NATIONAL BUREAU OF STANDARDS REPORT

9385

Development, Testing, and Evaluation of Visual Landing Aids
Consolidated Progress Report for the Period January 1 to March 31, 1966

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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NATIONAL BUREAU OF STANDARDS REPORT

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Development, Testing, and Evaluation of Visual Landing Aids

Consolidated Progress Report to

Ship Installations Division
and
Meteorological Division
Naval Air Systems Command
Department of the Navy

and to

Federal Aviation Agency

For the Period
January 1 to March 31, 1966

By
Photometry and Colorimetry Section
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Development, Testing, and Evaluation of Visual Landing Aids
January 1 to March 31, 1966

I. REPORTS ISSUED

Report No.	Title
9045	A Stub Approach Beacon
9053	Development, Testing, and Evaluation of Visual Landing Aids, Consolidated Progress Report for the Period October 1 to December 31, 1965
212.11P-57/66	Photometric Tests of a Semi-Flush Type Condenser-Discharge Approach Light (With a Straight Flashtube)
212.11P-59/66	Hardness Measurements on Three Prismatic-Head Runway Lights
Memorandum Report	The Effect of Continuous Operation on the Insulation Resistance of a Wheels-Up, Wave-Off-Light Transformer

II. VISIBILITY METERS AND THEIR APPLICATION

Slant Visibility Meter.

The first draft of a report describing the slant Visibility Meter and giving the results of field tests of the instrument has been prepared. Additional analysis of the slant visibility data has not resulted in any significant changes in the findings reported in earlier progress reports.

In analyzing the data, the fog density is assumed to be uniform horizontally but to vary systematically with height so that

$$\sigma_h = \sigma_o f(h)$$

The assumption that

$$f(h) = (1 + ah)$$

has been found to be satisfactory for a layer of fog at Arcata.

Frequently fogs at Arcata consist of several layers, each layer having a different value of "a". As many as four distinct layers have been observed below 400 feet. The lowest layer usually extends to between 50 and 100 feet above the ground. An assumption that the fog between the ground and a height of 200 feet consists of one layer has been a satisfactory approximation 90% of the time at Arcata.

Work on the report will continue but may be delayed because of preparations for the approaching fog season. The slant visibility meter is still out of operation awaiting delivery of parts for the air compressor.

Transmissometers.

High Pulse Rate Receiver. The high pulse rate receiver has continued to operate satisfactorily except that there has been a continuing decrease in receiver sensitivity of the order of two percent per week.

Shipboard Visibility Meter.

The detailed design study was begun during this period. Several of the circuit blocks in the electronic portion of the instrument have been developed or investigated. Many of these blocks will use transistor dc operational amplifiers to perform various functions.

A circuit has been found to provide the log of the ratio of the signal to the reference. The circuit uses an operational amplifier with a transistor junction in the feedback path. Two such circuits are used to provide an output proportional to the ratio of the inputs and also reduce the temperature dependent drift of the circuit. The signal from the photocell is expected to change by a factor of 10^3 depending on the visibility.

The log circuit therefore must have a dynamic range of at least 60 dB. With some refinements of the present circuit, 100 dB could be obtained if it were necessary. The circuit has been tested with a voltage divider at dc. The results follow:

Ratio (Numerical)	(dB)	Theoretical Output (Volts)	Actual Output (Volts)	Error (Volts)	(dB)
1	0	0	-0.03	-0.03	.18
3.33		1.76	1.79	0.03	.18
10.	20	3.38	3.40	0.02	.12
33.3		5.14	5.19	0.05	.30
100.	40	6.77	6.82	0.05	.30
333.		8.53	8.63	0.10	.60
1000.	60	10.15	10.29	0.14	.84

(20 dB = 3.38 V)

Most of the remaining time in this period has been spent developing a peak detector for the signal pulses. It has been a major problem to find a circuit that performs well for pulse amplitudes which vary by more than 100 to 1. Several circuits have been tried using operational amplifiers with diodes inside the feedback loop to eliminate the effects of the diode voltage drop. In testing one of the circuits, it was found that one of the commercial operational amplifiers used was not performing as would be expected. Further investigation revealed a tendency for oscillation which the manufacturer was unaware of. About a week was spent isolating this problem.

