NATIONAL BUREAU OF STANDARDS REPORT

6352

Development, Testing, and Evaluation of Visual Landing Aids
Consolidated Progress Report for the Period October 1 to December 31, 1958

By
Photometry and Colorimetry Section
Optics and 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. 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 of the 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.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($0.75), available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Inquiries regarding the Bureau's reports should be addressed to the Office of Technical Information, National Bureau of Standards, Washington 25, D. C.

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
Aerology Division
Bureau of Aeronautics
Department of the Navy
Washington 25, D. C.

For the Period
October 1 to December 31, 1958

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

Development, Testing, and Evaluation of Visual Landing Aids
October 1 to December 31, 1958

I. REPORTS ISSUED

Report No.	Title
5893 (Supplementary)	Report of a Survey of Visual Landing Aids
6190	Current-Intensity, Voltage-Intensity, and Current-Voltage Characteristics of Airfield Lighting Lamps
6225	Development, Testing, and Evaluation of Visual Landing Aids, Consolidated Progress Report for the Period July 1 to September 30, 1958
21P-37/58	Photometric Tests of Two Type 4519 Sealed-Reflector Lamps
21P-39/58	Physical and Electrical Tests of Connectors for Airport-Lighting Cable
21P-40/58	Physical and Electrical Tests of a Sample of Airport-Lighting Cable
Letter Report	Evaluation of Seadrome Circuit Diagrams

II. VISIBILITY METERS AND THEIR APPLICATION

Visibility Meter for Shipboard Use. Arrangements to obtain a nepholometer-type instrument from the Macbeth Corporation for study have not been completed. In the meantime, further consideration has been given to the problems involved in the design of a "back-scatter" type instrument. The following conclusions have been reached.

1. A flash tube should be used as the light source.

2. Because of the variations in the intensity of the source with changes in the input voltage, lamp characteristics, receiver sensitivity, etc., an instrument which alternately views a direct flash from the lamp and a flash from the light scattered from the fog should be used.

3. The output of the receiver should be either the ratio of the flux received from the scattered light and the direct light or the logarithm of the ratio.

4. The logarithm of this ratio is preferable, since Curcio and Knestrick found an essentially straight-line relation between the logarithm of the visibility and the logarithm of the amount of back-scattered light incident on the receiver.

5. The output should be recorded on a chart rather than appear only as the deflection of an oscilloscope.

6. The instrument should be automatic and not require manual adjustment to obtain a reading.

The design of an instrument based on these considerations has been started. In this connection, design and construction of an automatic recording spectroradiometer has just been completed by another group at the National Bureau of Standards. Many of the design features of this instrument are directly applicable to the design of the shipboard visibility meter and will be used.

Measurements of Illumination and Sky Brightness. Measurements have been made of the effects of the runway- and approach-light systems on the horizon sky brightness and horizontal illumination. The ambient horizon sky brightness was 0.005 footlambert or less. The brightness of the horizon sky above the runway centerline varied from 0.1 to 0.8 footlambert when the runway lights were at full intensity. The brightness varied with the fog density, being a maximum when the visibility was in the range 0.5 to 5 miles. Similarly the horizon sky above the axis of the approach lights varied from 2 to 10 footlamberts when the slopeline lights were at full intensity.

The illumination on the runway surface increased from 0.003 footcandle when the runway lights were off to 0.04 footcandle when the runway lights were at full intensity. This illumination varied only slightly with changes in fog density.

Errors in Transmissometer Measurements Resulting from Scattered Light from the Light Source. Sufficient data have been collected using a blue-sensitive phototube. The results of the tests to date are summarized in table II-1.

