NATIONAL BUREAU OF STANDARDS REPORT

7799

Development, Testing, and Evaluation of Visual Landing Aids
Consolidated Progress Report for the Period October 1 to December 31, 1962

By
Photometry and Colorimetry Section
Metrology Division

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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. Research projects are also performed for other government agencies when the work relates to and supplements the basic program of the Bureau or when the Bureau's unique competence is required. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

Publications

The results of the Bureau's research are published either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau publishes three periodicals available from the Government Printing Office: The Journal of Research, published in four separate sections, presents complete scientific and technical papers; the Technical News Bulletin presents summary and preliminary reports on work in progress; and the Central Radio Propagation Laboratory Ionospheric Predictions provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: Monographs, Applied Mathematics Series, Handbooks, Miscellaneous Publications, and Technical Notes.

A complete listing of the Bureau's publications can be found in National Bureau of Standards Circular 460, Publications of the National Bureau of Standards, 1901 to June 1947 ($1.25), and the Supplement to National Bureau of Standards Circular 460, July 1947 to June 1957 ($1.50), and Miscellaneous Publication 240, July 1957 to June 1960 (includes Titles of Papers Published in Outside Journals 1950 to 1959) ($2.25); available from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

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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
Washington 25, D. C.

For the Period
October 1 to December 31, 1962

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

Development, Testing, and Evaluation of Visual Landing Aids
October 1 to December 31, 1962

I. REPORTS ISSUED

Report No.	Title
7706	Development of a Transmissometer Calibrator
7757	Development, Testing, and Evaluation of Visual Landing Aids, Consolidated Progress Report for the Period July 1 to September 30, 1962
21P-44/62	Photometric Tests of Eight 500-Watt, PAR-56, "Quartzline" Lamps Submitted by General Electric Company
21P-58/62	Photometric and Electrical Tests of a 200-Watt, Semiflush Mount Pancake Light Manufactured by Strong Electric Corporation
21P-62/62	Photometric Tests of a Cold-Cathode, Transitorized, FMF-6 Seadrome Light Manufactured by Nelson Lights Company
21P-64/62	Photometric Tests of Two Type L-842 Semi-Flush Mount Pancake Lights Manufactured by Westinghouse Electric Corporation
21P-73/62	Test of the Removal of Stubs of Tube Base Adapters
21P-80/62	Photometric and Colorimetric Tests of a Type OB22 Double Obstruction Light Manufactured by Hughey and Phillips, Inc.

II. VISIBILITY METERS AND THEIR APPLICATION

Slant Visibility Meter. The weather during this period was very favorable for making visual observations in restricted visibility conditions for comparison with the slant visibility meter records and data. Approximately 900 sets of observations were obtained. Most of these observations were obtained in stable or gradually changing atmospheric conditions which should make them very valuable for use in analyzing the performance of the slant visibility meter. A set of observations can be obtained only at three-minute intervals; thus considerable time was spent in obtaining these data. The data have been tabulated and corrected for instrument and calibration errors. The slant visibility readings as a function of the height of the spot on the beam being viewed by the detector have been plotted for individual scans of representative conditions at intervals during each test.

The slant visibility meter equipment has been performing very satisfactorily. The lamp now in use has been in operation for 3000 hours with four stops and the intensity has decreased only about 30 percent. The detector has operated well with only an occasional vacuum tube failure. The calibrations of the detector show that its performance remains normal except as affected by poor electronic tubes. A severe windstorm in October blew down the 92-foot tower which supported our visibility targets. This storm also blew the roof from the instrument shelter which contained the indicators and recorders for the slant visibility meter and the associated transmissometers. The shelter was repaired, the tower replaced, and all units were returned to normal operation. At one time when the projector was stopped in a position just above the horizontal, a great number - perhaps several gallons - of insects accumulated in the vicinity of the projector. Apparently they were attracted by the light from the projector.

Shipboard Visibility Meter. Tests are being made using various types of phototubes and photomultipliers in the receiver to determine which type will give the best signal-to-noise ratio during daylight. Interference filters manufactured by Baird-Atomic, Inc. have been received but have not been tried in the receiver to determine their effect on the signal-to-noise ratio.

Transmissometer.

100 Percent Setting Calibrator. NBS Report 7706, "Development of a Transmissometer Calibrator" has been issued. Air Force Cambridge Research Laboratories is preparing a specification based on this report. A calibrator unit has been loaned to that organization.

Expanded Scale Indicator. Figures for the report on the development of the expanded scale indicator have been completed.

Nomographs for the Computation of Visual Range. The nomographs for solving the Allard's Law relation, $E = IT^{D}/D^{2}$ have been completed and instructions for their use have been prepared.

