NATIONAL BUREAU OF STANDARDS REPORT

9025

Development, Testing, and Evaluation of Visual Landing Aids
Consolidated Progress Report for the Period July 1 to September 30, 1965

By
Photometry and Colorimetry Section
Metrology Division
Institute for Basic Standards

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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NBS PROJECT December 1965 **NBS REPORT**

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Development, Testing, and Evaluation of Visual Landing Aids

Consolidated Progress Report to

Ship Aeronautics Division
and
Meteorological Management Division
Bureau of Naval Weapons
Department of the Navy

and to

Federal Aviation Agency

For the Period
July 1 to September 30, 1965

By
Photometry and Colorimetry Section
Metrology Division
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NBS

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NATIONAL BUREAU OF STANDARDS

Development, Testing, and Evaluation of Visual Landing Aids
July 1 to September 30, 1965

I. REPORTS ISSUED

Report No.	Title
8940	Development, Testing, and Evaluation of Visual Landing Aids, Consolidated Progress Report for the Period April 1 to June 30, 1965
212.11P-16/65	Photometric Tests of a Catapult Hook-Up Light for Aircraft Carriers, Mfg. by L. C. Doane Company
212.11P-34/65	Life Tests of Ten Developmental 6000-Hour Lamps for Use in a 300-mm Code, or Hazard, Beacon
212.11P-67/65 Letter Report	Photometric Measurements of the Red Obstruction Light on the Night Vision Flood Light Type No. 327 Manufactured by the L. C. Doane Company
212.11P-107/65	Photometric Tests of One Glass and Two Polyester-Resin Lenses for a Type L-842, Semiflush-Mount, Light
21P-111/65	Photometric Tests of Four Type Q20A/PAR56/2 Approach Light Lamps Manufactured by General Electric Company
21P-10/66	Photometric Tests of an Angle-of-Approach Light Manufactured by Lockheed-Georgia Company
212.11P-12/66	Electrical Tests of Two Solid-State Constant-Current Regulators
21P-17/66	Photometric Tests of an Integrated Plastic Lens for Use in the Lens Cell of the Fresnel-Lens Optical Landing System
Memorandum Report	A Study of Configurations for Distance-to-go Lights
Paper	"Can Infrared Improve Visibility Through Fog?" by A. Ashley and C. A. Douglas. Given at the IES National Technical Conference of August 29-September 2, 1965.

II. VISIBILITY METERS AND THEIR APPLICATION

Slant Visibility Meter.

There has been no progress on this task because of the emphasis on other work during the fog season.

Transmissometers.

High Pulse Rate Receiver. Severe drifts in the 100-Percent Setting Calibration were encountered with the transmissometer using the high pulse rate receiver. Marked changes in calibration with temperature were also encountered. The receiver was rebuilt to eliminate any possible changes in sensitivity caused by shifts in the position of the optical components or changes in the capacitance between the photomultiplier output dynode and ground.

These changes did not remove the instability. The photomultiplier tube was then changed. The stability was then much better. The instrument is now being operated continuously at NBS (Washington).

250-Foot Baseline Transmissometer. The 250-foot baseline transmissometers alongside the Weather Bureau 500-foot baseline transmissometer were operated throughout this period. The photopanel equipment for photographing the counters and auxiliary information of the transmissometers was received and installed in September. After a few days operations the camera was malfunctioning and it was replaced.

When the photopanel equipment was put into operation, the signal strength was found to be insufficient to operate the counter circuits. We were advised that for signal line runs of more than a few feet from the transmissometer indicator output to the input to the photopanel, coaxial cables were required to keep the cable capacitance from excessively loading the transmissometer indicator. After the twisted-pair signal cables were replaced with coaxial cables, the counters operated satisfactorily, but some minor input resistance adjustments were required for two systems.

There have been many hours of fog suitable for collecting data. During the month of September the records of the 500-foot baseline transmissometer show that there were 106 hours of visibility at or below three miles, 64 hours at or below one mile, 44 hours at or below one-fourth mile, and 8 hours of transmittance below 0.01 per 500 feet.

