NATIONAL BUREAU OF STANDARDS REPORT

9661

Development, Testing, and Evaluation of Visual Landing Aids
Consolidated Progress Report for the Period July 1 to September 30, 1967

By
Photometry Section
Optics Metrology Branch
Metrology Division
Institute for Basic Standards

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D. C., 20234.

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NBS PROJECT		NBS REPORT
2120411 2120414 2120641 2120653	December 26, 1967	9661

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 Administration

For the Period
July 1 to September 30, 1967

By
Photometry Section
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Development, Testing, and Evaluation of Visual Landing Aids

July 1 to September 30, 1967

I. REPORTS ISSUED

Report No.	Title
9608	Development, Testing, and Evaluation of Visual Landing Aids, Consolidated Progress Report for Period April 1 to June 30, 1967
212.11-103/66 Supplement	Life Test of "Factory-Aimed" Type PAR-64 Iodine-Cycle VASI Lamps
212.11-22/67	Photometric Test of Eight Type Q6.6A/PAR56/2 Approach-Light Lamps
212.11-26/67	Photometric Evaluation of a 500-Watt "Night Vision Flood Light"
212.11-28/67	Photometric Tests of a SATS Runway Centerline Light
212.11-32/67	Photometric Measurements of "Factory-Aimed" Type PAR-64 Iodine-Cycle VASI Lamps (Group 3)
212.11-34/67	Photometric Tests of a Type L-849 (I-Series) Condenser-Discharge Flashing Light

II. VISIBILITY METERS AND THEIR APPLICATION

Shipboard Visibility Meter.

During this period the construction of all units was completed and check-out of the system was completed. When the system was first tested, large undesired pulses appeared throughout the system each time the lamp fired. Several days of investigation showed that these pulses were due to the lamp trigger pulse. A resistor in series with the high voltage trigger wire to the flash tube eliminated the problem. This resistor reduces the current if the pulse arcs to the electrodes or to the reflector.

When the system was operated outdoors, a large amount of 60 Hz signal was observed in the output of the photomultiplier preamplifier in the night-operating mode. This was traced to the magnetic field from the rotary solenoid which removes the neutral density filter for night operation. The solenoid is operated from poorly-filtered half-wave rectified 60 Hz. The magnetic field effectively modulates the gain of the photomultiplier, and the current in the tube due to daylight was modulated at 60 Hz. Moving the solenoid away from the photomultiplier and operating the filter with a long linkage eliminated this problem. The shutter motor was then found to cause a similar problem. This motor was moved away from the photomultiplier and a chain drive installed to operate the shutter.

During the test period the system has been run overnight about 6 or 7 times. The only failures have been a timing lamp burning out after only a few hours of operation and a wire in the lamp high voltage cable breaking at the connector. Some additional strain relief has eliminated this problem. The system is now ready for testing on the roof of the Administration buliding. During the test period circuit drawings and a preliminary operating instruction manual will be prepared.

Fog Detector Field Tests.

A program for the testing of several types of fog detectors in the field at the Arcata Airport has been established. The primary purpose of these tests is to correlate the response from the different types of instruments with the atmospheric transmittance. Their performances as fog detectors will also be evaluated. These instruments will be installed on suitable mounts in the fog-variability-studies test area where several transmissometers are operated. This area is nearly level and is well removed from trees, sizeable structures, and irregular terrain features which are likely to affect atmospheric conditions.

The Edison Fog Detector.

A fog detector manufactured by Thomas A. Edison Industries was installed in the field for tests on August 15. This instrument measures the forward scatter of radiation from an ultra-violet source over a base line of approximately three feet. The receiver responds only to ultra-violet radiation and works in daylight as well as at night. All direct radiation from the source is carefully baffled from the detector, which then receives only the radiation scattered by the particles in the atmosphere. This equipment was mounted on an existing stand, which places the sampled area at approximately nine feet above the ground. This location is approximately 50 feet from the baseline of both a 250-foot and a 500-foot baseline transmissometer. The detector output signal was brought into the laboratory over approximately 3000 feet of cable, where it is amplified and recorded. The Edison fog detector has been in operation since August 15. Very little maintenance has been required. A change in weather conditions from clear to a visibility of one mile is readily apparent from the change in signal output. The recorded signals are approximately 5 and 10 volts when transmittance over 250 feet is 0.1 and 0.01, respectively. In clear conditions the instrument has a noise level of approximately 0.8 volts at night and 2 volts in bright sunshine. The response is much greater for drizzle and small raindrop conditions than for fog of the same transmissivity. The response of this instrument is dependent on the focus adjustment of the detector and of the projector lamp.