III. AIRFIELD LIGHTING AND MARKING

Visual Approach Slope Indicators.

PAR-64 VASI Lamps. First drafts of NBS Test Reports 21P-22/62, 21P-42/62, and 21P-45/62 were prepared, giving the results of candlepower, luminous output, and voltage maintenance as a function of burning time of twelve off-focus PAR-64 VASI lamps submitted by three manufacturers. No generalizations can be drawn from the data obtained except that one group of lamps had high maintenance, but lower initial intensity and luminous output, as would be expected.

Stub Approach Beacon System. A few pilot comments were obtained. These indicated that the stub approach beacon is useful for circling approaches to runway 13 at Arcata. An FAA pilot and a Pacific Airlines pilot asked why this beacon was not operating during a period when it was malfunctioning. (The beacon was out of commission for a period of time because the starting winding of the motor burned out and the contacts of an intensity transfer relay arced across. The motor has been repaired and a new intensity transfer and control box has been constructed.) After service was restored, type 399 PAR lamps were installed in the beacon. Three of these lamps had failed after only four days of operation. Cracks in the reflector part of the lamps were the reason for the failures. The lamps were mounted in the PAR-56 lampholders and were burning continuosly at low or high intensity. Since only light rain occurred during this period of operation, failure may have been due to inadequate shock resistant qualities of this group of lamps. Since these lamps were replaced, there have been no more failures, but the lamps have not been rained upon.

500-Watt, PAR-56, "Quartzline" Lamps. NBS Report 21P-44/62, giving the results of photometric tests of two types of 500-watt, 20-ampere, PAR-56, "quartzline" lamps, was released.

Intensity Maintenance of 500-Watt, PAR-56, "Quartzline" Lamps. As reported in the Progress Report for July 1 to September 30, 1962, a study is being made of the intensity maintenance of these lamps as a function of burning time. Intensity distribution measurements have been made after every 100-hour burning period. The prismatic cover lamps have been burned 300 hours, and the average peak intensity is greater than 95% of the initial peak intensity. The stippled cover lamps have been burned 400 hours. The quartz envelope on one of these lamps shattered after approximately 200 hours. The average peak intensity of the three intact lamps is greater than 95% of the initial peak intensity. That of the shattered lamp is less than 5% of the initial peak.

Photometric Measurements and Life Test of 300-Watt, 20-Ampere, PAR-56, Stippled Cover and Prismatic Cover Approach Light Lamps. Qualification tests are in progress of four stippled cover and three prismatic cover approach light lamps.

Photometric and Efficiency Tests of a Transformer-Type Pancake Light. NBS Report 21P-58/62 was issued showing the results of photometric tests and current-voltage measurements of a semi-flush mount pancake light manufactured by Strong Electric Company, Toledo, Ohio. Although a peak intensity of 9.5 kilocandles was given in the Progress Report for the last quarter, this was reduced to 8.2 kilocandles because of corrections necessary to bring the lamp to rated lumen output and the unit to rated input current. The apparent efficiency of the transformer was 83%.

Photometric Measurements of Two Type L-842 Pancake Lights. Tests were made of two bidirectional pancake lights manufactured by Westinghouse Electric Corporation for conformance to the photometric requirements of FAA Specification L-842. One lens of one light failed to meet the intensity distribution requirements. In addition to the photometric tests, tests were made of several of the 1/2-ampere fuses placed in parrallel with the lamp for proper operation at 2.8 amperes, the lowest current used in service. All passed the test. NBS Test Report 21P-64/62, giving the results of the tests, was issued.

Double Obstruction Light, Type OB22. Measurements were started for the purpose of comparing the performance of four different types of lamps in a type OB22 obstruction light. The four lamps to be tested are types 1020/66/A21 (1000 lumens), 100A21/TS (1300 lumens), 100A21P (1170 lumens), and a developmental 120-volt lamp (1200 lumens) intended as a long-life replacement for the 100A21P lamp.

Tests of 6000-Hour Obstruction Light Lamps. The life test of eight developmental 120-watt, 6000-hour, A-21 obstruction light lamps was completed.

Life Tests of 6000-Hour, 300-Millimeter Code Beacon or Hazard Beacon Lamps. The six developmental lamps for this test were still burning on life test.

Supplemental Tests of Gasket Material and Cable Assemblies. NBS Test Report 21P-25/62 Supplementary, issued last quarter, showed deficiencies in gaskets and cable assemblies supplied with a type AL-1 flush approach-light unit. A third set of samples was submitted for test. The cable assemblies met the requirements of the applicable specification, but the gaskets were deficient.

