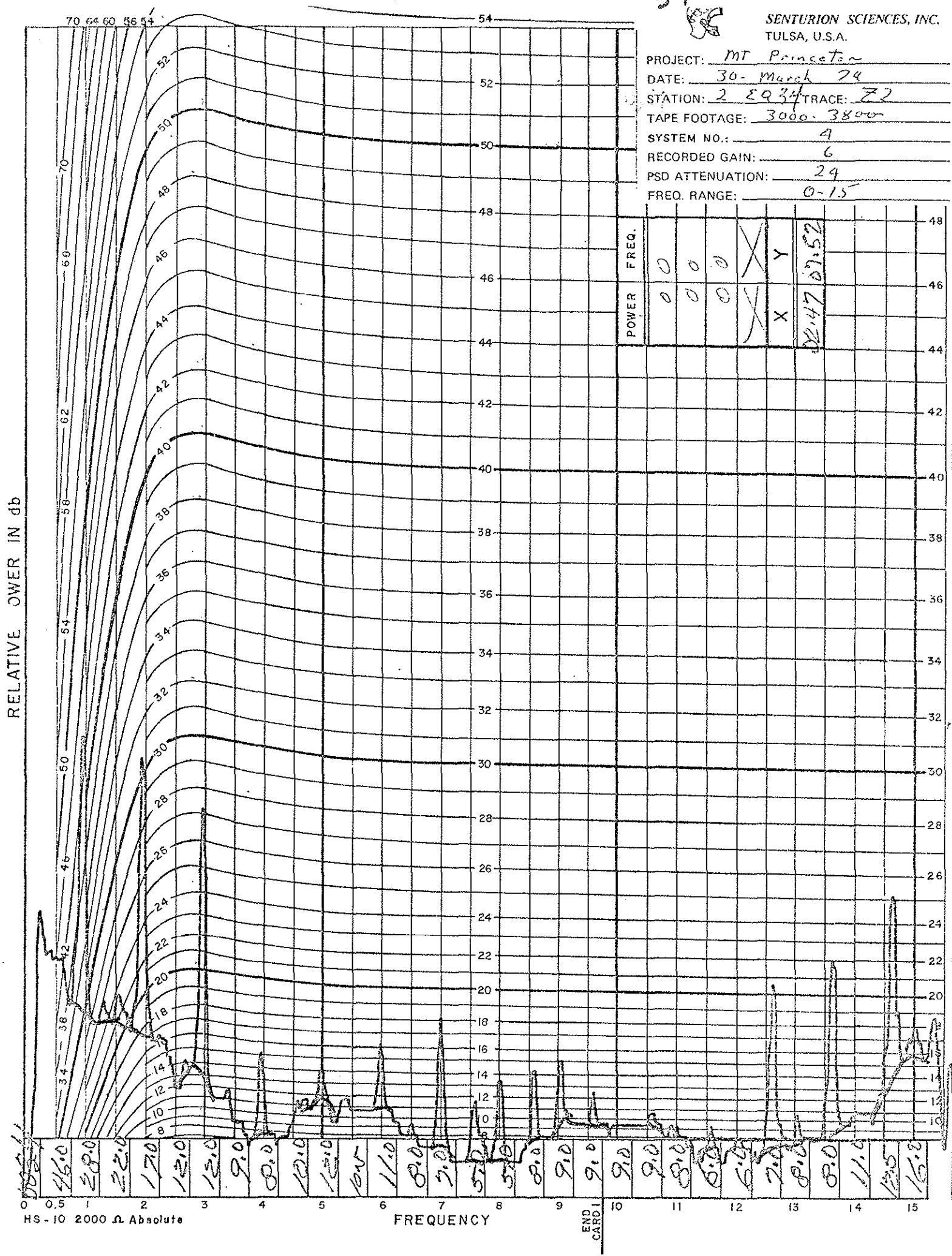
HS-10 2000 Ω Absolute

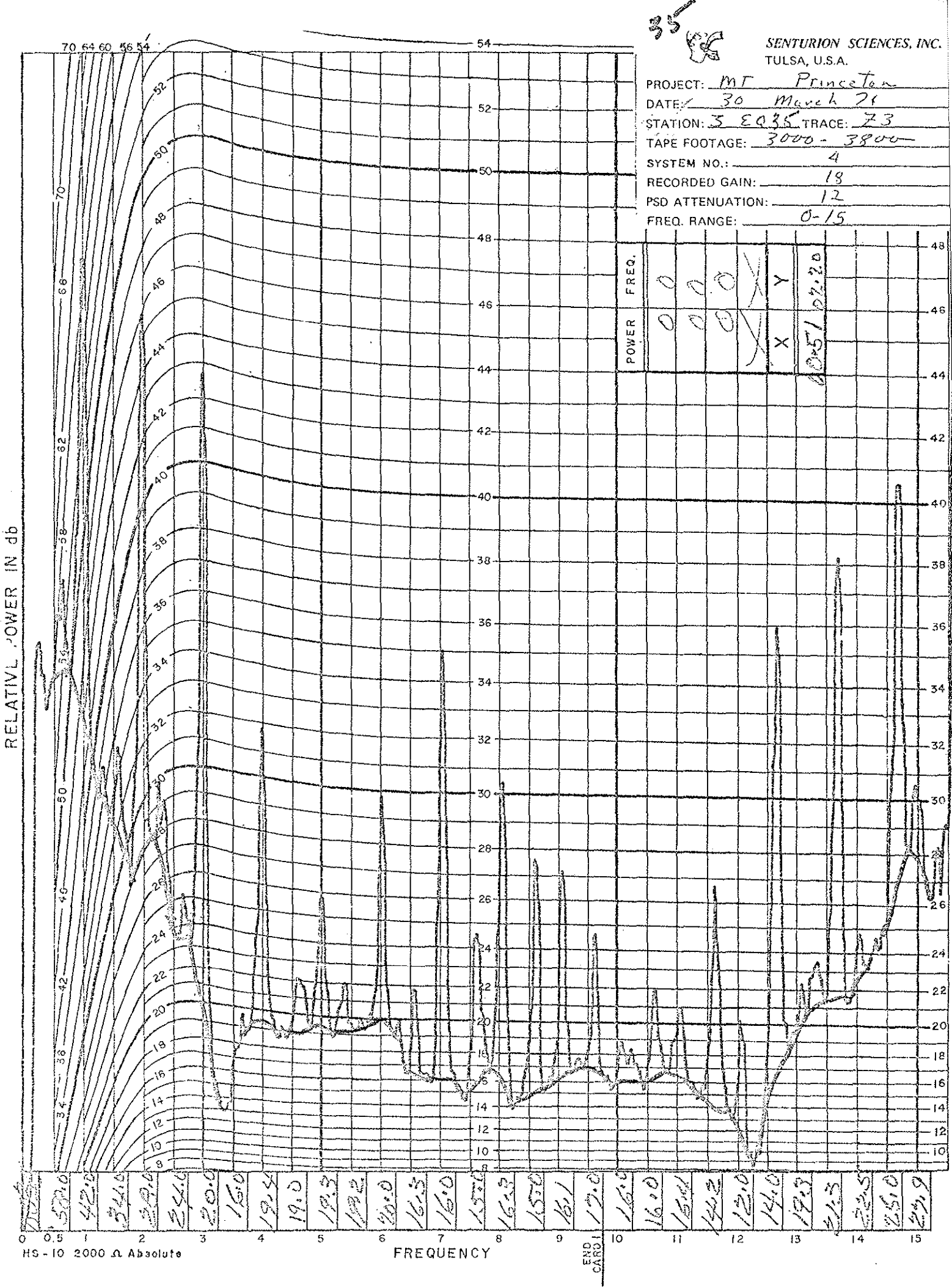
34

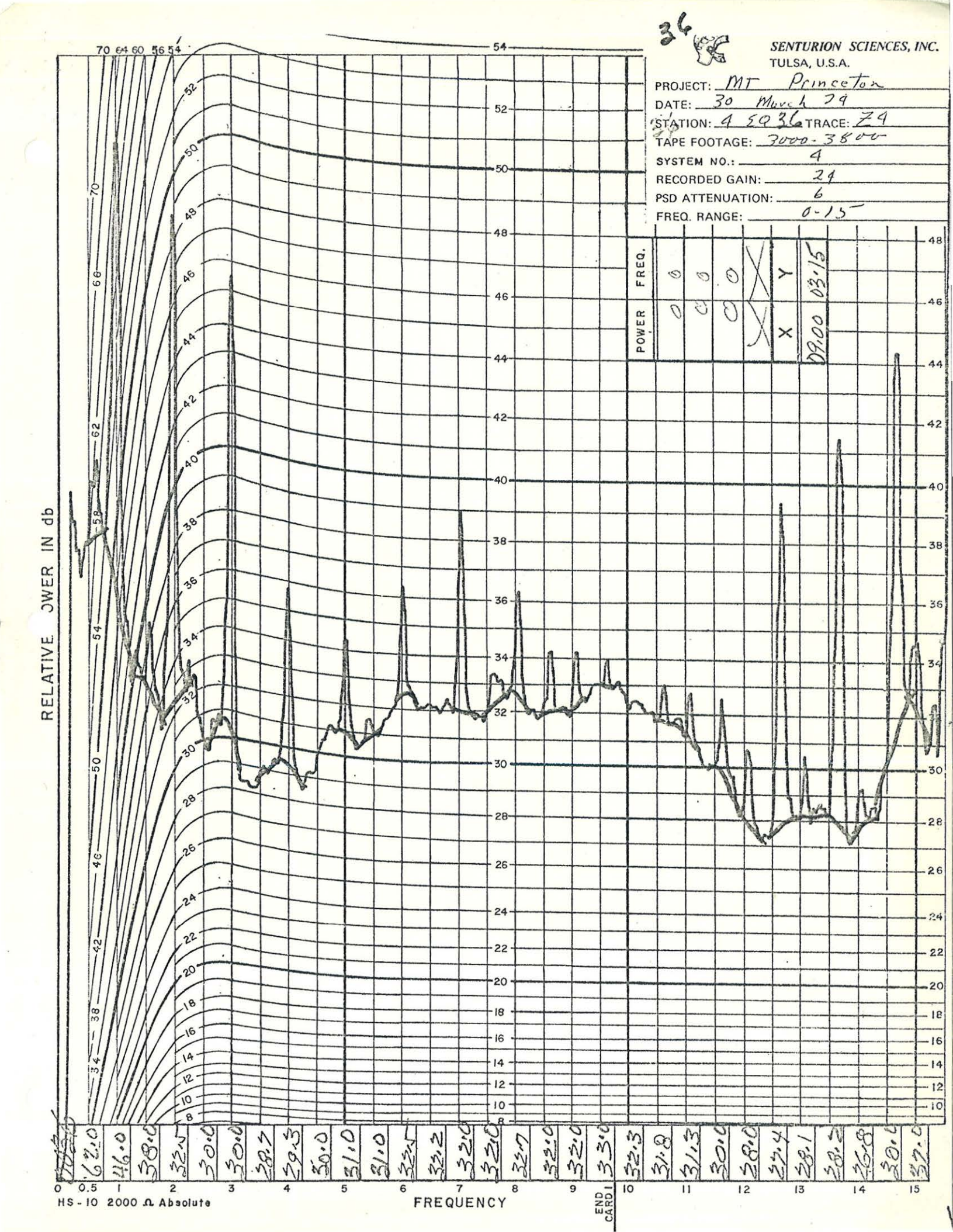
SENTURION SCIENCES, INC.
TULSA, U.S.A.

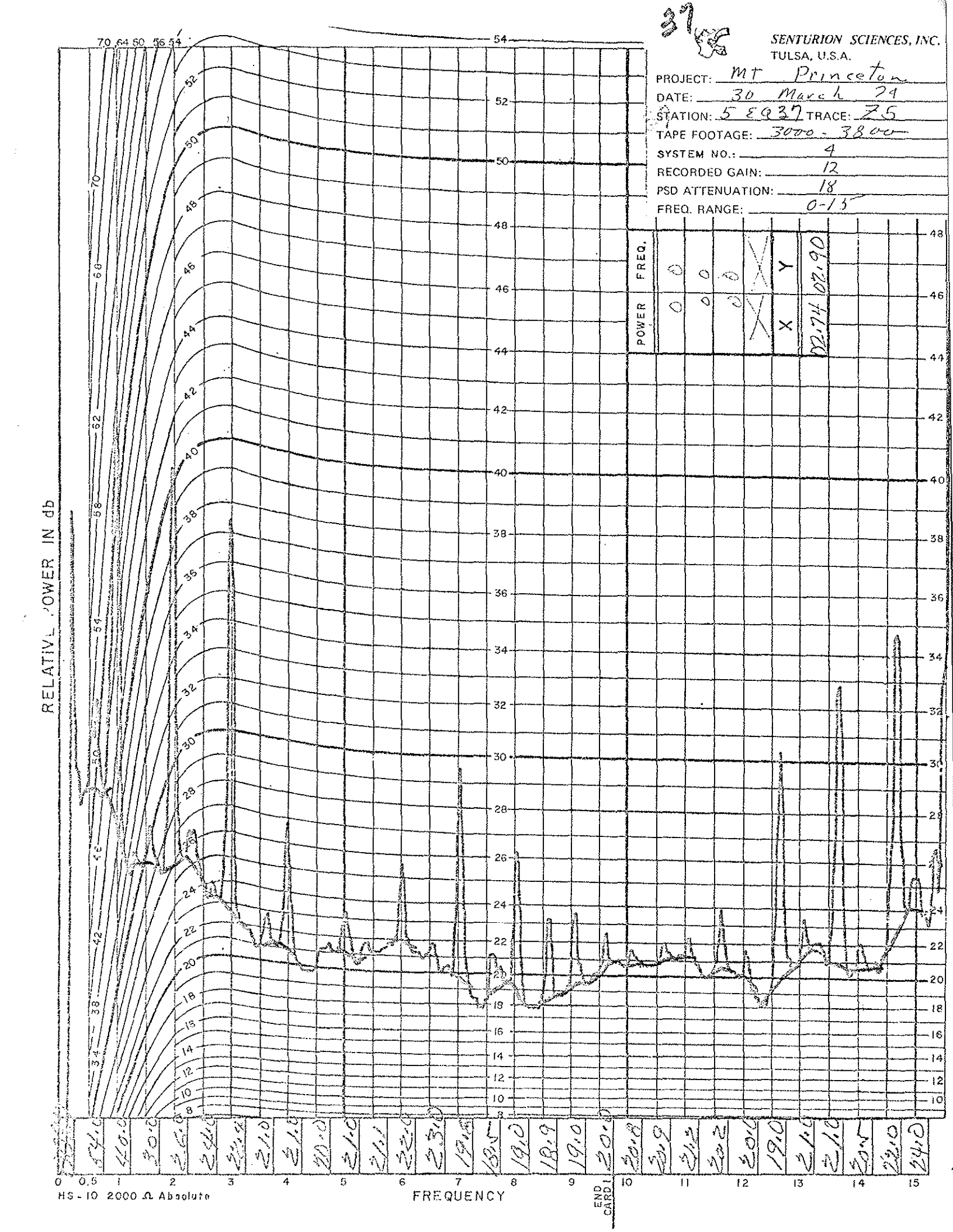
PROJECT: MT Princeton
DATE: 30- March 74
STATION: 2 E934 TRACE: Z2
TAPE FOOTAGE: 3000-3800
SYSTEM NO.: 4
RECORDED GAIN: 6
PSD ATTENUATION: 24
FREQ. RANGE: 0-15

	FREQ.					
POWER	0	0	0	X	Y	92.47 97.52
	0	0	0	X	X	




SENTURION SCIENCES, INC.
TULSA, U.S.A.
PROJECT: MT Princeton
DATE: 30 March 71
STATION: 3 E035 TRACE: Z3
TAPE FOOTAGE: 3000 - 3800
SYSTEM NO.: 4
RECORDED GAIN: 18
PSD ATTENUATION: 12
FREQ. RANGE: 0-15
POWER FREQ.
X
Y
RELATIVE POWER IN db
FREQUENCY
HS-10 2000 Ω Absolute
END CARD


36
SENTURION SCIENCES, INC.
TULSA, U.S.A.
PROJECT: MT Princeton
DATE: 30 March 79
STATION: 4 5936 TRACE: Z9
TAPE FOOTAGE: 3000-3800
SYSTEM NO.: 4
RECORDED GAIN: 24
PSD ATTENUATION: 6
FREQ. RANGE: 0-15
POWER FREQ.
0 0
0 0
0 0
X
Y
09:00 03:15
RELATIVE POWER IN db
FREQUENCY
HS-10 2000 Ω Absolute
END CARD 1


37
SENTURION SCIENCES, INC.
TULSA, U.S.A.
PROJECT: Mt Princeton
DATE: 30 March 79
STATION: 5 E 937 TRACE: Z 5
TAPE FOOTAGE: 3000 - 3800
SYSTEM NO.: 4
RECORDED GAIN: 12
PSD ATTENUATION: 18
FREQ. RANGE: 0-15
POWER FREQ.
X Y
02,74 02,90
RELATIVE POWER IN db
FREQUENCY
HS-10 2000 Ω Absolute
END CARD 1

38

SENTURION SCIENCES, INC.
TULSA, U.S.A.

PROJECT: MT Princeton
DATE: 30-March 78
STATION: 6 E638 TRACE: Z6
TAPE FOOTAGE: 3000 - 3800
SYSTEM NO.: 4
RECORDED GAIN: 12
PSD ATTENUATION: 18
FREQ. RANGE: 0-15

	FREQ.				
POWER	0	0	0	X	Y
	0	0	0	X	09:30:09:80

RELATIVE POWER IN db

FREQUENCY

HS-10 2000 Ω Absolute

END CARD 1

56.0 40.0 31.0 26.0 23.0 18.0 18.0 18.0 18.5 18.0 18.3 19.0 15.0 14.5 14.0 16.0 15.0 15.0 17.0 16.5 17.0 17.0 16.0 13.5 14.5 19.0 18.7 21.0 23.5 25.3

MT. PRINCETON
GROUNDNOISE CROSS SECTION A - A'

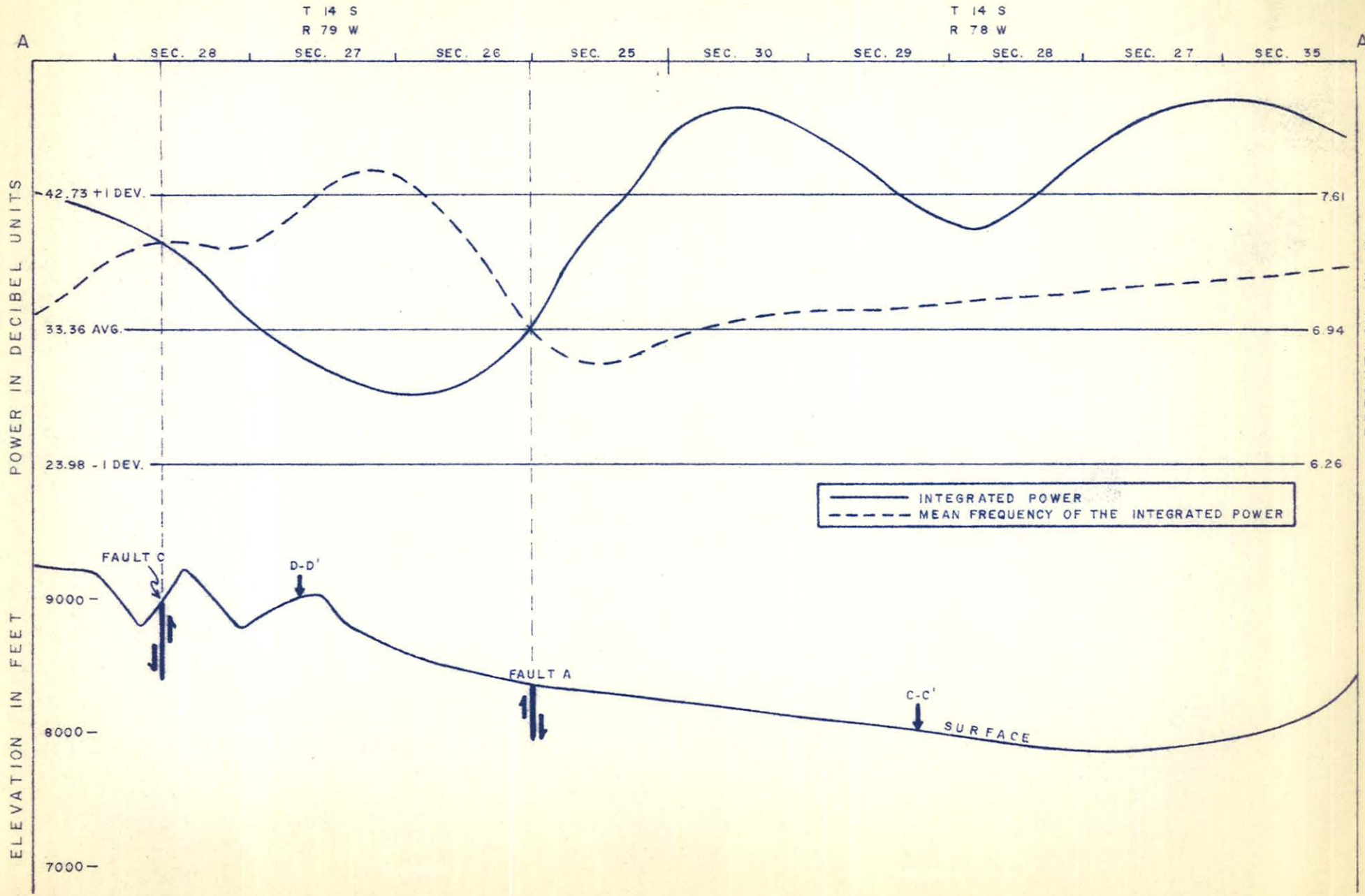


FIGURE 4
SENTURION SCIENCES, INC.

