NBS REPORT

5508

SURVEY OF PROPAGATION CHARACTERISTICS OF SEA TEST RANGE IN VICINITY OF THE NAVAL AIR MISSILE TEST CENTER, POINT MUGU

Progress Report No. 5

USNAMTC Project TED EL - 42036

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
BOULDER LABORATORIES
Boulder, Colorado

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards: the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside back cover.

Reports and Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers and reports. Reports are issued to the sponsoring agency of a particular project or program. Published papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three monthly periodicals, available from the Government Printing Office: The Journal of Research, which presents complete papers reporting technical investigations; the Technical News Bulletin, which presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions, which provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: The Applied Mathematics Series, Circulars, Handbooks, Building Materials and Structures Reports, and Miscellaneous Publications.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT		NBS REPORT
8370-12-8870	August 15, 1957	5508

SURVEY OF PROPAGATION CHARACTERISTICS OF SEA TEST RANGE IN VICINITY OF THE NAVAL AIR MISSILE TEST CENTER, POINT MUGU

Progress Report No. 5

The object of this study is to investigate over-water tropospheric propagation characteristics for both within and beyond line-of-sight paths. Information on the reliability of propagation and on variations in the velocity of propagation will be obtained for various tropospheric conditions. These measurements will supplement the measurements obtained in the Cheyenne Mountain experiment and will have particular application to ground-to-ground propagation in the Pacific coast region.

USNAMTC Project TED EL - 42036

Prepared by
F. M. Capps

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
BOULDER LABORATORIES
Boulder, Colorado

IMPORTANT NOTICE

NATIONAL BUREAU OF S
ments intended far use with
is subjected to additional e
tion, or open-literature listi
mission is obtained in writin
25, D. C. Such permission
been specifically prepared i

Approved for public release by the Director of the National Institute of Standards and Technology (NIST) on October 9, 2015.

r progress accounting docu-
orts is formally published it
ication, reprinting, reproduc-
s not authorized unless per-
u of Standards, Washington
cy for which the Report has
pies for its own use.

TABLE OF CONTENTS

		Page
I.	Introduction	1
II.	Analysis of Hourly Median Values of Basic Transmission Loss............................	1
III.	Analysis of Prolonged Space-Wave Fadeouts.....	3
IV.	Analysis of Fading Range......................	5
V.	Analysis of Month-to-Month Trends............	6
VI.	Conclusions..................................	7
VII.	Future Plans.................................	7
VIII.	Technical Personnel..........................	8
IX.	References...................................	9

I. INTRODUCTION

This is the fifth in a series of reports discussing results of propagation tests in the Point Mugu area 1, 2, 3, 4/. Measurement procedures, discussion of expected results on the basis of theoretical studies of the propagation paths, and meteorological characteristics were contained in Progress Report No. 2 2/. Since the completion of the preceding report (Progress Report No. 4) which contained data evaluation up to July 1, 1956 4/, results of radio measurements up to November 1, 1956, have been analyzed and are presented below. Only radio data will be included in this report. Comparison of radio and meteorological data for the first full year of operation on 394 Mc will be contained in another report.

Available radio data include measurements over the paths San Nicolas Island-Laguna Peak, and San Nicolas Island-Bldg. 50, both on 394 Mc.

II. ANALYSIS OF HOURLY MEDIAN VALUES OF BASIC TRANSMISSION LOSS

The data obtained for the period from July 1 through October 31, 1956, have been analyzed in the same manner as shown previously. 2/ Results are given in terms of hourly median values of basic transmission loss plotted for each month versus the time of day in the form of cumulative distributions, and in the form of scatter diagrams.

Figs. 1-4 show scatter diagrams of the diurnal variations of hourly medians for the San Nicolas Island-Bldg. 50, and the San Nicolas Island-Laguna Peak paths. Each dot represents one hourly median value measured during the hour indicated on the abscissa scale. The 10, 50, and 90 per cent lines indicate values of hourly median basic transmission loss not exceeded for 10, 50 and 90 per cent of all hours during the month. There is a noticeable diurnal trend for the Bldg. 50 median for July, August and September, with higher values of hourly median field intensity for afternoon and early evening hours. For the previous eight-month period, only March and June showed a slight diurnal trend, suggesting that such a trend occurs at Bldg. 50 only during the summer season. As stated in the previous report similar measurements over paths in eastern Colorado showed much more pronounced diurnal trends, with the maximum fields occurring during the early morning hours.

Fig. 5 shows cumulative distributions of the hourly median basic transmission loss values observed for both paths. The abscissas on this figure are so constructed that a straight line plotted on the graph would constitute a log-normal distribution of field strength. The table below summarizes significant percentage values taken from Fig. 5, and from a similar table of the previous report 4/ which characterize the behavior of hourly median values for November 1, 1955, through October 31, 1956. The number of hours shown are the ones for which reliable data were available. The overall monthly median is that value of hourly median basic transmission loss exceeded for 50 per cent of all hours during the month.

Overall Monthly Median Values of Basic Transmission Loss

Date	Laguna Peak		Building 50	
	No. of Hours	Median	No. of Hours	Median
Nov. 1955	700	128.7	465	142.2
Dec.	726	126.6	711	150.0
Jan. 1956	729	125.8	726	141.7
Feb.	627	127.2	640	148.6
Mar.	679	131.7	732	140.0
April	692	130.3	686	152.0
May	706	126.5	681	148.7
June	688	127.5	702	140.4
July	687	126.8	729	136.3
Aug.	726	127.4	711	140.6
Sept.	529	128.5	715	128.3
Oct.	587	124.2	725	144.9

Date	Laguna Peak				Building 50			
	1-50%	10-50%	50-90%	50-99%	1-50%	10-50%	50-90%	50-99%
Nov.55	7.4	3.4	5.1	10.8	22.0	17.0	11.8	14.0
Dec.	7.7	4.4	6.3	12.9	29.8	18.5	3.2	8.1
Jan. 56	5.1	3.2	6.1	11.8	23.7	15.3	9.6	11.8
Feb.	4.7	2.0	5.4	10.5	29.2	19.3	5.1	6.2
Mar.	8.0	4.3	5.4	10.8	19.1	12.8	15.0	17.8
Apr.	7.1	4.9	4.5	9.5	28.1	18.9	5.3	8.0
May	4.4	2.2	4.6	11.0	28.8	20.5	3.7	5.4
June	7.6	4.4	6.0	10.6	20.9	12.6	10.3	14.2
July	6.8	4.2	7.7	14.4	16.6	9.7	15.4	17.8
Aug.	6.8	3.2	7.1	13.0	19.3	13.3	11.2	14.8
Sept.	8.4	5.3	6.3	11.3	13.2	8.2	10.9	20.5
Oct.	5.4	2.8	5.0	12.5	24.0	15.9	6.9	9.2

Range of Hourly Median Values of Basic Transmission Loss in Decibels

The above tabulations show that no well defined seasonal trends are evident in the data for this four-month period. Variations in the monthly medians from month-to-month are less for Laguna Peak than for Building 50. This is also the case for the previous months from November, 1955, through June, 1956. The maximum variation in the monthly medians from month-to-month at Building 50 occurred between September and October and had a value of 16.6 db. The month-to-month behavior of basic transmission loss is also illustrated by the graphs of Figs. 12 and 13.

III. ANALYSIS OF PROLONGED SPACE-WAVE FADEOUTS

Prolonged space-wave fadeouts over the San Nicolas Island-Laguna Peak path were observed very frequently during the entire measurement period. In conformance with previous studies 5/ this term applies to those fadeouts for which the signal level dropped at least five decibels below the monthly median value for at least one minute, and only those fadeouts were considered in the study. For the purpose of the analysis fadeouts were classified according to the amount of time during which the signal level was reduced by at least 5, 10, 15, 20 and 25 db with reference to the monthly median level. The diurnal distribution of the fadeouts to the various levels is shown in Fig. 6 for each month. There is a diurnal trend for July and August, with the largest percentage of fadeout time occurring in the afternoon hours. This trend was not apparent for the previous months studied, nor is there an apparent trend for September and October.

Fig. 7 shows cumulative distributions of the durations of individual fadeouts observed at Laguna Peak. From these graphs, the percentage of occurrence of fadeouts of a given duration may be determined for each month. The following table shows a comparison of the median duration for various levels.

