NATIONAL BUREAU OF STANDARDS REPORT

5889

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

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Development, Testing, and Evaluation of Visual Landing Aids

Consolidated Progress Report
to
Ship Installations Division
Bureau of Aeronautics
Department of the Navy
Washington 25, D. C.

For the Period
January 1 to March 31, 1958

For
Bureau of Aeronautics Projects
TED No. NBS-AE-10002
TED No. NBS-AE-10011

U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

Development, Testing, and Evaluation of
Visual Landing Aids

January 1 to March 31, 1958

I. REPORTS ISSUED

Report No.	Title
2567 (Revised)	Development of a Special Test Set for Transmissometer Use.
5767	Development, Testing, and Evaluation of Visual Landing Aids, Consolidated Progress Report for the Period October 1 to December 31, 1957.
5781	A Redesign of the Switching Mechanism of the Type FMF-6B Channel Marker Light.
21P-9/58	Intensity Distribution Measurements of Four Type PR-12 Miniature Lamps.
21P-12/58	Photometric and Life Tests of Four 500-Watt, 20-Ampere, T-24 Airport Lamps.
21P-15/58	Mechanical and Thermal Tests of Runway Marking Materials.
Letter Report	Tests of Single-Conductor Submarine Cable.

II. RESEARCH AND DEVELOPMENT, LABORATORY TESTING, AND CONSULTATION SERVICES IN CONNECTION WITH VISIBILITY, AIRFIELD LIGHTING, AND FOG MODIFICATION PROBLEMS (TED NBS-AE-10002).

a. Visibility Meters and Their Application.

After a request was received for twenty-five copies of NBS Report 2567, Development of a Special Test Set for Transmissometer Use, for use by the Air Weather Service, this report was revised so that sets conforming to current practice can be obtained. The revisions consist of the minor circuit changes and modifications of adjustment procedures which experience with the test set has indicated to be desirable.

Because the difficulties encountered at the Field Laboratory with noise in the slant range visibility meter appear to be in the

phototube stage, arrangements have been made with the Continental Electric Company to supply a service test quantity of phototubes with a shadowless-anode and a structure designed to reduce microphonics. Delivery is expected next quarter.

The difficulties with the type WL-759 trigger tubes appear to have been solved. A conference was held on January 22 which was attended by representatives of the government agencies concerned and of the manufacturer. The difficulties experienced during the past three years were reviewed in detail. Following this conference the manufacturer revised the processing procedure and submitted a sample lot of tubes made with the revised procedure. Tests have been made of these tubes. Sensitivity, leakage, and stability are very satisfactory and there has been no significant drift in the starter-anode voltage required to trigger the tubes.

b. Airfield Lighting and Marking.

Intensity distribution measurements have been made of four PR-12 flashlight lamps and a report has been released. The data were obtained for use by a contractor in the design of a lens for portable battery-operated emergency lights. (NBS Test Report 21P-9/58).

Intensity distribution measurements have been made of an experimental fueling-lane light made by the L. C. Doane Company. This light uses a 200-watt, 6.6-ampere, PAR 46 sealed-reflector lamp. The intensity of this light is several times that of the lights now being used. A report is being prepared.

Runway-Distance-Marker Paints. The exposure of test panels for the study of the effects of outdoor weathering of fluorescent paint made at several Naval Air Stations was completed during the previous quarter. A report of the reflectance data obtained during this study is being prepared.

Runway-Marking Materials. Tests of physical properties (impact adhesion, plasticity, abrasion resistance, temperature cycling, and laboratory aging) were completed during the previous quarter. A report of the results of these tests has been prepared and released during this quarter (NBS Test Report 21P-15/58). Optical tests to observe the effects of these physical tests are expected to be completed during the next quarter.

c. Seadrome Lighting.

Battery-Operated Seadrome Lights. An improved 6-watt fluorescent channel-marker light is under consideration, and a study has been undertaken of several types of batteries for powering several possible lamp circuits.

The lamp circuits being considered are:

1. A modification of the circuit presently used in the type FMF-6B light. This circuit draws approximately 100 milliamperes from a 90-volt dry battery pack.

2. A circuit employing an electro-mechanical vibrator which draws approximately 2 amperes from a 6-volt lead-acid battery.

3. A circuit employing a transistorized inverter which the manufacturer specifies as drawing 1.2 amperes at 6 volts.

The types of batteries under study include:

1. The 90-volt dry battery in current use.
2. A 6-volt lead-acid charge-retaining battery.
3. A 6-volt silver-zinc battery
4. A 6-volt nickel-cadmium battery.

Table I shows the results of the study of these battery types to date. In these studies only the first two types of circuits listed were considered. Further studies including those of transistorized circuits will be made.