The Hoffman VMS-508A Fog Detector.

A VMS-508A fog detector, manufactured by the Hoffman Electronic Corporation, was received on loan from the U. S. Coast Guard for testing. This fog detector was developed from the prototypes tested at Arcata during the 1965 fog season. It is a backscatter-type device which utilizes a beam of near-infra-red light from a gallium-arsenide diode. The backscattered light is detected by a receiver containing a photovoltaic cell placed just above the projector. The centerlines of the light beam and the field of view of the receiver intersect at a point 7.5 meters from the transmitter. The projector, receiver, and control unit are designed to mount on a 3-inch vertical pipe. Some of the more important differences between this model and the prototypes are: 5-inch diameter, instead of 10-inch diameter, spherical mirrors; better protective housing; output signals suitable for recording directly by 1-milliampere d.c. recorders with input impedances of 1500 ohms; anti-condensation heaters for the mirrors and cover glasses; and targets and filters for calibration purposes. This particular model was designed for detecting the presence of fogs having visibilities of 1 to 5 miles. When this instrument was first put into operation, the recorded signal showed a very high noise background and a very erratic signal at all levels. The average background reading was approximately 0.20 milliamperes at night and 0.24 milliamperes in daytime. With the high background a satisfactory calibration could not be obtained. There is also some indication that the sensitivity of the instrument is below the design value. The Coast Guard has stated that they will supply a second unit for evaluation and comparison. The Hoffman fog detector was installed in the field with the receiver approximately 8 feet above the ground. This unit is installed near the Edison fog detector. The recorder is approximately 3000 feet away in the laboratory. The recorded

response shows changes in signal corresponding to changes in transmissivity. Even with the high background and erratic signal, decreases in transmittance below 0.9 over a 250-foot baseline can be recognized. When the instrument was first installed, a full scale reading was obtained when transmittance was below 0.1 but lower transmittances were required for a full scale reading after a few weeks' operation. Some of this loss in sensitivity resulted from smoke on the inside of the cover glasses. Apparently this smoke originated from the anti-condensation heaters on the cover glasses. The heat has cracked the glass on the projector. Despite the questionable quality of the signal, operation will be continued until further checks can be made.

The Frungel Side-Scatter Fog Detector.

A Frungel fog detector, type II, manufactured by Impulsphysik, Dr. Ing. Frank Frungel, G.m.b.H., was also obtained for test. This instrument had previously been used by the Coast Guard and the Weather Bureau. This fog detector measures the light scattered to the side of a projected beam. The source of the projected light beam is a sealed spark lamp which flashes at one to two pulses per minute. A "honeycomb" mechanical light collimator is placed in front of the projector to assure a collimated beam. This flashing beam passes near a photocell receiver consisting of a panel of 22 phototubes. The phototubes do not view the direct beam, but measure the light scattered to the side from aerosols in the area from two meters ahead of the phototube panel to five meters beyond this panel. A set of neutral grey filters is installed over the phototubes to limit the phototube current produced by daylight.

The projector worked very well, except that the flash rate is sensitive to variation of input voltage. The preamplifier and receiver amplifier and metering circuits were not operative when the instrument was received. Apparently some of the components in the potted units had failed. Weather Bureau personnel report that these circuits did not work during their tests and they used an operational amplifier to replace them. Further work on this instrument will be done using new amplifier and metering circuits when an operational amplifier is received.

Other Fog Detectors.

The Coast Guard is furnishing an AGA fog detector manufactured by AGA Aktiebolag. This instrument operates on the backscatter principle. This unit is expected to arrive at Arcata early next quarter. NBS has developed a shipboard visibility meter which may be ready for field testing by the end of the next quarter. There are possibilities of obtaining one or two other types of fog detectors for field testing in the near future.