Theoretically, the product of the transmittances from the 250-foot baseline instruments, T_{250}, should equal the transmittance from the 500-foot baseline instrument, T_{500}. The major source of differences

should be from nonuniformity of the atmosphere, which may be considerable although the actual measured paths are separated by approximately 10 feet. The sponsoring agencies will analyze the data. However, some preliminary analyses were made of the chart-recorded transmittances. In general, the T_{500} was approximately equal to the product of the two T_{250} transmittances. In stable atmospheric conditions, agreement was usually good, but in unstable conditions, the agreement may be much poorer. A plot of the product of the transmittances obtained from the two 250-foot baseline transmissometers against the transmittance of the 500-foot baseline transmissometer is given in figure 1. The products of the two T_{250} transmittances agree much more closely with the T_{500} transmittances than do the squares of either of the two T_{250} transmittances. (Transmittance over a 250-foot baseline squared, $(T_{250})^2$, should equal the transmittance of a 500-foot baseline, T_{500}, if atmospheric conditions are homogeneous.) During the course of the test the lens-heater circuits of both the 250-foot baseline transmissometers (recently borrowed from the Weather Bureau) developed ground faults. The insulation on this wiring is an asbestos type which resists the effects of higher temperatures but breaks down if moisture accumulates in the fittings. A different type insulation suitable for moisture resistance is needed. The small rise in temperature may not require the high heat-resistance qualities of asbestos insulation. One of the two receivers showed a change in sensitivity when the heater in the photopulse unit was energized. The indication of this change was an increase in sensitivity becoming as great as four percent. This trouble was corrected by replacing the WL-759 trigger tube.

Field Tests of Hoffman Backscatter Fog Detector.

The data collection program at Arcata for the initial evaluation of the Hoffman backscatter fog detectors has been completed. Two of these units were shipped to the Coast Guard in August. One of the remaining units was installed at the site of a 250-foot baseline transmissometer and was operated there for five weeks. The purpose of this installation was to collect data for comparison with the response of a shorter baseline transmissometer. At the end of the quarter, the final two units were dismantled for shipping to the Air Force Cambridge Research Laboratory for further testing and evaluation. The data collected at Arcata will be analyzed by the Cambridge Research Laboratory. The arrangement of the instruments is shown in figure 2.

Analysis of the data was not included as part of the task but some selected data were studied to determine performance and to recognize specific points requiring evaluation. As expected, the