Table II-1. Errors in Transmissometer Measurements Resulting from Scattered Light

Transmission per 500 feet %	Transmission Error		Approximate Visual-Range Error (Day)	
	Red-Sensitive Tube %	Blue-Sensitive Tube %	Red-Sensitive Tube %	Blue-Sensitive Tube %
0.1	1.2	1.1	0.5	0.5
0.01	3.4	2.5	0.7	0.5
0.001	10.0	4.4	1.4	0.6
0.0005	11.9	5.5	1.2	0.6

Thus it appears that although it has been expected that these errors resulting from light scattered from the source into the receiver would be large (see Middleton, Vision Through the Atmosphere, page 181), the errors are of no practical importance for the NBS transmissometer. Hence an extensive series of baffles as described by Middleton (and used by NBS in the early stages of transmissometer development) is unnecessary.

To determine the effect of increases in the size of the angular aperture of the receiver, the receiver unit of the instrument under study has been replaced with one having a variable field stop. A limited number of measurements will be made with several angular apertures.

WL-759 Tubes. Twenty trigger tubes have been ordered. These tubes will be tested using the several test methods which have been proposed and the results of the tests will be compared. After tests are completed, the tubes will be available for use in Navy transmissometers.

Slant-Visibility Meter. The instrument has been out of service for part of the quarter because of mechanical malfunctioning of the compressor of the projector and of the drive mechanism of the receiver. The equipment is being repaired and will be returned to service next quarter.

III. DEVELOPMENT OF AIRFIELD LIGHTING AND MARKING COMPONENTS

Runway Distance Markers. The internally illuminated runway distance markers have not yet been received from Cecil Field. Installation and testing of these markers will begin as soon as they arrive.

Transformer Characteristics. Measurements of the electrical characteristics of 200-watt, 6.6/6.6-ampere series isolating transformers operated in a saturated condition have been completed and a report has been drafted. These data are needed in the design of the lighting systems of destination signs, distance markers, etc., which should operate at a nearly constant brightness but which are supplied by the variable-brightness runway-lighting system. The characteristics of transformers of three manufacturers were measured using multiple-lamp loads ranging from 25 to 1000 rated watts. A type NC-3 regulator was used to supply the transformers.

Maintenance Manual. A review of information pertinent to airfield lighting equipment and maintenance has continued. It is believed that distribution of the technical data for airfield lighting equipment can be most effectively accomplished by compiling the information in two parts. The first part, which is intended for general distribution, would contain the information needed for identification, planning, and procurement and would indicate where other applicable information could be obtained. The second part would contain the detailed information necessary for the installation, operation, and maintenance of the equipment and would be distributed only to those requiring this information. This part could be an assembly of adequate Technical Orders and supplements to these orders.

Automatic Intensity Control of Approach- and Runway-Light Systems. Further consideration has been given to the design of an automatic intensity-control system. Particular attention has been given to the possibility of using the signal from the station transmissometer to operate the intensity control. The principal difficulty in using the transmissometer is the small differences in the transmittance corresponding to steps 3, 4, and 5. This is illustrated by the values shown in table III-1.

Table III-1. Relations Between Brightness Settings and Transmittance.

Brightness Setting	Transmission per 500 feet*			
	Approach Lights		Runway Lights	
	Night %	Day %	Night %	Day %
1	100 to 61	---	100 to 37	---
2	60 to 22	---	36 to 4.1	---
3	21 to 8.1	100 to 68	4.0 to 0.61	100 to 46
4	8.0 to 3.0	67 to 25	0.60 to 0.090	45 to 6.1
5	2.9 to 0	24 to 0	0.089 to 0	6.0 to 0

* These values are based upon data obtained at the Landing Aids Experiment Station and the Naval Air Test Center several years ago. Because of changes in approach-light-system configuration and runway-light design, the transmittances are probably not strictly applicable to present operations. It is believed, however, that values applicable to present operations will lie between the approach- and runway-light settings given above.

Since the uncertainty in the transmissometer reading resulting from background illumination and zero shifts may be as high as 2%, it is apparent that the use of a system of current-sensitive relays in the output of the transmissometer indicator would be unsatisfactory for nighttime conditions.

Survey of Visual Landing Aids. Detailed data on operations and installations were not included in NBS Report 5893, Survey of Visual Landing Aids. Since these data may be useful in future planning, they have been tabulated and issued as NBS Report 5893 (Supplementary).