Frangible Couplings. The report of "Test of the Removal of Stubs of Tube Base Adapters" has been issued (NBS Test Report 21P-73/62). Couplings modified as recommended in the report have been supplied to ASG for use in preparing a revised MS drawing.

Airfield Lighting Connector Field Tests. Early storms prevented investigation of the cause of the increased leakage of one of the connectors in the direct-burial field test of connectors. Any excavation during the rainy season may disturb the other connectors of the test. This investigation will be made as soon as the weather and stable soil conditions permit. Then a report of these field tests will be prepared. Additional measurements of ground resistance were made at the Arcata Airport, at Rhonerville Airport, and in the Eel River bottoms. The ground resistances at the two airports varied from 5 to 500 ohms, but in the river bottoms the resistance was 5 ohms or less.

"Fuses" for Series Pancake Lights. Present designs specify the operation of several low-wattage (generally 45 watts), 6.6-ampere lamps in a runway centerline lighting system from one isolating transformer. Unless some means of shorting the terminals of burned out lamps is provided, the failure of one lamp will extinguish all lamps on the sub-circuit with the failed lamps. The use of film cutouts has not been reliable when power is supplied through a 200-watt isolating transformer, particularly when the lighting system is operated at a low intensity setting. The source of the trouble is the low open-circuit voltage of the transformer. To overcome the difficulty, the Westinghouse Electric Corporation has incorporated a thermally actuated shorting switch in its design of a type L-842 light. This switch and an associated 50-ohm resistor in series with the heating element are connected in parallel with the lamp. This shunting circuit reduces the lamp current approximately 0.1 ampere when the system current is 6.6 amperes. Reducing the bypass current by increasing the resistance of the series resistor is not feasible since doing so would reduce the current through the thermal switch if the lamp should fail and the thermal switch would not be actuated if the system was operating at a low intensity setting.

Therefore, consideration was given to the use of a semiconductor device in place of the series resistor. Such devices are available with a sharp breakdown characteristic and when properly applied should pass a negligible current when connected in parallel with an operating 45-watt lamp and should pass sufficient current when the lamp filament opens to actuate the thermal shorting switch. Such devices are available from the International Rectifier Corporation under the trade name Klip-Sel Transient Voltage Suppressors. Types KA1DAF and KZ1DPF were connected in turn in place of the 50-ohm resistor in a Westinghouse Type L-842 light. The current through the shunting circuit was less than 0.001 ampere when the lamp was operating and the system current was 6.6 amperes. The current increased to the point at which the thermally actuated switch operated when the lamp was removed from its socket(s) and the system current was greater than 2.5 amperes. Thus, with the use of devices of this type, it would be possible to provide the protection now given in the Westinghouse type L-842 light without reducing the current through the lamp.

Cable Test-Detector Set TSM-11. A draft of a report on the tests and use of this equipment has been prepared. The report will include a discussion of the limitations and advantages of using this equipment for tracing cables or locating faults in cables, and additional instructions on how to use the equipment effectively, especially under conditions that are less than ideal. These more difficult conditions for locating faults or tracing cables include the presence of cross-talk or of interference from power cables, soil of low conductivity, grounding conductors (neutrals or counterpoises), underground pipe and conductors, and high-resistance or partial grounds. Experience in use of the TSM-11 equipment and familiarity with the location and performance of the electrical field installations are very important in obtaining satisfactory performance from this equipment.

IV. SEADROME LIGHTING

FMF-6 Seadrome Light. NBS Report 21P-62/62 was released. This report gives the results of photometric tests of a cold-cathode, transistorised FMF-6 seadrome light manufactured by Nelson Lights Company, South Pasadena, California.

V. CARRIER LANDING AIDS (TED NBS RSSH-32001)

Off-Glide-Path Indicator. Static observations of the performance of a Fresnel Lens Assembly to which experimental High-Low cells had been added were made during daylight on several occasions from an observation station on the roof of an apartment house 1.3 miles from the lights, and from the Naval Medical Center, 4 1/2 miles from the lights. The intensity of the system was sufficient to permit satisfactory viewing from the Naval Medical Center on only one occasion, a clear afternoon. On the mornings on which observations were made, the high sky and haze brightness limited the visual range to somewhat less than 4 miles. Observations indicated the following:

a. The High-Low cells provide a smooth transition from off-glide-path signal to the signal of the Fresnel.

b. The intensity of the High-Low cells was adequate when the cells were used without filters. The effective intensity of the cells was enough higher than the effective intensity of the "meatball" or of a datum arm that the High and Low cells were conspicuous when the "meatball" was just visible.