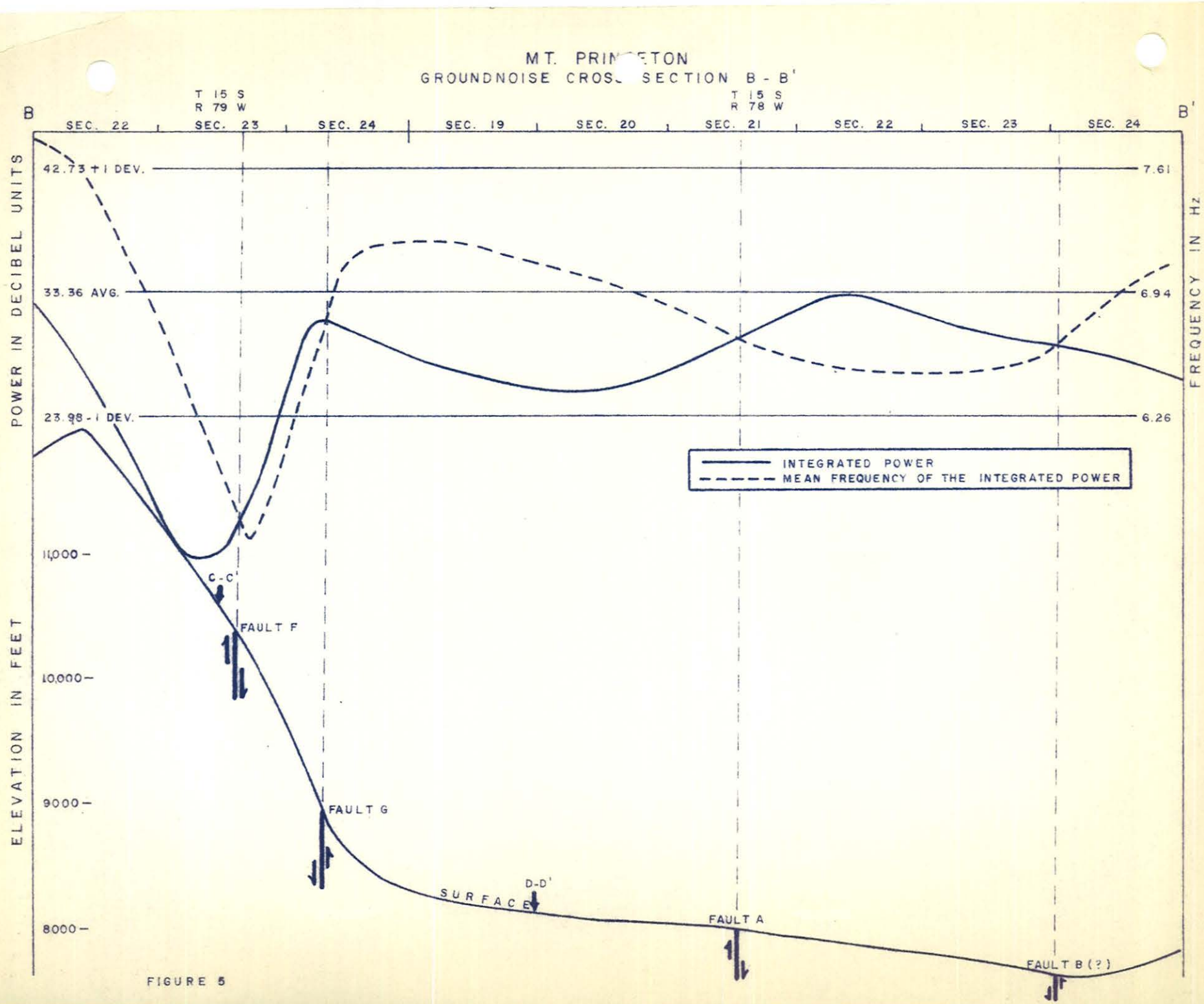

MT. PRINCETON
GROUNDNOISE CROSS SECTION B - B'
B
B'
T 15 S
R 79 W
T 15 S
R 78 W
SEC. 22
SEC. 23
SEC. 24
SEC. 19
SEC. 20
SEC. 21
SEC. 22
SEC. 23
SEC. 24
42.73 + 1 DEV.
33.36 AVG.
23.98 - 1 DEV.
7.61
6.94
6.26
POWER IN DECIBEL UNITS
FREQUENCY IN Hz
ELEVATION IN FEET
11,000
10,000
9000
8000
INTEGRATED POWER
MEAN FREQUENCY OF THE INTEGRATED POWER
C-C'
FAULT F
FAULT G
D-D'
SURFACE
FAULT A
FAULT B (?)

FIGURE 5

MT PRINCETON

GROUNDNOISE CROSS SECTION C - C

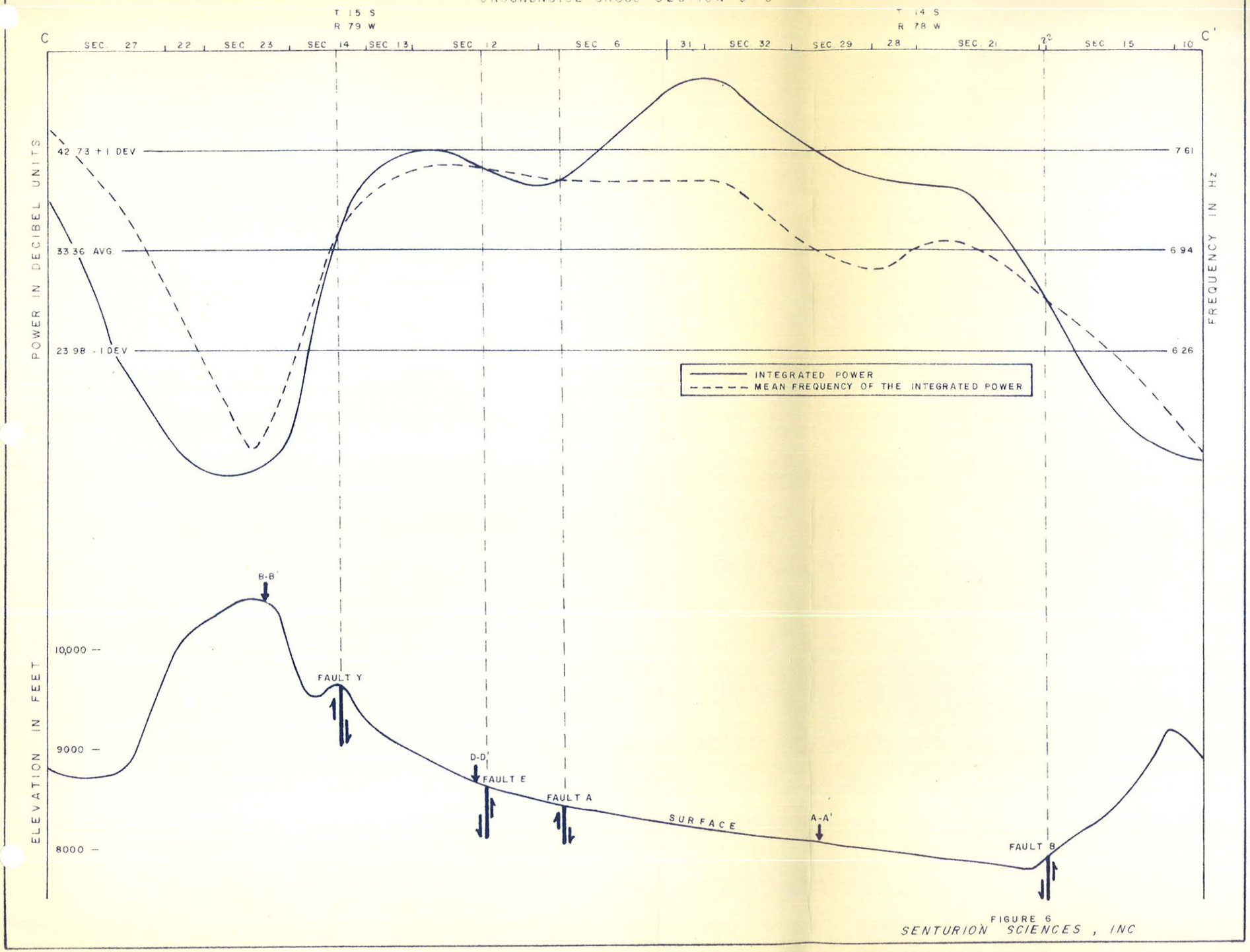


FIGURE 6

SENTURION SCIENCES, INC

MT. PRINCETON
GROUNDNOISE CROSS SECTION D - D'

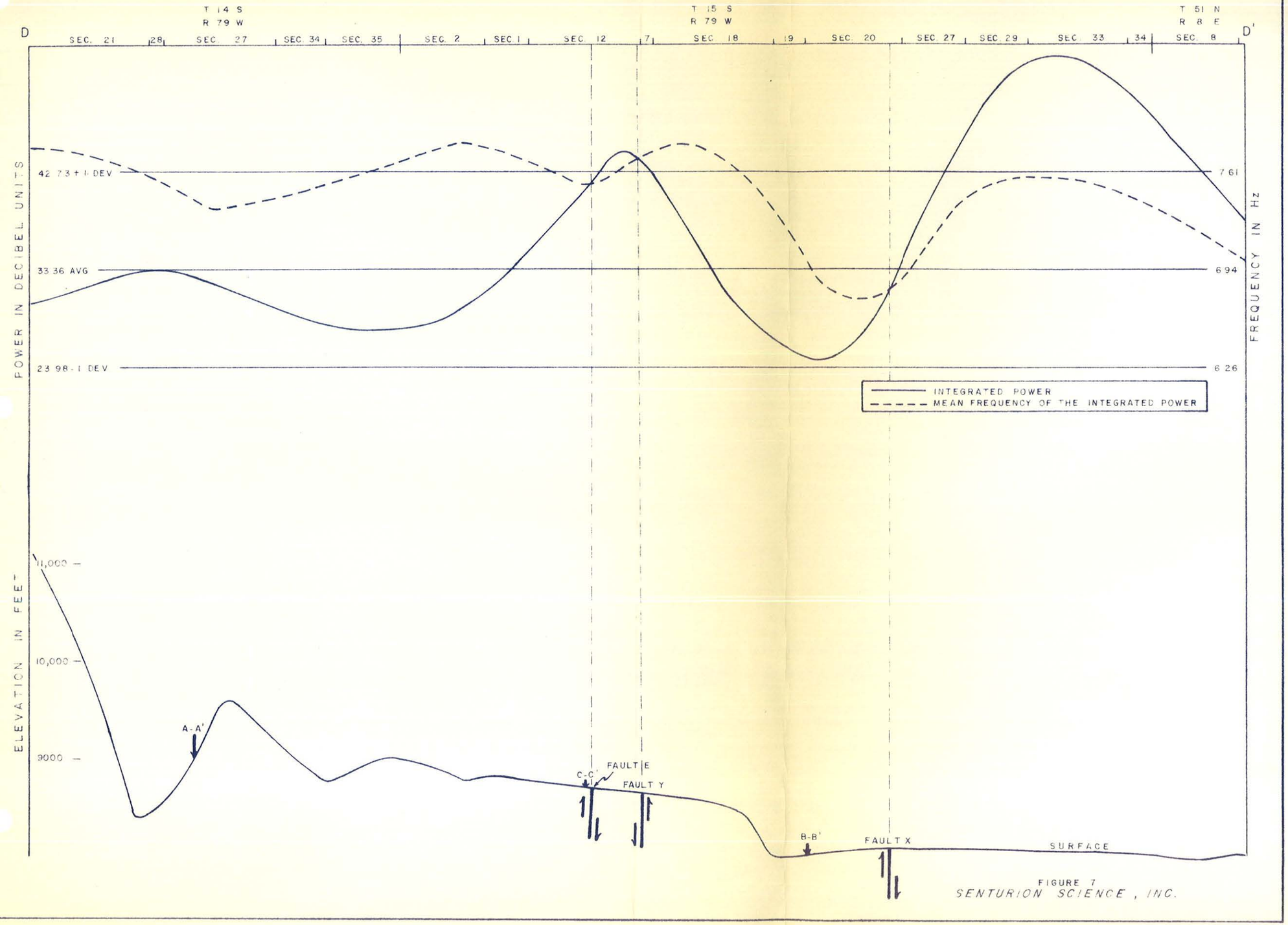
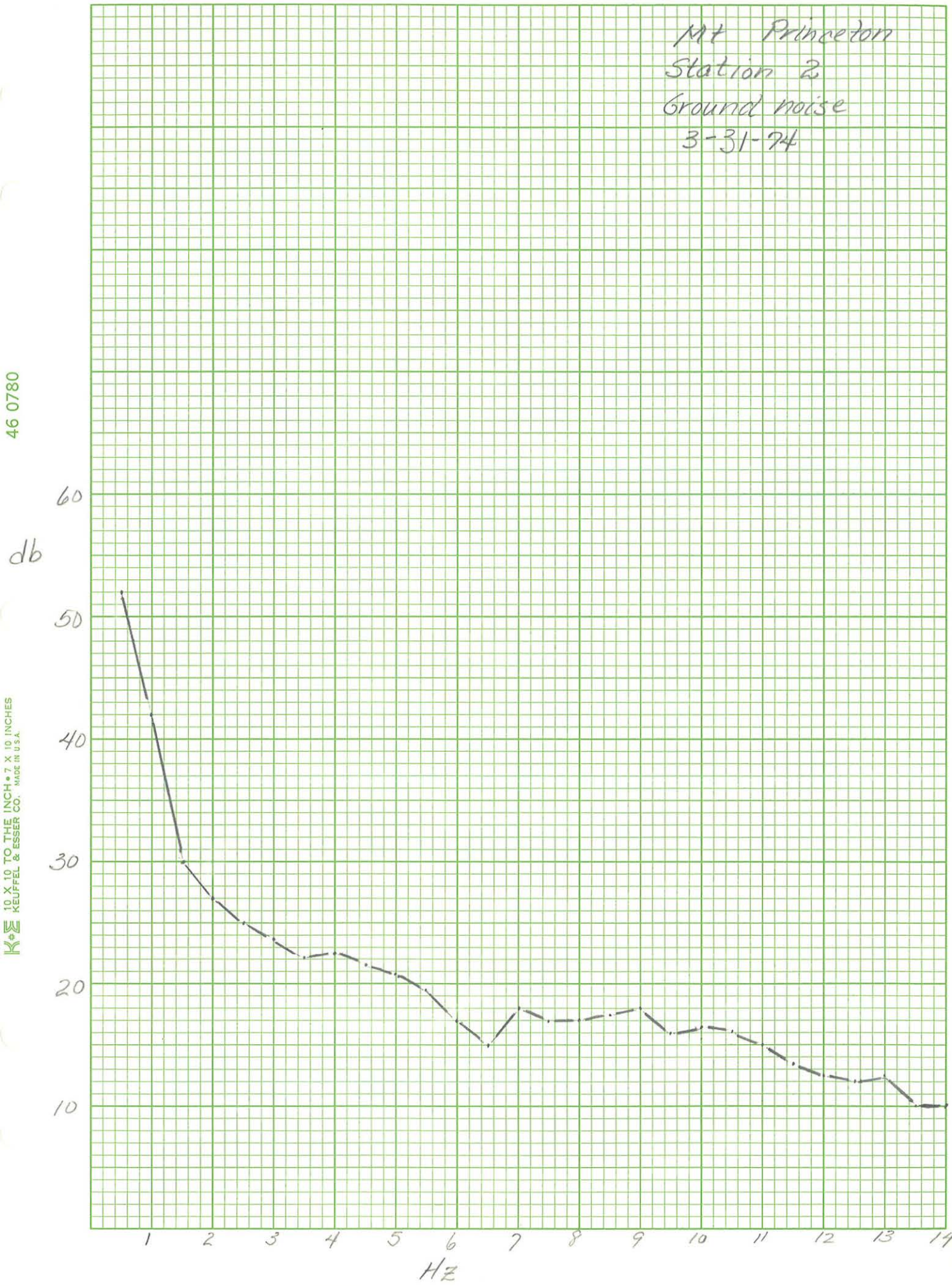
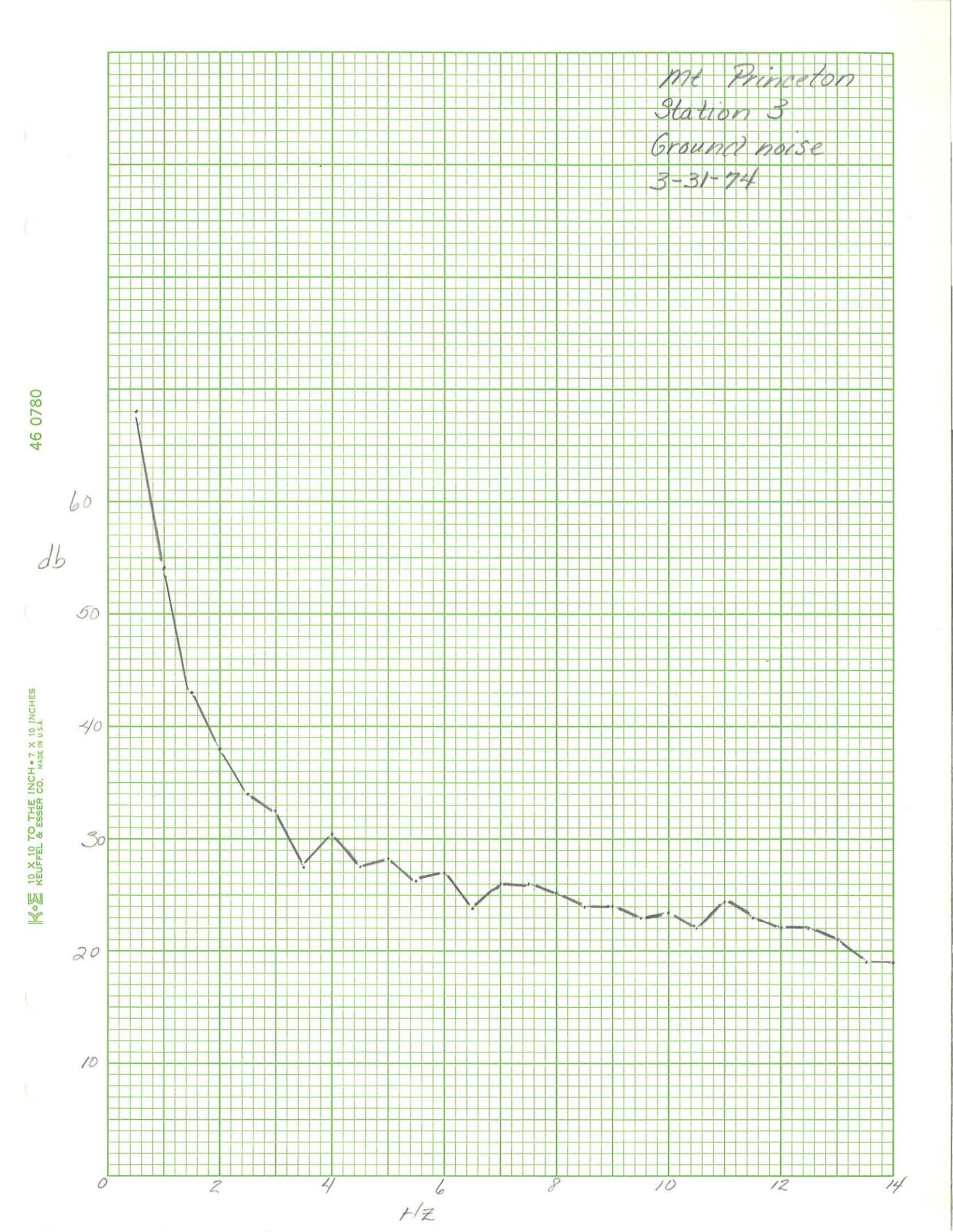