During the last week of this period a circuit was found which appears to have the performance required for this application. It combines the peak detecting with a holding circuit which will maintain the reading within 1 mV for the time period between flashes. The circuit is designed to handle pulses which are 10 V peak maximum. Preliminary test of the detector using a pulse generator with programable rise and fall times to simulate the signal wave form indicate that the circuit will give readings within 1% of the true peak value for the amplitudes of primary interest. Detailed testing of this circuit is now underway.

If the detector circuit proves satisfactory, components will be ordered. so two can be constructed, one for the signal pulses and one for the reference pulses. These will then be connected to the log-ratio circuit and some type of averaging circuit. Except for the amplifier to raise the photomultiplier signal to the working level of the peak detector, these are the major electronic components of the system. Consideration of the phototube assembly design will be started next quarter.

Fog Detector Tests.

The Coast Guard has established a program for testing a number of types of fog detectors at Arcata. Four types of detectors are included in the original test. These detectors are to be installed and calibrated at Arcata and will then be moved to the San Francisco area for a period of operation and comparison with the regular manual operation of the fog-warning equipment. The fog detectors were manufactured by Hoffman Electronic Corporation; by Walter Kidde and Company; by the Thomas A Edison Company and the Videograph III by Impuls Physik Gmbh., and procured from Automatic Power, Inc. The NBS Field Laboratory prepared the stands for mounting the units, built a temporary building for shelter and storage, and laid out the wiring for signal and power lines.

Fog Variability Studies.

Transmittance obtained from the four transmissometers at the fog variability test site at Arcata were tabulated for the daytime, low-visibility conditions of the 1965 fog season during the six test periods in which visual observation tests were made for threshold determinations. (The location of these transmissometers was shown in figure 2 of NBS Report No. 9025). The transmittances over the 500-foot baseline ranged from 0.004 to 0.4. During the tests, transmittance measurements were taken regularly at five minute intervals. The ratios of the transmittances obtained from transmissometers T-F, T-H, and T-S to the transmittance obtained from T-M (the most centrally located unit) were determined. Results of the analysis are given in table 1.

The differences in transmittances from site to site appear to be the result of local variations in conditions because the measurements were carefully checked for sources of instrument and installation errors. These results do not show the same relationship, especially for T-F, that was obtained during the fog seasons of 1963 and 1964. This inconsistency may be caused by the limited number of measurements assuming that these six test periods differed from normal conditions; however, observations in earlier years by Aeronautical Icing indicated that transmittance in the area of T-F and T-M tended to be greater than that at T-S. One of the interesting features of the fogs was that the transmittance in the area of at least one unit always seemed to be changing even though the transmittance in the areas of the other units was relatively stable. This study indicates that the atmospheric transmission in daytime at Arcata is seldom uniform or stable even in a very limited area with relatively homogenious terrain features.

Summary of Restricted Visibility Conditions at Arcata-Eureka Airport.

A summary has been prepared of the restricted visibility and ceiling conditions as reported by the Federal Aviation Agency Flight Service Station at Arcata for the last few years. This summary is given in table 2.

Table 1.