Fog Variability Studies.

There are no specific field tests of fog variability planned for this fog season. Records from the eight transmissometer installations will be obtained. A report covering a summary of the occurrence of low visibility conditions at the Arcata Airport for the 10-year period from 1957 through 1966 is being prepared. These data were obtained from the transmissometer at

the touchdown area of runway 31. Low visibility conditions as used in this report are defined as conditions when transmittance over a 500-foot baseline is 0.5 or less. The annual average amounts of these low visibility conditions were 349 hours night, 174 hours day, and 523 hours total. A summary of conditions which would have resulted in runway visual ranges (RVR) of 1000 feet or less at the Arcata Airport for 1965 and 1966 will be included in the summary report. These conditions totaled approximately 56 and 24 hours, respectively, for day and night in 1965, and 35 and 5 hours similarly for 1966. A summary of low visibility and low ceiling conditions as reported by the FAA Flight Service Station observers for several years will also be included in the report. The report will be completed next quarter.

The restricted visibility conditions at the Arcata Airport for the months of July, August, and September, as recorded by the elapsed time meters, were as follows:

Instrument flight rules (IFR)	1060 hours
Runway lights operated at step 5 intensity	109 hours
Transmittance below 0.5 over a 500-foot baseline in daytime	118 hours
Transmittance below 0.5 over a 500-foot baseline at night	268 hours

There were nearly twice as many hours of IFR conditions and runway light operation at full intensity during this quarter as during the previous quarter.

Transmissometers.

As was reported last quarter some transmissometer indicators have shown a gradual zero shift when the signal pulse rate is low. Further investigation has located the component causing this effect. Capacitor C204 (NBS Report No. 2588), which is a 0.1 microfarad "bathtub" type, sometimes develops a semipermanent charge which is slowly discharged during low- or no-signal conditions. This leakage causes a zero shift downward. Four of eight indicators at Arcata showed a marked indication of this effect. One indicator would shift as much as 6 percent of full scale, with the decrease continuing for at least 30 minutes. Replacing the bathtub capacitor with a plastic encapsulated type of the same capacitance reduced the shift to a negligible amount. Disconnecting the low side of this capacitor from the zero-adjusting circuit and connecting it to ground further reduced these shifts. A report on this change and modification will be issued next quarter.

A need for isolating the signal lines from the indicator, and a suitable way of accomplishing this isolation was reported in NBS Report No. 9453. Since other installations may encounter similar difficulties, tests were made to find a suitable type of transformer for the purpose, which is currently available. Any 500-ohm to 500-ohm line-to-line transformer having a frequency response with an upper limit above 20,000 Hz and a capacity of at least two volt-amperes is satisfactory.

Performance data regarding transmissometer calibration and maintenance were collected and transmitted to the Weather Bureau Research Group at NAFEC. This material included performance data obtained in the laboratory during the development of the instrument and performance and maintenance data obtained from the operation of the equipment at the Arcata Field Laboratory.

Type L-849 (I-Series) Condenser Discharge Flashing Light.

Photometric measurements were made of a type L-849 (I-Series) condenser discharge flashing light manufactured by Sylvania Electric Products Inc.

Operation of the unit is by direct connection into a 6.6-ampere constant-current line. FAA Specification for type L-849 lights, I-series, specifies operation with a primary input current of 2.8 through 6.6 amperes.

When the unit was operated in a constant-current circuit, it was determined that the voltage on the flashtube was 1975 volts with 6.6 amperes in the primary circuit, and 2000 volts with 2.8 amperes in the primary. The voltage peaks were maintained at 2000 volts during the test.

The unit did not meet the requirements of the specification for the type L-849 light for beam width at an intensity of 5000 candelas.

Improved Heliport Perimeter Light.