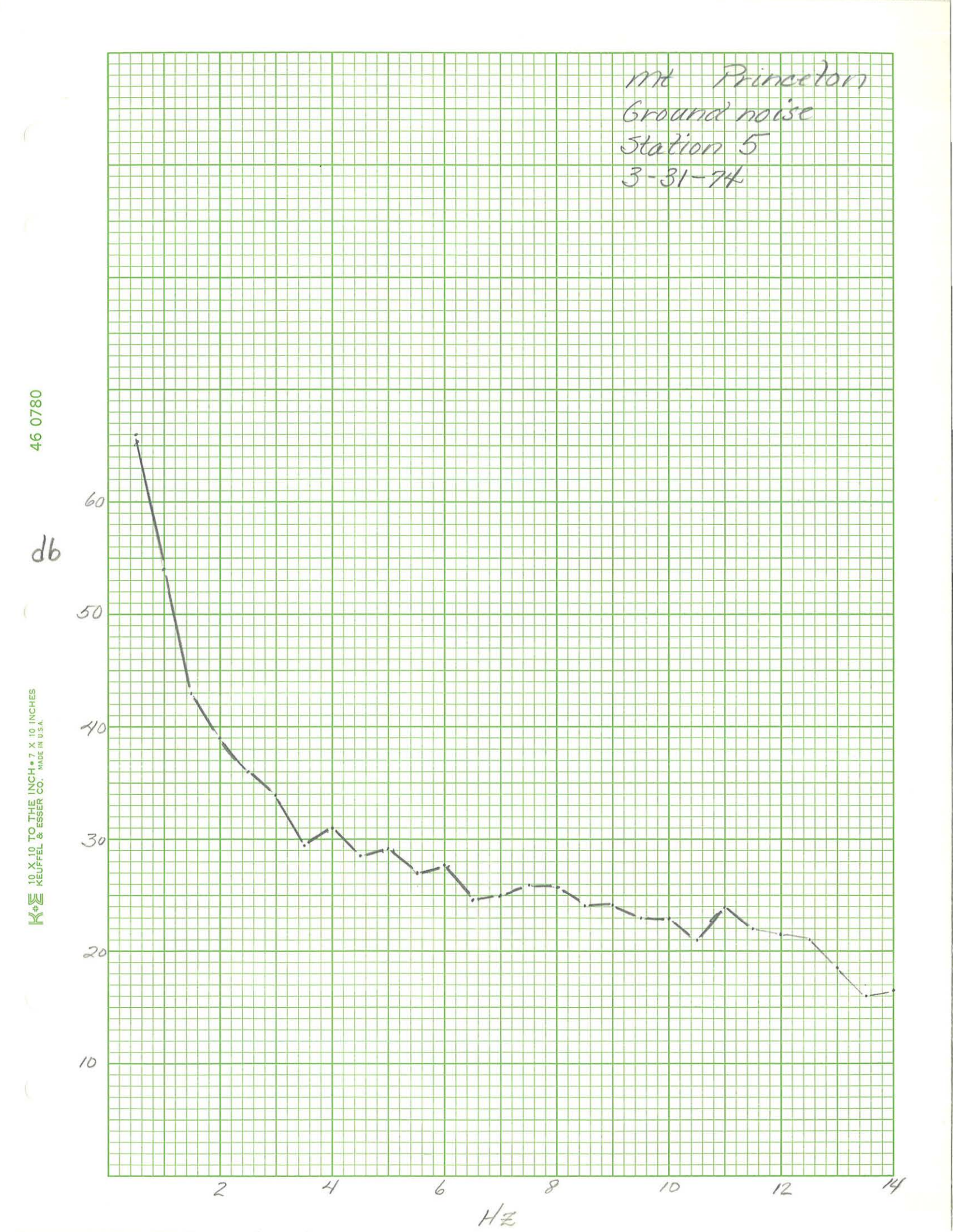
FIGURE 7
SENTURION SCIENCE, INC.

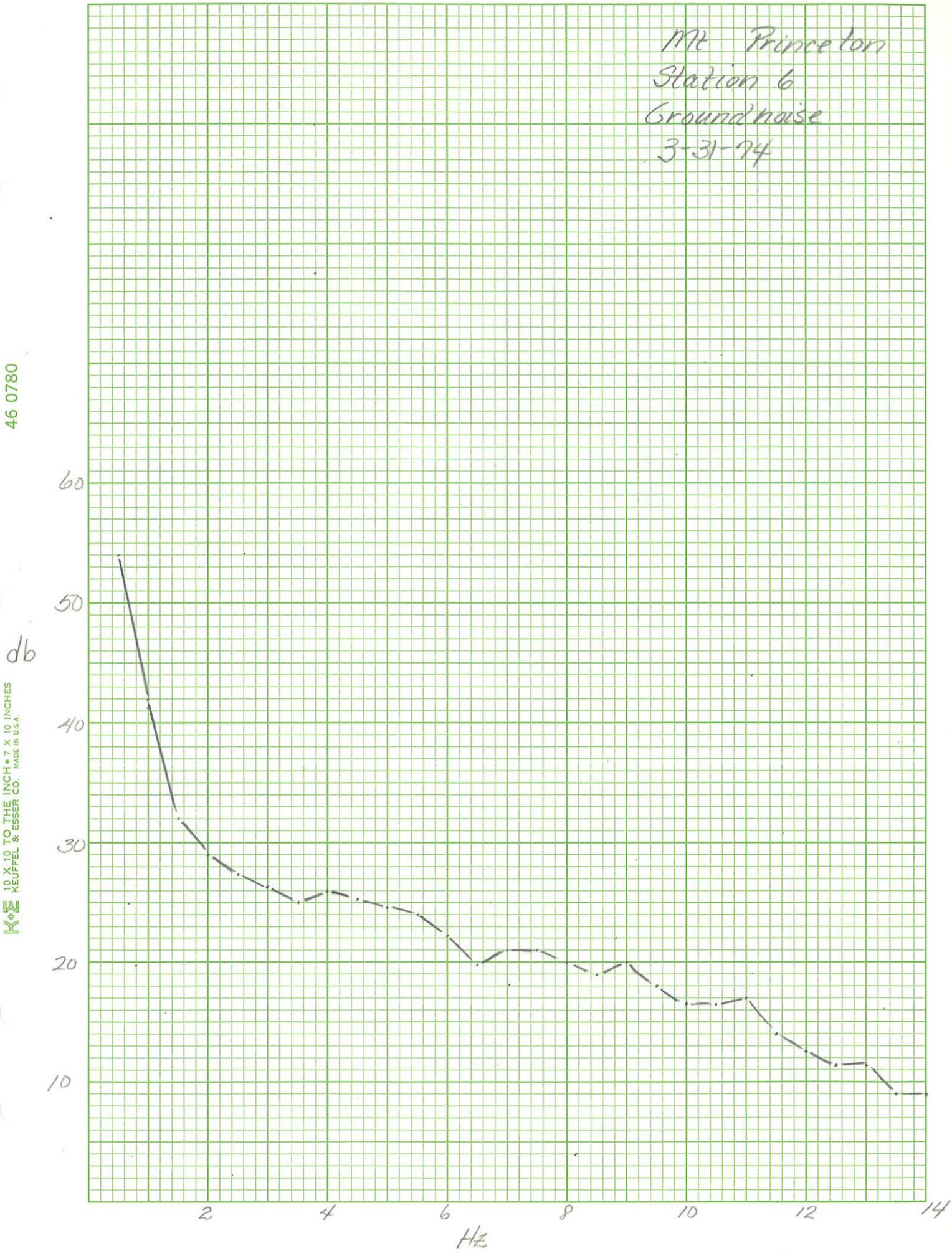

Mt Princeton
Station 1
(4-1-74)
Ground noise
db
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Hz
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

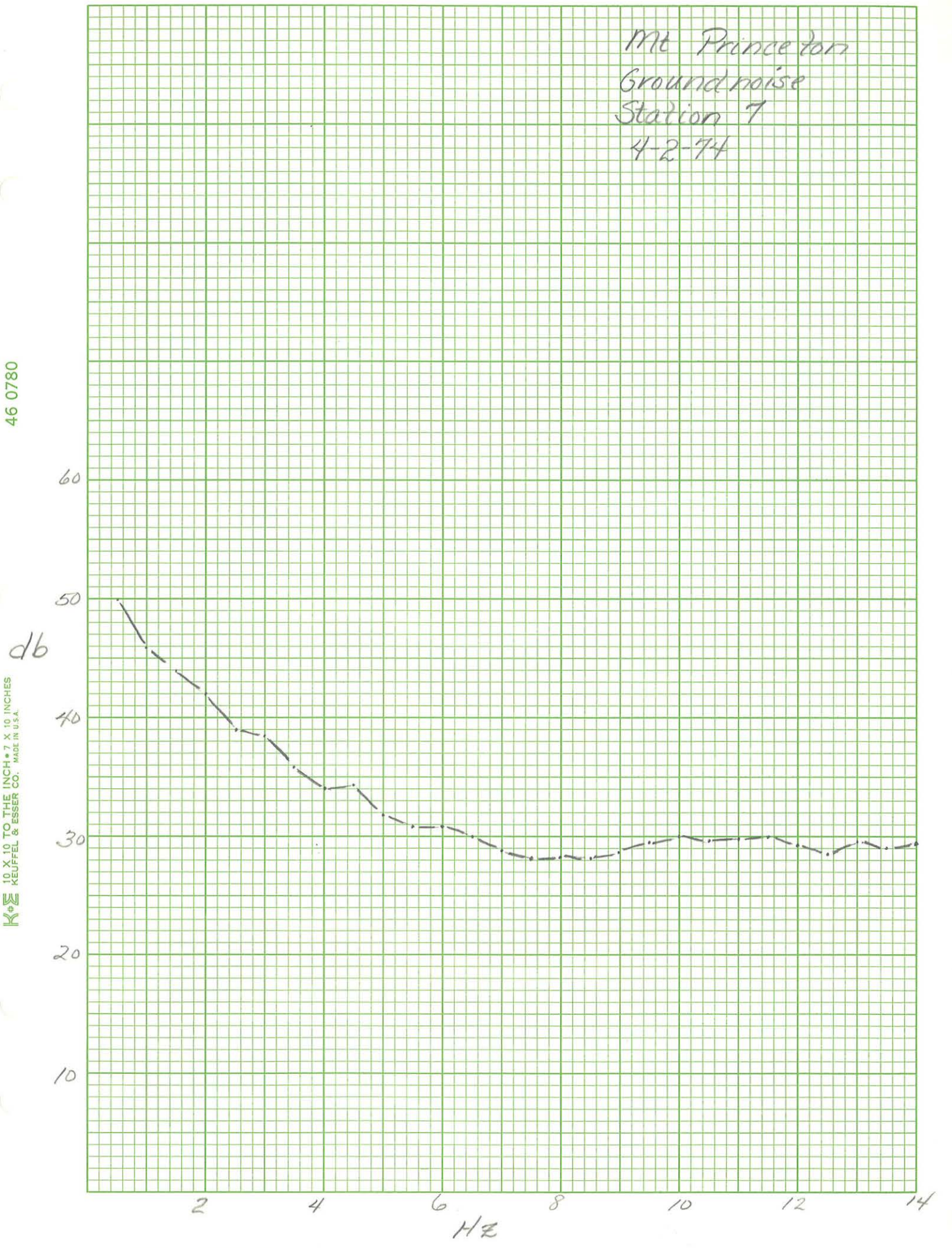


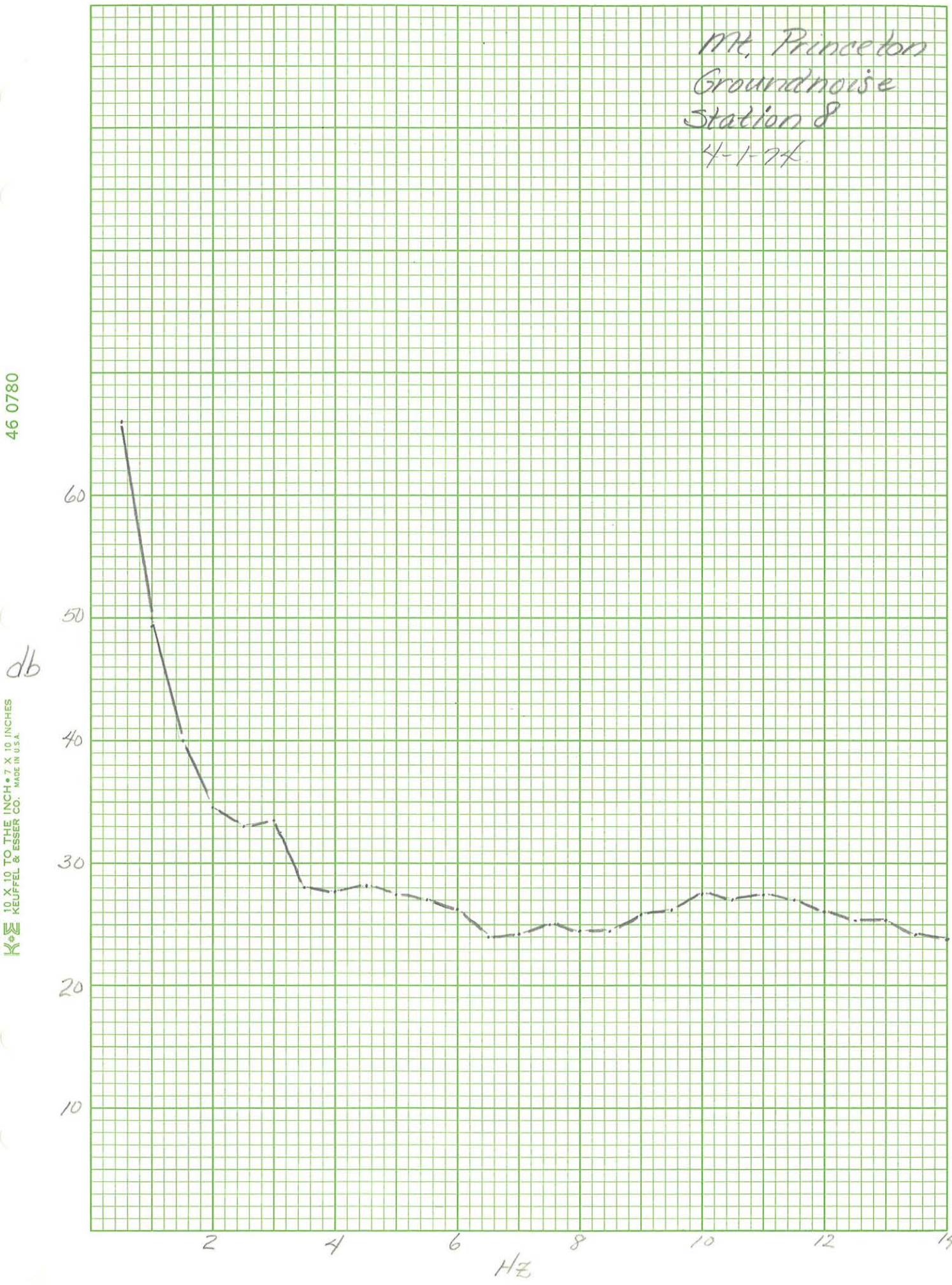

Mt Princeton
Station 3
Ground noise
3-31-74
60
db
50
40
30
20
10
0
2
4
6
8
10
12
14
Hz
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

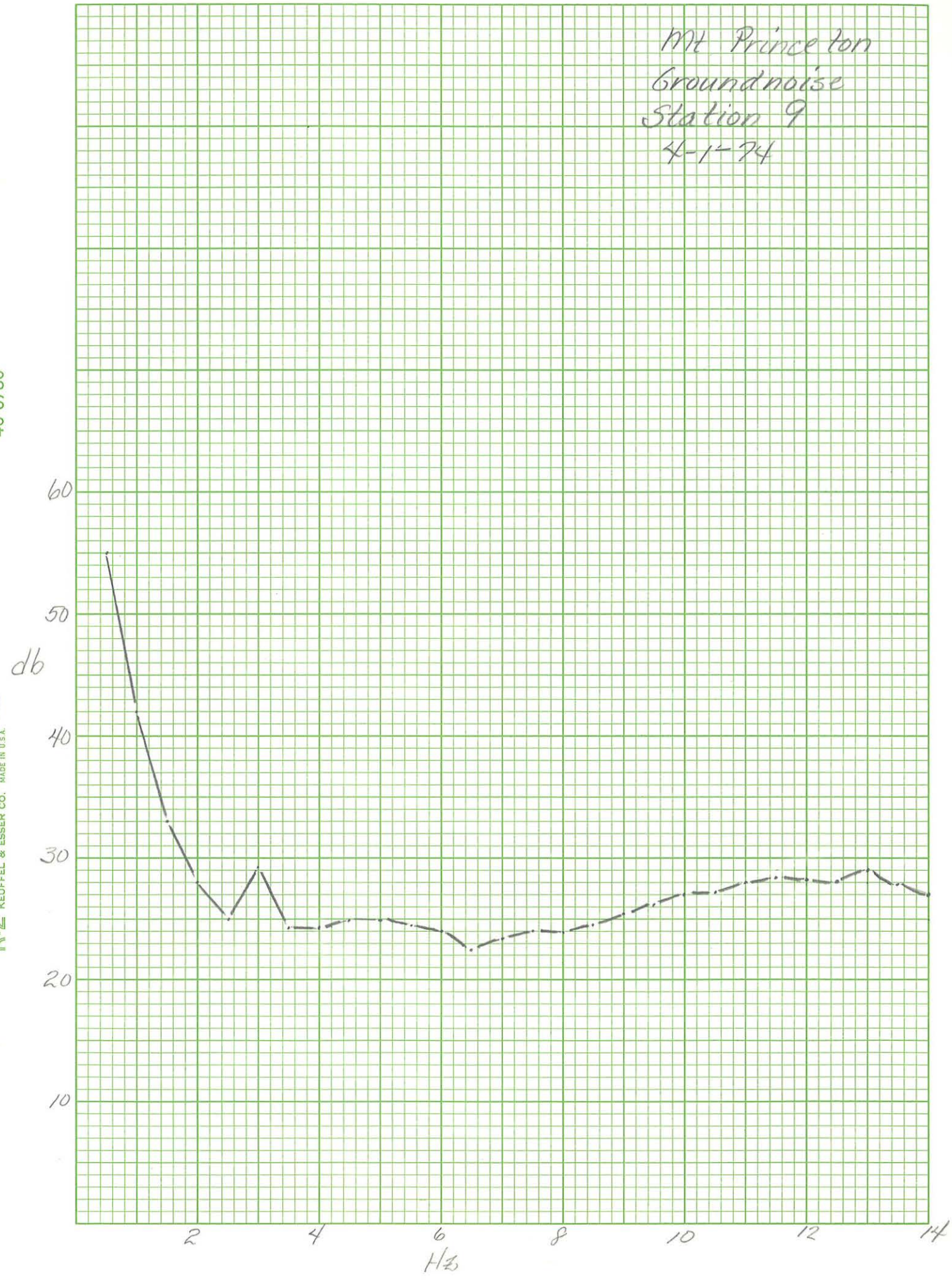

Mt. Princeton
Ground noise
Station 4
3-31-74
60
50
40
30
20
10
db
2
4
6
8
10
12
14
Hz
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