Comparison of Transmittance Measurements for Daytime Conditions
During Visual Observation Tests for the 1965 Fog Season

Interval Range Transmittance of T-M (T500)	--Transmittance-- T-M, T_{500} Average (T500)	Extremes	----------Ratios of Transmittance, T_{500}---------- T-F/T-M Average	Extremes	T-S/T-M Average	Extremes	T-H/T-M Average	Extremes	Number of Measurements in Average
0.20-0.39	0.24	0.23-0.25	0.74	0.65-0.82	1.17	1.07-1.28	0.52	0.41-0.63	2
0.100-0.199	0.132	0.100-0.181	0.89	0.44-1.64	0.74	0.34-1.51	0.74	0.44-1.50	23
0.070-0.099	0.085	0.074-0.099	0.77	0.48-1.18	0.59	0.47-0.69	0.62	0.39-0.84	14
0.040-0.069	0.050	0.040-0.069	0.81	0.50-1.34	0.67	0.52-0.98	0.69	0.52-0.93	33
0.020-0.039	0.029	0.020-0.039	0.87	0.49-1.97	0.74	0.42-1.55	0.76	0.44-1.08	59
0.0100-0.0199	0.0147	0.0100-0.0195	0.87	0.50-1.14	0.75	0.34-1.12	0.89	0.52-1.37	22
0.0070-0.0099	0.0082	0.0080-0.0098	1.04	0.74-1.29	0.60	0.24-0.98	1.22	0.73-1.46	9
0.0040-0.0069	0.0049	0.0049	0.80	0.80	0.41	0.41	1.14	0.83-1.45	2

Table 2.

Visibility Ceiling Summary for Arcata-Eureka Airport; Arcata, California

November 1962 through December 1965

Year	Ceilings					Visibility				
	Below 100 ft. (Hours/ Days)	Below 200 ft. (Hours/ Days)	Below 300 ft. (Hours/ Days)	Below 500 ft. (Hours/ Days)	Below 800 ft. (Hours/ Days)	Below 1/4 Mile (Hours/ Days)	Below 1/2 Mile (Hours/ Days)	Below 1 Mile (Hours/ Days)	Below 2 Miles (Hours/ Days)	Below 3 Miles (Hours/ Days)
Nov-Dec 62	101/17	147/20	208/25	264/27	294/34	127/20	165/21	278/27	304/27	355/34
1963	188/60	310/80	512/104	906/137	1440/184	200/65	312/86	560/113	864/138	1160/164
1964	433/92	690/121	920/131	1412/191	1797/208	432/92	620/113	874/142	1224/164	1544/190
1965	563/99	988/131	1345/151	1394/179	2408/206	552/96	809/114	1119/135	1520/167	1948/193

III. AIRFIELD LIGHTING AND MARKING

Stub Approach Beacon. The report on the design, installation, and performance of the stub approach beacon was issued as NBS Report No. 9045. This concludes work on this task. The stub approach beacon installation is being retained at the request of the Humboldt County Department of Aviation, but the beacon is presently inoperative awaiting installation of control circuits to the Flight Service Station.

Semi-Flush Type Condenser-Discharge Approach Light (With a Straight Flashtube). Photometric measurements were made of a semi-flush type condenser-discharge approach light with a straight flashtube operating in a horizontal position. The unit, with its own connecting power supply, was manufactured by Sylvania Electric Products Inc., Ipswich, Massachusetts. When the testing was begun on a Friday afternoon, the peak effective intensity was 3000 candelas. After about three hours of testing the peak was 2750 candelas. The unit was then set to operate continuously from Friday afternoon to Monday morning. The unit was intermittent in operation most of the week end. By Monday morning the peak effective intensity had dropped to approximately 2500 candelas, down 17% from the peak first recorded. On Monday it was not possible, however, to obtain 25 consecutive flashes.

6.6-Ampere, 200-Watt, T-14 Iodine-Cycle Lamps for C-1 Runway Lights. Three experimental 6.6-ampere, 200-watt iodine-cycle tubes mounted vertically in T-14 envelopes, for use in C-1 runway lights, were received from the General Electric Company, Cleveland, Ohio, for photometric tests. Measurements will be made of the three iodine-cycle lamps and of a 6.6A/T14P lamp with the conventional C-13 filament in a C-1 fixture.