Median Duration of Fadeout (In Minutes) to Indicated Level Below the Monthly Median Basic Transmission Loss Value					
Month	5 db	10 db	15 db	20 db	25 db
Nov. 1955	7.9	4.6	3.1	1.8	1.7
Dec.	8.7	6.8	6.2	3.2	2.4
Jan. 1956	9.0	4.3	2.2	1.8	*
Feb.	8.7	5.4	4.0	2.2	1.0
Mar.	6.7	4.8	2.5	1.5	1.3
Apr.	5.1	4.5	3.2	1.8	1.4
May	5.7	4.7	2.4	1.9	1.5
June	5.8	4.0	2.7	1.7	1.1
July	8.0	4.2	2.8	1.6	1.2
Aug.	6.2	3.2	2.2	1.4	1.1
Sept.	10.5	4.9	3.1	2.1	1.6
Oct.	8.7	5.7	3.0	1.9	1.5

* 43% of the observed 25 db fadeouts for January were longer than one minute.

Figs. 12 and 13 show the month-to-month trend in the percentage fadeout time (to the 5 db level below the monthly median). As an example, during July the Laguna Peak signal dropped to at least 5 db below the monthly median during approximately 20% of the total recording time.

The graphs of Fig. 7 also permit estimates of the fadeout duration for other percentage values, and show what percentage of the observed fadeouts at the various levels were longer than one minute. From the table it is seen that the month of December, 1955, shows the longest median duration of fadeouts for all except the 5 db reference level.

It is pertinent to tabulate the longest fadeout to the indicated levels which were observed during the period analyzed, as shown below.

Level in db	Duration in Minutes	Date and Hours of Occurrence	
5	265	Aug. 3	1459 - 1924
10	100	July 6	2133 - 2313
15	46	Oct. 2	1703 - 1749
20	17	Oct. 2	1716 - 1733
25	9	Aug. 2	1607 - 1616

It should be noted that a misprint occurred in the similar table shown on Pg. 5 of the previous report 4/. The "Hours of Occurrence" column for the 25 db level should read correctly 1217 to 1231 instead of 1211 - 1237.

IV. ANALYSIS OF FADING RANGE

The short-term variations observed at Bldg. 50 may be conveniently characterized by the fading-range, which by definition is the db difference of signal strength (or transmission loss) levels exceeded for 10 per cent and 90 per cent of each hour. Over a path of this type (extending slightly below the radio horizon) short-term variations may be caused by comparatively rapid changing atmospheric conditions due to ducts or ground based and elevated layers, producing a relatively slow fading signal. More rapid fading is normally caused by a field component due to scattering which is superimposed on a steady, or slowly varying component.

In order to obtain a picture of the amount of within-the-hour fading regardless of the associated refractive index profile, the fading range values observed at Bldg. 50 have been plotted on Figs. 8-11 in the form of scatter diagrams and cumulative distributions. In contrast to the behavior of the hourly median basic transmission loss values discussed above, no well-defined diurnal trend is found for the fading range. The following tabulation shows values taken from the cumulative distribution graphs of this and previous reports.

Date	Median Fading Range	Fading Range Exceeded for: 1% of all hrs. (db)	Fading Range Exceeded for: 10% of all hrs. (db)
Nov. 1955	6.5	23.2	14.5
Dec.	3.5	16.8	11.7
Jan. 1956	6.3	19.5	14.0
Feb.	4.4	21.6	13.5
Mar.	7.4	22.8	14.5
Apr.	3.9	19.1	12.4
May	5.8	18.6	13.1
June	10.0	19.6	15.6
July	10.7	20.0	15.6
Aug.	10.3	20.4	15.8
Sept.	9.3	21.8	15.6
Oct.	8.3	22.1	14.9

The values tabulated above are also shown graphically on Fig. 12.

V. ANALYSIS OF MONTH-TO-MONTH TRENDS

Fig. 12 shows the month-to-month trends in signal characteristics for both the Laguna Peak and the Bldg. 50 paths. On this figure the trend of overall monthly medians, of the 1% to 99% range of hourly medians, and of the fadeout percentages is depicted for the Laguna Peak path. For the Bldg. 50 path the fadeout percentages are replaced by the within-the-hour fading range.

Fig. 13 shows also additional month-to-month trends in signal characteristics for the Laguna Peak path. Besides the trend in the overall monthly medians and the fadeout percentages it also shows the month-to-month trends in median fadeout duration.

Fig. 12 indicates a certain amount of correlation between the range of hourly medians, and the percentage fadeout time observed at Laguna Peak. Both quantities show high values for the summer months, and comparatively lower values for February, May, and October. A comparison of the trend of monthly medians and fading range for Bldg. 50 shows especially for the period November to July very good correspondence between these quantities. Low transmission loss values (or high fields) correspond to high values of fading range, and vice versa. This, of course, may be expected from a study of the behavior during individual hours, where low transmission loss values are usually associated with a slower fading over a larger range, and high transmission loss values usually show rapid fading with a small range. The connection of these phenomena with meteorological characteristics has been pointed out before 3/, and will be further investigated in a future report. Fig. 13 indicates a very rough correspondence of the behavior of basic transmission loss, percentage fadeout time, and median duration of the individual fadeouts.

VI. CONCLUSIONS

Analysis of twelve months' transmission loss measurements on 394 Mc over the San Nicolas Island-Laguna Peak, and the San Nicolas Island-Bldg. 50 paths show similar results to those presented in the previous reports 3, 4/. Specifically, the presence of some diurnal trends, in hourly median basic transmission loss, fading range at Bldg. 50, and occurrence of prolonged space-wave fadeouts on Laguna Peak is noted.

VII. FUTURE PLANS

The next report will contain the evaluation of a full year's data in conjunction with meteorological parameters derived from refractive index profiles. Specifically, basic transmission loss, fading range, and the characteristics of prolonged space-wave fadeouts will be presented as functions of layer heights and refractive index gradients.

VIII. TECHNICAL PERSONNEL

The technical personnel of the National Bureau of Standards associated with this project and with the preparation of this report are as follows:

K. A. Norton, Chief, Radio Propagation Engineering Division
J. W. Herbstreit, Assistant Chief, Radio Propagation Engineering Division
R. S. Kirby, Chief, Radio Systems Application Engineering Sec.
A. P. Barsis, Project Leader
P. L. McQuate
F. M. Capps
Mrs. E. M. Norton
Mrs. M. E. Johnson
Mrs. M. Coyle
Mrs. B. D. Samsel
R. W. Lavine
Mrs. V. Weitzel

IX. REFERENCES

1. "Survey of propagation characteristics of sea test range in the vicinity of the Naval Air Missile Test Center, Point Mugu," National Bureau of Standards Report 3531, April 1, 1955.

2. "Survey of propagation characteristics of sea test range in the vicinity of the Naval Air Missile Test Center, Point Mugu," National Bureau of Standards Report 3572, March 9, 1956.

3. "Survey of propagation characteristics of sea test range in the vicinity of the Naval Air Missile Test Center, Point Mugu," National Bureau of Standards Report 5003, August 10, 1956.

4. "Survey of propagation characteristics of sea test range in the vicinity of the Naval Air Missile Test Center, Point Mugu," National Bureau of Standards Report 5052, March 15, 1957.

5. B. R. Bean; "Prolonged space wave fadeouts at 1046 Mc. observed in the Cheyenne Mountain propagation program," Proceedings of the IRE, 42, pp. 848-853, May, 1954.