Photometric measurements were made of several lamp-fixture combinations, namely of M-1, L-802, and L-810 fixtures and of Q6.6A/T4/CL, 6.6A/T10/2P, and 1020/66/A21 lamps, for use as heliport perimeter lights. The L-810-1020/66/A21 (60 watt) combination produced representative intensities as follows:

Elevation in Degrees	Intensity* in Candelas
0	120
2.5	175
5	200
7.5	215
10	225
12.5	225
15	185
17.5	120
20	75

* Average of intensities measured in two vertical planes.

When a 1020-lumen lamp was operated from a 6.6/6.6-ampere transformer in a 6.6-ampere circuit, the lamp current was 6.42 amperes. The relative intensity of the lamp at this current is 0.84. Therefore, the preceding intensity values should be multiplied by 0.84 if the lamps are to be operated from 30/45-watt transformers.

Centerline Light for the SATS System.

NBS Test Report 212.11-28/67 was issued giving the results of photometric measurements and water leakage tests of a centerline light for use in a SATS runway.

Shield For Circling Guidance Lights for SATS System.

A shield for the SATS circling guidance light has been designed and constructed. This shield consists of a polished alumimun spherical reflector that will attach readily to the lamp socket of the present light. (See figure 1). With the shield in position the horizontal beam spread of the light will be approximately 180^{o}. A report showing intensity distributions is being prepared. This type of shield should also be useful for taxiway lights.

20-Ampere, 500-Watt "Night Vision Floodlight".

NBS Test Report 212.11-26/67 was issued giving the results of photometric measurements of a "night vision floodlight" manufactured by the L. C. Doane Company.

Field Tests of Type L-842 Inset Runway Lights with Forced Drainage Modification.

The five type L-842 inset runway lights installed to test the effectiveness of the forced drainage modification are operating on a long term test. These lights are operated for three hours daily at rated lamp current. Within the first month of the test four lamps had failed. Apparently these were a defective group of lamps because there have been no failures since then. The lights have not been opened, except to replace lamps, and an inspection is not planned until after the ground has been thoroughly soaked.

Centerline Lighting For SATS.

Feasibility models are being constructed to test the possible use of electro-luminescent lighting material for SATS centerline lights. The completed units will be installed in the SATS system at NAS Lakehurst for an intensity and durability evaluation.

A similar type unit using miniature incandescent lamps in place of the electro-luminescent material will be constructed and evaluated at the same facility.

Figure 1. SATS Circling Guidance Light With Shield (Lens removed)

Q6.6A/PAR56/2 Approach-Light Lamps.

NBS Test Report 212.11-22/67 was issued giving the results of photometric tests of eight Q6.6A/PAR56/2 approach light lamps with a design life of 1000 hours. The lamps were put on life test. Four lamps burned out at 1075 hours. NBS Test Report 212.11-22/67 Supplementary will be issued giving the results of the life test.

Q6.6A/PAR56/3 Lamps with Clear Covers.

Twelve Q6.6A/PAR56/3 halogen-cycle lamps with clear instead of stippled covers were received for photometric tests and life test. The data obtained will be used for a proposed amendment to MS 24488. Measurements will also be made of the performance of semiflush lights lamped with these lamps.

"Factory-Aimed" Type PAR-64 Iodine-Cycle VASI Lamps.

The average life of eight 2000-hour, "factory-aimed" type PAR-64 iodine-cycle VASI lamps was 3320 hours. NBS Test Report 212.11-103/66 will be issued.

Field Tests of the NBS-Developed Cable Test/Fault Locator.

A set of equipment for tracing cables and locating faults in underground circuits, which was developed at NBS, is being field tested at Arcata. The principle of operation is similar to that of the AN/TSM-11 cable test/detector equipment but provisions have been added or improved for selecting either of three frequencies, varying the voltage of the test signal applied to the cable widely for better load matching, and reducing the likelihood of saturating the receiver amplifier stages. In tracing a cable, the high frequency works well but is picked up by other conductors, as would be expected. This pickup can be a problem unless the cable being tested is carefully followed along the full route. By changing the signal frequency when interference occurs, cable tracing was accomplished rather easily in the tests attempted. The keyed signal of the new signal generator is preferred to the pulsed signal of the TSM-11. Fault-location tests have been limited. The faults in a circuit with multiple high-resistance faults were not located. Testing will be continued.