IV. DEVELOPMENT OF SEADROME LIGHTING COMPONENTS

Channel Identification Lights. The motor-drive units of the four channel identification lights installed at NAS Norfolk have been replaced with new motor-drive units of the type described in the progress report for last quarter. Informal reports indicate the new units are operating satisfactorily.

Specification MIL-L-21703, Light, Runway Identification. This specification has been reviewed and the sections pertaining to the motor drive have been revised to require a drive of the new design. The assembly drawing of the light referenced in the specification, NBS 43-327, has been revised to show the new motor-drive unit and other improvements resulting from data obtained from Norfolk and from laboratory tests. The detail drawings of the light are now being revised to include the changes shown on the assembly drawing.

Drawings P-4406 and P-4416 Prepared by NAS Norfolk. The seadrome circuit diagrams prepared by NAS Norfolk have been reviewed and evaluated. The results of this work were reported by letter of October 21, 1958. The study indicated that the circuitry shown on the drawings would be satisfactory but that considerable simplification was possible.

Battery-Operated Sealane Lights. Arrangements are being made to obtain a transistorized inverter which will operate a 6-watt fluorescent lamp from a 12-volt storage battery from Lincoln Electronics, Anaheim, California. It is hoped that a unit of this type will be superior to a mechanical vibrator in efficiency and life.

V. DEVELOPMENT OF CARRIER LIGHTING AND MARKING COMPONENTS

Lights for Carrier Deck Personnel (TED NBS SI-5001). A service-test quantity of wands made of polyethylene has been constructed in the laboratory, and delivered to the Visual Landing Aids Branch, Bureau of Aeronautics, for service tests aboard a carrier. These wands were designed for flashlights using 2 C-size dry cells, as it is believed that the use of dry cells will be more satisfactory than the use of rechargeable cells and that the C-size is preferable to the D-size flashlight.

Goggle Lights. Completion of the construction of a service-test quantity of "eyeball" or goggle lights has been delayed pending receipt from the Bureau of Aeronautics of information on the desired location and size of the battery for the lights.

VI. PHOTOMETRIC AND ELECTRICAL TESTS OF AIRFIELD AND SEADROME LIGHTING EQUIPMENT (TED NBS SI-5003)

Connectors for Airport-Lighting Cable. A report giving the results of physical and electrical tests of connectors for airport-lighting cable supplied in kit form by A'G'A Division of Elastic Stop Nut Corporation of America, Elizabeth, New Jersey, has been released (NBS Test Report 21P-39/58). The connectors are intended for use with

non-metallic-sheathed cable having an outside diameter of 0.575 to 0.775 inch and a single No. 8 AWG conductor, and are interchangeable with connectors conforming to figure 6 of CAA Specification L-823.

The results of the tests and a study of the design of the connectors indicate that the service performance of connectors of this type will be superior to that of connectors of the type specified in figures 8 and 9 of Specification MIL-C-7192B(Aer).

Tests of the maintenance of insulation resistance are being made. Seven splices were prepared on short sections of 5000-volt runway-lighting cable. The sections were immersed in water and the insulation resistance was measured daily for 45 days using applied voltages of 10 kv and 15 kv. At the end of the 45 days, 5 kv was applied continuously to the connectors and resistance measurements were made weekly. After 60 days there had been no significant change in insulation resistance. The samples will be removed from the water and buried in the ground during the next quarter.

The insulation resistance of the connectors was so high (about 70,000 megohms) that it was necessary to use a galvanometer instead of the microammeter in the output of the "Takk" tester.

Airport-Lighting Cable. Physical and electrical tests of a length of airport-lighting cable have been completed and a report released (21P-40/58). This cable, which is understood to have been in stock for a number of years, was tested for conformance to the requirements of Specification MIL-C-4921. The test results indicate that the cable is satisfactory.