DIURNAL VARIATIONS OF MEASURED HOURLY
MEDIAN BASIC TRANSMISSION LOSS
394 Mc

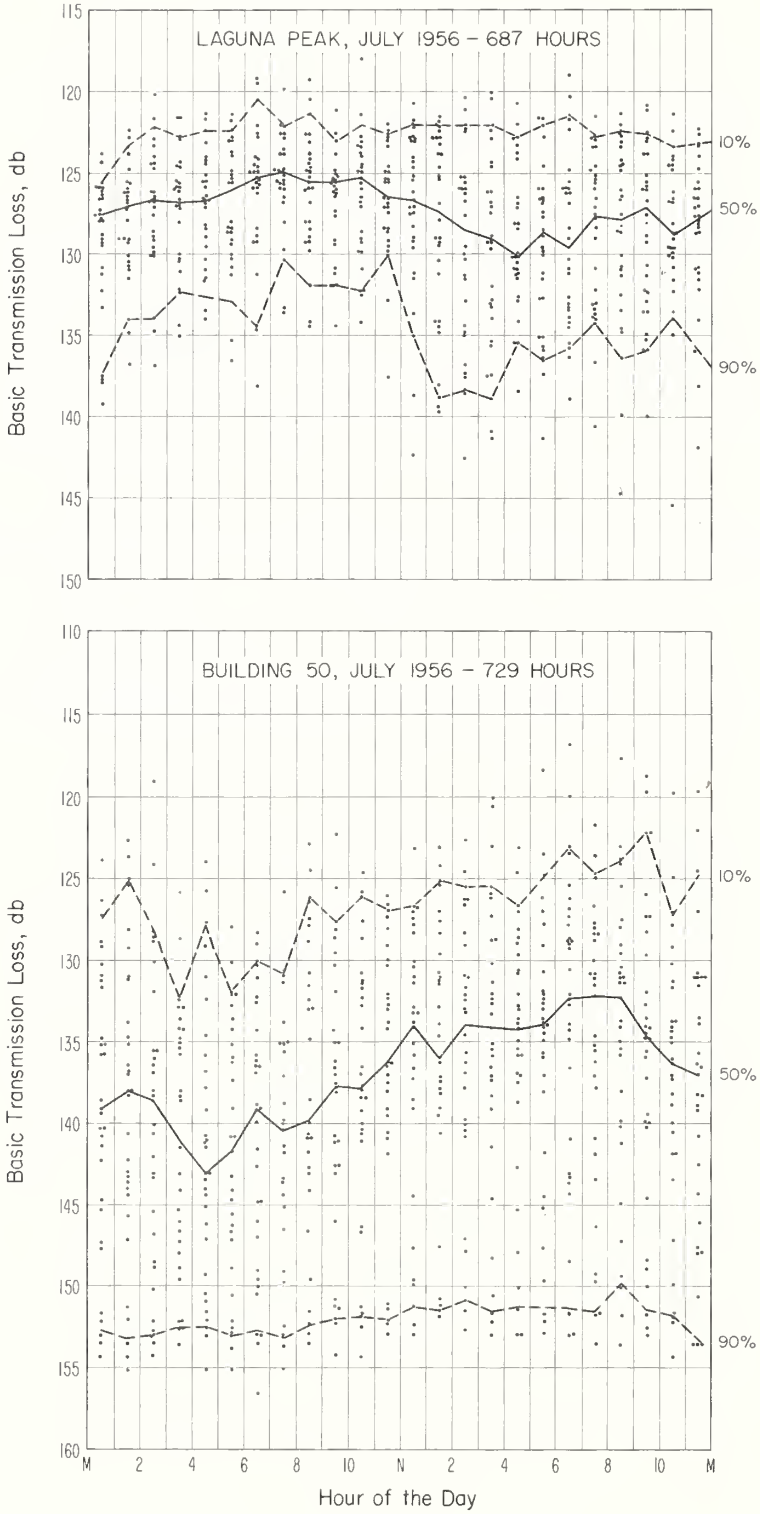


Figure 1

DIURNAL VARIATIONS OF MEASURED HOURLY
MEDIAN BASIC TRANSMISSION LOSS
394 Mc