Airfield Lighting Maintenance Manual.

Work on a revised draft of the section on Preventive Maintenance was continued during the early part of the quarter. This work was discontinued later to concentrate on preparing equipment for tests during the fog season. This work should be resumed soon.

Gage for Checking L-850 Light Base for Conformance to Specification.

A gage was fabricated for checking L-850 light bases. This gage will determine only whether a light head that meets the specifications can be mounted on the base, not the conformance of the bases to the specification. A "go" and a "no-go" gage will be constructed for this purpose.

III. CARRIER LIGHTING AIDS

Tri-Color Angle-of-Approach Indicator.

At the request of the Naval Air Systems Command a Westinghouse Tri-Color Angle-of-Approach Indicator was modified and sent to Philadelphia. Modifications included a rigid mounting base that is adjustable to various approach angles and an extension shield to restrict the stray light from the lens. (See figure 2).

The unmodified indicator is mounted on a 2-inch pipe or frangible coupling. When it is so mounted, it is susceptible to misalinement by shock and vibration. The modified mount is believed suitable for both shipboard and shore-base use.

IV. MISCELLANEOUS TECHNICAL AND CONSULTIVE SERVICES

The proposed FAA/DOD Specification for Airport-Lighting Constant-Current Regulators was reviewed and our comments were forwarded.

The following proposals and draft reports have been reviewed. Comments were forwarded by marked copies of the document and/or conferences with cognizant DOD and FAA personnel.

Design of a Meteorological Tower for NAFEC.
Report, Tests Made at the FAA Fog Chamber of an RVR Meter Made in Belgium.
Description of an Infra-red Airport Guidance System.
Program for Development of Transmissometer Calibration Techniques and Devices, Phase 1.
Interim Report, Evaluation of Several Multi-transmissometer Systems.
Technical Proposal for a New Visual Range Measuring Concept from Cambridge Systems.
Interim Report, Investigation of Various Aviation Obstruction Markers, by Mt. Auburn Research Associates, Inc.
Proposed Technical Approach, Depth of Flash Optical Landing System.
Proposal, Runway Centerline Lights, from Structural Electric Products Corp.

Numerous documents relating to the items on the agenda of the ICAO 5th Air Navigation Conference relating to visual aids have been reviewed and several conferences at which these documents were discussed were attended.