Cable-Fed Buoy-Mounted Seadrome Lights. Delivery of a service-test quantity of these lights has been completed. The lights are being held at the National Bureau of Standards pending shipping instructions. A report giving the results of life tests of the 500-watt, 20-ampere, T-24 lamps for use in these lights has been released. (NBS Test Report 21P-12/58.)

Approach-Light Lamps. Delivery of a service-test quantity of 500-watt, 20-ampere, PAR 56 approach-light lamps has been completed. Intensity distribution measurements have been made of lamps from this lot. A report will be prepared when the life test of the lamps is completed.

Battery	Type	Rated Volts per Cell	Volts-Total	Rated Amperes per Cell	Amperes Total Load	Rated Amp-Hrs.	No. of Cells Required	Weight (lbs)	Cost ($)	Volume (cu. ft.)	Length of Cycle (Months)	Kilocandle-Hrs. per Cycle*	No. of Cycles Available	Total Months of Service	Kilocandle-Hrs. Available	Candle-hours per $ of Original Investment
Burgess 3M60	Dry	90	90	**		--	4 Parallel	45	31.44	0.6	0.6	3.77	1	0.6	4	120
Willard DD-5-1	Lead-Acid	2	6	0.5	2	200	12 3 Series 4 Parallel	312	162.24	2.56	0.9	5.08	20 to 30	18 to 27	102 to 152	626 to 940
Willard DH-5-1	"	2	6	1	2	600	6 3 Series 2 Parallel	324	148.80	2.96	2.5	14.1	"	50 to 75	282 to 423	1895 to 2840
Willard DHB-5-1	"	"	"	"	"	"	"	498	239.00	4.48	"	"	"	"	"	1180 to 1770
Silvercel LR60	Silver-Zinc	1.5	90	**	0.1	60	60 Series	110	4080	1.0	2.5	15.0	60 to 100	150 to 250	900 to 1500	221 to 368
Silvercel LR300	"	1.5	6	**	2	300	16 4 Series 4 Parallel	148	3840	0.8	2.5	"	"	"	"	234 to 391
Sonotone 150L420	Nickel-Cadmium	6#	6	**	2	200##	3 Parallel	234	1092	1.64	1.25	7.0	100	125	700	641
Sonotone 300M320	"	6#	6	**	2	320##	2 Parallel	472	1702	3.70	1.3	7.5	"	130	750	441

* Based on a 6-watt green fluorescent lamp

** Not specified

\# Individual cells of the nickel-cadmium type are rated approximately 1.2 volts per cell. In this table, when referring to the nickel-cadmium type battery, the word "cell" should be interpreted as meaning a battery pack consisting of 5 cells in series, supplied by the manufacturer as a stock item and identified by the stock number listed in the first column of this table.

Estimated by manufacturer on the basis of their 5-hr. rate.

Photoelectric Control for Battery-Operated Seadrome Lights. A feasibility model of the photoelectric control outlined in NBS Report 5664, Progress Report for July 1 to September 30, 1957, has been designed and constructed. This device uses two groups of photocells connected to single-stage transistor amplifiers to start and stop the lights. A hand-held spotlight will activate the device from distances of more than 50 feet.

d. Carrier Lighting and Marking.

A brief study has been made of the problem of coding the "High" and "Low" cells of a lens-type optical glide-path indicator. The following coding appears satisfactory:

"Low" signal - Approximately 160 flashes per minute with the "on" and "off" periods equal.

"High" signal - Approximately 30 flashes per minute, with the "on" period three times as long as the "off" period.

The joint Navy-Contractor meeting held at Burroughs Research Center, Paoli, Pennsylvania, on February 11 was attended and the results of National Bureau of Standards studies in the field of optical glide-path systems were presented and their bearing on the designs of the systems being designed by the contractors discussed.

e. Lights for Carrier-Deck Personnel.

The flashlight-mounted illuminated wands have been further improved to achieve lighter weight and greater ease of production fabrication. A hollow, thin-walled conical plastic wand has been substituted for the solid wand described last quarter. Both the inside and outside of the wand have been frosted successfully by dipping in concentrated nitric acid. By defocusing of the lamp in the flashlight, adequate uniformity of brightness has been achieved. The design of the entire unit is now completed on a sample basis. The flashlight is so designed that it may be used with size C dry cells or with rechargeable nickel-cadmium batteries. A small connector is being installed at the rear of the flashlight for connection to a suitable charger, or for use with any interconnected lighting equipment such as chest, belt, or "eyeball" lights as may be desirable on the basis of new developments.

No further work has been done on other types of lighting equipment, since there has been no showing of interest. If further

development work is desired, a conference of interested officers should be arranged to provide information as to desirable goals.