Characteristics of Airfield-Lighting Lamps. A report has been completed summarizing the results of measurements at the National Bureau of Standards of the relative intensity-current and the relative intensity-voltage characteristics of lamps used in aviation ground lighting. This report, NBS 6190, includes the data given in a previous report, NBS 4463, and the data which have been obtained since the release of report 4463. It is believed that the data are now sufficiently complete so that the characteristics of new lamps can be determined by comparison with data given in the report for similar lamps with an accuracy sufficient for most engineering purposes.

Lamps for Lightweight Optical Glide-Path System. Intensity distribution measurements have been made of two type 4519 lamps, and the results reported (NBS Test 21P-37/58). Lamps of this type were used in the feasibility tests of the lightweight optical glide-path system. The measurements indicate that the intensity distribution of these lamps is not optimum. A distribution which is flatter both horizontally and vertically is desired. Efforts are being made to obtain a lamp with a more satisfactory intensity distribution.

VII. TECHNICAL AND CONSULTIVE SERVICES

"Bartow" Patent. The search of the technical literature and and National Bureau of Standards files for references pertinent to the patent infringement suit of the Welsbach Corporation has been completed. A memorandum listing these references and discussing their pertinency has been prepared and forwarded, with copies of most of the documents referenced, to the Department of Justice.

U. S. Standard for Signal Light Colors. Progress is being made in developing the details essential to the adoption of the U.S. Standard by the government and civil agencies that are cooperating in its development. The committee on aeronautical uses, under the chairmanship of Mr. W. C. Fisher, anticipates no difficulties since no changes in the color limits will be involved. The highway committee faces the most difficult problem because it is undertaking to persuade its sponsoring organizations to make several changes which will bring their colors closer to those now used for aeronautical lights. A first draft of Part III of the Standard has been completed and circulated.

Handbook on Signal Light Colors. The author's draft of the text has been completed and submitted to a reviewing committee. The problem of computing the chromaticity of filters of progressive thicknesses of the same glass has been solved by the development of a new 704 program which will save 90% of the time formerly required for such computations. This will greatly increase the scope of figures showing filter characteristics and probably will lead to the establishment of better tolerances for the similar chromaticity characteristic.

C.I.E. Meeting. Mr. Douglas attended the meetings of the C.I.E. Working Party on Aviation Ground Lighting which were held in London on September 30 and October 1. The meetings were devoted primarily to an exchange of technical information and views of factors related to these items. One purpose of this exchange was to provide guidance for some of the countries which are now becoming active in the field of aviation ground lighting. The group also inspected the lighting installations at Gatwick Airport from the ground and from the air.

The problem of a suitable intensity distribution for approach lights had been referred to the group by the International Civil Aviation Organization. The group decided after thorough discussion to recommend the distribution now used by the U. S. and described in the report of the Sixth Session of the Aviation Ground Aids Division of ICAO. The group also recommended to ICAO that beam spreads of lights be given as the spread at 50% of peak intensity and that omni-directional lights be defined as lights having a maximum change in intensity with azimuth of less than 4 to 1 at each angle of elevation.

Visits were also made to a number of British organizations concerned with lighting problems. A detailed report giving the results of the trip is being prepared.

Fog Dispersal. Representatives of several research organizations have consulted personnel of the Arcata Field Laboratory regarding atmospheric conditions, instrumentation, and test sites at Arcata in connection with fog dispersal research which will be done under contract for the Cambridge Air Force Research Center.

U. S. DEPARTMENT OF COMMERCE
Lewis L. Strauss, *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 headquarters in Washington, D. C., and its major laboratories in Boulder, Colo., 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 front cover.

WASHINGTON, D. C.

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

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

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Engine Fuels. Free Radicals Research.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Radiation Theory. Radioactivity. X-rays. High Energy Radiation. Nucleonic Instrumentation. Radiological Equipment.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. 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. 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 Safety Standards. Heat Transfer.

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

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

• Office of Basic Instrumentation.

• Office of Weights and Measures.

BOULDER, COLORADO

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. VHF Research. Ionospheric Communication Systems.

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

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


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