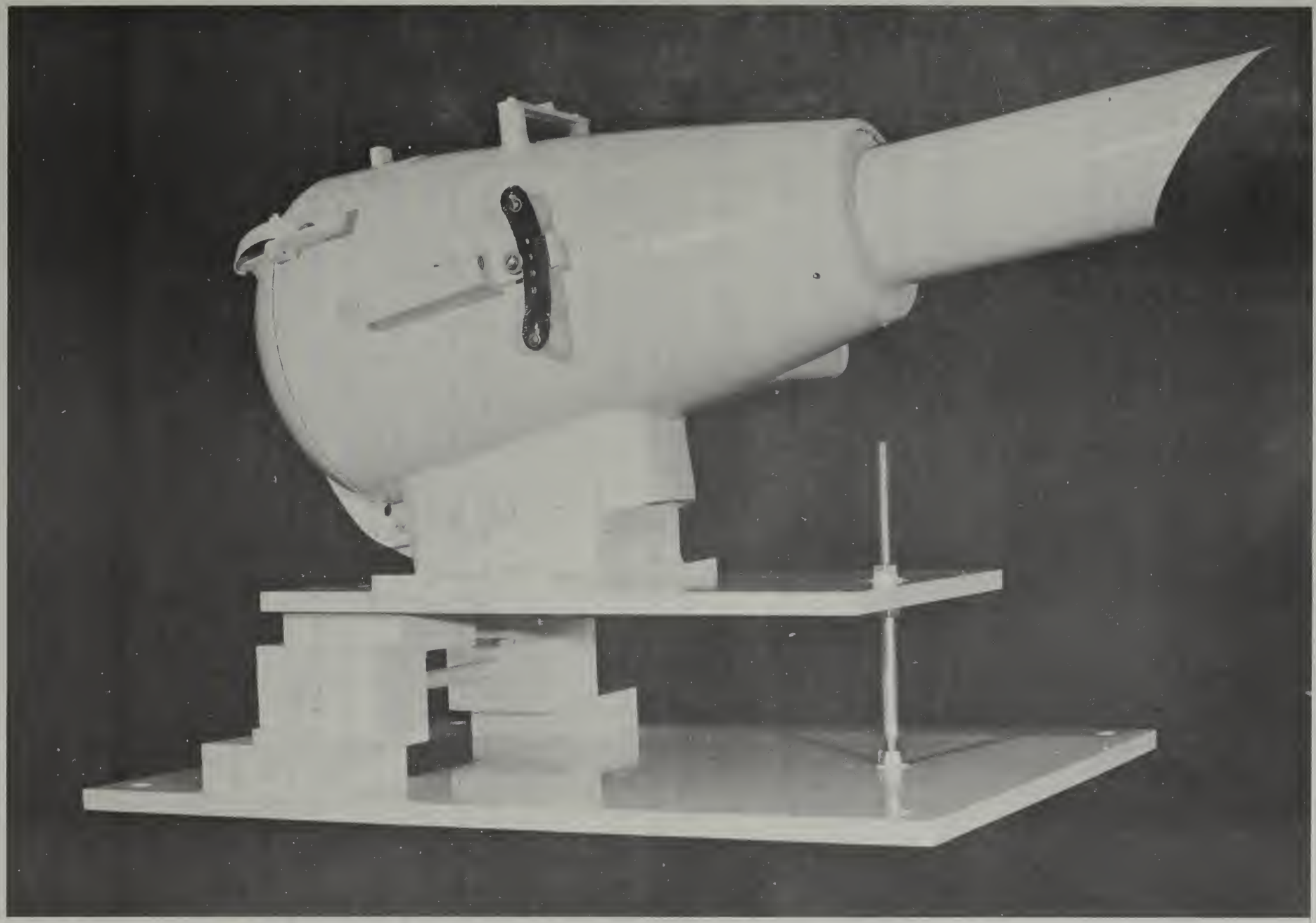

Figure 2. Tri-Color Angle-of-Approach Indicator
With Modified Mounting Base

Visit to NAFEC.

A trip was made to the National Aviation Field Experimental Center at Atlantic City for an inspection of their facilities for the photometry of flashing lights. It was determined there and through some checks made at NBS that a constant-voltage transformer on the input to the flashing light circuit was limiting the voltage to which the energy storage capacitor would charge.

V. MISCELLANEOUS

Army Materiel Command.

Representatives from the Army Materiel Command contacted the Arcata Field Laboratory in regard to occurrence and conditions of fog in the area. If they have suitable instruments available, they will furnish recorders for wind direction and velocity, temperature, and relative humidity, to record the information from the Weather Bureau's remote weather station. They would like copies of this information for correlation with the transmissometer records.

Runway Markings at Arcata Airport.

Plan drawings of the runway markings as installed at the Arcata Airport were forwarded to NAFEC for use in proposed tests on a simulator to determine the effectiveness of this system. Note: To date the FAA has not authorized the use of RVR for operations at Arcata because the runway markings are not standard.

155-mm, Fresnel Drum Lenses.

The chromaticities and transmittance ratios of three red and three green 155-mm Fresnel drum lenses were determined. The average transmittance ratio of the red lenses was 0.292. The average transmittance ratio of the green lenses was 0.479! The chromaticity of the red lenses met the requirements of MIL-C-25050 for aviation colors, having chromaticity coordinates $x = 0.667$, $y = 0.332$ for a source of $2854^{\circ}K$. For a source of $2854^{\circ}K$ the chromaticities determined for the green lenses were slightly outside the yellow-green limit for aviation green, having chromaticity coordinates of $x = 0.290$, $y = 0.479$. However, since the chromaticities of the lenses were determined by visual comparison with glass filters, there is considerable uncertainty in the chromaticities determined for the green lenses because of the difference between the spectral transmittances of the lens and the comparison filters. Moreover, the green lenses became more yellow when viewed from directions below the peak of the beam and more blue when viewed from above the peak.


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