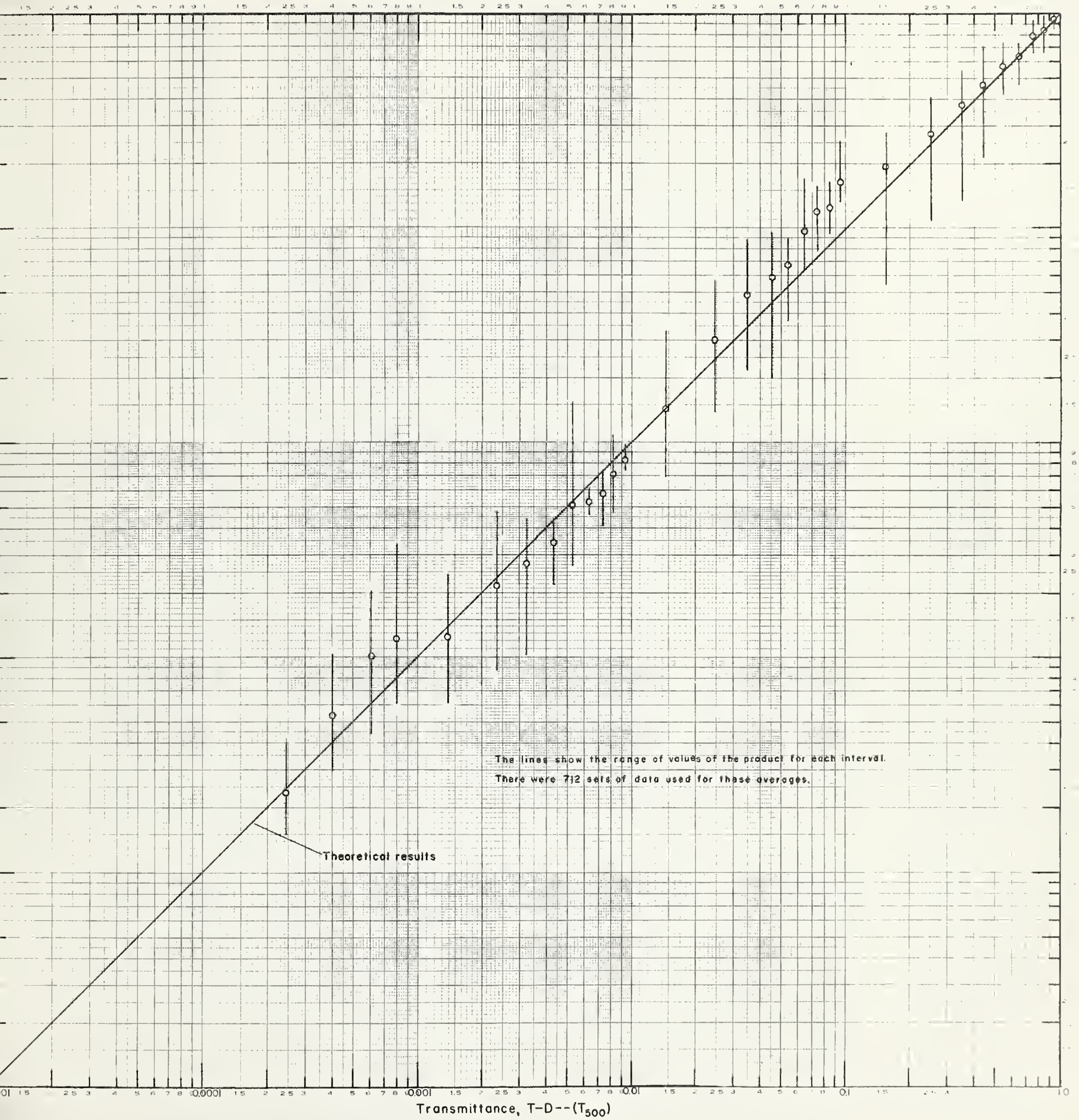

Figure 1. Comparison of the product of transmittances from the 250-foot baseline transmissometers with transmittance of the 500-foot baseline unit