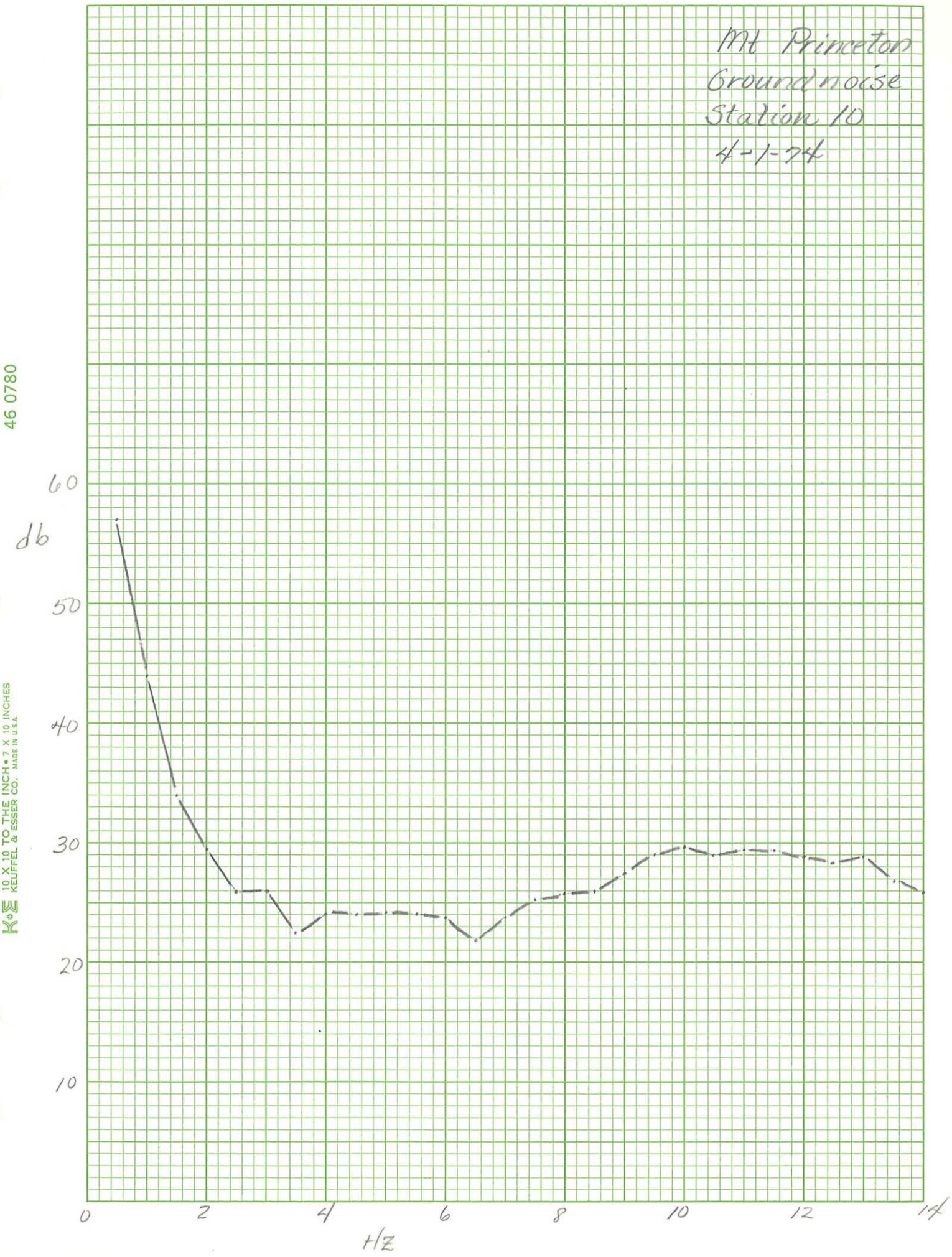

mt Princeton
Ground noise
Station 5
3-31-74
db
60
50
40
30
20
10
2
4
6
8
10
12
14
Hz
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

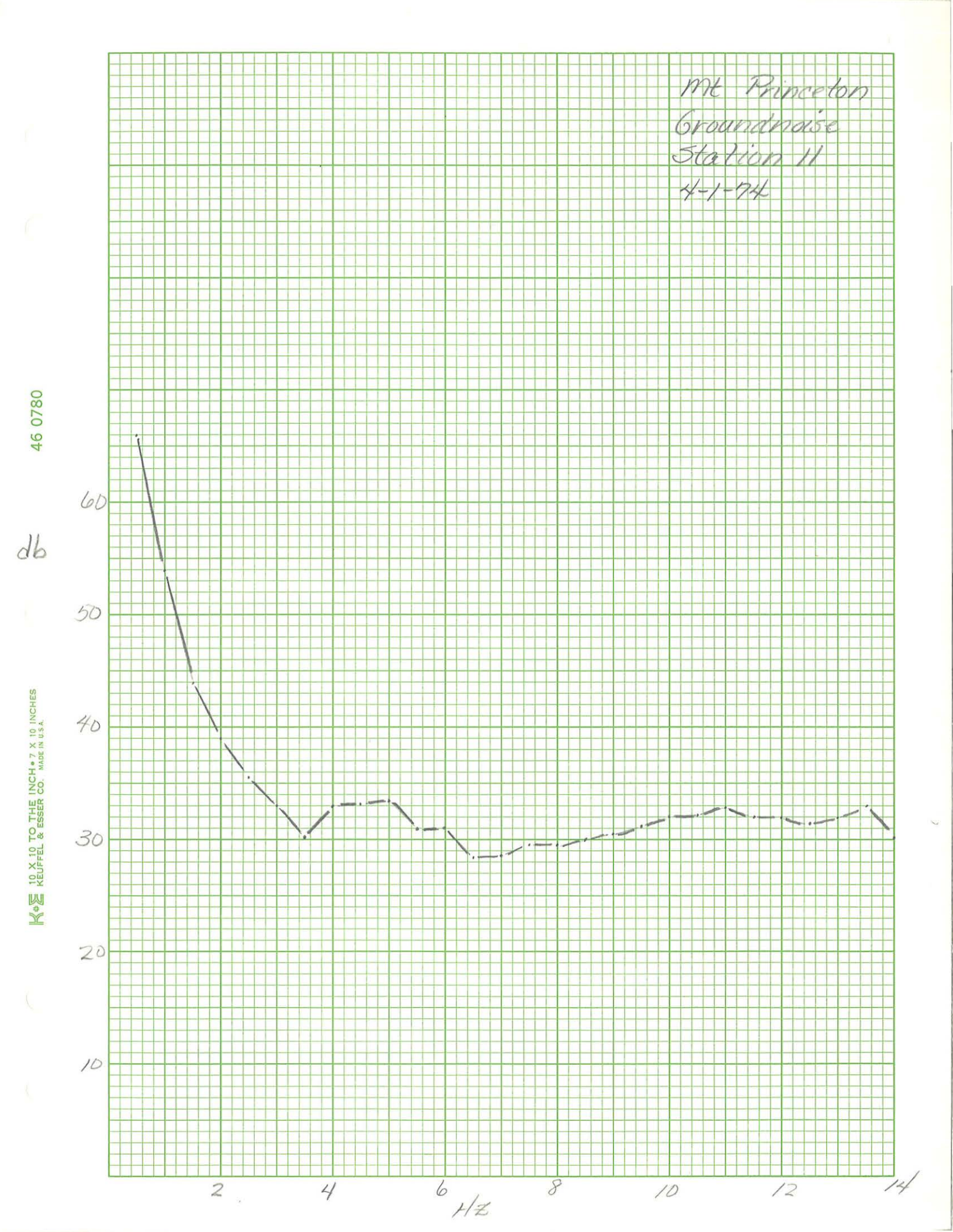

Mt Princeton
Station 6
Groundnoise
3-31-94
60
50
40
30
20
10
db
2
4
6
8
10
12
14
Hz
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

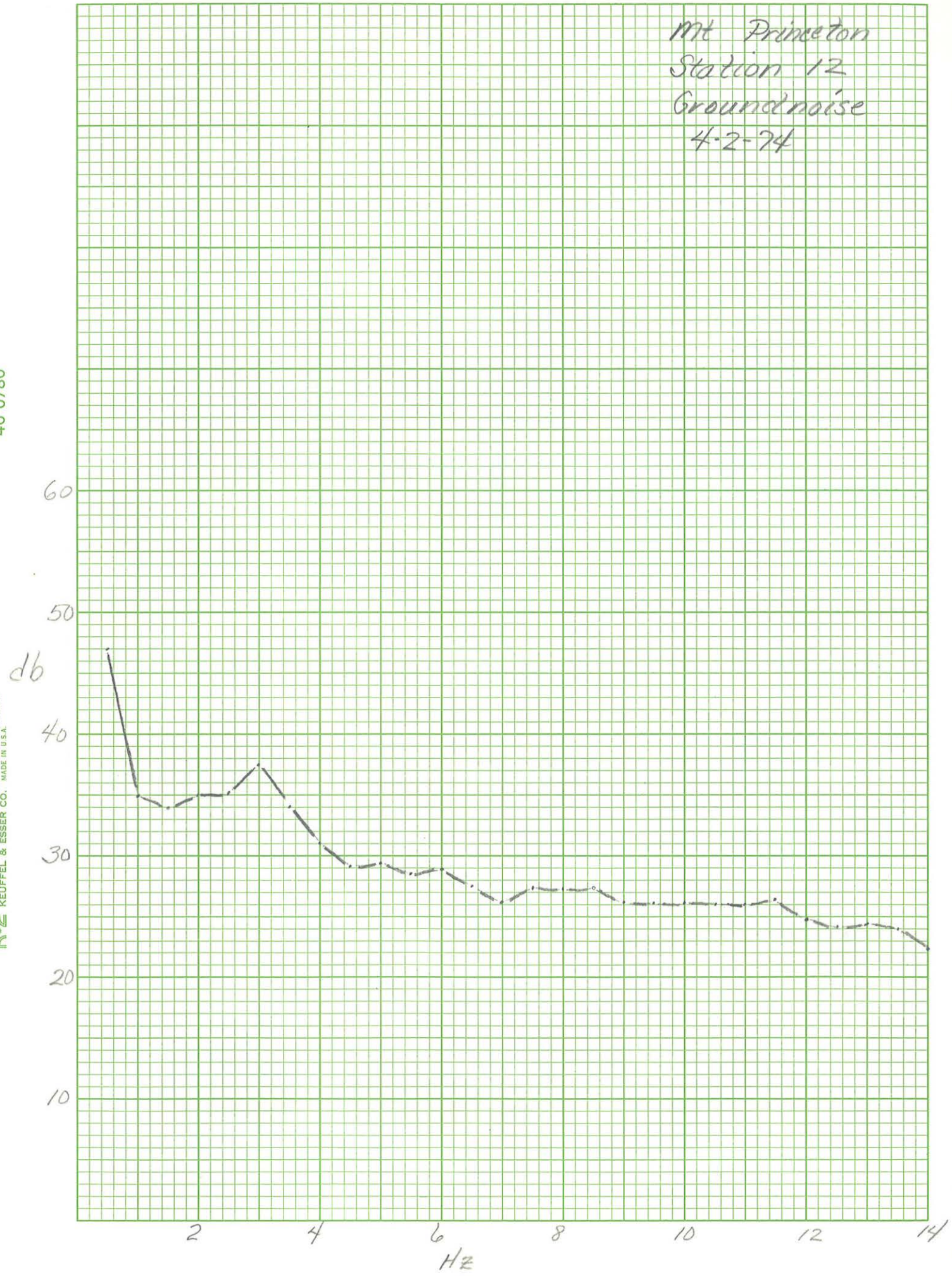

Mt Princeton
Groundnoise
Station 7
4-2-74
60
50
40
30
20
10
db
2
4
6
8
10
12
14
Hz
46 0780
KE 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

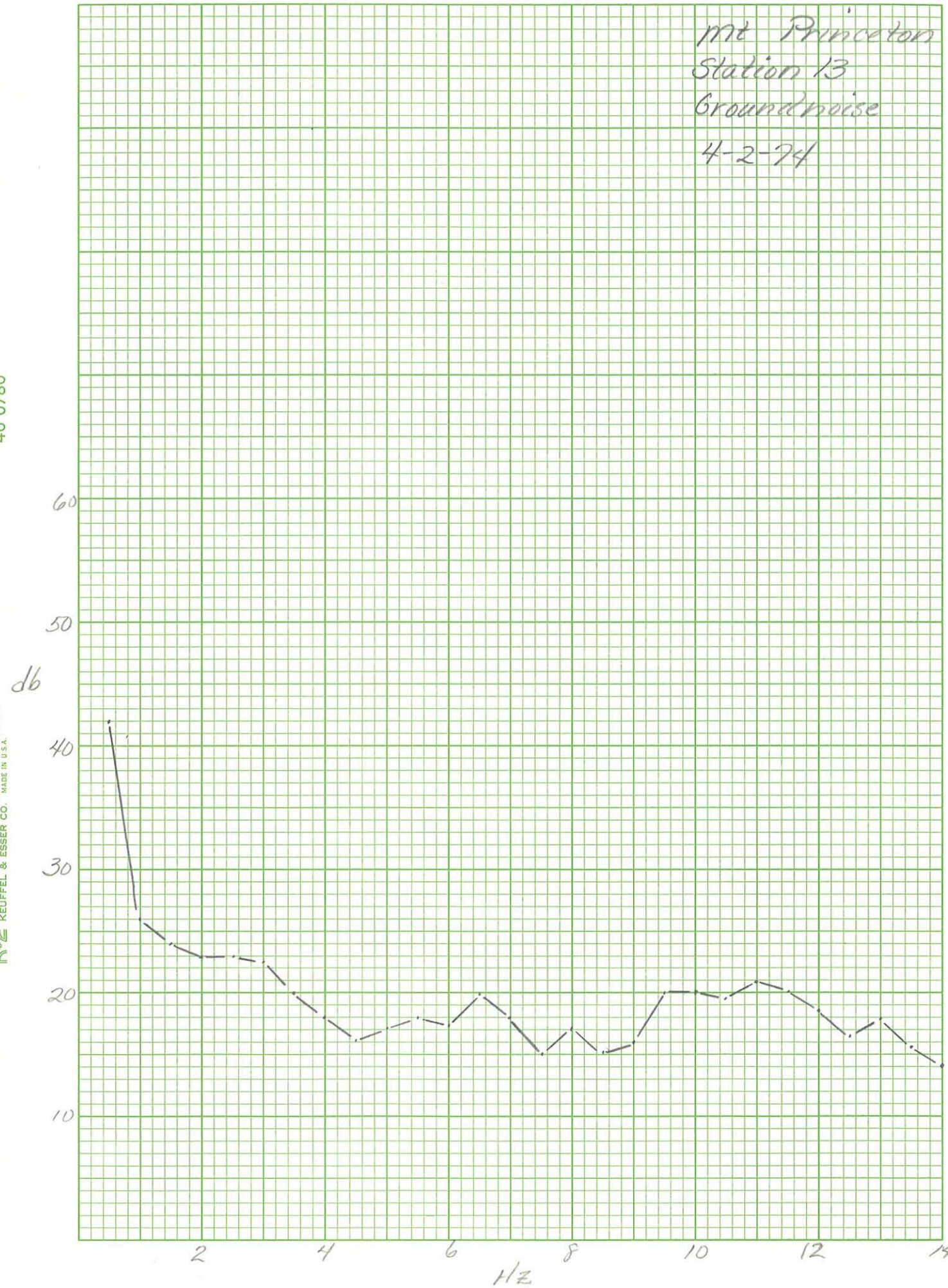

Mt. Princeton
Groundnoise
Station 8
4-1-74
60
50
40
30
20
10
db
2
4
6
8
10
12
14
Hz
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.


Mt Princeton
Groundnoise
Station 9
4-1-74
60
50
db
40
30
20
10
2
4
6
8
10
12
14
Hz
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

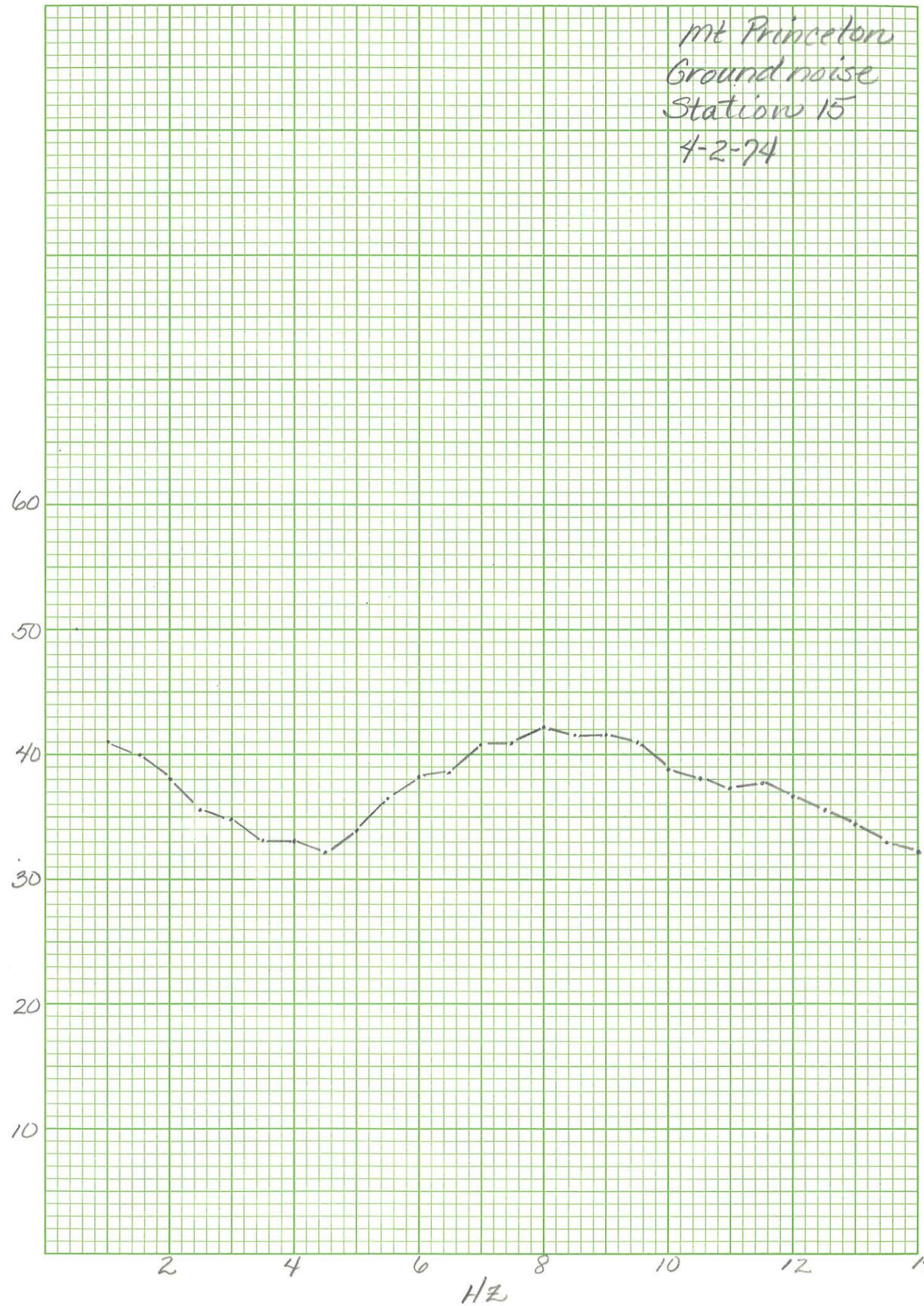

Mt Princeton
Groundnoise
Station 10
4-1-74
60
db
50
40
30
20
10
0
2
4
6
8
10
12
14
Hz
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