PAR-Type Lamps for MC-2 Type Prismatic Semiflush-Mount Runway Lights. The problem of evaluating the PAR-type lamps when used in the type MC-2 prismatic-head semiflush-mount runway light has been further investigated. A jig with three parallel concentric masks, each with a pair of slots, was constructed that simulated quite satisfactorily the conditions encountered in the type MC-2 light: the three pairs of slots correspond dimensionally and spatially to the entrance and exit windows of the prisms (a class BBC ½ inch projection bidirectional unit) and to the cut-off areas of the two light channels in the top of the light unit. Vertical intensity distributions through the jig were similar to those obtained from the same lamp in the light, both as to peak intensity and beam spread. Horizontal distributions were less similar as regards beam spread, probably because of the refraction of the prism. The jig may prove useful in predicting (and testing for) the performance of PAR type lamps in the unit. Some of the dimensions are critical: since the effective height of the jig window is only ½ inch high for the peak of the beam, an alinement deviation of only .01 inch can make an 8% difference

in the relative beam intensities. The jig may be useful for comparing the peak intensities and the beam elevation of the two beams of bidirectional units for checking filament alinement (assuming, of course, that the reflector is symmetrical).

An attempt was made to check the filament alinement by masking in turn the upper and lower halves of the PAR lamp and comparing the two vertical intensity distributions. The results were not satisfactory.

Hardness Measurements of Prismatic-Head Runway Lights. Hardness measurements have been made of three prismatic-head lights, made to conform to specification M1L-L-26202 except that a harder material was used for the castings in an effort to obtain a light which would withstand hook impact. NBS Test Report 212.11P-59/66 was issued.

Runway Centerline Lights for SATS Mat. Construction of the fixture was completed and photometric measurements were made of the new, unpainted aluminum fixture. This condition is representative of the optimum conditions under which the fixture could operate. To represent adverse operating conditions, the fixture was painted flat black and the measurements were repeated. The following is a comparison of the two sets of results.

Traverse	Condition	Intensity at 0° V (candelas)	Peak Intensity (candelas)	Location of Peak	Beam Spread at 50% of Peak Intensity
Vertical at 0° Horizontal	Unpainted	4.5	69	1.3°V	-----
	Painted	3	41	2°V	-----
Horizontal at 1.3° Vertical	Unpainted	---	73	-0.8°H	11.6°
	Painted	---	40	-0.8°H	11.2°

At the request of NAEL (SI), exploratory photometric measurements were made of a centerline light for the SATS mat manufactured by the L. C. Doane Company. The results of the measurements are given below. The values in the table are approximate values only.

Plane of Traverse	Angle of Plane	Maximum Intensity (candelas)	Location of Max. Intensity[1]	Beam Spread[2]	Location of Beam Axis[3]	Vertical Cut off (Low)
Vertical	0°H	230	+10.5°V	11.6°	+9.6°V	+2.2°
Horizontal	10.5°V	255	+ 2°H	19.6°	-0.8°H	-----

[1] Angles are taken as positive when the photometric axis was above or to the right of, as viewed from the light, the geometric axis of the light.

[2] Beam Spread is defined as the width of the beam between the points which are 50% of the maximum intensity.

[3] Beam Axis is defined as the axis midway between the points which are 50% of the maximum intensity.

After the photometric measurements were completed, the light was tested for water leakage as follows: the light was operated in a series circuit at rated current for a period of two hours and then plunged into ice water where it remained for a period of twenty minutes. This procedure was then repeated once, and the unit was opened for inspection. There was water in the lamp compartment approximately 3/16 inch deep. The lamp compartment was then filled with water and the lid was tightened slowly. Water leaks were detected around both lenses. The light was operated in this condition for 30 minutes, and the leaks around the lenses continued.