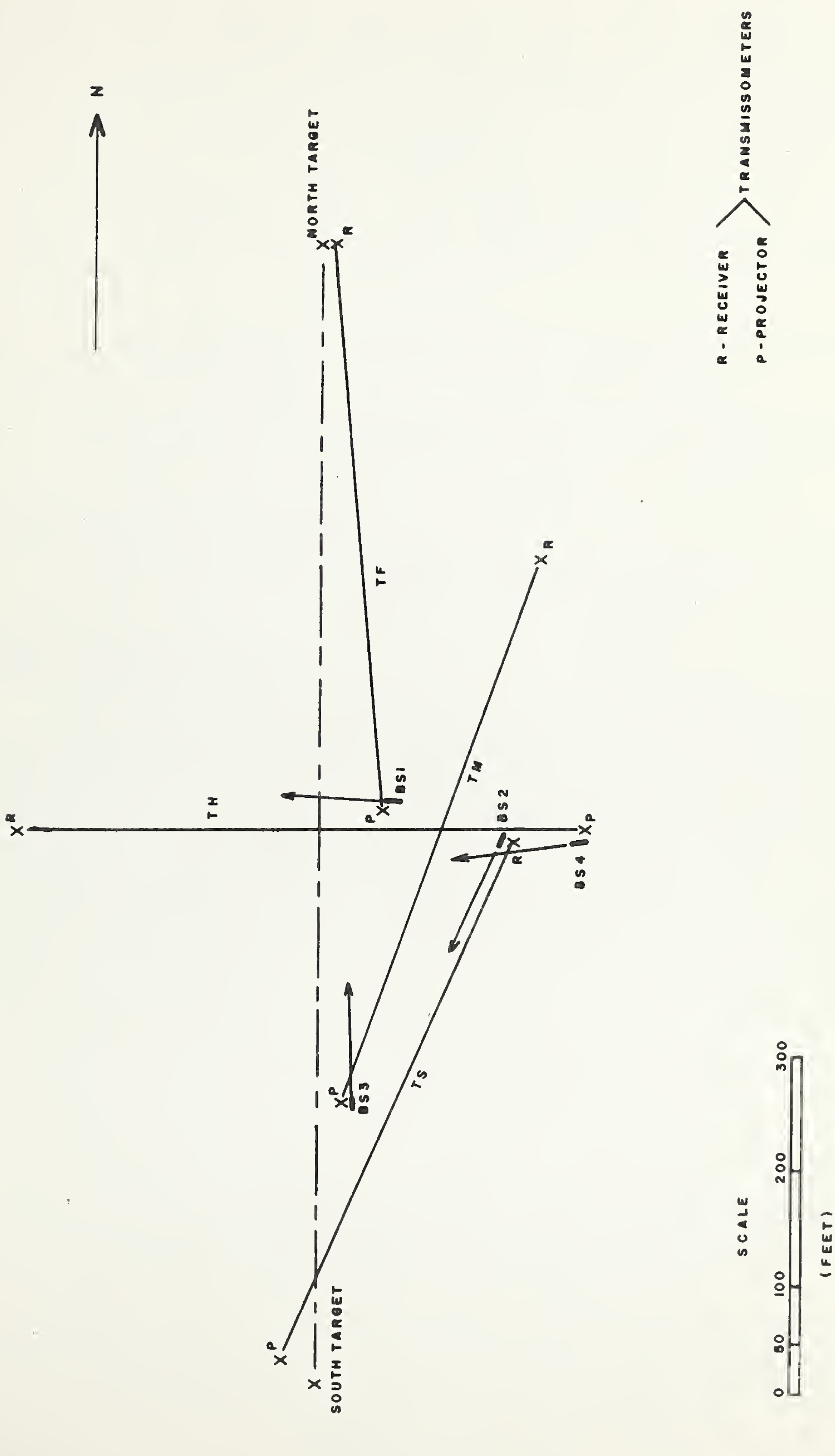

Figure 2. INSTRUMENT LOCATION LAYOUT FOR BACKSCATTER DEVICE TEST

output of the backscatter meter increases as the transmission decreases. The average response as a function of transmittance over a 500-foot baseline for several selected fogs is shown in figure 3. Note that curves could be reasonably approximated by a single straight line but a better approximation would be obtained by more than one straight line with slightly different slopes. This change in slope may be the result of changes in particle size distributions for different transmittance ranges. The change in particle size may also account for part of the variation in output at a given transmittance, although sampling error is probably the major reason for this latter variation.

A comparison of the readings of backscatter meters 1, 3, and 4 with the readings of backscatter meter 2 is shown in figure 4.

Only a very little data were obtained in rains that were not accompanied by fogs. These data are summarized in table 1.

Shipboard Visibility Meter.

The initial design work for a service test model of a backscatter visibility meter has continued.

Fog Variability Studies.

Use of instruments to determine visibility conditions assumes, or at least implies, that the atmospheric conditions are uniform horizontally and changes tend to be gradual. Obviously these assumptions may be incorrect and likely to introduce appreciable error. With the recent emphasis on operations with lower visual ranges, better knowledge on the variation of conditions in fog is needed in order to more accurately inform the pilots of existing conditions and to make more reliable short-period forecasts of changes. The first attempt to evaluate fog variability at Arcata involved installing two 500-foot baseline transmissometers approximately back to back in an area that was nearly level which had little nearby change in terrain or vegetation. Early data indicated that in fog conditions appreciable differences in transmittance are frequent, but the nature of the variations was not easy to determine. The installation now includes a third transmissometer overlapping half of the area sampled by the original transmissometers and a fourth transmissometer with its baseline approximately perpendicular to the baseline of the other three units. The location and arrangement of these installations are shown in figure 2. Data were obtained during the fog season of 1964. Additional data are being obtained during the fog season of this year. The installation and the maintenance procedures have been improved to eliminate or reduce possible instrument errors in indication.