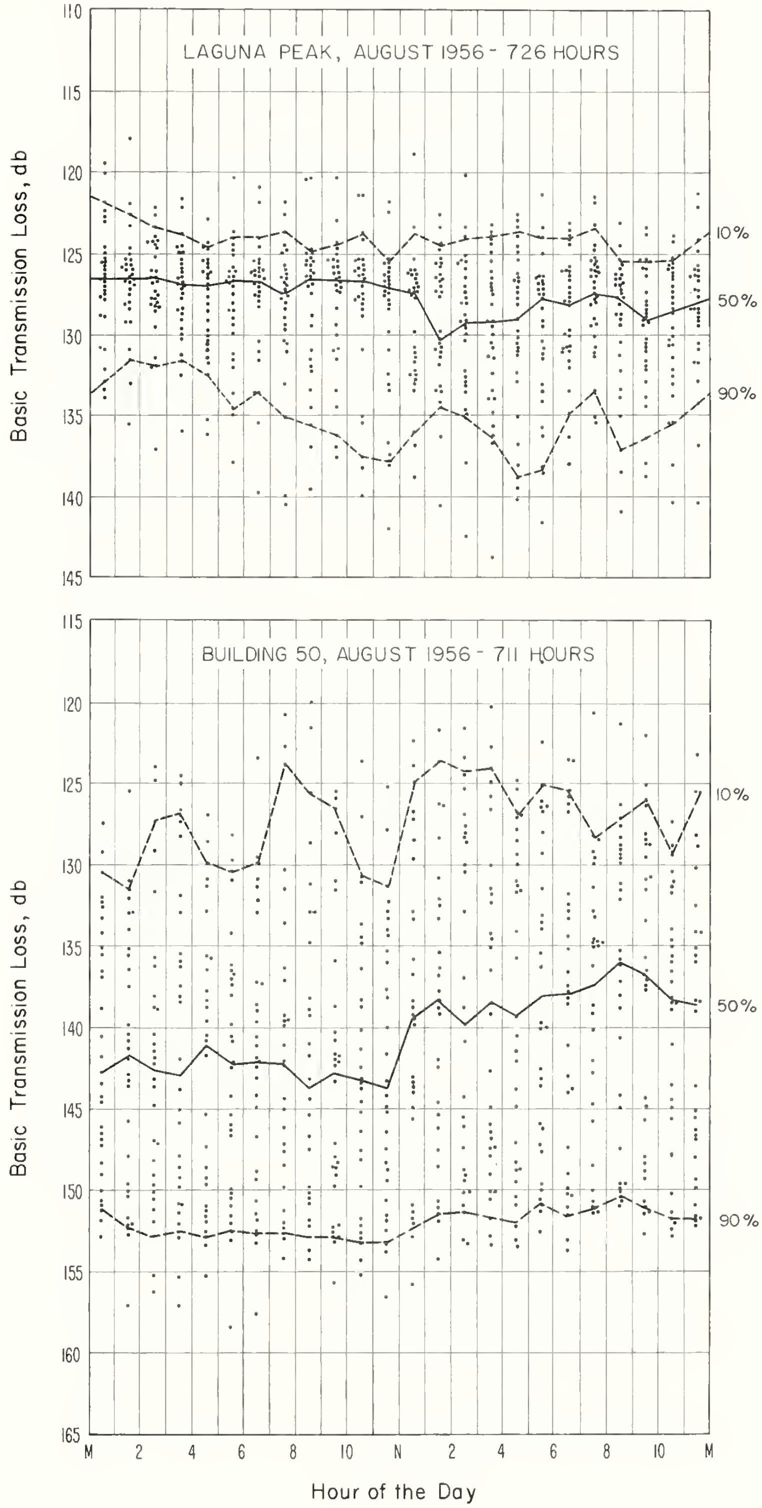


Figure 2

DIURNAL VARIATIONS OF MEASURED HOURLY
MEDIAN BASIC TRANSMISSION LOSS
394 Mc

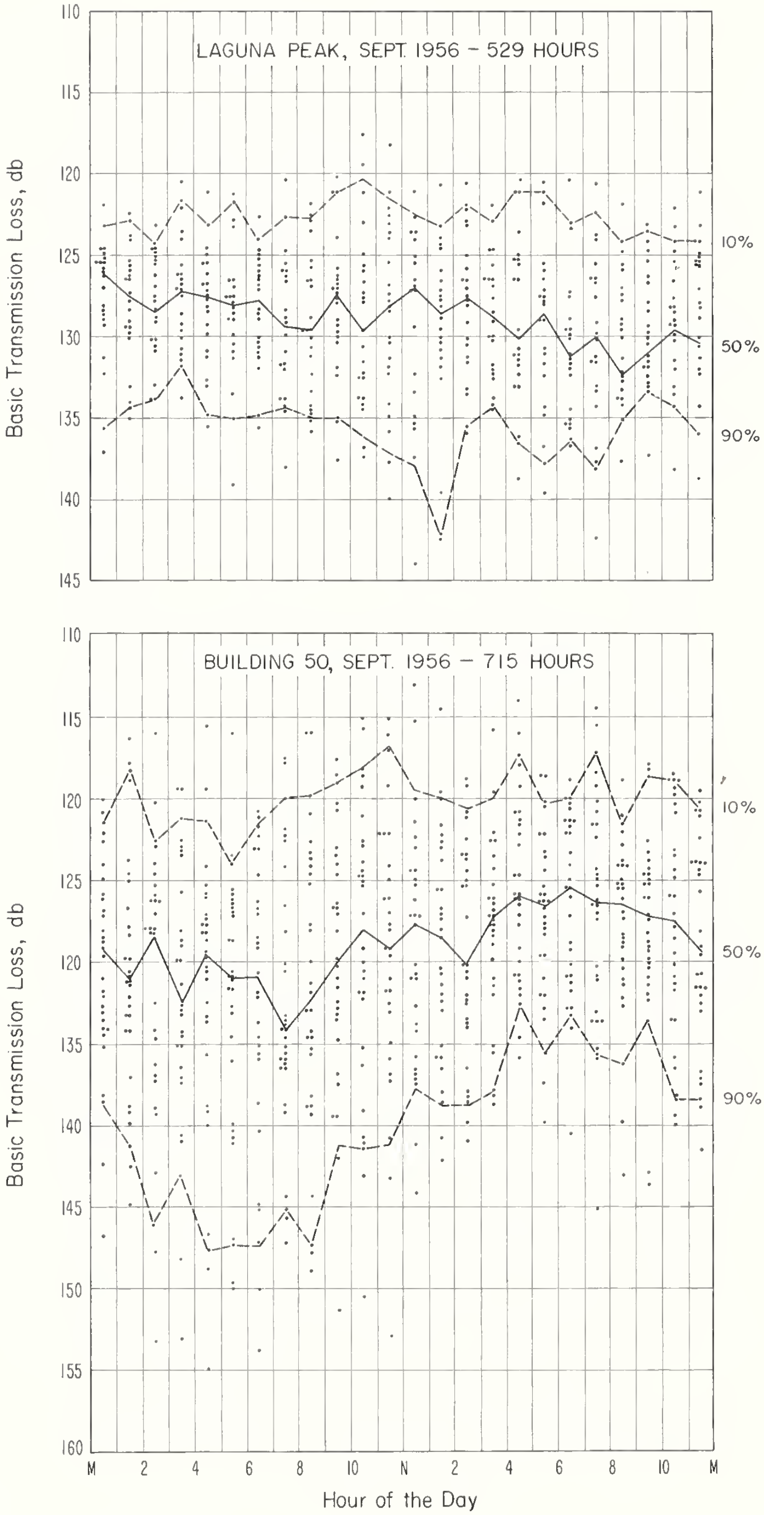
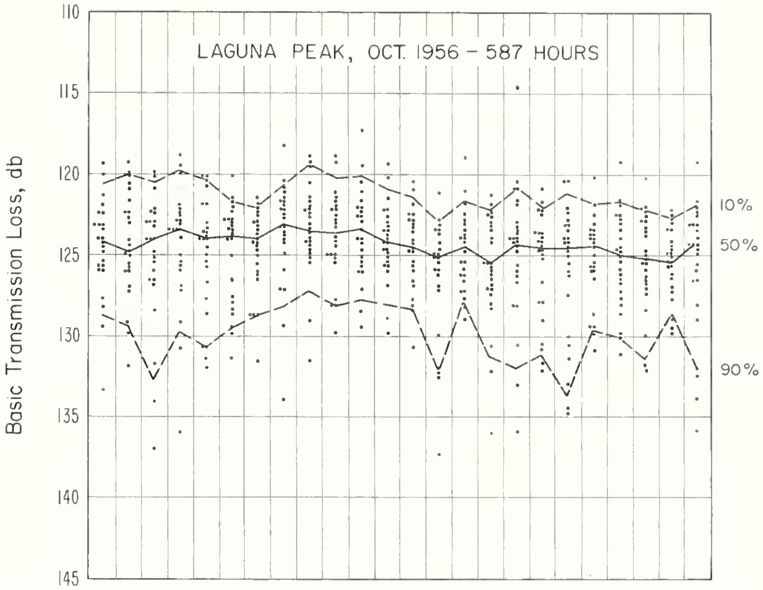