Heliport Beacon Code Demonstration Model. The construction of the model for the study of heliport beacon codes has been completed, and observations were made by representatives of F. A. A., Navy, Air Force, and other interested personnel. The code as outlined in the progress report for last quarter (NBS Report 9053) was found adequate and acceptable. A turntable speed of 12 r.p.m. appears to be satisfactory, and the design and construction by NBS of a full scale operating beacon is under consideration.

Inset Light Lenses. Several red, yellow, green and blue lenses and filters were furnished by Kopp Glass for the purpose of determining their suitability for use in a 45-watt inset light. The particular light, lenses, and filters were chosen because they were readily available. They appear to be satisfactory, although the blue lenses and filters are somewhat paler than specified in MIL-C-25050. Neither the lenses nor the filters changed the shape of the intensity distributions by any appreciable amount. A report of the results of the measurements is being prepared.

Open-Circuit Secondary Voltages of Isolation Transformers. Measurements have been made of the peak-to-peak voltages of three isolation transformers with open secondary circuits. These transformers were 200-watt, 6.6/6.6 ampere, series-series isolation transformers energized by a 15-kilowatt, type NC-3 constant-current regulator which was also energizing a runway lighting circuit with fifty 200-watt lights. The transformers were in-

tended to meet Military Specification MIL-T-27535A requirements and were made by American Gas Accumulator Company (A'G'A), Jefferson Electric Company, and Line Material Company. With the primary current at 6.6 amperes, the peak-to-peak open-circuit secondary voltages were 825, 1075, and 950 volts, respectively. With corresponding root-mean-square open-circuit secondary voltages of 92, 111, and 88 volts, respectively. When one-fifth of the transformers in the runway lighting circuit had open secondaries, the peak-to-peak open-circuit secondary voltage of the A'G'A transformer was 950 volts.

Improved Cable-Fault Location Set. Work during the past three months consisted of designing the Receiving Unit circuitry. The circuit has been designed to work well over the temperature range of -25°C to + 75°C and no selected components or adjustments are required to build or operate it. The actual temperature range for which the Receiving Unit can be used is likely to be limited by the battery used to power it rather than by the electronic circuit. Common penlight (size AA) carbon-zinc flashlight cells should be satisfactory from -15°C to +50°C, with cell life in excess of 100 hours at 25°C. Other types of batteries are available in the AA size which can be used if operation at very low or at very high temperatures is required. The voltage gain of the receiver from the input terminals to the headphone jack is approximately 100,000 at the frequency for which the amplifier is tuned. A switch tunes the amplifier to any of three frequencies: tentatively 150, 270, and 570 cycles per second. The selectivity of the amplifier approximates that of a single tuned circuit with a "Q" of 12. The old model (TSM-11) receiver has a "Q" of approximately 6.

Except for minor detail work the circuitry for both the Receiving Unit and for the Signal Generator appears to perform well, so parts are being ordered to construct a complete prototype model for testing. Delays in obtaining components from supplies are expected, so progress will probably be slow during the coming quarter.

Airfield Lighting Maintenance Manual. A draft of Part II of the manual on "Maintenance of Airfield Lighting Systems" was prepared. This part of the manual covers maintenance, testing, and repair. This section includes periodic, routine and preventive maintenance schedules and techniques: maintenance testing and insepctions: and general and special information on repairs. Also included are the requirements for equipment and personnel for a good maintenance program.