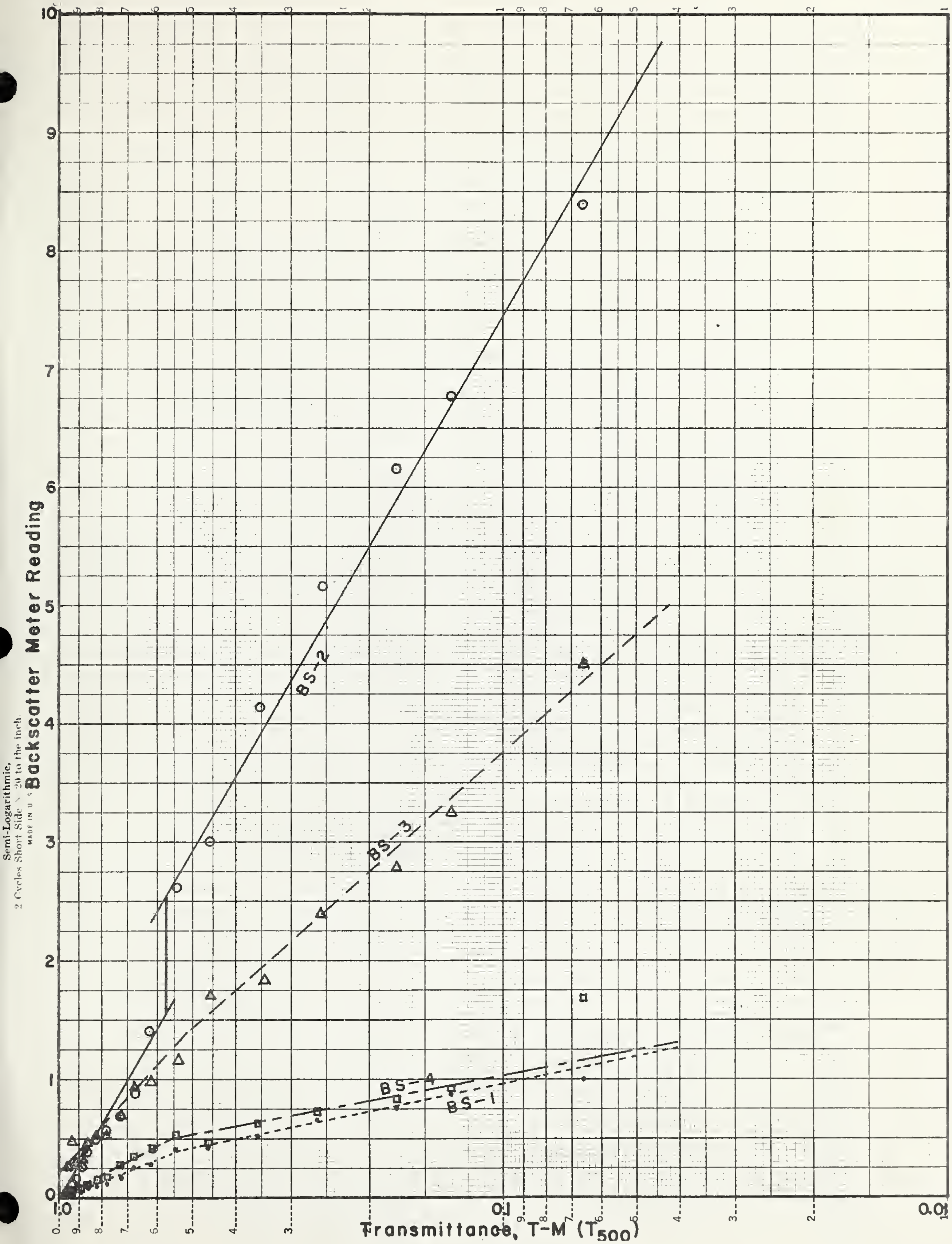

Figure 3. Backscatter meter response as a function of the logarithm of transmittance indicated by T-M