In the meantime, several samples of the flashlight-wand are being constructed and should be completed very shortly. These represent an immediate improvement in several respects over presently used wands insofar as they are lighter, smaller, more uniformly bright than the present wands and can be used with rechargeable batteries. It is recommended that evaluation quantities be procured as soon as possible for fleet trial, and, if such trial warrants, that the new design be made standard for fleet use.

f. Personnel.

Messrs. R. T. Vaughan and R. W. Crouch of the staff of the section have been assigned to aviation ground-lighting projects. Their assignment will expedite the work on these projects.

g. Facilities.

A facility for the life testing of series lamps has been installed in the Lamp Test Building of the National Bureau of Standards. A type C-1, 4-kilowatt regulator is used. Regulated voltage is supplied to the regulator. An automatic cutoff is provided so that the failure of a lamp will de-energize the circuit.

III. VISIBILITY AND BRIGHTNESS TESTS, SURVEYS, EVALUATION AND ANALYSIS OF VISUAL LANDING AIDS, BASIC TESTS AND EQUIPMENT, AS A FIELD SERVICE AT ARCATA, CALIFORNIA (TED NBS-AE-10011).

a. Airfield Lighting and Marking.

The preparation of four hundred copies of NBS Report 5243, Maintenance of Airfield Lighting Systems, Part III, Troubleshooting Procedures for Series Circuits, has been completed. These were prepared for the Bureau of Aeronautics for distribution to their field organizations and Naval and Marine Corps Air Stations.

Approach Beacons. The approach beacons were observed on a flight in clear, daytime conditions. The approach was made as a standard glide slope approach. The beacons were first seen when the aircraft was about 8 miles from the threshold. They provided considerable alignment guidance at a distance of 5 miles. The threshold lights did not contribute much to the guidance until the aircraft was within 2 miles of the threshold. The approach beacons have been

prepared for shipment and will be shipped to a station for operational testing as soon as the authorization is obtained. The autotransformers and contactors for the service test installations have been received at this time. A report giving the results of the development and testing of the approach beacons should be completed during the next quarter.

Taxiway-Turnoff Indicator. A test was made to determine if scattered light from a high-intensity beam of light directed across a runway would have any practical application for indicating taxiway turnoffs at night. The possibility that such a beam could provide directional, as well as locational, information was considered important. The test was made in conditions of fairly good visibility (approximately 5 miles). Under this condition the beam of light was of little use. The light reflected from the surface of the runway provided more information, but neither the scattered light in the beam nor the light reflected from the pavement could be seen at a sufficient distance to provide the needed information. Additional tests under more restricted visibilities will be made when suitable atmospheric conditions occur, to determine what information increased scattered light may provide.

Comments from pilots indicate that the color is of more importance than the placement of lights when the lights are placed in the rows of runway lights to mark taxiway turnoffs.

Wind-Direction Indicator. Pilot comments obtained during the survey of visual landing aids at Air Stations in California indicated a need for a wind-direction indicator in the vicinity of the threshold. To study this problem, a remote-indicating wind-direction indicator has been fabricated and installed adjacent to the touchdown area on runway 31. The remote indicator was placed about 25 feet to the left of the runway edge and approximately 1000 feet from the threshold. The indicator has a four-foot square black background and a white arrow three feet long with an 18-inch point and a shaft six inches wide. The arrow is pivoted at its center. It is driven by a selsyn motor through a 4.4/1 gear train. This selsyn is driven from a wind vane connected through a 1/4.4 gear train to a selsyn transmitter. The indicator background and arrow are mounted vertically in the same manner as the runway distance markers. The arrow has a neon tube mounted on it for night use. At present the neon arrow is operated continuously from a 115-volt source. The two assemblies are constructed of light wood and are designed to be frangible. Nearly all pilot comment has been favorable and indicates that the indicator should be placed nearer the threshold so that it will be more useful for landing aircraft. The indicator will be relocated nearer the

threshold and additional pilot comment will be requested. The transmitter will remain in its present location approximately 1100 feet from the threshold and approximately 75 feet off the left side of the runway pavement.

No pilot has reported confusion of the meaning of the indication of the arrow, which is:

↑ head wind

↓ down wind

→ wind from right

← wind from left

(The arrow assumes any position and is not limited to the four examples.) The 4.4/1 gear ratio was used to provide some damping of the movement which was experienced with a 1/1 ratio of the transmitter and receiver selsyns. According to pilots, the neon red tube on the white arrow causes some light "flare" which reduces the effectiveness of the arrow at distances greater than 2000 to 2500 feet.