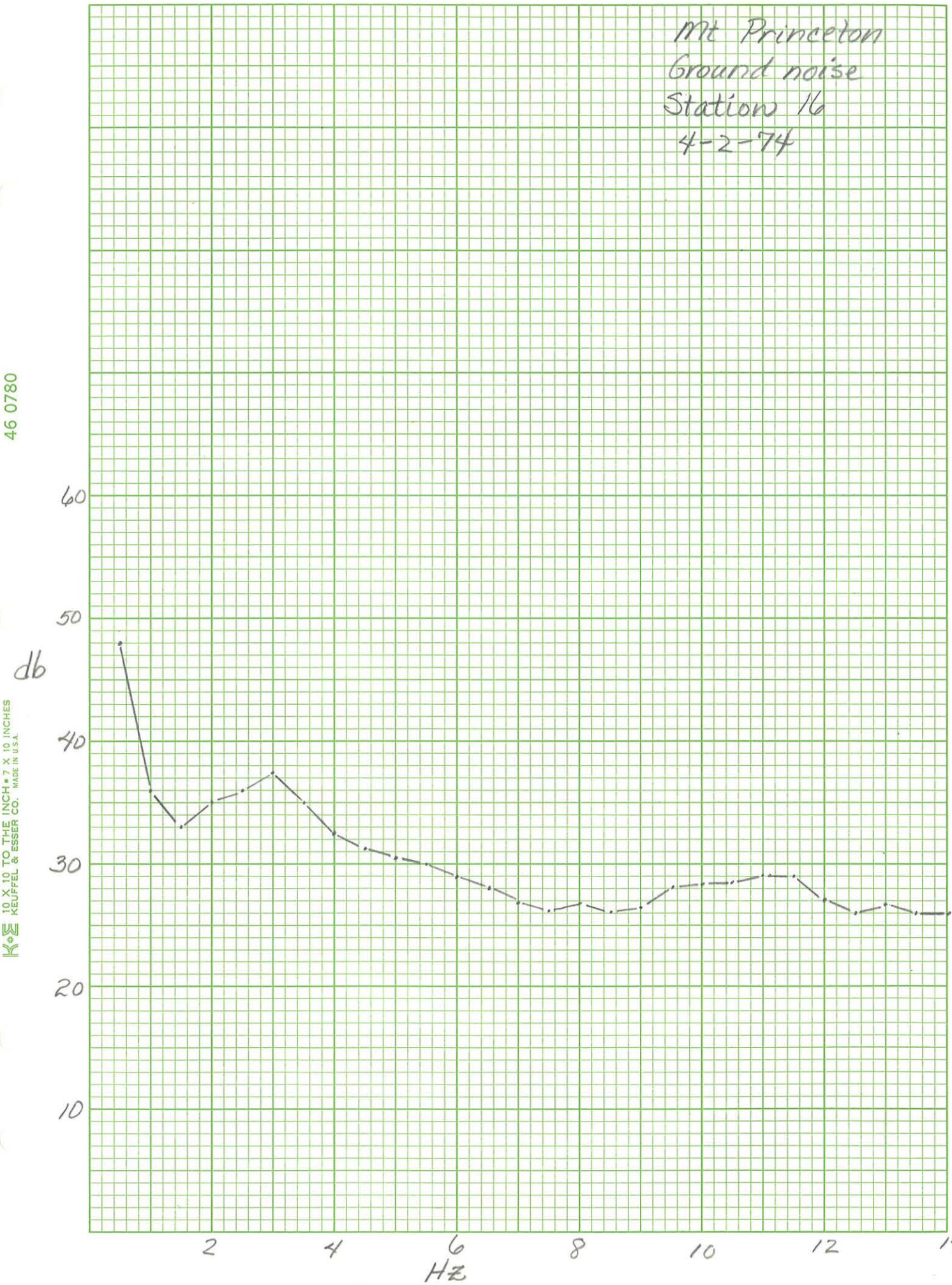

Mt Princeton
Groundnoise
Station 11
4-1-74
db
60
50
40
30
20
10
2
4
6
8
10
12
14
Hz
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

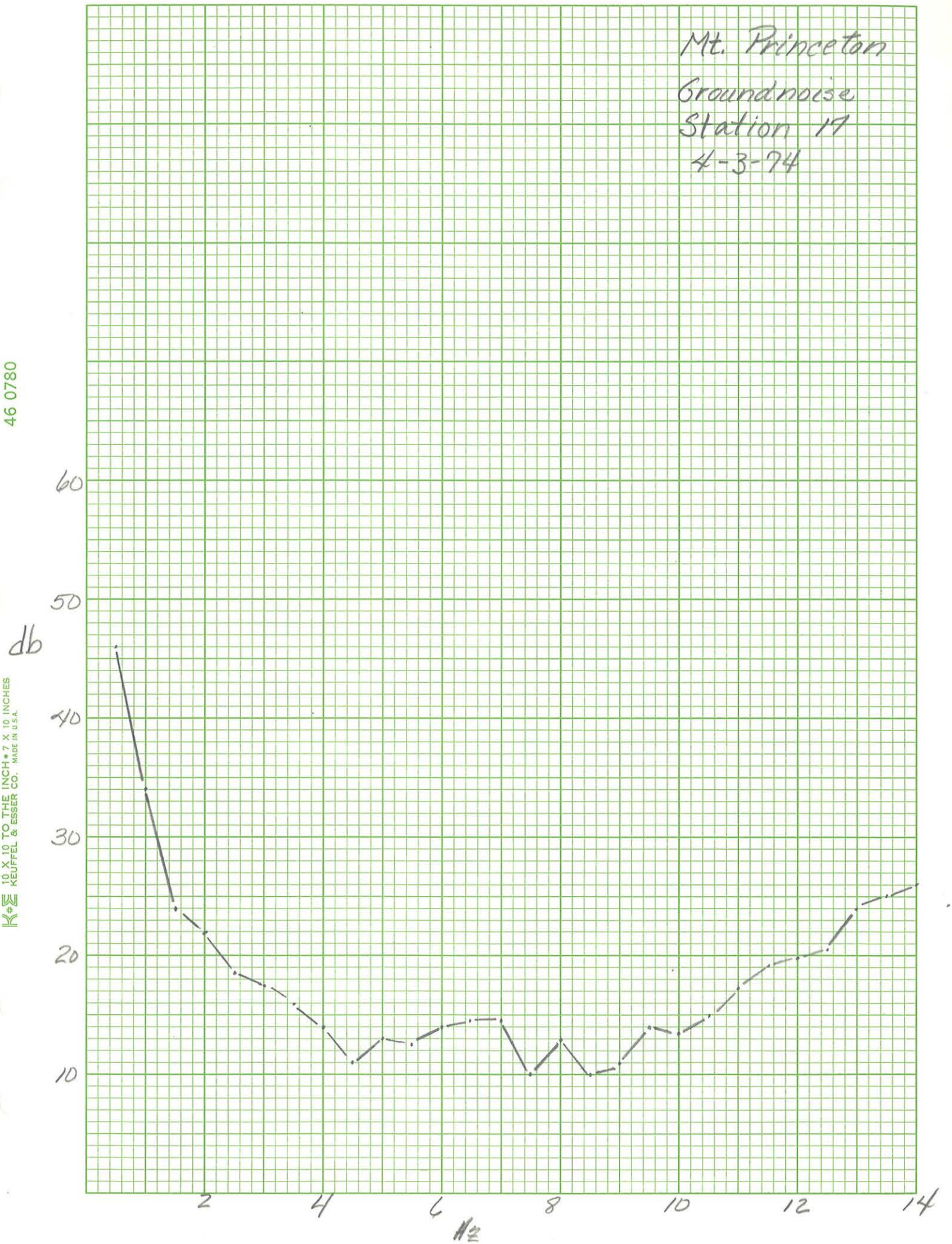


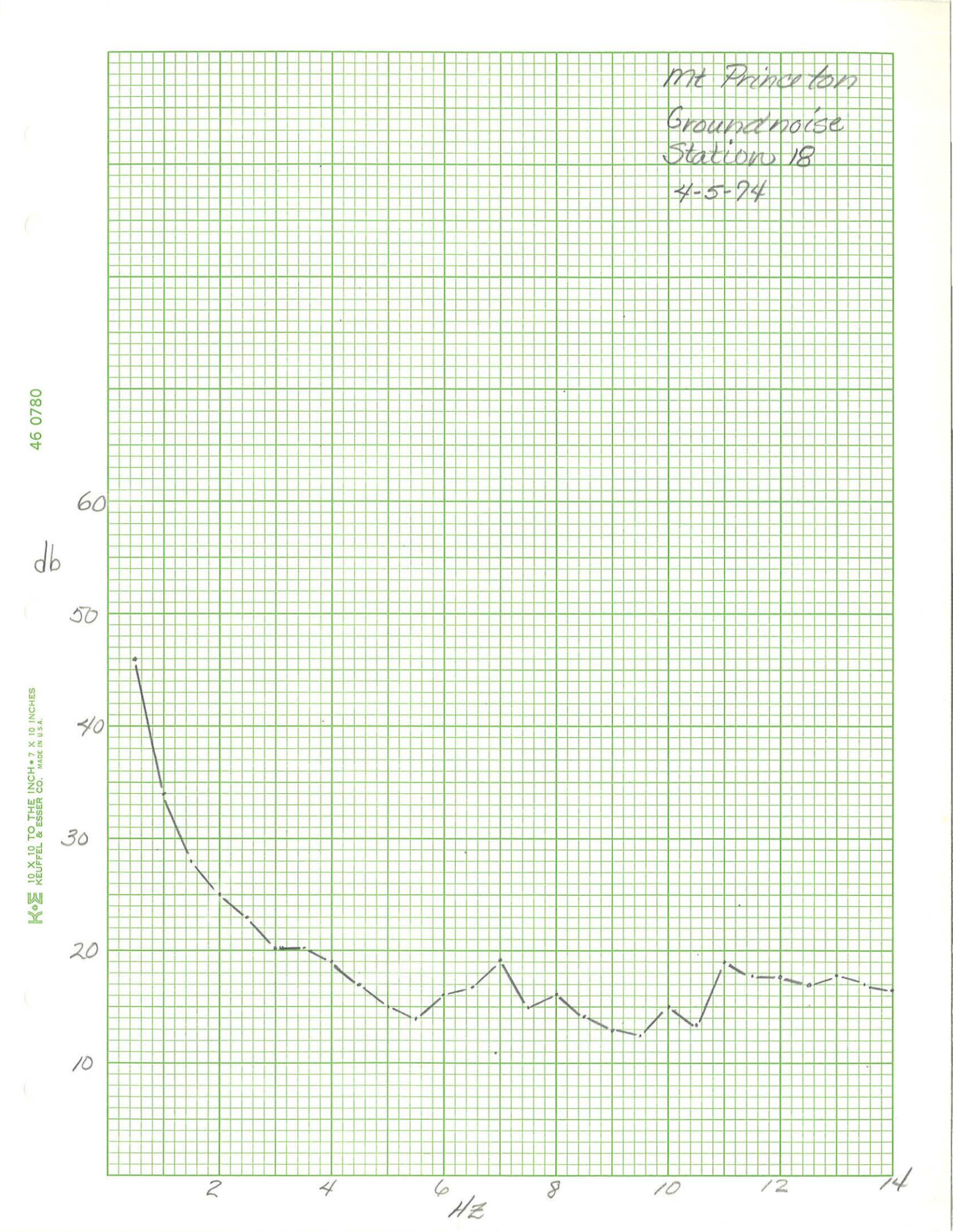


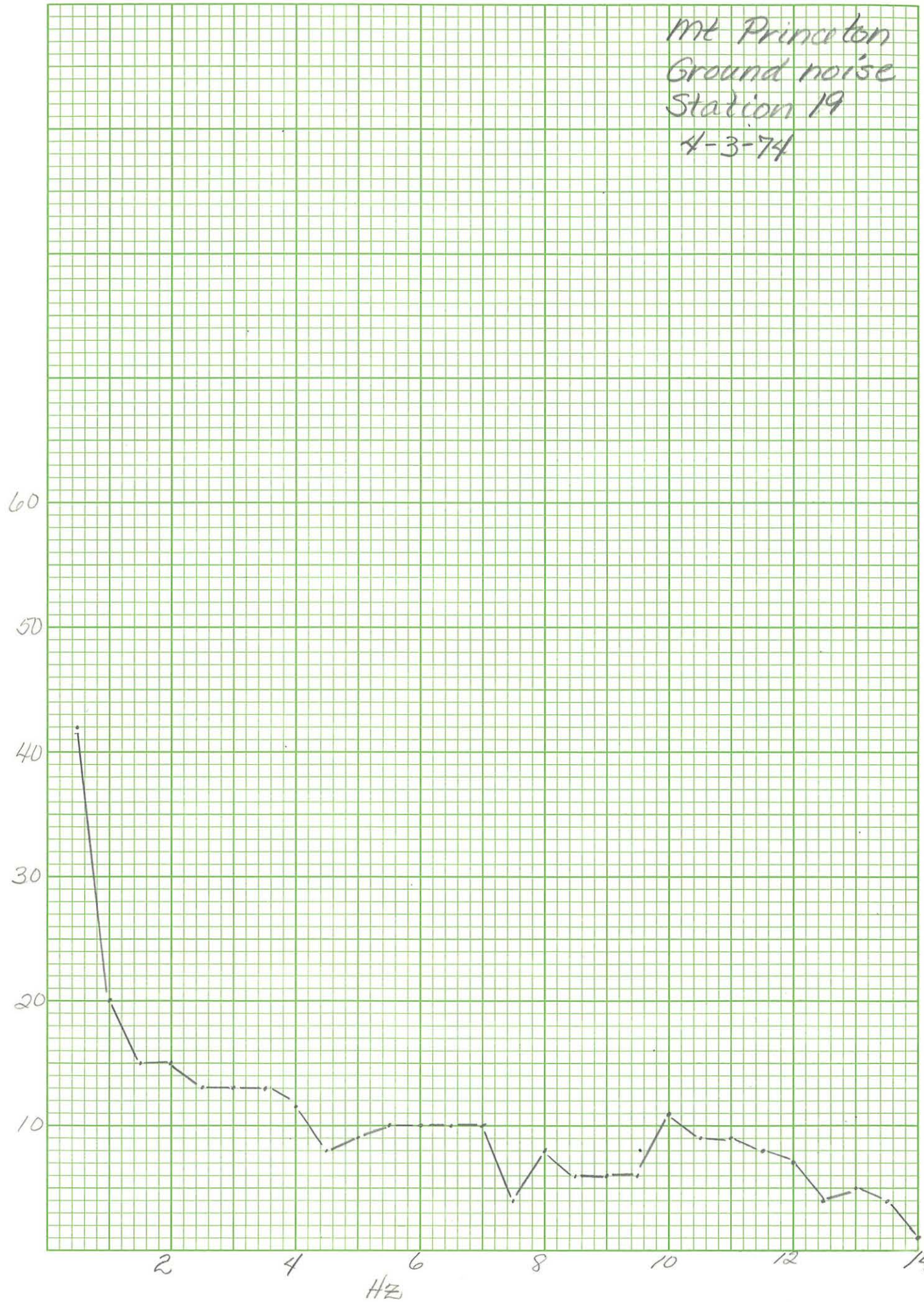

Mt Princeton
Groundnoise
Station 14
4-3-74
60
50
40
30
20
10
db
2
4
6
8
10
12
14
Hz
46 0780
K&E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