Figure 3

DIURNAL VARIATIONS OF MEASURED HOURLY
MEDIAN BASIC TRANSMISSION LOSS
394 Mc



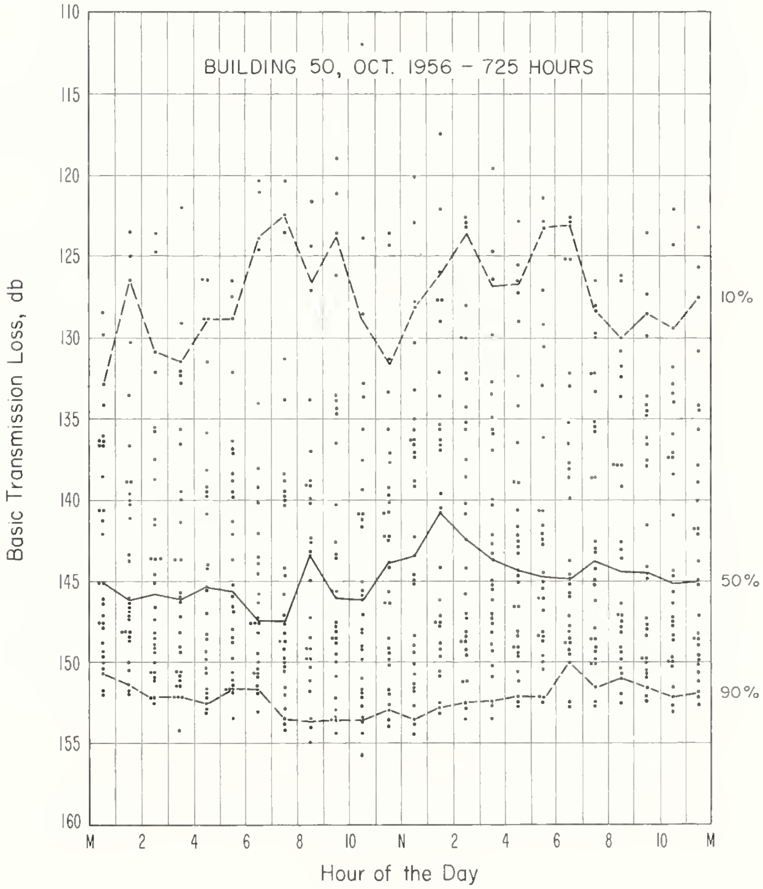


Figure 4

CUMULATIVE DISTRIBUTIONS
OF HOURLY MEDIANS
394 Mc

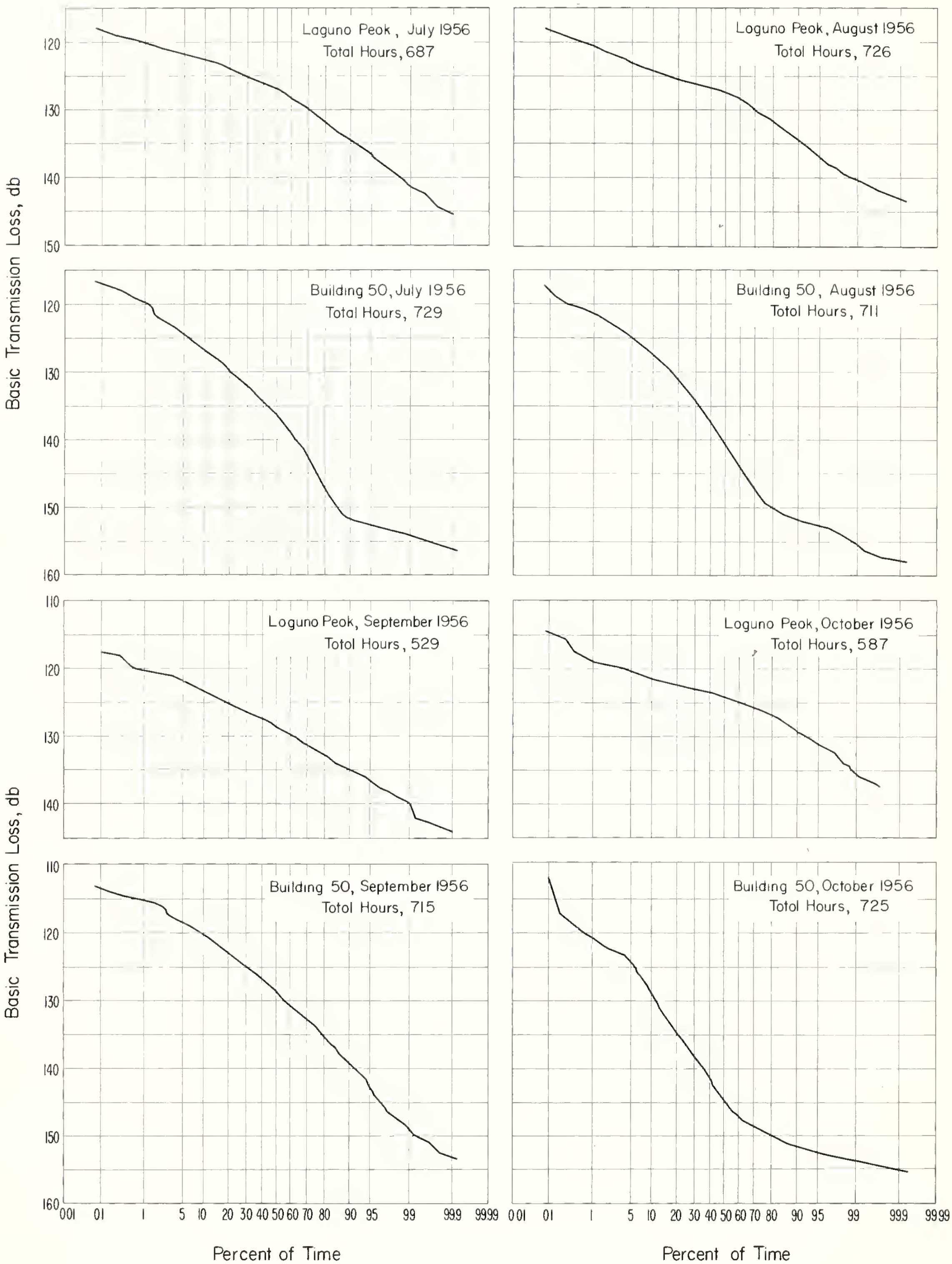


Figure 5

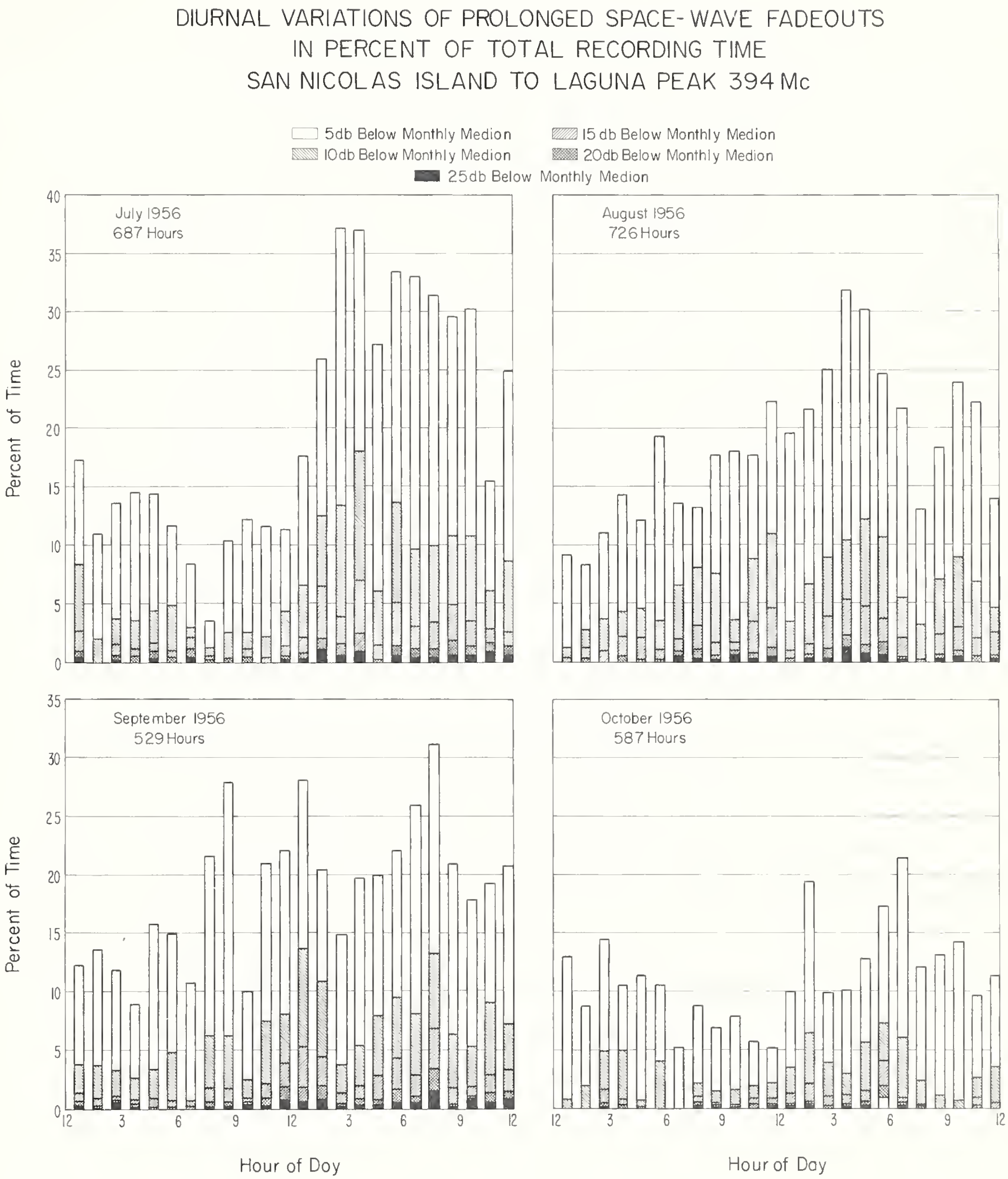

DIURNAL VARIATIONS OF PROLONGED SPACE-WAVE FADEOUTS
IN PERCENT OF TOTAL RECORDING TIME
SAN NICOLAS ISLAND TO LAGUNA PEAK 394 Mc
5db Below Monthly Median
15 db Below Monthly Median
10db Below Monthly Median
20db Below Monthly Median
25db Below Monthly Median
July 1956
687 Hours
August 1956
726 Hours
September 1956
529 Hours
October 1956
587 Hours
Percent of Time
Hour of Day