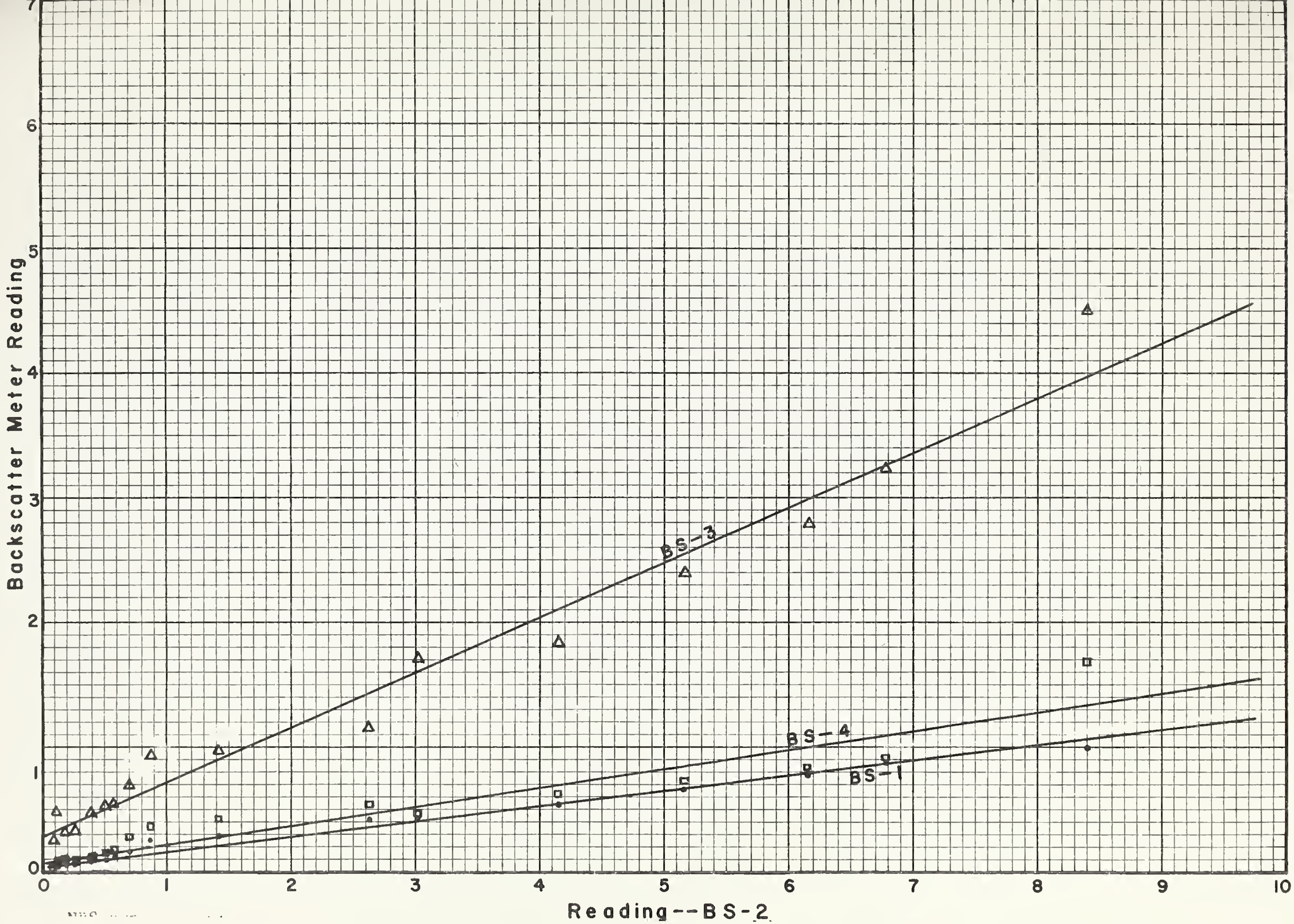

Figure 4. Comparison of the other backscatter meter readings with backscatter meter BS-2

Table 1. Evaluation of Backscatter Response in Rain

	Rain			Rain and Fog			Fog without Rain		
Trans-mittance Interval	Average Trans-mittance T-M	Average Reading BS-2	Number of Readings	Average Trans-mittance T-M	Average Reading BS-2	Number of Readings	Average Trans-mittance T-M	Average Reading BS-2	Number of Readings
Over 0.96	0.965	0.050	10						
0.94-0.96	0.949	0.068	27	0.946	0.095	2			
0.92-0.94	0.932	0.093	28	0.934	0.098	6	0.929	0.086	51
0.90-0.92	0.914	0.113	6	0.914	0.172	10	0.908	0.141	27
0.88-0.90	0.884	0.115	1	0.895	0.163	8	0.892	0.176	22
0.86-0.88	0.860	0.125	1	0.863	0.155	3	0.868	0.20	7
0.84-0.86				0.841	0.33	2	0.849	0.194	5
0.82-0.84				0.827	0.21	6	0.826	0.27	2
0.80-0.82	0.803	0.175	1	0.806	0.35	3	0.813	0.35	5
0.78-0.80							0.790	0.37	15
0.75-0.78							0.767	0.45	10
0.70-0.75				0.726	0.34	2	0.716	0.44	5
0.65-0.70				0.670	0.54	2	0.668	0.65	3

Visibility Thresholds.

Observations for comparison with the transmissometer-indicated visibility during dense fog conditions were made during the fog season of 1964 and are continuing. The observations indicate that for nighttime the observed range correlates well with the visibility derived from the transmissometer indication. The past observations during daytime agree very well with visibilities indicated by the transmissometers for ranges down to 1000 feet, but in denser fogs the indicated visibility is definitely less than the observed visibility. Since correlating some of the observed visibilities with transmissometer readings appears to result in extremely low-contrast threshold constants, the emphasis during the current fog season will be to check for and eliminate any sources of error in the transmissometers or in large changes in density of fog near the ground affecting the visual range of the observations. Until the end of this quarter there was very little daytime fog dense enough to limit visibility to the test range. Observations were made on two occasions. Much more dense fog is expected during the next reporting period.

III. AIRFIELD LIGHTING AND MARKINGS

Stub Approach Beacon.

Preparation of the draft of the report on the stub approach beacon has been delayed because of the emphasis on obtaining data on other tasks during the fog season. The draft should be completed during the next quarter.

Temperature Rise Test of an MC-2 Type Light with a 300-Watt Lamp.