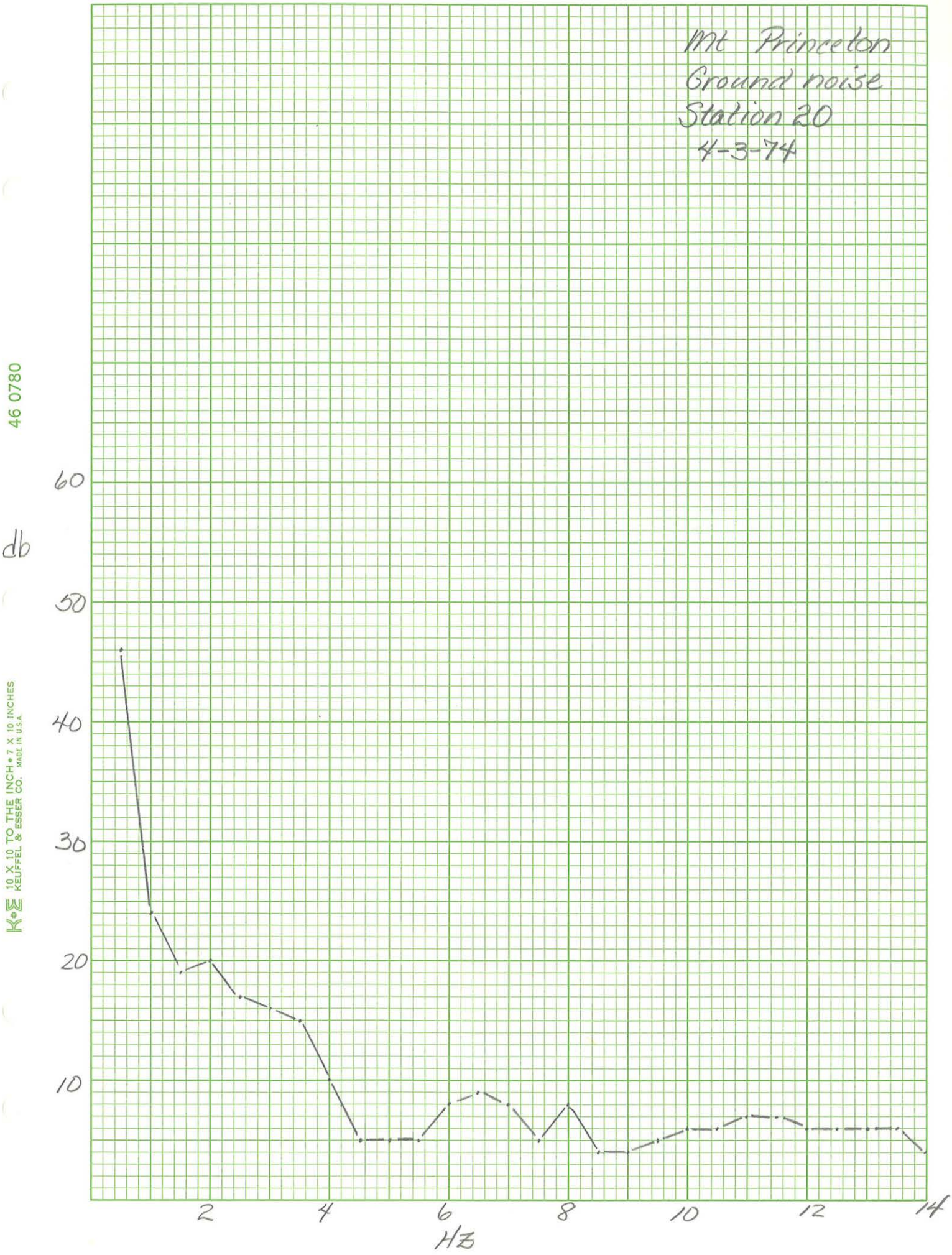


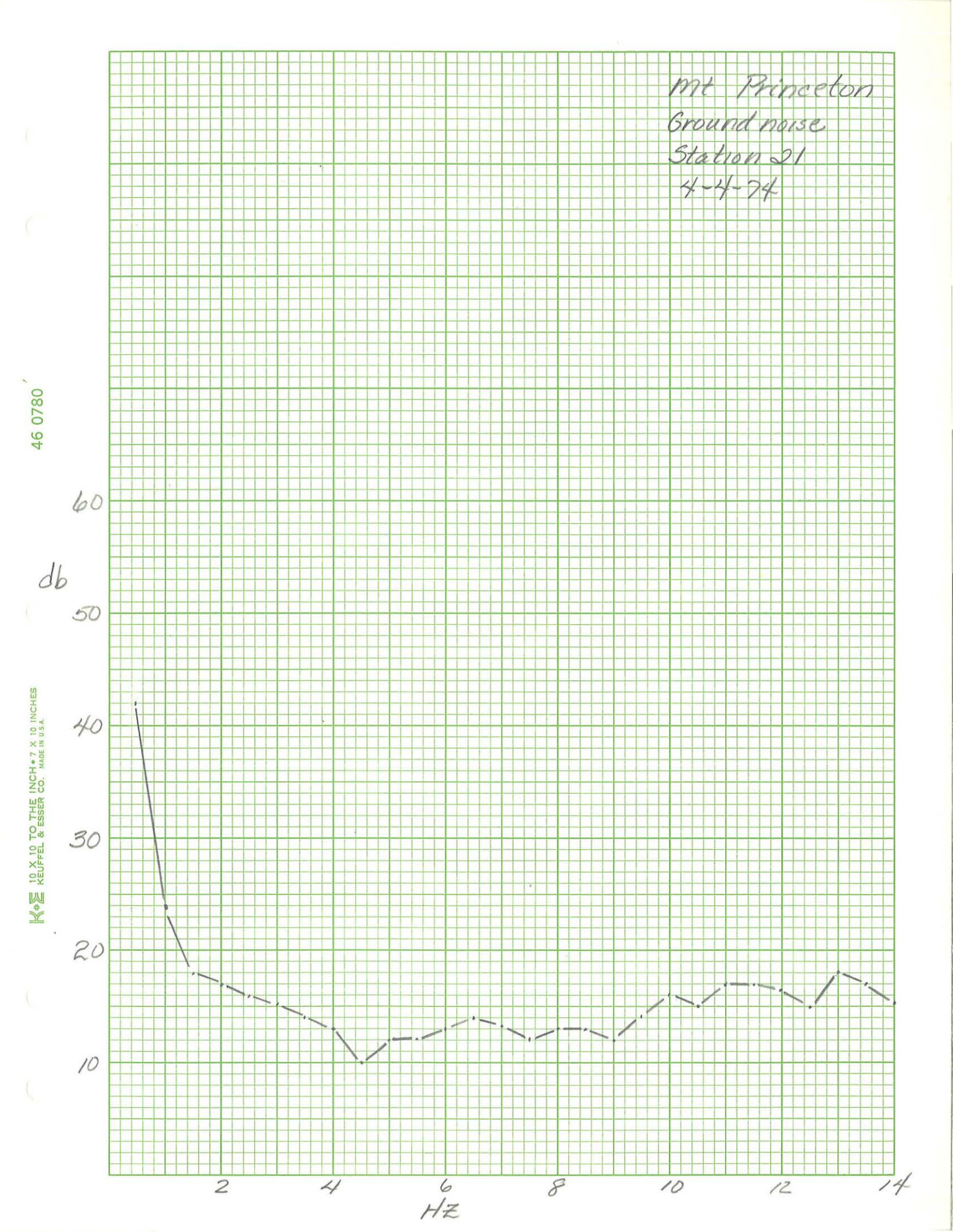


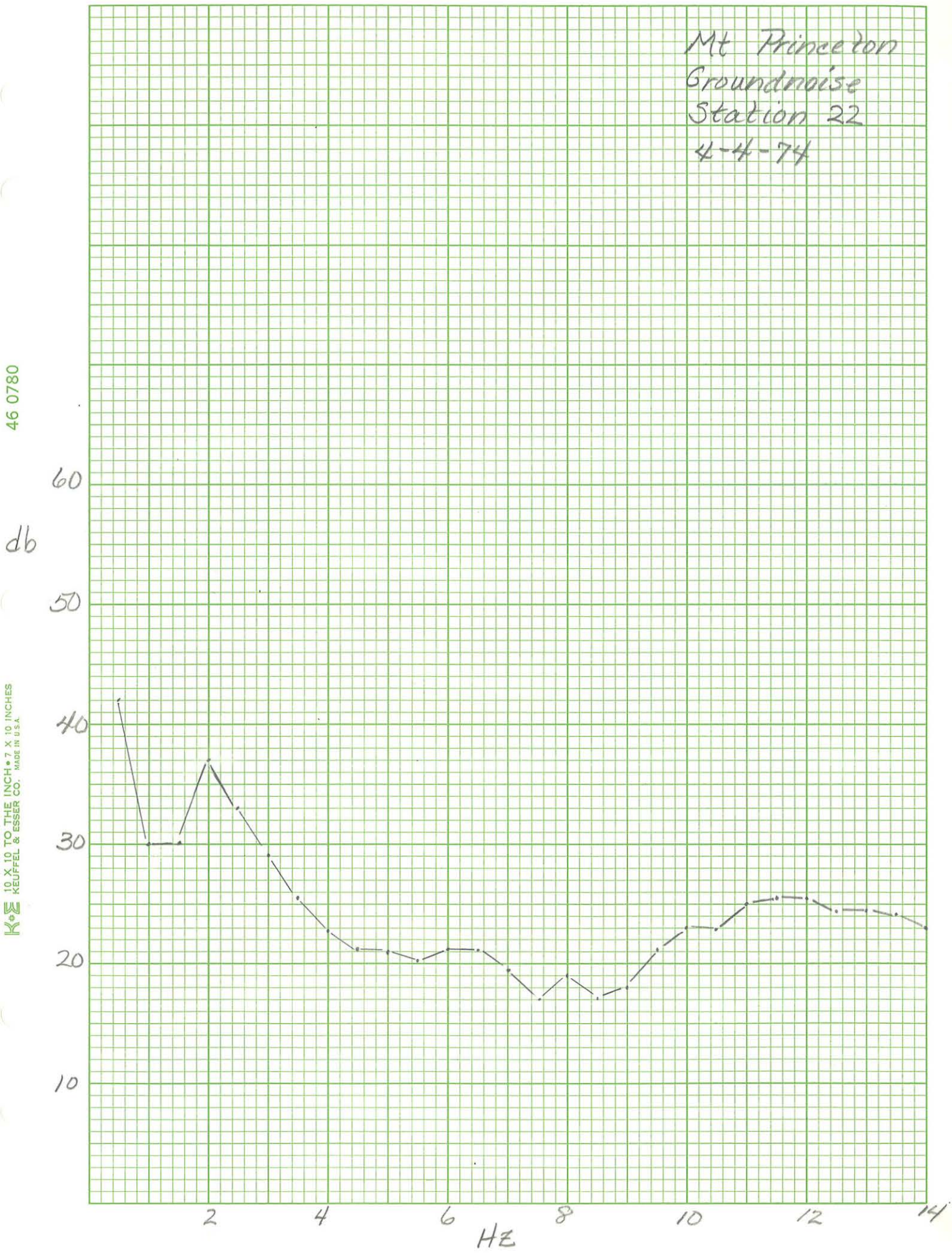

Mt. Princeton
Groundnoise
Station 17
4-3-74
60
50
db
40
30
20
10
2
4
6
8
10
12
14
Hz
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

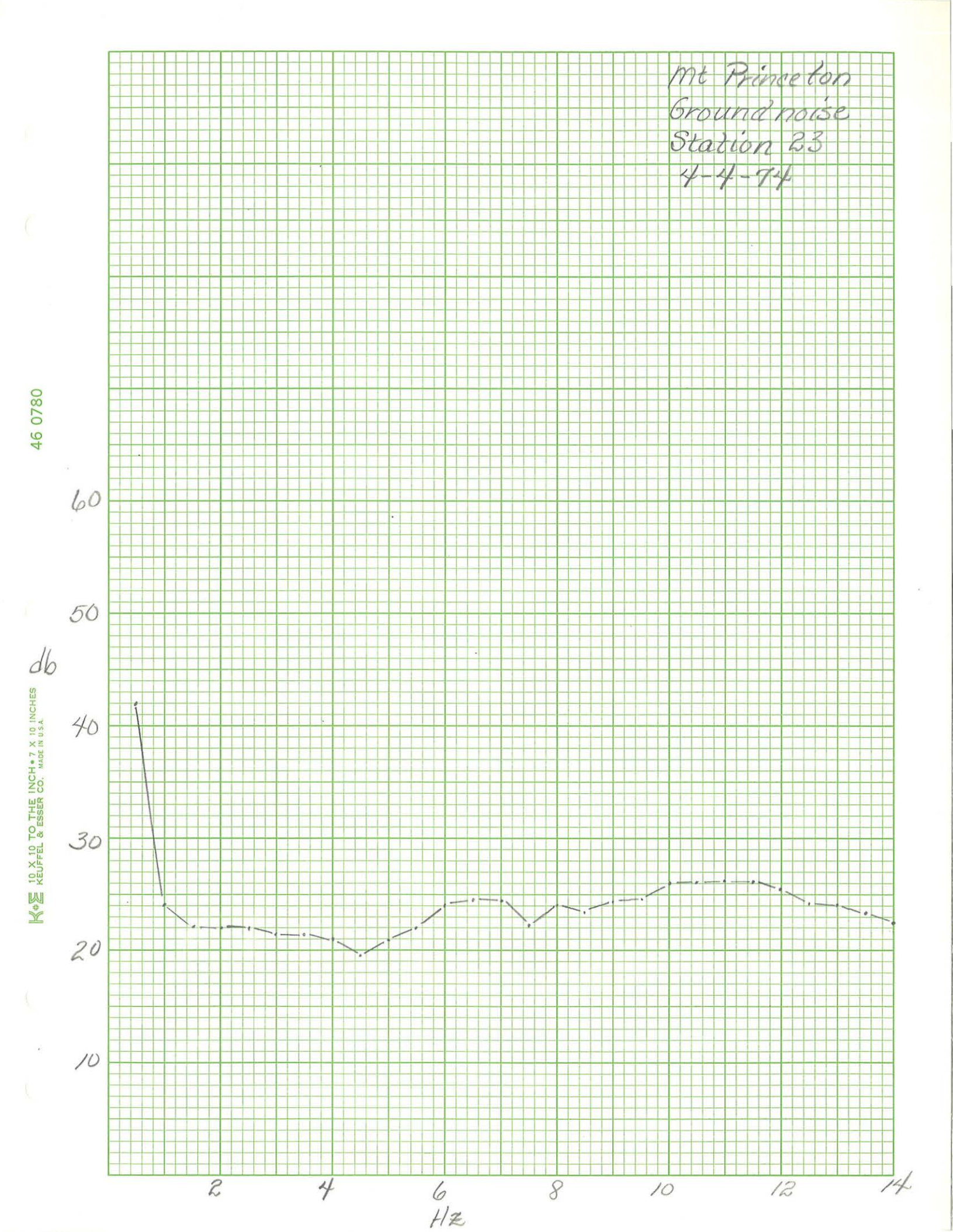

Mt Princeton
Groundnoise
Station 18
4-5-74
60
db
50
40
30
20
10
2
4
6
8
10
12
14
Hz
46 0780
KE 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

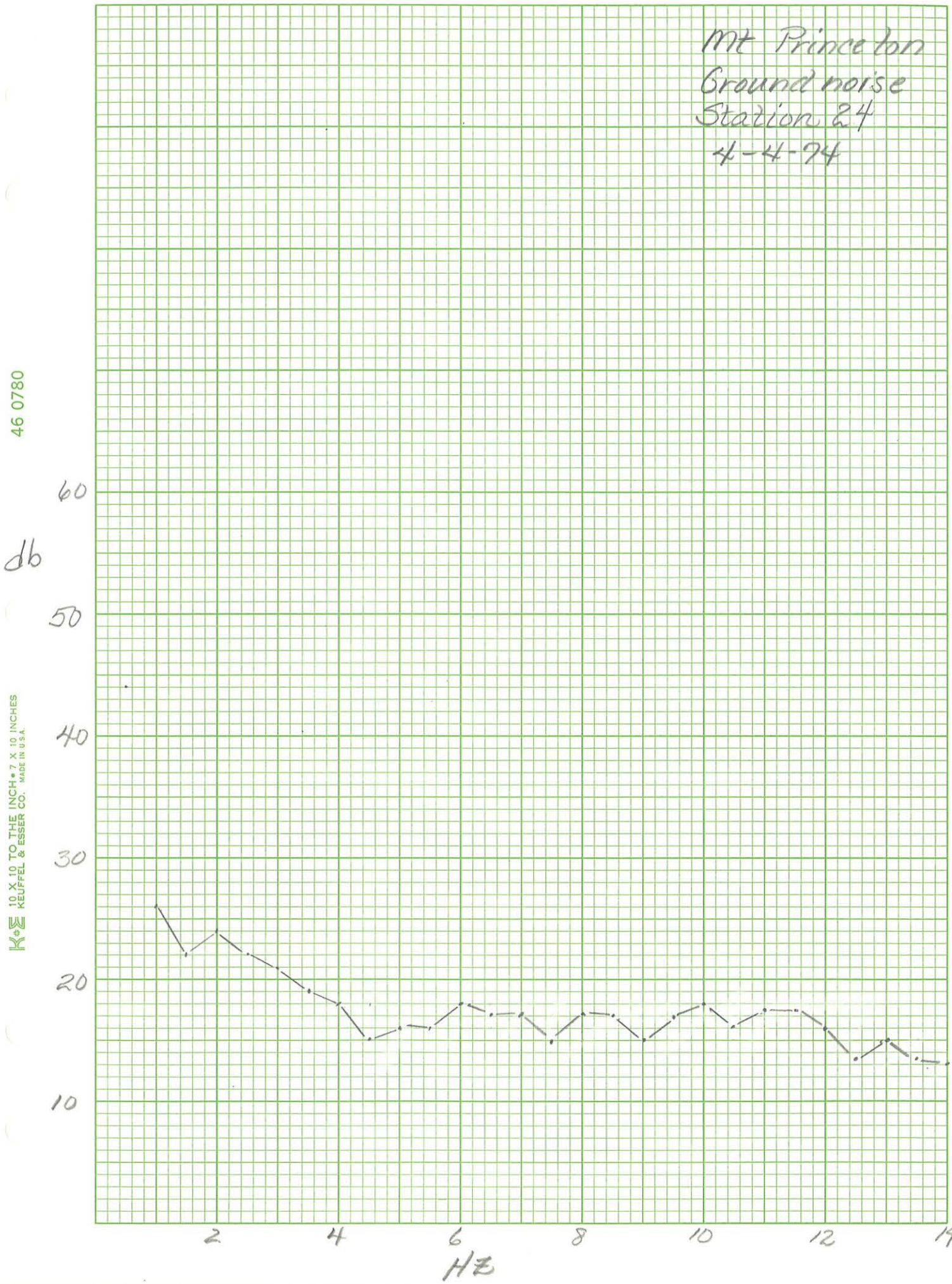


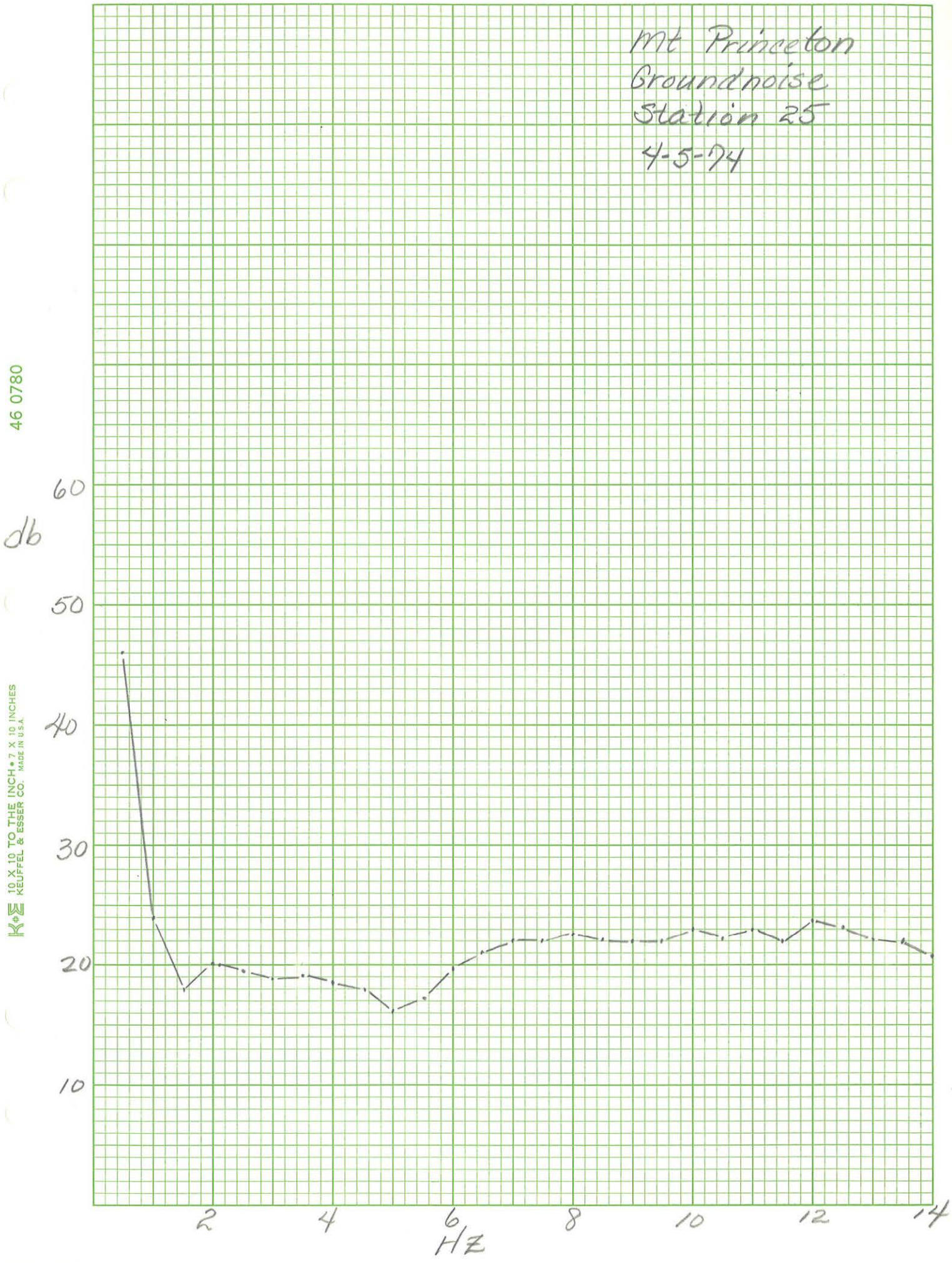

Mt Princeton
Ground noise
Station 20
4-3-74
60
db
50
40
30
20
10
2
4
6
8
10
12
14
Hz
46 0780
KE 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

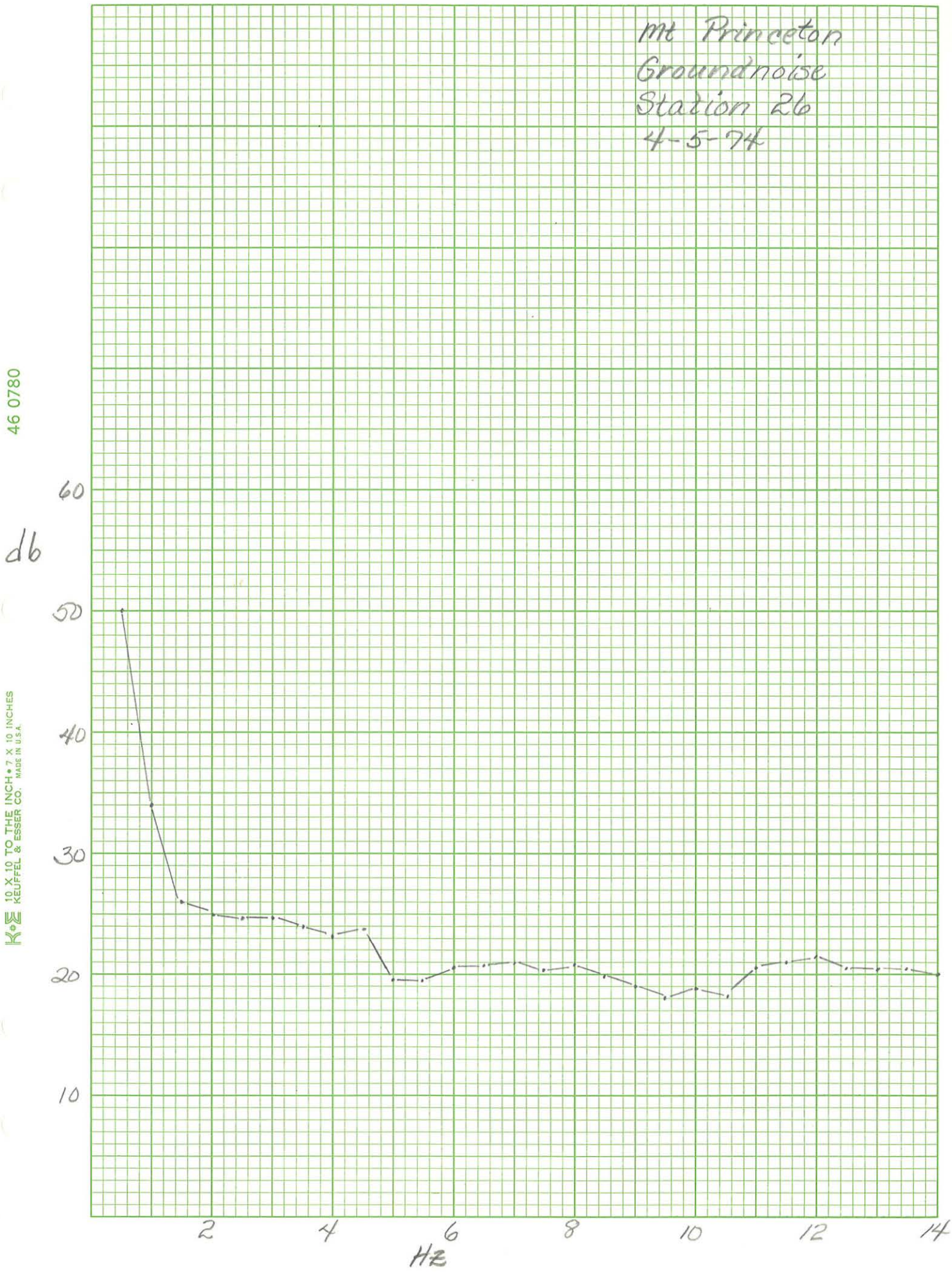

Mt Princeton
Ground noise
Station 21
4-4-74
60
db
50
40
30
20
10
2
4
6
8
10
12
14
Hz
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