Figure 6

CUMULATIVE DISTRIBUTION OF THE DURATIONS OF PROLONGED SPACE-WAVE FADEOUTS SAN NICOLAS ISLAND TO LAGUNA PEAK 394 Mc

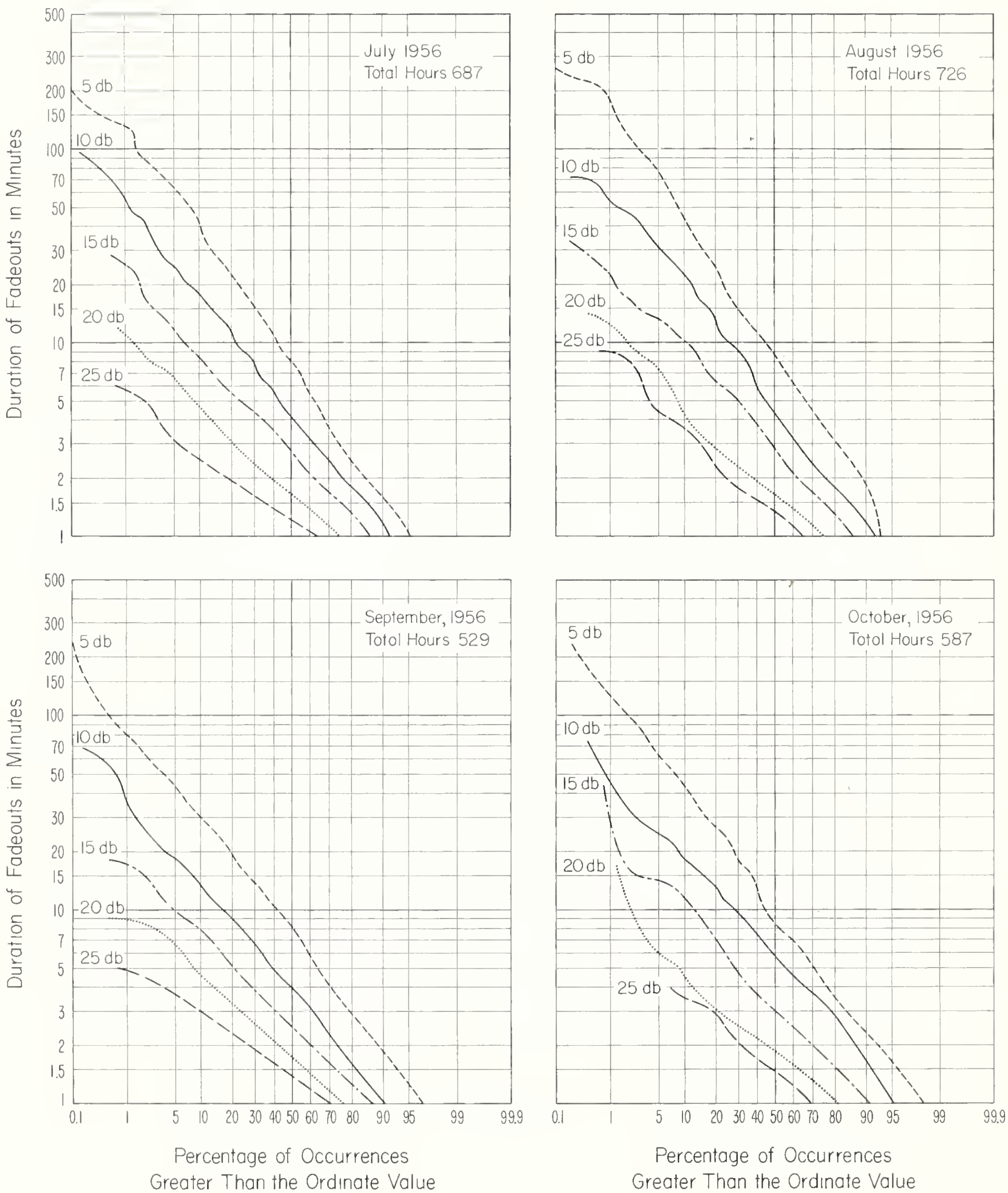
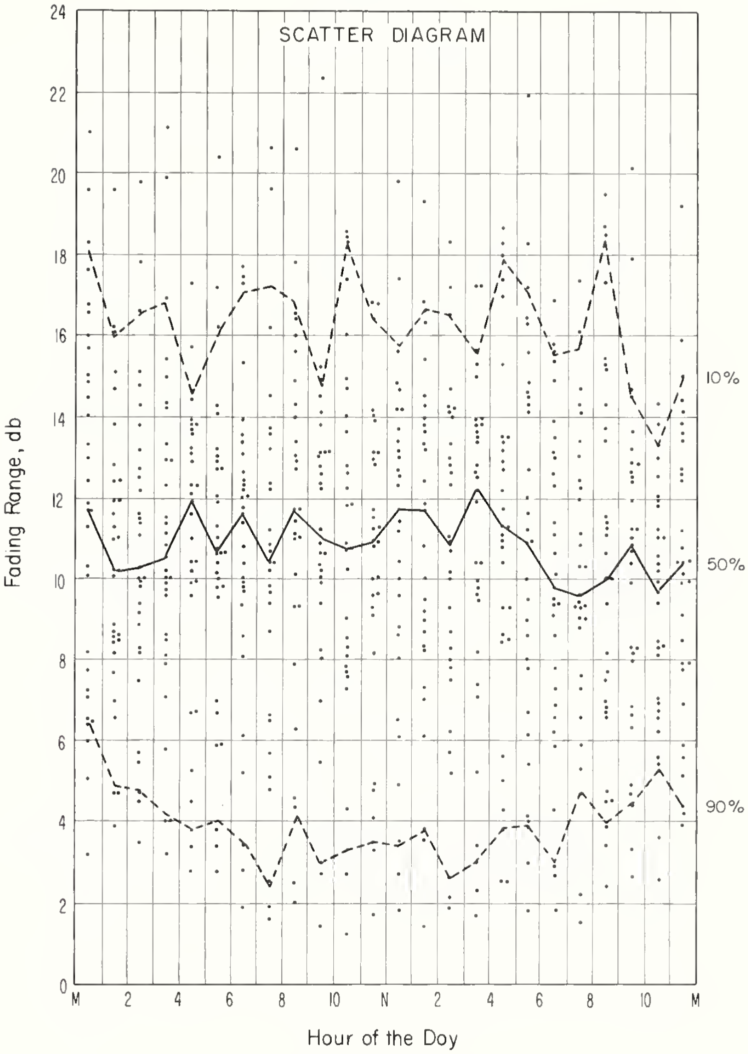


Figure 7

WITHIN-THE-HOUR FADING RANGE
SAN NICOLAS ISLAND TO BLDG. 50
JULY 1956, 729 HOURS
394 Mc



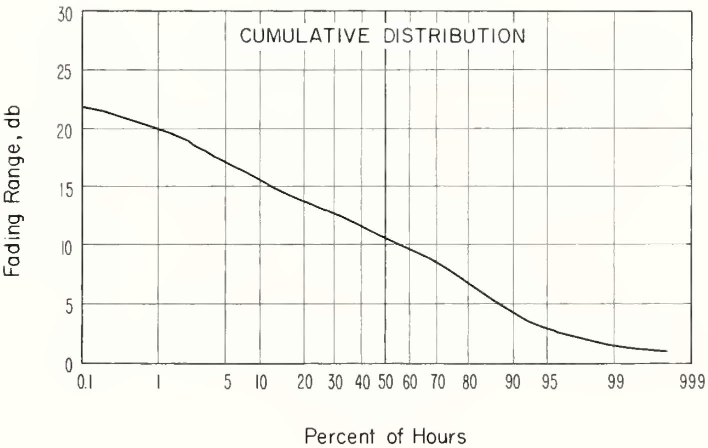


Figure 8

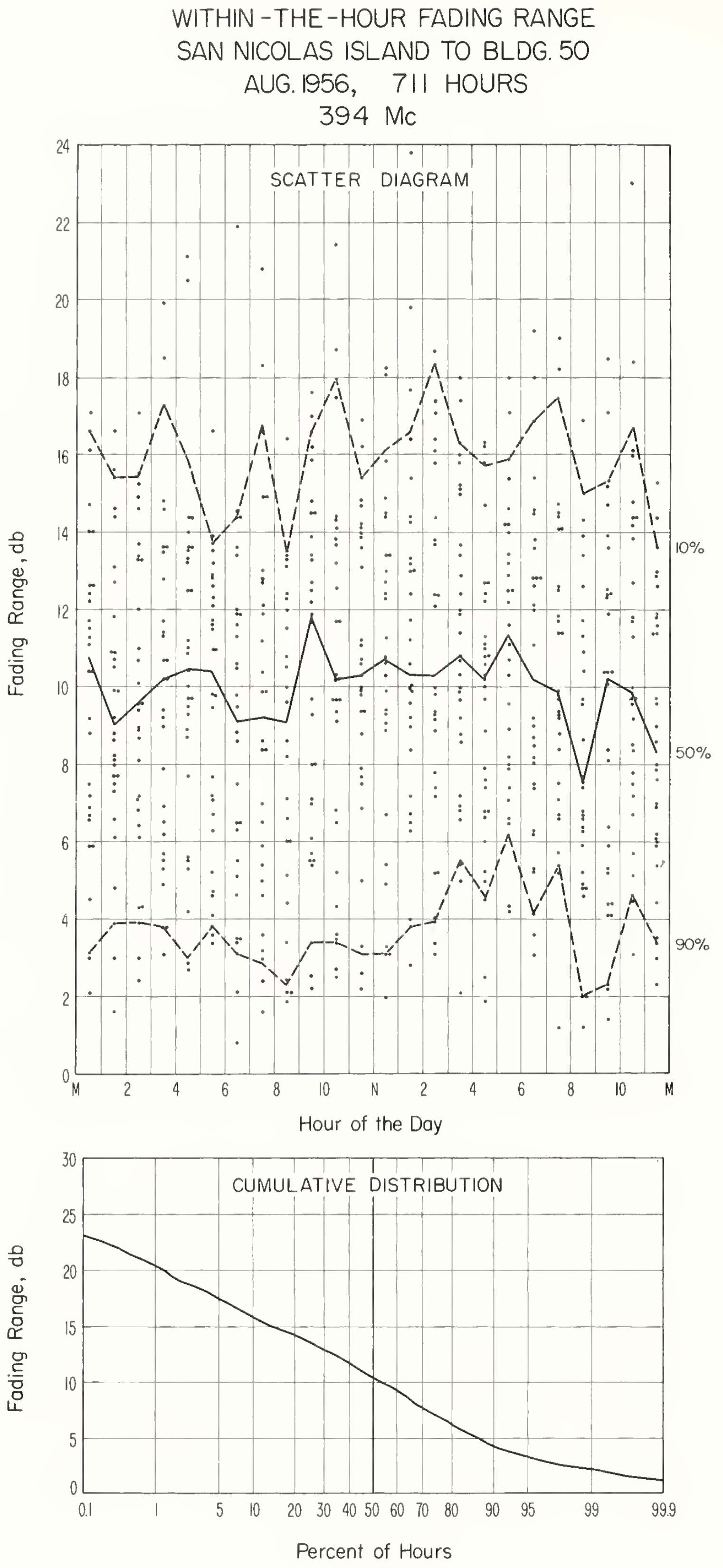

WITHIN-THE-HOUR FADING RANGE
SAN NICOLAS ISLAND TO BLDG. 50
AUG. 1956, 711 HOURS
394 Mc
SCATTER DIAGRAM
Fading Range, db
10%
50%
90%
Hour of the Day
M
2
4
6
8
10
N
2
4
6
8
10
M
CUMULATIVE DISTRIBUTION
Fading Range, db
Percent of Hours
0.1
1
5
10
20
30
40
50
60
70
80
90
95
99
99.9