Temperature rise measurements were made of an MC-2 type light lamped with a 300-watt lamp and installed in a compact inset-type base. A 30-inch by 30-inch by 18-inch concrete slab was prepared. A base was then cemented into a prepared socket in the slab with epoxy. Thermocouples were installed at various locations at which temperature readings were desired. The light with a PAR-56, 300-watt, 20-ampere lamp as the source was installed. The light was energized at rated current and the temperatures were recorded. The light was operated continuously for 48 hours and then deenergized. The equilibrium temperatures at various points were as follows:

1. Inside the light between the prisms directly above the lamp -- 430°F
2. On the base of the lamp -- 340°F
3. Outside on the top of the light between the prisms -- 200°F
4. In the free air inside the light near the bottom of the can -- 185°F
5. In the free air inside the light near the top of the can -- 275°F
6. On the inside wall of the can near the top -- 330°F
7. On the inside bottom of the can -- 185°F
8. In the epoxy between the can and the concrete, one inch below the top of the can -- 175°F
9. In the earth six inches below the surface and 24 inches from the can -- 60° to 65°F.

PAR-56 Lamps for MC-2-Type Prismatic Semiflush-Mount Runway Lights.

A broad investigation was begun into the lamps used in the MC-2-type prismatic semiflush-mount runway lights. Information reaching the National Bureau of Standards indicated that a much higher peak intensity would be obtained if the 6.6A/PAR56/3 lamp were replaced by a 200PAR46/66 lamp. (The latter is an off-focus lamp designed in a shipboard floodlight.) Both lamps are 6.6-ampere, 200-watt types.

Preliminary tests at NBS indicated a higher peak intensity when the PAR-46 lamp was used in the unit. Further investigation revealed that the PAR-56 lamp (300-hour design life) was operating at a color temperature near 2800°K while the color temperature of the PAR-46 lamp (500-hour design life) was about 3000°K. Note: The color temperature of the 300-hour lamp should be about 20°K higher than that of the 500-hour lamp.

A more representative size sample of the lamps being tested is being obtained for additional measurements.

Polyester-Resin Lenses for a Type L-842 Semiflush-Mount Light.

Intensity distribution measurements were made of a type L-842 Westinghouse semiflush-mount runway light with two polyester-resin lenses manufactured locally by NAS North Islane, and one glass lens inserted in turn in the light. One plastic lens was damaged on one surface during cleaning and was subsequently polished with a fine abrasive. Peaks of 800, 650, and 530 candelas were obtained with the unit with the glass lens, the polished lens, and the unpolished lens, respectively. NBS Test Report 212.11P-107/65 was issued.

Distance-To-Go Lights.

A memorandum report has been prepared which gives the results of a subjective evaluation of several different types of configurations of symbols and digits representing distance-to-go markings. Scale models were constructed in which the inset lights which comprise the symbols were represented by dots of fluorescent paint. An overhead source of ultraviolet light caused the dots to fluoresce, and they were viewed in a darkened "tunnel". The point of observation was a simulated height of 15 feet above the runway surface at a simulated viewing distance of 500 feet. Under these conditions a system using longitudinal rows of lights with short cross bars appeared to be the most satisfactory.

Lightweight Regulators for SATS Lighting Systems.

NBS Test Report 212.11P-12/66 has been released. This report gives the results of the tests of the two solid-state, constant-current regulators developed and constructed by Bernard Electronics Company, Washington, D. C. The regulators and the loads on the regulators operated satisfactorily during the tests. Both regulators meet the efficiency requirements but not the power-factor requirements of the respective specifications for the regulators in current use.

Output Characteristics of Series-Series Transformers.

Several types of 300-watt and 500-watt transformers were tested in a series runway-lighting circuit using series lamps and multiple lamps as loads, to determine the most suitable transformer-lamp combination for use in VASI systems supplied from a runway - lighting circuit. A report on the results of the tests is being prepared.

Angle-of-Approach Light.

Photometric tests were made of a portable battery-operated three-color angle-of-approach light manufactured by the Lockheed-Georgia Company. The lamp in the unit was operated at 9.84 (rated) volts. Peak intensities are given below. Intensities of the type AA-1 angle-of-approach light are included for comparison.

Beam Color	Indication	Intensity (candelas)	
		Test Unit	Type AA-1 Unit
Red	Too low	1.2	4.8
Green	Glide Path	1.9	9.0
Yellow	Too high	4.5 - 5.2	28

NBS Test Report 21P-10/66 was issued.

IV. CARRIER VISUAL LANDING AIDS

Flash Rate of the Low, Red Cell of the FLOLS.

A study has been made of a number of pertinent reports concerning flashing lights and an analysis has been made of the factors affecting the selection of a flash frequency for the low, red cell of the Fresnel Lens Optical Landing System. The results have been reported by letter. A flash rate of the order of 180 flashes per minute appears desirable. A mechanical shutter will be required to obtain this flash rate.

Night Vision Floodlight.