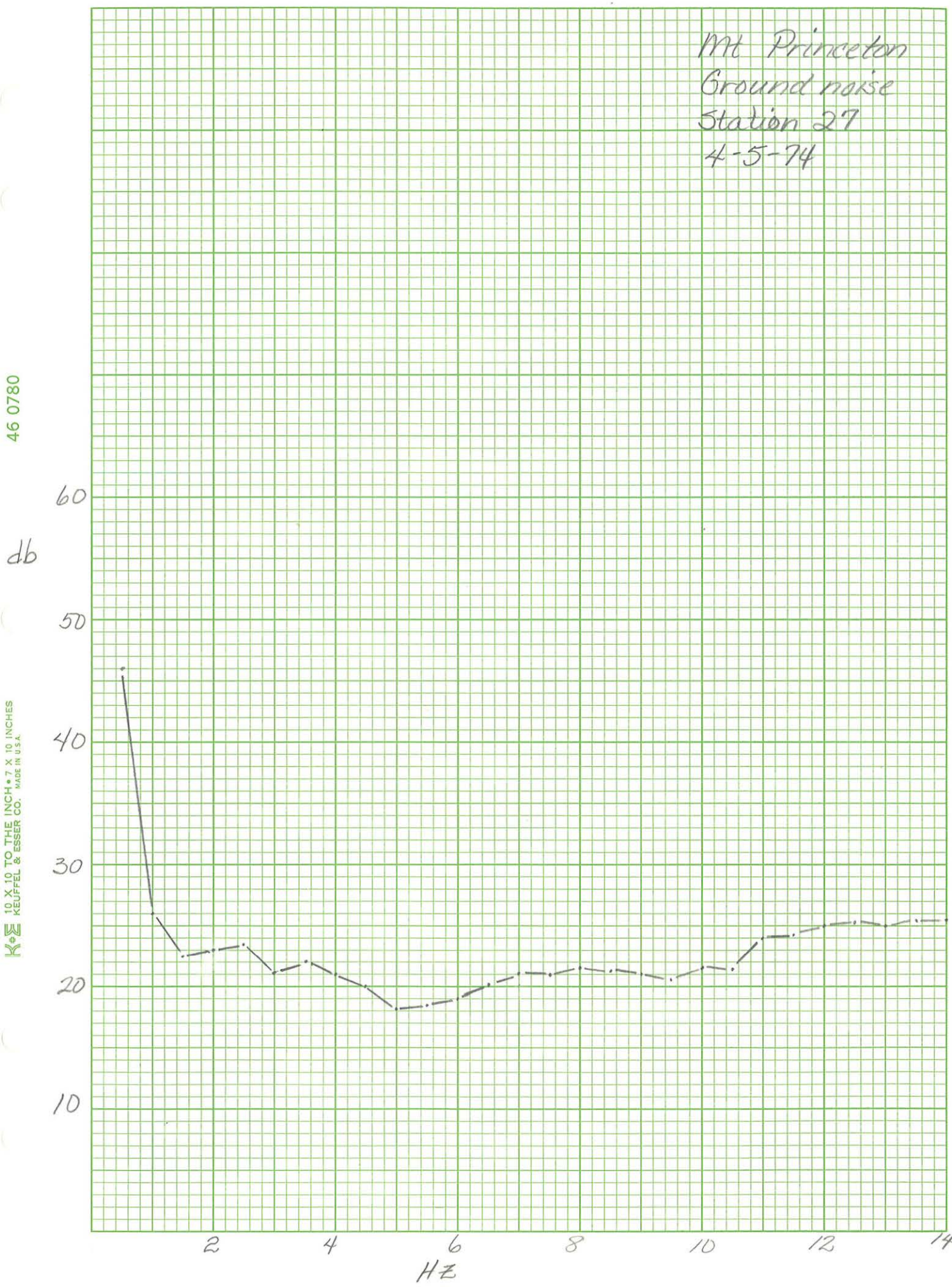

Mt Princeton
Groundnoise
Station 22
4-4-74
60
db
50
40
30
20
10
2
4
6
8
10
12
14
HZ
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

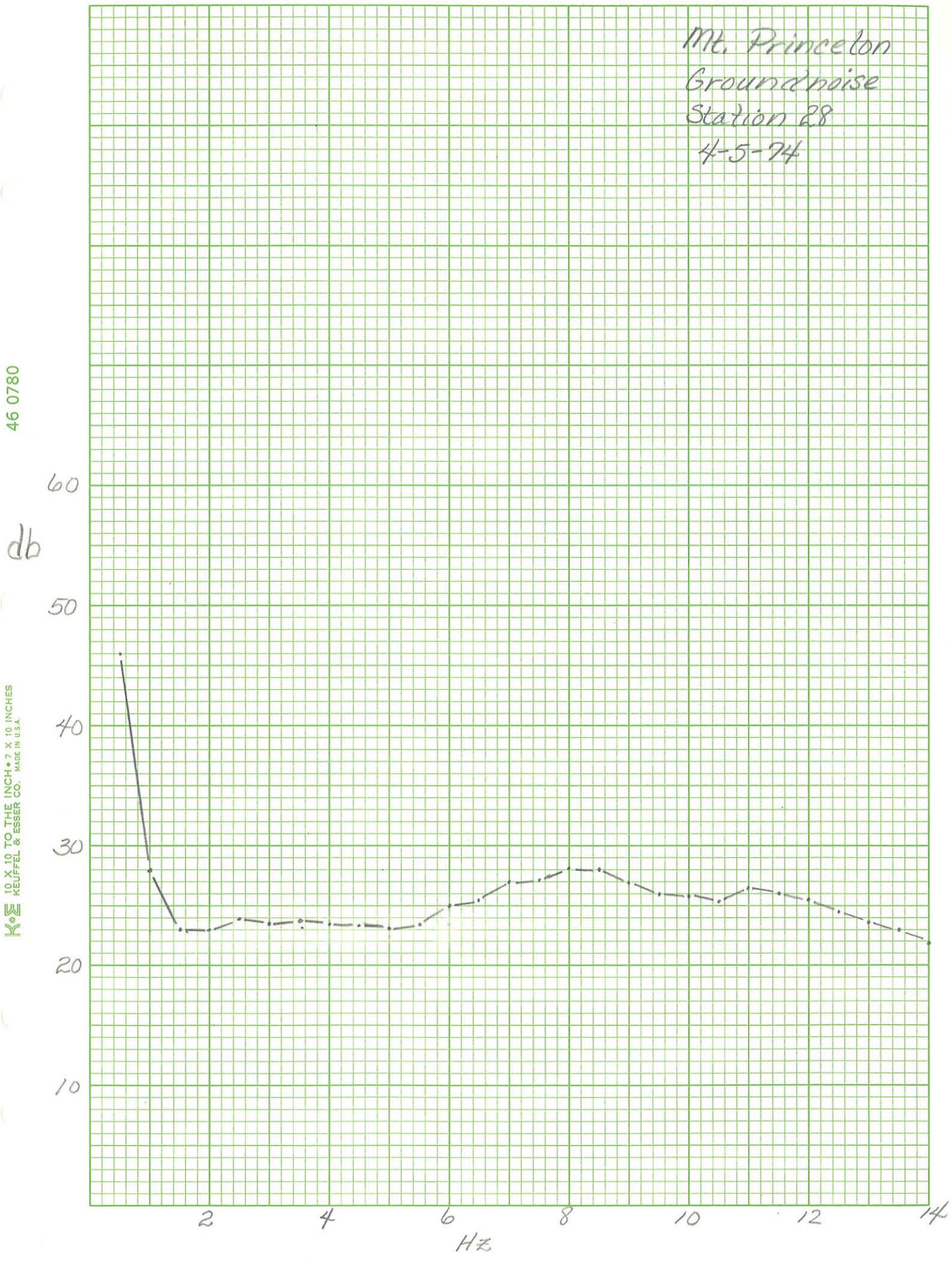

Mt Princeton
Groundnoise
Station 23
4-4-74
60
50
db
40
30
20
10
2
4
6
8
10
12
14
Hz
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

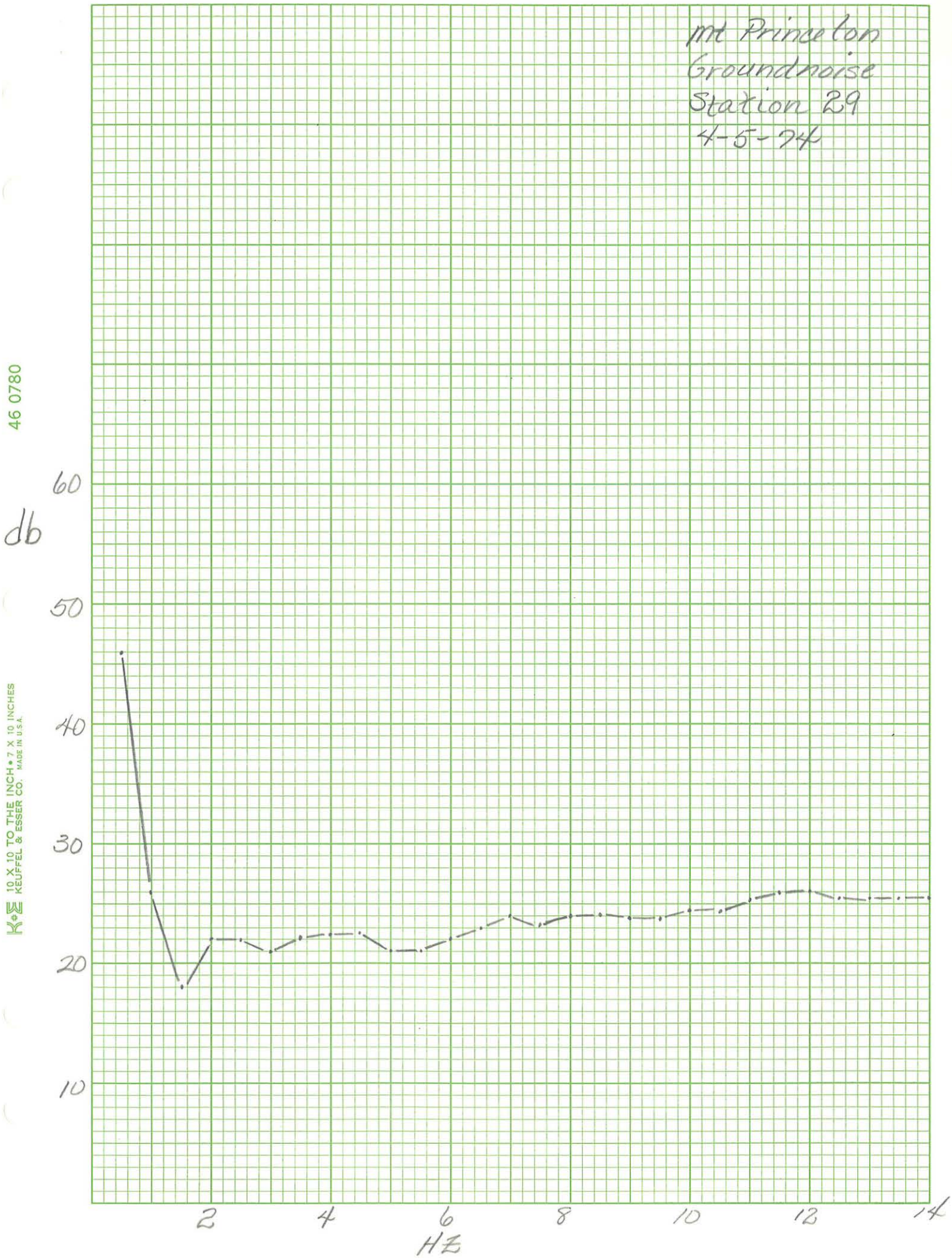

Mt Princeton
Ground noise
Station 24
4-4-74
60
db
50
40
30
20
10
2
4
6
8
10
12
14
HZ
46 0780
K&E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

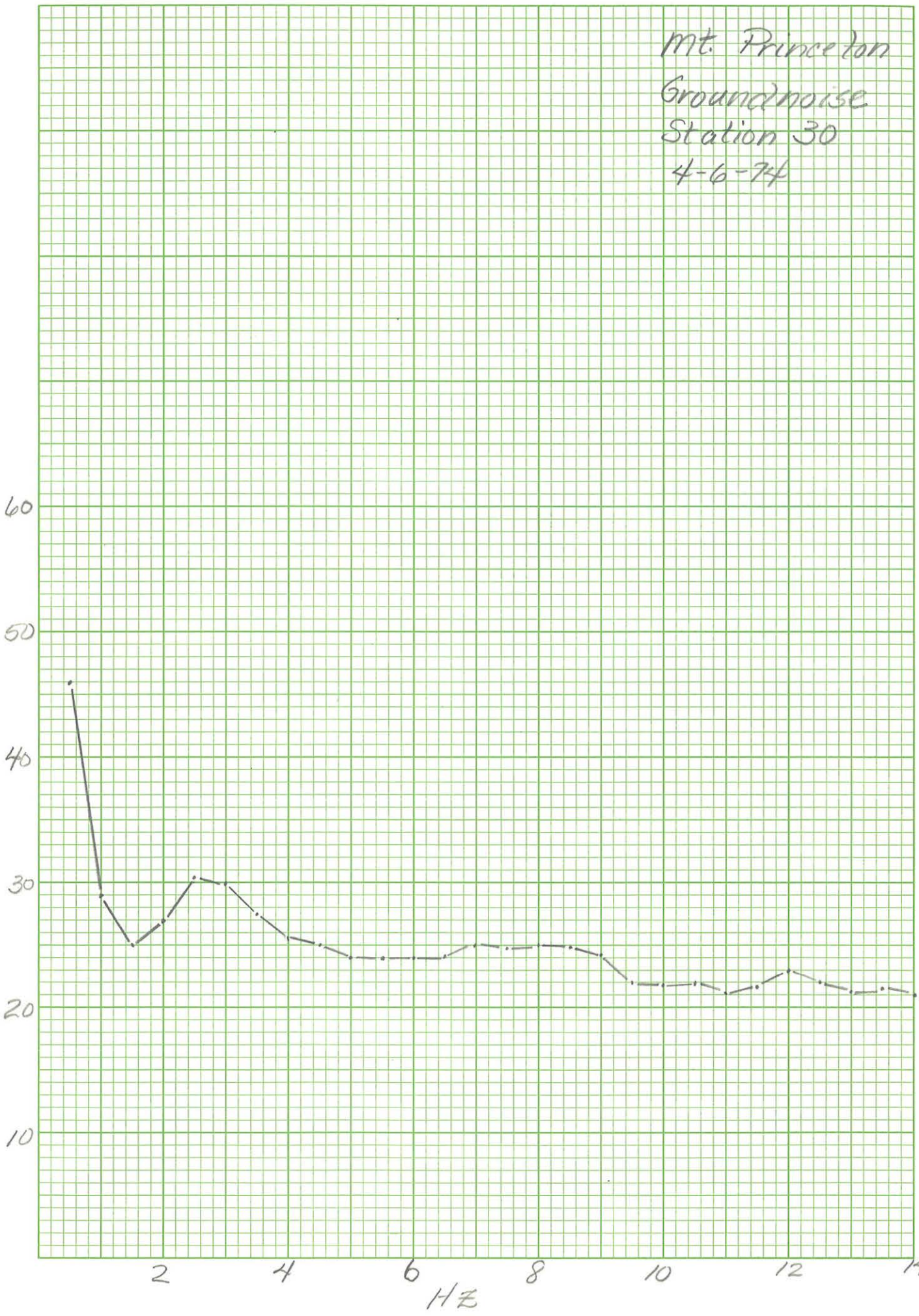

Mt Princeton
Groundnoise
Station 25
4-5-74
60
db
50
40
30
20
10
2
4
6
8
10
12
14
Hz
46 0780
KE 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

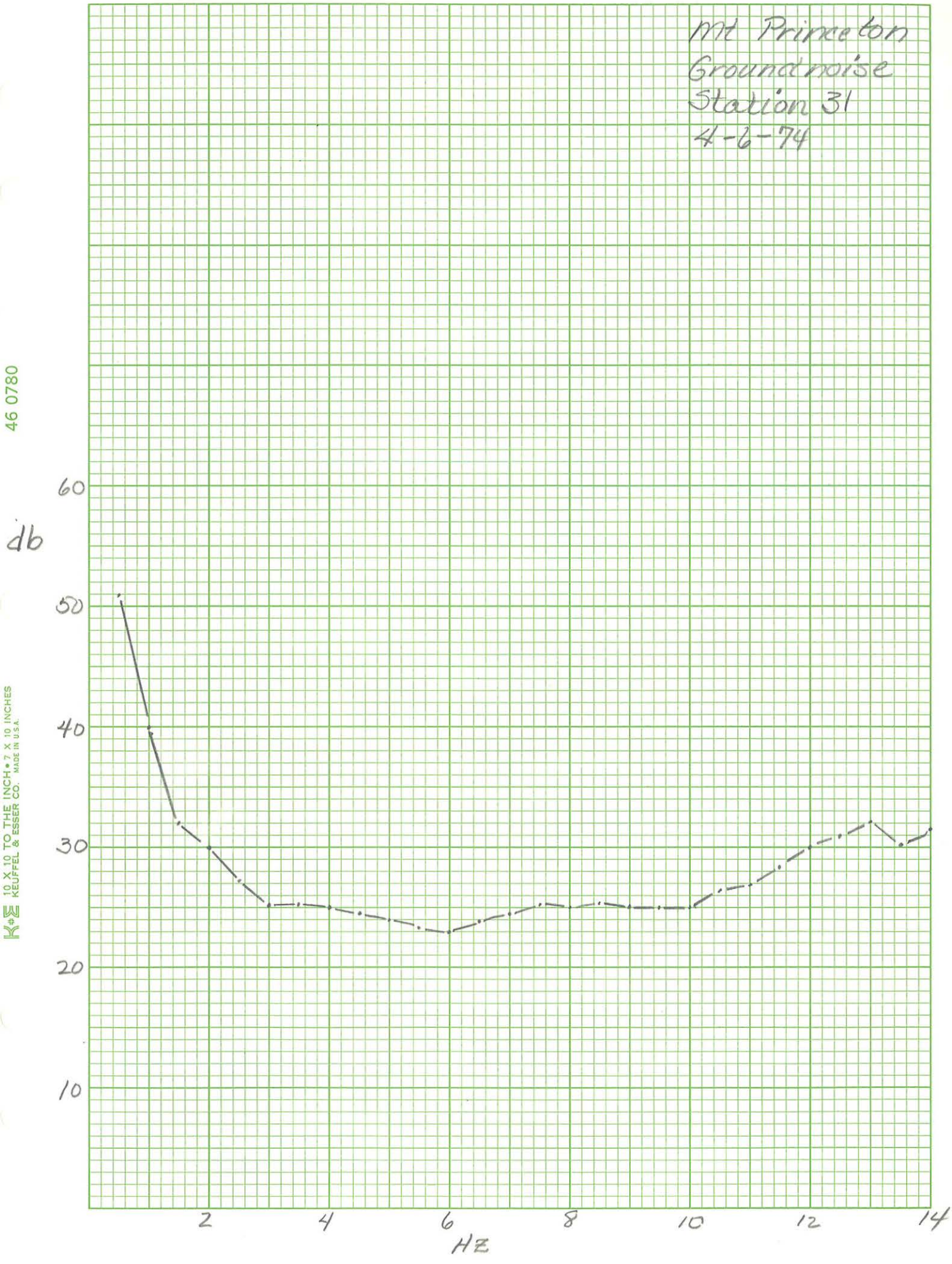

Mt Princeton
Groundnoise
Station 26
4-5-74
60
db
50
40
30
20
10
2
4
6
8
10
12
14
Hz
46 0780
K+E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