Figure 9

WITHIN-THE-HOUR FADING RANGE
SAN NICOLAS ISLAND TO BLDG. 50
SEPT. 1956, 715 HOURS
394 Mc

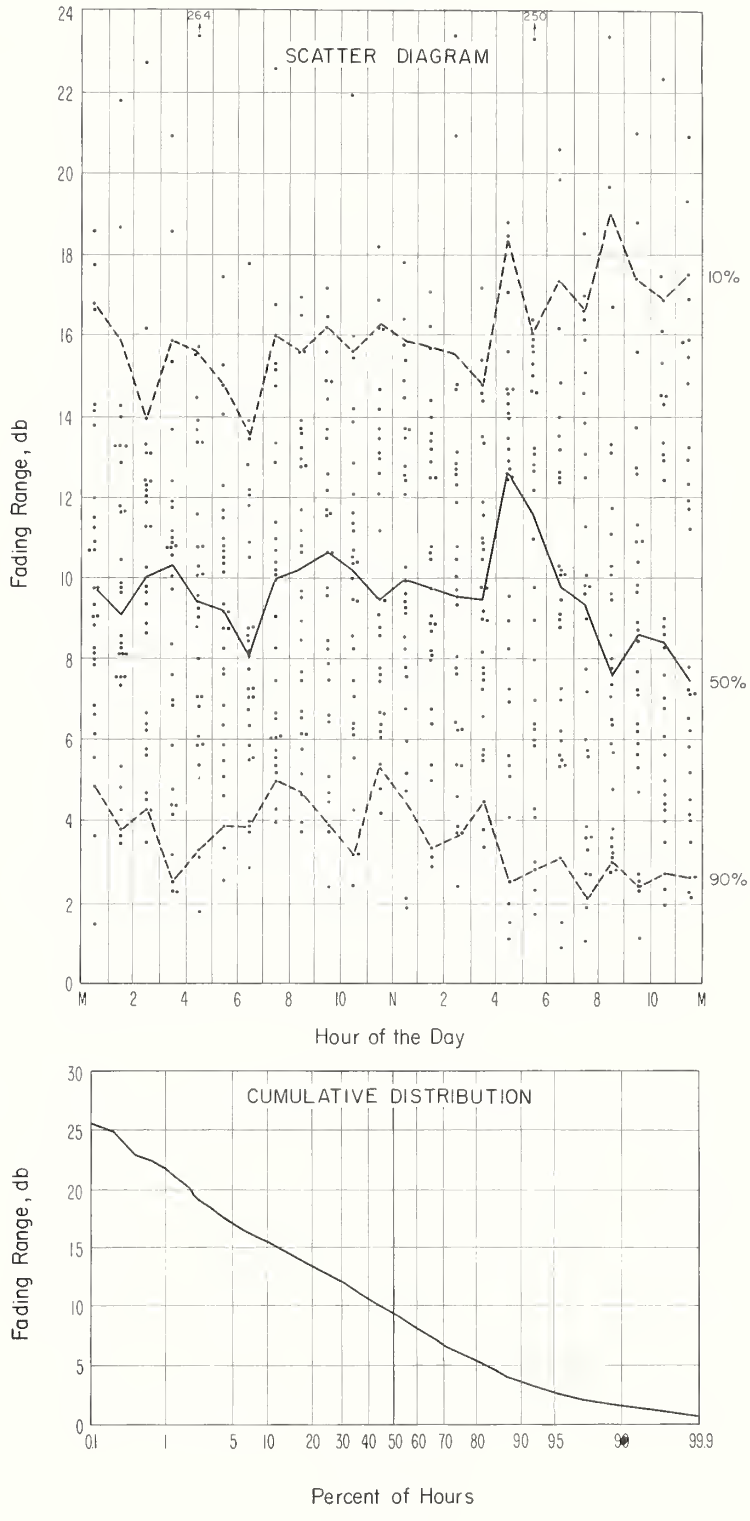
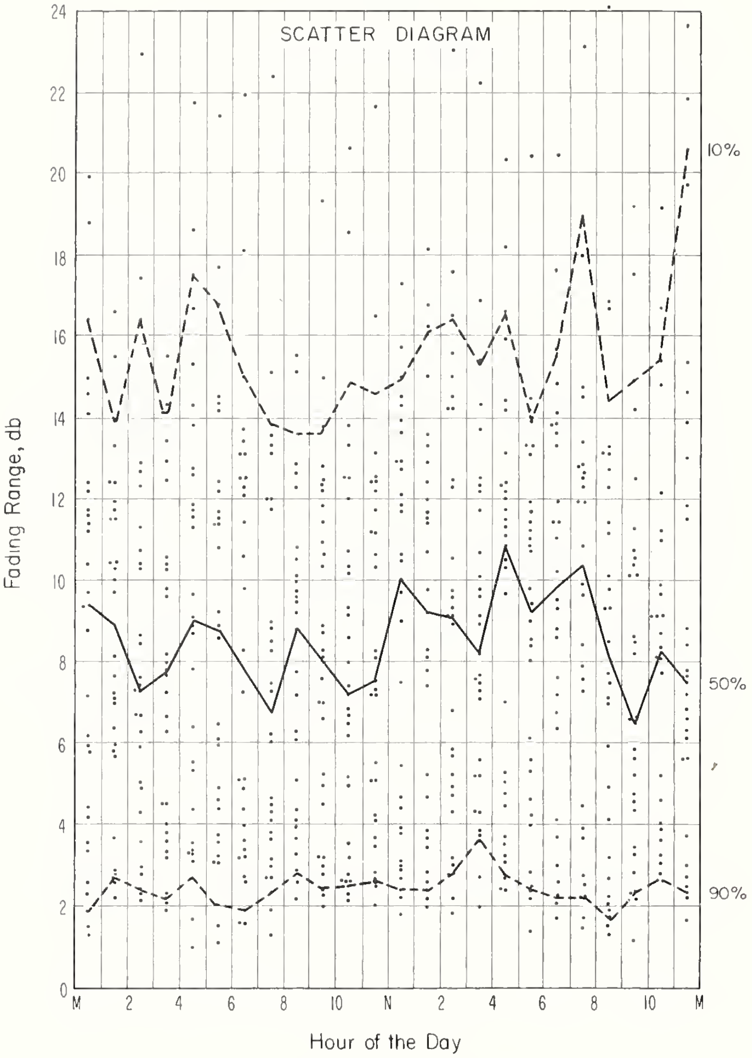


Figure 10

WITHIN-THE-HOUR FADING RANGE
SAN NICOLAS ISLAND TO BLDG. 50
OCT. 1956, 725 HOURS
394 Mc



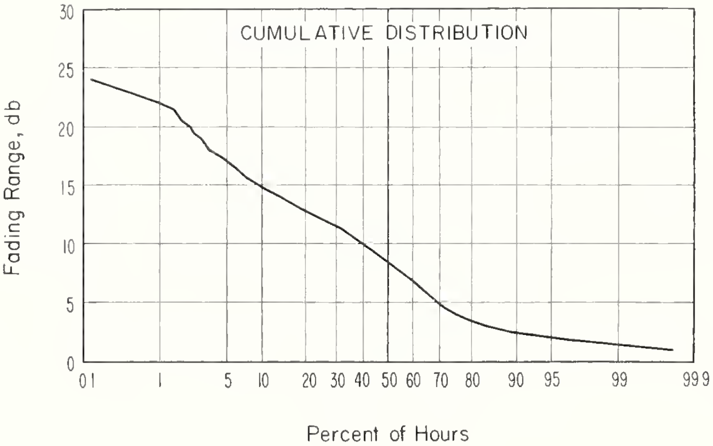


Figure 11

MONTH-TO-MONTH TRENDS IN PACIFIC COAST PATHS
SIGNAL CHARACTERISTICS
SAN NICOLAS ISLAND - LAGUNA PEAK AND BUILDING 50
394 MC