Transformer and Cable Failures at Murray Field. The Humboldt County Department of Aviation has encountered problems of water getting into the cable and isolation transformers of the taxiway lighting circuits at Murray Field at Eureka, California. This was an FAA assistance installation made in 1959 and used FAA Specification L-833 30-45 watt isolating transformers; L-824 Type B, 3000-volt electrical cable; and L-823 plug and receptacle cable connectors. All components were by manufacturers on the Approved Airport Lighting Equipment list. The cable connectors and transformers were vulcanized to the cable and leads. Examination of the defective components by NBS Field Laboratory personnel disclosed that water had accumulated in amounts sufficient to enlarge or form a knot under the sheath in the cable at the connectors, in the leads to the transformers, and inside the transformer cases. In some cases the pressure was sufficient to rupture the sheath of the cable or the transformer. It appears that the moisture entered the cable or leads in areas which were roughened to provide adhesion during the vulcanizing process for attaching the connectors or transformers. The pits in the roughened areas of the sheath of the cable seemed excessively deep and extended well beyond the area where the vulcanizing material was applied. Some pinhole type defects were detected in some sections of the cable but no pinholes were found in the transformers or in the leads of the transformers.

IV. CARRIER LIGHTING AND MARKING

Modulated Tri-Color Glide-Slope Indicator. Construction of the feasibility model of the modulated tri-color glide slope indicator has been completed. The unit has been installed on the 900-foot outdoor photometric range at NBS, Washington. It has been demonstrated to interested personnel of other agencies.

Portable Photoelectric Photometer for Measuring Output of Carrier Deck Lights. Additional modifications to the portable photometers have been made so that they can be used to check additional types of carrier-deck lights.

V. MISCELLANEOUS TECHNICAL AND CONSULTIVE SERVICES

Numerous technical inter-agency conferences relating to problems of visual range and airfield lighting have been attended. Review of proposals and drafts of reports and specifications has continued.

Storage Space in Photometric Laboratory at Arcata.

Shelves have been provided in the photometric laboratory in the former Administration building at the Arcata Airport for records and equipment which were being damaged by moisture accumulated during storage in the warehouse. Part of this building is heated periodically and the photometric laboratory had been connected to this heating system. This should better protect records and equipment which are infrequently used but are still valuable.

Photometry of Colored Light.

The paper "Photometry of Colored Light" by A. C. Wall, has been completed and submitted to the National Bureau of Standards Editorial Committee for review. The paper is intended to be presented at the Illuminating Engineering Society National Technical Conference in August, 1966.