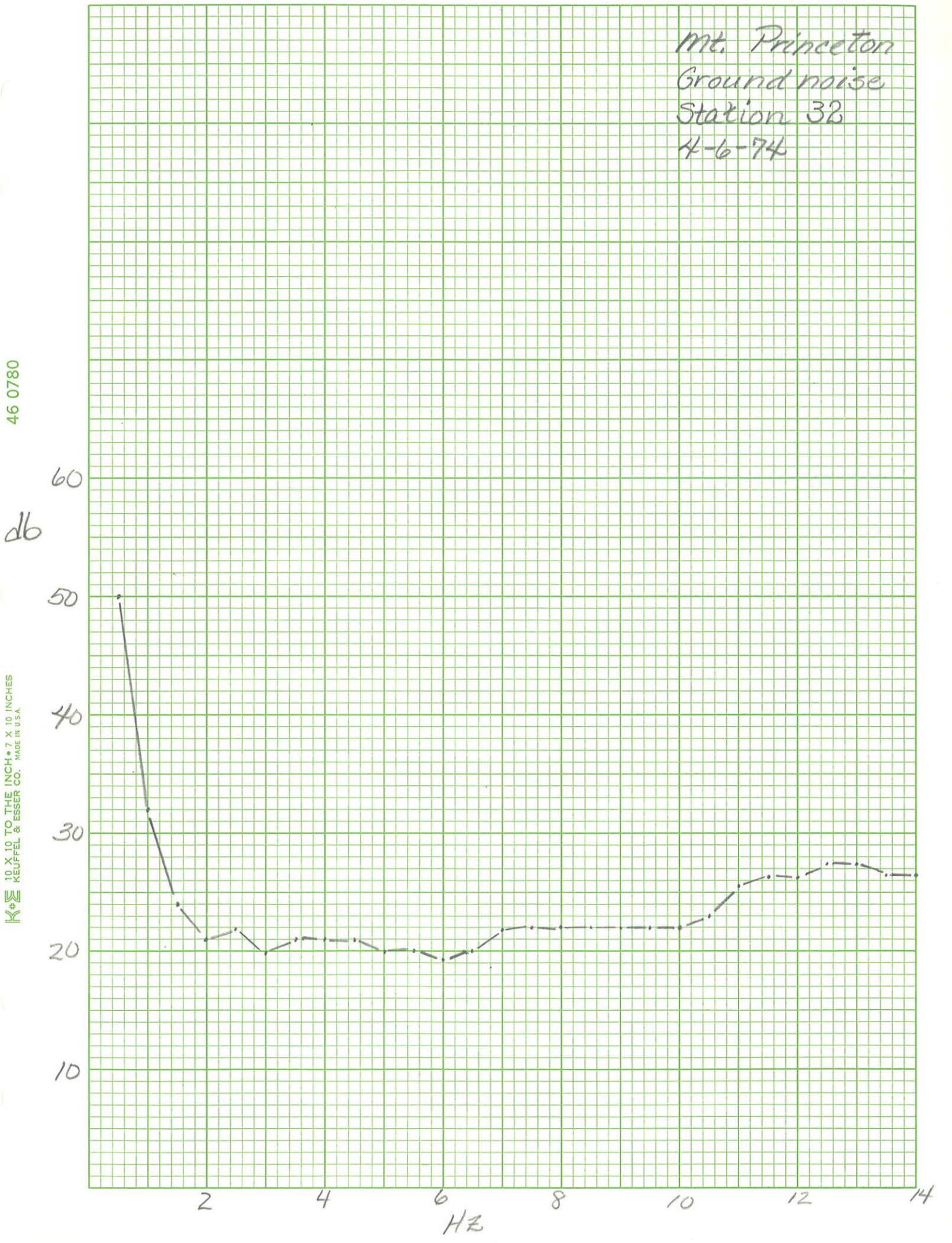

Mt Princeton
Ground noise
Station 27
4-5-74
60
db
50
40
30
20
10
2
4
6
8
10
12
14
Hz
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

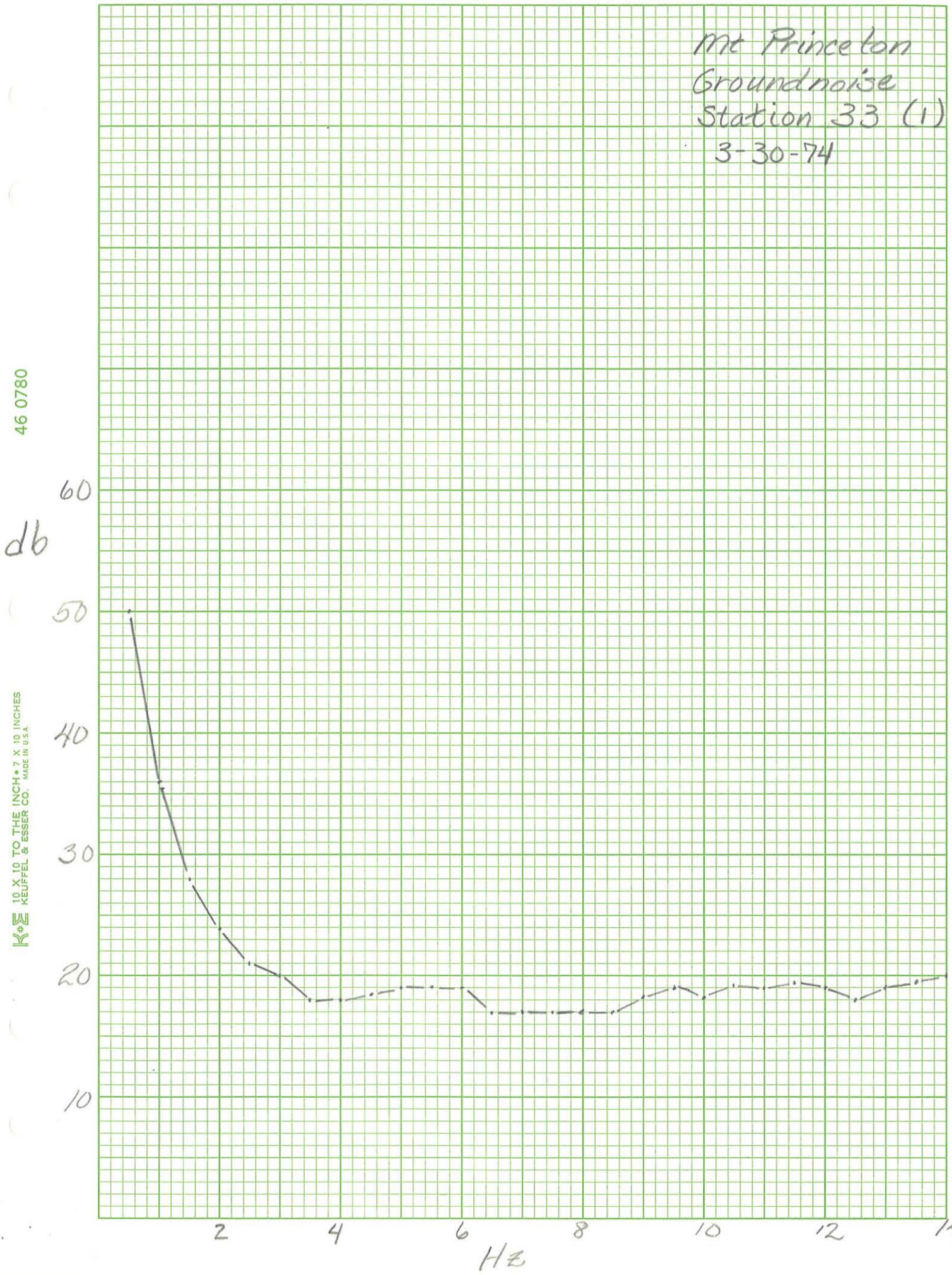

Mt. Princeton
Groundnoise
Station 28
4-5-74
60
db
50
40
30
20
10
2
4
6
8
10
12
14
Hz
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

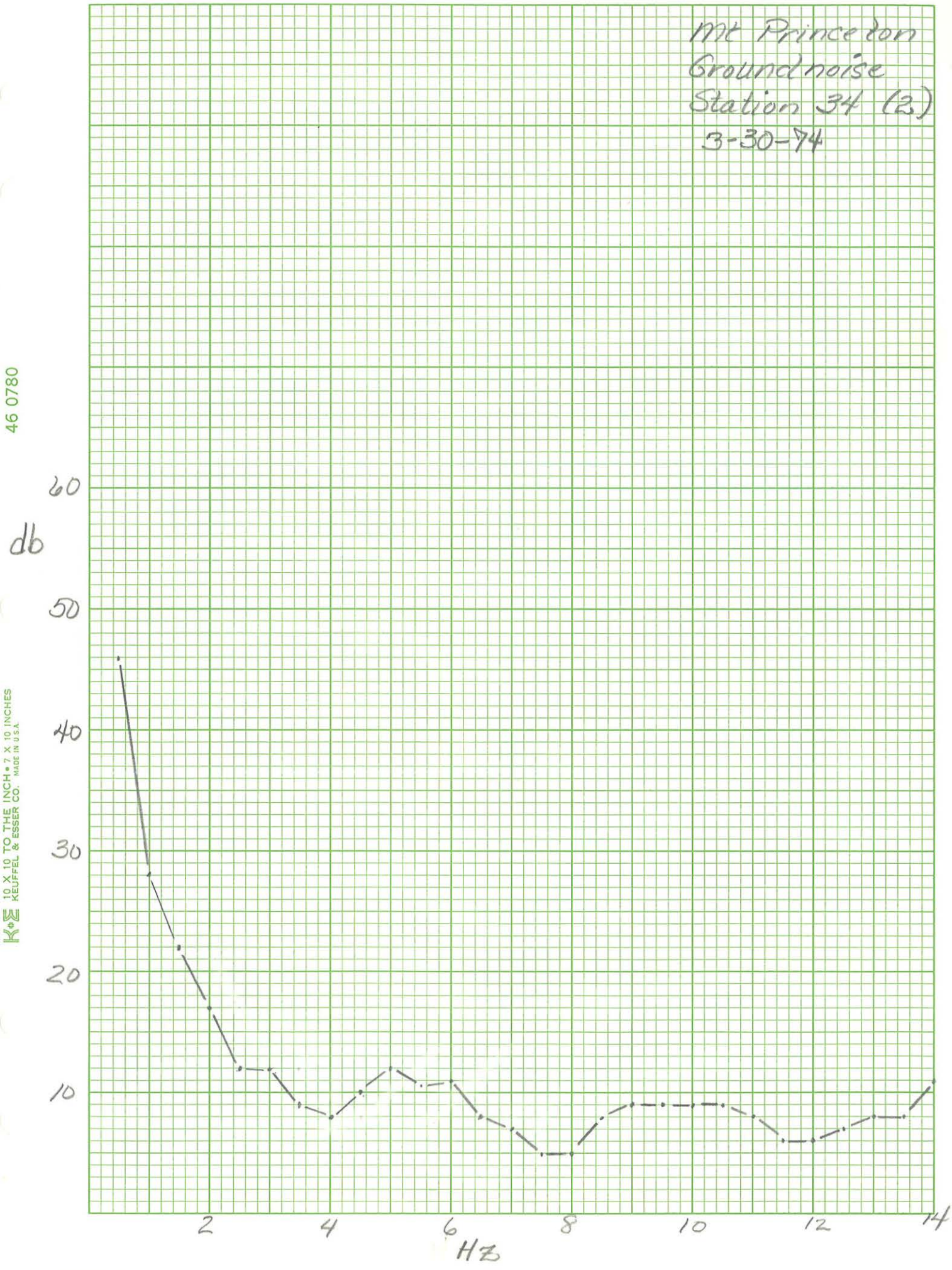

Mt Princeton
Groundnoise
Station 29
4-5-74
60
db
50
40
30
20
10
2
4
6
8
10
12
14
HZ
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

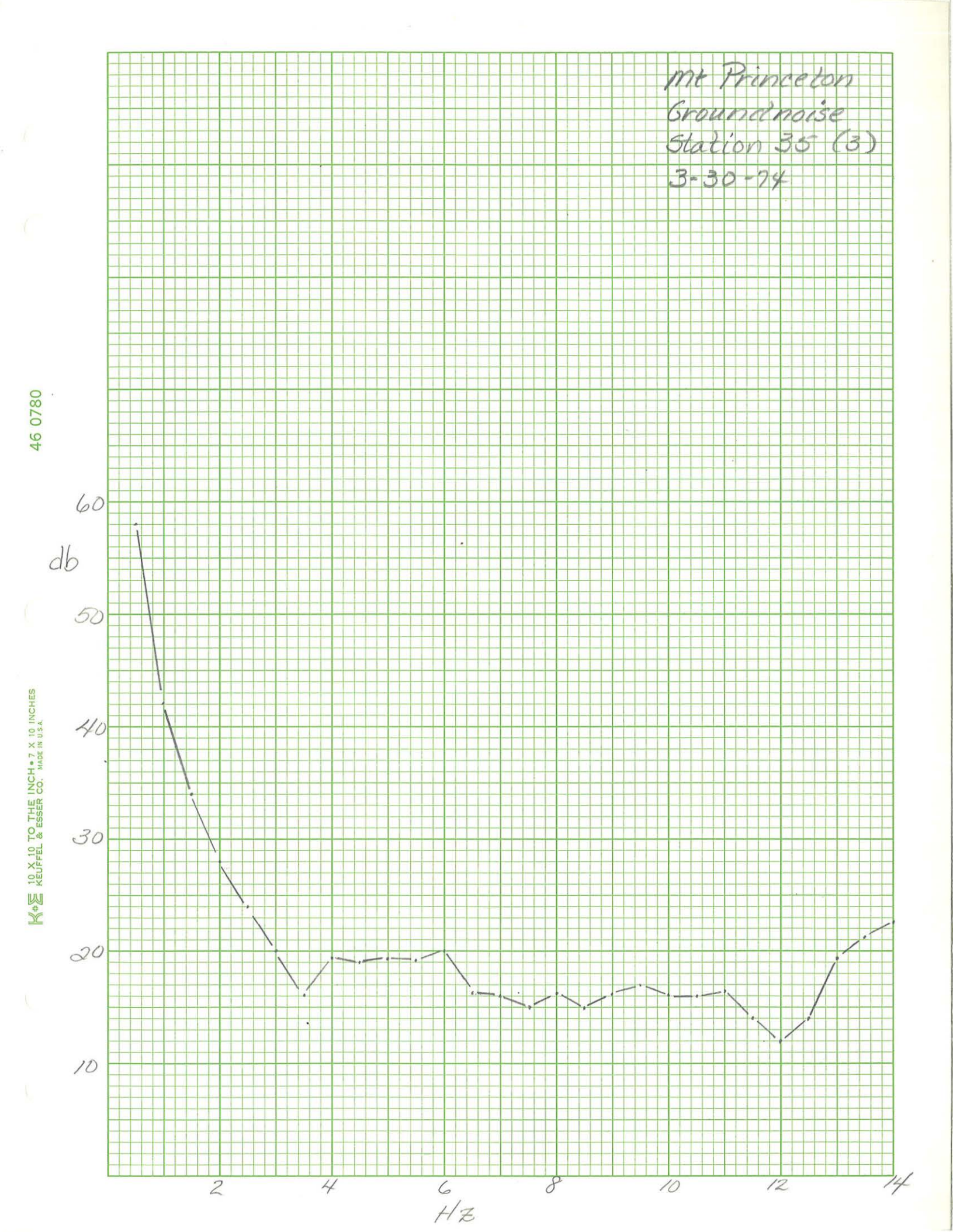


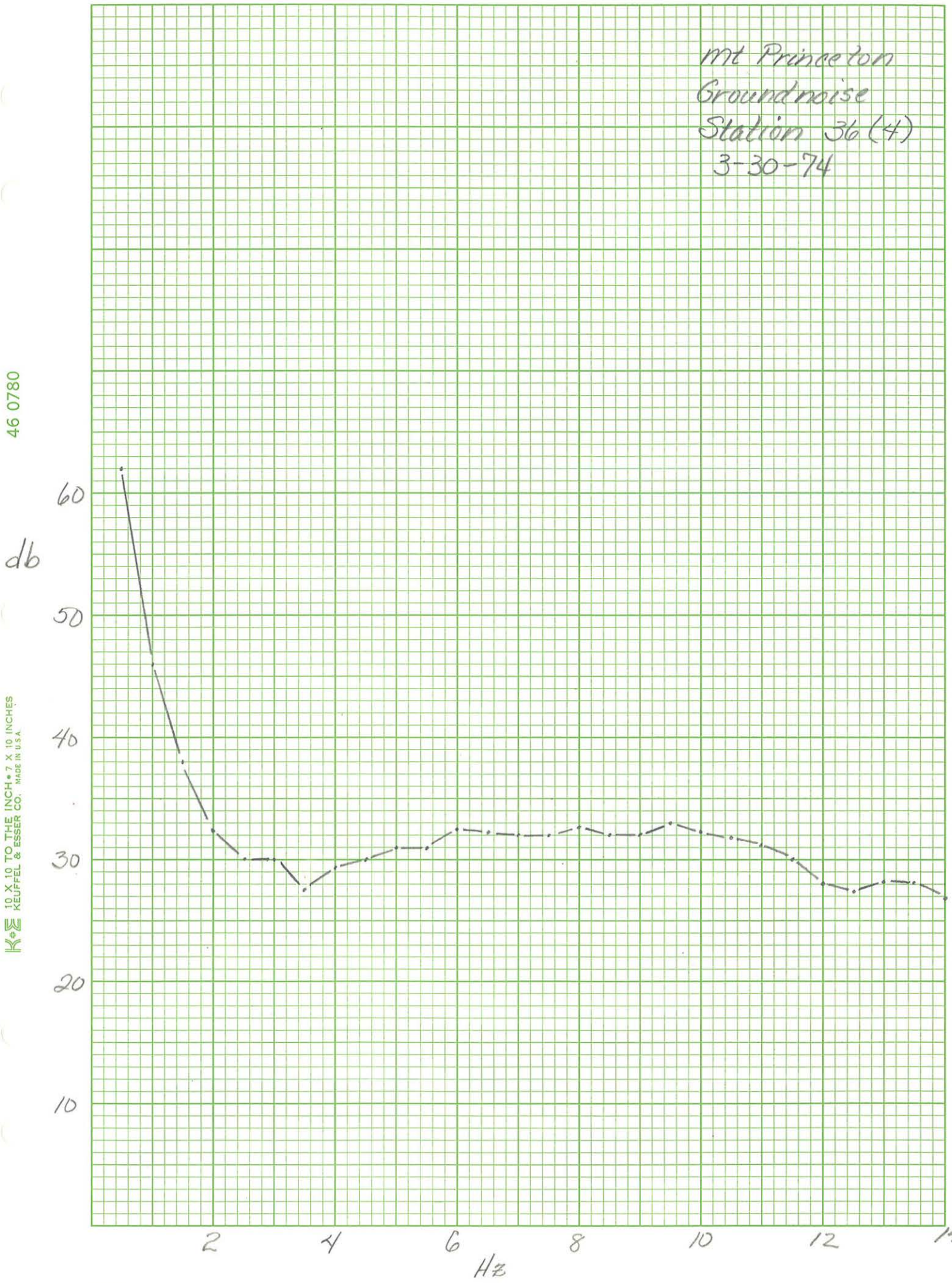

Mt Princeton
Groundnoise
Station 31
4-6-74
db
60
50
40
30
20
10
2
4
6
8
10
12
14
HZ
46 0780
K+E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.


Mt. Princeton
Ground noise
Station 32
4-6-74
60
db
50
40
30
20
10
2
4
6
8
10
12
14
Hz
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.




Mt Princedon
Groundnoise
Station 34 (2)
3-30-74
60
db
50
40
30
20
10
2
4
6
8
10
12
14
Hz
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.


Mt Princeton
Groundnoise
Station 35 (3)
3-30-74
60
db
50
40
30
20
10
2
4
6
8
10
12
14
Hz
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.


mt Princeton
Groundnoise
Station 36 (4)
3-30-74
db
60
50
40
30
20
10
2
4
6
8
10
12
14
Hz
46 0780
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.