Intensity distribution measurements were made of the red obstruction light atop the Night Vision Floodlight, Type No. 327, manufactured by the L. C. Doane Company. The intensity in the direction of the zenith was 0.22 candela. The average intensity at 0.0° elevation in the direction of the perpendiculars to the four faces of the light was 0.05 candela. This is the zone of minimum intensity on the obstruction light. Letter Report 212.11P-67/65 was issued. (A recommendation was incorporated that "if the intensity of the obstruction light has been found to be satisfactory in service, consideration should be given to amending Specification MIL-L-81129 to require that the intensity of this light be not less than 0.3 candela nor more than 3 candelas.")

Catapult Hookup Light.

Intensity measurements were made of a catapult hookup light manufactured by the L. C. Doane Company. The unit incorporates a red glass filter. When installed it projects a red beam in a vertical direction. Two types of metal guard for the glass filter were provided, one with round holes, and one with triangular holes. With the former the peak was nearly 10° from the vertical and was 6 candelas. With the latter the peak was vertical and was 8 candelas. NBS Test Report 212.11P-16/65 was issued.

Integrated Plastic Lens for Fresnel-Lens Optical Landing System.

Photometric tests were made of a lens cell of the Fresnel-Lens Optical Landing System (1) with a conventional optical system and (2) with an integrated plastic lens, manufactured by the Oxford Corporation, which replaces both the Fresnel lens and the lenticular lens (both plastic) of the conventional system. The integrated lens was made of transparent yellow epoxy resin; the back surface is planar; the front, a cylindrical lens with its axis horizontal plus vertical flutes. Source slits of 0.07 inch were used for both tests. A comparison of the two lens systems follows:

	INTENSITY	
	Conventional Two Lens System (kilocandelas)	Integrated Single Lens System (kilocandelas)
Peak	22	37
0.1° spread	21	22
0.2° spread	15	4.2
0.3° spread	3.5	2.1
0.4° spread	1.3	1.3

The integrated lens was not tested for chromaticity. NBS Test Report 21P-17/66 was issued.

Portable Photoelectric Photometer for Measuring the Output of Carrier-Deck Lights.

Construction of the photometer has continued. Carrier-deck lights of several types have been obtained from Navy stock. The design of the calibrator is being modified so that the photometer can be used to check the condition of these lights.

V. MISCELLANEOUS TECHNICAL AND CONSULTIVE SERVICES

Review of Specifications.

Review of Military specifications and drawings has continued. In particular, a draft of a Visual Landing Aids Technical Order for the Bureau of Naval Weapons was reviewed and comments forwarded informally. The principal deficiency in this technical order was that it described only those lights of the VLA System installed and operated by the Federal Aviation Agency.

VI. MISCELLANEOUS

Visitors at Arcata: LCDR Kenneth Urfer from the Coast Guard and Mr. Franklyn Nickl of Hoffman Electronics Corporation were checking further on the performance of the backscatter meters. Mr. A. N. Hill of the Weather Bureau was here for familiarization with our operations and a briefing on projects in which he has an interest. Mr. H. Dean Parry, also of the Weather Bureau, was checking on the RVR assessment program and related projects and was interested in the nature of fogs. Mr. Bernard Silverman, Air Force Cambridge Research Laboratory, and Mr. William Ornett, Federal Aviation Agency, were reviewing the present status of our operations and considering the possibility of using this area for their own fog evaluation projects.

Sample quantities of single-conductor, #8AWG direct burial cable insulated with cross linked polyethylene were purchased for field tests by the Marine Corps and by NBS at Arcata. Connector kits suitable for the small diameter of this cable were also purchased.

The draft of the University of California final report, "Evaluation of Runway Lighting Systems for Effectiveness in Dense Fog" was reviewed. In this connection, an analysis was made of the interrelations between Allard's and Koschmeider's laws and between illuminance and contrast thresholds. This analysis was forwarded with the review.

A section, "Visual Range of Luminous Signals",was prepared for inclusion in the Fourth Edition of the IES Lighting Handbook.

A paper, "Can Infrared Improve Visibility Through Fog?" , by A. Ashley (of the Airborne Instruments Laboratory) and C. A. Douglas was presented at the National Technical Conference of the Illuminating Engineering Society. In this paper the fundamental system parameters (atmospheric attenuation, detector sensitivity, radiant intensity of source and effects of background) were examined to determine whether the use of infrared sources and detectors, instead of visible sources and the eye, for marking airport runways and taxiways offers potential for further development. The conclusion was generally negative.

A discussion of the paper "Guidance in Fog on Turnpikes" by Spencer and Levin was presented at the annual meeting of the Illuminating Engineering Society.

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