Runway Distance Markers. No tests have been made this quarter due to lack of fog. Some reworking of the signs has been done. The fluorescent orange sign has been repainted with a flat black background and fluorescent orange numerals. The international orange sign was repainted. The dot sign was reduced in size to 3' x 5'. Tests will commence when the weather becomes suitable.

b. Electrical Engineering.

Visual Landing Aids Survey. The final draft of the survey of the seven West Coast Navy and Marine Corps Air Stations was completed and returned to Washington for processing. An appendix of the Pilots' Comments was prepared and will be included in the report.

Maintenance Manual. Work on the next section of the Maintenance Manual will be resumed during the next quarter. The next section to be prepared will be Routine and Preventive Maintenance Section.

Cable-Fault Finding. The primary feeder cable to the visibility test range failed and the TSM-11 was used to determine the location of the fault (ground). The ground fault was quickly and accurately located. Tests and checks made last summer with dry soil conditions with this equipment gave unsatisfactory results. (See NBS Report 5767, Progress Report for October to December 1957.) This test

was made when the ground had been well soaked by rain over an extended period. Checks with the local Power Company indicate that a good ground (20 ohms) is very difficult, if not impossible, to obtain in this area. Further checks of the TSM-11 will be made as the ground dries out during the next several months.

Over-Current Protector for Monocyclic-Square Regulators. The over-current protector was returned to Washington where it was rebuilt to correct the difficulties reported in the Progress Report for the previous quarter (NBS Report 5767). It has been re-installed in the vault. A pilot light will be connected to indicate the operation of the protector. Further tests will be made during the next quarter to determine if this equipment meets design requirements.

c. Research in Visibility and Visibility Measurements.

Effective Intensity of Flashing Lights. Some changes in the method of treating the data have been made. The draft of the report was checked. The field-test section of this report has been completed and most of the analyses of results are complete. The effective-intensity equation proposed by Blondel and Rey,

$$I_e = \frac{\int_{t_1}^{t_2} I\,dt}{a + t_2 - t_1}$$

appears valid. The lights tested had flash durations of approximately 0.25 and 0.45 seconds and 30 and 200 microseconds. The value of "a" is different for daytime and nighttime conditions. For the lights of longer flash duration a value of "a" between 0.2 and 0.3 was obtained for daytime and a value of approximately 0.4 for nighttime. For the condenser-discharge lights the values of "a" are 0.1_5 for daytime and 0.3_5 for nighttime conditions.

Slant Visibility Meter. The projector motor was completely burned out as a result of a power failure and has been replaced. Apparently the circuit breakers failed to operate properly. In addition, the compressor became unserviceable and was replaced with a piston-type compressor obtained from the Weather Bureau. A storage tank was installed in the air line to the lamp to smooth the air flow. The air pressure has been increased from 7 lbs/in^2 to 10 lbs/in^2. The slip rings carrying power to the lamp failed again. There was evidence of corrosion at points where the brushes remain stationary during down time. The slip rings were removed and replaced with flexible leads. Lamp life has been improved considerably as a result of these

changes. The average life of lamps from lot #10 was 140 hours before the modifications and is now 480 hours. The latest lamp put into service has operated 768 hours. It has been repeatedly started and stopped and has been off for periods as long as two days. Considerable time has been spent in trying to locate a source of noise in the detector of this instrument. The noise comes from the preamplifier and is eliminated by removing the phototube. All critical components have been checked or changed, but the source of the noise has not been found.

Transmissometers. Additional field checks of the transmissometer calibrator indicate that it continues to operate satisfactorily. A report giving the results of the field tests will be completed in the near future.

Comparison tests of the stability of indicators with standard and modified bridges have continued.

No data on the effects of scattered light on transmission measurements were obtained this quarter as there were no periods of very low visibility. The red-sensitive phototube has been replaced by a blue-sensitive phototube in order to obtain a measure of the variation of the scattered-light error with wavelength.

Brightness and Illumination Measurements. The installation of the instruments, signal lines, and remote indicating equipment is now nearly complete. This equipment will provide simultaneous measurements of horizontal illumination and of horizon sky brightness and illumination on a vertical plane as a function of azimuth at two locations approximately 5000 feet apart. The data will be used to study the possibility of using a central location for measurements of this type at an airfield.

d. Facilities.

Approach Lights. The Civil Aeronautics Administration plans to replace the present slopeline approach-light system with a complete Configuration A system by July 1, 1958.

Weather. Installation of equipment, and other field work has been delayed this quarter because of heavy rainfall. The rainfall for January was 11 inches and for February 15 inches.

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U. S. DEPARTMENT OF COMMERCE
Sinclair Weeks, *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. Nuclear Physics. Radioactivity. X-rays. Betatron. 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. Analog 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.

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. Calibration Center. Microwave Physics. Microwave Circuit Standards.


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