c. The addition of a red filter to the Low cell increased the conspicuity of the signal when the system was viewed at distances somewhat less than maximum range but decreased the range of this cell so that it could not be seen as far as the "meatball" or the datum arms. On one occasion when the useful range of the "meatball" and datum arms was somewhat more than 1.3 miles, the Low cell with red filter was not usable at 1.3 miles, but without the filter the signal was conspicuous at this distance.

d. The use of a green filter in the High cell was unsatisfactory. The range was less than that of the Low cell with a red filter and, in addition, the signal blended with the light from the datum arms and with the sky light.

e. Turbulence from the chimney of an apartment house near the line of sight at times produced a marked "blooming" of the "meatball" and the datum arms, making their signal unusable at times. From this it may be deduced that the "fuzzy meatball" reported in several reports of carrier-landing accidents was caused by the shimmer and turbulence produced by stack gases in the line of sight.

Sequence-Flashing Light Controller System. Observations were made of the effects of varying the duration and voltage of pulses applied in sequence to the lights of a simulated centerline light system. The observations indicated that in order to obtain adequate conspicuity of the pulsed signal, the pulse duration should be not shorter than 0.1 second and that a pulse voltage superimposed on the steady-state voltage as high as the rated voltage of the lamps will be required. The results of these observations have been incorporated into the draft of the specification for a sequence-flashing light controller system.

VI. MISCELLANEOUS TECHNICAL AND CONSULTIVE SERVICES

Review of Specifications and Drawings. The technical sections of the following specifications and drawings were reviewed and the comments have been forwarded.

MIL-L-6363D	General Requirements for Aviation Service Incandescent Lamps
W-L-101f	Lamp, Incandescent (Electric, Large, Tungsten Filament)

A revised list of aviation lamps has been prepared for this specification and is being referred to the lamp manufacturers for comment. The following lamps are included on the list.

Multiple Lamps

Watts	Volts	Bulb	Base
40	115 & 120	A21	Medium Prefocus
100	115 & 120	A21	Medium Prefocus
500	115 & 120	T20	Medium Bipost
620	115 & 120	PS40	Mogul Prefocus
1000	115 & 120	T20	Mogul Bipost
1200	115	T20	Mogul Bipost

Series Lamps

Watts	Current	Bulb	Base
30	6.6	T-10	Medium Prefocus
45	6.6	T-10	Medium Prefocus
204	6.6	T-14	Medium Prefocus
500	20.0	T-20	Medium Prefocus

MIL-C- (Draft)	Cable Connectors, Kit
MIL-T- (Draft)	Isolating Transformer for Wheels Warning Light
MIL-S- (Draft)	Strobe System, Centerline Guide Light (See Section V of this Report.)
Drawing MS 17814(ASG)	Frangible Coupling, Runway Marker Light
Drawing MS 17815(ASG)	Clamp Assembly, Runway Marker Light
Drawing MS 24526(ASG)	Airport Marker Light Base

VII. MISCELLANEOUS

Coast and Geodetic Survey. Personnel of the Coast and Geodetic Survey have worked at the Arcata Airport and in the vicinity making an obstruction and planning survey. They have placed new markers at the airport which will be convenient for our use.

Heliport Lights. Several angle-of-approach indicator lights (Type AA-1) and portable, battery-powered fluorescent lights (originally intended for floodlighting the LSO during night, field carrier-landing practice) were supplied to the Naval Observatory for use as lights for a temporary heliport.

Photometry of Flashing Lights. A study has been made of the flash characteristics of a number of battery-operated, barricade-type emergency lights with incandescent lamps to determine the feasibility of developing a simplified method of determining the effective intensity of lights of this type. It was found that the assumption that the flashes consist of rectangular pulses could result in significant errors when applied to certain types of lights. If the light is flashed by a switch of negligible resistance (for example, a relay), if the internal resistance of the battery is very low, and if the lamp is a low-current lamp, the light flashes have an approximately square wave form. However, if the resistance of the switch is not negligible as is the case when a transistor is used as the switching element, if the internal resistance of the battery is high, or if a low voltage, high current lamp is used, the wave form of the flash becomes nearly triangular in shape. This change in wave form affects the determination of both the effective intensity and the flash duration. Hence the use of a single "shortcut" method does not appear to be feasible.

U. S. DEPARTMENT OF COMMERCE
Luther H. Hodges, *Secretary*

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

THE NATIONAL BUREAU OF STANDARDS

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

WASHINGTON, D. C.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Office of Weights and Measures.

BOULDER, COLO.

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

CENTRAL RADIO PROPAGATION LABORATORY

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

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

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

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

RADIO STANDARDS LABORATORY

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

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

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