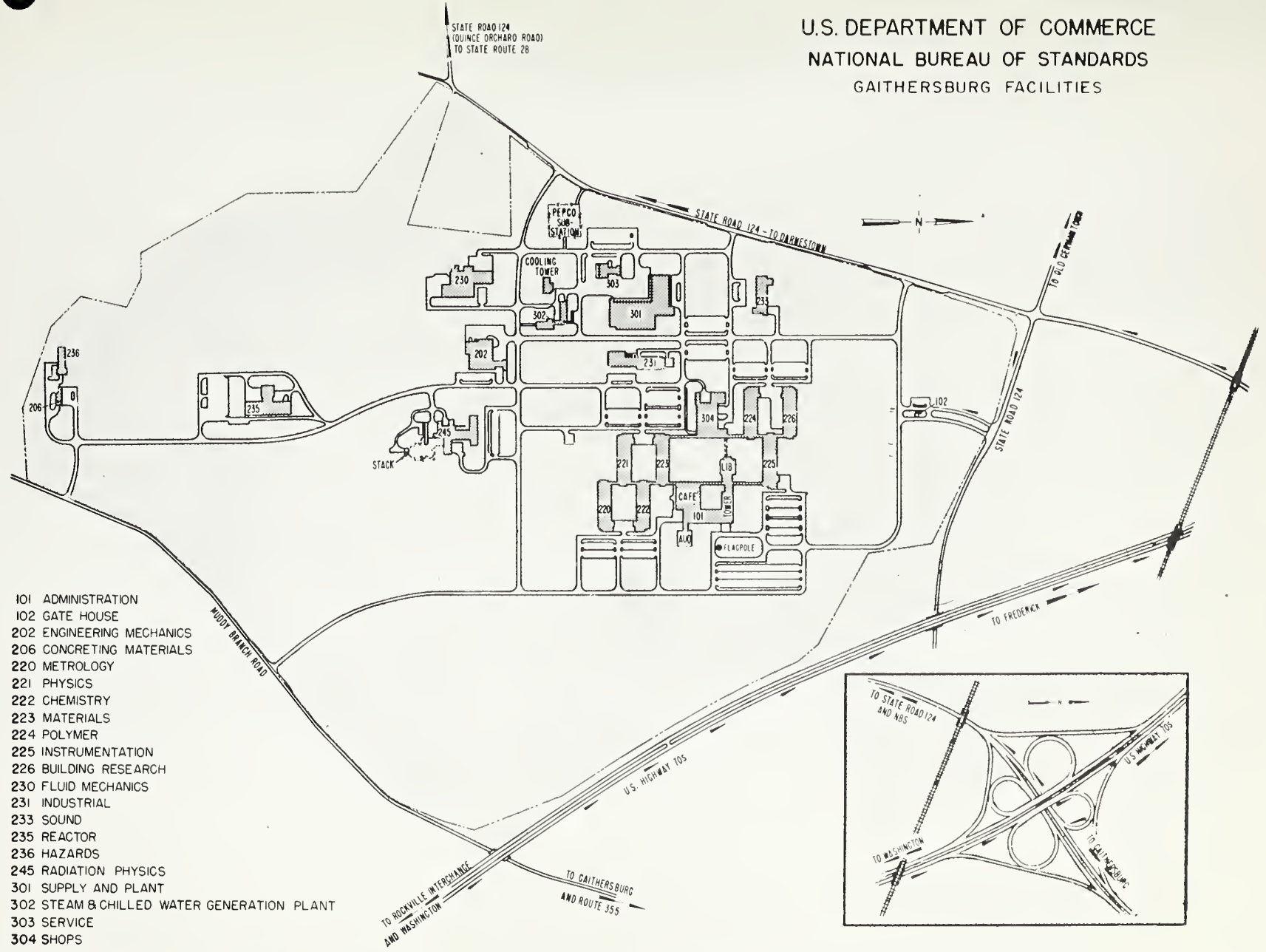
Photometry of Projectors.

NBS Report 8168 "Review of Elementary Theory of the Photometry of Projectors", has been prepared as a paper for formal publication. The paper will be presented at the Illuminating Engineering Society National Technical Conference in August, 1966.

VI. MISCELLANEOUS

Move to Gaithersburg Facility.

The general move of the National Bureau of Standards to the new facilities at Gaithersburg, Maryland, started late in the quarter. The Photometric Laboratories were among the first to move. A map of the new facilities is shown in figure 1. The Aviation Ground Lighting offices and laboratories are located in the Metrology Building (Bldg. 220) on the B corridor of the third floor. The mail address is Room A-311 MET, National Bureau of Standards, Washington, D. C. 20234. The stop number for mail sent through the Inter-Agency Mail and Messenger Service is 3. The telephone number is 301-921-2761, or by tie line 164-2761.


U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
GAITHERSBURG FACILITIES
STATE ROAD 124 (QUINCE ORCHARD ROAD) TO STATE ROUTE 28
STATE ROAD 124 - TO DARNESTOWN
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TO FREDERICK
MUDDY BRANCH ROAD
U.S. HIGHWAY 70S
TO ROCKVILLE INTERCHANGE AND WASHINGTON
TO GAITHERSBURG AND ROUTE 355
TO STATE ROAD 124 AND NBS
TO WASHINGTON
101 ADMINISTRATION
102 GATE HOUSE
202 ENGINEERING MECHANICS
206 CONCRETING MATERIALS
220 METROLOGY
221 PHYSICS
222 CHEMISTRY
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231 INDUSTRIAL
233 SOUND
235 REACTOR
236 HAZARDS
245 RADIATION PHYSICS
301 SUPPLY AND PLANT
302 STEAM & CHILLED WATER GENERATION PLANT
303 SERVICE
304 SHOPS

Figure 1


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