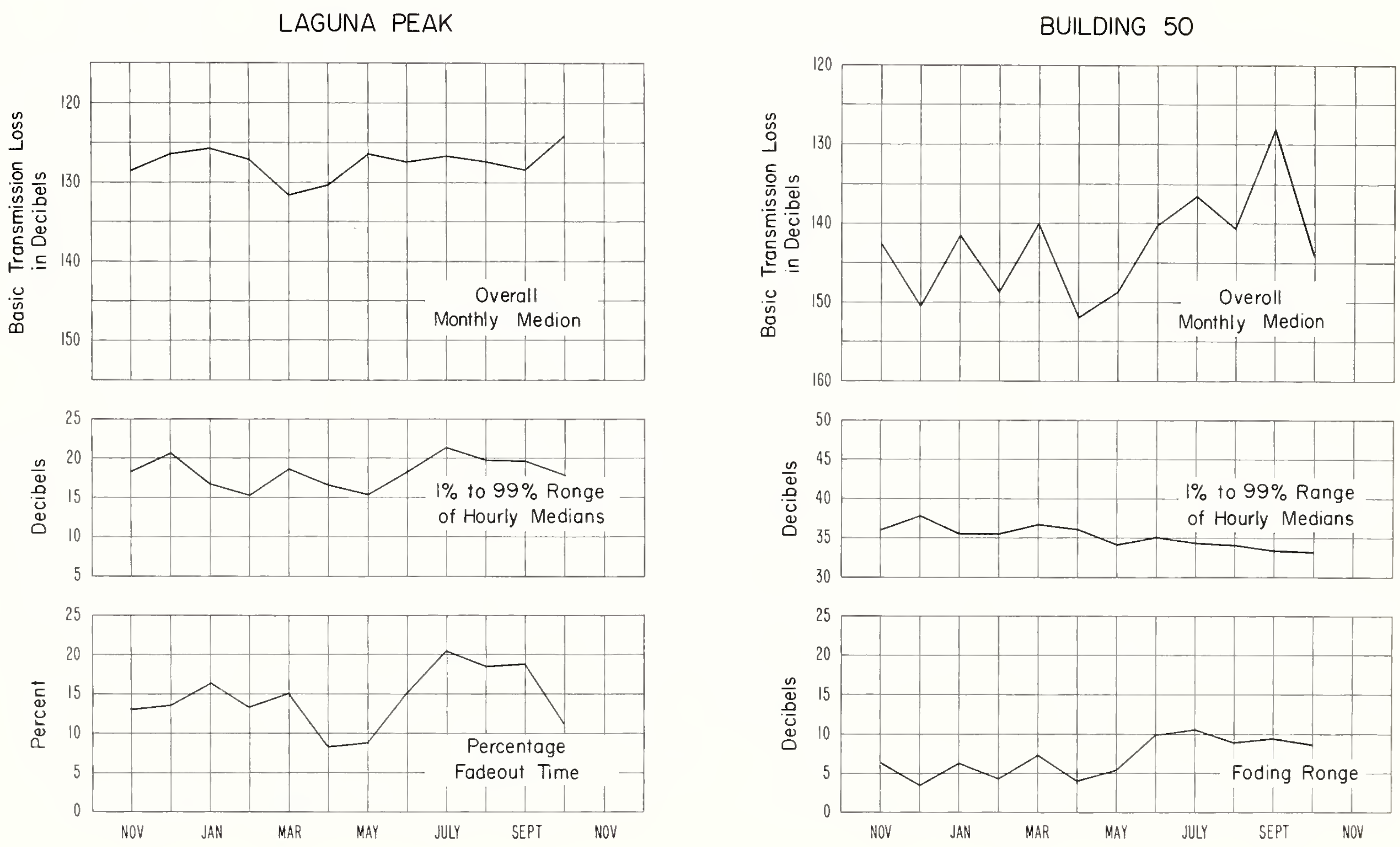


Figure 12

MONTH-TO-MONTH TRENDS IN SIGNAL CHARACTERISTICS OVER WITHIN-THE-HORIZON PATH SAN NICOLAS ISLAND-LAGUNA PEAK 394 MC

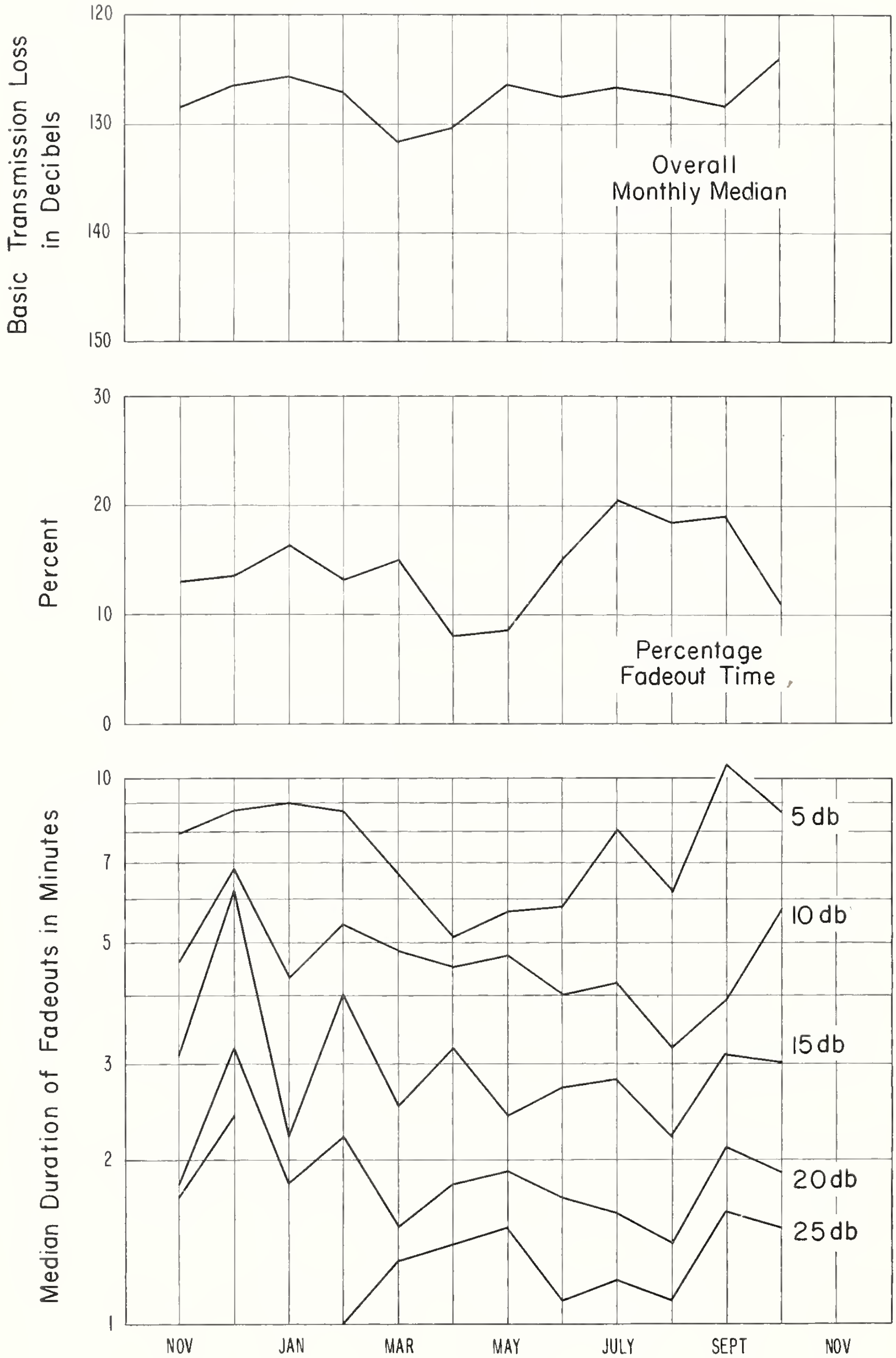


Figure 13

U. S. DEPARTMENT OF COMMERCE
Sinclair Weeks, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of the scientific program of the National Bureau of Standards at laboratory centers in Washington, D. C., and Boulder, Colorado, is given in the following outline:

Washington, D.C.

Electricity and Electronics. Resistance and Reactance. Electron Tubes. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

Heat and Power. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology and Lubrication. Engine Fuels.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Nuclear Physics. Radioactivity. X-rays. Betatron. Nucleonic Instrumentation. Radiological Equipment. AEC Radiation Instruments.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Gas Chemistry. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Organic Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Air Conditioning. Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Specifications. Heat Transfer.

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

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analogue Systems. Application Engineering.

- Office of Basic Instrumentation
- Office of Weights and Measures

Boulder, Colorado
BOULDER LABORATORIES
F. W. Brown, *Director*

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships.

Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Systems. Navigation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering.

Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Calibration Center. Microwave Physics. Microwave Circuit Standards.

Commerce-Standards-Boulder, Colo

NBS